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IMPEDYME
Dynamometer
Testbench

Battery Emulation

Inverter Testing

Motor Emulation

SIMULINK Enabled

Fiber-optic Communications

High Power

High Frequncy

Regenerative Energy

Introduction

4Q DYNAMOMETER TESTBENCH

IMPEDYME's Dynomometer Testbench is a comprehensive, high-performance testing platform for developing and validating control techniques on motor-driven systems. It features a dual-machine setup with an Induction Machine (IM) coupled with a Permanent Magnet Synchronous Machine (PMSM). Using this configuration, one machine to act as the Device Under Test (DUT) while the other serves as a programmable load. Thus, an operator can simulate a wide range of real-world conditions for applications like wind turbine emulation, electric vehicle motor testing, and railway traction among others.

TYPICAL APPLICATIONS

Our Dynomometer Testbench is ideal for developing and evaluating control strategies under simulated load conditions. When combined with IMPEDYME's CHP products that can control and deliver power, it forms a complete drive prototyping setup that can emulate complex physical behaviors at a reduced form factor. Typical applications include:

- **Traction Inverter Testing**: Performance evaluation, validation, and control of traction inverters, essential for electric vehicles and railway traction systems.
- **Wind Turbine Emulation**: Replication of aerodynamic torque load, while the second machine simulates the generator function.
- **Electric Vehicle (EV) Motor and Drive Control**: Impedyme's Testbench allows for the evaluation of motor control strategies under simulated road conditions. Moreover, It supports the testing of acceleration, deceleration, regenerative braking, and efficiency across different speed and load profiles. This is essential for the development and testing of electric vehicle propulsion systems.
- **Railway Traction Systems**: Measurement of traction drive performance for high-power, variable-load conditions.
- **Aerospace Actuator and Motor Testing**: This testbench allows for the testing of aerospace motors and actuators under simulated flight conditions, including high-torque, variable-speed, and emergency braking scenarios.
- **Research & Development in Motor Control Algorithms**: Research institutions and laboratories can use Impedyme's Testbench to develop and validate new control algorithms. This includes Model Predictive Control (MPC), Field-Oriented Control (FOC), and Direct Torque Control (DTC) under realistic conditions.

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HIL AND PHIL FEATURE AT A GLANCE

Hardware-in-the-Loop (HIL) is a testing technique used to validate the performance and functionality of embedded systems. In HIL testing, a real-time simulation of the environment in which the system operates is created, allowing engineers to test and refine the system under various conditions without needing a physical prototype.

Power-Hardware-in-the-Loop (PHIL) extends the HIL concept by including the physical power hardware in the simulation loop. This means that the actual power equipment, such as power converters, generators, and motors, is interfaced with the real-time simulation, allowing for a more comprehensive testing of power systems and control algorithms.

IMPEDYME COMBINED HIL AND PHIL (CHP) CAPABILITIES

Connecting a real-time simulator with an amplifier to create a PHIL setup involves addressing various technical challenges: system stability, signal accuracy, interface compatibility, safety, and reliability. Overcoming these challenges requires careful planning, precise calibration, and robust system design. Impedyme's Combined HIL and PHIL solutions are engineered to address these complexities. We offer a reliable and efficient platform for advanced testing and validation of power systems. Impedyme's integrated approach not only ensures technical excellence but also delivers significant cost advantages, making it an ideal choice for educational institutions and R&D labs.

Integrated with MATLAB Simulink®, our products offer flexible test editing functions to perform independent channel tests conforming to rigorous testing requirements.

REAL TIME SIMULATOR

Filtering, Compensation and Protection Components

HIL

PHIL

SENSOR

POWER AMPLIFIER

Combined HIL and PHIL (CHP)

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IMPEDYME Dynamometer Testbench Key Features

- Four (4) Quadrant Operation: Support both motoring and loading functions for comprehensive testing flexibility.

Dual-Machine Setup:

- One 4 kW squirrel cage Induction Machine for 380V/50Hz or 460V/60Hz operation.
- One 4 kW Permanent Magnet Synchronous Machine for 400V/1800 rpm operation.
- Combined amplifier and signal processing unit within a stand alone test system.
- High Dynamic Torque & Speed Control: Precise control for both high and low-speed ranges.
- Integrated Bidirectional Torque Sensor
- Space-saving advance thermal management system (stand-alone liquid cooled)
- Fiber-optic communications to enhance EMI immunity, data transmission bandwidth and security.
- High-performance processor and FPGA technology for the most demanding real-time requirements.

Using a **Combined HIL and PHIL (CHP)**, in IMPEDYME's Dynamometer Testbench can:

- Conduct Comprehensive Validation: Test the complete system, including control algorithms and power hardware, ensuring all components work together seamlessly.
- Improve Design Efficiency: Identify and resolve issues early in the development process, reducing the need for costly and time-consuming physical prototypes.
- Enhance Safety and Reliability: Validate the performance of power equipment under various conditions, ensuring the final product is safe and reliable.

- **Save Time:** Streamline the testing process by avoiding the separate integration of HIL and amplifiers, resulting in significant time savings.
- **Reduce Costs:** Minimize expenses related to multiple testing systems and physical prototypes, providing cost-effective solutions for educational and R&D labs.
- **Optimize Space:** Efficiently utilize lab space with a compact CHP setup, ideal for small to medium lab environments in educational institutions.

IMPEDYME's Dynamometer Testbench ensures protected testing implementing multiple safety controls including Over Voltage Protection, Over Current Protection, Over Temperature Protection, and external parameter detection.

The advanced thermal management system is stand-alone and liquid cooled with high-power components on a small footprint. It offers significantly higher efficiency and, conversely, smaller cooling systems (compared to air cooled systems). This is space-saving technology has lower energy consumption compared to building chillers and requires no external or central cooling installation.

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SOFTWARE, DATA ACQUISITION AND REPORTINGS

IMPEDYME's testing software provides a user-friendly setup for closed and open-loop torque and speed control. The test data can be stored, displayed, and printed in various formats, including a spreadsheet file for additional analysis. Real-time data Visualization can be displayed in tabular, graphical, and universal report formats for easy analysis.

DEVICE DESCRIPTION

In IMPEDYME's Dynomometer Testbench two machines are coupled together with a torque sensor placed in-between. As for the brake and the resolver, they are directly integrated into the PMSM. Fig. 2 illustrates the Motor Testbench and its parts.
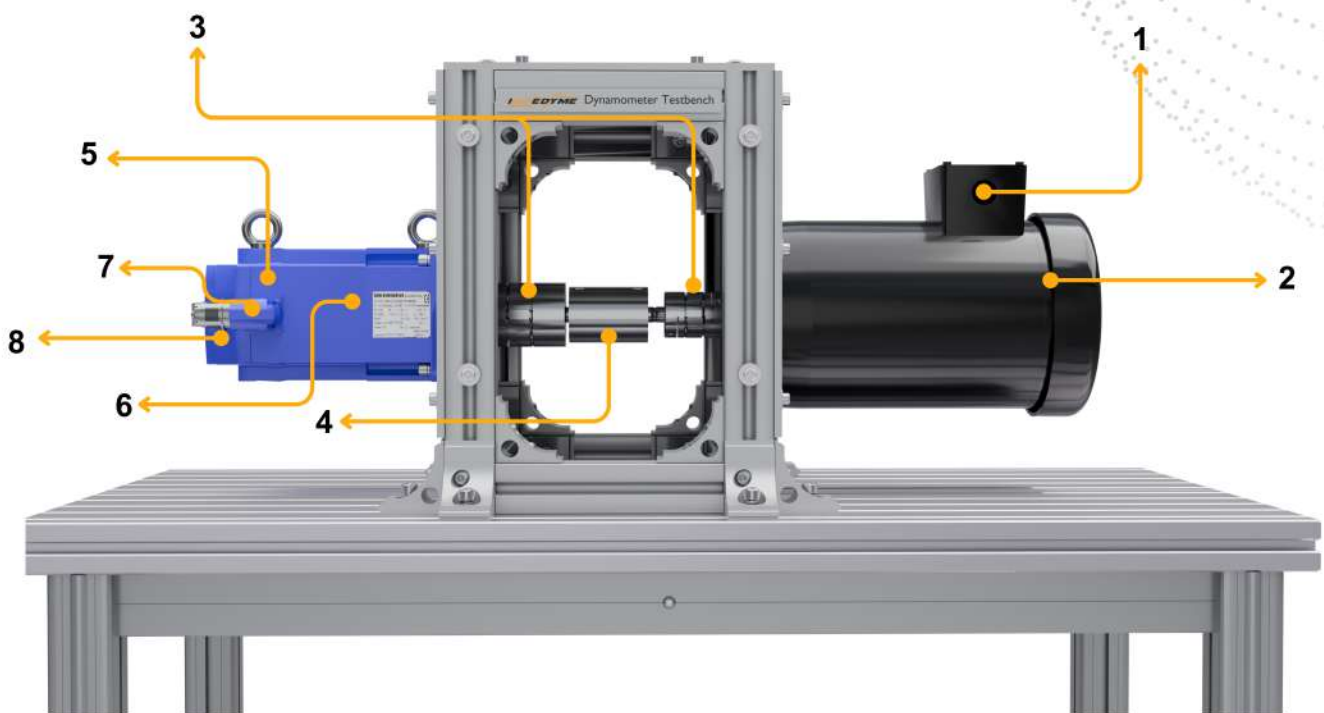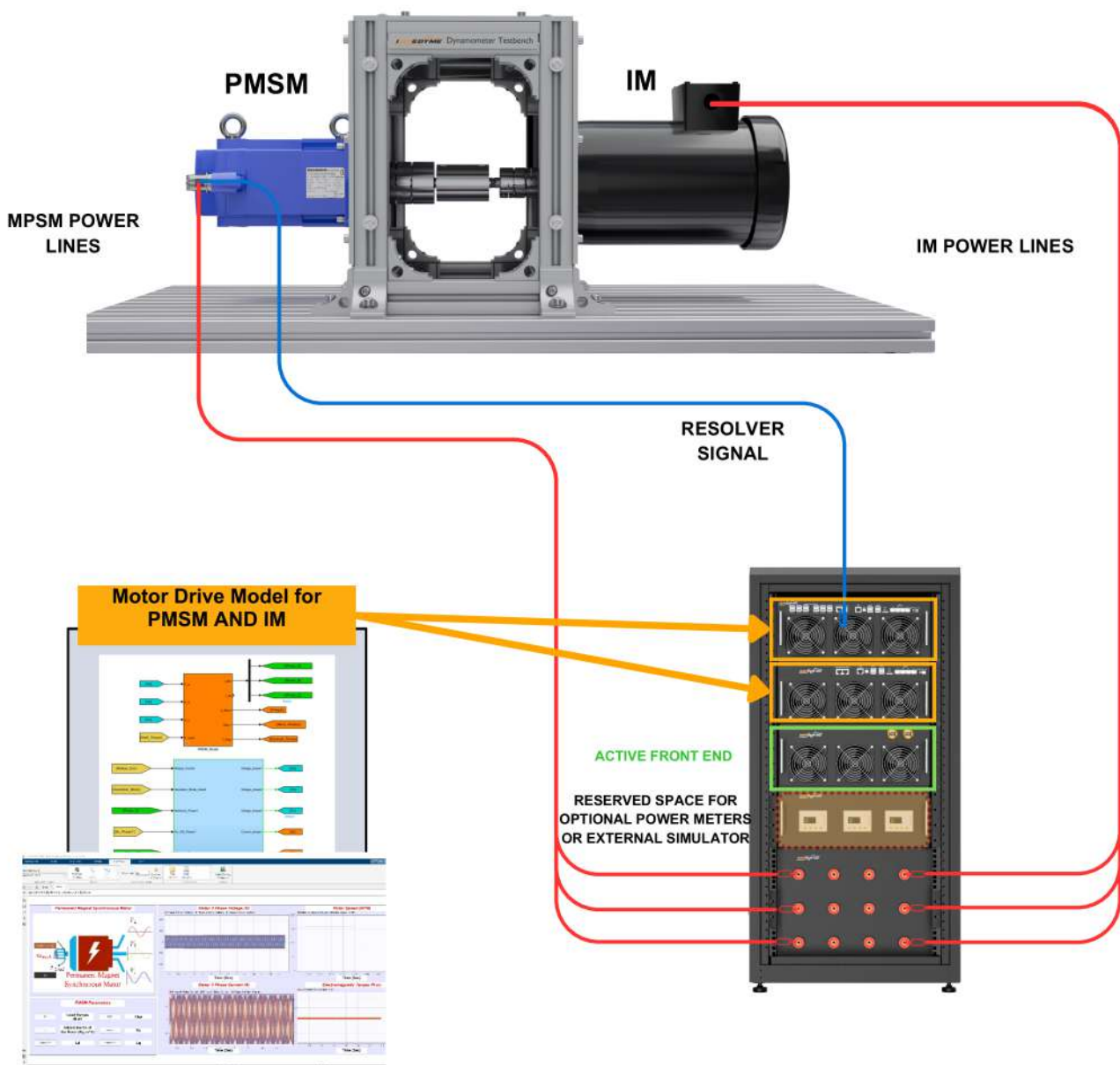

1) TERMINAL BOX IM (POWER)
2) INDUCTION MACHINE
3) FLEXIBLE COUPLINGS
4) TORQUE SENSOR
5) BRAKE
6) PERMANENT MAGNETS SYNCHRONOUS MACHINE
7) POWER & SIGNALS PLUGS (PMSM)
8) RESOLVER

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INSTALLATION AND CONFIGURATION

Due to its substantial weight, proper lifting equipment is required for transporting and positioning IMPEDYME's Testbench. Given these weights, caution and appropriate equipment should be used during handling to prevent injuries and equipment damage. It is recommended to position the Testbench at a safe distance from operators or to install protective barriers around it, particularly when testing high-power applications, where any sudden movement or failure could pose risks. Each motor power line should be connected to the cabinet and CHP modules allow emulating complex physical behaviors at a small scale and programable within IMPEDYME's software package.

PMSM

IM

MPSM POWER LINES

IM POWER LINES

RESOLVER SIGNAL

Motor Drive Model for PMSM AND IM

ACTIVE FRONT END

RESERVED SPACE FOR OPTIONAL POWER METERS OR EXTERNAL SIMULATOR

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MECHANICAL DESIGN AND INSTALLATION

IMPEDYME's Dynamometer Testbench is built with a focus on durability, stability, and ease of use. Constructed on a robust frame, the testbench offers exceptional stability even under the intense operational demands of high-torque, high-speed testing. Adjustable feet are incorporated into the frame design, allowing the testbench to be securely leveled on a variety of surfaces, ensuring minimal vibration and movement. This stability is crucial for accurate data acquisition, as even slight shifts or vibrations can affect the precision of torque, speed, and position measurements.
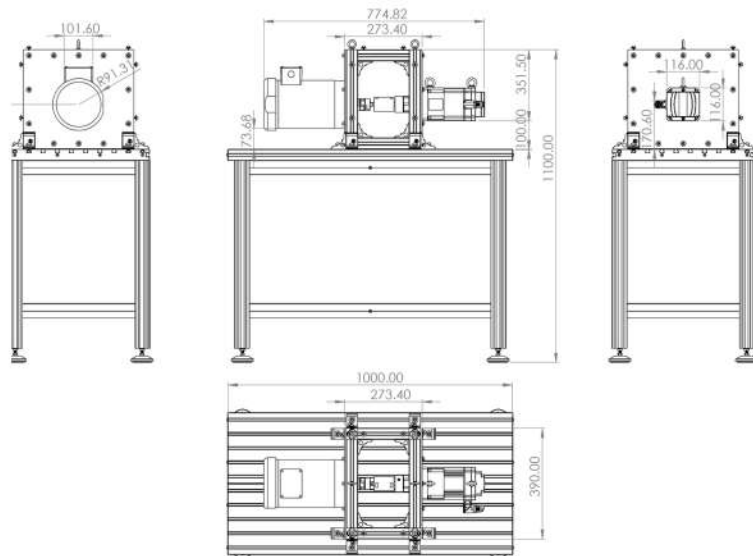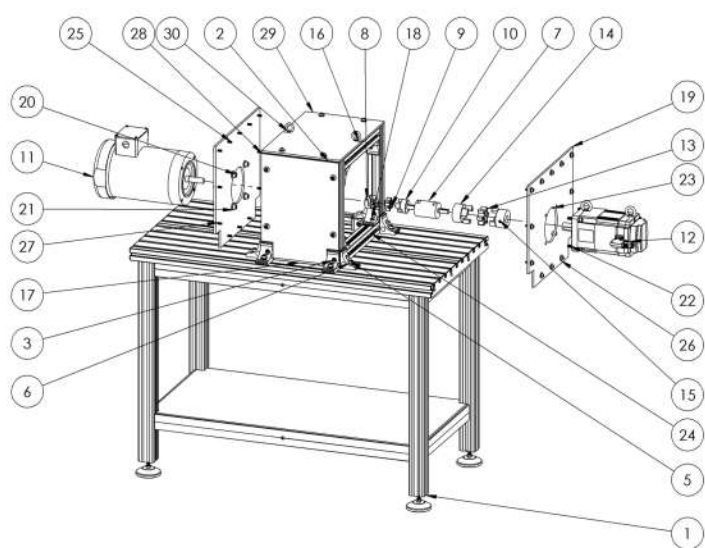
ITEM NO.	DESCRIPTION	QTY
1	T-Slot Fixturing Table	1
2	Heavy Duty Slotted Framing	4
3	Heavy Duty Slotted Fitting	8
4	18-8 Stainless Steel Square Nut	8
5	18-8 Stainless Steel Socket Head Screw	8
6	18-8 Stainless Steel Split Lock Washer	15
8	Vibrate-Damping Precision Flexible Shaft Coupling	1
9	Durometer 92A Spider for 1-5/8" OD and 41mm OD vibrate-Damping Precision Flexible Shaft Coupling	1
10	Vibrate-Damping Precision Flexible Shaft Coupling	1
11	Face-Mount AC Motor	1
12	AC Servmotor	1
13	Durometer 98A Spider for 2-1/4" OD and 57mm OD vibrate-Damping Precision Flexible Shaft Coupling	1
14	Vibrate-Damping Precision Flexible Shaft Coupling	1
15	Vibrate-Damping Precision Flexible Shaft Coupling	1

ITEM NO.	DESCRIPTION	QTY
16	Heavy Duty Slotted Framing	4
17	Heavy Duty Slotted Framing	4
18	Heavy Duty Slotted Fitting	24
19	Servomotor Support	1
20	18-8 Stainless Steel Socket Head Screw	4
21	17-4 PH Stainless Steel Socket Head Screw	4
22	18-8 Stainless Steel Socket Head Screw	4
23	Zinc-Plated Steel Hex Nut	4
24	Heavy Duty Slotted Fitting	38
25	18-8 Stainless Steel Socket Head Screw	36
26	Bumax 88 Stainless Steel Oversized Washer	36
27	electricalmotor support	1
28	top plate	1
30	Steel Eyebolt-for Lifting	2

• All specifications are subject to change without notice.

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