EFFICIENT ANALYZATION OF DYNAMIC ELECTRIC VEHICLES APPLICATIONS FOR REAL ROAD TESTS AND TEST BENCHES

DEWETRON

THE MEASURABLE DIFFERENCE.

> Determination of efficiency and losses during real drive, test bench and charging

> State of the art recording of dynamic processes

> Portable and flexible battery powered Power Analyzer with data acquisition incl. sensor supply

> Synchronous calculation of all relevant input channels incl. several power groups for battery, inverter and multiple motor

> Synchronous sampling up to 10 MS/s/ch

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INTRODUCTION

Conventional cars have been tested for performance for many years. According the NEDC (New European Driving Cycle), standard driving cycle testing at the test bench since the 1980s (with a last modification in 1997) has included fuel economy and emission levels analysis of car engine systems.

The relationship between the test bed results to the results under real conditions are a weakness with this method of testing. Results from the NEDC test bench test are often far away from the results collected under real driving conditions. This problem is also common to other driving cycle testing like the 10-15 Mode in Japan or the FTP72 & FTP75 in USA.

The newly developed WLTP standard (Worldwide Harmonized Light Vehicle Test Procedure) is a more realistic procedure for the evaluation of conventional cars and future electric vehicles like the Hybrid, BEV (Battery Electric Vehicles), PHEV (Plug-In Hybrid Electric) and FCEV (Fuel Cell Electric Vehicles). WLTP is more dynamic and yields better results matching to on-road performance.

The primary differences between the NEDC and WLTP are the longer duration of 30 minutes per cycle, 23.3 km instead of 11 km distance, high speed of 131 km/h instead of 120 km/h, average speed between 34 km/h and 46.5 km/h, stationary reduced from 25% to 13.4%, a cold start and a higher acceleration and deceleration during the drive.

Additionally, the change from a 2-zone (City and Freeway) condition to a 4-zone (Low, Medium, High and Extra-High) test based on real driving values makes it more realistic and comparable.

But even more realistic is an on-road test under real conditions. These tests are becoming more and more important for evaluation during development, to increase efficiency and reduce costs . On-road testing offers a comprehensive view of the product that includes all parameters for battery management and autonomous driving as well as to evaluate the interaction of different tasks.

A comparison test at one of the latest EV model in China shows different values between test bench (WLTP) realroad (WLTP) and manufacturer datasheet (NEDC) according power consumption:

	Datasheet (NEDC)	Testbench (WLTP)	Realroad (WLTP)
kWh/100 km	15.3	16.2	18.5

Hybrid, BEV, PHEV and FCEV evaluation testing requires highly accurate measurement of all electrical and mechanical parameters, communication interfaces (e.g. CAN/CAN-FD and Automotive Ethernet) in combination with a precision Inertial Measurement Unit (IMU) with DGPS (Differential Global Positioning System). A processor unit with a Kalman filter is also used for the evaluation of Inertial sensors and GPS signals.

An example of some test parameters is shown in Figure 1.

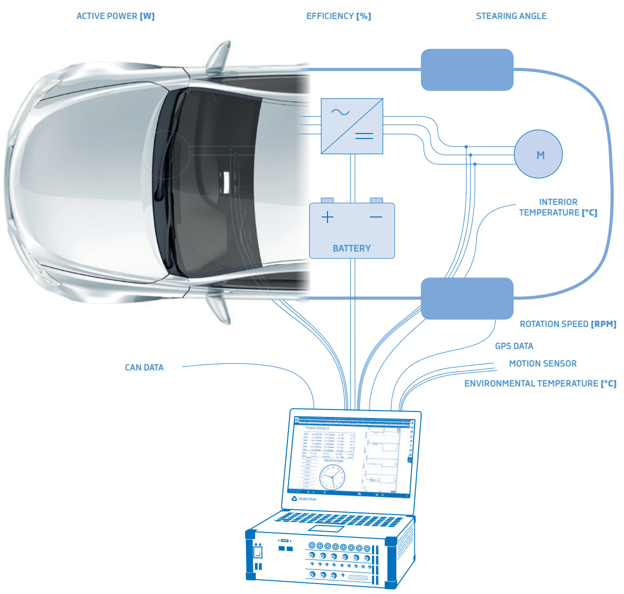

Figure 1: Example of an EV measurement configuration

CHALLENGES

1. To ensure accuracy, tests including power and energy are not allowed to source the measurement equipment from the vehicle in order to avoid an impact on the measurement values. Therefore, the measurement system must be equipped with an internal battery with minimal weight.

2. To avoid asynchronous data, wrong time stamps and hours of work processing the combinations of all data, with the risk of human errors, data for all parameters are recorded with one system.

3. To fulfill all needed measurement tasks, a suitable measurement system, which includes different analogue inputs for all input channels, is required. The measurement system needs a high count of measurement channels with individual sampling rates and resolution settings for every application.

4. Gapless recording of high sampled inputs is a key element, especially during the development process of the electrical drive train of a new vehicle. With an accurate measurement of all raw data (complete signal – every sample point stored on SSD), recorded data then serves a basis for further testing and helps to avoid repeating measurements again to correct post calculations of missing parameters.

5. Two of the most important elements in test bench and real road applications are the inverter and motor. Particularly, the exact frequency detection of the power parameters with filtered time correction. All software calculated parameters in power measurement are based on the previous frequency detection and are therefore the key to accuracy. Power analyzers with manual cut-off filters cannot guarantee the exact frequency for dynamic process. In combination with mechanical parameters it is absolute essential to have compensation for any filter delays, including the cut-off filter for the zero-crossing algorithm and any anti-aliasing filter for the analogue inputs.

6. Because of rapid acceleration and deceleration processes during the drive, the AC currents of the motor(s) are changing quickly so a measurement system with the capability of accurate periodic value calculations and not only the capability to calculate in different "update rates", (which means a calculation of a time window including more periods) is required.

7. In most measurements the integrity of the data recorded is significantly related to the sensors used. Inaccuracy in this part in the measurement chain has the biggest impact on the all over measurement result, with the exception of incorrect measurement settings. This impact is intensified by temperature and position changes and fast changing signals. So, very important for the electrical component of the efficiency analyzation, is the current sensor collecting accurate data. State of the art sensors based on the zero- flux principle must be used in power related application to avoid big phase shifts, wrong amplitude in AC measurement and high offsets caused by remanence in DC measurement at the HV-Battery.

Because of the high amount of energy and quality of dual-output accurate voltage supply, the challenge is the power supply to this sensor from the measurement system.

8. For the development and analyzation of inverters, specifically visualization and gapless recording of the over voltage peaks of the PWM signals for insulation and efficiency or for higher frequency testing, a high sampling rate is a big advantage. For this high-end task, including internal data transfer with hundreds of MB/s, the system requires a strong internal bus with high CPU power and state of the art measurement software.

TYPICAL MEASUREMENT CONFIGURATION AND SETUP

Depending on the application different sensors are used, but the core elements in most EV measuring are the electrical drive train, mechanical parameter and the IMU including GPS and parameters from the vehicle busses. The number of channels for the electrical component of the measurement is shown in Figure 2. This number of channels can increase by the number of motors or the number of phases of each motor (e.g. 6-phase permanent-magnet synchronous machine).

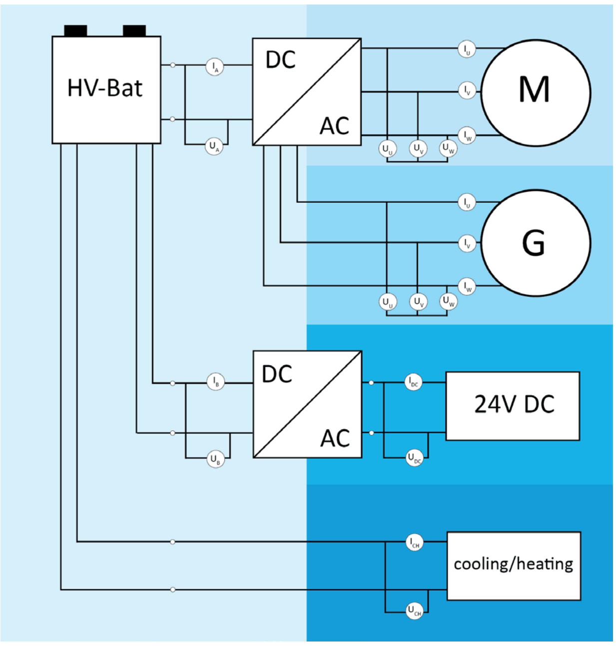

Figure 2: Electrical drive train

In Figure 3 the measuremnt system with IMU and GPS units on top of a EV is shown.

Figure 3: EV equipped with DEWETRON measurement all in one solution

The measurement system used for this example is a battery-based DAQ measurement system, DEWE2-A4, (Detail picture: Figure 4) with the capability to fulfill all requirements named in chapter II: “Main challenges for EV on-road tests”. The measurement system is used with a ADMA-IMU, from one of the markets established automotive systems and is fully integrated with Dewetron’s OXYGEN measurement software.

Figure 4: DEWE2-A4

For applications on test benches it is common to use a stationary system like a DEWE2-PA7 or a DEWE3-PA8 with an “all-in-one” test bench design and more input channels.

VISUALIZATION OF MEASURED DATA

An addition to the collection of highly accurate raw data in combination with calculated values (e.g. power parameter) is visualization and reporting. To have an overview during the drive it is essential to check the plausibility of the data during the test to avoid problems.

Figure 5 shows the actual velocity of a car with a standard WLTP cycle in the background as a comparison during the test (software visualization screen).

Figure 6 displays dual measurement screens, velocity and battery power in a recorder on top and a XY-Diagram with velocity in X and power in Y on the bottom, to show a direct relationship.

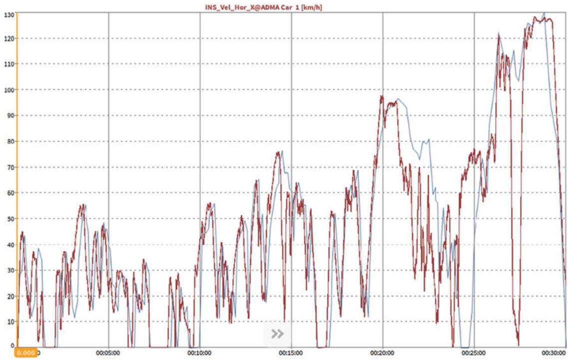

Figure 5: Velocity of a WLTP real road test with traffic

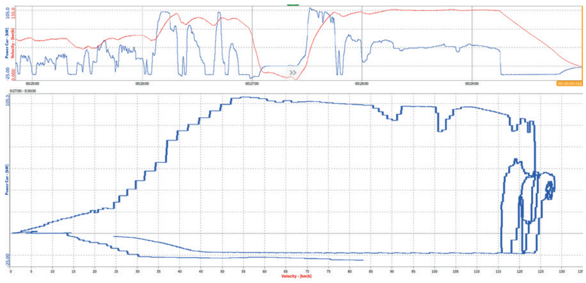

Figure 6: Power and Velocity in Recorder and in relation (XY-Diagram)

During post processing, not only analogue or bus data are needed. For comparison and further testing, an accurate tracking of position and weather conditions, including visualization, is prerequisite (Figure 7).

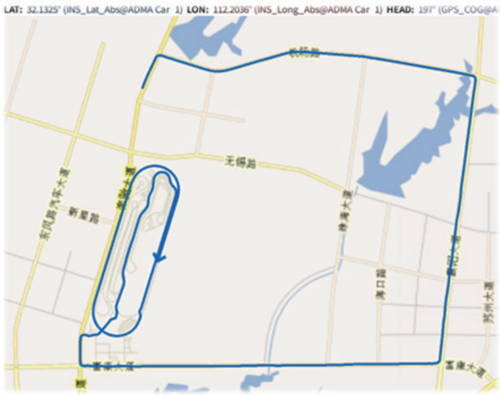

Figure 7: Positioning visualization in Oxygen Software

ADDITIONAL ON-DRIVE TESTING

For multiple car tests where comparison of on- and offline data are required, the Automotive feature of OXYGEN is performed. This feature is an online and offline tool for multi car testing and for future analyzation, including analyzation related to autonomous driving improvement.

Figure 8: Oxygen Automotive visualization

THE EXPERT

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Ing. David PFLANZL, BSc graduated from the University of Applied Sciences in Burgenland (Eastern Austria) in Energy and Environmental Management and is currently finishing the Master's Course in Sustainable Energy Systems. Prior working at DEWETRON he was employed as a high voltage test field Engineer at a well-known Manufacturer of electrical hydro and turbo generators. Now he is working as an Application Engineer and Technical Sales in the field of Power Analysis, Power Quality, E-Mobility, General Test and Measurement and Sustainable Energy Systems for DEWETRON since 2013.

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