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].

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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.

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 DOC ORC/ICC applications are Results Scope Graphs Save results Debugging further divided CCC. into separate sub programs for specific types of tests like high voltage 0,03 insulation tests, local DB Loading defaults from DB Reading limits for special S AC transfer func-HP voltage [V] Connection to Keithley 275 Current lead Rmin Lohmj Coil R ErrMa tion measure-Figure 2. DOC Instrumentation Contiments, or DC ohnuity Check application window. mic parameters measurements. Typical window of measurement sub program is presented on figure 2.





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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 different with kinds of diagnos- Figure 3. Signal name translation in tic connectors and

Circuit name → Extraction Database Extraction Test script Measurements Signals available low voltage test applications.

RE2700

various types and numbers of current leads.

scripts İS pre-➤ Extraction on Database figsented ure 3. Extraction </ Circuit type (validation)/ A similar idea was applied to the ✓ Validation script ✓ Substitution → Parsing verification criteria Display messages of recorded val-Measurements: voltage drop, resistance, The great ues. voltage drop on reference complexity of the requires cabling Hardware dependent values (applied current, reference resistance) different / taking for each criteria circuit type. As al-Hardware independent constants (resistance limits, etc.) mentioned ready Figure 5. Measurement results validaacceptance tion process. 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



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quench heaters) web based statistical analysis tools were created.

ments, where many identical objects are tested (e.g.

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.

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References

responsible

mathematical

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with

parser.

• At the development's starting point it was not clear



ria had to be ad-Figure 4. Application for generating together measurement scripts front panel. justed with the measurement campaign progress and more statistics becoming available.

Taking into account those requirements it was decided to create an application which makes use of inde-

Sector and the sector

Figure 5 shows Description v-tap continuity check dataflow used Save entry 6 Delete entry 6 Save as new during the meas-Figure 6. Tool for generating validation urement results scripts. verification. Figures 4 and 6 are presenting front panel of the MIC test script and validation script editors respectively.

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

- [1] A. Kotarba et al., "Automatic Measurement System for Verification of the LHC Superconducting Circuits", IPAC'11, San Sebastian, September 2011, TUPS093; www.JACoW.org.
- [2] D. Bozzini et al., "Automatic system for the D.C. high voltage qualification of the superconducting electrical circuits of the LHC machine", EPAC'08, Genoa, June 2008, WEPD008. p. 2416; www.JACoW.org.

[3] A. Kotarba et al., "Electrical quality assurance of the superconducting circuits during LHC machine assembly", EPAC'08, Genoa, June 2008, WEPD016. p. 2440; www.JACoW.org.

