THE AUTOMATIC QUENCH ANALYSIS SOFTWARE FOR THE HIGH LUMINOSITY LHC MAGNETS EVALUATION AT CERN

M.F. Gomez de la Cruz, H. Bajas, M. Bajko, J.V. Lorenzo Gomez, F.J. Mangiarotti, H. Reymond, A. Rijllart, G. Willering, CERN, Geneva, Switzerland

ICALEPCS2017 Barcelona · Spain, October 8-13 · Palau de Congressos de Catalunya

ABSTRACT

The superconducting magnet test facility at CERN (SM18) has been using the Automatic Quench Analysis (AQA) software to analyse the quench data during the Large Hadron Collider (LHC) magnet test campaign. This application was developed using LabVIEW™ in the early 2000's by the Measurement Test and Analysis section (MTA) at CERN. During the last few years, the SM18 has been upgraded for testing the High Luminosity LHC (HL-LHC) magnet prototypes.

These HL-LHC magnets demand a high flexibility of the software. The new requirements were that the analysis algorithms should be open, allowing contributions from engineers and physicists with basic programming knowledge, execute automatically a large number of tests, generate reports and be maintainable by the MTA team. The paper contains the description, present status and future evolutions of the new AQA software that replaces the LabVIEW™ application.

GRAPHICAL USER INTERFACE

AQA makes use of a custom user interface to select the analysis and reporting settings and options.

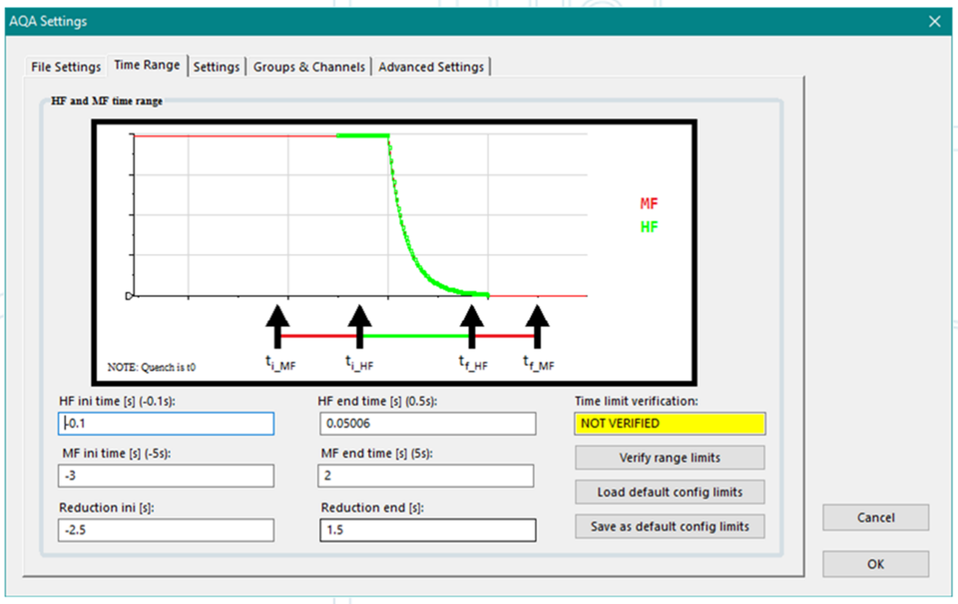


Figure 1: Time Range tab of the customize AQA dialog.

Takes advantage of running within the NI DIAdem® software to display the internal data and graphs.

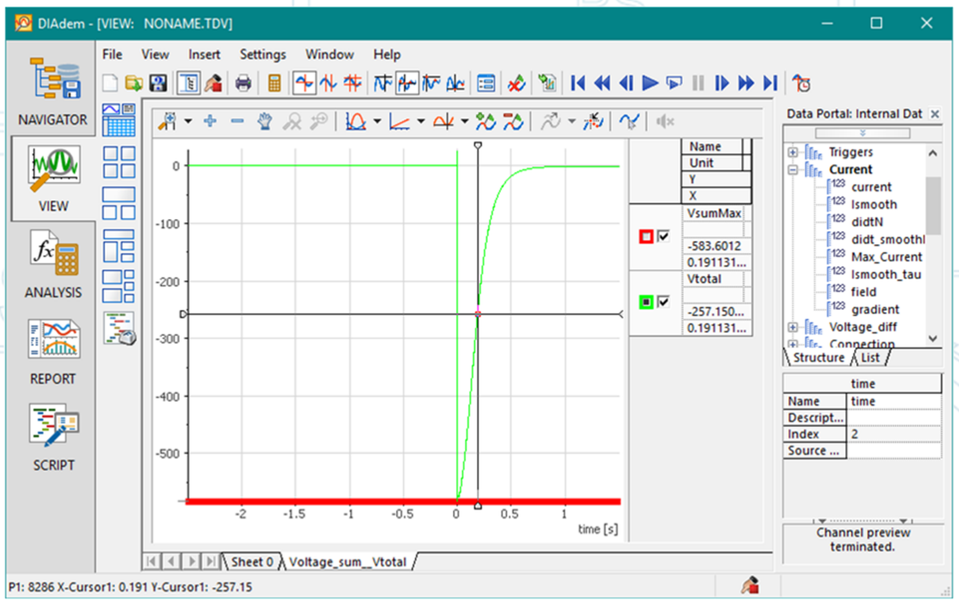


Figure 2: User interaction interface to verify and modify the absolute maximum value of the magnet voltage.

PRE-ANALYSIS

CONCATENATION

The High (HF) and Medium (MF) Frequency data produced by the DAQ system from the magnet tests are concatenated.

BUILD PATH

The file names and paths are generated to follow the hierarchy and naming conventions in the storage server.

ORDER

Signals are ordered in the TDMS file using a property defined in the DAQ system or using signal name pattern recognition.

REDUCTION

AQA offers the possibility to cut the signals at the beginning and end to focus the analysis around the quench event.

GET EXISTING COIL VOLTAGE GROUPS

Filters the existing coil voltage groups that could be selected for computing the indirect measurements during the analysis.

LOAD CONFIGURATION FILE

The magnet configuration file is automatically detected and loaded into the Data Portal with the use of data plugins.

ANALYSIS

QUENCH LOCATION

The quench detection system triggers few milliseconds after. This module determines the moment the quench happened.

TRIGGER TIME

The trigger time determines the beginning of the response to protect the magnet against a quench.

QUENCH HEATER

This module allows the verification of the reaction and functioning of the quench heaters to spread the quench along the affected magnet.

CURRENT ANALYSIS

Get the quench time from the current extraction and looks for the best fit function that describes the extraction curve.

FIELD & GRADIENT

High magnetic field values provoke quenches. The stored energy in form of magnetic field has to be converted to heat.

COIL VOLTAGE

Every magnet coil voltage can independently be analyzed to compute the indirect measurements.

REPORTING

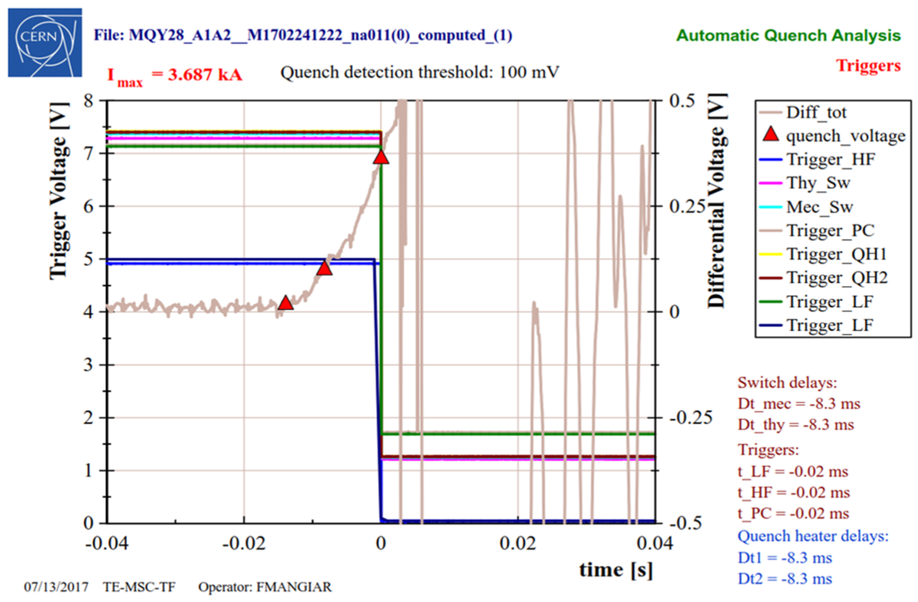
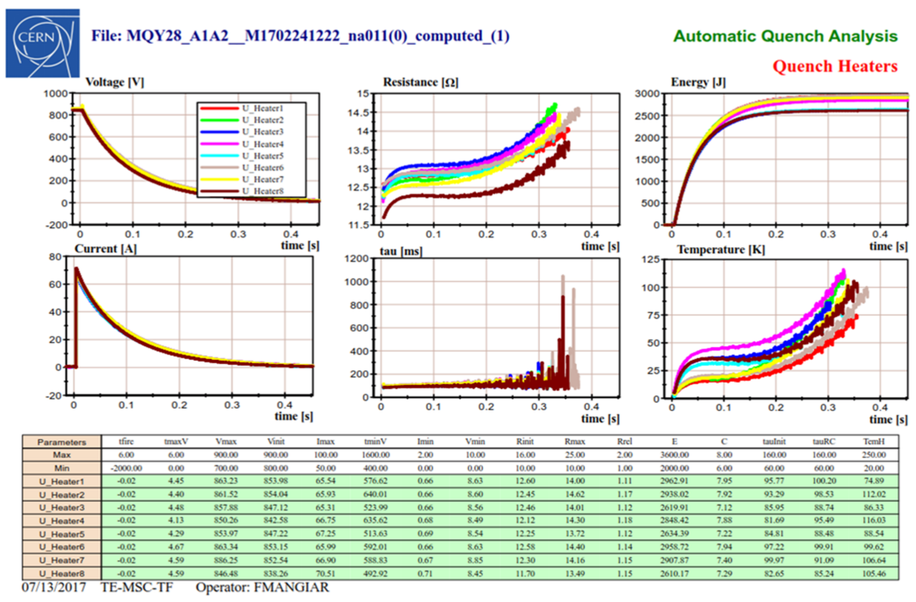


Figure 3: Report of triggers.



Parameters	tfire	tmaxV	Vmax	Vinit	Imax	tminV	Imin	Vmin	Rinit	Rmax	Rrel	E	C	tauInit	tauRC	TempH
Max	6.00	6.00	900.00	900.00	100.00	1600.00	2.00	10.00	16.00	25.00	2.00	3600.00	8.00	160.00	160.00	250.00
Min	-2000.00	0.00	700.00	800.00	50.00	400.00	0.00	0.00	10.00	10.00	1.00	2000.00	6.00	60.00	60.00	20.00
U_Heater1	-0.02	4.45	863.23	853.98	65.54	576.62	0.66	8.63	12.60	14.00	1.11	2962.91	7.95	95.77	100.20	74.89
U_Heater2	-0.02	4.40	861.52	854.04	65.93	640.01	0.66	8.60	12.45	14.62	1.17	2938.02	7.92	93.29	98.53	112.02
U_Heater3	-0.02	4.48	857.88	847.12	65.31	523.99	0.66	8.56	12.46	14.01	1.12	2619.91	7.12	85.95	88.74	86.33
U_Heater4	-0.02	4.13	850.26	842.58	66.75	635.62	0.68	8.49	12.12	14.30	1.18	2848.42	7.88	81.69	95.49	116.03
U_Heater5	-0.02	4.29	853.97	847.22	67.25	513.63	0.69	8.54	12.25	13.72	1.12	2634.39	7.22	84.81	88.48	88.54
U_Heater6	-0.02	4.67	863.34	853.15	65.99	592.01	0.66	8.63	12.58	14.40	1.14	2958.72	7.94	97.22	99.91	99.62
U_Heater7	-0.02	4.59	886.25	852.54	66.90	588.83	0.67	8.85	12.30	14.16	1.15	2907.87	7.40	99.97	91.09	106.64
U_Heater8	-0.02	4.59	846.48	838.26	70.51	492.92	0.71	8.45	11.70	13.49	1.15	2610.17	7.29	82.65	85.24	105.46

Figure 4: Report of quench heaters.

The software module for the automatic report generation is in charge of automatically loading the report templates. The result is shown on the DIAdem Report panel where each tab summarizes the different aspects of the analysis. The user can navigate through the different reporting tabs to examine the results. The report is also saved as a PDF for future reference.

CONCLUSIONS

This new **Automatic Quench Analysis** (AQA) tool developed in a user friendly language, VBScript, permits to analyse series of magnet tests in an automatic or semi-automatic way. The mechanical engineers can easily tune the analysis settings by editing the configuration files.

The new AQA has been the result of the **collaboration** of two teams, one providing the mechanical engineering expertise and the other, the programming and software development competences.

Thanks to the new **flexibility** and **modularity** of the tool, as well as the documentation and **guidelines** for the VBScripts, it is now easier to **expand** the functionalities or modify existing analysis modules when new conditions are requested. The fact that these adaptations can now be done directly by the mechanical engineers, speeds-up the development cycle. This ensures the **maintainability** of the analysis over the lifetime of the HL-LHC magnets.

The generated results will be sent to a database to improve the magnet traceability and quality assurance.

CERN | EN ENGINEERING DEPARTMENT

TUMPA08

e-mail: mf.gomez.cruz@gmail.com