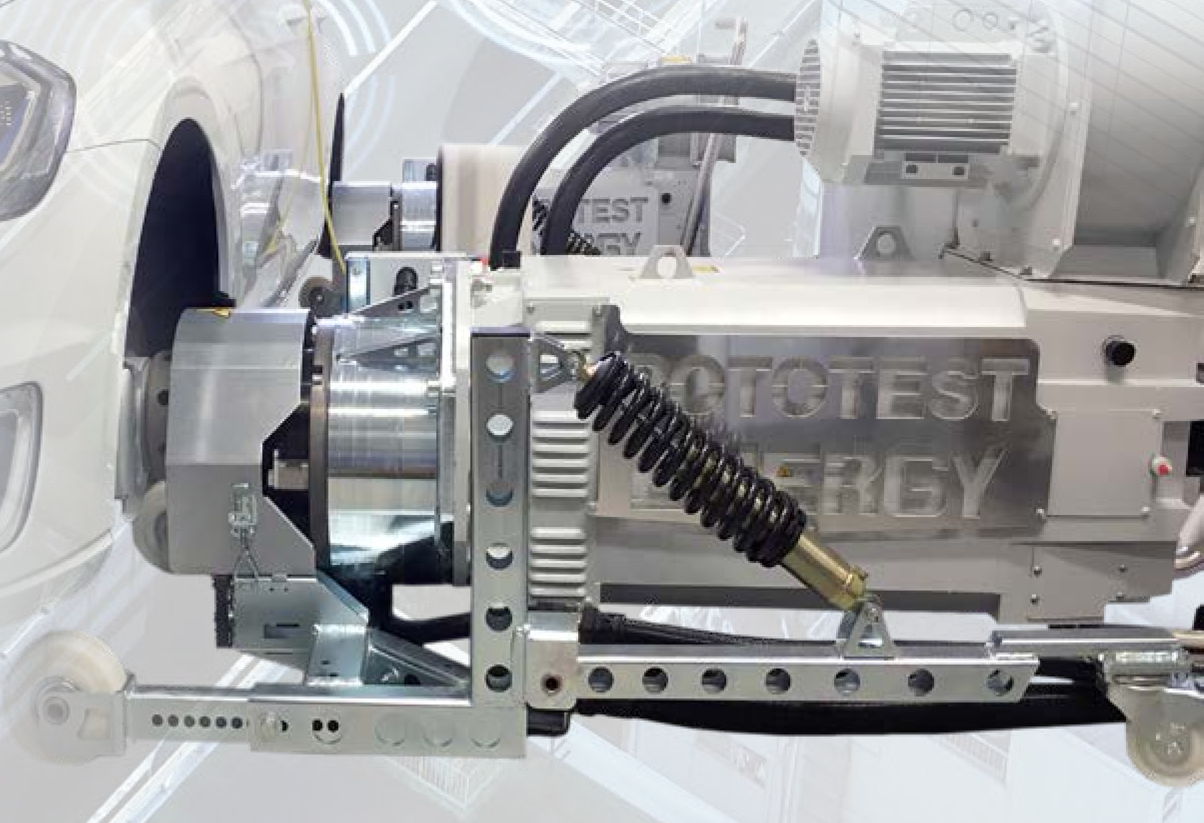
TOYO

Flexible Powertrain Chassis Dynamometers

PRODUCT BROCHURE



Hub-Mounted Chassis Dynamometer with Steering Operation Capability

ROTOTEST Energy

Minimum Preparation Time and Reliable Repeatability New Paradigm for "Road Load Simulation Testing" is here

MINIMUM INFRASTRUCTURE REQUIREMENTS

Unlike traditional roller-type chassis dynamometers (CDM) that need a large facility like an underground pit (*as shown in figure 1*), the ROTOTEST Energy system can be set up in a more compact space with a level floor plan, such as a garage (*as shown in figure 2*), and only requires power supply at 400V, 3 phase. This means that a comprehensive range of tests can be conducted without the need for costly facility modifications.

Additionally, there may be a need for additional equipment, such as cooling and exhaust infrastructure, to support the ROTOTEST test environment, but overall, the ROTOTEST Energy system offers increased cost savings and greater flexibility in testing setups.

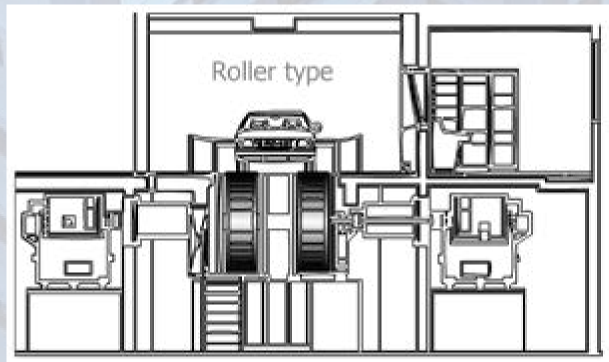


Figure 1: Conventional Roller-Type CDM

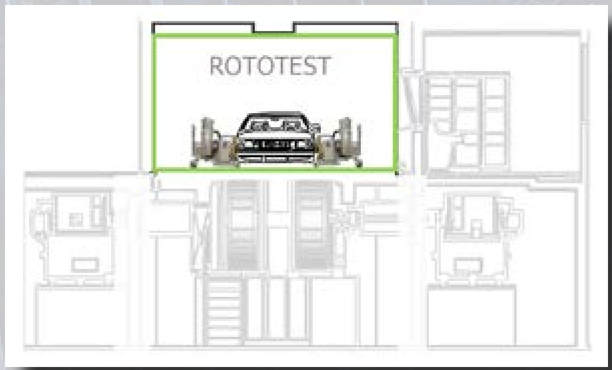
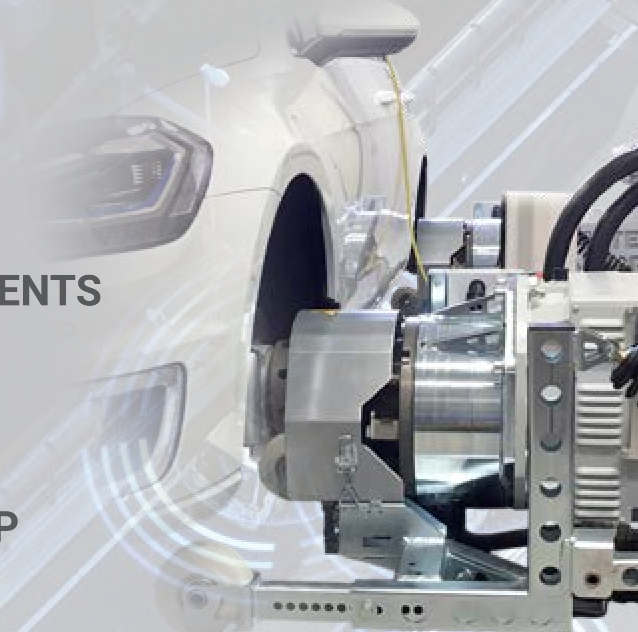


Figure 2: ROTOTEST

COST-EFFECTIVE

PERFORM/VALIDATE EPA CERTIFICATION REQUIREMENTS

EASY TO SETUP



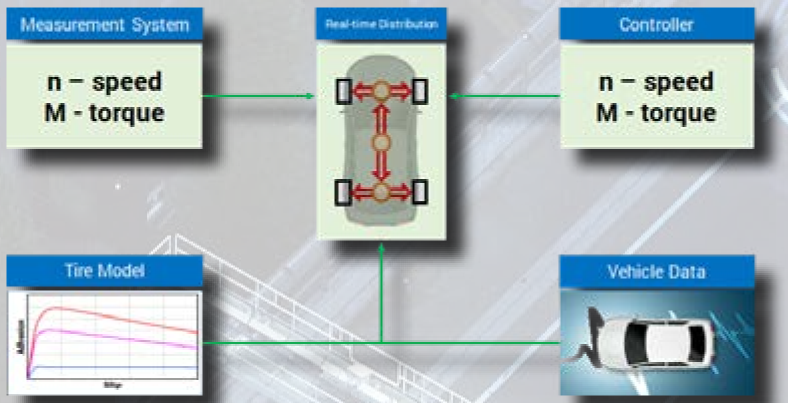


Figure 3: Real-time Torque Distribution

MODULE FOR VARIOUS TEST REQUIREMENTS

By utilizing a state of the art 4Q control system and the ROTOTEST Active Inertia technology, the vehicle's inertia can be simulated electronically to replicate true road conditions. In addition to being able to simulate different types of driving patterns, each tire can be modeled using a "magic formula" (*see figure 3)*.

- Constant torque, constant speed
- Sweep
- Road load simulation
- Individual torque control, etc.

STEERING OPERATION CAPABILITY

Due to its unique structure, ROTOTEST Energy provides a bench test with steering operations. This is something not typically achievable with conventional CDM. The steering angle can be rotated to +/- 20 degrees (*see figure 4*). You can simulate driving situations including steering operation, evaluate for ADAS, autonomous car, etc.

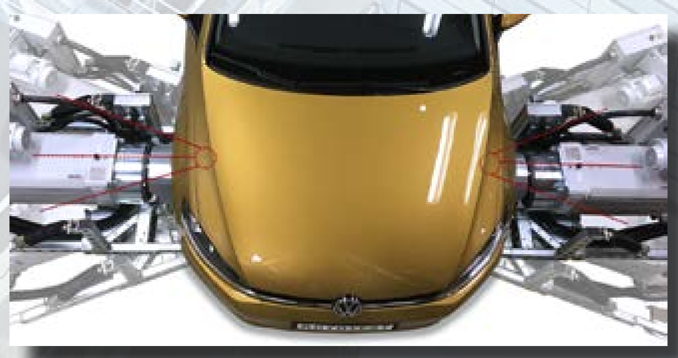


Figure 4: Steering Controls

EXPANDABLE TEST MODULE

STEERING OPERATION

CRITICAL MEASUREMENTS

SHORT SET UP TIME

When using other hub-mounted chassis dynamometers, it can take an inordinate of amount of preparation time to ready a vehicle for testing. However with ROTOTEST, you can be ready for testing (*see figure 5*) in the same amount of time required to install four common tires. Please note set up times are based on information from OEM's and Engineering Consultants.

	ROTOTEST Energy	Competitors
Set up time	10-15 minutes	3-6 hours
Time to remove	10-15 minutes	30-60 minutes
Number of operator(s)	1-2	2-4
Operation rate per day (assume 2h/test, 7h/days)	about 86%	about 29%

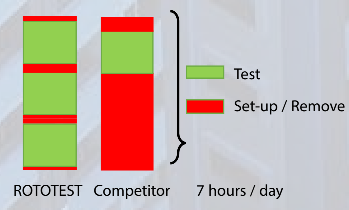


Figure 5: Comparison of Set up and Operation Times

Please visit our the ROTOTEST microsite on our website for further information including links to demonstration videos. https://toyotechus.com/automotive_measurement/powertrain_and_chassis

STEERING ASSISTANT SYSTEM

The ROTOTEST dynamometer offers an optional steering assistant system, which enables precise reproduction of steering reaction forces. With this optional add-on, simulated lane change maneuvers can be performed in a highly accurate and controlled manner, allowing for exhaustive testing and evaluation of advanced driver assistance systems (ADAS) and autonomous vehicle driving scenarios in a laboratory setting.

This feature enhances the capability of the ROTOTEST dynamometer to replicate real-world driving conditions and enables comprehensive testing of steering performance, contributing to the development and validation of cutting-edge automotive technologies.

BUILT-IN TORQUE TRANSDUCER

The ROTOTEST Energy system incorporates a unique patented design that includes a torque transducer built directly into the hub, allowing for accurate torque measurements.

Furthermore, the system stores calibration information locally on the dynamometer unit. This ensures that the torque measurements are reliable and precise, as the calibration data is readily available and can be easily accessed without the need for external references or additional equipment. This innovative design contributes to the system's overall accuracy and repeatability, making it a reliable tool for precise torque measurement during testing and analysis.

PERFORM AND VALIDATE EPA CERTIFICATION REQUIREMENTS

ROTOTEST Dynamometers are fully compatible with EPA (Environmental Protection Agency) driving cycles, including the Federal Test Procedure (FTP) and the US06 cycle. The system is designed to meet the strict tolerances and response requirements set by EPA for accurate and reliable testing. Additionally, ROTOTEST Dynamometers can be used for certification testing in accordance with Federal Regulation 40 CFR Part 86 Section 86.108. This makes the system a compliant and trustworthy solution for meeting regulatory standards and conducting emissions and performance testing in accordance with EPA regulations.

MEASUREMENT SYSTEM WITH HIGH ACCURACY AND REPEATABILITY

One of the notable advantages of using ROTOTEST Energy, a hub-mounted chassis dynamometer, is the ability to measure torque directly at the hub position. This method offers exceptional accuracy and consistent repeatability in comparison to conventional roller-type dynamometers.

As the torque measurement is not affected by the vehicle's tires (as shown in *figure 6*), the system achieves high levels of repeatability, making it ideal for benchmark testing. Furthermore, the ROTOTEST Energy unit can be automatically tilted to adjust the torque measurement line, as illustrated in *figures 7 and 8*. This feature allows for precise customization and fine-tuning of the torque measurement, further enhancing the accuracy and reliability of the testing results.

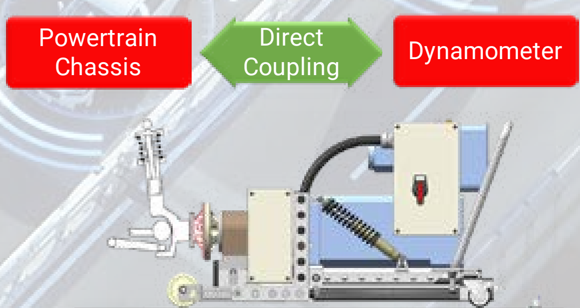
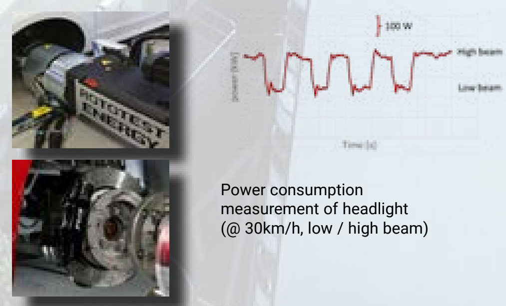
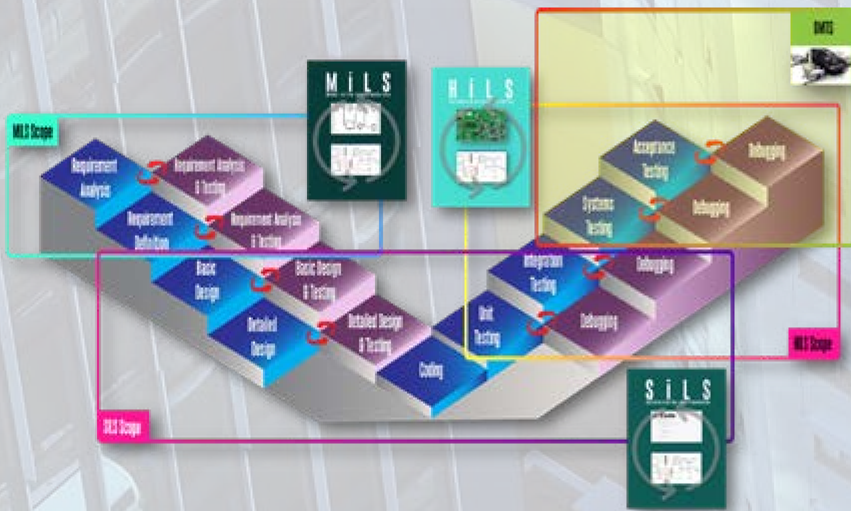


Figure 6



Power consumption measurement of headlight (@ 30km/h, low / high beam)

Figures 7 & 8



ENGINEERED BY TOYO

The Driving & Motion Test System (DMTS), developed by TOYO, is a state-of-the-art driving test system that incorporates a steering function, enabling comprehensive testing and development of autonomous vehicles. With DMTS, it is now possible to conduct driving tests in a laboratory setting that replicate real-world road conditions, allowing for the final step in the “Model Based Development” (MBD) framework to be performed in a fully controlled environment. This eliminates the challenges typically associated with the last stages of traditional MBD, providing precise and reliable results. The advanced capabilities of DMTS make it an invaluable tool for automotive testing and development, pushing the boundaries of autonomous vehicle technology to new heights.

VEHICLE DYNAMICS SIMULATOR

TOYO’s Vehicle Dynamics Simulator utilizes advanced vehicle motion simulation software to create a comprehensive virtual environment/ scenario that can be integrated with a conventional chassis dynamometer (CDM) test environment. This innovative approach allows for real-time simulation of vehicle motion, bridging the gap between simulation-based testing and real-world conditions. By providing a realistic and controlled virtual environment, the Vehicle Dynamics Simulator enables accurate and efficient testing of vehicle dynamics and performance on a CDM, providing valuable insights for automotive development and validation. With this cutting-edge technology, TOYO is pushing the boundaries of testing capabilities, offering a seamless integration of virtual and physical testing for enhanced accuracy and efficiency in automotive research and development

500 KW - 250 KW MODEL FOR ROAD LOAD SIMULATION

The ROTOTEST Energy 500-250 4WD system comprises of two dynamometer axles, one with a power rating of 500 kW and the other with a power rating of 250 kW. This configuration allows for testing of both 4-wheel drive (4WD) and 2-wheel drive (2WD) vehicles, depending on the vehicle being tested.

The system is designed to deliver high repeatability, ensuring accurate and consistent results during benchmark testing. Additionally, the ROTOTEST Energy system offers several power models to choose from, allowing you to customize the system based on your specific testing requirements. This flexibility and versatility make ROTOTEST Energy an ideal solution for a wide range of testing scenarios.

APPLICATION EXAMPLE: INDIVIDUAL WHEEL TORQUE CONTROL

With ROTOTEST Dynamometers, you have precise control over each wheel's torque independently, as the dynamometers are directly connected to each wheel. This allows for detailed analysis and testing of various scenarios.

For instance, in *figure 9*, the left graph illustrates the torque distribution when all tires, except the front left one, are driving on a snow-covered road. On the other hand, the right graph in *figure 10* represents the situation when the steering wheel is turned.

Additionally, using ROTOTEST Dynamometers, you can simulate the running resistance of a vehicle by defining its mass and the coefficient of friction (μ) for each tire, as shown in *figure 11*. This enables the simulation of different road conditions for specific tires, allowing for comprehensive testing and analysis of various scenarios.

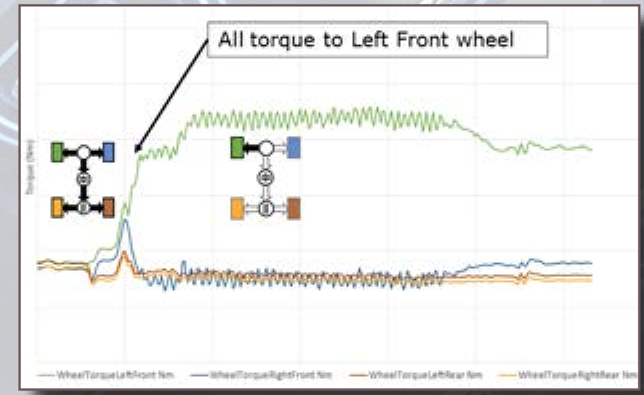


Figure 9: Torque Distribution in Snow Covered Road Scenario

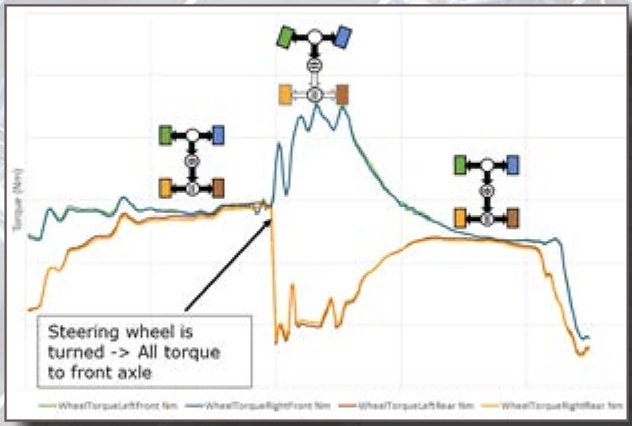


Figure 10: Torque Distribution during Steering

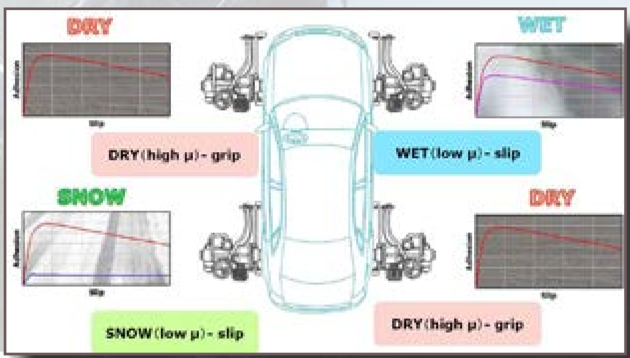


Figure 11: Running Resistance Simulation

BUILT-IN CLIMATE PROTECTION (CP) MODEL (-31° TO 105° F; -35° TO 40° C)

The extended operational temperature range of this model ranges from -31° to 105° Fahrenheit (-35° to 40° Celsius), making it suitable for use in a wide range of climate conditions. With ample space, the system can be integrated into an existing climate chamber for testing in controlled temperature environments. Moreover, the steering operation is designed to function even in very low temperature conditions, enabling evaluations of vehicle performance and response in harsh and extreme weather conditions.

This capability is valuable for testing and validating automotive technologies under varying environmental conditions, ensuring reliable performance and safety across a wide range of temperatures.

APPLICATION EXAMPLE: ENERGY FLOW MANAGEMENT EVALUATION

The graph on the right, as shown in *figure 12*, depicts power consumption data for an air conditioner.

By running a gasoline engine at 1,500 rpm, the power consumption of the air conditioner, along with the generator loss, can be precisely measured as a power difference. The hubmounted ROTOTEST Energy, with its accurate torque measurements, enables precise characterization of energy flows.

This data is valuable for evaluating and optimizing the energy efficiency of automotive systems, such as air conditioning and generator performance, during operation under various conditions.

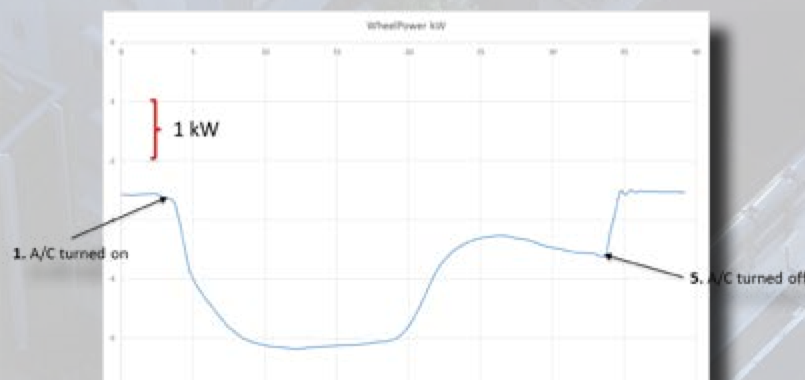


Figure 12: Power Consumption with Air Conditioner On

LOW NOISE MODEL FOR NOISE, VIBRATION, AND HARSHNESS (NVH) TEST

The ROTOTEST Energy dynamometers are designed to minimize noise interference during NVH (Noise, Vibration, and Harshness) measurements. Unlike traditional roller type dynamometers, the ROTOTEST units generate very low tire noise, which can significantly impact the accuracy of NVH measurements.

In addition, ROTOTEST Energy NVH models offer customization options to further reduce noise levels. For example, blowers for cooling can be removed and the dynamometer can be covered with sound insulation boxes, providing an additional layer of noise reduction. Moreover, the ROTOTEST Energy NVH models can be installed in semi-anechoic chambers, which are specifically designed to minimize external noise interference, allowing for highly precise and accurate NVH measurements without any external disturbances. This ensures reliable and high-quality NVH testing results for automotive development and evaluation purposes.

APPLICATION EXAMPLE: NVH TEST

Operational noise driving at 100 km/h (62 mph)is only about 45 dBA. Therefore you can evaluate NVH phenomena which are usually buried in noise coming from tires. In addition, there is no need to bind the vehicle. So it is possible to minimize changes to the NVH character due to binding. Refer to *figure 13*.

Some examples include evaluating noise from EPS, making precise noise measurement (intake / exhaust, powertrain, etc.) and performing contribution analysis in indoor pass-by noise test.

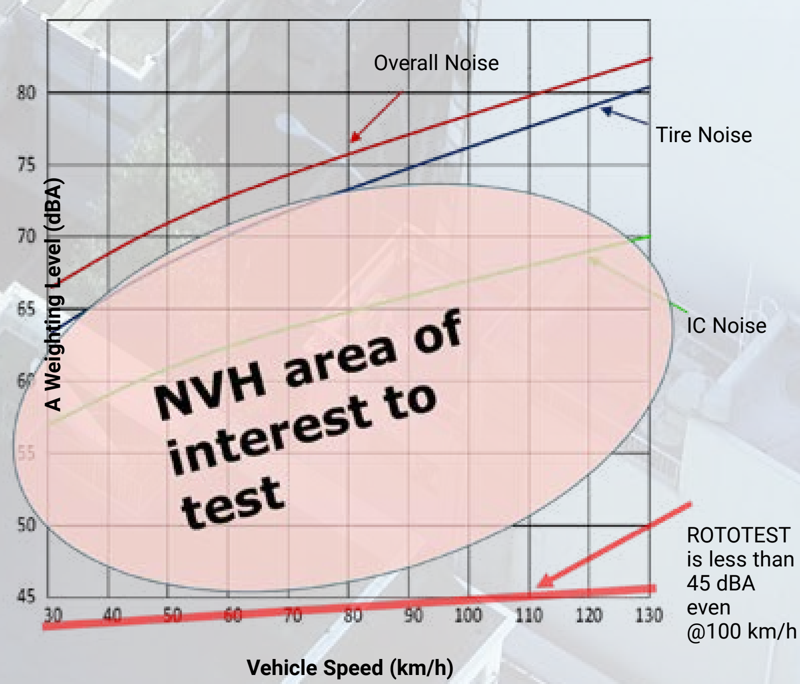


Figure 13: Relationship between Noise and Speed

ROTOTEST Standard S85 High Torque

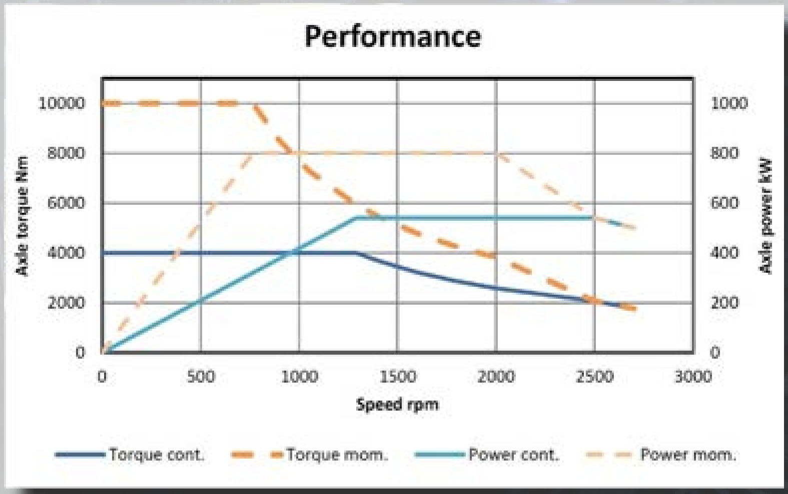
HIGH-TORQUE, HIGH-POWER, AND SYMMETRICAL TESTING REQUIREMENTS

The ROTOTEST Energy s85 4WD model offers several distinct characteristics that make it a versatile and powerful tool for automotive testing and evaluation.

High Torque Capacity: The ROTOTEST Energy s85 4WD model is designed to handle high dynamic loads, making it suitable for a wide range of testing scenarios, including simulations of high-torque applications. This ensures that the dynamometer can accurately replicate real-world conditions and provide reliable results for testing highperformance vehicles.

Power Capacity: The ROTOTEST Energy s85 4WD model is equipped with a high power capacity, enabling it to handle full load testing of high-performance vehicles. This makes it ideal for testing vehicles with powerful engines and high-performance drivetrain systems, ensuring accurate and consistent performance measurements.

Symmetrical Configuration: The ROTOTEST Energy s85 4WD model features a symmetrical configuration, providing equal capacity on both axles. This allows for balanced testing of all four wheels, ensuring accurate and consistent results for 4WD vehicles. The symmetrical configuration also enables precise and controlled testing of various driving conditions, including straight-line acceleration, cornering, and braking, providing valuable data for vehicle development and evaluation. The ROTOTEST Energy s85 4WD model offers a robust and capable solution for high-torque, high-power, and symmetrical testing requirements. Its advanced features and capabilities make it a valuable tool for automotive engineers and researchers who require accurate and reliable results for their testing and evaluation needs.



SPECIFICATIONS

Each system consists of dynamometers (2WD or 4WD), SCU, and MPU. The SCU is a system control unit, while MPU is the main power unit of each dynamometer.

GENERAL SPECIFICATIONS	
Torque Uncertainty	< 1% of measured value
Speed Uncertainty	0.1 rpm
Repeatability	< 0.05%
Inertia	0.6 kg ·m^2(300 kW unit)
Maximum Axle Load	3,500 kg
Temperature Range	+59° to +104° F; +15 to +40 C (except climate model)
Humidity	10-90%, non-condensing
Altitude	< 1,000 m above sea level
Power (SCU)	240 VAC (8A) or 120 VAC (16A) @ single phase
Power (MPU)	400 VAC, 50 / 60 Hz @ 3 phase
Cooling method	Air Cooling

STANDARD RE500 MODEL		
System	ROTOTEST Energy 500-250 4WD	
Component	1 axle of RE-500 (Dyno), 1 axle of RE-250 (Dyno), MPU-500×2, MPU-250×2, SCU-4E×1	
Power† 2WD	500 kW/400 kW	(momentary/continuous)
Power† 4WD (50/50 split)	500 kW/400 kW	(momentary/continuous)
Torque 2WD	6,000 Nm/2,550 Nm	(momentary/continuous)
Torque 4WD (50/50 split)	5,960 Nm/2,450 Nm	(momentary/continuous)
Speed 2WD/4WD	2,700 rpm	(maximum hub speed)
Vehicle Speed 2WD/4WD	330 km/h	(equivalent, wheel dia 650 mm)

CLIMATE MODEL		
System	ROTOTEST Energy 230-CP 4WD	
Component	2 axles of RE-230-CP (Dyno), MPU-230CP x 4, SCU-4E x 1	
Power† 2WD	230 kW/120 kW	(momentary/continuous)
Power† 4WD (50/50 split)	460 kW/240 kW	(momentary/continuous)
Torque 2WD	2,800Nm/1,200 Nm	(momentary/continuous)
Torque 4WD (50/50 split)	5,600 Nm/2,400 Nm	(momentary/continuous)
Speed 2WD/4WD	2,500 rpm	(maximum hub speed)
Vehicle Speed 2WD/4WD	300 km/h	(equivalent, wheel dia 650 mm)
Environment	-31° to 105° F (-35° to 40° C) | 10-95% (humidity), IP54	(non-condensing)

NVH MODEL		
System	ROTOTEST Energy 300-NVH 4WD	
Component	2 axles of RE-300-NVH (Dyno), MPU-300 x 4, SCU-4E x 1	
Power† 2WD	300 kW	(5 min‡)
Power† 4WD (50/50 split)	600 kW	(5 min‡)
Torque 2WD	2,980 Nm	
Torque 4WD (50/50 split)	5,960 Nm	
Speed 2WD/4WD	3,000 rpm	(maximum hub speed)
Vehicle Speed 2WD/4WD	360 km/h	(equivalent, wheel dia 650 mm)
Noise	less than 45 dBA	

STANDARD S85 MODEL		
System	ROTOTEST Energy S85	
Component	2 axles of RE-300-NVH (Dyno), MPU-300 x 4, SCU-4E x 1	
Power 2WD	800 kW / 1072 bhp; 530 kW / 734 bhp	(momentary/continuous)
Power 4WD (50/50 split)	800 kW / 1072 bhp; 800 kW / 1072 bhp	(momentary/continuous)
Torque 2WD	10000 Nm / 7376 lb-ft; 4000 Nm / 2950 lb-ft	(momentary/continuous)
Torque 4WD (50/50 split)	20000 Nm / 14751 lb-ft; 8000 Nm / 5901 lb-ft	(momentary/continuous)
Speed 2WD/4WD	2,700 rpm	(maximum hub speed)
Vehicle Speed 2WD/4WD	330 km/h; 205+ mph	(equivalent, wheel dia 650 mm)*
Torque Accuracy Class	better than 0.1 (std) / 0.05 (opt)	
Speed Uncertainty	less than 0.025%	
Measurement Repeatability	better than 0.05%	
Ambient Temperature Range	+15 °C to +40 °C	
Relative Humidity	10% to 90%, non-condensing	
Altitude**	< 1000 m above sea level	

† at 68° F (20° C)
‡ defined as a 5 minute run / 30 minute cool down
* Maybe limited by continuous power
** Higher altitude is possible but may degrade continuous performance under certain conditions

ABOUT ROTOTEST INTERNATIONAL AB

Founded in January 1988, Rototest was established by a group of engineers with solid experience in product development in the vehicle industry. After a few years, devoted to intense development and testing, Rototest pioneered the market by introducing the world's first hub-coupled dynamometer. The company is based in Sweden.

Rototest test solutions is today used by many of the world's renowned industrial companies in more than 25 countries across North America, Europe, Asia and Africa.

ABOUT TOYO CORPORATION

TOYO is committed to providing the automobile industry with leading edge test and measurement solutions, and we maintain a fully staffed and functioning technical research lab in Atsugi, Japan.

The lab is equipped with the latest ROTOTEST Energy systems. The lab also serves as a demonstration facility where customers interested in the solution can see ROTOTEST test systems in operation. TOYO is a partner of Rototest.

TOYO

TOYOTech

47623 Lakeview Blvd, Fremont, CA 94538
Phone: 510-438-9548 | E-mail: info@toyotechus.com
http://www.toyotechus.com