



Hall Probe Calibration System Software Requirement Document

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Author: **Joseph Z. Xu**

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Reviewed and Approved By: _____ Date _____

Isaac Vasserman

Tel: 2-9612, Email: isaac@aps.anl.gov

Reviewed and Approved By: _____ Date _____

Shigemi Sasaki

Tel: 2-9702, Email: sasaki@aps.anl.gov

Functional Owner _____ Date _____

Ned D. Arnold

Tel: 2-6332, Email: nda@aps.anl.gov

Functional Owner _____ Date _____

Elizabeth R. Moog

Tel: 2-2787, Email: moog@aps.anl.gov

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1 Executive Summary

This document presents the high level requirements for the APS Magnetic Measurement Lab Hall probe calibration software system. The current issue of the requirement document provides descriptions, scenarios, and requirements for the calibration system. The document is structured to provide descriptions/scenarios and high-level requirements, in meeting the current and possible future needs of the scientists who use the system in the lab.

The software system will seamlessly integrate and automate the following instruments (sub-systems):

1. Danfysik System 8000 – MPS 853 Precision Magnet Power Supply System
2. Metrolab PT 2025 High Precision NMR Teslameter System
3. Motorized NMR Probe Support Stage System Powered by Animatics SmartMotor Servo Motors
4. Group 3 Teslameter System
5. HP 3458A Multimeter System

The software system shall provide user friendly GUI interfaces to operators in carrying out the calibration measurement tasks.

2 Introduction

This document provides the high level requirements for the APS Magnetic Measurement Lab Hall probe calibration software system. It includes a general overview of the calibration system, descriptions of all the sub-systems, and the requirements as well as scenarios for the software system that integrates the sub-systems and automates the measurements. This document shall be revised to meet the needs of the scientists who carry out the measurements. This is a living document.

All the architecture, design, and testing documents of the system shall reference to this document.

3 System Overview

All the Insertion Devices (IDs) at the APS are characterized and fine tuned against their design specifications at the Magnetic Measurement Lab before they get installed into the storage ring. The ID magnetic field spatial distributions are characterized by high precision Hall probe systems. These Hall probe systems need to be calibrated frequently. The Hall probe equipment calibration system is designed to calibrate the Hall probe systems. The calibration system comprises the following sub-systems:

1. A Danfysik System 8000 – MPS 853 Precision Magnet Power Supply System and a large electromagnet to generate tunable uniform magnetic field.
2. A Group 3 Teslameter System to provide the magnetic field measurements generated by the electromagnet.
3. A Metrolab PT 2025 High Precision NMR Teslameter System to provide accurate magnetic field measurements generated by the electromagnet. It is based on the Nuclear Magnetic Resonant Effect to provide precise and absolute magnetic field measurements. In order to provide high precision measurements, it is equipped with a group of six (6) large probes to cover deferent field ranges. The probes positions are coordinated by motorized stages.
4. A Hall probe system to be calibrated. The readout unit of the system is an HP 3458A Multimeter System.

Here is how the system operates. At a specific magnetic field strength point:

1. The System 8000 – MPS 853 produces the uniform magnetic field.
2. The Group 3 Teslameter provides the reference field measurements.
3. The PT 2025 then yields the absolute field measurements.
4. The readout of the Hall probe system, the HP 3458A in this case, then can be calibrated versus the absolute field measurements.
5. Repeat step 1 – 4 to scan across the magnetic field strengths
6. When the field crosses a big range, the probes shall be swapped accordingly, in order to provide accurate measurements.

All the sub-systems are equipped with GPIB interfaces, except the motorized stages, that will be replaced with Animatic SmartMotor Servo Motors that has RS232 serial interfaces.

4 System Requirements

The system requirements are categorized into the following areas: platform, backend interfaces, sub-systems, user interfaces, data format, and others.

4.1 Platforms

4.1.1 Computer Platforms

REQ 1000 Start

Summary: Shall support IBM compatible personal computer (PC) platforms.

Description: The system shall be able to run on any IBM compatible personal computers that are equipped with:
Pentium processor or equivalent
128 MB RAM minimum
250 MB disk space

Satisfies REQ:

REQ 1000 End

4.1.2 Operating Systems

REQ 1100 Start

Summary: Shall support Windows XP Professional.

Description: The system shall support Windows XP Professional, with Service Pack 1 or later.

Satisfies REQ: 1000

REQ 1100 End

4.2 Backend Interfaces

4.2.1 GPIB Interfaces

REQ 2000 Start

Summary: Shall support IEEE 488.2 GPIB Interface.

Description: The system shall support TNT4882C based IEEE 488.2 board for PCI bus.

Satisfies REQ: 1100

REQ 2000 End

4.2.2 Serial Interfaces

REQ 2100 Start

Summary: Shall support RS-232 Serial Interface.
Description: The system shall support RS-232 Serial Interface.
Satisfies REQ: 1100
REQ 2100 End

4.3 Sub-Systems

4.3.1 Electromagnet Power Supply

REQ 3000 Start

Summary: Shall support Danfysik System 8000 – MPS 853 Precision Magnet Power Supply System.

Description: The system shall support Danfysik System 8000 – MPS 853 Precision Magnet Power Supply System via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 2000

REQ 3000 End

REQ 3020 Start

Summary: Shall support both local and remote modes.

Description: The system shall support both local and remote modes of the Danfysik System 8000 – MPS 853 Precision Magnet Power Supply System via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 3000

REQ 3020 End

REQ 3040 Start

Summary: Shall support Main Power ON and OFF.

Description: The system shall support Main Power Switch ON and OFF of the Danfysik System 8000 – MPS 853 Precision Magnet Power Supply System via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 3000

REQ 3040 End

REQ 3060 Start

Summary: Shall support Polarity Changes, if the hardware supports

Description: The system shall support Polarity Changes of the Danfysik System 8000 – MPS 853 Precision Magnet Power Supply System via IEEE 488.2 GPIB interfaces, if the power supply system hardware has the feature.

Satisfies REQ: 3000

REQ 3060 End

REQ 3080 Start

Summary: Shall support Magnet Field setting in Tesla.

Description: The system shall support setting the current output of the Danfysik System 8000 – MPS 853 Precision Magnet Power Supply System via IEEE 488.2 GPIB interfaces. The system shall convert the current unit into correspondent magnet field unit in Tesla

Satisfies REQ: 3000

REQ 3080 End

REQ 3100 Start

Summary: Shall support the *current control mode, current field setting in Tesla, polarity status (if hardware supports), current status, and error messages* readout.

Description: The system shall support *current control mode, current field setting in Tesla, polarity status (if hardware supports), current status, and error messages* readout from the Danfysik System 8000 – MPS 853 Precision Magnet Power Supply System via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 3000

REQ 3100 End

REQ 3120 Start

Summary: Shall support Magnet Field setting loop back in Tesla.

Description: The system shall support fine tune of the current output of the Danfysik System 8000 – MPS 853 Precision Magnet Power Supply System, based upon the readout of the Group 3 Teslameter readouts. The system shall convert the current unit into correspondent magnet field unit in Tesla

Satisfies REQ: 3080, (Group 3 Teslameter REQs)

REQ 3120 End

REQ 3140 Start

Summary: Shall support Initialization and Reset.

Description: The system shall support Initialization and Reset of the Danfysik System 8000 – MPS 853 Precision Magnet Power Supply System via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 3000

REQ 3140 End

4.3.2 Group 3 Teslameter

REQ 4000

Summary: Shall support Group 3 Teslameter System.

Description: The system shall support Group 3 Teslameter system via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 2000

REQ 4000 End

REQ 4020 Start

Summary: Shall support Initialization and Reset.

Description: The system shall support Initialization and Reset of the Group 3 Teslameter system via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 4000

REQ 4020 End

REQ 4040 Start

Summary: Shall support field readout.

Description: The system shall support magnetic field readout of the Group 3 Teslameter system via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 4000

REQ 4040 End

REQ 4060 Start

Summary: Shall support field readout offset.

Description: The system shall support field readout offset of the Group 3 Teslameter system, based upon the Metrolab PT 2025 High Precision NMR Teslameter system lock-on readings.

Satisfies REQ: 4040, (PT 2025 REQs)

REQ 4060 End

4.3.3 Metrolab PT 2025 High Precision NMR Teslameter

REQ 5000 Start

Summary: Shall support Metrolab PT 2025 High Precision NMR Teslameter System.

Description: The system shall support Metrolab PT 2025 High Precision NMR Teslameter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 2000

REQ 5000 End

REQ 5020 Start

Summary: Shall support both Local and Remote modes.

Description: The system shall support both local and remote modes of the Metrolab PT 2025 High Precision NMR Teslameter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 5000

REQ 5020 End

REQ 5040 Start

Summary: Shall support both Manual and Auto modes.

Description: The system shall support both Manual and Auto modes of the Metrolab PT 2025 High Precision NMR Teslameter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 5000

REQ 5040 End

REQ 5060 Start

Summary: Shall support switch of the Field Sense (Polarity).

Description: The system shall support the selection of the Field Sense of the Metrolab PT 2025 High Precision NMR Teslameter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 5000

REQ 5060 End

REQ 5080 Start

Summary: Shall support Multiplexer Channel selection

Description: The system shall support the selection of any specific Multiplexer Channel of the Metrolab PT 2025 High Precision NMR Teslameter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 5000

REQ 5080 End

REQ 5100 Start

Summary: Shall support Multiplexer Range selection

Description: The system shall support the selection of a specific multiplexer range of the Field Sense of the Metrolab PT 2025 High Precision NMR Teslameter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 5000

REQ 5100 End

REQ 5120 Start

Summary: Shall support Search and Quit Search Mode selection

Description: The system shall support the Search and Quit Search Mode selection of the Field Sense of the Metrolab PT 2025 High Precision NMR Teslameter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 5000

REQ 5120 End

REQ 5140 Start

Summary: Shall support Initialization and Reset.

Description: The system shall support Initialization and Reset of the Metrolab PT 2025 High Precision NMR Teslameter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 5000

REQ 5140 End

REQ 5160 Start

Summary: Shall support Probe Automatic Positioning.

Description: The system shall support Probe Automatic Positioning based upon the selected field range at the Metrolab PT 2025 High Precision NMR Teslameter.

Satisfies REQ: 5000, 6060

REQ 5160 End

REQ 5180 Start

Summary: Shall support the *current control mode, current field reading in Tesla, lock-on status, field sense, active probe number, active channel number, and error messages* readout.

Description: The system shall support *current control mode, current field reading in Tesla, lock-on status, field sense, active probe number, active channel number, and error messages* readout from the Metrolab PT 2025 High Precision NMR Teslameter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 5000, (Motorized Stage REQs)

REQ 5180 End

4.3.4 NMR Probe Support Stage System

REQ 6000 Start

Summary: Shall support the Z-direction motion control.

Description: The system shall support the control of an Animatics SmartMotor Servo Motor via an RS-232 interface, which drives the stage Z-direction.

Satisfies REQ: 2100

REQ 6000 End

REQ 6020 Start

Summary: Shall support the manual Z-direction motion control in 1/10 millimeter.

Description: The system shall support the control of the Z-direction SmartMotor via an RS-232 interface and provide manual step motion in 1/10 of millimeter, in both directions.

Satisfies REQ: 6000

REQ 6020 End

REQ 6040 Start

Summary: Shall support the fine tune of the Z-distances between different NMR probes.

Description: The positions for the NMR probes reference to the number 1 probe are predefined. However, the system shall provide a user interface to fine tune the Z-distances between different NMR probes. The fine tuned positions shall be installed in the NVDS so the newly fine tuned position will become the predefined positions.

Satisfies REQ: 6000

REQ 6040 End

REQ 6060 Start

Summary: Shall support the automatic positioning of the NMR probes at the Z-direction.

Description: The system shall support the automatic positioning of the correct NMR probes at the Z-direction according to the predefined positions of the probes and the field range.

Satisfies REQ: 5000, 6000, 6040

REQ 6060 End

4.3.5 HP 3458A Multimeter

REQ 7000 Start

Summary: Shall support HP 3458A Multimeter.

Description: The HP 3458A Multimeter is currently used to record voltages of the measurement Hall probes. Therefore, the software system shall support HP 3458A Multimeter via IEEE 488.2 GPIB interfaces, to calibrate the measurement Hall probe systems.

Satisfies REQ: 2000

REQ 7000 End

REQ 7020 Start

Summary: Shall support both Local and Remote modes.

Description: The system shall support both local and remote modes of the HP 3458A Multimeter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 7000

REQ 7020 End

REQ 7040 Start

Summary: Shall support Initialization and Reset.

Description: The system shall support Initialization and Reset of the HP 3458A Multimeter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 7000

REQ 7040 End

REQ 7060 Start

Summary: Shall support the voltage readouts to Tesla unit conversion.

Description: The system shall support voltage readouts to Tesla unit conversion with predefined conversion parameters. The parameters can be fine tuned through its user interface. The fine tuned conversion parameters shall be installed in the NVDS so the new parameters will replace the predefined values.

Satisfies REQ: 7000

REQ 7060 End

REQ 7080 Start

Summary: Shall support the *voltage readouts and convert to Tesla unit, current status, and error messages* readout.

Description: The system shall support *voltage readouts and convert to Tesla unit, current status, and error messages* readout from the HP 3458A Multimeter via IEEE 488.2 GPIB interfaces.

Satisfies REQ: 7000

REQ 7080 End

4.4 User Interfaces

REQ 8000 Start

Summary: Shall provide Graphic User Interfaces (GUI).

Description: The system shall provide Windows XP compatible, user friendly GUI interfaces.

Satisfies REQ: 1100

REQ 8000 End

REQ 8020 Start

Summary: Shall provide a main operation window that contains all the major input and display (read only) parameters, indicators, and command buttons (switches).

Description: The system shall provide a main operation window that contains all the major input and display (read only) parameters, indicators, and command buttons (switches). The input parameter fields shall have predefined default values to start an automatic calibration scan without any fine tunings. Each input value will be parsed to make sure it is within the valid region. The display (read only) parameters, indicators shall include the system status and other major system parameters.

Satisfies REQ: 8000

REQ 8020 End

REQ 8040 Start

Summary: Shall provide multiple sub-windows for each sub-system that contains all the major input and display (read only) parameters, indicators, and command buttons (switches).

Description: The system shall provide multiple sub-windows for each sub-system that contains all the major input and display (read only) parameters, indicators, and command buttons (switches) for the specific sub-system. The input parameter fields shall have predefined default values to start an automatic calibration scan without any fine tunings. Each input value will be parsed to make sure it is within the valid region.

Satisfies REQ: 8000

REQ 8040 End

REQ 8060 Start

Summary: Shall provide online help for each input and display (read only) parameters, indicators, and command buttons (switches).

Description: The system shall provide online help for each input and display (read only) parameters, indicators, and command buttons (switches).

Satisfies REQ: 8000

REQ 8060 End

REQ 8080 Start

Summary: Shall provide real-time plot diagram window to display the calibration parameters from the MPS 853 absolute value and the value from the HP 3458A.

Description: The system shall provide real-time plot diagram window to display the calibration parameters from the MPS 853 absolute value and the value from the HP 3458A in the format of NMR lock-in field B

(Gauss) – Constant K (provided by Hall Probe manufacture) X HP 3458A Voltage Measurement vs. NMR lock-in field B (B-kV vs. B).

Satisfies REQ: 8000

REQ 8080 End

4.5 Data Files

REQ 9000 Start

Summary: Shall provide data file with compatible data format.

Description: The system shall provide calibration data file with compatible format for the Hall probe system to read and calibrate.

Satisfies REQ: 1100

REQ 9000 End

REQ 9020 Start

Summary: Each data file shall include the reference temperature, the constant k, the Hall probe zero field offset, the readings of PT 2025, and the HP 3458A.

Description: The system shall provide data files. Each data file shall include the reference temperature, the constant k, the Hall probe zero field offset, the readings of PT 2025, and the HP 3458A calibration data.

Satisfies REQ: 9000

REQ 9020 End

REQ 9040 Start

Summary: Data file shall be in ASCII format.

Description: Data file shall be in ASCII format, with three (3) columns, separated by Tabs. The columns represent the reordered data from the PT 2025 High Precision NMR Teslameter System, the Group 3 Teslameter System, and the HP3458A respectively.

Satisfies REQ: 9000

REQ 9040 End

REQ 9060 Start

Summary: Shall provide automatic data head to each calibration data file.

Description: The system shall provide data file, a file head with user comments, calibration start and end field, time stamps, and other information to each calibration data file.

Satisfies REQ: 9000

REQ 9060 End

5 Open Issues

6 Acronym List

APS	Advanced Photon Source
GPIB	General Purpose Interface Bus
GUI	Graphic User Interface
ID	Insertion Device
NMR	Nuclear Magnetic Resonance