DATA SHEET

Scienlab Test Bench Guard

SL1070A

KEYSIGHT TECHNOLOGIES

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General Information

Scienlab's Test Bench Guard (TBG) is an essential safety feature for operating battery test stands. It monitors the system to supervise the status and actions of the test stand. A safety programmable logic controller (PLC) is the backbone of the system. The TBG can be divided into two main safety features:

- **Active** safety features react in order to prevent hazard events:
    - Integrated sensors (e.g. Current-, Voltage-, Gas-, etc.) in the Scienlab Test Systems and the Test Chamber detect threshold limit violations or error states.
    - A reaction matrix with basic safety features guarantees testing under preset conditions as determined by the customer
    - A redundant measurement system works independent from the tester for significant values such as current, voltage and DUT temperature.

- **Passive** safety features react to minimize the effects of hazardous events:
    - Integration of external safety features such as sprinkle water/mist, N2 inertization, and building fire alarm control of 3rd Party components

The logical connection and trigger rules of these active and passive safety features are defined in the **Safety Matrix**. This Matrix is defined in cooperation with the customer during the project. Keysight recommends a **Risk and Hazzard Analysis** which forms the base of the safety concept and the Safety Matrix. Combinations of active and passive safety features fulfill demands on different Hazard-Levels.

Figure 1 shows a TBG system diagram. PLC "satellites" are installed in the Keysight Battery Test System and in the Test Chamber. Test Chamber Satellites connect to the Chamber's signal in- and outputs (I/Os) and facility's signal in- and outputs Other satellites connect to the internal signals of the Battery Test System.

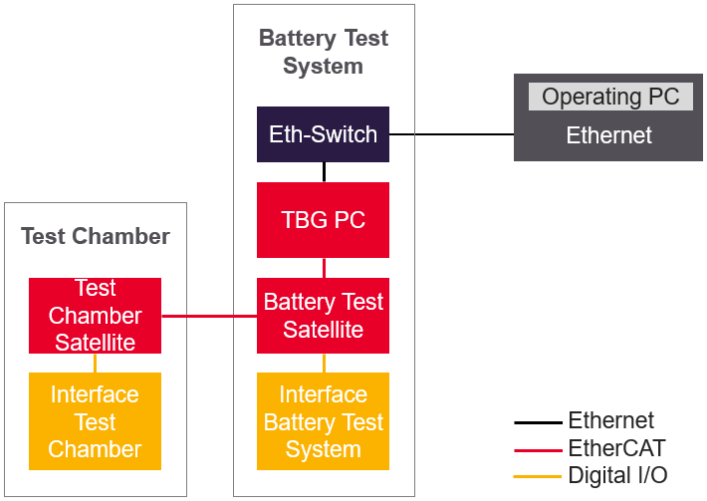

Figure 1 Schematic representation of the Scienlab Test Bench Guard

SL1070A Test Bench Guard

Operating Computer for Test Bench Guard (TBG)

- Beckhoff Industrial PC integrated in battery test system

Software

- TwinCAT Soft-PLC
- Test Bench Guard Control Software:
    - Visualization of the state and values of the signals
    - User:
        - Sets limits
        - Acknowledges errors
        - Sets a signal filter time
        - Disables/enables specific signals
        - Saves and loads presets
    - Requirements: Windows operating system

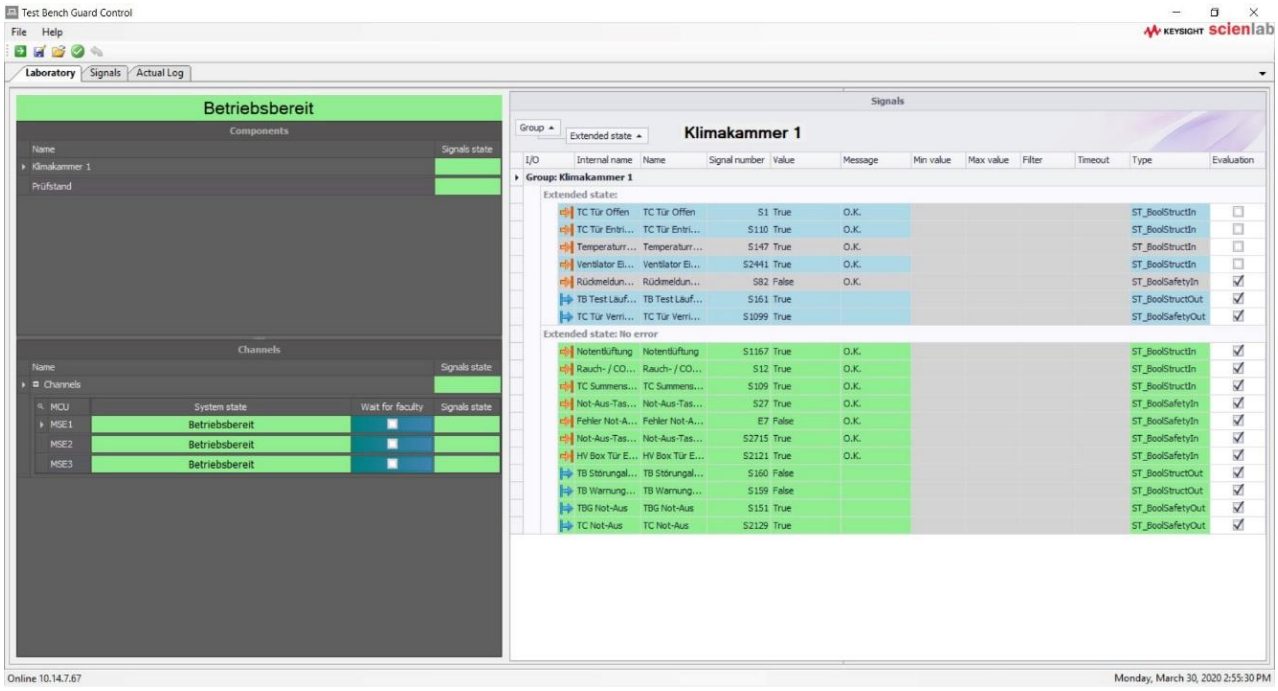

Figure 2 Screenshot of Scienlab Test Bench Guard Control

Safety

Twin safe terminals and Twin safe-PLC to ensure reliable operation of the TBG

- Connects to other TBG components by real-time capable EtherCAT bus system
- Supports up to performance level E according to DIN EN ISO 13849
- Cut-out scenarios are defined by the safety matrix
- Inclusion and parametrization of analogue switch-off criteria is possible as well as CAN messages
- Signal inputs include:
    - Climate chamber door closed (safety input signal)
    - Associated feedback signal for function monitoring
- Signal outputs inlcude:
    - Close output contactor channel x (safety output signal)

Battery Test System Satellite

The Test Chamber Satellite collects signals or measurements related to the chamber and enables communication between the Scienlab Battery Test System and Test Bench Guard.

- EtherCat Bus
- Monitoring of the power stage MCU (Measurement and Control Unit) status
- Signal inputs e.g.:
    - Status of output contactors
    - Status power amplifier
    - MCU switch-off limit
- Signal outputs e.g.:
    - TBG-release for output contactors
    - Shutdown MCU
- Physically integrated into Battery Test System Cabinet
- Power supply through Battery Test System

Emergency Stop Integration

The Emergency Stop button on the Battery Test System (and other test stands) shuts down the system in case of an emergency. In a test stand, it is important that other components also react to those emergency shutdown actions. Integrated signals include the following:

- Signal inputs
    - Status of emergency stop button (safety input signal)
    - Status emergency stop test chamber (safety input signal)
    - Status emergency stop button laboratory operated (safety input signal)
    - Status emergency stop relay Battery Test System
    - Status emergency stop relay test chamber
- Signal outputs
    - Emergency signal TBG to Battery Test System (safety output signal)
    - Emergency stop TBG to test chamber (safety output signal)
    - Emergency stop TBG to building (safety output signal)
    - Associated feedback signals

Safety matrix

Together with Test Bench Guard, hardware a PLC logic must be implemented. This logic is called Safety Matrix and runs on the internal industrial PC (IPC) of the Test Bench Guard. This Matrix determines how input and output signals are connected to understand test parameter changes. Because of the individual requirements and safety concepts, Safety Matrices are tailored to the customer’s hazard and risk analysis.

Figure 3 shows a sample of the safety matrix. It depicts the connection between the input signal on the left hand side and the output signal at the top.

Safety Matrix

Variant

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Legend:
X, X1 = Signal triggers when the input condition is fulfilled
X (y) = Signal triggers after y ms when the input condition is fulfilled
X1 has priority over X

Yellow Color: Safety signal, assigned to yellow terminals
Grey Color: Standard signal, assigned to grey terminals

Group			Group	Battery Test System (BT)			Test Chamber	Laboratory				
			Component name	SL1000A 1000V, 600A, 360 kW								
			Secondary language output signal description	Fast stop channel1 TBG to BT	Hardware release power stage 1	Software release Ch.1	Emergency Stop Ch. 1 TBG to TC	External emergency stop from TBG	TBG operating signal	Output contactor Ch. 1 closed	Fire alarm test area	Signal lamp
Group	**Component name**	**Secondary language input signal description**	**Trigger condition**	low	low	low	low	low	low	high	high	high
Battery Test System (BT)	SL1000A 1000V 600A 360 kW	Fast stop button at BT pressed	low	X	X	X		X				
		Error in relay S37	true	X	X	X		X				
		Error in relay S2	true	X	X	X						
		CAN_PC_Ch1_StCodeMSE	true		X (500)	X						
		Isolation fault channel 1	low		X (500)	X						
		Common alarm channel 1	low		X (500)							
		Limit value violation Channel 1	low		X (500)							
		Output contactor ch.1 closed	high							X		
Test Chamber	TBG Satelite	Door open	low		X							
		CO-Concentration limit value exceeded (pre-alarm)	low		X (500)	X						X
		O2-Concentration limit value exceeded (pre-alarm)	low									
		H2-Concentration limit value exceeded (pre-alarm)	low		X	X						
		Central Fast stop EXTERNAL	low	X	X	X		X				
		Error in Relay S151	true	X	X	X		X				
		Building fire alarm	high	X	X	X		X			X	

Battery Test System (Internal Signals)	SL1000A 1000V 600A 360 kW	Feedback contact of relay S37
		Feedback contact of relay S2
TBG internal Signals	TBG Satelite	Feedback contact of relay S1126

Figure 3 Extract of a safety matrix

Remark: The Safety Matrix is defined in cooperation with the customer during the project. To ensure a smooth project and adhere the scheduled delivery date (SSD) the approved Safety Matrix has to be available to Keysight 5 weeks in advance of SSD. As the approved Safety Matrix is an important milestone in each project a delay may affect the date of delivery.

General Options

SL1070A-204 Integration into Central Building Control System

This option enables the communication to customer's high-level laboratory monitoring system. For example, it could activate a fire alarm or start ventilation over an open pressure relief flap.

- Standard Signal outputs
    - Status of TBG (safety output two phase signal)

Note: Requires SL1070A-108 Test Chamber Satellite (if not available clarification needed).

SL1070A-101 Manual Parallel Connection

Enables parallel connections of multiple channels to raise channel current – connection is manual. This option increases test flexibility and gives customers the power to balance the parameter higher test capacity and higher current as needed from case to case.

- Support for manual parallel connections up to the number of Battery Test channels supported by the TBG
- Monitoring the current and voltage limit values of the respective master channel, if the redundant measurement is used while in parallel operation
- Sum formation of the individual channel values with regards of the redundant measurement is calculated for the correct monitoring of the current limits while in parallel operation

Note: Requires option SL1079-CM1 Manual Parallel Connection in Battery Test System.

SL1070A-102 Automatic Parallel Connection

Enables parallel connection of multiple channels to raise channel current – connection is automatic via control program Energy Storage Discover (ESD).

- Detection of the automatic parallel connection of two channels in one Battery Test Bench
- Automatic adjustment of current and voltage limits for redundant measurements to parallel operation values
- Automatic totals of the individual channel values of the redundant measurements for the correct monitoring of the current limits in parallel operation
- Signal inputs
    - Relay status of channels

Note: Requires option SL1079-CM2 Automatic Parallel Connection in Battery Test System. Not available for the cell tester SL1007A.

SL1070A-103 /-104 /-105 Redundant Current and Voltage Measurements

Safety feature adding independent measurement hardware and software for current and voltage measurement.

- Increases failsafe testing
- Programmable reaction to safety limits overshoots
- Integration of redundant output current and voltage measurements of a battery test channel into the TBG
- Integration of redundant measurements unit via CAN communication
- Parameterization of limit values, filter times and timeout times
- Timeout monitoring

Note: Requires option SL1079A-BP1/CM3 redundant current/voltage measurement in Battery Test System.

SL1070A-106 Integration of BMS-CAN

Safety feature enabling communication between Battery Management System (BMS) of battery and TBG. The BMS supervises the battery and provides specific battery data including safety limits. Reaction to overshoots to those limits can be programmed.

- Integration of the DUT BMS-CAN
- One CAN connection with up to 116 messages per DUT
- Parameterization of limit values, filter times and timeout times
- Timeout monitoring

Note: Requires additional unit like SL1064B for CAN communication and SL1079-BP2/CM4 BMS CAN connection in Battery Test System. Not available for cell test systems.

SL1070A-107 Redundant Temperature Measurements

Safety feature adding independent measurement hardware and software for temperature measurement.

- Increases failsafe testing
- Programmable reaction to safety limit overshoots
- Monitor central temperature in climate chamber or battery surface temperature
- Prepared for connection of PT100 RTD Temperature sensors (not included), up to one per channel
- Detection of the resistance value via two-wire measurement
- Parameterization of limit values and filter times is possible

Note: Requires Option SL1070A-108 Test Chamber Satellite. Not available for the cell tester SL1007A.

Chamber Related Options

Depending on the safety concept, different sensors and safety features in or on the test chamber are necessary. The following options describe the interface to the Test Bench Guard. Each test chamber needs the matching interface and/or hardware to perform the required safety feature.

SL1070A-108 Test Chamber Satellite

The Test Chamber Satellite collects signals or measurements related to the chamber and enables the communication between test chamber and TBG.

- EtherCAT Bus
- Standard input signals:
    - Status of chamber door (safety input signal)
    - Status of chamber

SL1070A-201 Gas Sensor(s) (e.g. CO or H_2)

Enables the integration of a gas sensor placed in a test chamber. Gas sensors are normally used to detect a hazardous event of a battery. For example, a rise of CO concentration inside the chamber can indicate a fire and a rise of H_2 concentration can indicate a failure of the structural integrity of a battery and an outgassing of cell chemicals. Depending on the safety concept and cell chemistry different sensors could be used. Normally those sensors have different thresholds to have a more adequate reaction to concentration changes.

- Input signals:
    - Gas concentration exceed main alarm level (safety input signal)
    - Gas concentration exceed pre alarm level
    - Status of sensor

Note: Chamber needs to be equipped with appropriated sensor(s).

SL1070A-202 Inerting

Availability of oxygen is a crucial component if a sparking event ignites into a fire. Therefore, suppression of oxygen concentration in the air surrounding the battery below ignition limits can be an effective way to prevent a hazardous fire. Testing would only be allowed when the O_2 concentration is below a set limit. To monitor the concentration an O_2 a sensor is needed. This sensor uses two different thresholds to have a more adequate reaction to concentration changes. This sensor is available with or without Safety Integrity Level (SIL).

- Input signals:
    - O_2 concentration in chamber (main alarm and safety input signal)
    - Inerting switched off (safety input signal)
    - O_2 concentration in chamber (pre-alarm)
    - N_2 gas warning system device in chamber fault
    - N_2 pressure and flow monitoring

Note: Chamber must be equipped with O_2 sensor and Inerting option. N_2 supply is not included in this option.

SL1070A-203 Rupture Disk

Some test chamber manufacturers provide a Rupture Disk in the top of the chamber. This plate is designed to break if the pressure inside the chamber reaches a specific value. This pressure increase can indicate an event inside the chamber. This safety option analyses if the Rupture Disk is intact or broken.

- Input signals:
    - Status rupture disc

Note: Requires Option SL1070A-108 Test Chamber Satellite and the corresponding option in the Test Chamber. Depending on chamber manufacturer, a Rupture Disk might be replaced by an overpressure flap, which does not need a safety signal and therefore is not integrated in the TBG.