Safe Drop Test Measurements for HV Electric Vehicle Batteries

HV Measurement of Sensor Voltages

In the development of modern electric vehicles, tests on high-voltage subsystems and components must be continuously adapted and extended to new standards. The following example shows how accelerations inside and outside a high-voltage battery pack are measured during a drop test to verify vehicle safety. CSM measurement technology offers a simple solution because a subsystem with both high- and low-voltage components can be measured synchronously with a single measurement system utilizing high sampling and data rates.

Background

The use of high-voltage components in modern electric vehicles poses new challenges for automobile manufacturers and Tier 1 suppliers: High-voltage components must undergo a variety of tests to ensure the safety of occupants in every situation and over the entire life cycle of the vehicle. A complex variety of international standards must be met for specific markets. For example, a drop test for the high-voltage battery in electric vehicles is often prescribed, although the test conditions vary regionally (Tab. 1).

Region	International		USA			Korea	China
Standard	SAE J2464	SAE J2929	UL 2580	USABC	FreedomCAR	KMVSS 18-3 Annex 1-48	QC/T 743
Drop Height (m)	2	≥ 1	1	10	≥ 10	4.9	1.5
Surface	Flat Surface		Concrete	Cylindrical steel object		Concrete	Wood
Battery Charge Level (in %)	95 - 100		Maximum Charge Level	100		80	100

Tab. 1: Comparison of the conditions for a battery drop test in international standards

This use case explains how a battery pack is drop-tested according to the Korean requirement "Korea Motor Vehicle Safety Standard" (KMVSS). Tests for other markets are similar, see Fig. 1. The KMVSS stipulates that the battery pack (with a charge level of 80 %) must be dropped onto a concrete floor from a height of 4.90 meters (KMVSS Annex 1 - Part 48).

The test is part of a series of tests designed to ensure that the battery will not explode or catch fire in certain situations. Without successfully passing this test it is not possible to sell electric vehicles with this battery in Korea.

Challenge

When performing this drop test, the acceleration is measured at various points inside and outside the high-voltage battery pack. Inside the pack, accelerometer data must be determined in a high-voltage-safe manner and acquired synchronously with other accelerometers mounted on the outside of the pack housing. Without a high-voltage-safe measurement system, any instrumentation inside the battery pack could become conductive and cause severe damage to data acquisition equipment or possibly endanger life. Furthermore, the measurement must be carried out with a high sampling rate in order to record the dynamics of the forces occurring at impact.

The CSM Measurement Solution
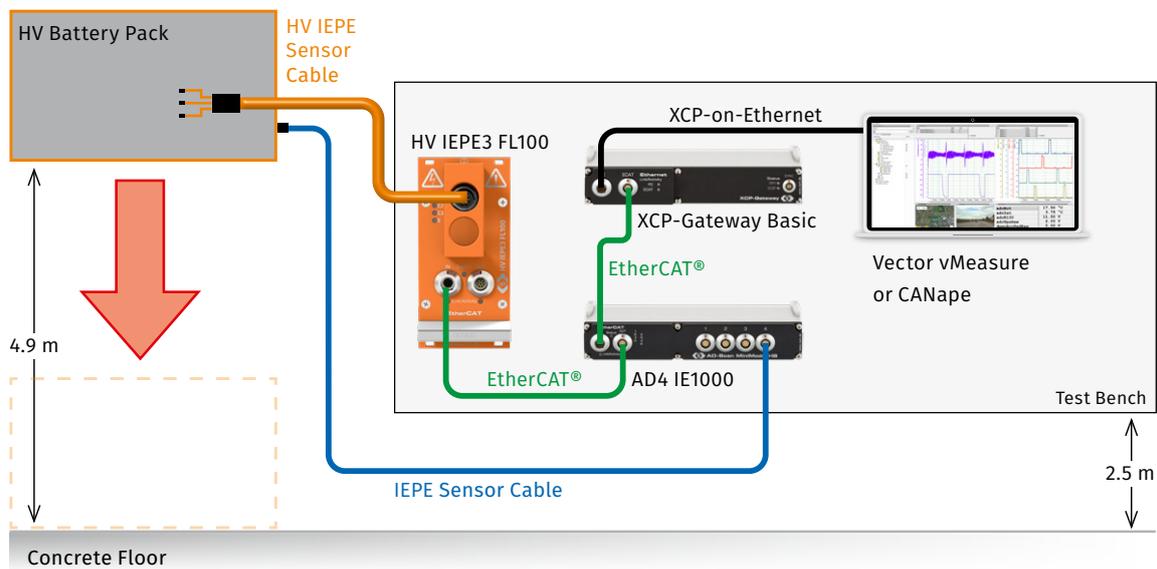
All measurement modules are placed at half the drop height to optimize the length of the signal cables and in order to minimize signal interferences.

Acceleration measurement within the pack: Using standard commercial off-the-shelf accelerometers, a specially designed, HV-safe sensor cable is inserted into the battery pack via cable glands for high-voltage-safe isolation of the sensors. Within the battery pack, three commercially available uniaxial accelerometers are connected to the sensor cable via a tiny adapter box.

Accelerometer data from within the battery is recorded with the CSM **HV IEPE 3 FL100** high-voltage measurement module. This measurement module was specially developed for the use of IEPE sensors in HV environments and records data from the accelerometers with up to 100 kHz data rate per channel.

Acceleration measurement outside the pack: The data from other accelerometers mounted on the battery pack housing is collected with the CSM **AD4 ECAT IE100** measurement module. This module records the data of the accelerometers with up to 100 kHz data rate per channel.

An **XCP-Gateway** ensures the high-precision synchronization of the two measurement modules by means of the Distributed Clock method integrated in the Ethernet standard. Thus, the synchronous acquisition of all measured values from both inside and outside the battery pack is achieved. The Gateway is also the interface to the data acquisition software by converting the signals from EtherCAT® bus to the XCP-on-Ethernet standard.

Data acquisition and analysis are carried out with software from Vector Informatik, e.g. vMeasure exp or CANape, which allow simple integration of the CSM measurement modules during both the system configuration and data playback.
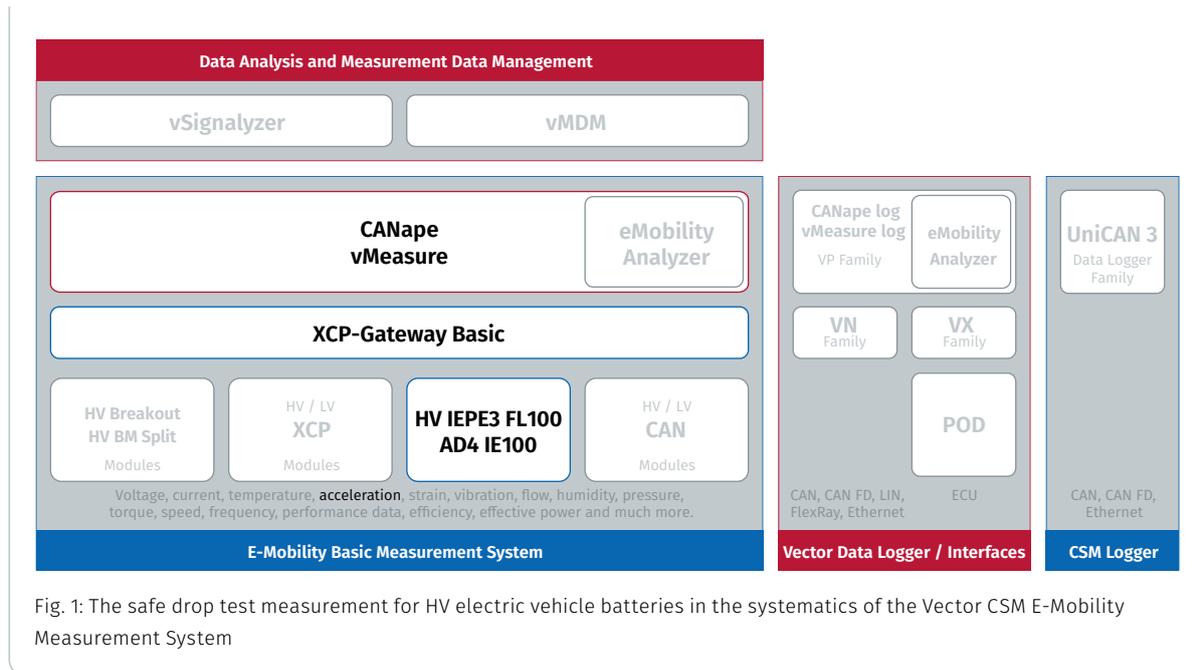
Data Analysis and Measurement Data Management	
vSignalyzer	vMDM

CANape vMeasure / eMobility Analyzer

XCP-Gateway Basic

| HV Breakout HV BM Split Modules | HV / LV XCP Modules | HV IEPE3 FL100 AD4 IE100 | HV / LV CAN Modules |

Voltage, current, temperature, **acceleration**, strain, vibration, flow, humidity, pressure, torque, speed, frequency, performance data, efficiency, effective power and much more.

E-Mobility Basic Measurement System

CANape log vMeasure log VP Family	eMobility Analyzer
VN Family	VX Family
POD	

CAN, CAN FD, LIN, FlexRay, Ethernet / ECU

Vector Data Logger / Interfaces

UniCAN 3 Data Logger Family

CAN, CAN FD, Ethernet

CSM Logger

Fig. 1: The safe drop test measurement for HV electric vehicle batteries in the systematics of the Vector CSM E-Mobility Measurement System

Benefits

With this Vector CSM measurement solution, the drop test can be performed according to the KMVSS specifications, or other similar regional requirements. Thanks to CSM's high-voltage measurement technology, the conditions within a high-voltage battery pack can now be measured safely during the drop test. The utilization of a single measurement system for capturing data simultaneously from both inside and outside the HV environment offers particular advantages. The measurement data is synchronized and at a high data rate to capture the acceleration dynamics of the drop test.

Featured Products

HV IEPE3 FL100

CSM's HV IEPE3 FL100 measurement module was specially designed for measurements with IEPE sensors, e.g. triaxial acceleration sensors, in a high-voltage environment. It offers three analog inputs with a modified sensor supply for the connection of IEPE sensors. Sensor cables such as the K960, designed for this module, enable the safe operation of standard sensors in HV environments.

AD4 ECAT MM Series - Type IE100

CSM's AD4 ECAT IE100 measurement module is ideally suited for the most accurate analysis of high-frequency signals with measurement data rates of up to 100 kHz per channel. It offers a high-precision and unipolar sensor excitation from 5 to 24 V DC for a variety of sensors, that is adjustable per channel.

XCP-Gateway Series

CSM's XCP-Gateway Series protocol converters were specially developed for CSM EtherCAT® measurement modules and for measurement tasks with multiple measurement channels and high measurement data rates. The XCP-Gateway is available in "Basic" and "pro" versions. The "pro" version has two CAN interfaces via which CAN-based CSM measurement modules can be connected and integrated into the XCP-on-Ethernet measurement data protocol. In the "pro" version, temperature data from the HV Breakout Modules can also be transferred directly via EtherCAT®.

Complete solutions from a single source:

CSM provides you with comprehensive complete packages consisting of measurement modules, sensors, connecting cables and software - customized to your individual needs.

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