ISrc and LEBT Controls - System Requirement Specification

	Name	Role/Title
Owner	Saeed Haghtalab	ICS - Control System Integrator
Reviewer	Karl Vestin Maria Romedahl	ICS - Hardware and Integration Group Leader ICS - Technical Coordinator
Approver	Timo Korhonen	ICS - Chief Engineer

TABLE OF CONTENT **PAGE**

1. SCOPE

The scope of this document is to provide the Requirement Specification for the Control System of the Ion Source and Low Energy Beam Transfer (ISrc and LEBT) system [1].

The main function of the ISrc and LEBT system is to provide a proton beam (with chopped and focused pulses) to the ESS accelerator.

2. ISSUING ORGANISATION

This document is issued by the Hardware and Integration Group in the Integrated Control System (ICS) division of ESS.

3. REQUIREMENTS

The following sections contains the requirements of the ISrc and LEBT Control System.

Requirements are identified with their device mnemonic that is the **ISRC_LEBT**, **ISRC**, **LEBT** or **ITLCK** acronym, followed by the requirement's category and a progressive counter:

- ISRC_LEBT.<CATEGORY>.<COUNTER>
- ISRC.<CATEGORY>.<COUNTER>
- LEBT.<CATEGORY>.<COUNTER>
- ITLCK.<CATEGORY>.<COUNTER>

Two requirement categories are identified. Not all categories (and sub-categories) are used by all device mnemonic.

- Constraint Requirements (CON)
- Control (Functionality) Requirements (CTRL)

This requirement document has been created based on the signal lists in ref [2]. Please note that Vacuum and Cooling control systems are not in the scope of current document.

The design of the Control System for the Ion Source and LEBT shall follow the ICS Handbook[3]. However, this control system can be designed with following exceptions. These exceptions are motivated by resource availability at the time of design and should be ported to the ICS standard noted in ICS Handbook as soon as possible.

- VME architecture can be used instead of the µTCA;
- Motion controls for the LEBT can be based on Delta Tau Geobrick solution instead of Beckhoff EtherCAT;
- A local timing system can be used instead of global ICS timing system for tests in Catania;
- A local protection system can be used and there should be the consideration for ESS MPS/PSS interfaces in Lund;

3.1. Constraint Requirements

3.1.1. ISRC_LEBT Constraint Requirements

Id	Text	Trace up to
General		
ISRC_LEBT.CON.001	The Control System shall follow all the SW and HW technologies described in ICS Handbook [5] except those mentioned in 3Requirements section above.	ICS Handbook[3]
ISRC_LEBT.CON.002	The Control System shall provide the timing event/signal to the following subsystems: - Magnetron - Chopper	
ISRC_LEBT.CON.003	It shall be possible for the timing system to select the repetition rate of the main pulse in range of [1-14] Hz.	
ISRC_LEBT.CON.004	Until the time that ESS timing system gets ready, The Ion Source and LEBT control system shall provide timing event/signal to following Beam Diagnostics instrument located in LEBT: - FC - BCM - EMU - DPL - NPM	
ISRC_LEBT.CON.005	An individual GUI shall be provided for each subsystem of Ion Source and LEBT like Solenoids, Magnetron, iris etc. with detailed relevant information for each of them.	

3.2. Functional Requirements

3.2.1. ISRC Control Requirements

Id	Text	Trace up to
General		
ISRC.CTRL.001	The GUI shall be provide as “Ion Source” that have an overview of all equipment required for operating the Ion Source. This page shall contain only those information that are frequently used during operation.	
Magnetron		
ISRC.CTRL.100	It shall be possible for the timing system to select length (ms) of the main pulse in range of [1 - 57] ms.	
ISRC.CTRL.101	It shall be possible to operate the magnetron in both pulsed and continuous mode.	
ISRC.CTRL.102	It shall be possible to set the "Forward Power" provided by the Magnetron in range of [0 - 2000] W.	
ISRC.CTRL.103	It shall be possible to monitor the measured "Forwarded Power" provided by the Magnetron in range of [0-2000] W.	

Id	Text	Trace up to
ISRC.CTRL.104	It shall be possible to monitor the measured "Reflected Power" provided by the Magnetron in range of [0-2000] W.	
ISRC.CTRL.105	It shall be possible to Enable / Disable the "Filament" of the Magnetron.	
ISRC.CTRL.106	It shall be possible to Switch On / Off the Magnetron.	
ISRC.CTRL.107	It shall be possible to monitor the status of connection, as connection is OK / notOK.	
ISRC.CTRL.108	It shall be possible to monitor the status of filament, as filament Ready / not Ready.	
ISRC.CTRL.109	It shall be possible to monitor the status of microwaves generation, as microwave On / Off.	
ISRC.CTRL.110	It shall be possible to monitor the status of the RF Generator's fault, as Generator OK / notOK.	
ISRC.CTRL.111	It shall be possible to set the pulse low level in range of [0-2000] W.	
ISRC.CTRL.112	It shall be possible to set the pulse high level in range of [0-2000] W.	
Automatic Tuning Unit (ATU)		
ISRC.CTRL.200	It shall be possible to operate with the ATU in both Manual and Automatic Mode.	
ISRC.CTRL.201	When operating in Manual mode, it shall be possible to adjust the X and Y position of the ATU in range of [0-10000] unit.	
ISRC.CTRL.202	It shall be possible to monitor the actual X and Y position of the ATU in range of [0-10000] unit.	
ISRC.CTRL.203	It shall be possible to Enable/Disable the adjustment of the ATU on both axis.	
ISRC.CTRL.204	It shall be possible to monitor the status of the ATU as OK / notOK.	
Repeller Extraction Power Supply		
ISRC.CTRL.300	It shall be possible to set the "Target Voltage" of the Repeller's Power Supply in range of [-3500 - 0] V.	
ISRC.CTRL.301	It shall be possible to set the "Maximum current" of the Repeller's Power Supply in range of [0 - 10] A.	
ISRC.CTRL.302	It shall be possible to monitor the actual "Voltage" of the Repeller's Power Supply in range of [-3500 - 0] V.	
ISRC.CTRL.303	It shall be possible to monitor the actual "Current" of the Repeller's Power Supply in range of [0 - 10] A.	
ISRC.CTRL.304	It shall be possible to Switch On / Off the Repeller's Power Supply.	
ISRC.CTRL.305	It shall be possible to monitor the status of the Repeller Power Supply as OK / notOK.	
Magnetic System (coils) in HV Platform		
ISRC.CTRL.400	It shall be possible to set the "Maximum Voltage" of each coil's Power Supply in range of [0 - 10] V.	
ISRC.CTRL.401	It shall be possible to set the "Current Target" of each coil's Power Supply in range of [0 - 500] A.	

Id	Text	Trace up to
ISRC.CTRL.402	It shall be possible to monitor the actual "Voltage" of each coil's Power Supply in range of [0 - 10] V.	
ISRC.CTRL.403	It shall be possible to monitor the actual "Current" of each coil's Power Supply in range of [0 - 500] A.	
ISRC.CTRL.404	It shall be possible to independently Switch On / Off each coil's Power Supply.	
ISRC.CTRL.405	It shall be possible to monitor the status of each coil's Power Supply as OK / notOK.	
ISRC.CTRL.406	It shall be possible to set an "Over Voltage Protection" threshold for each coil's Power Supply in range of [1 - 15] V. The power supply shall immediately turn off the output if the output exceeds this voltage.	
High Voltage Power Supply		
ISRC.CTRL.500	It shall be possible to set the "Target Voltage" of the High Voltage Power supply in range of [0 - 100] kV.	
ISRC.CTRL.501	It shall be possible to set the "Maximum Current" of the High Voltage Power supply in range of [0 - 150] mA.	
ISRC.CTRL.502	It shall be possible to monitor the actual "Voltage" of the High Voltage Power supply in range of [0 - 100] kV.	
ISRC.CTRL.503	It shall be possible to monitor the actual "Current" of the High Voltage Power supply in range of [0 - 150] mA.	
ISRC.CTRL.504	It shall be possible to monitor the status of the High Voltage Power Supply as OK / notOK.	
ISRC.CTRL.505	It shall be possible to select the operation mode of the High Voltage Power Supply between "Normal" and "Ramp".	
ISRC.CTRL.506	When set in Ramp mode, it shall be possible to configure the ramp speed in range of [0-1000] V/s	
ISRC.CTRL.507	It shall be possible to power On / Off the High Voltage Power Supply.	
Temperature Monitors		
ISRC.CTRL.600	It shall be possible to monitor the Plasma chamber temperature on the High Voltage platform.	
ISRC.CTRL.601	It shall be possible to monitor the coils temperature on the High Voltage platform.	
ISRC.CTRL.602	It shall be possible to monitor the Matching transformers' temperature on the High Voltage platform.	
ISRC.CTRL.603	It shall be possible to monitor the water temperature on the High Voltage platform.	
ISRC.CTRL.604	It shall be possible to monitor the ambient temperature.	
ISRC.CTRL.605	It shall be possible to monitor the Dew point temperature.	
H2 Injection System in HV Platform		
ISRC.CTRL.700	It shall be possible to read the vacuum level of H2 Injection system. A [0 - 10] V signal corresponding to the vacuum level shall be provided for control system.	
ISRC.CTRL.701	It shall be possible monitor the vacuum status of H2 Injection system as Vacuum Ok / notOK.	
ISRC.CTRL.702	It shall be possible to Open / Close the H2 Isolation valve.	

Id	Text	Trace up to
ISRC.CTRL.703	It shall be possible to get the H2 Isolation valve feedback as Closed / Opened.	
ISRC.CTRL.704	It shall be possible to set the H2 flow rate in range of [0 - 1000] sccm.	
ISRC.CTRL.705	It shall be possible to monitor the actual H2 flow rate in range of [0 - 1000] sccm.	

3.2.2. LEBT Control Requirements

Id	Text	Trace up to
General		
LEBT.CTRL.001	The GUI shall be provide as “LEBT” that have an overview of all equipment required for operating the LEBT. This page shall contain only those information that are frequently used during operation.	
LEBT.CTRL.002	The Control System of the LEBT shall be able to control the Solenoids.	
LEBT.CTRL.003	The Control System of the LEBT shall be able to control the Steerers.	
LEBT.CTRL.004	The Control System of the LEBT shall be able to control the Iris. The Control System of the LEBT shall be able to control the Chopper.	
Solenoids		
LEBT.CTRL.100	It shall be possible to set the "Maximum Voltage" of each solenoid's Power Supply in range of [0 - 30] V.	
LEBT.CTRL.101	It shall be possible to set the "Target current" of each solenoid's Power Supply in range of [0 - 500] A.	
LEBT.CTRL.102	It shall be possible to monitor the actual "Voltage" of each solenoid's Power Supply in range of [0 - 30] V.	
LEBT.CTRL.103	It shall be possible to monitor the actual "Current" of each solenoid's Power Supply in range of [0 - 500] A.	
LEBT.CTRL.104	It shall be possible to Enable / Disable the output of each solenoid's power supply.	
LEBT.CTRL.105	It shall be possible to set an "Over Voltage Protection" threshold for each solenoid's Power Supply in range of [0 – 30] V. The power supply will immediately turn the output off if the output exceeds this voltage.	
LEBT.CTRL.106	It shall be possible to monitor if “Over Voltage Protection" turned off the output or not.	
LEBT.CTRL.107	It shall be possible to monitor the status of each solenoid’s Power Supply as OK / notOK.	
LEBT.CTRL.108	It shall be possible to set the control mode of each solenoid's Power Supply in "Local" or "Remote". In Local mode, the power supply can be controlled from its front panel and in Remote mode, the power supply shall be controlled via LAN and SCPI commands.	

Id	Text	Trace up to
LEBT.CTRL.109	It shall be possible to monitor the control mode of each solenoid’s Power Supply in "Local" or "Remote".	
Steerers		
LEBT.CTRL.200	It shall be possible to set the "Maximum Voltage" of each steerer's Power Supply in range of [0 - 12.5] V	
LEBT.CTRL.201	It shall be possible to set the "Target current" of each steerer's Power Supply in range of [0 - 120] A.	
LEBT.CTRL.202	It shall be possible to monitor the actual "Voltage" of each steerer's Power Supply in range of [0 - 12.5] V.	
LEBT.CTRL.203	It shall be possible to monitor the actual "Current" of each steerer's Power Supply in range of [0 - 120] A.	
LEBT.CTRL.204	It shall be possible to set an "Over Voltage Protection" threshold for each steerer's Power Supply in range of [1 - 15] V. The power supply will immediately turns the output off if the output exceeds this voltage.	
LEBT.CTRL.205	It shall possible to monitor if “Over Voltage Protection" turned off the output or not.	
LEBT.CTRL.206	It shall be possible to Enable / Disable the output of each steerer's power supply.	
LEBT.CTRL.207	It shall be possible to reverse the polarity of each steerer's Power Supply.	
LEBT.CTRL.208	It shall be possible to monitor the status of each steerer's Power Supply as OK / notOK.	
LEBT.CTRL.209	It shall be possible to set the mode of each solenoid's Power Supply in "Local" or "Remote". In Local mode, the power supply can be controlled from its front panel and in Remote mode, the power supply shall be controlled via LAN and SCPI commands.	
LEBT.CTRL.210	It shall be possible to monitor the control mode of each solenoid’s Power Supply in "Local" or "Remote".	
Chopper		
LEBT.CTRL.300	It shall be possible to Enable / Disable the Chopper HV power supply.	
LEBT.CTRL.301	It shall be possible to monitor the status of Chopper Power Supply as OK / notOK.	
LEBT.CTRL.302	It shall be possible to set the Chopper HV power supply in range of [0 - 10] kV.	
LEBT.CTRL.303	It shall be possible to monitor the actual Chopper HV power supply in range of [0 - 10] kV.	
LEBT.CTRL.304	It shall be possible to monitor the current of the HV platform connected to the Chopper.	
LEBT.CTRL.305	It shall be possible to set the delay of the pulse generated by timing system for Chopper in range of [0 - 1] s.	
LEBT.CTRL.306	It shall be possible to set the length of the pulse generated by the Chopper in range of [1 - 57] ms.	
LEBT.CTRL.307	It shall be possible to monitor the Chopping voltage alarm as OK / notOK.	

Id	Text	Trace up to
Iris		
LEBT.CTRL.400	It shall be possible to set the aperture of the Iris in range of [1 - 76] mm.	
LEBT.CTRL.401	It shall be possible to set the speed of the Iris in range of [1 - 5] mm/s.	
LEBT.CTRL.402	It shall be possible to monitor the current aperture of the Iris in range of [1 - 76] mm.	
LEBT.CTRL.403	It shall be possible to run an initialization procedure to put all motors in their max position automatically (iris wide open, 76mm of aperture).	
LEBT.CTRL.404	It shall be possible to monitor if the initialization process is running or not.	
LEBT.CTRL.405	It shall be possible to reset the motion controller of the Iris in order to save the current data and reset/restart the motion controller.	
LEBT.CTRL.406	It shall be possible to monitor if Iris blades are moving or not.	
LEBT.CTRL.407	It shall be possible to monitor if there is cabling issue or not.	
LEBT.CTRL.408	It shall be possible to emergency stop the iris while blades are moving.	
LEBT.CTRL.409	It shall be possible to monitor if motors are at Min/Max limit or not for all 6 motors.	
LEBT.CTRL.410	It shall be possible to monitor if each motors are in their final position or they are moving yet.	
LEBT.CTRL.411	It shall be possible to set an offset for each blade of the Iris in range of [-42 - 42] mm.	
LEBT.CTRL.412	It shall be possible to adjust the centre of the Iris in range of [-20 - 20] mm.	
LEBT.CTRL.413	It shall be possible to select between "Triangular" and "Flat" blades kind.	
LEBT.CTRL.414	There shall be a representation of all 6 blades in Iris GUI that shows the actual shape of the Iris.	

3.2.3. Interlocks Requirements

Id	Text	Trace up to
General		
ITLCK.CTRL.001	Each potential control system problem shall be considered in interlock system and shall be classified in an event.	
ITLCK.CTRL.002	Each event has to have one or more inputs (that causes that interlock event) and one or more outputs (that are the actions that should be taken against inputs) to mitigate the problems.	
ITLCK.CTRL.003	Each event shall be memorized and must be acknowledged/rearmed by operator.	
ITLCK.CTRL.004	It shall be possible to reset a fault condition once the operator acknowledges it.	

Id	Text	Trace up to
ITLCK.CTRL.005	A GUI shall be provided as “Interlock” that have an overview of the Interlock system and its events. This page shall have an indicator for status of each event.	
ITLCK.CTRL.006	It shall be an individual GUI for each Interlock events. In this GUI, all events inputs / outputs shall be specified and there shall be an indicator to show which input causes the event and which outputs turned off due to this event.	
Interlock Events		
ITLCK.CTRL.101	Interlock system shall detect the connection failure between GND PLC and remote I/O in HV platform and take proper actions in case of this failure.	
ITLCK.CTRL.102	Interlock system shall detect the connection failure between GND PLC and EPICS side and take proper actions in case of this failure.	
ITLCK.CTRL.103	The interlock system shall have an interface with MPS. This interface consists of one digital input to get MPS status and one digital output to send Interlock system status to MPS.	
ITLCK.CTRL.104	The interlock system shall have an interface with PSS. This interface consists of: - One digital input indicating the HV power supply permit. - One digital input indicating PSS status signal (OK/notOK). - One digital output to send HV power supply interlock relay (On/Off).	
ITLCK.CTRL.105	The Interlock system shall manage FC and EMU to not being inserted into vacuum chamber at the same time to avoid collision. It means that the interlock system shall send the ‘EMU/FC insert’ command to EMU/FC controllers and receive ‘EMU/FC inserted’ command from each of them.	
ITLCK.CTRL.106	The Interlock system shall have direct interface (hardwire connection) to High Voltage Power Supply to stop the power supply in case relevant events occurred.	
ITLCK.CTRL.107	The interlock system shall have an interface with water cooling system to get the water flow status as OK/notOK signal and take proper action in case of failure.	
ITLCK.CTRL.108	The interlock system shall have an interface with water cooling system to get the water temperature as OK/notOK signal and take proper action in case of failure.	
ITLCK.CTRL.109	The interlock system shall have an interface with vacuum system to get the vacuum status as OK/notOK signal and take proper action in case of failure.	
ITLCK.CTRL.110	The interlock system shall have an interface with solenoids and Steerers power supplies to get the power supply status as OK/notOK digital signal and send the Interlock OK/notOK signal to power supplies. A proper action shall be taken by interlock system based on these inputs.	

Id	Text	Trace up to
ITLCK.CTRL.111	The interlock system shall have an interface with coils power supplies in HV platform to get the power supply status as OK/notOK digital signal and send the Interlock OK/notOK signal to power supplies. Proper action shall be taken by interlock system based on these inputs.	
ITLCK.CTRL.112	It shall be possible to set an upper threshold for the temperature of the Water on the HV platform in range of [0-100]°C. In case of exceeding this temperature, the Interlock system shall take proper action.	
ITLCK.CTRL.113	It shall be possible to set an upper threshold for the temperature of the Water in GND in range of [0-100]°C. In case of exceeding this temperature, the Interlock system shall take proper action.	
ITLCK.CTRL.114	The Control system shall prevent to reverse the polarity of Steerers when the “Current” is not set to zero.	

4. GLOSSARY

Term	Definition
ATU	Automatic Tuning Unit
EMU	Emittance Measurement Unit
EPICS	Experimental Physics and Industrial Control System
FC	Faraday Cup
GND	Ground Platform
GUI	Graphical User Interface
HV	High Voltage
ICS	Integrated Control System
ISRC	Ion Source
LEBT	Low Energy Beam Transport
PS	Power Supply

5. REFERENCES

[1] *ISrc and LEBT Controls - Detailed Systems Design Document (ESS-0177833)*
[2] *Source PLC I/O List (ESS-0131500)*
[3] *ICS Handbook (ESS-0067637)*

DOCUMENT REVISION HISTORY

Revision	Reason for and description of change	Author	Date
1	First issue	Saeed Haghtalab	2018-07-04