



**Model BHP/EPB™ Test Bench for Brake Hydraulic Pressure and Electric Parking Brake Systems**

## Overview

The Model BHP/EPB™ Brake Hydraulic Pressure (BHP) and Electric Parking Brake (EPB) Systems test bench from MB Dynamics accurately measures and controls the hydraulic pressure and EPB power levels applied to brake calipers during buzz, squeak & rattle (BSR) testing, as well as brake durability, stability, functional or performance testing. Varied brake pressures are applied according to timing diagrams, as well as automated or manually program-controlled repeat cycles, as required to assess brake caliper/rotor assembly noise, useful service life, and other critical performance metrics.

The Model BHP/EPB™ test bench supports a brake caliper/rotor assembly that is bolted onto a fixture. The fixture is attached to either the vibration exciter or test bench. The brake caliper line is routed to a panel-mounted air-to-hydraulic pressure booster unit. Controlled hydraulic fluid pressure is applied to the brake caliper's inlet port. Hydraulic brake fluid pressure commands and pressure ON/OFF time sequences are then entered and controlled via MB's own supplied Model BHP/EPB™ software. The software commands the test bench System Interface Control Box to either perform data acquisition and control of applied brake pressures, or to apply and/or release the EPB, depending upon end-user needs.

The test bench may be further synched with MB Dynamics' own Millenium™ Dynamic Test Controller as to allow for test bench START/STOP functionality according to end-user defined schedules. The Millenium also synchronizes noise measurements by triggering data acquisition via MB's own BSR SUITE™ vibration analysis software and sound measurement system. This combined functionality allows for synchronized BSR testing to be flexibly conducted under different ON/OFF pressures, EPB ON/OFF power levels, and timing cycles. The software also graphically displays caliper pressure, EPB voltage, and EPB current data in real-time. Displayed data may be saved at any time and exported to either Excel or a Windows-based PC clipboard. To minimize unwanted noises during BSR testing, the system's hydraulic panels, air panels, and EPB DC power supply are located outside of the test bench acoustic enclosure. The System Interface Control Box and PC monitor/mouse/keyboard are located inside with the operator.

### **MB Dynamics, Inc.**

25865 Richmond Road • Cleveland, OH 44146 USA  
Tel: +1 216 292 5850 • Fax: +1 216 292 5614  
For Sales: sales@mbdynamics.com • For Service: service@mbdynamics.com  
www.mbdynamics.com

### Applications

- Squeak & rattle or BSR testing of brake calipers and drums under a variety of brake pressure conditions, in accordance with GMW16316 “Objective Brake Component Squeak & Rattle Test”
- Brake caliper development & qualification testing while subjected to automated brake fluid pressures & EPB controls, and while calipers are undergoing durability, mileage accumulation, performance cycling, and other durability testing.
- Automated cycling of different pressures, ramp rates, ON/DWELL times, OFF times, total test time, etc. of both hydraulic brake and EPB calipers
- Full manual parameter control for troubleshooting, warranty, and development testing

### Specifications

<b>Pressure Range</b>	5 to 150 bar
<b>Pressure Control</b>	± 2 bar for <40 bar; ± 5% for ≥40 bar
<b>Pressure Change Rate</b>	≤ 150 bar/sec; positive & negative slopes have same ramp rates
<b>Brake Fluid Type</b>	DOT4 only (for other fluids, please consult MB Dynamics)
<b>EPB Voltage</b>	Typically 12 VDC nominal, adjustable from 0 to 32 VDC
<b>EPB Current</b>	Current limit, adjustable from 0 to 30 ADC
<b>Test Timing by Operator</b>	Start Delay, Ramp Rate, Hold, Delay Between Cycles, Delay between pressure and EPB cycles, Total Test Duration
<b>Automatic Control Mode</b>	System uses parameters from Test Timing to automatically command application of pressure and/or EPB power
<b>Manual Control Mode</b>	Operator manually applies/releases pressure or EPB power
<b>Combined or Independent Mode</b>	Pressure and EPB test can be combined or run separately
<b>Triggered Control Mode</b>	Operation of Automatic Control Mode triggered from Millenium Dynamic Test Controller, which starts/stops the automatic cycle
<b>System Interface Control Box</b>	<ul style="list-style-type: none"> <li>• Analog Circuits provide gain adjustment and signal conditioning for pressure command and feedback signals</li> <li>• Safety Circuits designed to attempt to prevent unsafe operation from inadvertently occurring by monitoring: overpressure, data communications, and E-STOP</li> <li>• EPB Circuits apply electrical signals to caliper’s EPB connector and include a programmable DC switching power supply and Current Monitor and Direction (Polarity) Control</li> </ul>
<b>Hydraulic Panel</b>	Houses all components to supply and control brake fluid pressure by servo controlling air pressure using a unique combination of pneumatic and hydraulic components
<b>Air Panel</b>	Supplies filtered, regulated, and controlled air to hydraulic panel so brake fluid pressures and rates can be achieved & controlled
<b>Linkage to Millenium Controller</b>	Available for automated operation with vibration test, with both hydraulic pressure and EPB functionality. Millenium vibration controller establishes a schedule to send START bit HI (turning ON whatever pressure/EPB profile is loaded into the BHP/EPB Bench) and said Pressure/EPB test runs as long as Millenium holds START bit HI. When START goes LO (on schedule as programmed in Millenium GUI’s), pressure and EPB turn OFF.
<b>File System</b>	Uses standard Windows commands and file structure
<b>Data Storage</b>	<ul style="list-style-type: none"> <li>• Test setup files saved as .bpd for retrieval, use, and editing</li> <li>• Copy data displayed in graphs to Windows clipboard</li> <li>• Export data to Excel</li> </ul>
<b>Underlying Code Base</b>	National Instruments LabVIEW

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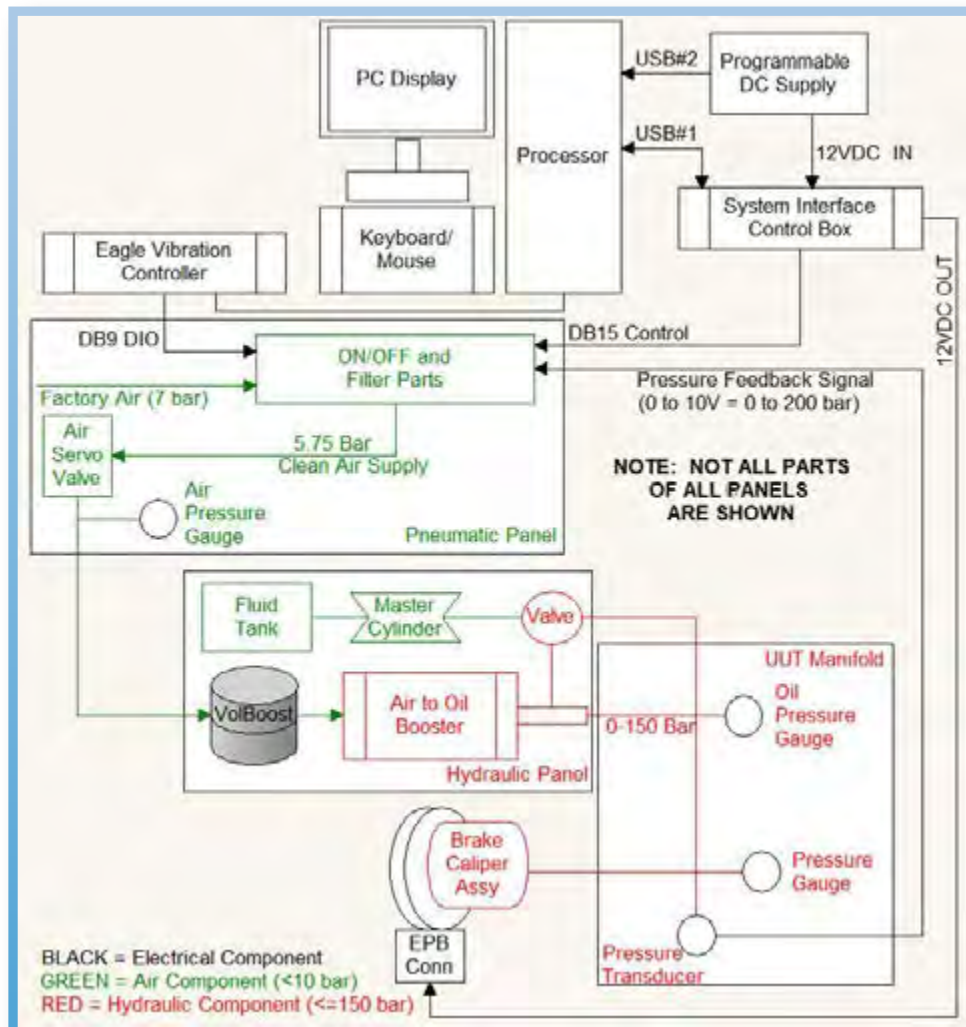
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### Model BHP/EPB™ Test Bench Deliverables:

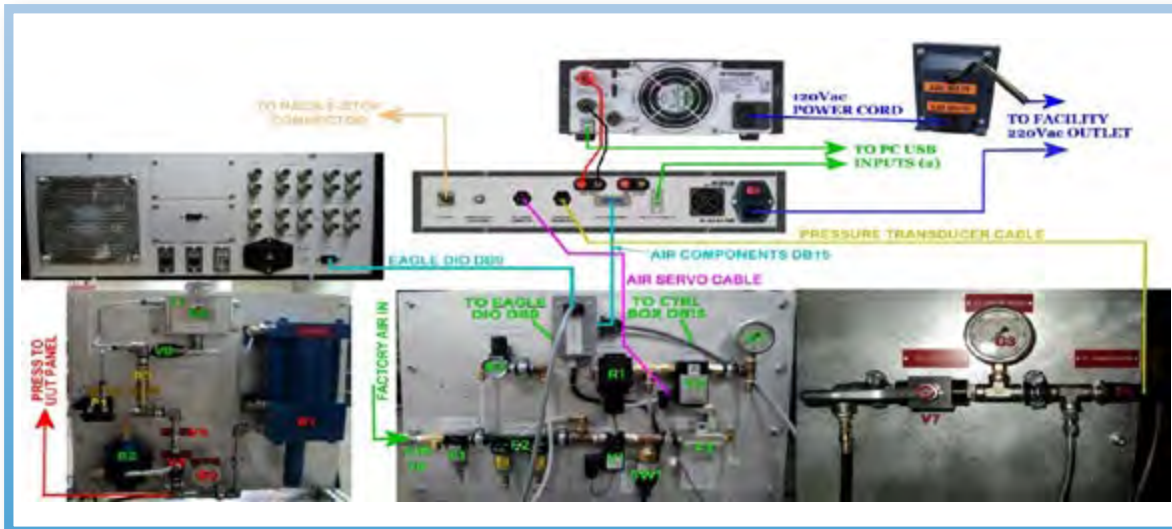
BHP/EPB™ Test Bench Application Software	EPB Programmable DC Power Supply
Hydraulic Processing Panel to supply $\leq 150$ bar	Software & Driver Installation Instructions
Air Processing Panel to servo-control air to hydraulic	Interconnecting Hoses, Cables (Turnkey)
UUT Manifold Panel to disconnect UUT without bleeding system after each UUT changeover	Bench User's Manual Application Note
System Interface Control Box	Bench Bleeding Instructions Application Note

### Typical System Components: System Block Diagram

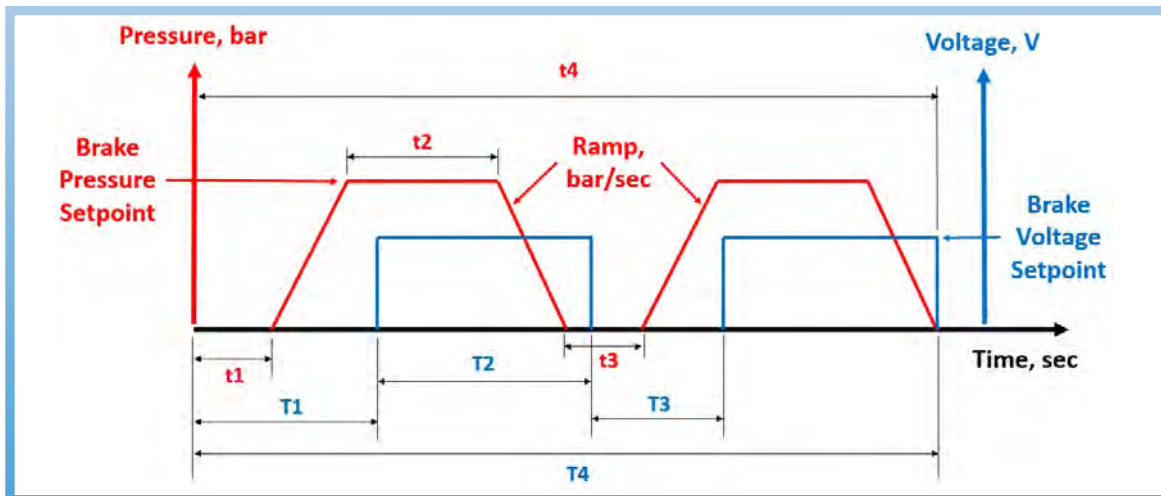


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### Brake Caliper Timing Diagram for Test Setup and Performance



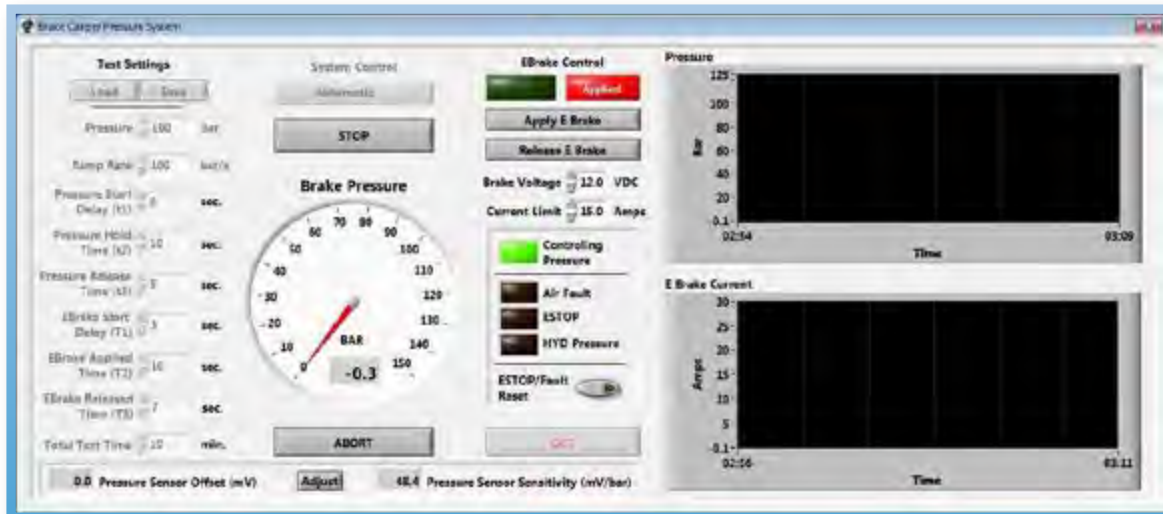
Brown traces show timing of hydraulic pressure: Start Delay ( $t_1$ ), Ramp (bar/sec), Dwell or Hold ( $t_2$ ), Ramp (bar/sec), Release Time ( $t_3$ ), and Total Test Time ( $t_4$ ).

Blue traces show timing of EPB voltage ON/OFF from Start Delay ( $T_1$ ) to power ON or Applied ( $T_2$ ) to Release Time or power OFF ( $T_3$ ) and Total Test Time ( $T_4$ ).

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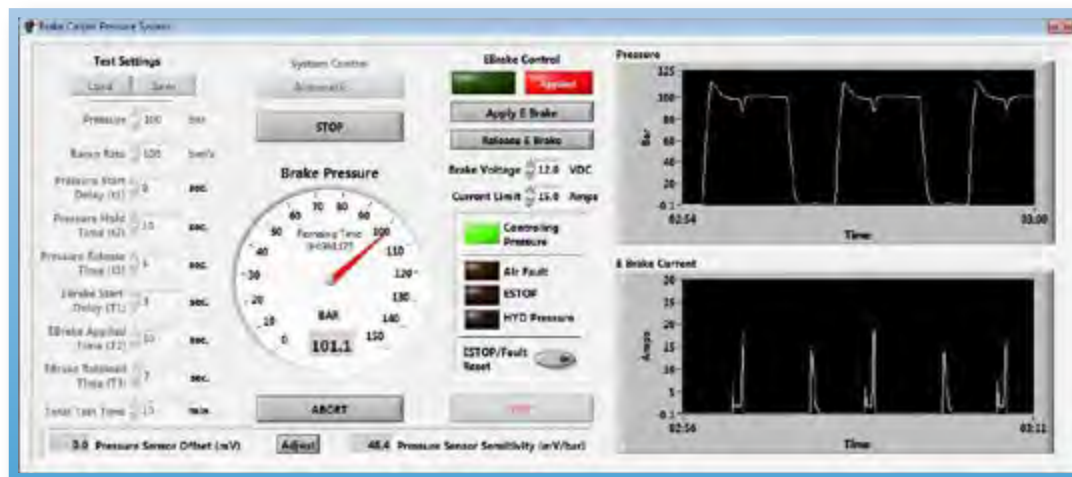
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## BHP/EPB™ Test Bench Software, Main Setup and Runtime GUI



## Software Control Over all Applications that Follow

### Typical Results, Runtime Screen, of a Combined Brake Pressure Test at 100 bar and EPB Test



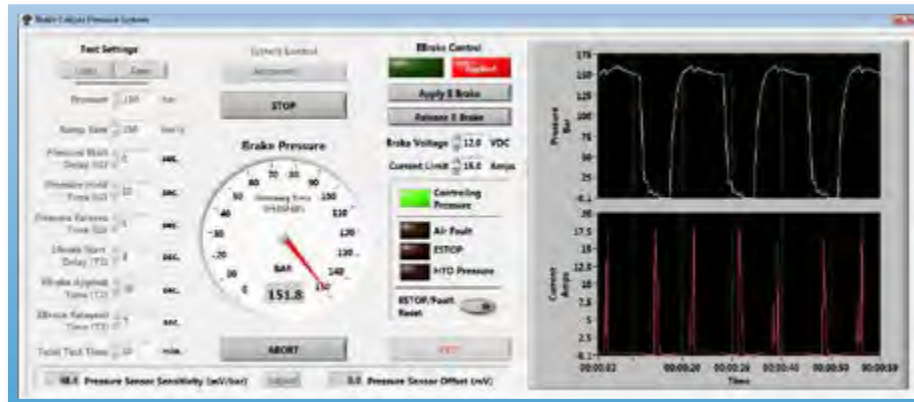
With no time delay at the start of the test ( $t_1 = 0$ ), 100 bar pressure is applied at a ramp rate of 100 bar/sec, held at 100 bar for 10 seconds, ramps down at the same 100 bar/sec, and then pressure is OFF for 5 seconds before the cycle repeats for a total test duration of 10 minutes.

Simultaneously, EPB functionality starts three (3) seconds after the beginning of the test ( $T_1 = 3$  sec.), a Brake Voltage of 12 VDC is applied until the programmed motor current (analogous to EPB braking force) is reached, at which point in time the system turns OFF the EPB supply with the resulting current trace shown. At the end of this apply cycle, a retract command is sent (reverse voltage) for a pre-programmed time limit (to avoid excessively back driving the motor mechanism) before this EPB cycle (distinct and separate from the pressure time cycles) starts again, maintaining its 3 second start delay. This EPB cycle continues for the same 10-minute duration.

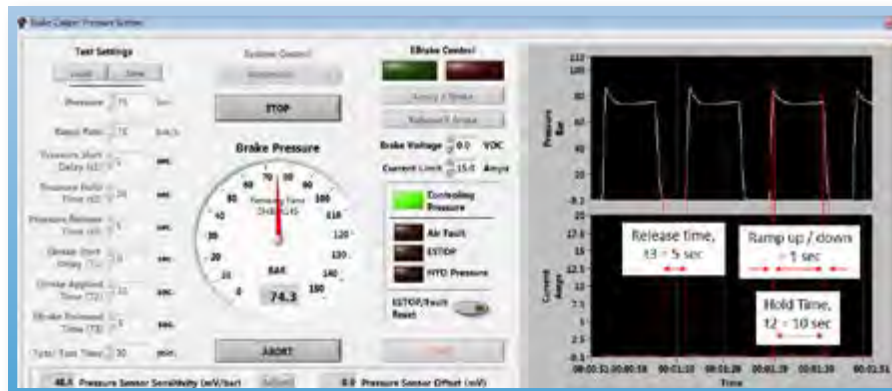
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## Full Performance 150 bar test combined with 12 VDC, 15 Amp EPB test



## Test demonstrating ramp rates of 75 bar/sec for a 75-bar pressure-only test

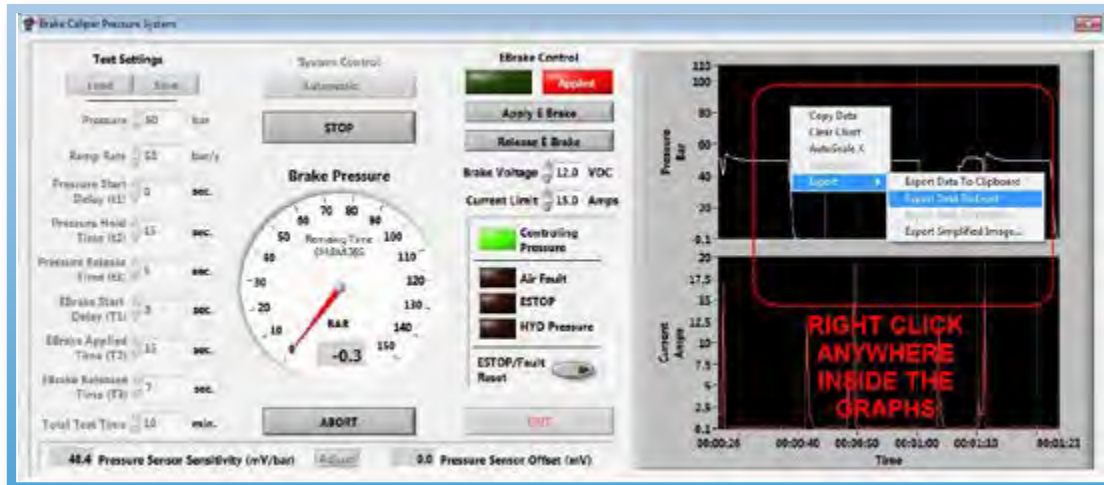


Run-time pressure at the instant data were saved is 74.3 bar, shown on the meter. This test is accurate within 0.9% of the 75-bar target. Red vertical markers have 1 second spacing so this plot shows the rise and fall at 75 bar/second. Pressure Release Time,  $t_3$ , is 5 seconds, the Pressure Hold Time at 75 bar is 10 seconds. Pressure overshoot decays within about 2 seconds. The EPB was turned OFF by setting the Brake Voltage to 0.0 VDC.

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## Data Formatting, Display, and Storage Options



Right clicking anywhere inside either of the two displayed graphs opens the upper control box, allowing the operator to:

- a) COPY DATA – Copies the image inside the gray graph area to the Windows clipboard to a .PNG file
- b) CLEAR CHART – Erases all data displayed in both graphs; allows “fresh” data to be acquired
- c) AUTOSCALE X – Autoscales horizontal axis to highest value currently displayed in the window
- d) AUTOSCALE Y – Autoscales vertical axis to highest value currently displayed in the window
- e) EXPORT – Clicking this option opens the second sub-pull-down as shown. Operator can:
  - 1) EXPORT DATA TO CLIPBOARD – Copies the entire time/pressure and time/current data pairs to the clipboard
  - 2) EXPORT DATA TO EXCEL - Excel spreadsheet opens and the data from the graphs is exported to the spreadsheet with TIME as COL1, PRESSURE as COL2, and EBRAKE CURRENT as COL3. The data can be manipulated and graphed inside Excel as any normal data file.
  - 3) EXPORT SIMPLIFIED IMAGE – Using LabVIEW commands, exports to a Bitmap (.BMP), Encapsulated Postscript (.EPS), or Enhanced Metafile (.EMP) or otherwise saves to a user-selected file name

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### Recommended Optional Accessories for BSR and Durability Testing

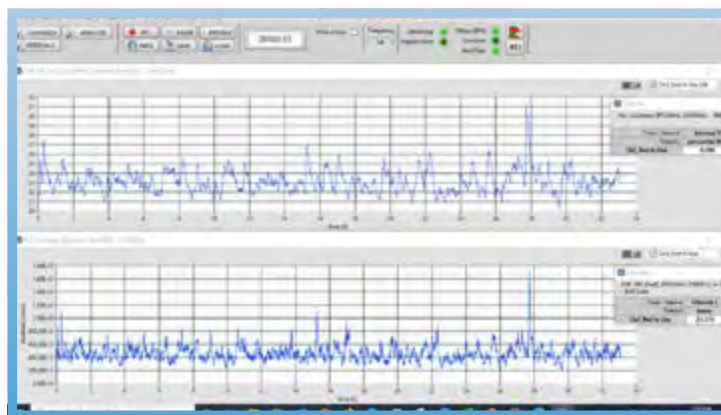
#### Millenium™ Dynamic Test Controller

- Synchs Model BHP/EPB™ test bench for START/STOP functionality on end-user defined schedules
- Synchs noise measurements by triggering data acquisition via MB's own BSR SUITE vibration analysis software and sound measurement system
- Static and dynamic control of up to 8 outputs, 16 inputs, and 8 individual actuators
- Supports electrodynamic, electromagnetic, pneumatic, and hydraulic actuators; linear and rotary motion control test systems; or subcomponents
- Supports acceleration, velocity, displacement, force, and motion profiles, with capability to mix profile types, in order to simulate a typical end-user environment



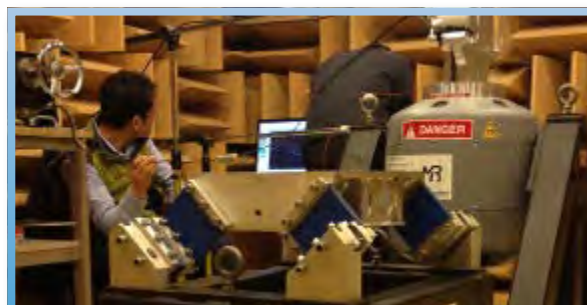
#### BSR SUITE™ Vibration Analysis Software and Sound Measurement System

- Seamless compatibility with the Model BHP/EPB™ test bench
- Complete solution for NVH, Squeak & Rattle, Sound Quality Testing, RLDA, Sound & Vibration Measurements, and Drive-File Generation
- Fast and simple operation
- Comprehensive analysis and assessment of functional and operating noise
- Predefined test configurations for multi-channel road load data acquisition, drive-file generation and objective Squeak & Rattle and Sound Quality testing
- Signal statistics and user defined thresholds or reference-curves can be used for objective evaluation



#### Test Engineering Services

- Fully virtual or in-person
- More than 40-year experts in automotive testing
- Test equipment specification assistance
- Test method and operating procedure development
- Applications troubleshooting assistance
- Dynamic testing; results interpretation; design and production verifications
- Road load data acquisition (RLDA) and processing
- New test system installation and validation
- Full applications engineering support
- Local technical support in more than a dozen countries
- Field service and on-site training
- Test laboratory support



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