Advancement of MEIDACS II – Control and Measurement System

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Abstract

MEIDACS II continues to extend its functions, while keeping the compatibility with various measuring instruments and the standard data output format of the Association for Standardization of Automation and Measuring Systems (ASAM). For drivetrain systems, the function of collecting communication and data with the Electronic Control Unit (ECU), which is used in the test specimen, has been expanded. By preparing a communication interface to respond to various models-based development tools and in response to the expansion of customer's virtual models, this product can build a Hardware-In-the-Loop (HIL) simulation system that links to real-time facilities with dynamometer equipment. For the chassis dynamometer system, the functions of temperature correction in the road load settings and the automatic inertia response tools were expanded in order to meet the various regulations.

1 Preface

The operation measurement system, MEIDACS II (hereinafter referred to as "MEIDACS II"), is suitable for a wide range of test applications. MEIDACS II continues to advance, including compatibility with various measuring instruments and a Hardware-In-the-Loop Simulation (HILS) system, support the functional expansions, and comply with various regulations. This paper introduces the drivetrain system and chassis dynamometer system supported by MEIDACS II.

2 MEIDACS II

MEIDACS II is provided with the following features.

2.1 Compatibility with ASAM Standard Data Format

ASAM means Association for Standardization of Automation and Measuring System. Data can be output as measurement data in a data format standardized by the ASAM and can be analyzed using general-purpose data analysis software. Data can also be registered in ASAM Open Data Service (ODS). The supported data formats are as follows.

(1) ASAM Transport Format in Extensible Markup Language (XML) (ATFX)

(2) Measurement Data Format (MDF)

2.2 Multi-Point Measurement Equipment (MDP-2000)

This equipment has a high-speed digital signal processor with arithmetic functions to convert physical quantities, and is designed to centrally manage various measurement signals (e.g., analog, pulse, digital signals, and field networks). The equipment can be incorporated into a variety of systems and used as an interface. By introducing this equipment to MEIDACS II, measurement items and recording output items can be expanded. **Fig. 1** shows the external appearance of the multi-point measuring equipment (MDP-2000). **Table 1** shows the basic specifications.

2.3 Compatibility with Various Measuring Instruments

MEIDACS II is compatible with power analyzers and battery emulators in order to perform electric vehicle power consumption performance evaluations, inverter evaluations, motor evaluations, battery evaluations and other evaluations as needed. In addition, MEIDACS II is compatible with measuring instruments in order to perform a variety of tests that differ for each customer. The measuring

Fig. 1 **Multi-Point Measuring Equipment (MDP-2000)**

Various signals can be expanded by incorporating the multi-point measuring equipment (MDP-2000) in MEIDACS II.

Table 1 **Basic Specifications of Multi-Point Measuring Equipment (MDP-2000)**

As the basic specifications, analog I/O, pulse I/O, and digital I/O can be processed.

Item	Specifications
Unit power source	AC85～264 V 1Φ 50/60 Hz
Analog input	
No. of channels	128ch (Max.)/64ch (standard)
Rated input	DC 0～±10 V
Low-pass filter	Digital filter (IIR)
Analog output	
No. of channels	256ch (Max.)/64ch (standard)
Rated output	DC 0～±10 V
Pulse input	
No. of channels	32ch (Max.)/16ch (standard)
Input system	TTL input or sinusoidal waves, dry contact input (exclusive selection)
Rated input	1 Hz～100 kHz
Polarity output	Open drain output (Phase A and Phase B for fixed channels)
Pulse output	
No. of channels	32ch (Max.)/16ch (standard)
Output system	TTL output or open drain output
Rated output	1 Hz～100 kHz
Digital input	
No. of channels	128ch [bit] (Max.)/64ch [bit] (standard)
Input system	Dry contact input
Digital output	
No. of channels	128ch [bit] (Max.)/64ch [bit] (standard)
Output system	Open drain output

instruments corresponding to Table 2 are shown, and the image of the system configuration is shown in Fig. 2.

Table 2 **Corresponding Measuring Instruments**

MEIDACS II is corresponding to various measuring instruments.

Instruments	Details
Power analyzer	Measurement of electric power, voltage, current, frequency, etc.
Battery emulator	Simulation of battery performance
Exhaust gas analyzer	Measurement of exhaust gas discharged from a vehicle
Smoke meter	Measurement of black smoke discharged from diesel engine
Opacimeter	Measurement of unburnt component contained in the PM
Blowby meter	Measurement of blowby gas leaking into engine crankcase
Fuel consumption meter	Measurement of fuel mass flow, momentary volumetric mass flow, and integrated flow rate

3 MEIDACS II-DT

MEIDACS II-DT has the following features for drivetrain system testing.

3.1 Communication Functions with Electronic Control Unit (ECU)

ASAM MCD-3 MC/ASAP3, the interface between the test control system and Measurement and Calibration (MC) tool, is used as the communication protocol to communicate with the ECU mounted on the test specimen. The configuration allows measurement through Integrated Calibration and Acquisition Systems (INCA). In addition, if data needs to be measured at high speed, data can be collected in line with the characteristics of the measurement item, usage, and evaluation purpose via the ES910.3 prototyping/interface module that supports the iLinkRT protocol. Fig. 3 shows an image of a system configuration using INCA.

3.2 Response to Model-Based Developments

In order to support various model-based development tools for drivetrain systems and customer virtual model expansion, we created a communication interface with FEV's xMOD. A HILS system can be constructed by linking the simulation model and the high-speed controller of MEIDACS II in real time. Various vehicle component simulation models (e.g. engine, tires, brakes, body) created by using the simulation model software can be used for co-simulation on a common simulation platform. The xMOD and dynamometer system work together to provide a highly versatile HILS model-based devel-

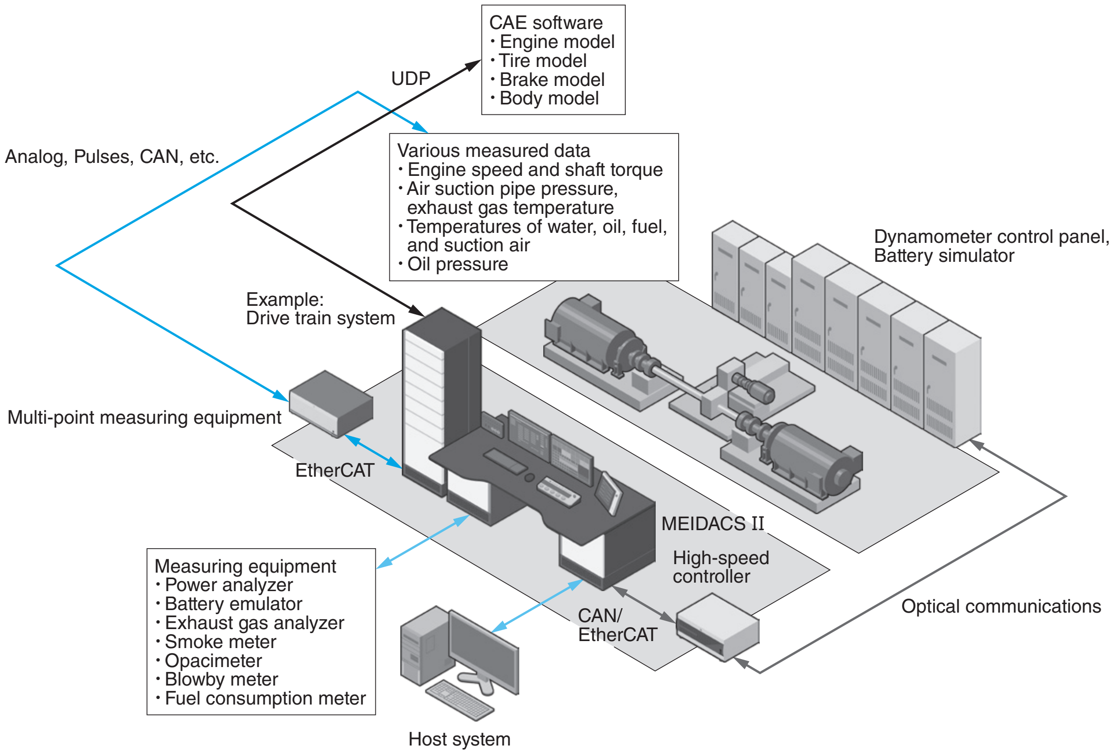


Fig. 2 **Image of System Configuration**

An example of MEIDACS II system configuration is shown. This is the combination with multi-point measuring equipment, various measuring instruments, CAE software, and host system.

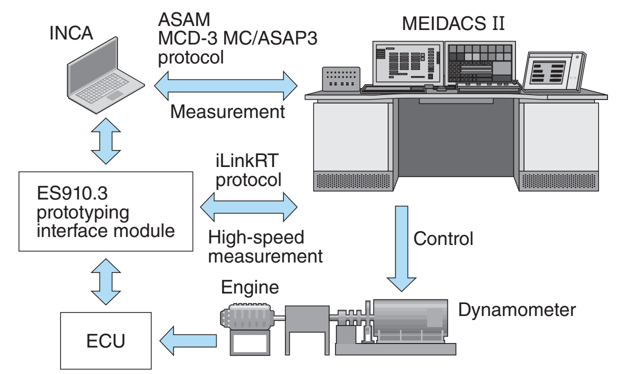


Fig. 3 **Image of System Configuration Using INCA**

Data can be gathered from the ECU via the INCA and ES910.3 prototyping interface module.

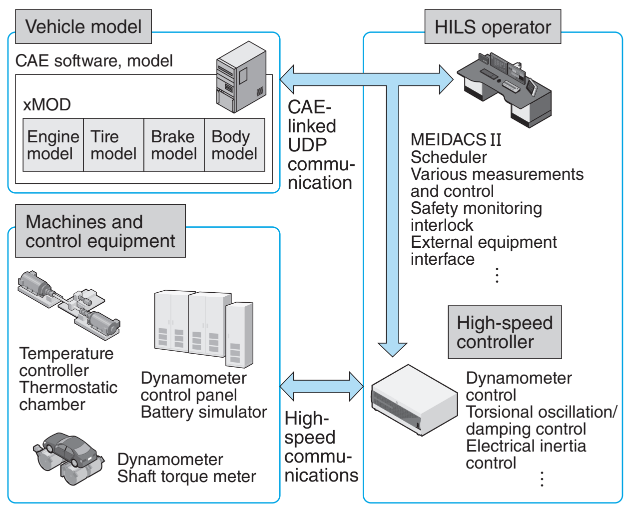


Fig. 4 **Configuration of HILS Test System by Using xMOD**

Since various simulation models can be made better with the xMOD, the HILS test system with high general-purpose versatility can be established in combination with MEIDACS II.

opment environment. **Fig. 4** shows the configuration of the HILS test system.

4 MEIDACS II-CH

Test methods and measurement technologies are also changing as automotive technology changes and environmental regulations become stricter. The specific requirements are: United Nations (UN) Regulation No. 154 (hereinafter referred to as “UNR154”), Code of Federal Regulations (CFR) part 1066 (hereinafter referred to as “CFR1066”), and Test Requirements and Instructions for Automobile Standards (TRIAS) JC08 mode. Such changes are reflected and updated in the above regulations. MEIDACS II-CH continues to meet the requirements of these changes. Below are three specific examples of requirements-meeting cases. We received many requests from customers for the below listed points.

4.1 Temperature Correction for UNR154 Load Set

To keep 20℃ for goal running resistance setting under the environmental condition of 23℃, the UNR154 stipulates to calculate coefficients (A, B, C) of chassis dynamometer braking force given from the derivation in a form of quadratic function of vehicle speed V ($A + B \times V + C \times V^2$). In the case of the Ambient Temperature Correction Test (ATCT), it is necessary to use Term A and Term B of the chassis dynamometer braking force coefficient under the environmental condition of 23℃ and to convert Term C (value equivalent to air resistance coefficient) of the chassis dynamometer braking force coefficient to that of 14℃. In the case of the UN Global Technical Regulation (GTR) No.15 Amendment6, similarly as for the ATCT, Term C of the chassis dynamometer braking force coefficient must be converted to −7℃. Therefore, we developed a function by which thermal compensation can be switched over between valid and invalid so that thermal compensation can be conducted at any temperature. **Fig. 5** shows a thermal compensation screen for road load settings.

4.2 Inertia Response Auto-Evaluation Tool

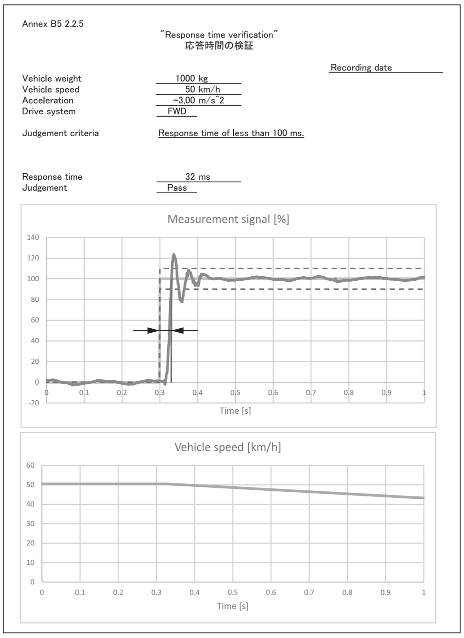
Up until now, inertia response evaluation for UNR154 and CFR1066 was performed manually. In response to the customer's request for an automatic evaluation tool, we prepared an automatic inertia response evaluation tool that complies with UNR154 and CFR1066 regulations. **Fig. 6** shows the report results for response times for each regulation. From the report's results, it can be seen that the response time of the evaluation conditions is calculated and the evaluation is performed up to the judgement. It allows customers to conduct evaluations tailored to their own facility management and operation.

(a) Compensation for 14℃

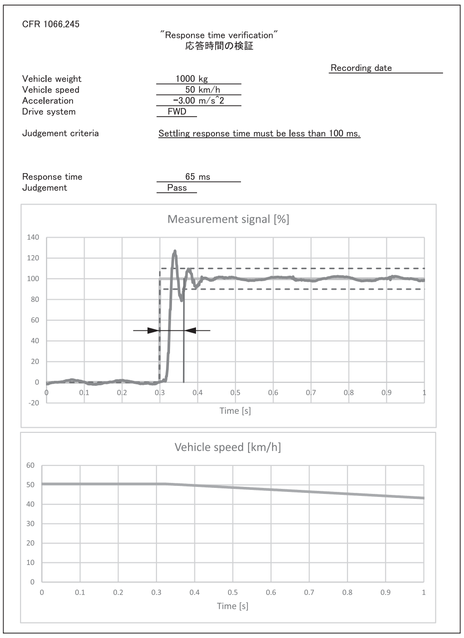
(b) Compensation for −7℃

Fig. 5 Thermal Compensation Screen for Road Load Settings

An example of thermal compensation screens is shown where (a) shows compensation of temperature at 14℃ and (b) at −7℃.



(a) UNR154



(b) CFR1066

Fig. 6 Each Evaluation Result Report by Inertia Response Automatic Evaluation Tool

An example of evaluation results by using Inertia response automatic evaluation tool is shown where (a) is for the UNR154 and (b) is for the CFR1066.

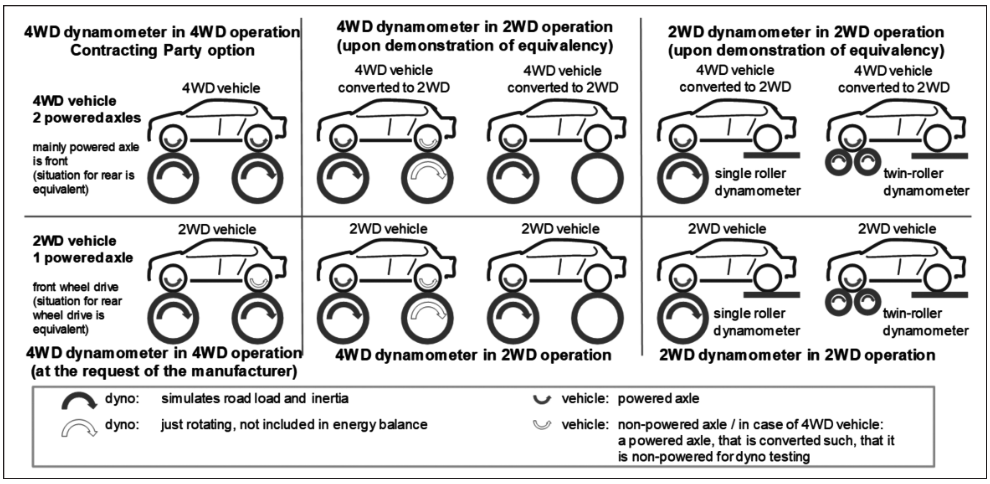
4.3 Constant Speed Control of Front and Rear Rollers of 4WD Chassis Dynamometer

Fig. 7 shows test configuration(1) that allows selection of dynamometers under UNR154. Two methods are now permitted when testing two-wheel drive (2WD) vehicles on a four-wheel drive (4WD) chassis dynamometer.

The first method is to either not apply a load to the non-driving wheels and do not allow them to rotate, or to rotate them at the same speed as the driving wheels.

The second method, which is limited to the situation where there is the request of the automobile manufacturer and we receive the permission from the approval authority, is to absorb the braking force of the non-driving wheels. This is to reproduce the road load and inertia of both the driving and non-driving wheels. In addition to measuring exhaust gas, fuel consumption rate, or power consumption rate, for example, there are evaluations tailored to vehicle testing purposes. The 4WD chassis dynamometer takes into account transient phenomena when the four wheels are rotating, just like when driving on a real road, thereby making it possible to evaluate phenomena that are difficult to reproduce when driving on a real road. For this purpose, constant speed control performance of the front and rear rollers is important.

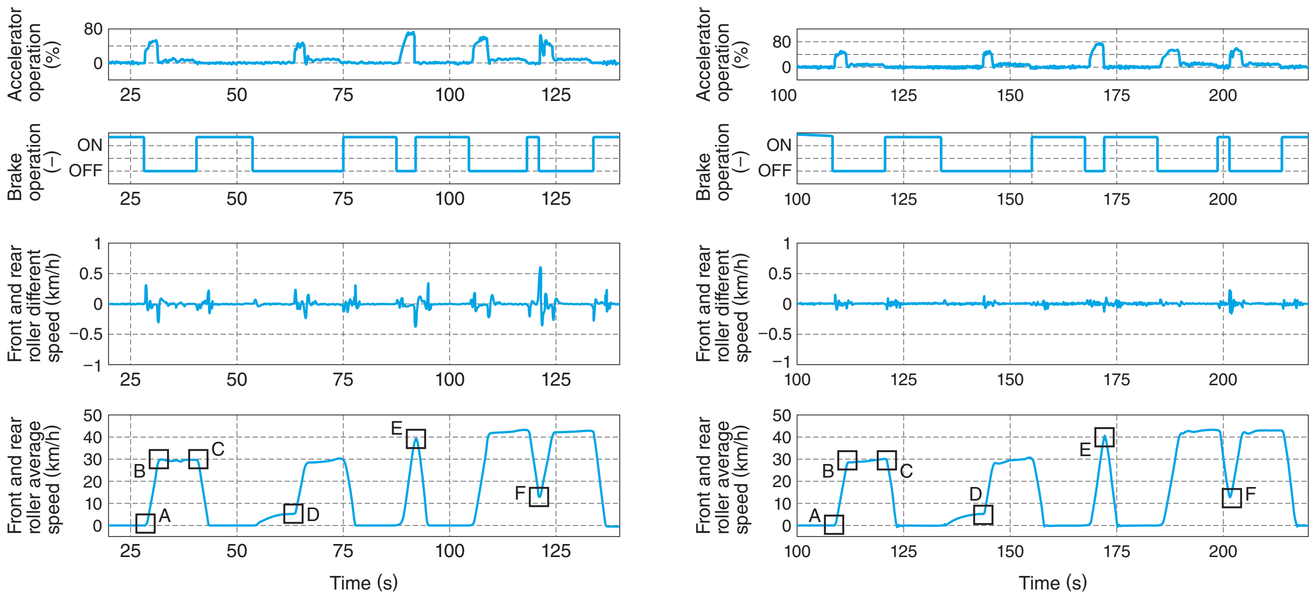
In order to improve the responsiveness of front and rear roller constant velocity control, a new control method was applied to the control system. Using a front-wheel drive electric vehicle, we confirmed the constant speed control performance of the front and rear rollers. Fig. 8 shows the test results from the differential speed of the front and rear rollers during transient operation with an acceleration of ±4 m/s². A to F are six evaluation points where the vehicle's driving force and braking force change significantly. A is the change point from stop to start, B is the change point from acceleration to steady state, C is the change point from steady state to deceleration, D is the change point from creep vehicle speed to acceleration, E is the change point from acceleration to deceleration, and F is a speed changing point from deceleration to acceleration. Using the signals in the evaluation, we measured the stroke amount of the accelerator pedal and the state of the brake pedal (pushing pedal/release: ON/OFF). For roller speed, we measured the differential speed of the front and rear rollers (the difference between the front and rear roller speeds) and the average speed of the front and rear rollers (the arithmetic means of the front and rear roller speeds). At the six evaluation points during transient operation, measurements were taken with a sampling time of 1 ms, and the differential speed of the front and rear rollers was processed with a low-pass filter to remove harmonic noise. Although the evaluation was not conducted using the same processing methods such as sampling time and moving average processing described in The Japanese Automobile Standards Organization (JASO) E018 "Road vehicles – Performance requirements and evaluation method of chassis dynamometer test system for the purpose of reproducing driving conditions on the road", by applying the new control



Source: UN Regulation No. 154

Fig. 7 Test Configuration that Allows Selection of Dynamometers

Dynamometer type assignment is shown for the testing vehicles conforming to the WLTP.



A: Start, B: Acceleration to steady, C: Steady to deceleration, D: Creep start, E: Acceleration to deceleration, F: Deceleration to Acceleration

(a) Conventional control system (b) New control system

Fig. 8 **Test Results from Differential Speed of Front and Rear Rollers during Transient Operation with Acceleration of ±4 m/s².**

The test results are shown. This is result of the front and rear roller constant-speed control where (a) Conventional control system and (b) New control system is applied.

method, the speed difference between the front and rear rollers is smaller than with the conventional control method and the performance was improved.

5 Postscript

We believe that MEIDACS II, which is custom-made for each test application and continues to advance, will continue to be useful by keeping compatibility with various equipment and will be widely used as the requirements for automotive-related test equipment change.

Going forward, we will continue to provide products and services that meet the needs and expectations of our customers, including compliance with various regulations and performance requirements according to the intended use.

《Reference》

(1) UN Regulation No. 154 - Worldwide harmonized Light vehicles Test Procedure (WLTP), https://unece.org/transport/documents/2021/02/standards/un-regulation-no-154-worldwide-harmonized-light-vehicles-test (Reference: 2022.11.11)