The State Machine Based Automatic Conditioning Application for PITZ

D Melkumyan, P Boonpornprasert, Y Chen, J Good, M Gross, H Huck, I Isaev, D Kalantaryan, M Krasilnikov, O Lishilin, G Loisch, A Oppelt, M Otevrel[1], B Petrosyan, H Qian, Y Renier[2], F Stephan, G Trowitzsch, G Vashchenko, DESY, 15738 Zeuthen, Germany

[1]CEITEC, Brno University of Technology, 612 00 Brno, Czech Republic

[2]DPNC, Geneva University, 1211 Geneva, Switzerland

INTRODUCTION

The Photo Injector Test Facility at DESY in Zeuthen (PITZ) [1] was built to test and to optimize high brightness electron sources for Free-Electron Lasers (FELs). In order to achieve high accelerating gradients and long RF pulse lengths in the RF gun cavities, an extensive and safe RF conditioning is required. A State Machine based Automatic Conditioning application (SMAC) was developed to automate the RF conditioning processes, allowing for greater efficiency and performance optimization.

THE RF SETUP AND THE GUN

The gun prototype 4.5 conditioning setup consisting of a 10-MW multi-beam klystron, an upgraded RF waveguide distribution system, two 10-MW THALES vacuum RF windows, directional couplers, Ion Getter vacuum Pumps (IGP) and a Pressure Gage (PG), photomultipliers (PMT) and electron detectors (e-det) located around the gun coupler is shown in Figure 1.

The PITZ photo electron gun is a 1.6 cell normal conducting L-band cavity, with cathode located at the back wall of the half-cell. The electron beam is generated at the cathode by a laser pulse and then accelerated by RF fields and focused by the solenoid fields.

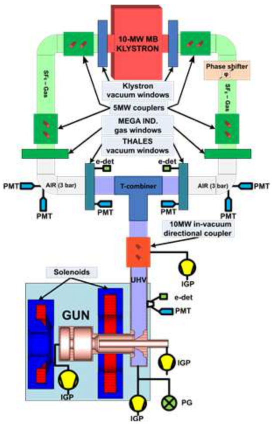

Fig. 1: The PITZ RF Setup (v. 4.5, 2018).

THE SMAC

The SMAC was developed to automate the conditioning process for the RF cavities. It is written in Java and uses State Chart XML (SCXML) as the finite-state machine execution environment based on Harel state-charts [2]. Application employs the DOOCS [3] and TINE [4] for the communication with the control systems of PITZ. Communication between GUI and SXML processing layer is performed via DOM [5] events. The overall structure and data flow of SMAC application is shown in Figure 2. The authorization module guaranties that only one instance of SMAC is working at the same time.

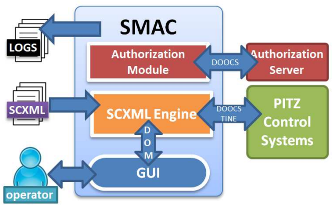

Fig. 2: Overall structure and data flow.

Figure 3: Segment of SCXML code.

THE SCXML

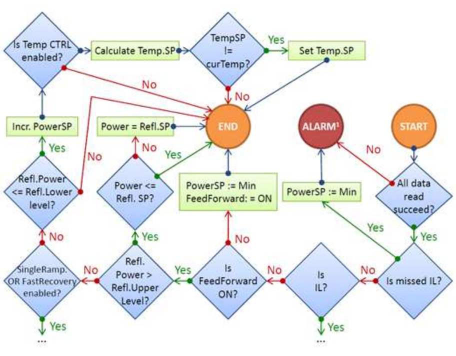

Fig. 4: Segment of the RF ramping flow diagram.

SCXML engine capable of executing a state machine defined using a SCXML document that describes the application flow. Figure 3 shows a SCXML file segment that defines top-level states of the RF conditioning process which involves simultaneous monitoring and controlling various operating parameters (e.g. IL status, RF power, gun temperature, etc.). Figure 4 shows a segment of the RF ramping flow diagram.

THE GUI

The interface for the SMAC application provides the user control of the conditioning process and relevant monitoring data. The profile panel allows operator to pre-configure the conditioning settings in order to quickly apply them to a new run.

The GUI is created by using the Java Swing toolkit and available via Java Web Start (JWS) which provides a simple way to launch an application via a network. Figure 5 shows a screen snapshot of the SMACs interface whilst running.

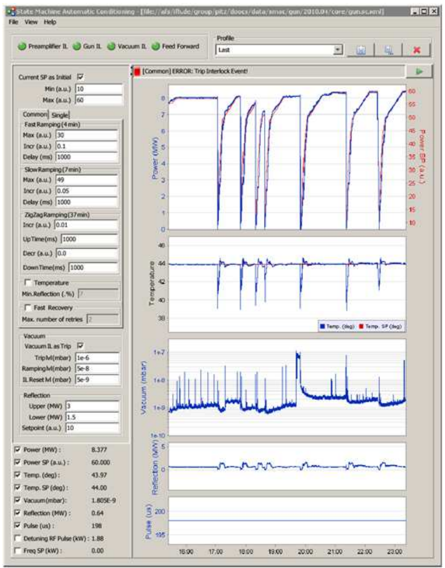

Figure 5: A screenshot of the GUI.

CONDITIONING ALGORITHM

The conditioning algorithm consists of gradually increasing the RF power and the RF pulse length but keeping a low rate of vacuum spikes in the cavity in order to prevent any damage from break-downs.

Currently, SMAC implements two ramping modes, namely, Single and Common:

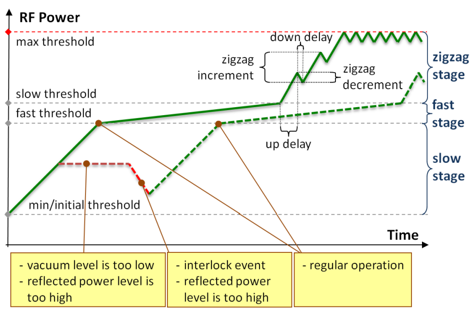

Figure 6: Common mode of the RF power ramping.

1. Single mode is based on the “Fast Ramping” algorithm [6]. Thus the RF frequency is changed to follow the resonance frequency and the temperature of the gun cavity is continuously adjusted for slightly overheated operation.
2. Common (or continues) mode is shown in Figure 6: RF power is steadily increased until a significant vacuum spike or until breakdown occurs. The common mode consists of several stages (“fast”, “slow” and “zigzag”) with different RF ramping speeds.

CONCLUSIONS

In this paper, we have presented the main design features and the current implementation status of the SMAC application. This implementation was intended as a proof of concept, applying a state-chart approach toward the development of the automatic conditioning application. The SMAC application was brought into operation in 2010 and has been used at PITZ very successfully for all RF cavities. Since then the application is left to run unattended overnight. The SMAC continues to be improved by feedbacks and suggestions from the physicists.

REFERENCES

[1] PITZ, “Photo Injector Test Facility at DESY,” http://pitz.desy.de
[2] D. Harel, “Statecharts: A visual formalism for complex systems,” Science of Computer Programming, vol. 8, no. 3, pp. 231–274, June 1987.
[3] DOOCS, “DOOCS is a distributed control system,” http://doocs.desy.de
[4] TINE, “Three-fold Integrated Networking Environment,” http://tine.desy.de
[5] DOM, “Document Object Model Events,” https://www.w3.org/TR/WD-DOM-Level-2/events.html
[6] Y. Renier et al., “Fast Automatic Ramping of High. Average Power Guns,” in Proc. IPAC’17, Copenhagen, Denmark, May 2017, Paper TUPIK052.