2026 EDITION

Technical Catalog

HYPERDYNE

An integrated technology portfolio spanning elastic-actuator hardware, control & algorithms, system applications, and evaluation & benchmarking infrastructure.

T1
Hardware Core Technology

T2
Control & Algorithm Core Technology

T3
System Applications

T4
Evaluation & Benchmarking

VISION

Beyond Earth, operating in space environments— next-generation high-power intelligent work.

◆ MANIFESTO

Beyond Physical AI

'Hyper Physical Intelligence'

A broad **ultra-precise physical-work platform** that turns virtual results from AI into reality through high-performance actuation.

From robotics to heavy industry and defense, all the way to **space-scale heavy equipment**.

HYPERDYNE is the **future of Realization**.

BUSINESS SECTORS

Where HYPERDYNE Drives

01 **HEAVY INDUSTRY**

Electric heavy equipment & construction robots

02 **ROBOTICS**

Humanoid joints & autonomous mobile robots

03 **MOBILITY**

Vehicle chassis · suspension · steering drive

04 **DEFENSE**

High-power, high-precision defense systems

05 **SPACE**

Extreme-environment & space-scale mission drives

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14 technology items across four pillars — T1 Hardware, T2 Control & Algorithms, T3 System Applications, T4 Evaluation & Benchmarking.

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SECTION

T1 Hardware Core Technology

4 ITEMS · DRIVE STACK

Built on four-axis design capability across motor, transmission, elastic element, and inverter — covering every drive requirement. A four-product lineup spanning Rotary/Linear × Quasi-Hyper/Hyper, scaling from collaborative-robot and humanoid joints to high-load industrial and vehicle applications.

Four-Actuator Lineup

A	QRHD — Quasi Rotary Hyper Drive	06
B	QLHD — Quasi Linear Hyper Drive	07
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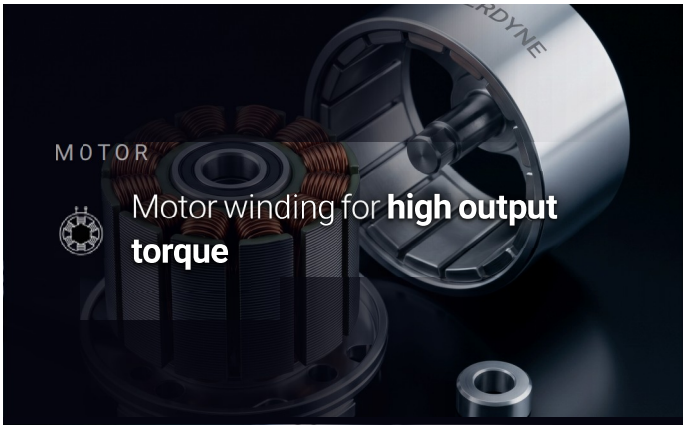
T1 Hardware Core Technology

4 ELEMENTS · DRIVE STACK

HYPERDYNE leverages design expertise across **motors, gearboxes, elastic elements, and inverters** to address every actuation requirement and deliver the optimal solution.

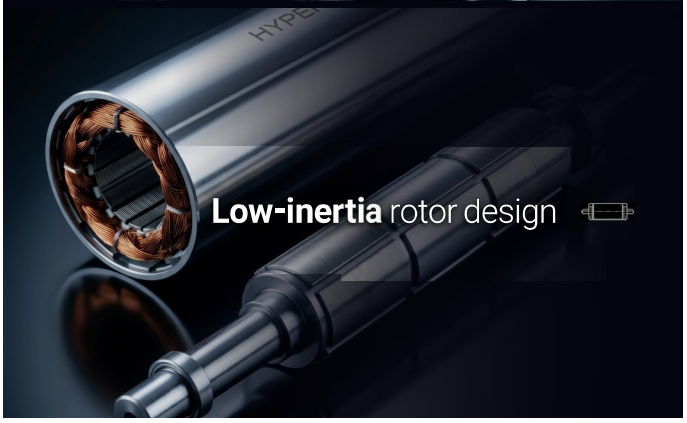


MOTOR

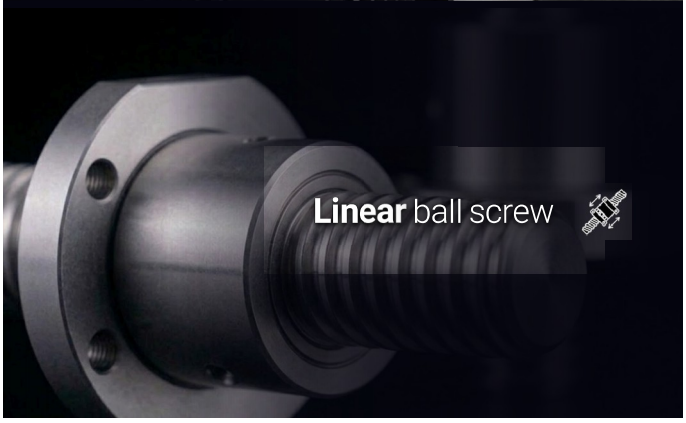
Motor winding for **high output torque**

GEARBOX

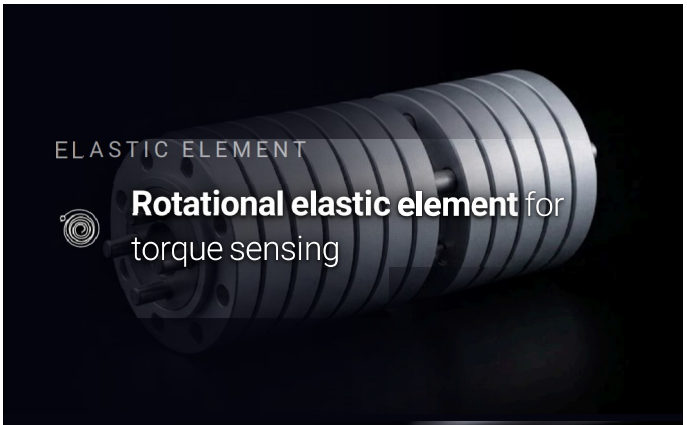
Rotational Wolfrom planetary gearbox



Low-inertia rotor design



Linear ball screw

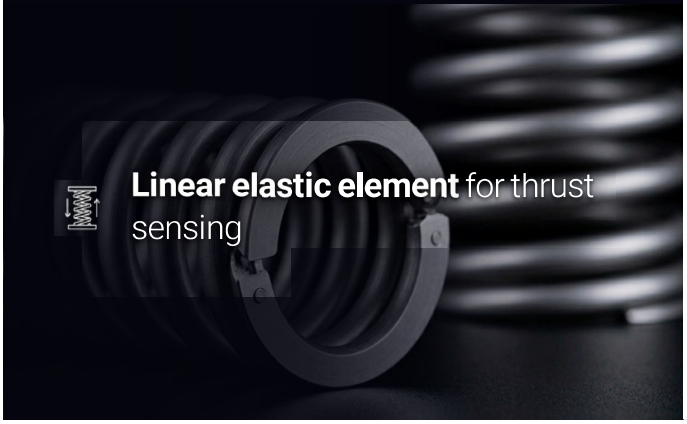


ELASTIC ELEMENT

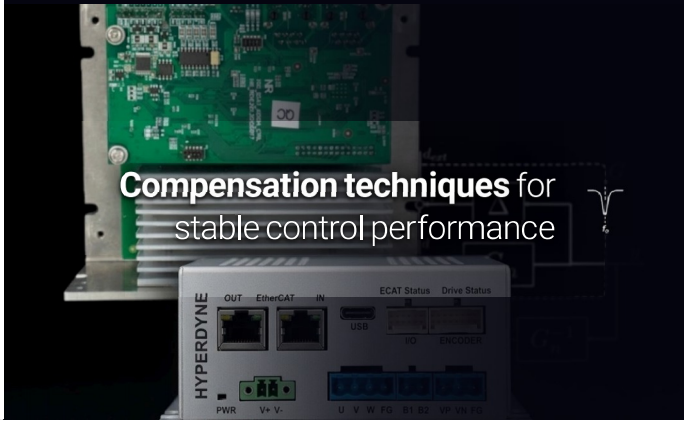
Rotational elastic element for torque sensing

INVERTER

Technology enabling **high-bandwidth control**



Linear elastic element for thrust sensing

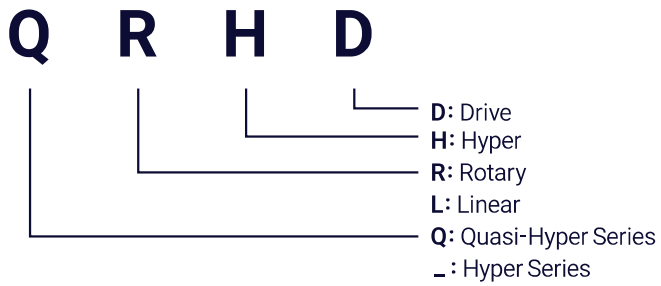


Compensation techniques for stable control performance

T1 Hardware Core Technology

4 ELEMENTS · DRIVE STACK

Naming Convention



Quasi-Hyper Series — actuators optimized for high-load applications, with force-transmission efficiency of approximately 80%.

Hyper Series — actuators designed for high-load and high-efficiency operation, achieving force-transmission efficiency above 95%.

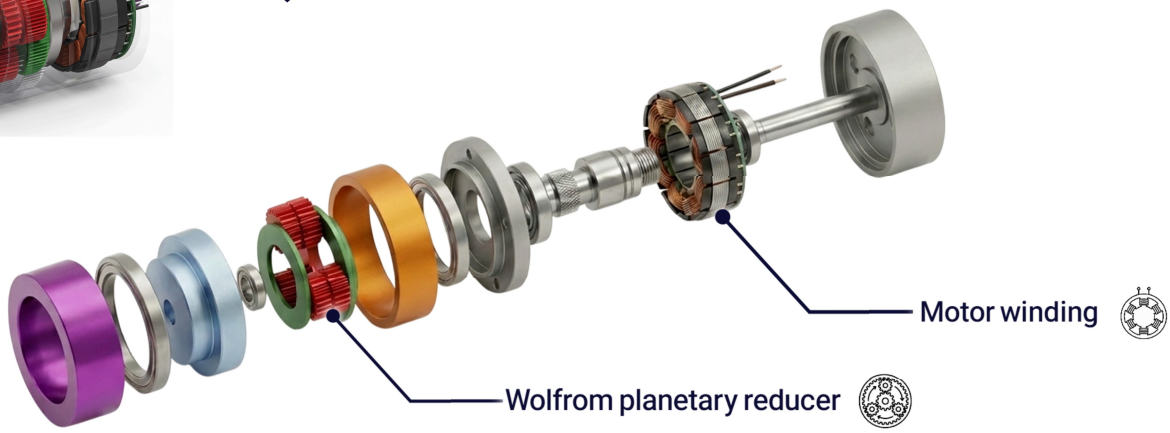
Product Lineup

	Rotary	Linear
Quasi-Hyper Series	Required Tech	Required Tech
Hyper Series	Required Tech	Required Tech

T1-A Quasi Rotary Hyper Drive (QRHD)

HIGH-REDUCTION ROTARY ACTUATOR

Quasi Rotary Hyper Drive
QRHD



Overview

This rotary actuator achieves high efficiency and excellent backdrivability through the optimal design of a two-stage planetary reduction structure. By simultaneously optimizing the gear tooth numbers and profile shift coefficients, forward and reverse transmission efficiency are maximized, enabling higher efficiency and superior backdriving characteristics compared to harmonic drives of similar class. The actuator delivers medium-to-high torque within a compact volume and is packaged as an integrated unit with a BLDC motor, allowing direct application to collaborative robot and humanoid joints.

Features

- Two-stage planetary reduction (Wolfrom type) — medium-to-high reduction ratios and high torque within compact volume
- Quasi-Newton simultaneous optimization of tooth numbers and profile shift coefficients — maximizes forward and backdriving efficiency
- Minimized backdriving initiation torque — advantageous for contact-force detection and sensorless force estimation
- Integrated BLDC motor packaging — outer diameter and mounting pattern compatible with comparable harmonic drives

Advantages

- Significantly improved forward-drive efficiency vs harmonic drives — reduced heat and power loss
- Minimized backdriving initiation torque — contact-force detection and force estimation without an additional torque sensor
- Maximized mechanical bandwidth — suitable for joints requiring fast position and force response
- Direct replacement within same external dimensions as comparable harmonic drives — no system redesign

Applications

Collaborative robot & humanoid joint actuators

Human-robot interaction (HRI) systems

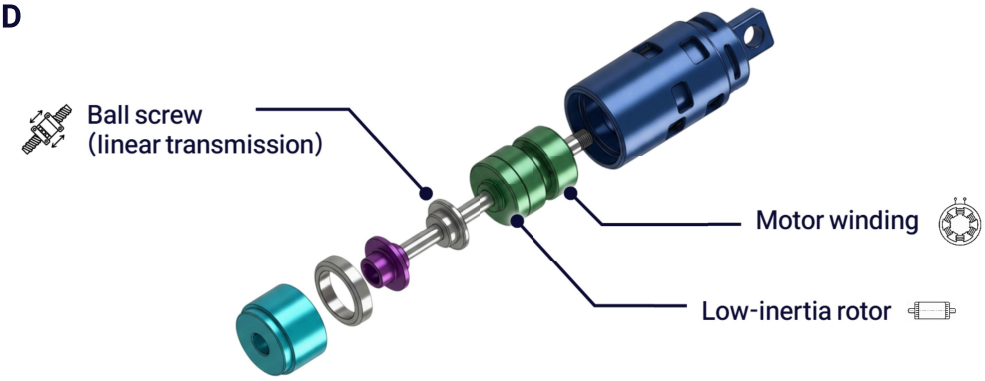
Systems requiring **sensorless force estimation**

High-efficiency industrial joints replacing **harmonic reducers**

T1-B Quasi Linear Hyper Drive (QLHD)

HIGH-REDUCTION LINEAR ACTUATOR

Quasi Linear Hyper Drive
QLHD



Overview

This linear actuator features an optimized design that combines a high-lead ball screw with a single-stage planetary reduction mechanism. By leveraging the inherently high backdrivability and fast linear response characteristics of the high-lead ball screw, it is well suited for linear actuation applications requiring long stroke and high-speed response. When combined with current- and encoder-based sensorless force estimation, precise axial force control can be achieved without an additional force sensor. Its compact and lightweight integrated packaging also enables installation in space-constrained environments.

Features

- High-lead ball screw + single-stage planetary reducer — fully electric design optimized for backdrivability, responsiveness, and compactness
- High backdrivability via high-lead ball screw — compliant linear motion characteristics that respond flexibly to external forces
- Serial configuration of BLDC motor, planetary reducer, and ball screw — compact, lightweight integrated packaging
- Current- and encoder-based sensorless thrust estimation — precise force control without an additional force sensor

Advantages

- Excellent backdrivability via high-lead ball screw — high responsiveness to external forces and compliant linear motion
- Maximized mechanical bandwidth — suitable for high-speed linear position and force control
- Compact, lightweight packaging with single-stage planetary reducer — installable in space-constrained environments
- Sensorless force estimation enables precise axial force control without an additional force sensor

Applications

Active strut

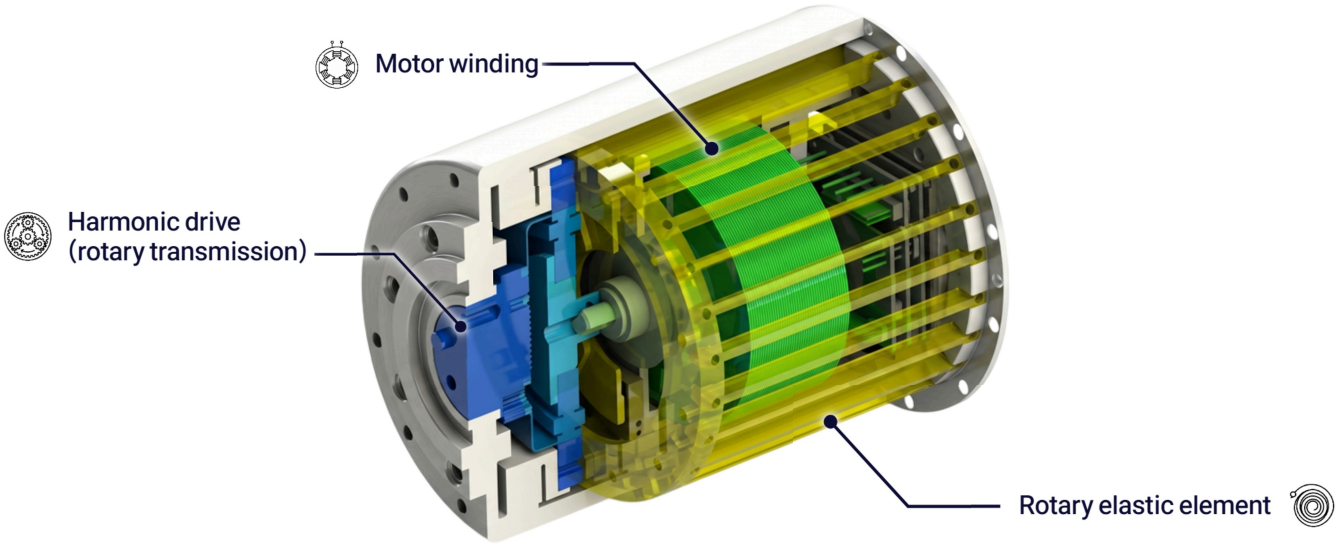
Industrial linear
position-control actuators

Robot arms & legs
linear joint actuators

Cooperative & wearable linear joints
requiring **backdrivability**

T1-C Rotary Hyper Drive (RHD)

ELASTIC-ELEMENT ROTARY ACTUATOR



Overview

This rotary series elastic actuator (SEA) incorporates an elastic element in series with a high-reduction gearbox. The deformation of the elastic element is measured using an encoder to estimate absolute torque with a single sensor, enabling accurate torque sensing without additional hardware. High-fidelity impedance control is achieved through disturbance observer (DOB)-based active compensation of motor cogging and torque ripple. The inherent low-pass filtering characteristic of the elastic element absorbs external impacts, improving both actuator durability and operational safety.

Features

- High-reduction gearbox with serially connected torsional elastic element — integrates high torque transmission and precise force measurement in SEA architecture
- TFSEA architecture: absolute torque measurement using a single encoder — minimizes sensor count and simplifies mechanical structure
- DOB-based active compensation of cogging and torque ripple — high-fidelity torque control
- Elastic deformation–based variable impedance spectrum with verified bidirectional linearity

Advantages

- TFSEA architecture: absolute torque measurement using a single encoder — simplifies structure and wiring
- High-fidelity impedance control via DOB-based ripple compensation — precise force interaction
- External impact absorption through low-pass filtering of the elastic element — protects gearbox and drivetrain, improves durability
- Flexible torque-density and compliance design through combination of elastic stiffness and reduction ratio

Applications

E-corner module
rotary suspension

Legged robots

Systems requiring
high-fidelity joint torque control

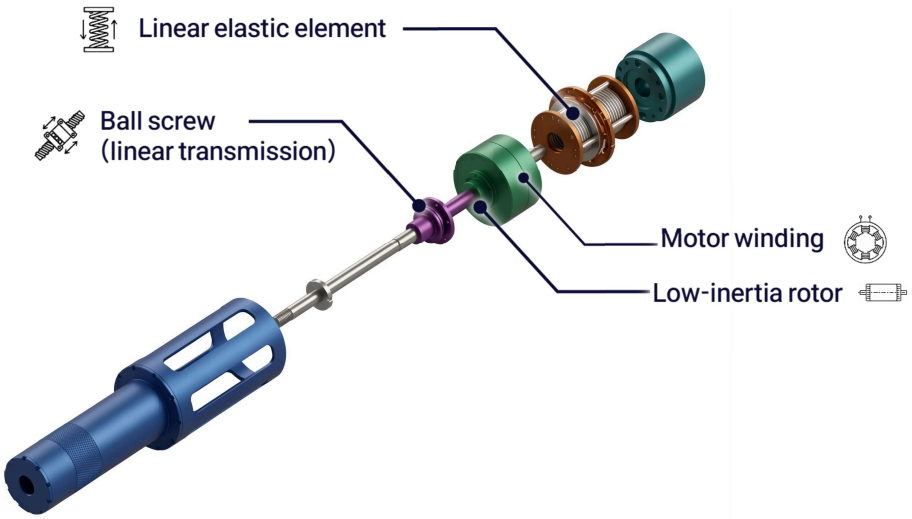
Systems requiring
precise human interaction

Systems requiring
low-impedance high-torque control

T1-D Linear Hyper Drive (LHD)

ELASTIC-ELEMENT LINEAR ACTUATOR

Linear Hyper Drive
LHD



Overview

This high-load linear series elastic actuator (SEA) incorporates an elastic element in series with a low-lead ball screw. The motor, ball screw, planetary reducer, and elastic element are serially integrated within a single strut structure, enabling precise axial force control through encoder-based measurement of elastic deformation without disturbance-sensitive force sensing. The elastic element both absorbs external impacts and provides force information, allowing reliable linear force control without an additional force sensor.

Features

- Low-lead ball screw with serially integrated elastic element (F-SEA) — integrates high thrust transmission and precise force sensing in SEA architecture
- F-SEA architecture: serial motor–screw–nut–elastic element–rod configuration — integrated impact absorption and axial force measurement
- Encoder-based measurement of elastic deformation — disturbance-robust precise force sensing without an additional force sensor

Advantages

- F-SEA architecture with encoder-based measurement of elastic deformation — disturbance-robust precise force sensing and control
- Integrated elastic element absorbs external impacts — protects ball screw and gearbox, improves durability and operational safety
- High thrust capability via low-lead ball screw — optimized for high-load linear actuation applications

Applications

Humanoid lower body
requiring high thrust

Rack-and-pinion systems
requiring force control

Active struts requiring
high-precision force control

T2 Control & Algorithm Core Technology

2 SERIES · 6 CHALLENGES · CONTROL STACK

HYPERDYNE actuators cover an exceptionally broad range of motion and force control. The **Quasi-Hyper Series** requires solving inherent challenges from high-ratio reduction — limited backdrivability, restricted force sensing, and gearbox complexity. The **Hyper Series** requires solving challenges from the integrated elastic element — physically constrained control bandwidth, nonlinear and uncertain dynamics, and a fundamentally new approach to torque measurement. HYPERDYNE possesses a complete control-technology full-stack capable of solving every one of these challenges.

Quasi-Hyper Series

Quasi-Hyper Series · CHALLENGE 1

Backdrivability Limitations

◆ CAPABILITIES

The Q-Series, optimized for high power output, employs high-ratio reduction gearboxes — which inherently exhibit poor backdrivability. HYPERDYNE possesses dedicated technologies to enhance the intrinsic efficiency of the hardware itself.

◆ WHAT WE DELIVER

+ Friction-compensation–based backdrivability enhancement
+ Inertia-compensation–based backdrivability enhancement

Quasi-Hyper Series · CHALLENGE 2

Force Sensing Limitations

◆ CAPABILITIES

The Q-Series, optimized for high power output, does not include dedicated force-transmission sensing devices. Achieving sensorless estimation and control of output force is therefore essential.

◆ WHAT WE DELIVER

+ Capability in designing diverse observers
+ Impedance control via sensorless estimation

Quasi-Hyper Series · CHALLENGE 3

Gearbox Complexity

◆ CAPABILITIES

HYPERDYNE thoroughly understands and accurately models the inherent hardware characteristics of reduction gearboxes — including torque ripple and backlash — and provides effective compensation control technologies.

◆ WHAT WE DELIVER

+ Modeling of complex gearbox characteristics
+ Compensation control for torque ripple and backlash

Hyper Series

Hyper Series · CHALLENGE 1

Physical Bandwidth Limit Imposed by the Elastic Element

◆ CAPABILITIES

Once an elastic element is introduced, the control bandwidth of the actuator becomes physically constrained. Through years of accumulated research, HYPERDYNE has developed a complete control-technology stack to overcome this fundamental limitation.

◆ WHAT WE DELIVER

+ Precise force and impedance control based on detailed dynamic modeling
+ Universal applicability — from compact precision systems to high-load applications including vehicle suspension, steering, and robotic legs
+ Natural-dynamics control that leverages the energy-storage property of the elastic element as a performance asset

Hyper Series · CHALLENGE 2

Model Complexity & Uncertainty

◆ CAPABILITIES

Elastic actuators are inherently complex modules. In addition to internal nonlinearities such as spring nonlinearity, gearbox ripple, motor cogging, inter-component friction, and axis-misalignment errors, uncertainties arising from interaction with the external environment must also be rigorously addressed.

◆ WHAT WE DELIVER

+ High-precision analysis and control reflection of spring nonlinearities
+ Real-time compensation of gearbox ripple and motor cogging
+ Robust control under varying external load conditions

Hyper Series · CHALLENGE 3

Force/Torque Estimation Methodology

◆ CAPABILITIES

Force sensors are expensive and vulnerable to mechanical shock. HYPERDYNE — leveraging its diverse elastic-element technologies — has developed methods to effectively estimate torque without sensors and apply it directly within the control loop.

◆ WHAT WE DELIVER

+ Real-time estimation of external interaction torque without force sensors
+ Consistent external-torque frequency response across wide stiffness variations
+ Robust external-force estimation under high-impact and high-vibration environments
+ Ground reaction-force estimation for vehicle suspension/steering and quadruped robots

SECTION

T3 System Application Technology

2 CATEGORIES · 5 ITEMS

A field-deployed industry–academia portfolio combining HYPERDYNE hardware (T1) with control and algorithms (T2). From vehicle chassis, suspension, and steering to walking platforms and actuator-based application modules — organized into two subcategories and five systems.

A Vehicle Chassis · Suspension · Steering Systems

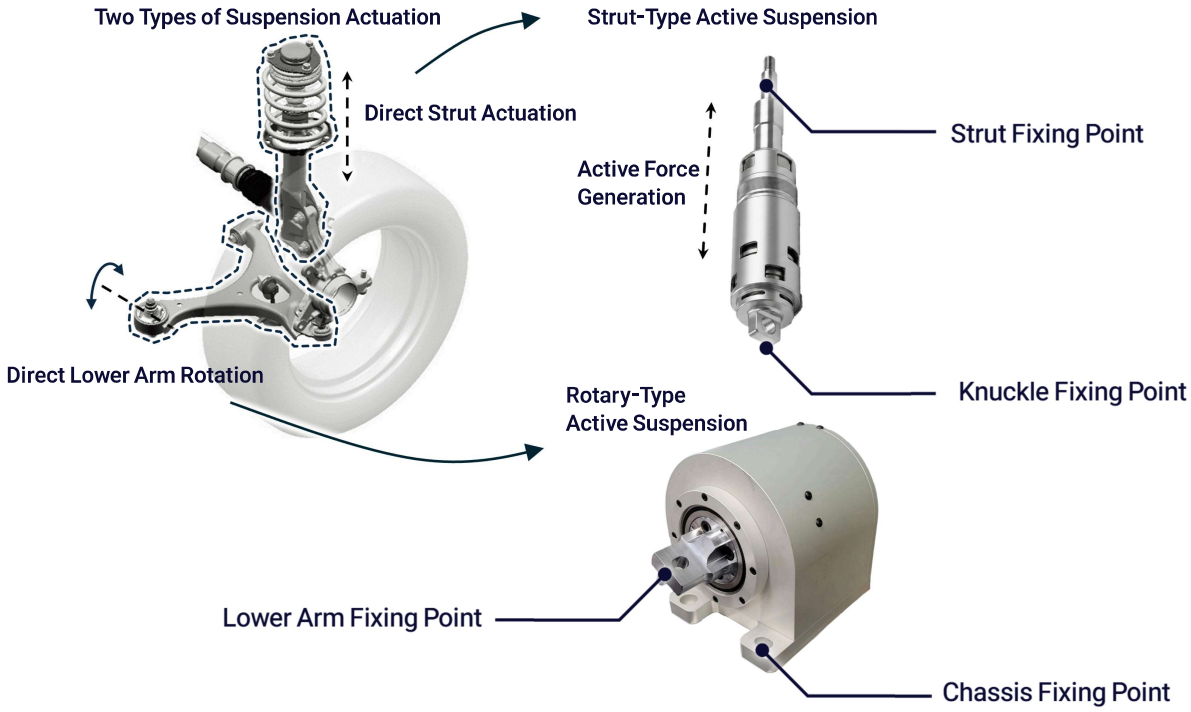
A-1	Four-Wheel Independent Active Suspension	12
A-2	Active Roll Stabilizer (ARS)	13
A-3	Next-Generation Linear Active Strut	14

B Special-Environment & Locomotion Platforms

B-1	Excavator Robot Platform	15
B-2	Five-Bar Linkage 2-DOF Hopping Platform	16

T3-A-1 Four-Wheel Independent Active Suspension

ACTIVE SUSPENSION SYSTEM



Overview

A four-wheel independent active suspension system has been developed by applying high-load elastic actuators to each wheel of the vehicle. The system enables real-time control of force and impedance in response to road inputs. Through joint development with Hyundai Motor Company and Hyundai WIA, both HILS testing and prototype-level performance validation have been successfully completed.

Features

- Configuration: elastic-actuator–based active suspension system
- Control: Skyhook and Groundhook control strategies
- Validation: HILS-based lifting experiments using a real corner module
- Joint development: Hyundai Motor Company and Hyundai WIA

Advantages

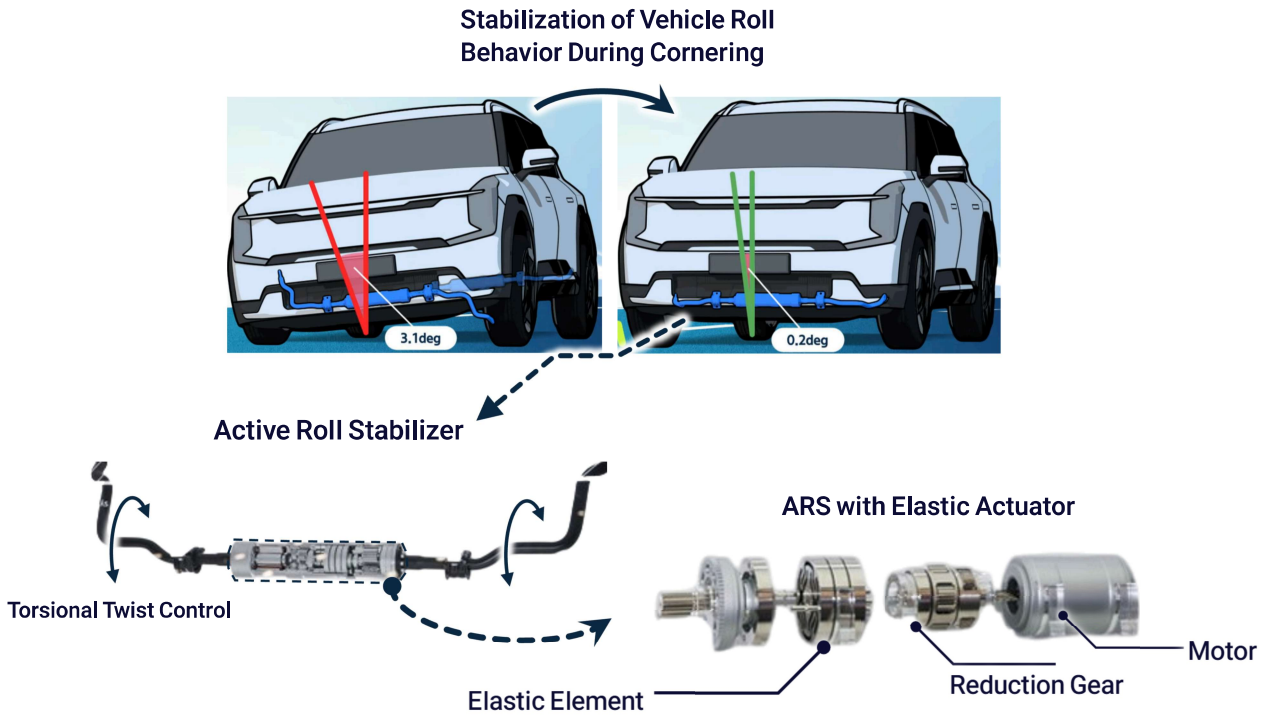
- SEA-based high-torque, precision force control delivers active damping and stiffness beyond passive mechanical suspension
- Disturbance-observer–based robust control ensures stable behavior under irregular road disturbances
- Quarter-car-level HILS validation under vehicle-representative conditions — verified stiffness realization and damping-force effectiveness
- Real-time trade-off between ride comfort (damping) and handling (stiffness), adaptively optimized to driving conditions

Applications

Premium passenger and SUV active suspension	Electrified platform (EV) underbody integrated suspension
Active damping for off-road and irregular-terrain vehicles	Ride-comfort optimization platform for autonomous vehicles

T3-A-2 Active Roll Stabilizer (ARS)

ANTI-ROLL BAR SYSTEM



Overview

The Active Roll Stabilizer (ARS) is a self-balancing active roll control system that simultaneously improves driving stability and ride comfort by actively controlling vehicle body roll motion during cornering. A rotary series elastic actuator (SEA) drives the stabilizer bar, enabling continuous variation of roll stiffness according to driving conditions while achieving both high torque output and precise force control.

Features

- Target control torque 1,000 Nm · step response within 200 ms · time constant ~30.5 ms
- Serial configuration: motor – three-stage planetary reducer – torsional elastic element – stabilizer bar
- Floating stator structure — actuator housing rotates together with left–right vehicle body motion
- Spring displacement/stiffness-based torque estimation + feedforward + feedback (FB-PD) force and impedance control

Advantages

- High-torque precision force control up to 1,000 Nm based on rotary SEA elastic deformation (RMS error below 10%)
- Active suppression of vehicle body roll — maximizes cornering grip and steering stability while improving ride comfort
- Continuously variable roll stiffness and damping (impedance control) — supports both sport and comfort driving modes
- Low-pass filtering effect of elastic element absorbs external impacts — protects drivetrain and gearbox, improves durability

Applications

Active Roll Stabilizer (ARS) and 48V chassis systems for passenger cars and SUVs

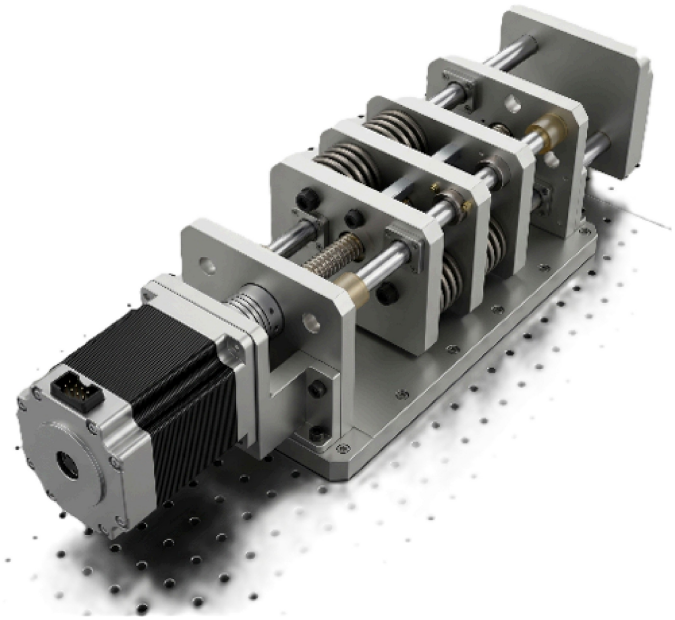
Premium suspension and cornering-stability control modules for EVs and hybrids

Off-road SUVs and pickup trucks requiring stabilizer decoupling

Active chassis control for ride comfort and driving safety in autonomous vehicles

T3-A-3 Next-Generation Linear Active Strut

LINEAR ACTIVE STRUT



Overview

The Next-Generation Linear Active Strut is an automotive active suspension actuator jointly developed with Hyundai Motor Company. To overcome the limitations of conventional hydraulic struts—oil leakage, bulky structure, and limited response performance—the system integrates a BLDC motor, ball screw, planetary reducer, and a series elastic actuator (SEA)-based linear drive module within a single strut cylinder as an electro-mechanical integrated architecture. With independent control at all four wheels, the system enables real-time regulation of vertical damping force and vehicle body motion, improving both ride comfort and driving performance simultaneously.

Features

- Max thrust up to 6 kN · stroke speed > 1 m/s · target force rate 23 kN/s
- BLDC motor (Kt 0.11 Nm/A · 14 pole-pairs) + ball screw (lead 10–25 mm) + planetary reducer (ratio 4.5–7.5)
- F-SEA architecture: serial motor–screw–nut–elastic element–rod — integrated impact absorption and force sensing
- 150 A-class motor driver · linear displacement sensor · quarter-car test rig–based PoC vehicle-level validation completed

Advantages

- Faster response and more precise damping-force control vs hydraulic systems — target 23 kN/s force rate for 4 kN step input
- Encoder-based measurement of elastic deformation in F-SEA architecture — disturbance-robust precise force sensing and control
- DOB-based two-degree-of-freedom control combined with non-conductive liquid cooling — sustains stable continuous-operation performance

Applications

Four-wheel active suspension for high-performance and premium passenger sedans

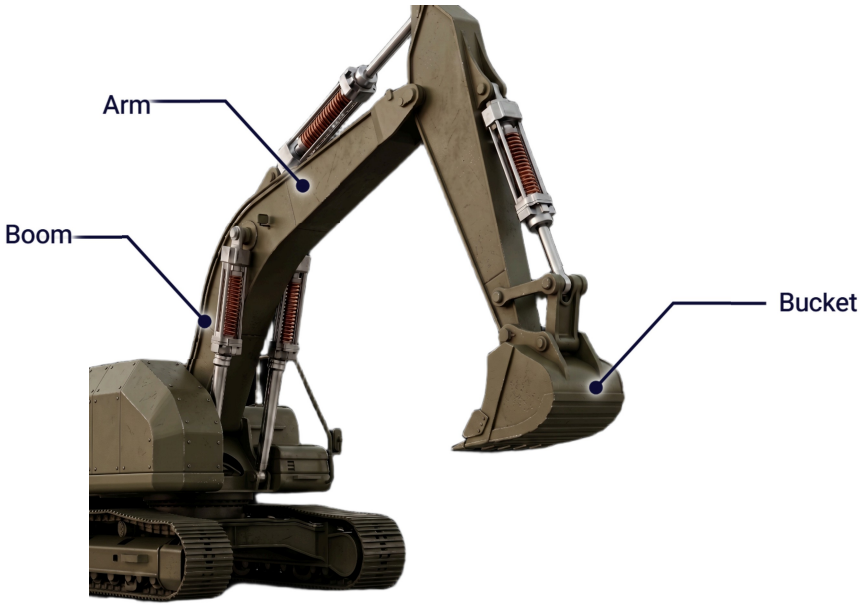
Active struts for ride-height adjustment and roll/pitch control in EVs and SUVs

Ride-comfort enhancement and precise body-attitude control for autonomous vehicles

Development platform for quarter-car HILS testing and active suspension control algorithms

T3-B-1 Excavator Robot Platform

HIGH-LOAD · HIGH-PRECISION FORCE-CONTROLLED ROBOT



Overview

A next-generation electric excavation robot that integrates high-power series elastic actuators (SEA) into the boom, arm, and bucket axes. It simultaneously achieves ultra-precise force sensing at the 0.1 N level and high-output force up to 70 kN — capabilities unattainable with conventional hydraulic excavators — enabling human-level tactile interaction for defense EOD, demining, extreme-environment tasks (high vacuum, cryogenic), and autonomous excavation.

Features

- Boom actuator — max thrust 73.3 kN · max speed 125 mm/s · motor power 24.5 kW · force-control bandwidth 5 Hz
- Arm actuator — max thrust 70.1 kN · max speed 155 mm/s · motor power 22.5 kW · force-control bandwidth 8 Hz
- Bucket actuator — max thrust 33.3 kN · max speed 195 mm/s · motor power 19.5 kW · force-control bandwidth 12 Hz

Advantages

- Simultaneous realization of ton-level output (up to 73.3 kN) and ultra-precise force control at 0.1 N resolution
- Direct force estimation via elastic-deformation measurement — no additional load cells required
- Impact-absorbing elastic structure protects motor, gearbox, and control system under harsh operating conditions
- Real-time physical-data generation at the actuator level — directly applicable to Physical AI–based autonomous operation

Applications

Defense and special equipment — demining, EOD, and explosive handling requiring precise contact control

Extreme-environment systems — high vacuum, cryogenic, and fine-dust environments (space exploration, lunar operations)

Construction and heavy-equipment automation — autonomous excavation based on precise contact and reaction-force control

Physical AI automation platforms — direct integration with autonomous-operation software via sensing-enabled actuator interfaces

T3-B-2 Five-Bar Linkage 2-DOF Hopping Platform

LEGGED LOCOMOTION PLATFORM

Overview

A five-bar 2-DOF parallel platform driven by two base-mounted motors through serial and parallel links to a single end-point. Concentrating the actuators on the body side dramatically reduces the reflected inertia at the leg tip, enabling a legged-robot platform well suited to high-bandwidth force control and instantaneous impact response.

Features

- Configuration: 2 base-mounted motors + 4-link, 5-bar closed-loop parallel mechanism (2-DOF end-point)
- Control space: joint / Cartesian / rotational workspace — triple representation supported
- Sensor-less ground reaction force estimation based on a Ground Contact Force Observer (GCFO)
- Validation: hopping experiments at 1,400 N/m virtual stiffness with force-plate-based ground-reaction measurement

Advantages

- Actuators on the base minimize end-point reflected inertia — fast response and low impact transmission
- Parallel structure offers high stiffness and power density while keeping the links themselves lightweight — ideal for high-speed hopping and running
- Two-axis independent drive with bi-articular coordinate transform — intuitive force/position control in Cartesian (x, y) space
- Rotational-workspace-based GCFO enables real-time contact-force estimation without force/torque sensors

Applications

Hopping/running leg modules for quadruped and biped robots (SLIP model)

Research platform for low-energy locomotion and hopping leveraging natural dynamics

Test rig for shock-absorbing landing control and landing-strategy optimization

Benchmark for sensor-less ground-reaction estimation and impedance-control algorithms

SECTION

T4 Evaluation & Benchmarking Infrastructure

4 ITEMS · DYNAMOMETER · 4-STEP PROTOCOL · QUARTER-CAR & HALF-CAR HILS · ROBOT HILS

Test and validation infrastructure that enables quantitative analysis of actuator dynamics and objective benchmarking.

Evaluation & Benchmarking Infrastructure

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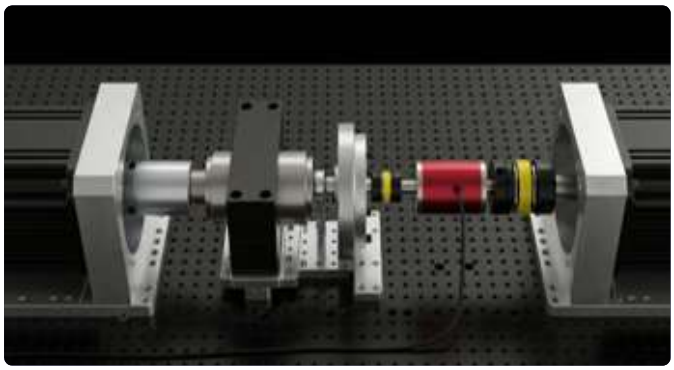
T4-A Dynamometer Test Infrastructure

DYNAMOMETER TEST INFRASTRUCTURE

Single-axis Dynamometer



Dual-end Dynamometer

Overview

A baseline setup that fixes the test actuator stator with a 3-jaw chuck and arranges an encoder, torque sensor, and AC servo motor in series on a single shaft. The self-centering 3-jaw chuck clamps actuators of various outer diameters without dedicated jigs, and the entire hardware is reconfigurable for different test conditions.

Features

- Self-centering 3-jaw chuck — clamps actuators of various outer diameters without dedicated jigs
- No-load / fixed-load / external-load & excitation setups switched on a single hardware (no disassembly required)

Advantages

- System identification, controller performance, and disturbance-response tests run on a single infrastructure
- AC servo motor switches between position / velocity / force control modes for static and variable load application

Overview

A setup that mounts the test actuator directly on a central bracket with AC servo motors at both left and right ends. Independent control of the two motors enables bi-directional load and excitation, while a central in-line torque sensor and encoder simultaneously measure position and torque.

Features

- Independent left/right AC servo motor control — simultaneous bi-directional load and excitation
- Test actuator mounted directly at center + in-line torque sensor & encoder for simultaneous position/torque measurement

Advantages

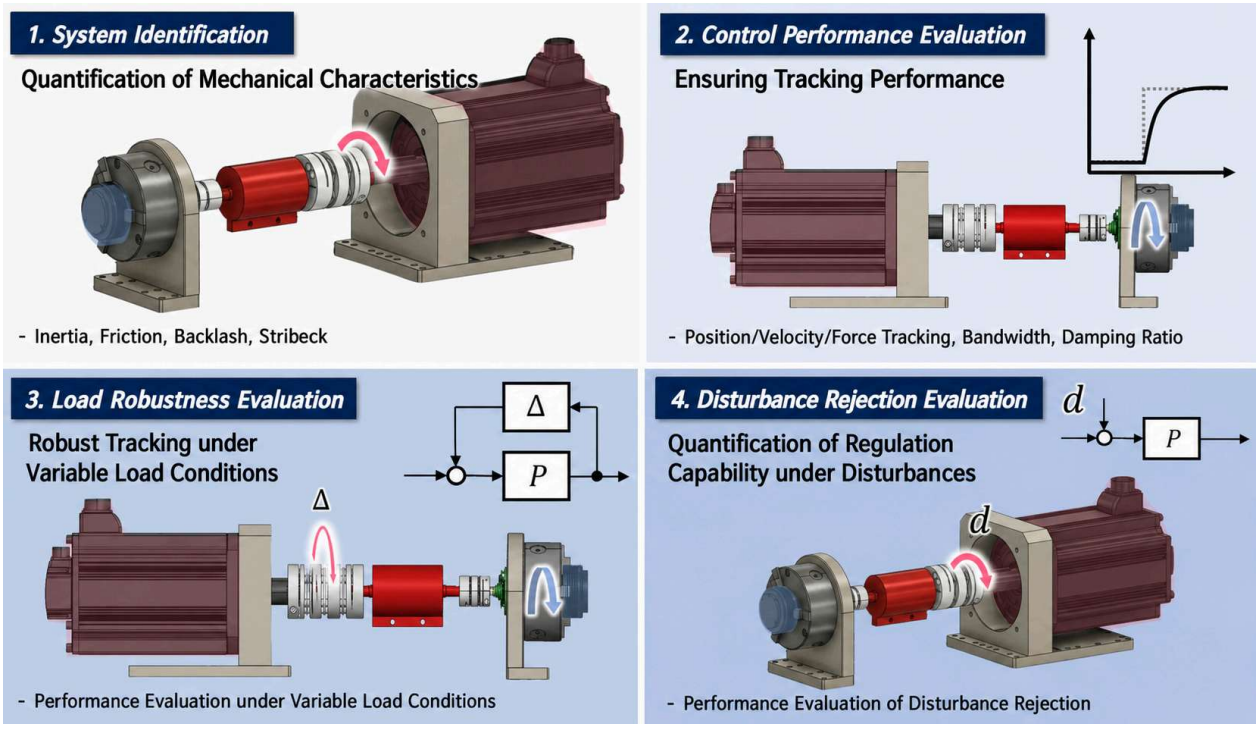
- Enables bi-directional load and superposed excitation tests not reproducible on a single-axis setup
- Time- and frequency-domain standard excitation profiles (Step / Ramp / Chirp / PRBS) for direct cross-model comparison

Applications

Dynamic-characteristic evaluation of cobot and humanoid joint actuators	Quantitative back-drivability and transparency assessment
Active-suspension actuator test & evaluation	Dynamic-characteristic benchmarking of commercial and new actuators

T4-B 4-Step Actuator Dynamic-Characterization Protocol

4-STEP EVALUATION PROTOCOL



Overview

A four-step evaluation protocol established to systematically reveal the dynamic performance of actuators that static catalog specs cannot capture. The protocol proceeds in order: ① system identification, ② control performance under non-ideal conditions, ③ static and variable load robustness, ④ dynamic disturbance / back-drivability interaction — yielding both time- and frequency-domain metrics at every step for objective cross-actuator comparison.

Features

- Step 1 — System identification: friction, backlash, inertia, and other base parameters
- Step 2 — Control performance: response speed, steady-state error, vibration suppression
- Step 3 — Load robustness: static and variable load disturbance handling
- Step 4 — Interaction: chirp-based dynamic disturbance and back-drivability assessment

Advantages

- Provides identical-condition test scenarios that enable 1-to-1 comparison between actuators
- Integrated evaluation of position / velocity / force control performance and interaction performance
- Quantifies key humanoid / cobot metrics such as back-drivability
- Real-time validation system grounded in measured data

Applications

Dynamic benchmarking of commercial and new actuators

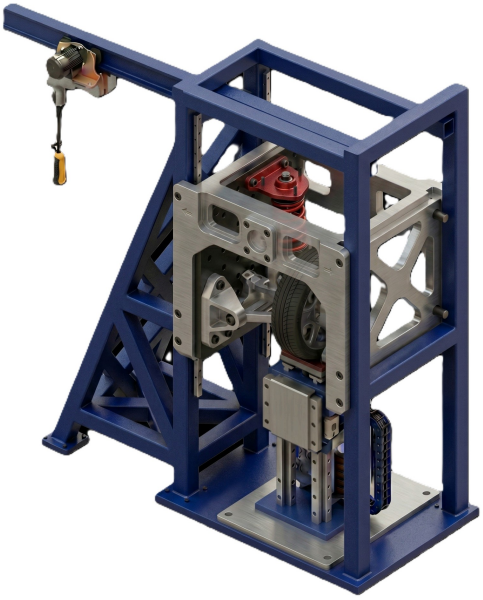
Comparative analysis across QDD / SEA / harmonic-reducer types

Actuator selection process for robot manufacturers

Performance validation for actuator control-algorithm R&D

T4-C-1 Quarter-Car HILS Tester

QUARTER-CAR HILS TESTER



Overview

A HILS tester that mounts a real suspension on a quarter-car frame replicating one quarter of a vehicle, and reproduces road inputs through a linear-motor shaker. It validates damping and stiffness control algorithms of active suspensions (active struts, semi-active dampers, etc.) at the physical-prototype level before vehicle integration.

Features

- Quarter-car frame + real suspension strut mounted
- Direct linear-motor drive — reproduces structured/unstructured road profiles (ISO 8608, etc.)
- MacPherson / double-wishbone compatible — adjustable links and mounts cover multiple vehicle geometries
- Electric-winch sprung-mass loading — 50 kg load step combinations, single-operator usable
- Mechanical gravity-compensation springs — no dynamic interference, zero maintenance
- In-house motion controller + model-based advanced control (feedforward + feedback + iterative learning)

Advantages

- Validates the stability and performance of suspension control algorithms at the physical level prior to vehicle integration
- Reproduces a wide range of scenarios from ISO 8608 road profiles to actual driving-data replay
- Immediate SW customization — adding test modes, modifying control logic, and other on-site requests handled directly
- Fully domestic system — no lead time on parts, service, or technical support

Applications

Validation of vehicle active-suspension control algorithms

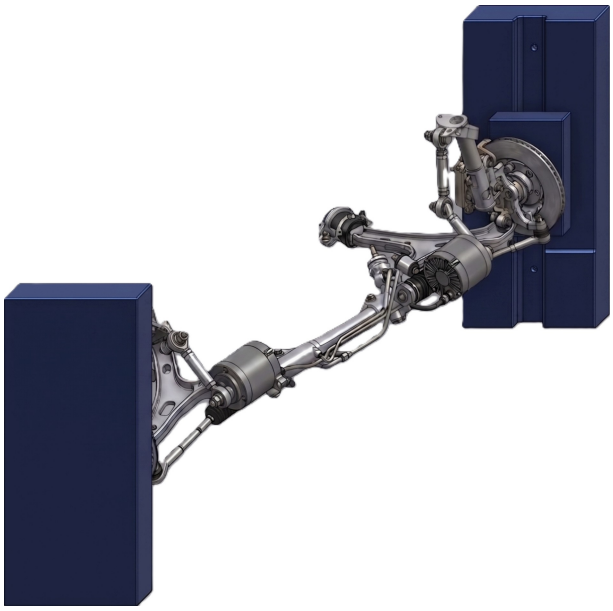
Performance and durability evaluation of Linear Active Struts (LAS)

Demonstration of zero-force / impedance control logic

Validation platform for next-generation electrified-hydraulic integrated dampers

T4-C-2 Half-Car HILS Tester

HALF-CAR HILS TESTER



Overview

A half-car (1/2 vehicle) HILS tester that simultaneously simulates the left and right wheels, validating active roll-control algorithms (ARS, Active Roll Stabilization) — including roll-direction behavior — at the physical-prototype level. It experimentally evaluates left-right wheel coupling, roll stiffness, and anti-roll-bar effects that quarter-car rigs cannot reproduce.

Features

- Two independent left/right linear-motor shakers — in-phase (heave) and anti-phase (roll) excitation
- Half-car frame with real left/right suspensions and an anti-roll bar (stabilizer) mounted
- Integrated testing of active anti-roll bars (ARS), semi-active dampers, CDC, and other roll-control devices
- Same adjustable link/mount structure as the quarter-car rig — covers different track widths and suspension geometries
- Independent left/right sprung-mass loading — reproduces asymmetric (offset) loading conditions

Advantages

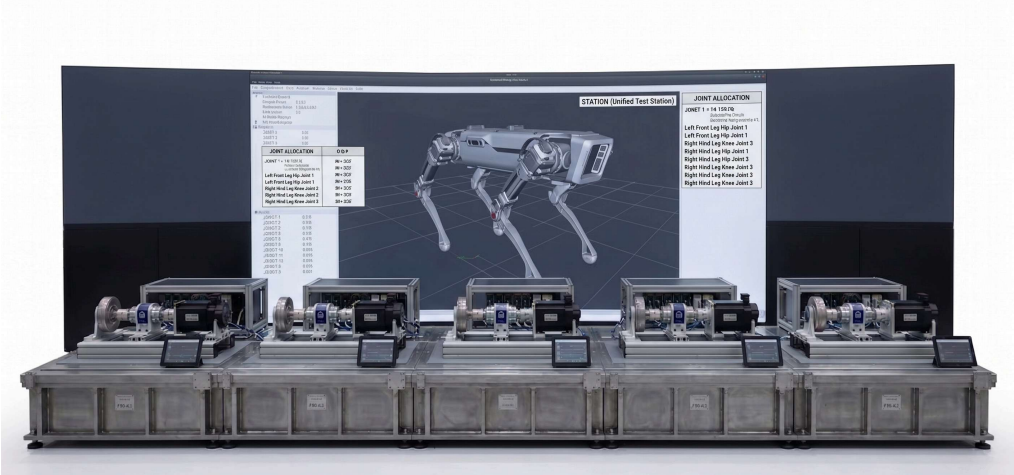
- Direct measurement of lateral dynamics — roll natural frequency, roll damping ratio, roll stiffness — at the physical level
- Reproduces cornering load-transfer scenarios — quantitatively evaluates anti-roll-bar and ARS control performance
- Simultaneous left-right excitation enables separation of heave and roll modes
- Shares control SW and motion-controller platform with the quarter-car tester — unified operation, minimized learning cost

Applications

Validation of active roll-control (ARS) and lateral-dynamics algorithms	Quantitative evaluation of anti-roll-bar / stabilizer effectiveness
Cornering and load-transfer scenario reproduction	Integrated test platform for combined ride/handling control development

T4-D Robotic HILS Platform

ROBOTIC HILS PLATFORM



Overview

A universal Hardware-in-the-Loop Simulation (HILS) platform that enables joint-level validation of robots with arbitrary morphologies — quadrupeds, manipulators, humanoids, and other systems — without requiring a fully built physical robot. The simulation calculates the joint loads generated by the robot's geometry and motion, a dynamometer array reproduces these loads in real time, and the measured responses of the actual actuators are fed back into the simulation. This lets actuator and controller validation — traditionally possible only after completing the full robot — begin from the early design stage, and extends to a Design-in-the-HILS-loop framework where parameters such as motor specs, gear ratios, link lengths, inertia, and stiffness are automatically explored and optimized within the HILS environment.

Features

- N-axis dynamometer array, scalable according to robot morphology
- Real-time loop of 1 ms, 1 kHz, with EtherCAT-synchronized control
- Customizable simulation environment including terrain, gravity, contact conditions, and external disturbances

Advantages

- Enables integrated validation of actuators and controllers before physical robot fabrication, significantly reducing design-modification cost and development time
- Applicable regardless of robot type — quadrupeds, bipeds, manipulators, humanoids — allowing multi-robot R&D on the same infrastructure
- Allows flexible modification of virtual robot geometry, environments, and disturbance conditions — flat ground, slopes, space, and disaster environments
- Supports automatic exploration and optimization of design parameters such as link length, reduction ratio, inertia, and stiffness within the HILS loop

Applications

Pre-validation of actuators for arbitrary robot morphologies, including quadrupeds, bipeds, manipulators, and humanoids

Validation of control algorithms and RL policies before deployment to physical robots, plus sim-to-real data acquisition

Optimization of motor, reducer, and link design parameters through an automated Design-of-Experiments loop

Digital-twin-based virtual R&D platform and preliminary evaluation of new robot concepts

THANK YOU

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