SwissFEL MAGNET TEST SETUP AND ITS CONTROL AT PSI

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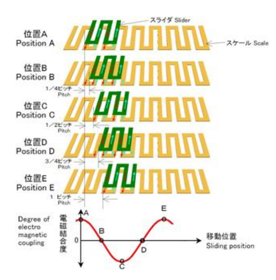
INTRODUCTION

High brightness electron bunches will be guided in the future Free Electron Laser (SwissFEL) at Paul Scherrer Institute (PSI) by several hundred magnets. The SwissFEL machine imposes very strict requirements not only to the field quality but also to mechanical and magnetic alignments of these magnets. To ensure that the magnet specifications are met and to develop reliable procedures for aligning magnets in the SwissFEL and correcting their field errors during machine operations, the PSI magnet test system was upgraded. The upgraded system is a high precision measurement setup based on Hall probe, rotating coil, vibrating wire and moving wire techniques. It is fully automated and integrated in the PSI control system, which is based on EPICS.

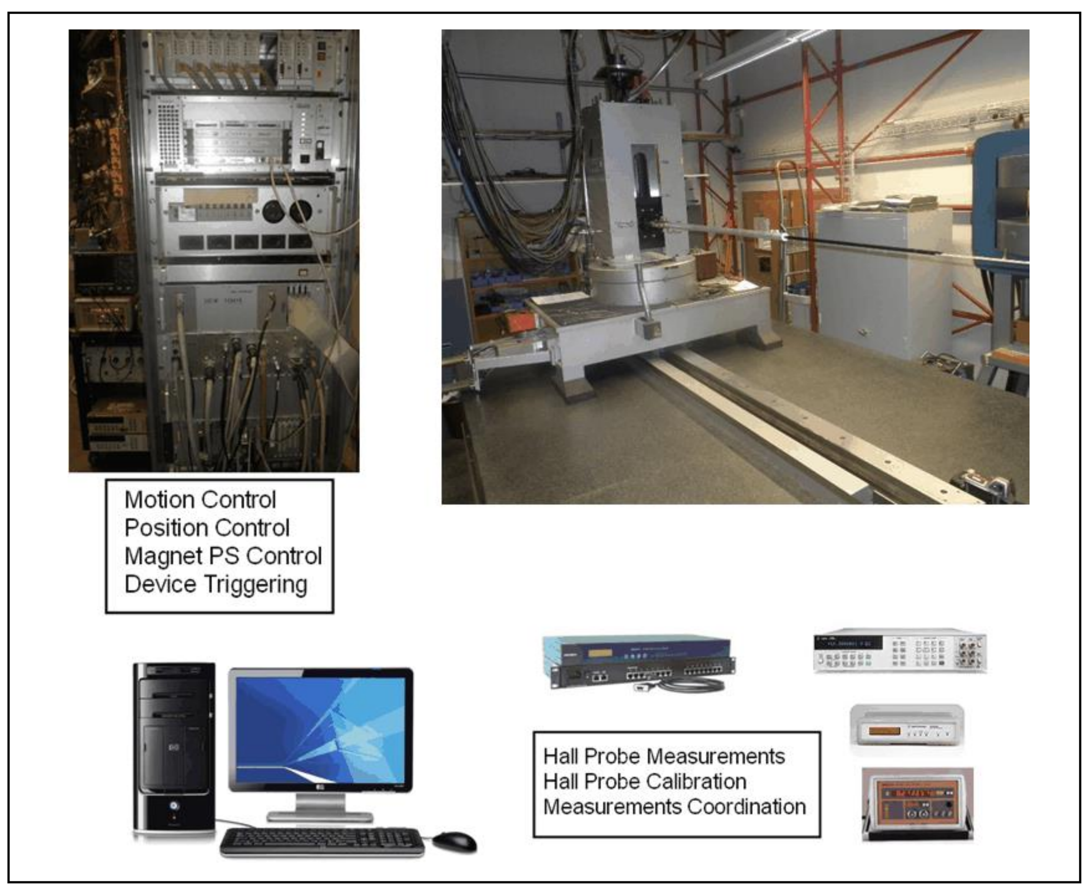
Hall Probe Measurements

Main magnetic field measurements and field mapping in dipoles are performed using Hall probes. A computerized Magnet Measuring Machine (MMM) is used for automatic fast magnetic field measurements.

The MMM is an extremely precise positioning device sliding on compressed air pads over a flat, carefully machined granite block. The position is determined by the Inductosyn detector unit providing a 0.5 µm accuracy.

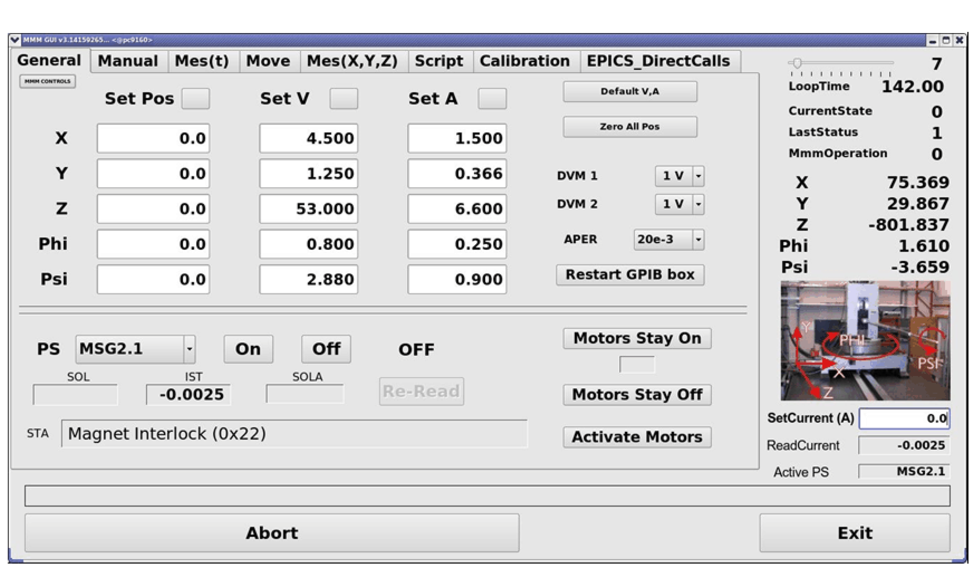


All measurements are performed in a continuous scan mode, i.e. the machine doesn't stop to make a particular measurement. With the maximum speed of the machine along the longest axis (Z) the longest drive takes less than one minute per line and is totally independent of the number of measurement points.



MMM controls components

- The magnet current is set by PSI digital power supply (PS) controllers, which are handled by dedicated IPAC (VME) modules
- Hall probe potentials are recorded by the Agilent 3458A digital multimeter (GPIB). Data triggering is done by a VME DIO module.
- Hall probe calibrations are done based on the Metrolab PT2025 NMR teslameter (GPIB).
- Hall probe motion in any of five possible directions is provided by a dedicated stepping motor (MAXv, VME).



MMM measurements are done with the use of a specially designed GUI tool, which is called mmmgui.

- Based on the Qt toolkit
- Runs on a Linux PC console
- A single user application
- Qt tabs or MMM panels are associated with MMM operational modes
- Performs all necessary calculations for device triggering at quasi-equidistant measurement points

The mmmgui also automates the Hall probe calibration process, which makes it an especially valuable tool for magnet measurement applications. All calibration steps are directed by the software. The user has to only define the number of the DVM device readings to average (which helps to reduce measurement noise) and the set of magnet power supply currents, at which the probe potentials are compared with the NMR device data. All calibration process status information is provided on the MMM Calibration panel. At any time, based on physics measurement criteria also provided on the panel, the user can interrupt/stop the calibration or skip/repeat a measurement point. As soon as the calibration is finished, the measurements data become available in EPICS and are written on the computer disk (in a file with a specified name and predefined data format), which can be used for any post processing analysis.

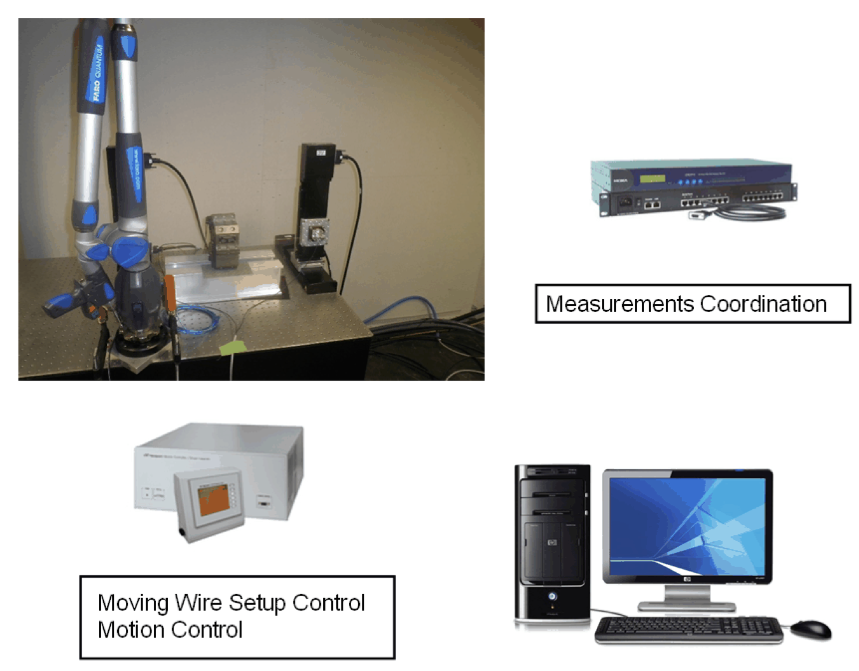
Vibrating Wire Test Bench

The most accurate technique to define the magnetic axes of multipole magnets is a single stretched vibrating wire method. A stretched wire exited by an alternating current (AC) starts oscillating in the magnetic field. Essentially, when the wire stretched in a multipole magnet stops vibrating, the effective magnetic axis and the wire are aligned. So, to locate the magnet axis, the wire should move until its oscillations vanish.

Vibrating wire controls setup

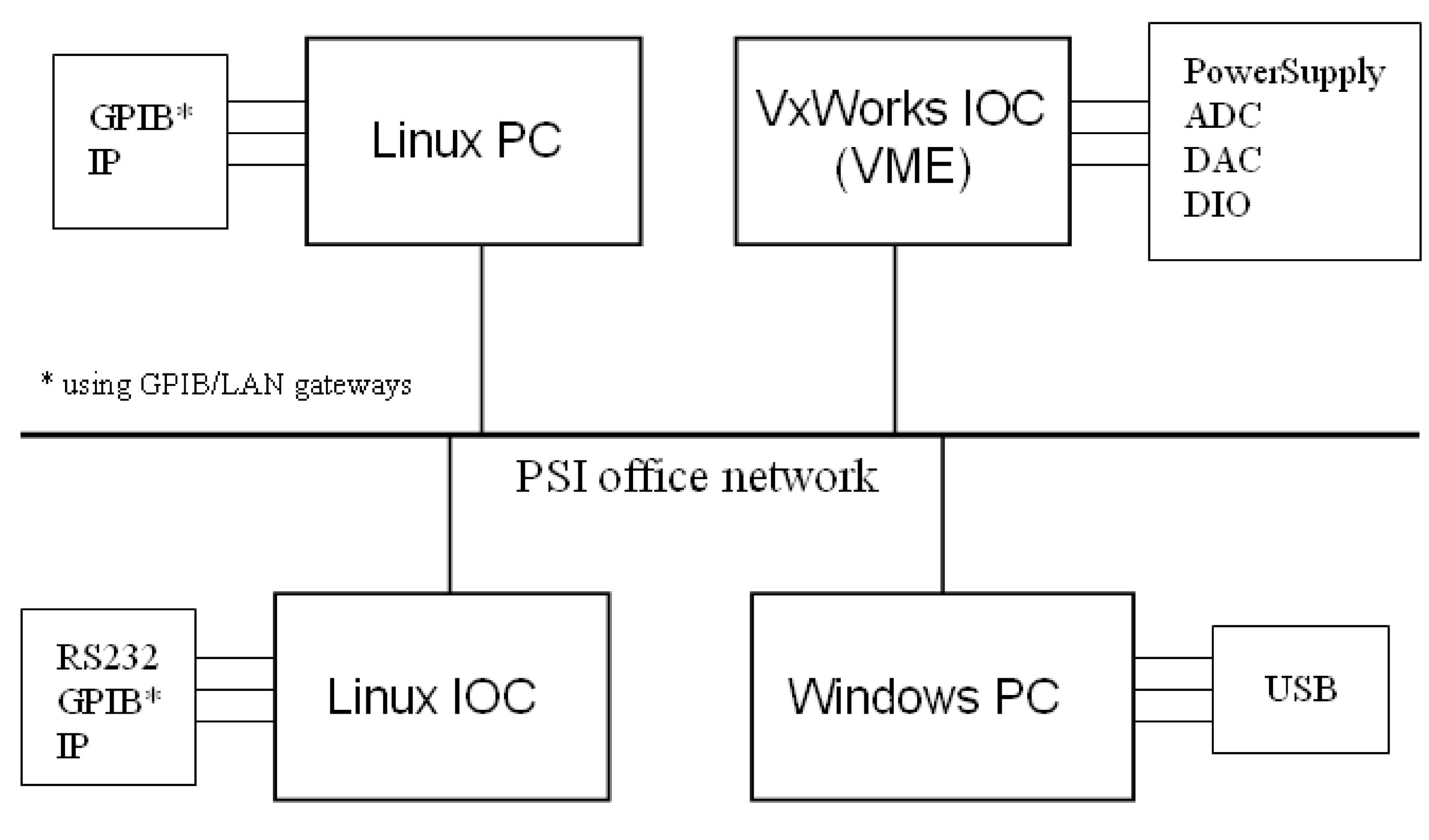
- The vibrating wire test bench is installed in a separate room, which is not air conditioned, to minimize the air flow. The magnet and air temperature are monitored by the control module developed at PSI (resolution is 0.01º C).
- Electronics is kept outside of this room to make sure that temperature changes during measurements are low and slow.
- Four Newport motorized linear stages move the wire horizontally and vertically. They are handled by SMC100 controllers (RS232).
- Two lock-in demodulators of a digital lock-in amplifier (HF2LI, Zurich Instruments) are used for the vibration detection and two for the wire position detection.

Moving Wire System



Single stretched moving wire and rotating coil techniques are the most suitable for harmonics measurements in multipole magnets. The idea is to move a wire or a coil along a circle in the magnet aperture and to measure the magnetic flux change as a function of the rotation angle.

Main controls components:
- Newport XPS motion controller with advanced trajectory and synchronization features (external triggering).
-Agilent 3458A digital multimeter (GPIB).



General SwissFEL magnet measurement controls layout

CONCLUSIONS

The new PSI magnet measurement setup is ready for testing SwissFEL magnets. Each its subsystem is associated with the used measurement technique. All subsystems are automated following PSI controls standards. The automation software is implemented as a set of tools supporting magnet measurement subsystems. Each tool consists of a main control application handling the measurement process and few GUI panels, which are used to run that application and monitor its state.

As a part of the EPICS based control environment, the magnet measurement data are very easy to work with. For instance, the data archiving is done with the use of a standard EPICS Archiver. Applications written in MATLAB and popular scripting languages (e.g. Python, Bourne shell) allow users to efficiently handle magnet measurement processes remotely, perform online and offline data analysis, and generate measurement data reports.