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**ATLAS Operator Interface Requirements Specification**

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# INTRODUCTION

An operator interface for the Argonne Tandem Linac Accelerator System (ATLAS) utilizing Control System Studio Best Operator Interface Yet (CSS BOY) is required to control and monitor the ATLAS hardware.

## Purpose

This document describes the design requirements of the operator interface for the ATLAS project. The interface is a GUI built on an Eclipse framework called CSS BOY which will interface with EPICS.

## Scope

The interface will be built using CSS BOY from <http://ics-web.sns.ornl.gov/css/products.html> . Although system interfaces are common at Argonne, the use of CSS BOY is new and therefore may require insight into system limitations and deployment structure. Because many of the widgets and display components for ATLAS have already been chosen, the interface will be designed with these specific components in mind.

## Assumptions and Constraints

### Assumptions

Before the operator interface design can begin, the specification requirements document must first be completed and all interested parties must agree to the information contained herein.

Functional testing of the operator interface can be performed using an EPICS soft IOC.



### Constraints

Time constraints?

## Document Overview

The design methodology will be briefly described before presenting the details of the functional requirements. A section for other requirements will be presented.

The appendices include a glossary of terms used throughout this document as well as interface design diagrams.

Table 1: Summary of functional requirements

# DESIGN METHODOLOGY

This document was developed through communications with members of the Magnetic Devices Group. The information contained herein was provided in particular, by Matt Kasa and Chuck Doose who are currently working hands on with the device prototype. Information was also obtained from ICMS.

# FUNCTIONAL REQUIREMENTS

# User Requirements

There are several different types of users from the standpoint of the control system and they include machine physicists, beamline users, and maintenance personnel. All of these users will generally have the same requirements, differences will be noted.

SCU1.9 Beamline user control shall be in units of energy (eV)

SCU2.0 Machine physicists and SCU0 team shall have control over main coil in (Amps)

SCU2.1 User display shall be either MEDM or CSS BOY to comply with APS standards

## Main Power Supply

SCU 1.0 Main power supply requirements:

SCU 1.0.1 Remote communications interface.

This will allow for remote control/monitoring of the main power supply

Shall use an IEEE standard communication protocol.

(Preferred interfaces RS232 or Ethernet TCP/IP)

SCU 1.0.2 Remote and local enable/disable of power supply output.

This feature will likely be used for maintenance and storage-ring operations for to disable device operation during studies and possible maintenance periods.

SCU 1.0.3 Remote reset capability.

The control shall provide a reset for over voltage conditions which can ocurr due to superconductor quenching

SCU1.0.4 Output Voltage Range

The output voltage to the main coil of the device shall have a remote and locally adjustable range of 0 – 5 VDC.

Analog voltage used to program current output

SCU1.0.5 Remote and local voltage read backs

The power supply shall have both remote and local readbacks for the output coil voltage of 0 – 5 VDC.

SCU1.0.6 Over Voltage Protection

The power supply shall have an output over voltage protection which can be adjusted both locally and remotely between 0.12 – 5 VDC

SCU1.1 **Current Control**

The main coil power supply shall have an adjustable current control which can be adjusted both locally and remotely.

SCU1.1.1 Output Current Range

The main coil power supply shall have an output current range of 0 – 850 Amps DC.

SCU1.1.2 Current Read Back Values

The main coil power supply shall have current read backs available both locally and remotely with a range of 0 – 805 Amps DC.

SCU1.2 **Current Ramping Control**

The main coil power supply shall have remote current ramping capability.

SCU1.2.1 Up/Down Current Ramping

The main coil power supply shall have the capability of providing remote current ramping using analog voltage control.

The main coil power supply shall have a slew rate of the lesser value between what the APS storage-ring will permit during beam operations and 10 Amps/second. This will insure not only minimal storage-ring beam disturbance but also that the main coil magnet does not quench; this can occur in about 10 ms. [3]

Note:

Existing power supply is Agilent 6680A which only has a GPIB interface, output voltage range of 0 – 5 VDC, output current range of 0 – 875 amps, programming accuracy of voltage 0.04% + 5mv and current of 0.1% + 450ma, 1.5mv rms ripple and 10mv pk-pk. There is a desire to use this power supply due to a low ripple current.

SCU1.3 **Correction Power Supply**

SCU1.3.1 Corrector Power Supply Synchronization

The corrector coil supply(s) shall be sychronized to the main coil power

supply according to lookup table provided my Magnetic Devices group.

SCU1.3.2 Corrector Supply Output Current Range

The corrector power supply has an output current range between 0 – 100

Amps DC.

SCU1.3.3 Corrector Supply Current Readbacks

The corrector power supply shall have both local and remote current

readbacks in the range of 0 – 100 Amps DC.

SCU1.3.4 Corrector Supply Voltage Output

The corrector power supply shall have a voltage output range of 0 – 10

VDC.

SCU1.3.5 Corrector Supply Voltage Readbacks

The coorector supply shall have both local and remote readbacks in the

range of 0 – 10 VDC.

SCU1.3.6 Overvoltage Protection

The corrector supply shall have an adjustable overvoltage protection

setpoint range between 0.12 – 10 VDC which can be adjusted locally and

remotely.

SCU1.4 **Cryogenic Temperature Monitoring**

The cryogenic temperature monitoring system must meet all requirements within this section SCU1.4.

SCU1.4.1 Maximum Number of Temperature Sensors

There shall be a maximum of 32 temperature sensors located in various places within the cryogenic chamber. These locations can be found in Figure 3 in Appendix B at the end of this document.

SCU1.4.2 Temperature Range

The temperature range to be measured is between 4 – 300 Kelvin

SCU1.4.3 Temperature Measurement Resolution

The control system shall have a 0.1 Kelvin measurement resolution

between 4 – 150 Kelvin otherwise 1 Kelvin

SCU1.4.4 Temperature Measurement Speed

The control system shall provide a minimum of one reading per second

per sensor

SCU1.4.5 Temperature Measurement Accuracy

All temperature measurements shall have an accuracy of ±0.3 Kelvin

between 4 – 150 Kelvin, otherwise best effort.

SCU1.4.6 Parallel Measurements

All temperature measurements can be performed 8 at a time in parallel

from each of up to 4 temperature monitor devices.

SCU1.4.7 Remote and Local Temperature Read Back

Local temeperature read backs shall be available for local operation of the

SCU0 ID. Remote temperature read backs shall be available using a

standard IEEE communication protocol with RS232 being preferred.

SCU1.4.8 Hardware Alarm Outputs

High temperature hardware alarm outputs must be provided for each

temperature sensor

Note:

Currently using the [Lakeshore Model 218s](https://icmsdocs.aps.anl.gov/docs/groups/anl/@apsshare/@magneticdevices/documents/manual/aps_1418321.pdf) (APS\_1418321) temperature monitor which could have GPIB, IEEE-488 or RS232 interface with over temperature alert for each sensor.

SCU1.5 **Liquid Helium (LHe) Level Monitoring**

Liquid helium level shall be maintained for device cooling with the monitoring

being performed by a hardware device with an RS232 or Ethernet IEEE standard

interface to the control system for value readback

SCU1.5.1 Level Monitoring Accuracy

The control system shall provide accuracy of level monitoring appopriate

for the hardware device providing measurements.

SCU1.5.2 Level Monitoring Resolution

The control system shall provide a monitoring resolution appropriate for

the hardware device providing measurmemnts and measurements shall be

in cm.

SCU1.5.3 Remote and Local Level Read Backs

LHe level read backs shall be present both locally and through a standrad remote interface in compliance with SCU1.4.7.

SCU1.5.4 Hardware Alarm Outputs

To be provided to the control system by the monitoring device with the

threshold value to be determined

SCU1.5.5 Maximum Number of Devices

There shall be a maximum of 2 LHe level monitors to be used in the

system

Note:

Currently using [American Magnetics Model AMI-135-2K](https://icmsdocs.aps.anl.gov/docs/groups/anl/@apsshare/@magneticdevices/documents/manual/aps_1418323.pdf) (APS\_1418323) with the following specifications:

* resolution of 0.1%, 0.1cm, or 0.1 inches
* Hi/Lo alarm relay outputs rated at 30 VAC or 60 VDC up to 0.5 amps max
* Sample and hold time from 0.1 to 600 minutes or hours
* Analog output of 0 – 10 VDC 16-bit resolution with an error of ±1.1% and a voltage drift of 100ppm per degree C.
* 4 – 20ma analog output at 24 VDC and a resoultion of 16-bits with an error of ±0.25% and current drift of 75ppm per degree C.
* Input power requirement of 90 – 132 VAC
* 19-inch rack mounted

SCU1.6 **Main Coil DC Current Transducer**

Currently using an obsolete [Ultrastab 860R](http://www.gmw.com/electric_current/Danfysik/860_862/860.html) manufactured by Danfisyk and it is unclear which exact model is going used if any. These units have status, interlock, and analog output connectors. This would be used to monitor output current from both the main and the correector power supplies.

A current transducer may not be used at all but rather a analog output from the power supplies could be used to provide the current output feed back required for control of the main coil supply.

SCU1.6.1 Main Coil Current Transducer Communications

The communications shall be IEEE standard compliant or analog.

The exisitng device has a GPIB interface as well as 0 – 1 VDC analog

output voltage that is proportional to the current being measured.

SCU1.7 **Magnet Voltage Tap Read Backs**

Remote read back of magnet voltage taps shall be provided; the range is 0 – 10

VDC

SCU1.8 **Heater Current Power Supply**

The power supply for the heater current shall provide 20 VDC output at a

maximum current of 2 Amps.

SCU1.9, SCU2.0, and SCU 2.1 were previous discussed in this document.

SCU3.0 **Interlocks**

All deivce interlocks shall be performed using hardware optionally being

processed by a microprocesor for decision making if necessary. This section

describes the types of interlocks required by the system.

SCU3.1 Magnet Interlocks

The following table provides information on magnet interlocks

|  |  |  |  |
| --- | --- | --- | --- |
| **Sub-system** | **Event** | **Signal** | **Action** |
| Magnet | Magnet overheat | (TT19 OR TT20) > Tmax2 | Start current ramp down |
|  | Quench | Power supply over-voltage trigger | Start current ramp down |
|  | Main coil voltage increase | (V7) or (V8) > Vmax1 | Start current ramp down |
|  | Corrector coil voltage increase | VT9or VT10 > Vmax2 | Start current ramp down |

Table 2: Magnet Interlocks

SCU3.3 LHe Tank Level

When the liquid helium level is less than Lmin2 (TBD) ramp main power

supply to zero amps. LI1 or LI2 < Lmin2.

SCU3.4 **Current Leads**

The following table provides information about the current leads to the

magnets of the device.

|  |  |  |
| --- | --- | --- |
| HTS current lead overheat: |  |  |
| 500A HTS lead 1 | (TT09 – TT02) > T2max2 | Start current ramp down |
| 500A HTS lead 2 | (TT10 – TT02) > T2max2 | Start current ramp down |
| 100A-US HTS lead 1 | (TT13 – TT04) > T1max2 | Start current ramp down |
| 100A-US HTS lead 2 | (TT14 – TT04) > T1max2 | Start current ramp down |
| 100A-DS HTS lead 1 | (TT11 – TT04) > T1max2 | Start current ramp down |
| 100A-DS HTS lead 2 | (TT12 – TT04) > T1max2 | Start current ramp down |
| HTS current lead overvoltage |  |  |
| 500A HTS lead1 | VT1 > Vmax3 | Start current ramp down |
| 500A HTS lead2 | VT2 > Vmax3 | Start current ramp down |
| 100A-DS HTS lead1 | VT3 > Vmax4 | Start current ramp down |
| 100A-DS HTS lead2 | VT4 > Vmax4 | Start current ramp down |
| 100A-US HTS lead1 | VT5 > Vmax4 | Start current ramp down |
| 100A-US HTS lead2 | VT6 > Vmax4 | Start current ramp down |

Table 3: Current Lead Interlocks

SCU4.0 **Warnings**

The following table shows the warning information that the control system shall provide.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sub-system** | **Event** | **Signal** | **Action** |
| Beam chamber | Beam chamber is hot | (TT21 OR TT22 OR TT23 ) > Tbc max | Start warning image on control panel (SWI) |
|  |  |  |  |
| Magnet | Coils are warm | (TT19 OR TT20) > Tmax1 | SWI |
|  |  |  |  |
| Current leads | HTS current lead overheat: |  |  |
|  | 500A HTS lead 1 | (TT09 – TT02) > T2max1 | SWI |
|  | 500A HTS lead 2 | (TT10 – TT02) > T2max1 | SWI |
|  | 100A-US HTS lead 1 | (TT13 – TT04) > T1max1 | SWI |
|  | 100A-US HTS lead 2 | (TT14 – TT04) > T1max1 | SWI |
|  | 100A-DS HTS lead 1 | (TT11 – TT04) > T1max1 | SWI |
|  | 100A-DS HTS lead 2 | (TT12 – TT04) > T1max1 | SWI |
|  |  |  |  |
| Radiation shields | Shield is hot: |  |  |
|  | 60K shield | TT24 > TT24max | SWI |
|  | 20K shield | TT25 > TT25max | SWI |
|  |  |  |  |
| LHe tank | LHe level is low | LI1 < Lmin2 | SWI |
|  | LHe level is low | LI2 < Lmin2 | SWI |
|  | Pressure is high | PT2 > PT2max | SWI |
|  | Recondenser temperature is high | TT15 > TT15max | SWI |
|  | Tank temperature is high | TT16 > TT16max | SWI |
|  |  |  |  |
| Cryostat vessel | Insulating vacuum is poor | PT1 > P1max | SWI |
|  |  |  |  |
| Cryocoolers | Stage is hot: |  |  |
|  | Cryocooler DS TOP – 1st stage | TT01 > TT01max | SWI |
|  | Cryocooler DS TOP – 2nd stage | TT02 > TT02max | SWI |
|  | Cryocooler US TOP – 1st stage | TT03 > TT03 max | SWI |
|  | Cryocooler US TOP – 2nd stage | TT04 > TT04 max | SWI |
|  | Cryocooler DS BOT – 1st stage | TT05 > TT05max | SWI |
|  | Cryocooler DS BOT – 2nd stage | TT06 > TT06max | SWI |
|  | Cryocooler US BOT – 1st stage | TT07 > TT07 max | SWI |
|  | Cryocooler US BOT – 2nd stage | TT08 > TT08 max | SWI |
|  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| Cryocooler compressors |  |  |  |
|  | Compressor DS TOP | CI1 = High | SWI |
|  | Compressor DS TOP | CI2 = High | SW1 |
|  | Compressor DS TOP | CI3 = High | SW1 |
|  | Compressor DS TOP | CI4 = High | SW1 |
|  | Compressor US TOP | CI5 = High | SWI |
|  | Compressor US TOP | CI6 = High | SWI |
|  | Compressor US TOP | CI7 = High | SWI |
|  | Compressor US TOP | CI8 = High | SWI |
|  | Compressor DS BOT | CI9 = High | SWI |
|  | Compressor DS BOT | CI10 = High | SWI |
|  | Compressor DS BOT | CI11 = High | SWI |
|  | Compressor DS BOT | CI12 = High | SWI |
|  | Compressor US BOT | CI13 = High | SWI |
|  | Compressor US BOT | CI14 = High | SWI |
|  | Compressor US BOT | CI15 = High | SWI |
|  | Compressor US BOT | CI16 = High | SWI |

(Threshold parameters to be defined)

Table 4: SCU0 Warnings Provided

# OTHER REQUIREMENTS

# Hardware Interfaces

A power supply controller is being developed by the Power Supply Group. The controller will be responsible for synchronizing the corrector coil power supplies with the main coil power supplies as well as providing electronic level interlock logic. The preferred device interface is either RS232 or Ethernet, although the currently selected main power supply only has a GPIB interface available.

For the RS232 type devices the communication could be over Ethernet to a Moxa box (Ethernet to serial port converter) and be monitored and controlled via a soft Input Output Controller (IOC) running on a workstation or laptop computer.

The main power supply which has a GPIB interface (if used) would most likely be an Ethernet to GPIB converter which could also be monitored and controlled via a soft IOC.

It is not clear at this time that a VME crate would be required for actual hardware input/output since the devices currently in use typically have an external interface and are commercially available off the shelf (COTS).

# Software Interfaces

Currently there is not an interface control document which specifies the software interfaces but for APS all interfaces would be compatible with other APS project applications and would use the EPICS software toolkit which would be developed, deployed, and maintained by the AES Controls Group.

# Communications Interfaces

This control shall be capable of communicating information to and from the system via the LAN using the EPICS Channel Access (CA) communication protocol.

# Hardware/Software Requirements

If a soft IOC were to be used then the system would require an already existing workstation for the IOC to run on; however, if other hardware I/O were to be required then the hardware platform would most likely be the standard APS VME64x rack mounted crate manufactured by Dawn VME Products. The workstation would likely be running Red Hat Linux Enterprise operating system while the VME crate would run the vxWorks operating system; both are compatible with EPICS.

# Operational Requirements

This control system must be operational 24/7 during APS beam time.

# Security

Standard Channel Access Security (CAS) is to be used to control which users have access to the control system operation and when. This is typical for other APS control systems.

# System Reliability

1. Magnet quenching which can occur in as little as 10ms could cause stored beam to be inadvertently dumped and should be avoided whenever possible.
2. Since the device is cooled with a closed liquid He system there exists the possibility of the vessel pressure going to a high level which should also be avoided.

# Recoverability

The foreseen failure modes of this system are related to hardware, software, and computer issues; including PV gateway problems. In the event that the system is unavailable to the user due to system failure either hardware or software system recovery must be performed in a timely manner consistent with APS call-in procedures for system recovery and repair.

In the event of a power outage all systems should be powered on with the power supply currents at zero amp output.

A clear role of system component responsibility must be conveyed to those that will be responsible for the equipment required to operate the device.

# Error Handling

Any system errors should be handled automatically by the control system in a failsafe way whenever possible.

# Validation Rules

SCU3.0 System validation shall be performed after every shutdown to insure proper device operation. A clear understanding of personnel responsible for device testing should be conveyed.

# Conventions/Standards

All data formats and communication interfaces shall be IEEE compliant.

# APPENDIX A - GLOSSARY

EPICS – Experimental Physics Industrial Control System

MEDM – Motif Editor Display Manager (Standard APS EPICS Display Screens)

CSS BOY- Control System Studio, Best Operator Interface Yet

# APPENDIX B - Figures



Figure 1: SCU ID Electrical Connections

Figure 2: SCU ID Pressure Sensor Connections



Figure 3: SCU ID Temperature Sensor Diagram