

KIT-Quench Detection System for Superconducting Coils and Current Leads

General Description:

The latest KIT - Quench Detection System **UNIQD Type 3450** (EU patent-registered) is an advanced device for operational supervision of superconducting components like magnets or current leads.



The detector is designed as a stand-alone safety device and is able to check two superconducting segments permanently by special differential measurement techniques.

One QD system (cabinet) consists of up to 128 programmable Quench Detection Units (QDU), an embedded PC for event / data logging and additional supervision of detectors (second level instance). The system is designed as scalable modular device to a maximum amount of 512 groups / cabinets (= up to 65536 detectors).

The QDU offers an analogue input realised as a bridge front end with several limiting functions to high voltages. A special filter design is used for noise reduction. Adjustable sensing polarities and a 0% to 100% balancing feature of inputs enable reliable and specific detection of Quench conditions. The QDU screens and checks the differential voltages of the superconductors permanently. In case of a quench it triggers the discharge of the coils directly. The detectors onboard memory offers a high-resolution recording of the quench signals with adjustable pre- and post-running (ring-buffer).

Each QDU transfers stored signal-data via serial interface RS-485 (optically isolated) to the data acquisition unit. This unit (embedded industrial PC) also serves as a supervisor to all attached QDUs.

The electronic design of the QDU allows operation under high voltage levels to ground of up to 5 kV RMS (1 minute).

Frontend and outputs of the QDU are very well isolated and strictly separated by an intergrated optical isolation.

A thermally balanced and calibrated input network allows the setting of low thresholds in spite of high input voltage tolerance.



Some characteristics of the KIT-Quench Detection Unit / System:

- Extra Low Power FPGA-design for a maximum of flexibility
- Stand-alone operation by on-board parameter storage
- Dual-channel communication
- Reconfigurable without dismounting (remote update of FPGA-configuration)
- Digital controlled analogue signal processing, filtering and noise suppression; (adaptive) digital signal processing upgradeable without dismounting
- Event-controlled system (rated response time)
- Internal detector-redundancy (duplex detector)
- Adjustable check for broken wires of quench detection cables / connectors
- Rugged long-life and fail-safe design / extensive internal self diagnostics
- 10 seconds on-board quench event recording (sampling rate 100kS/s, 12 Bit res.) / adjustable quench event pre-/ postrecording
- All parameters (e.g. RC-filter time-constants, thresholds, balancing etc.) are digitally adjustable by remote commands / keywords
- High isolating DC-DC converter (power supply of detector) and strict optical isolation of inputs / outputs / communication interfaces
- Two independent 24VDC quench event signals for interfacing with external control systems (e.g. PLC, circuit interrupter)
- Comprehensive All-In-One Windows® software suite “*QVision*” (running on embedded PC) for calibration, diagnostics, convenient parametrization and data management. *QVision* also includes status and event check / event logging and an automatic operational supervision of up to 128 detectors. The operational supervision in *QVision* provides an universal remote interface to upper / lower control levels for an easy access of status data of up to 512 cabinets = 65536 detectors). Interface to quench detection units is based on high-speed-RS485 bus-system. Interface to the embedded PC is based on ethernet and / or RS485 bus-system.
- Bilingual documentation and software (German / English)

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Technical specifications of detector UNIQD Type 3450 (extraction):

Voltage supply of detector (*):	24VDC +/- 15 % 5VDC for display (supplied by back panel)
Current consumption of detector:	approx. 98mA (without display)
Differential input voltage range:	+/- 1250mV / +/- 8000mV (unbal. / balanced)
Adjustable thresholds for Quench detection:	0 -1250mV (+/-)
Lowest threshold / lowest step size:	+/- 5 mV
Selectable sensitivity:	positive, negative, bipolar
Dynamic of ADC:	12 Bit (lowest resolution is 1,2 mV)
Sampling rate:	100 KS/sec
Gradient memory (GRAM):	1M x 16bit
Max. potential separation to GND: (detector type 3450)	Rated 5 KVAC (RMS) / 1 Minute Reinforced Isolation UL 60950-1 (DC/DC-Converter) Reinforced Isolation EN 60747-5-5 (Optoelec. Couplers) 8.5 KV eff. / IEC 130.1 (Lemo FCJ - ECJ 4B / 464)
Maximum input voltage:	500V input to HVGND 1000V input to input
Rise time (without filtering):	< 500µs (10% bis 90%)
Time constants of RC filters:	0,01 / 0,02 / 0,05 / 0,1 / 0,2 / 0,5 / 1 / 1.5 sec.
Outputs:	2 separate detector outputs 24 VDC(*) (outputs can be wired or by operation mode)
Output characteristics:	A. Permanently set after Quench (Reset by acknowledge) B. Pulse after Quench (duration is adjustable) C. Direct mode (output is directly set/reset by comparator)
Serial interfaces:	Master HS-RS485 (max. 1152000 Bd) Slave HS-RS485 (max. 1152000 Bd)

(*) = By corresponding back-panel type 3450-220-R1-BV2 / 2019

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Design:	19"-Plug-in module, 3 RU / 12 HP PCB: 100mm * 340mm
Total power requirements of rack: (= 8 detectors including operation of displays and backplane)	25 W - 55 W max. (depends on settings)
Operation temperature range:	0°C < T < 50°C
Storage temperature range:	-5°C < T < 60°C
Humidity:	< 85% rel. h. (non-condensing)
Vibration and shock:	ETS 300 019-2-4
EMC:	EN 55022 and EN 55024
ROHS:	since 2010
Soldering:	Silver free soldering is possible on request

Development and Production according to:

DIN EN ISO 9001 Quality management systems
DIN IEC 60086 T 2-38 (Temperature & Humidity)
DIN IEC 60654-3 (mechanical effects)

References:

FRIB - Michigan State University / USA
W7-X - IPP-Greifswald
HZB - Helmholtz-Zentrum Berlin
GSI - Helmholtz-Zentrum für Schwerionenforschung GmbH / Darmstadt
KARA - Karlsruhe Research Accelerator - KIT
TOSKA - Karlsruhe Institute of Technology - KIT
KATRIN - Karlsruhe Institute of Technology - KIT

EU Patent specification:

EP 2 315 042 A1

General:

The KIT Quench detection system *UNIQUD* is based on an approved electronic layout and system design. Continuous and save operation since 16 years at different installations / locations provides extensive expertise in quench detection at KIT.

Until the end of 2020 more than thousand detectors have been manufactured by KIT-IPE and / or industrial sub-contractors.

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GENERAL INFORMATIONS

A basic quench-detection system consists of:

- (1) 19 inch quench-detector plug-in module(s) (Quench Detector Unit - QDU)
- (2) 19 inch quench-detector rack with DC-connection / communication backplane (connection of 8 detectors per rack max.)
- (3) Embedded industrial PC with HS-RS485-full-duplex interface (connection of 16 racks = amount of max. 128 QD-units per cabinet(s))
- (4) License of All-In-One software suite *QVision* running on a Windows® system
- (5) Switching cabinet (optional)
- (6) 24V DC power-supply (optional)
- (7) UPS (optional)

Dimensions:

QD-Unit:

50 mm x 128 mm x 367 mm
(Width x Height X Length)

(Over-all dimensions including handle-bar and HV-connector)



QD-Rack (supporting 8 QD-Units):

480 mm x 170 mm x 422 mm
(Width x Height X Length)

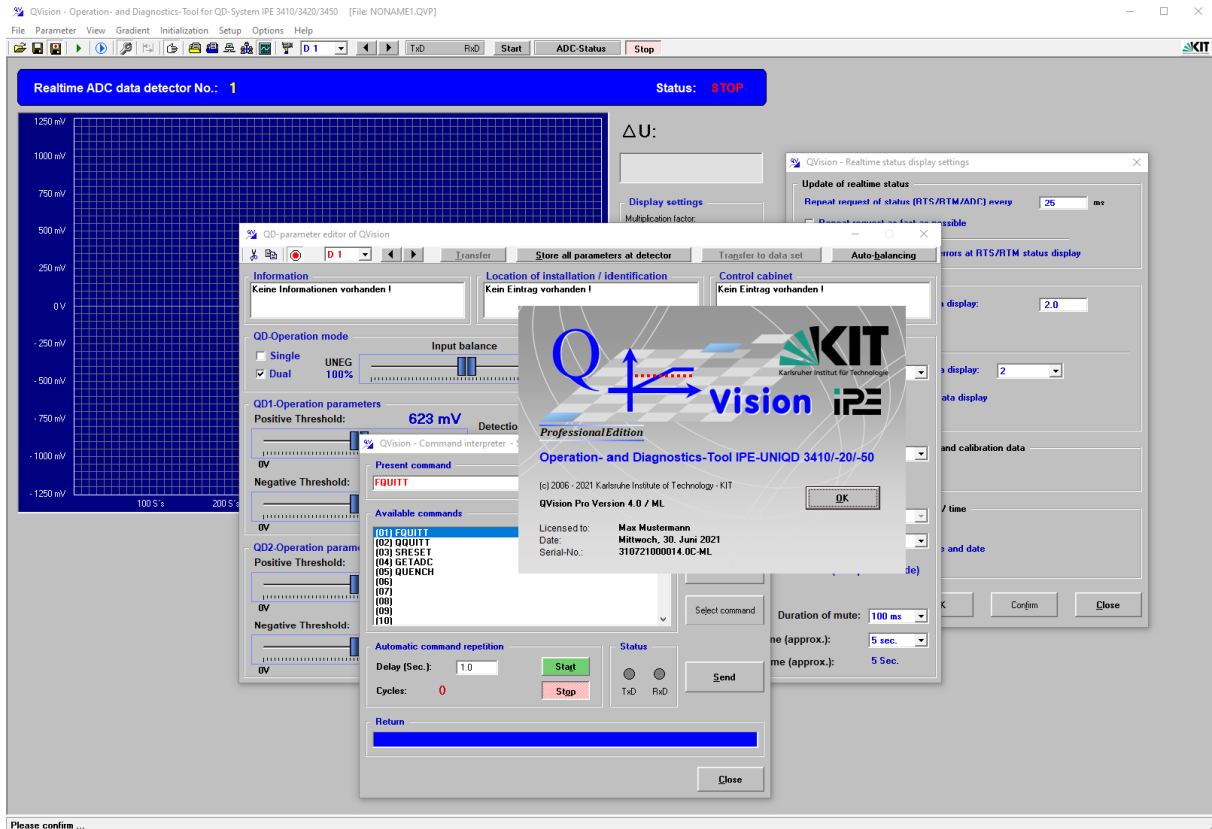
(Over-all dimensions including handle-bar of QD-Units and stick-up backplane)



Cabinet(s) (optional) of KIT-QD-system, consisting of max 16 QD-racks (= 128 QD-Units);




Example of small turn-key Quench Detection System UNIQUD with embedded industrial PC



Latest - All-In-One - Software Suite QVision Version 4.0 Professional (Version 2021) running on Microsoft Windows® operating system including:

- **Data management for an amount of up to 128 detectors**
- **„Intelligent“ parameter editor with online transmission of parameters**
- **Integrated real time status displays (single or multi detector / ADC display etc.)**
- **Detailed interface and detectors diagnostics**
- **Command interpreter supports instruction set of the detector (and remote host operation of QVision for testing purposes)**
- **Calibration menu**
- **Menus to readout / view the gradient memory (QRAM)**
- **Menu for automatic balancing of all connected detectors (max. 128); automatic noise level detection, resp. balancing to residual differential voltage**
- **Selectable language German/English (including all data outputs / log-files of QVision)**
- **Optional password security to prevent unauthorized parametrization**

(extraction)

QVISION - Operational Supervision Mittwoch, 30. Juni 2021 16:20:55 

Quench detector

001 002 003 004 005 006 007 008
 009 010 011 012 013 014 015 016
 017 018 019 020 021 022 023 024
 025 026 027 028 029 030 031 032
 033 034 035 036 037 038 039 040
 041 042 043 044 045 046 047 048
 049 050 051 052 053 054 055 056
 057 058 059 060 061 062 063 064
 065 066 067 068 069 070 071 072
 073 074 075 076 077 078 079 080
 081 082 083 084 085 086 087 088
 089 090 091 092 093 094 095 096
 097 098 099 100 101 102 103 104
 105 106 107 108 109 110 111 112
 113 114 115 116 117 118 119 120
 121 122 123 124 125 126 127 128

Settings

Gradient mem. (GRAM) at Quench event:
 Automatically save / Create event list
 Make additional ASCII export file

Differential ADC data:
 Continuously save ADC data
 Time interval (target): 100 ms

Remote operation (Start/Stop/Status):
 Enabled

Time stamp of Quench event created by:
 COM-CTS Software

Events

0001 Operational supervision started. H16M20S52 V2021-M06-D30

Location: Laboratory
Status: RUN Start: 30.06.2021 / 16:20:52
Temperature: ---- Stop:

Readout of gradient memory (GRAM)

Remaining time required:

Acknowledge Quench Acknowledge Fault

Actual time interval:

Operation Remote-Status / ID: 001
 R-COM: RxID TxID

Stop operational supervision Close

Info: Operational supervision is activated ...

Legend: QUENCH (red), F-SYS (orange), F-DET (magenta), F-COM (yellow), NOT ACTIVE (grey), OK (green)

Operational Supervision included in QVision for second layer status and event recording and automatic readout of detectors QRAM memories after quench event.

The operational supervision mode is designed for reliable continuous 24/365 operation and supports an integrated remote interface (via RS323 or RS485) for online-access of all important detector and cabinet data (e.g. ADC-Data, temperature, status bits) and control of the operational supervision mode itself (start, stop etc.).