SOFTWARE TOOLS FOR ELECTRICAL QUALITY ASSURANCE IN THE LHC

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Introduction

A great diversity of circuits and configurations met in the LHC machine forces the use of several software technologies within one application.

This quality assurance system was developed in parallel with the machine assembly. It was expected to verify the correctness of many parameters that have never been measured before and thus be able to quickly adapt to the new circumstances. Therefore, the set of measurements and the acceptance criteria were expected to change as the installation and development works were progressing.

A flexible software platform had to flawlessly drive the dedicated hardware [1], stay in accordance with the machine layout and safely store the measured values, while allowing a central management of the full software structure.

Test Families

The applications have been divided into three families: TP4 (Test Procedure 4) for superconducting circuits powered via the DFBs (Distribution Feed Boxes), DOC (Dipole Orbit Corrector) for locally powered superconducting orbit correctors and MIC (Magnet Instrumentation Check) for local magnet voltage pickups and quench heaters. Hardware setup for each type of tests has been described in [1].

Database

A database system constitutes a core of each application. It is used in order to read application settings and store measured values. As there is no access to the network at the measurement positions each system is working on a local database (MS Access). After coming back to the surface infrastructure it synchronises its local database with the centrally hosted Oracle storage: the measured values are copied in the Oracle structure; all the settings used for the tests in the tunnel as well as the most recent layout of the machine are copied from the Oracle to the local database. Figure 1 presents layout of the main database.

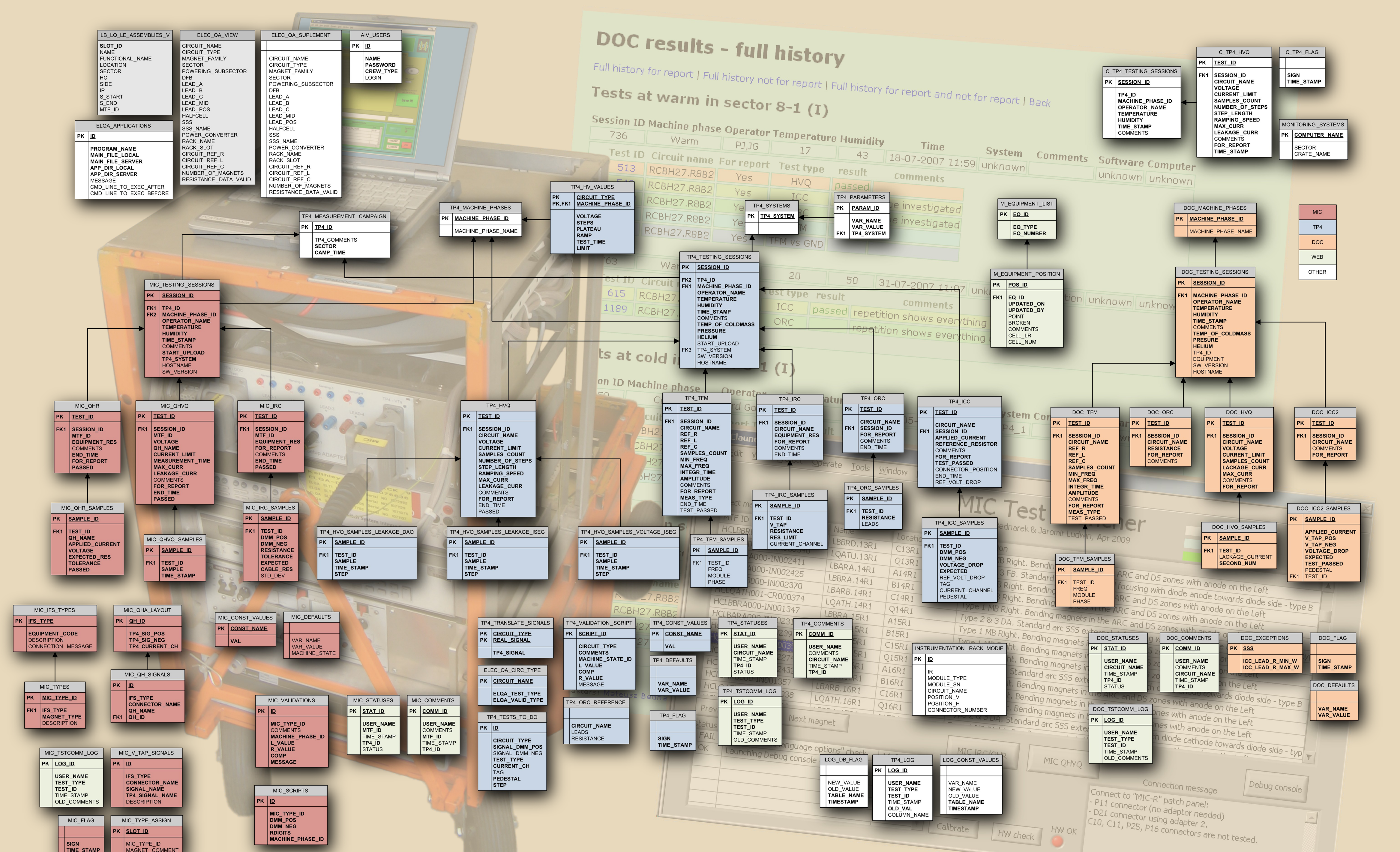

Figure 1. Entity Relationship Diagram of the main database.

Data Acquisition

The hardware part of the measurement system as well as the user interface for the test benches are driven by a set of LabVIEW applications. Families of aforementioned applications are further divided into separate sub programs for specific types of tests like high voltage insulation tests, AC transfer function measurements, or DC ohmic parameters measurements. Typical window of measurement sub program is presented on figure 2.

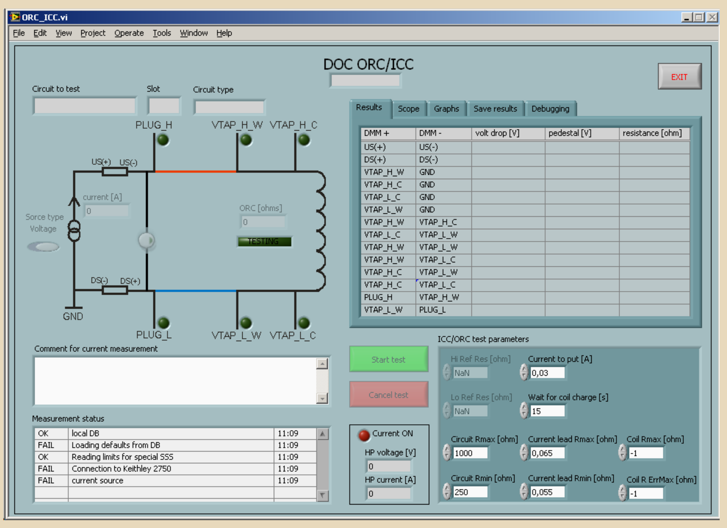

Figure 2. DOC Instrumentation Continuity Check application window.

Systems' Flexibility

There were several issues that had to be kept in mind when developing the test applications for the TP4 and MIC family:

- There exist many types of circuits with different kinds of diagnostic connectors and various types and numbers of current leads.
- At the development's starting point it was not clear which signals should be measured and which precision was needed.
- A very flexible way of validating the results was needed as the acceptance criteria had to be adjusted together with the measurement campaign progress and more statistics becoming available.

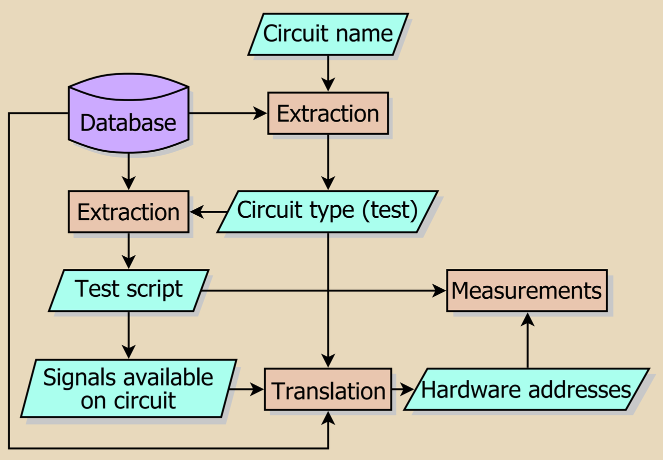

Figure 3. Signal name translation in low voltage test applications.

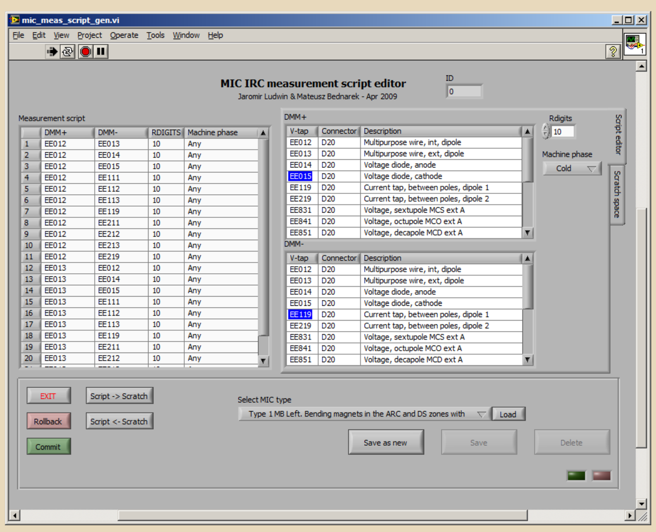

Figure 4. Application for generating measurement scripts front panel.

Taking into account those requirements it was decided to create an application which makes use of independently prepared test scripts and validation scripts. The idea of test scripts is presented on figure 3.

A similar idea was applied to the verification criteria of recorded values. The great complexity of the cabling requires taking different criteria for each circuit type. As already mentioned the acceptance thresholds were often modified in order to follow the best, growing knowledge about the qualified circuits. Furthermore checking the correctness of electrical connections in the circuit often requires evaluating several mathematical formulas. Therefore the application responsible for the validation process is equipped with a mathematical formula parser. Figure 5 shows dataflow used during the measurement results verification. Figures 4 and 6 are presenting front panel of the MIC test script and validation script editors respectively.

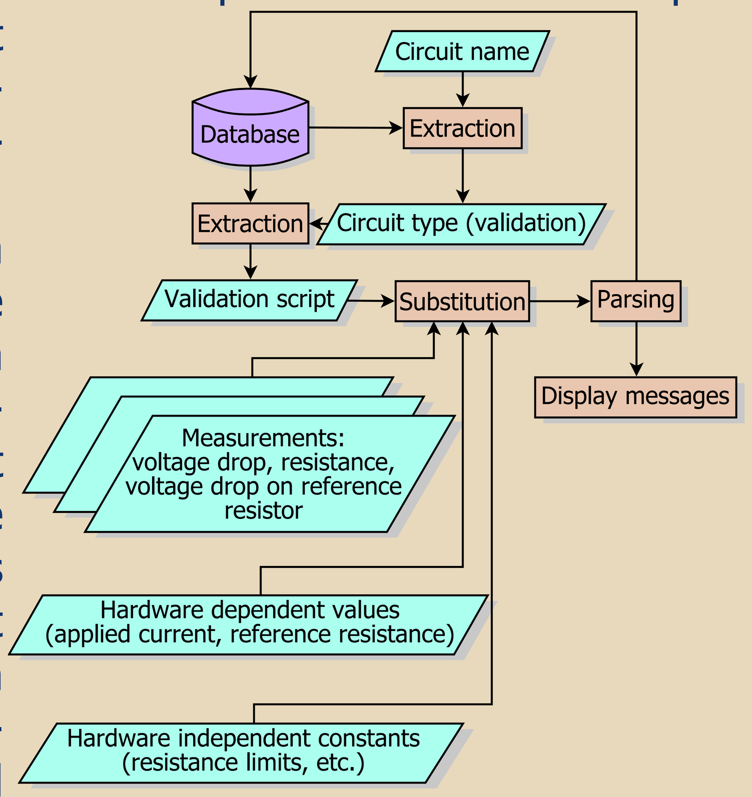

Figure 5. Measurement results validation process.

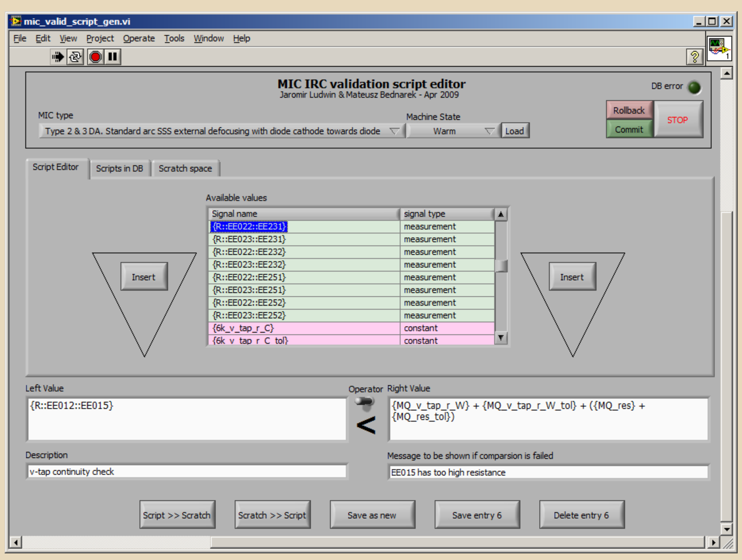

Figure 6. Tool for generating validation scripts.

Tests Follow-up and Reporting

Each application family has its own set of web pages used to check the current status of tests, analyse results and modify or add nonconformities data. Example of TP4 follow-up page is shown in the background of figure 1.

In case of tests where the result is represented as a set of multiple values, the user can export the data in a Comma Separated Values format by clicking the proper link on the test results page. For some measurements, where many identical objects are tested (e.g. quench heaters) web based statistical analysis tools were created.

Conclusions

The very difficult and complex task of performing the electrical quality assurance of a big prototype machine such as the LHC was successfully accomplished thanks to the described software tool-chain.

Further Work

Currently the hardware part of the measurement system is being upgraded in view of the upcoming long shut-down in the LHC. As new functionalities and improvements will be added, the software upgrade will follow.

Acknowledgements

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References

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