

# Scienlab BMS Environment

SL1010A



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## Solution Overview

As an established energy storage test system manufacturer, Keysight has a sound knowledge of Battery Management Systems (BMS) and batteries. Based on many years of engineering experience, Scienlab created a testing solution which leaves nothing to be desired.

### SL1010A Scienlab BMS Environment

A BMS assumes important safety, control, and regulation functions. Those functions include monitoring parameters such as voltage, current, temperature, and state of charge (SOC). A BMS also regulates thermal management, energy management, cell balancing, and performance.

The modular system architecture enables individual compilation including ready-to-use cell-models. It also enables flexible control of the system. The emulators are implemented by standardized interfaces into hardware-in-the-loop (HiL) environments such as Vector or dSpace.

The SL1010A Scienlab BMS Environment from Keysight enables you to test and improve all the above-mentioned functions of the BMS during the BMS development. Instead of real cells, Scienlab Cell Emulators are connected to emulate various cell types including ready-to-use cell-models. The modular system architecture enables individual compilation and flexible control of the system. The emulators are implemented by standardized interfaces into HiL environments such as Vector or dSpace.

### Fields of application

- Reproducible testing and optimization of the BMS
- Emulation of individual cells as well as modules and packs at cell level
- Validation of all BMS development steps with respect to hardware and software
- Testing of newly developed algorithms (balancing, SOC, SOH)
- Testing of fault cases (over-temperature, over-voltage, etc.)
- Tests with passive and active balancing circuits (Inductive and capacitive)
- Verification of measuring accuracy in various operating situations
- Validation of end products

### Scienlab BMS Environment – Hardware-in-the-loop solution



Emulator fronts of the Scienlab BMS Environment.

## System architecture

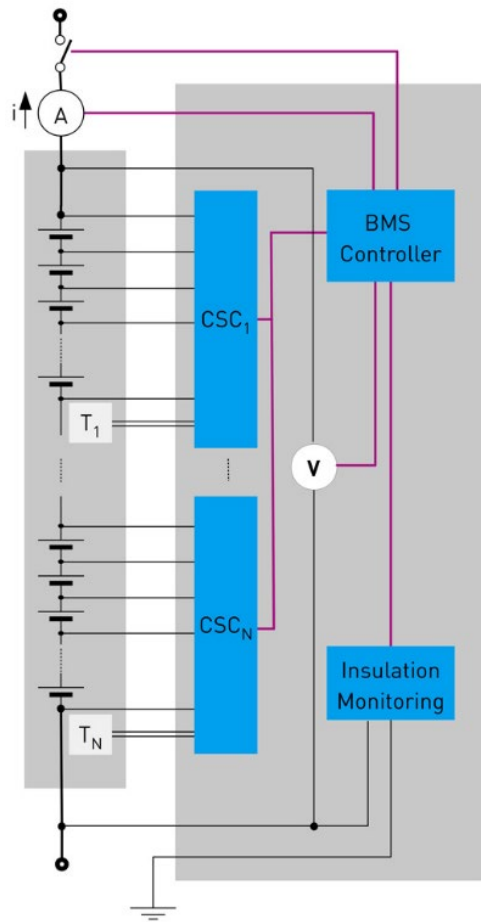


Figure 1. Battery and BMS.

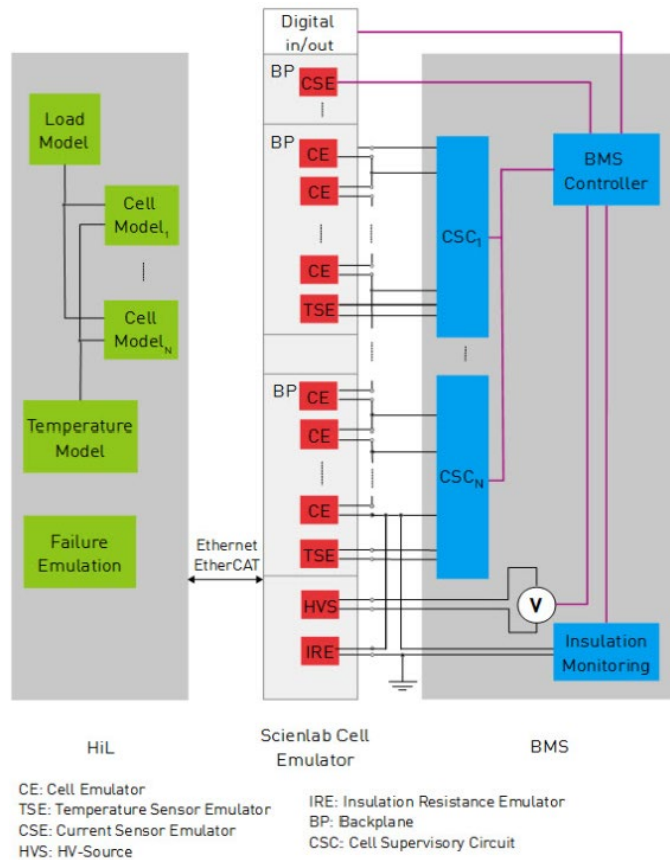


Figure 2. BMS Environment.

## Delivered documentation

BMS Environment documentation:

- CE Declaration of conformity
- Operating instructions Scienlab BMS Environment
- Getting started Scienlab BMS Environment
- Circuit diagram
- Acceptance and calibration report
- Documentation of the Simulink Battery-HiL-Model
- Documentation of graphical user interface (GUI)

## System Options

### Cell emulator (CE) channels

#### SL1010A-803 Cell emulator ( $\pm 5$ A)

One cell emulator plug-in card includes two channels of two independent cell emulators. The dielectric strength of both channels each other, to protective earth (PE) and to another plug-in card is 1 kV. The amount of in series connectable channels is limited only by the sum of single cell voltages ( $< 1$  kV). The range of output voltages covers typical battery voltages and is prepared for new operation fields like cells with high voltage materials.

The cell emulators have analog class AB amplifiers and allow a continuous and interruption-free transition between source and sink operation. To minimize internal power losses, the analogue amplifier positive and negative operation voltages are variable and operating depending on the output voltage.

Description	SL1010A-803
Voltage	0 to 8 V
Current (parallel operation)	$\pm 5$ A ( $\pm 10$ A)
Power (parallel operation)	$\pm 40$ W ( $\pm 80$ W)
Electric strength	1 kV

Table 1. Output CE

Cell emulators feature a high precision measurement technique with traceable calibration and guarantees its measurement accuracy within the specific operating- and temperature range. The maximum control deviation is identical to the specified systematic error (that means, the setting accuracy and the measuring accuracy are identical). Keysight recommends annual calibration. Calibration and adjustment are possible without removing the system from its installation. All system channels are synchronized via the internal data-bus and all data logging and set-value outputs are synchronous.

By use of this measurement signal processes alias effects will be avoided by pulsed balance systems and charges of short-term current pulses will be correctly acquired, also.

Description	Measurement	Maximal systematic error	Resolution
Voltage (measured and set value)	0 to 8 V	$< \pm 0.2$ mV (offset), $\pm 0.01\%$ of measured value	64 bits (float)
Current measurement	$I \leq  5$ A	$< \pm 1$ mA (offset), $\pm 0.05\%$ of measured value	64 bits (float)
Charge measurement	$I \leq  5$ A	$< \pm 50$ $\mu$ C per 50 ms integration time, $\pm 0.05\%$ of measured value	64 bits (float)
Recommended re-calibration period	12 months		

Table 2. Measurement accuracy cell emulator

In addition to the current measurement, every cell emulator offers a positive and negative charge acquisition. This additional measured value to determine e.g. the state of charge (SOC).

The output stage has a signal rise- and fall-time of 20  $\mu\text{s}$  typical. The small signal bandwidth is typical 1 MHz. A high bandwidth is necessary to emulate high-frequency current-pulses of the active balance-circuitry a sufficient low internal resistance at the cells even at a higher frequency range. Output stages with a lower bandwidth are not able to react on current load changes fast enough, this would result dynamic voltage errors.

A rise-time of set-point changes is achieved in the software by connecting a  $dU/dt$  limiter. By this parametrization, you can choose different compromises between rise-time and over-swing.

Voltage step	Chosen $dU/dt$	Rise/fall time	Overswing	Setting time
0 to 8 V	8 V/ms	800 $\mu\text{s}$	< 1 mV	< 1 ms
8 to 0 V	8 V/ms	800 $\mu\text{s}$	< 1 mV	< 1 ms
3 to 5 V	Maximum	< 80 $\mu\text{s}$	< 1 V	< 1 ms
5 to 3 V	Maximum	< 80 $\mu\text{s}$	< 1 V	< 1 ms

Table 3. Output dynamic cell emulator

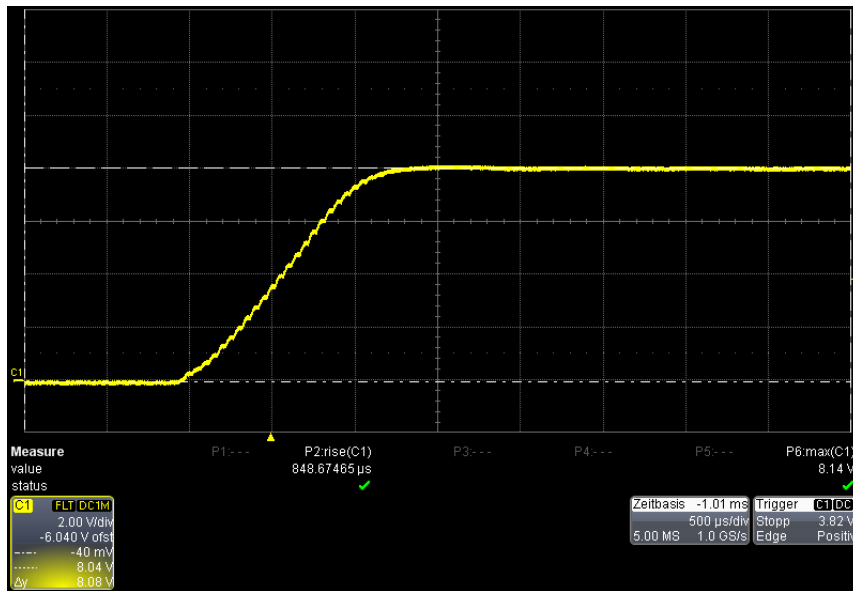


Figure 3. Voltage step from 0 to 8 V (850  $\mu\text{s}$  set) 0 incl. output filter.

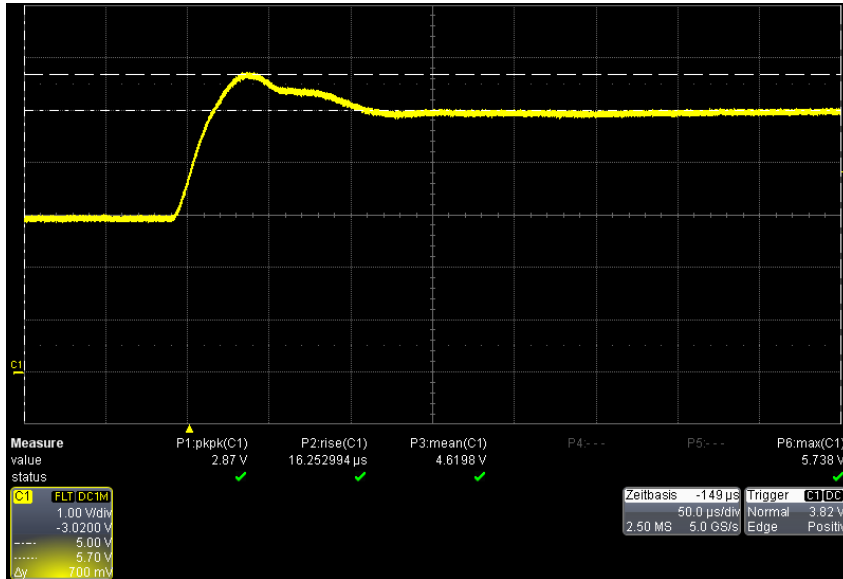


Figure 4. Voltage step from 3 to 5 V (max) incl. output filter.

Residual ripples and noise are low in the analog output stage. Table 4 shows the interfering voltages at the output of the impedance filter (input of BMS) at a measurement bandwidth (-3 dB) of 1 MHz. It is valid over the entire operating range of the cell emulator in voltage mode.

Description	Specification
Effective values	Typical 160 μV
Peak-to-peak value	Typical 1.06 mV

Table 4. Interference voltage of the cell emulator

### Integrated failure emulation (cell emulator)

- Open circuit
- Short circuit
- Reverse polarity (effective output voltage  $\pm 8$  V)
- Over-/under-voltage

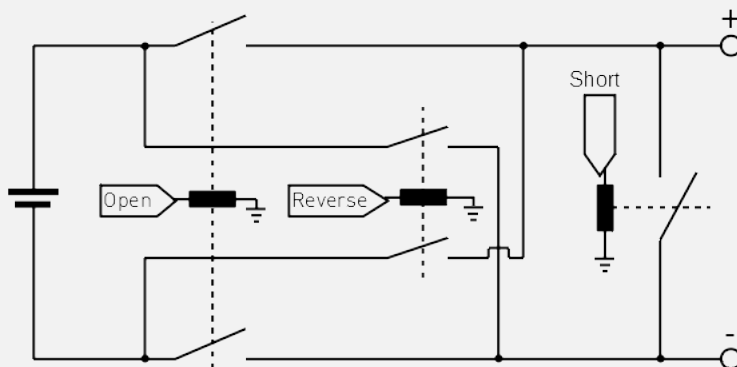


Figure 5. Schematic of the on-board cell emulator failure emulation.



## Cell emulator options

### SL1010A-401 Current measurement extension

For currents lower than  $\pm 10$  mA, the measurement accuracy can be extended.

Description	Measurement	Maximal systematic error	Resolution
Voltage measurement	0 to 8 V	$< \pm 0.2$ mV (offset), $\pm 0.01\%$ of measured value	64 bits (float)
Current measurement (Optional SL1010A-401)	$I \leq  10$ mA	$< \pm 2$ $\mu$ A (offset), $\pm 0.05\%$ of measured value	64 bits (float)
Current measurement	$I \leq  5$ A	$< \pm 1$ mA (offset), $\pm 0.05\%$ of measured value	64 bits (float)
Charge measurement (Optional SL1010A-401)	$I \leq  10$ mA	$< \pm 100$ nC per 50 ms integration time, $\pm 0.05\%$ of measured value	64 bits (float)
Charge measurement	$I \leq  5$ A	$< \pm 50$ $\mu$ C per 50 ms integration time, $\pm 0.05\%$ of measured value	64 bits (float)

Table 5. Measurement accuracy cell emulator

### SL1010A-102 Output filter for impedance compensation

For each cell emulator plug-in-card, output filters are installed on a profile rail (e.g. in a testing cabinet). These passive filters allow an acquisition of current and charge even with high frequency changes at the output (such as active balancing).

The current/charge must not be absorbed in a current sink, otherwise the measurement of current (amperes) and charge (coulombs) is wrong and the SOC cannot be calculated. The filter compensates for the cable inductance in the system wiring and allows emulation of the cell terminal voltage with the correct cell-impedance at the filter output. This enables a cable length between cell-emulator and filter of up to 8 m. The top-hat rail filters are 1 cm wide per channel. This allows for a short, direct wiring of BMS modules beneath the top-hat rail.



Output filter

## Temperature sensor emulator channels

The Scienlab Temperature Sensor Emulator (TSE) emulates cell temperatures by setting a voltage proportional to a temperature sensor output voltage.

It is designed as a compatible plug-in-card to the cell emulator. Each plug-in-card includes four TSE channels, isolated against each other and to other system components up to an electric strength of 1 kV. Each channel is capable to emulate typical temperature sensors like PT100, PT1000 and NTC (10k, 100k). To compensate long feed lines and its resistance, a resistance measurement (4-wire) is used.

SL1010A-201 Temperature sensor PT100 – including cables and calibration

SL1010A-202 Temperature sensor PT1000 – including cables and calibration

SL1010A-203 Temperature sensor NTC 10 k $\Omega$  – including cables and calibration

SL1010A-204 Temperature sensor NTC 100 k $\Omega$  – including cables and calibration

Description		Specification	Step Width [ $\Omega$ ]
SL1010A-201 PT100 (etc.)	Setting range 1	0 to 5 k $\Omega$ (others on request)	0.076 $\Omega$
	Accuracy	$\pm 0.1\%$ of set value	
SL1010A-202 PT1000	Setting range 2	800 $\Omega$ to 112 k $\Omega$	0.076 $\Omega$
	Accuracy	$\pm 1\%$ of the set value	
SL1010A-203 NTC 10K (etc.)	Setting range 3	500 $\Omega$ to 475 k $\Omega$	8.39 $\Omega$
	Accuracy	$\pm 1\%$ of set value	
SL1010A-204 NTC 100K (etc.)	Setting range 4	2.6 k $\Omega$ to 3.5 M $\Omega$	53.3 $\Omega$
	Accuracy	$\pm 1\%$ of set value	
Cycle time		< 1 ms	
Electric strength		1 kV	

Table 6. Specifications of the temperature sensor emulator

### Integrated failure emulation:

- Open circuit
- Short circuit (0  $\Omega$ )

**Note:** Resistive sensors will be connected to a series resistor ( $R_V$ ) and a reference voltage ( $U_{ref}$ ) typically. The TSE can be connected in the same way. The limits and accuracies are described below.

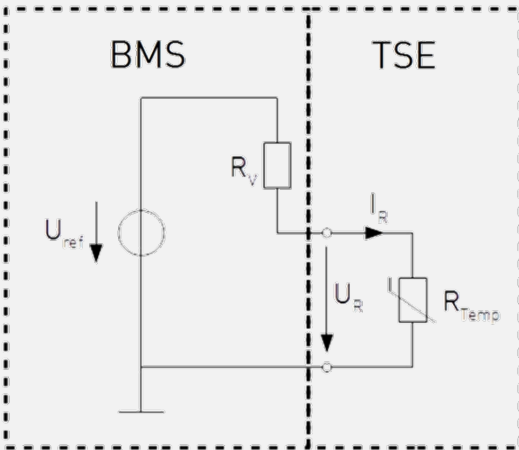


Figure 6. Equivalent circuit diagram.

Voltage and current at the emulated sensor must not exceed the two following values:

$$|I_R| \leq I_{R,max}$$

, with  $I_{R,max} = \frac{500 V}{R_{Temp,max}}$

$R_{Temp,max}$  describes the maximum value of the TSE depending on the setting range.

Different sensor ranges can be selected by the DIP switch on the circuit board (see section performing initial commissioning).

Emulated sensor	$R_{Temp,max}$	$I_{R,max}$
e.g. PT100	4.99 k $\Omega$	100 mA
--	112 k $\Omega$	4.46 mA
e.g. NTC (10 K)	475 k $\Omega$	1.05 mA
--	550 k $\Omega$	909 $\mu$ A
e.g. NTC (100 K)	3.5 M $\Omega$	143 $\mu$ A

Table 7. Sensor range and output current limits

The accuracy of the schematic of the TSE depends upon the measurement current of the temperature sensor input of the BMS. For the calibration process of the TSE three operating points are determined. Each of these three operating points triggers a different schematic accuracy error. The accuracy of the TSE is a combination of these three errors. If these three errors are within the tolerance range the accuracy ( $\pm 1\%$  of the Resistance set point) of the TSE is ensured.

The accuracy of the schematic of the TSE is put together by the following three errors:

1. Input offset current ( $I_0$ )
2. Output offset voltage ( $U_0$ )
3. Gradient failure/gain error ( $F_R$ )

The accuracy of the TSE depends on the schematic of the BMS and the operating point. The deviation of the target value  $R$  and the real value  $R^l$  can be calculated with the following formula.

$$R^l = \frac{R \cdot (1 + F_R) \cdot (U_{ref} + I_0 \cdot R_V) + U_0 \cdot R_V}{U_{ref} - I_0 \cdot R \cdot (1 + F_R) - U_0}$$

If the three described errors ( $I_0$ ,  $U_0$  and  $F_R$ ) are not exceeding the limits shown in Table 8, the accuracy shown in Table 6 will be guaranteed. The measured values of  $I_0$ ,  $U_0$  and  $F_R$  of each TSE channel will be recorded in the calibration protocol which is part of the delivery scope of the Scienlab BMS Environment.

Error	Maximum limit
Input offset current ( $I_0$ )	+6.066 x 10 <sup>-10</sup> A
Output offset voltage ( $U_0$ )	+1 mV
Gradient failure/gain error ( $F_R$ )	±287.4 mV

Table 8. TSE error limits for  $I_0$ ,  $U_0$  and  $F_R$

## Current sensor emulation (CSE)

The current sensor emulator emulates the charge- and discharge current of the battery pack by setting a voltage referring to the output voltage of a shunt- or hall sensor.

The current sensor emulator is designed as a compatible plug-in-card to the cell emulator. Up to four front ends for shunt or hall sensors can be connected. All channels are isolated against each other and to other system components up to an electric strength of 1 kV.

SL1010A-301 Shunt emulator incl. cable

SL1010A-302 Hall emulator incl. cable

Description		Specification
SL1010A-301 Shunt	Setting range	±200 mV (offset) (others on request: ±100 to 500 mV)
	Positioning accuracy	±20 µV (offset) ±0.1% of set-point
SL1010A-302 Hall	Setting range	±5 V
	Positioning accuracy	±500 µV (offset) ±0.1% of set-point
Cycle time		< 1 ms

Table 9. Output current sensor emulator (shunt and hall)

### Integrated failure emulation:

- Open circuit (via external. HiL control)
- Maximum channels selectable between shunt and hall emulators are 96

## Insulation Resistance Emulator (IRE)

### SL1010A-IRE Insulation Resistance Emulator

The Insulation Resistance Emulator allows an emulation of insulation errors at battery pack voltages for R<sub>ISO</sub> tests. It can be chosen if a battery positive or negative pole insulation resistance must be emulated to PE.

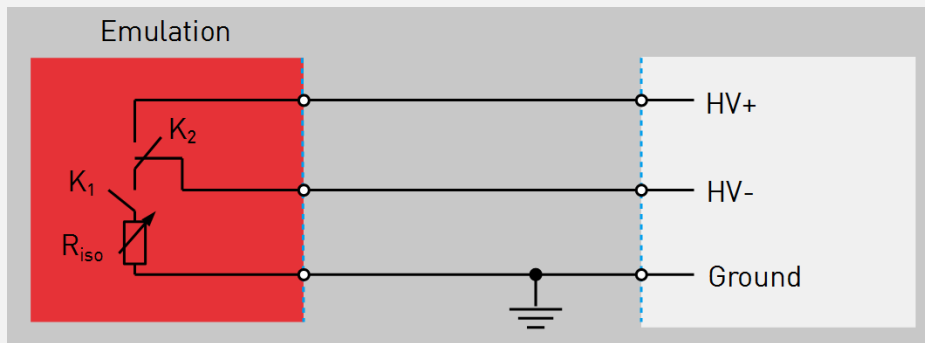


Figure 7. Schematic of the Insulation Resistance Emulator.

### Approach:

1. Select between HV+/Ground or HV-/Ground (K<sub>2</sub>).
2. Choose insulation resistance value R<sub>iso</sub>.
3. Closing relay K<sub>1</sub> to initiate test case.

Description	Specification
Setting range of R <sub>iso</sub>	1 kΩ to 100 MΩ
Positioning accuracy 1	1% @ 1 kΩ to 1 MΩ
Positioning accuracy 2	2% @ 1 MΩ to 100 MΩ
Cycle time	< 1 s
Dielectric strength	1.25 kV
Max. current	32 mA

Table 10. Specifications of IRE

## HV source

### SL1010A-HV2 HV source (1000 V)

Controllable high voltage sources can be used to emulate the DC link of the battery. A BMS has typically 2 HV measurements. The first one is the sum of the series connection of all cells. The other one is located after the output relay, at the connection to e.g. inverter.



Source: FuG

- Type: FuG MCP 140-1250
- Voltage range 1 to 1000 V
- Current range: 0 to 100 mA
- Voltage accuracy:  $\pm 0.04\%$  full scale
- Ethernet interface
- 19" 3 U rack model
- Maximum quantity allowed = 4

## Cabinet options

### Safety

- Following safety requirements are given for the entire system
- System limits to protect specimen (DC-voltage, DC-current) parametrizable
- Self-protected cell-emulators will switch off in event of fault
- Over-temperature protection
- Emergency stop
- Door contact switch
- Emergency stop input for e.g. lab emergency stop
- Designed for durability operation and long lifetime

### Interface

- Gbit/s Ethernet interface (including a Gigabit Ethernet-switch)
- 1 kHz (1 ms cycle time) TCP/IP update ratio at a dedicated multipoint-communication with a Gigabit-Ethernet capable HIL-system

### Electricity feed-in

- 3, N, PE; 400 V (+10%/-5%); 50 Hz ( $\pm 0.2$  Hz); pre-fuse (provided on-site) 16 or 32 A gG (depending on system size)
- 10 m supply cable (via cabinet's roof) with CEE-plug

### Dimensions

- Dimensions (W x D x H) mm: see Table 11 (displayed height is without cooling unit and rollers)
- Rollers (approx. 8 cm high)
- Cooling units (removeable): Height 0.45 m
- Emulator cables: 4 m each

Cabinet option	Dimensions (W x D x H) mm
SL1010A-702	800 x 800 x 1200
SL1010A-706	800 x 800 x 2000
SL1010A-713	1600 x 800 x 2000
SL1010A-720	2400 x 800 x 2000
SL1010A-727	3200 x 800 x 2000

Table 11. Dimensions of each cabinet option

### Device under test (DUT) test environment

#### Integrated testing area

- Comfortable possibility to set up BMS (Battery Management Controller (BMC) and Cell Supervising Circuit (CSC)) into the test environment
- Integrated in emulator cabinet
- Incl. cabling between emulators and testing cabinet
- Top-hat rails as transition points for all emulators
- Easy cabling between emulator outputs and BMS
- Exchangeable board for various BMS
- Door contact for emergency stop



Example of a BMS Environment with test area (red)

	SL1010A-D01 (120 channels)	SL1010A-D02 (240 channels)
Dimensions (DxWxH)	400 x 400 x 800 mm	400 x 400 x 1400 mm

Table 12. Dimensions of the integrated test area



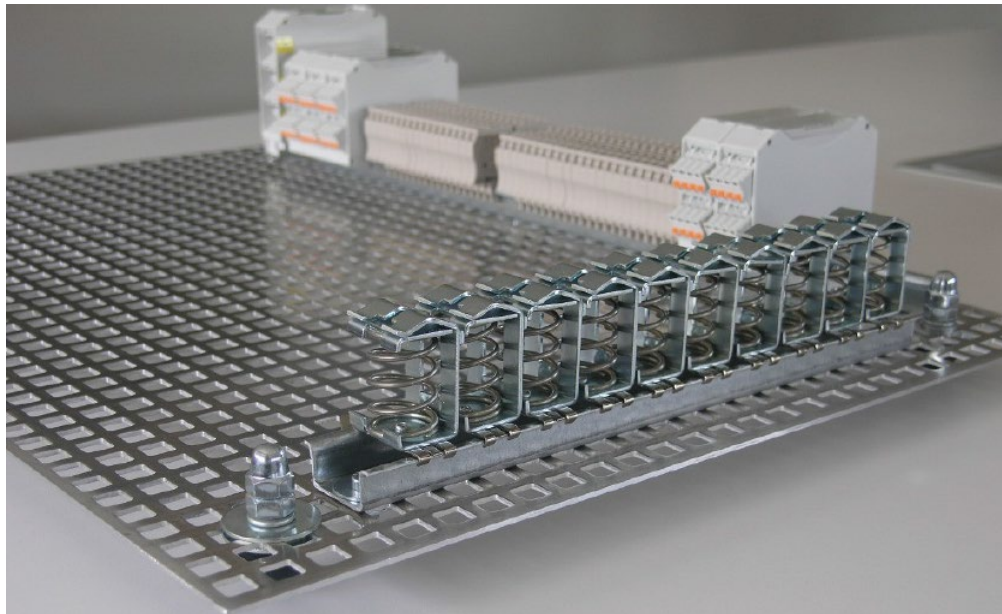
SL1010A-D01 Compact integrated testing area for DUT – supports up to 120 channels

SL1010A-D02 Large integrated testing area for DUT – supports up to 240 channels

SL1010A-D05 Small testing board - supports up to 60 channels

### External testing board

This option offers an external testing board for connection between the BMS to the emulator outputs. A grounded plate includes all the clamps of the selected components and output filters (if selected).



Example of external BMS testing board

SL1010A-D05 (60 channels)	
Dimensions (WxD)	400 x 600 mm

Table 13. Dimensions of the external BMS testing board

## Software Information

During the development and verification of a BMS it is necessary to test all interfaces and features of the DUT to ensure correct operation. Thus, it is possible to ensure efficient and safe operation of a battery with a final product. For fast and safe testing, it is of advantage to emulate the component that is connected with the BMS while testing.

At the analogue interfaces of the BMS, components such as cells and sensors must be emulated.

Therefore, Keysight emulators of the BMS environment are utilized. A BMS has even more interfaces that are necessary for the operation of a battery, such as communication, control- and measurement signals and imitation of the electrical system.

Besides the emulators, Keysight offers a HiL solution for the Scienlab BMS Environment. Keysight is working together with Vector Informatik and dSpace.

The HiL-system accomplishes the following tasks:

- Modelling of the Scienlab BMS Environment
- Calculation of all target values on the basis of a model
- Control of Scienlab Emulator
- Control of HiL-components (in-/outputs, CAN, etc...)
- Control of test bench components
- Implementation of automated test sequences

Keysight's Scienlab PowerHiL BMS Environment is controlled by a state-of-the-art real-time system. The powerful real-time PC calculates up to more than 100 cell models simultaneously in real-time with a sample rate of 1 kHz. The real-time system offers CAN interfaces for simulation of several devices.

The user interface for the Scienlab BMS Environment offers the possibility to control all emulators, I/O's and communication interfaces manually. It also offers access to the signals, measured by the HiL system and to the model. Because of the large number of variables, signals and set-point values, it is possible to automate tests.

### Signal measurement generation

Many BMS contain digital, PWM and analog in- and outputs for functions like:

- Control of output relays
- Cooling system
- Activation
- Fan speed feedback
- Fault feedback
- Heating system
- Activation
- Temperature feedback
- Fault feedback
- Interlock
- Approval to the charger

### Communication

The real-time system offers CAN interfaces which can be used for the simulation of e.g.:

- Vehicle CAN bus
- Charger CAN bus
- Debug CAN interface (for development)
- Measurement of communication between real components
- Manipulation of the communication between bus participants (man-in-middle)

**Note 1:** This option contains only the basic communication interfaces without a residual bus simulation.

**Note 2:** Some BMS units use SPI or Iso SPI for communication between BMC and CSC modules. If required, Keysight can provide a specific offer for the integration.

## Software engineering

The Scienlab BMS Environment offers fast, flexible and reproducible tests of battery management systems (BMS) by emulating the behavior of cells, sensors and communications.

For testing the different functions of a BMS, the cell emulators have to react like real cells. For different steps of the development, cell models with different levels of complexity will be needed. After the development of BMS and battery test systems, Keysight used this knowledge to create extensive models to emulate the behavior of cells and other components of a battery pack.

To parametrize the cell models with the correct parameters, procedures to measure and characterize cells are necessary. Beside the identification of the parameters for the model, these procedures bring up necessary values for the parametrization of the BMS (cell limits, SOC estimate, etc.).

Finally, a real-time hardware will be needed to calculate the cell models during the BMS tests.

## Battery Model

The basic battery model is part of the delivery scope and characterizes the behavior of a cell in one operating point. Furthermore, the open-circuit voltage is described as a result of the SOC cell model as a parametrizable Matlab/Simulink block or as a TwinCAT3 function block.

The model structure is shown in Figure 8. The values of all the cell model parameters can be change by the user on the graphical user interface or in an automated test case.

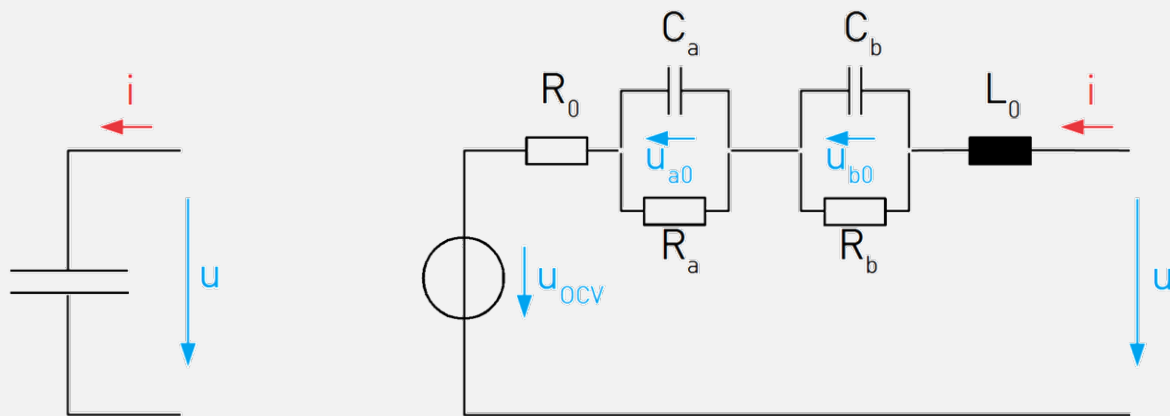


Figure 8. Structure of a cell (left) and a Li-Ion cell model (right).

Model-parameters (specified as constants):

- Open-Circuit Voltage  $U_{OCV}$  (SOC) [V]
- Internal resistance  $R_0$  [ $\Omega$ ]
- Internal impedance  $L_0$  [H]
- R-C elements ( $R_a$ ,  $R_b$  [ $\Omega$ ],  $C_a$ ,  $C_b$  [F])
- Initial voltages of the capacitors ( $U_{a0}$ ,  $U_{b0}$ , [V]);
- Description of the model
- Parametrization example

A block diagram of the model is shown in Figure 9.

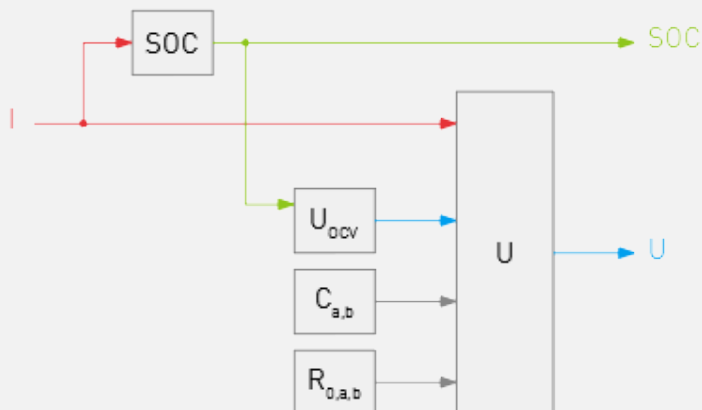


Figure 9. Basic cell model with constant parameters.

### Test automation

Because of the large number of variables, signals and set-point values, it is difficult to get reproducible results in manual operation mode. For this case, the real-time system comes with a test automation software.

The test automation tool enables the user to simplify test design by combining different programming languages and graphical notations in one integrated design environment, to define and reuse test cases for and across product lines by supporting parameters, electronic control unit (ECU) variants and test variants.

## SL1098A-XXX Hardware in the Loop (HiL) Options

Keysight is working with dSpace and Vector to offer you the best suitable option and configuration of the HiL for your Scienlab BMS Environment. The SL1098A-XXX HiL Options presented below are standard configurations which are adaptable to your specific customer needs and requirements.

Contact [bd.sl@keysight.com](mailto:bd.sl@keysight.com) to get more information.

## Scalexio – dSpace HiL BMS



Scalexio dSpace HiL

### Graphical user interface

The user interface for the Scienlab BMS Environment offers the possibility to control all emulators, I/O's and communication interfaces manually. It also offers access to the signals, measured by the HiL system and to the model.

The values of the Scienlab BMS Environment can be set before starting a test. (SOC, SOH, cell temperature, environment temperature, status of systems like cooling, heating, relays, etc.) These values will be the initial values of the model. By activating the system, these values will be shifted to the outputs of the BMS Environment. During the test, state changes can be fulfilled. Changes like a charging/ discharging current can be set and will be considered in the real-time model calculation, depending on the degree of complexity. The model output values will be shifted to the emulators etc. and will also be displayed as system state values on the user interface. Thereby the user has a continuous overview of the system state.

At the same time, specific measurement values can be chosen by the user and will be saved in a report file. This offers a subsequent analysis of the BMS reaction, caused by the behavior of the environment.

Furthermore, it is possible to emulate different kind of failures to investigate the desired reaction of the developed BMS. Beside typical operation points, it is very important to verify the BMS reaction in dangerous states.

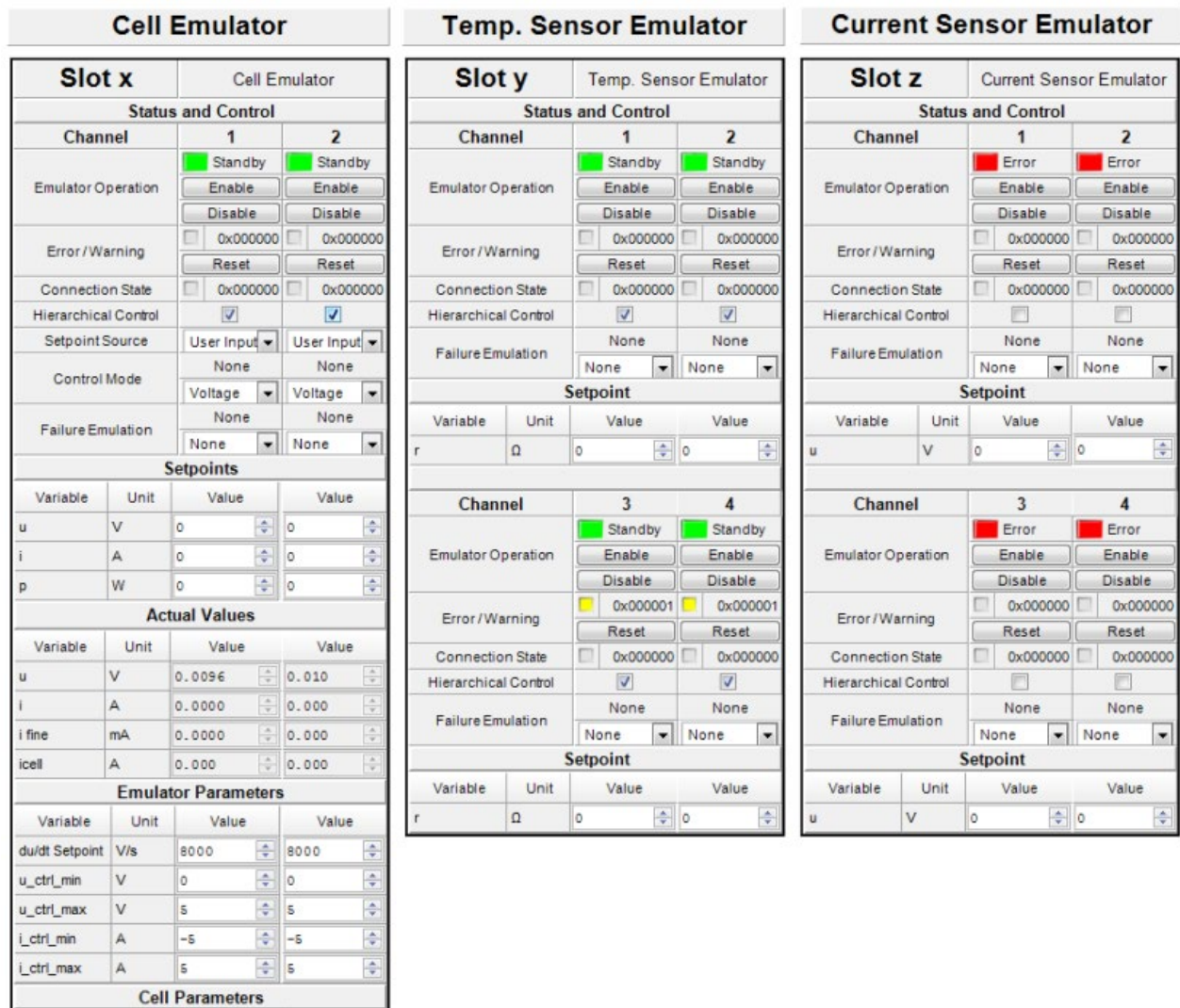


Figure 10. Example of ControlDesk graphical user interface.

**The delivered dSpace real-time system contains the following components:**

System cabinet and accessories	
The real-time system is mounted in a 19" cabinet.	<ul style="list-style-type: none"> <li>• 19" rack with nine height units</li> <li>• Roll able version on request (optional)</li> </ul>
1x optical IOCnet interface on back of the cabinet for extensions.	
1x Ethernet interface (1 Gbit/s) on back of cabinet.	
Host interface for communication with host-PC on back of cabinet.	
SCLX_RTTPC_RACK	SCALEXIO RT-PC Xeon E3-1275v3 with 4 Cores at 3.5 GHz, 4 IOCNET links, rack-mount version, 3 U
SCLX_POWER_SUP_GEN	TDK-Lambda Genesys power supply (60 V, 25 A).
SCLX_SLOT_UNIT_6S	6 Slot Unit for HighFlex boards



SCLX_UNIT_CARRIER	SCALEXIO Unit Carrier for DS2680
HSL_PATCH	Cable for connection of the real-time PC
6x HYPERTRONICS_CON90_CAB_QT	90 pins Hypertronics connectors
HYPERTRONICS_CRIMP	Crimp tool for Hypertronics connectors
HYPERTRONICS_EXTRACT	Extract tool for Hypertronics connectors
SCLX_CASTERS_STD	SCALEXIO Caster Wheels for standard rack
<b>Interface modules</b>	
<p><b>DS2680 (I/O Modul)</b></p> <ul style="list-style-type: none"> <li>• 20x Analog In 0 to 60 V, 16 bits</li> <li>• 30x Analog Out 1: 15x 0 to 10 V, 14 bits, 2x -10 to +10 V, 14 bits, 7x -20 to +20 V AC, 14 bits and 0 to 10 V, 14 bits current output 0.1 to 30mA</li> <li>• 30x Digital In 0 to 60 V</li> <li>• 28x Digital Out 0 to 60 V, 0.08 Arms</li> <li>• 18x Flexible In -6 to +6Arms, 16 bits current or 0 to 60 V digital voltage measurement</li> <li>• 2x Load channels 300 mA</li> <li>• 1x Power Control channel for control of low voltage power supply unit</li> <li>• 6x Power switches 0 to 60 V, 0 to 24 Arms</li> <li>• 12x Resistance simulation channels 15.8 <math>\Omega</math> to 1 M<math>\Omega</math>, <math>\pm</math>80 mA</li> </ul>	
<p><b>DS2671 – HighFlex CAN Interface Board with 4 CAN channels</b></p> <ul style="list-style-type: none"> <li>• 4 multifunctional bus channels</li> <li>• Highspeed CAN and CAN FD: ISO 11898-2, ISO 11898-1:2015, ISO 11898-3, non-ISO CAN FD</li> <li>• FlexRay</li> <li>• LIN 2.0</li> <li>• K-line ISO 9141</li> <li>• RS232, RS422, RS485</li> <li>• TTL driver</li> </ul>	
<p><b>2x DS2601</b></p> <ul style="list-style-type: none"> <li>• 10 galvanic isolated channels for signal measurement on each board</li> <li>• Load connections for plugging loads of up to 2 W on the board</li> <li>• External load connection (for real loads or substitute loads &gt;2 W)</li> <li>• Up to 10 channels connected in parallel to increase the continuous current to max. 80 A</li> <li>• Status LED for overall board status</li> <li>• 10 channel-specific LEDs to indicate channel voltage</li> </ul>	
<p><b>Real-time PC</b></p> <p>The PowerHiL testbench will be controlled by a SCALEXIO real-time PC from dSPACE with the following configuration:</p> <ul style="list-style-type: none"> <li>• Intel Xeon E3-1275v3 Multiprocessor system</li> <li>• 4 GB RAM</li> <li>• Optical IOCnet interface board DS</li> </ul>	

Software license	
PLATFORM_API	Platform API Package with USB dongle
FAILURE_SIM	Failure Simulation Package
RTICANMM_BS	RTI CAN Multimessage Blockset
CFD_I_200	ConfigurationDesk Implementation Version for 200 I/O channels
AUD_BASIC	AutomationDesk Basic Version
CONTROLDESK CONTROLDESK_BNV	ControlDesk Bus Navigator Module with USB dongle
SCLX_FS_200	SCALEXIO Failure Simulation for 200 Functions
Ethernet Solution	
Power source TDK Lambda	

General vector configurations



Example of Vector Hardware

User input

The operation of the BMS Environment can be applied with the controlling software on a computer. Besides manual set point settings, automated test procedures are possible. The user interface of the BMS Environment offers the opportunity to control the emulators I/O's and communication interfaces manually. Moreover, it offers the access to the HiL-system measured signals as well as to the model.

Figure 11 and 12 show the CANoe graphical user interface.



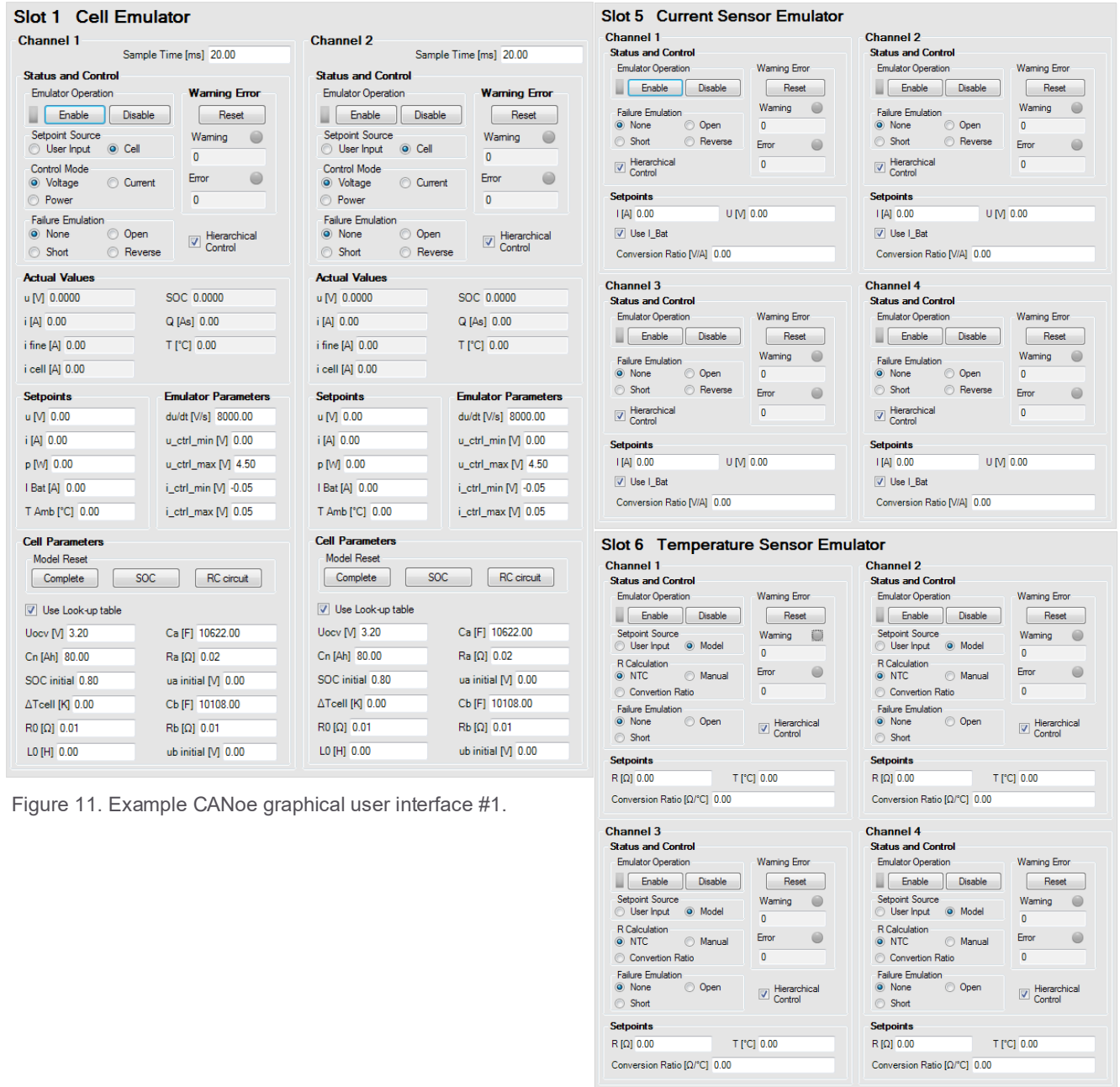


Figure 11. Example CANoe graphical user interface #1.

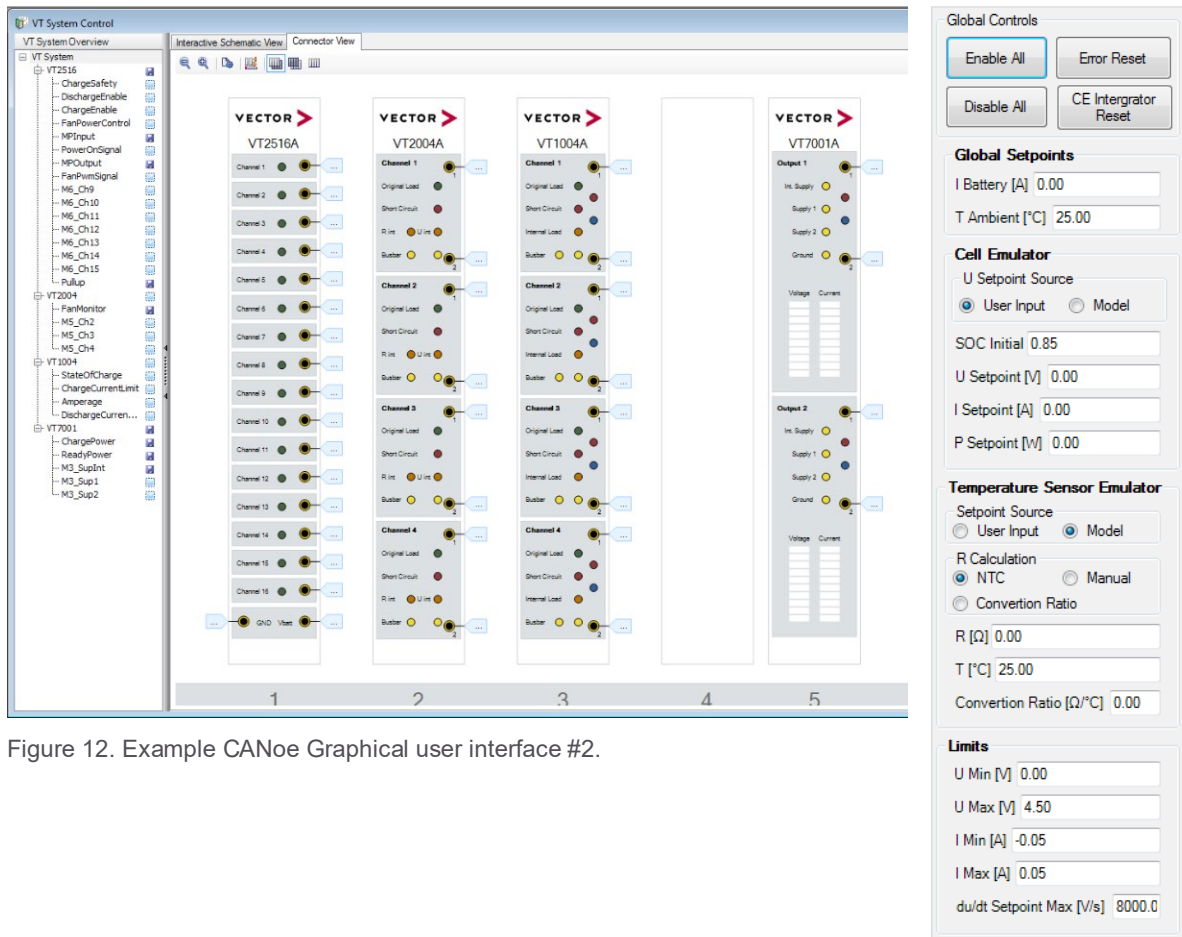


Figure 12. Example CANoe Graphical user interface #2.

The values of the BMS Environment can be defined before start (SOC, cell temperature, ambient temperature, status of the systems for example cooling, heating, relay). These values are used as initial values for the model. By activating the system, these values are transmitted to the outputs of the BMS Environment. While testing, more status changes can be made. Modifications such as charging/ discharging can be specified in the real time model measurement by consideration of the degree of complexity. The initial values of the model are transferred to the emulators and displayed in the user interface as status values. Thereby the user has a continuously overview of the system status. At the same time, measurement values that are chosen by the user can be saved in a report file. Thus, subsequent analysis of the BMW reaction by environmental impact are possible.

Furthermore, it is possible to emulate several cases of faults to evaluate the desired reactions of the developed BMS. Besides the analysis of typical working points, it is also important to analyze the reaction of a BMS in critical working points.

## **Software license CANoe**

Software-tool for preparation and implementation of (restbus-) simulation (CAN-bus), for communication analysis and for testing of control units in distributed systems.

- Version 11.0
- Delivery without data carriers
- Option Ethernet activated
- Licensing technology hardware based
- License type: standard license
- Interface to EXAM

## **Service**

- CANoe-RT-PC assembly, configuration (95293)

## **Provided documentation**

- BMS Environment – Getting Started
- Documentation of Simulink HiL-models
- Documentation of the GUI
- Manual for the embedding of own battery models
- Description of the Scienlab specific Ethernet Protocol (SLEP).

## **Vector Configuration A - RT-PC without VT-System**

### **Hardware**

- Rack-IPC 19" E3-1275 ATC236E (99935)
- Vector Keyman (05080) (USB Dongle)
- VN7572 (07112) (FlexRay network interface)
- Vncable D62Y9 (05088)
- External Network Card

### **Software**

- CANoe License
- CANoe Option Ethernet License

## **Cabling from HiL I/Os to integrated testing area**

Wiring of all the the I/Os of the VT System to the integrated testing area. Comfortable possibility to set up BMS (BMC and CSC) into the test environment.

## Rack Integration

The 19" Real Time PC is mounted into the BMS Environment Cabinet. Including communication and power supply cables.

## Vector Configuration B - RT-PC including VT System and I/Os

The Vector VT System is a modular test hardware to connect the communication networks and the I/O interfaces to the test system.

### Hardware

- Rack-IPC 19" E3-1275 ATC236E (99935)
- Vector Keyman (05080)
- 19" Subtrack VT System (29065)
- ATX power supply Silent 500 W (100 to 240 V,  $\pm 10\%$ )
- 2 case fan
- CPU Intel XEON E3-1275v5 -32 GB DDR4 Ram ECC (2x 16 GB)
- Graphic VGA, DVI-D, DisplayPort
- 1x VT8012 (Backplane of the VT system with 12 slots for VT-module)
- 1x VT2516A (Digital module of the VT systems for 16 digitally used control units in- and outlets)
- 1x VT7001A (Power supply for DUT)
- 1x VTC8920 (200 W, 12 Volt-power supply VT-module for installation in the VT system)
- 1x 2004A (4x analog multifunctional I/Os)
- 1x VT6204 (network module: CAN, Flexray; Lin)
- 1x (System Desktop Case)
- Connection of two monitors (1920 x 1200) via DVI and DisplayPort or one monitor with 4 k resolution (3840 x 2160)
- 2x Gigabit Ethernet, 2x USB 2.0 front, 3x USB 3.0 back, 1x PCIeX16 (X8 signal), 10x PCIeX16 (X4 signal)
- SSD 240 GB
- At CANoe RT: Windows 7 embedded 64 bits
- At IPC: Windows 7 Ultimate or Windows 10

### Software

- CANoe License
- CANoe Option Ethernet License

## Cabling from HiL I/Os to Integrated Testing Area

Wiring of all the the I/Os of the VT System and the VT Modules/Cards to the integrated testing area. Comfortable possibility to set up BMS (BMC and CSC) into the test environment.

## Rack Integration

The 19" Real Time PC and the 19" VT System are mounted into the BMS Environment Cabinet. Including communication and power supply cables.

## Future Channel Extension

The future channel extension enables you to expand the number of cell emulators, temperature sensor emulators and current sensor emulators.

- SL1010A-851 Future Cell Emulator Channel Extension
- SL1010A-852 Future Temperature Sensor Emulator Channel Extension
- SL1010A-853 Future Current Sensor Emulator Channel Extension

## System Cooling Selection

Cooling option	Article number	Inlet/ outlet	Description
SL1010A-K01 Air cooling with fan – 2.5 kW	SK 3209.XXX	1/2 "	Air/water heat exchangers roof-mounted
SL1010A-K02 Air cooling with fan – 4 kW	SK 3210.XXX	1/2 "	Air/water heat exchangers roof-mounted
SL1010A-K03 Air cooling with compressor – 2 kW	SK 3385.XXX	-	Cabinet cooling per air-air-heat exchanger TopTherm roof-mounted cooling units 'Blue eye'
SL1010A-K04 Air cooling with compressor – 3.8 kW	SK 3387.XXX	-	Cabinet cooling per air-air-heat exchanger TopTherm roof-mounted cooling units 'Blue eye'

Table 14. Cooling options

## Project Management, Consulting and Installation Services

Service features depend on the facilities, customer expertise, and overall scope of the project. For that reason, it is not possible to give exact service efforts without knowing the customer's requirements and goals. Keysight offers the following services to secure a successful project execution and reduce ramp-up time for our customers.

### PS-XPM-100-SL Project management services

Keysight recommends Project management services for each test bench project. By ordering the Project management services, an experienced project manager is dedicated to your project and acts as a direct communication interface from Keysight to the customer's project management team. The project manager takes over the responsibility:

- To develop and manage the project plan
- To track project progress and milestones
- Communication project status regularly and ensure any unscheduled project events or project deviations are communicated and promptly discussed with the customer project team
- To provide complete and accurate project documentation to the customer.

### PS-XINS-100-SL Project installation services

These services provide installation expertise to manage, deliver and coordinate local facilities installation for the test bench. Specific installation efforts depend on the customer's individual facility, the locally available power and cooling and the test bench being delivered.

### PS-XENG-100-SL Project engineering services

Project engineering services provide specialized engineering services during project development and implementation. The customer's project team will have access to engineering expertise to aid in various tasks specific to their project including but not limited to – safety matrix and test bench guard, facilities and lab layout, special power requirements, etc.

### PS-XCOM-100-SL Project commissioning services

Project commissioning services for the test solution provide an experienced test bench engineer to validate and complete the test bench setup in readiness for the customer's initial usage. It includes validating specific hardware and software configurations per the project requirements and any specific consulting agreed to beforehand, given the test bench's customer-specific usage.

## HS0003A-103 DUT Residual Bus Simulation

In order to work with the test bench directly after delivery, send the Device Under Test (DUT) to Keysight. The DUT is integrated into the test bench and is commissioned together with the BMS Environment. It includes:

- Residual CAN bus simulation of the customer DUT
- Integration of an existing CAN .dbc-file in test-bench Simulink model
- Integration of the DUT Parameters into the graphical user interface
- Commissioning of the Test Bench including the DUT at Keysight Bochum

**Note:** The .dbc-file has to be available to Keysight engineers six weeks prior to the commissioning at Keysight.

## HS0002A-102 Remote Support Service

Keysight offers the Remote Support Service to support, consult and train the customer's operation personnel. Remote Support Service is executed via remote (phone/internet). It includes:

- Customer DUT Issues and Test Case Consulting
- Direct access to an experienced system specialist via phone/internet.
- Support for failure analysis and trouble shoot
- Software and programming support and consulting for Test Cases
- 1 package = 1 day (8 hours)

## HS0004A-100 Staff Training

Staff Training is made up of:

- Software Training (depends on which HiL was chosen)
- dSPACE: ConfigurationDesk (SCALEXIO Hardware introduction, hardware resource assignment)
- Vector: CANoe (VT-System, hardware resource assignment)
  - Matlab model, CAN-Bus configuration

After the Staff training the participants will be able to:

- Control the BMS Environment
- Write and implement test cases
- Implement changes to the battery model
- Observe and analyze measured data

**Note:** The Staff training is for maximal of four people and a duration of two days. The training will take place on customer site (on request)

Learn more at: [www.keysight.com](http://www.keysight.com)

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: [www.keysight.com/find/contactus](http://www.keysight.com/find/contactus)

