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CONTROL SYSTEM FOR THE FRANZ FACILITY

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Abstract

The Frankfurt Neutron Source at the Stern- Gerlach Zentrum (FRANZ) will use the reaction of ^{7}Li(p,n)^{7}Be to produce an intense neutron beam. The neutron energy will be between 10 and 500 keV depending on the primary proton beam, which is variable between 1.8 and 2.2 MeV. A volume type ion source will be used to deliver a 120 keV proton beam with currents up to 200 mA. Like any other facility, FRANZ will need a powerful and reliable control system that also allows monitoring the whole accelerator target areas and experiments. Also interlock and safety systems have to be included to protect personnel from radiation hazards associated with accelerator operations and accompanying experiments. The FRANZ control system is still under development. The ion source will be the first element to be controlled, and to gain experience. A test ion source will be used for testing and examining the performance of this control system. The plasma properties, filament ageing and an internal control loop for stable beam production with respect to controlling issues will be discussed.

INTRODUCTION

In this paper, the control system of the FRANZ facility and of all its components will be discussed. On the one hand it controls the operation status of each component permanently, on the other hand it delivers data relevant for service and personal security maintenance. This system deals with all "slow" tasks of FRANZ while there will be rf control systems and fast control loops on the ns to µs scale separately.

The FRANZ proton driver consists of a volume type ion source delivering a 200 mA d.c proton beam at an energy of 120 keV. The proton beam will be transported to the low energy beam transport (LEBT) which consists of four solenoids and a chopper system for producing beam pulses of 100 ns with a repetition rate around 250 kHz.The main acceleration of the proton beam will be provided by a radio-frequency quadrupole (RFQ) working at 175 MHz with an output energy of about 700 keV followed by an IH-DTL for achieving 2.0 MeV beam energy which may be varied by ±0.2 MeV in the following 5 gap rebuncher of the CH-type. In a next project step, a Mobley- type bunch compressor will be realized where 9 rf linac bunches will pass in individual paths and will be focused on the neutron production target within 1 ns. The neutron production target is a solid Li target. Figure 2 shows a scheme of the FRANZ facility [1-2].

FRANZ CONTROL SYSTEM

In the FRANZ facility a "Mesh Networked Data Acquisition and Control System (MNDACS)" is used as a control System [3-4]. It is a Java based control system which is developed in house by C. Wagner. It consists of a kernel that manages all device drivers, graphical user interface (GUI) and driver abstraction layer (DAL) and provides the access to devices with local drivers or drivers loaded at different computers (see Fig. 1). The project approach is to build a mesh system to tolerate control unit breakdowns with a load balancing between units.

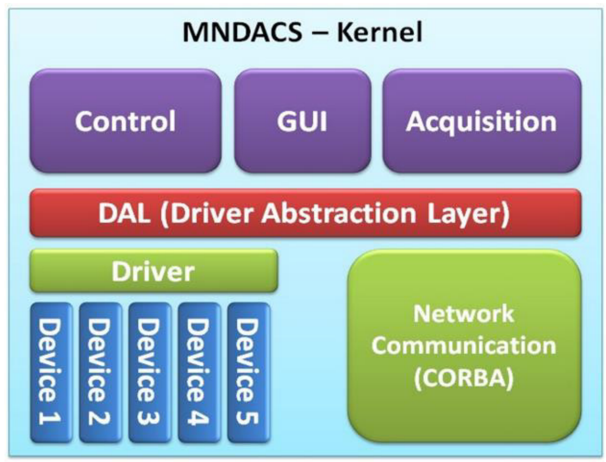

Figure 1: Program architecture of MANDACS.

The FRANZ control system consists of two basic layouts; the high level control and the data acquisition through the Ethernet layout, and the low level layout for the interlock and security system like emergency shutdown (see Fig. 3). All the devices will be connected to the TCP/IP Ethernet, which will be used as a physical communication backbone. To prevent software induced device outage, the number of computers will be as low as possible.

The network topology for FRANZ is shown in Fig. 4, where 1 Gbe links are used between devices and computers. At the FRANZ control system, three types of communications are used:

- Devices directly connected to the network (if possible).
- Connected through a converter in case of having a common interface like RS232.
- Connected through a computer in case of using an interface like USB.

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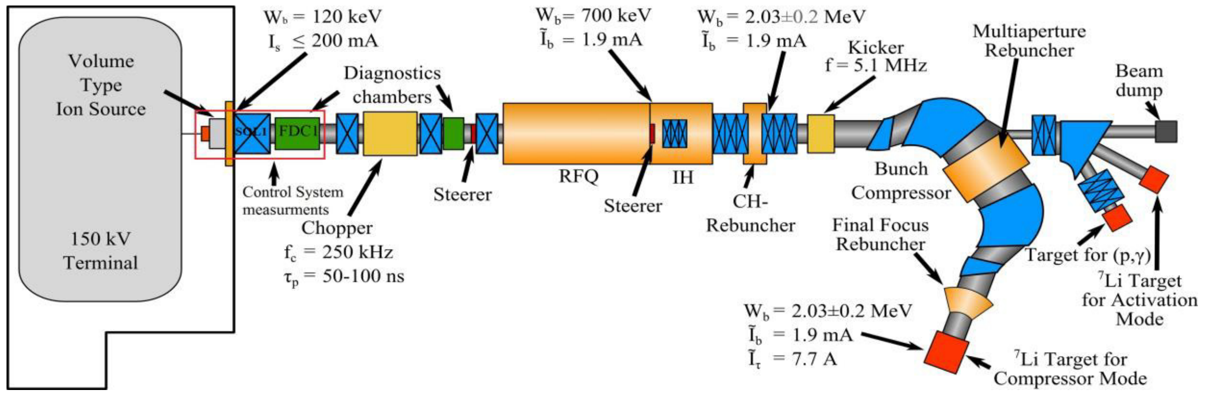

Figure 2: Schematic layout of Frankfurter Neutron Source at Stern-Gerlach-Zentrum.

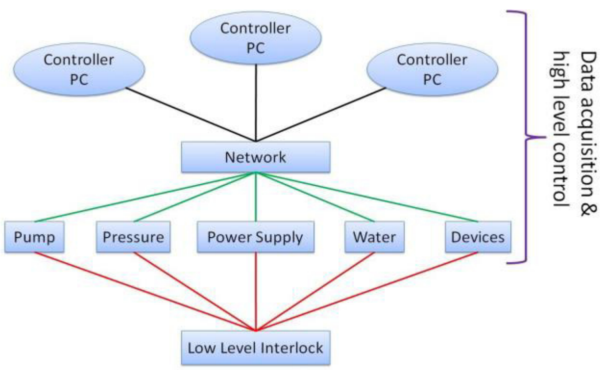

Figure 3: Layout levels of FRANZ control system.

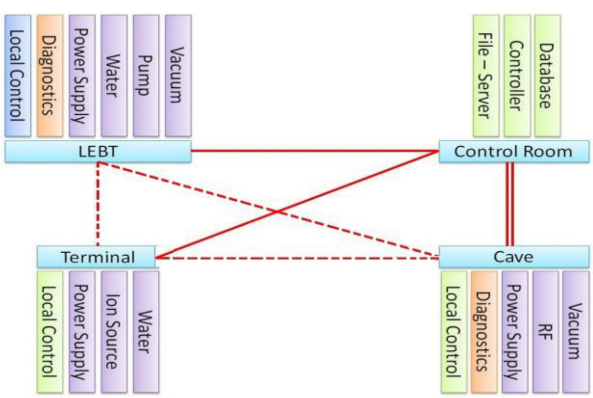

Figure 4: Network topology for FRANZ.

ION SOURCE CONTROLLING

In FRANZ, a volume type ion source delivering proton beams up to 200 mA is used (Fig. 5).

The main advantages of using this kind of ion source are: low plasma temperature, high emission current and low investment costs. The aging of the process limits filament life time to about 3 weeks of continuous operation. This might be considered as a disadvantage of such a kind of ion source. Therefore, the control system should provide information that is needed to predict the time for a next source service.

Thus, FRANZ CS should provide all data for:

- Readjustment of source parameters.
- Compensation of the aging filament effects.
- Estimation of filament exchange (maintenance).

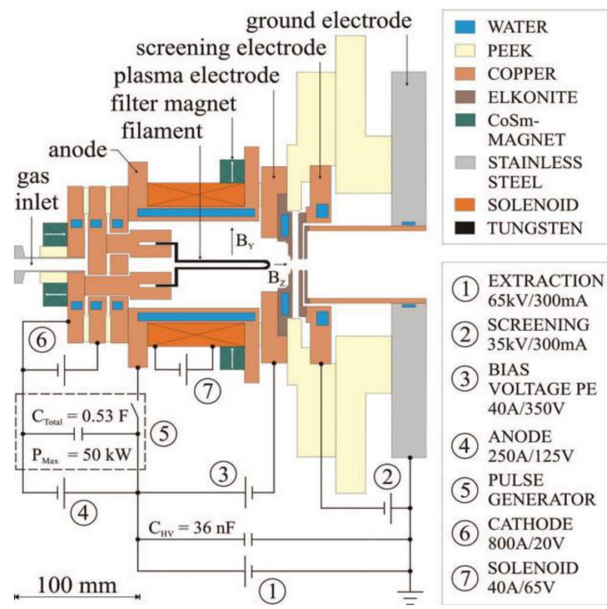

Figure 5: A schematic cross section of the FRANZ ion source [1].

The control of the ion source is divided into different parts which need to be controlled. The first steps are the controlling of the filament heating up and filament ageing, and later the process will be extended to control more aspects. One should start with filament conditioning in order to prepare the ion source and to remove the de-gassing, water and dust from the filament to prevent hot spot and quick break down. The de-gassing problem should be treated very carefully to prevent producing macro holes on the surface and reducing the filament life time. The control loop for filament conditioning (Fig. 6) was prepared and it was tested partially in MNDACS. As can be seen in the loop, the initial value of the filament current is set in addition to the shift (FWHM) to have the correct current value. The

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pressure, current and voltage will be read automatically.

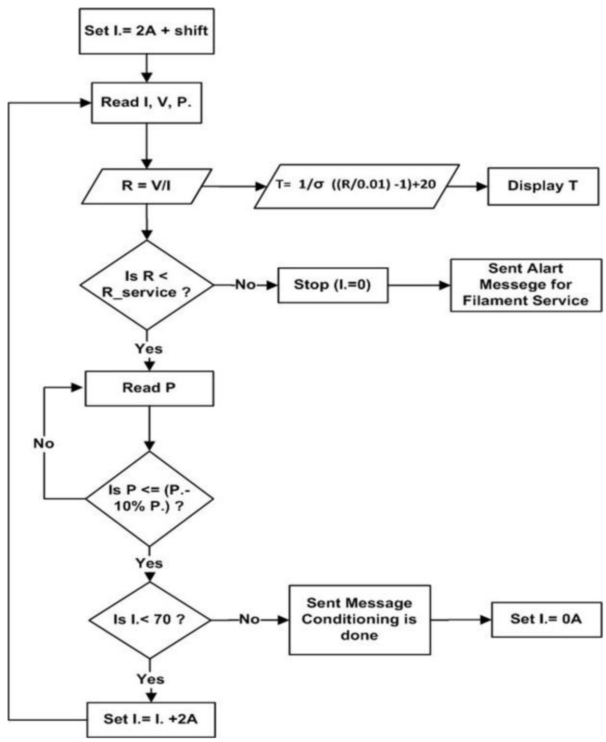

Figure 6: Filament conditioning and ageing loop.

The resistance of the filament and the vacuum pressure are calculated at each filament current level and the results are stored in the database (Fig. 7).

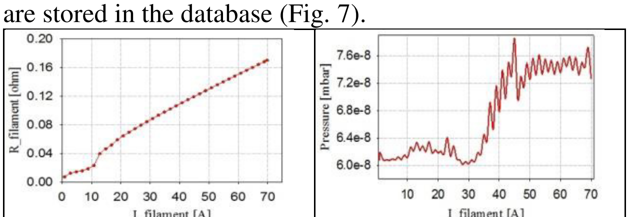

Figure 7: Filament resistance and chamber pressure vs filament current.

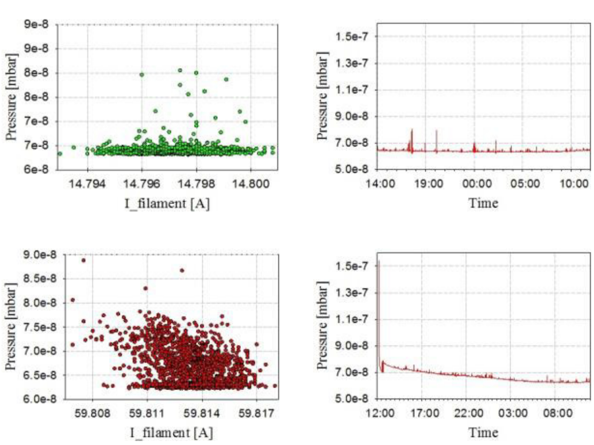

Figure 8: The de-gassing behaviour versus time at two different filament currents 15 A and 60 A.

The de-gassing behaviour and resistance variation for different filament current is shown in Figs. 8-9.

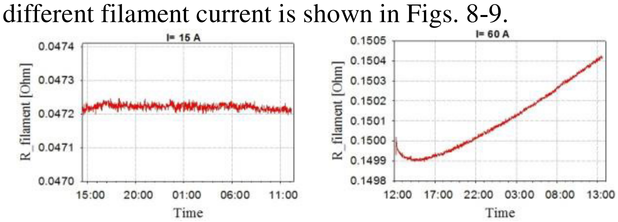

Figure 9: Filament resistance variation versus time at two different filament currents 15 A and 60 A.

Since it is important to indicate the lifetime of the filament for maintenance, the resistance will be compared with a maximum tolerable resistance at which the filament breakdown based on the results from previous experiments (Fig. 10) has to be expected in the near future.

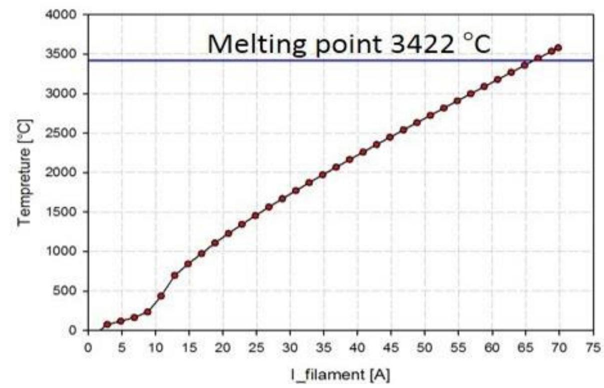

Figure 10: Filament temperature as calculated from the resistance data versus the filament current in one example.

CONCLUSION AND OUTLOOK

The FRANZ control system is based on the Java programming language because of the scalable security features. The GUI for FRANZ provides easy and fast data presentation for users. The controlling of the first element (ion source) was established and the control algorithm for filament conditioning and aging has been implemented in MNADCS and checked successfully. The control algorithm will be extended and tested on the other components.

REFERENCES

[1] W. Schweizer et al., Rev. Sci. Instr. 85, 02A743 (2014).
[2] O. Meusel et al., Proceeding of International Topical Meeting on Nuclear Research Applications and Utilization of Accelerators, 4-8 May 2009, Vienna, AT/RD-07.
[3] sourceforge.net-website: http://sourceforge.net/projects/mndacs.
[4] S. Alzubaidi et al., Procceding of IPAC 14, Dresden, Germany THPRO103, pp. 3134 (2010).