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List of Abbreviations

| Abbreviation | Definition |
| --- | --- |
| ICS | Integrated Control Systems |
| EPICS | Experimental Physics and Industrial Control System |
| PLC | Programmable Logic Controller |
| CF | Conventional Facilities |
| MBL | Medium Beta Linac |
| HBL | High Beta Linac |
| SPK | Spoke (cryomodule) |
| CWL | Cooling Water Low temperature |
| CWM | Cooling Water Medium temperature |
| CWH | Cooling Water High temperature |
| WP16 | ACCSYS Work Package 16 |
| DTL | Drift Tube Linac |
| CS | Control System |
| IKC | In-Kind Contract |
| MPS | Machine Protection System |
| ADM | Arc Detector Module |

# Scope

The document contains the Control System Design Description of the Drift Tube Linac (DTL), the fifth component of the of the ESS linear accelerator.

This document describes requirements for the DTL control system. This document can be therefore a future reference for maintenance, adaptations and new implementation activities.

# Issuing organisation

This document is issued by Istituto Nazionale di Fisica Nucleare – Laboratori Nazionali di Legnaro (INFN-LNL).

# Context

ESS is an accelerator driven neutron spallation source. The linear accelerator, or Linac, is thus a critical component.

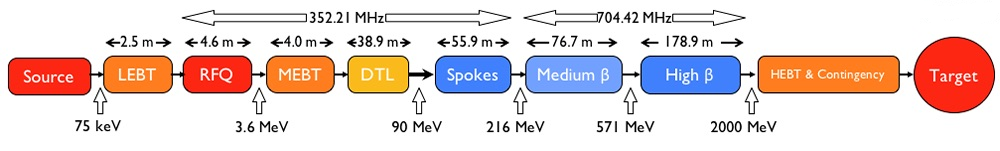


Figure 1 - Schematic picture of the different parts of the ESS machine.

This document describes the control architecture for the drift tube linac (DTL) named ESS DTL. This DTL will accelerate a proton beam with a 62.5 mA pulse peak current from 3.62 to 89.91 MeV. The DTL is designed to operate at 352.21 MHz, with a duty cycle of 4% (2.86 ms pulse length,14 Hz repetition period). Permanent magnet quadrupoles (PMQs) are used as focusing elements in a lattice scheme - that is, with half of the drift tubes left empty, leaving space for steerer magnets and beam diagnostics. Figure 2 shows a general side view of the DTL apparatus.

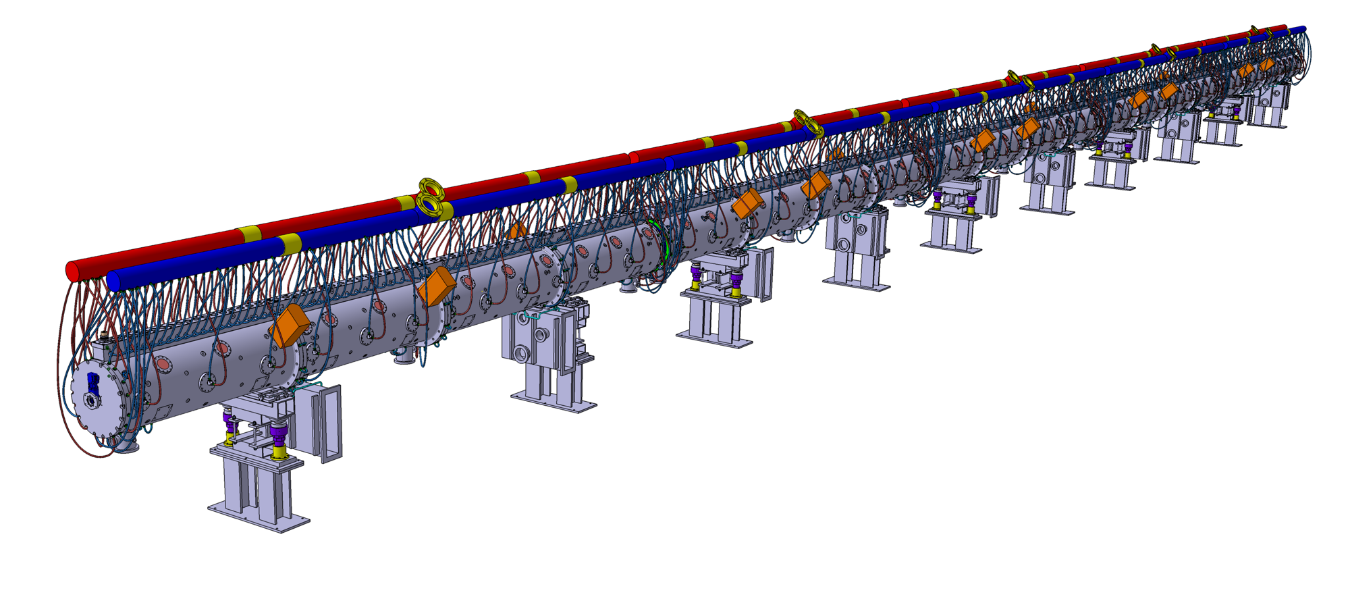


Figure 2 – 3D Mock-up of the DTL apparatus.

The entire Linac accelerator and, as consequence, the DTL requires dedicated equipment and strategies for the control. Figure 3 is a schematic synthesis of whole systems.

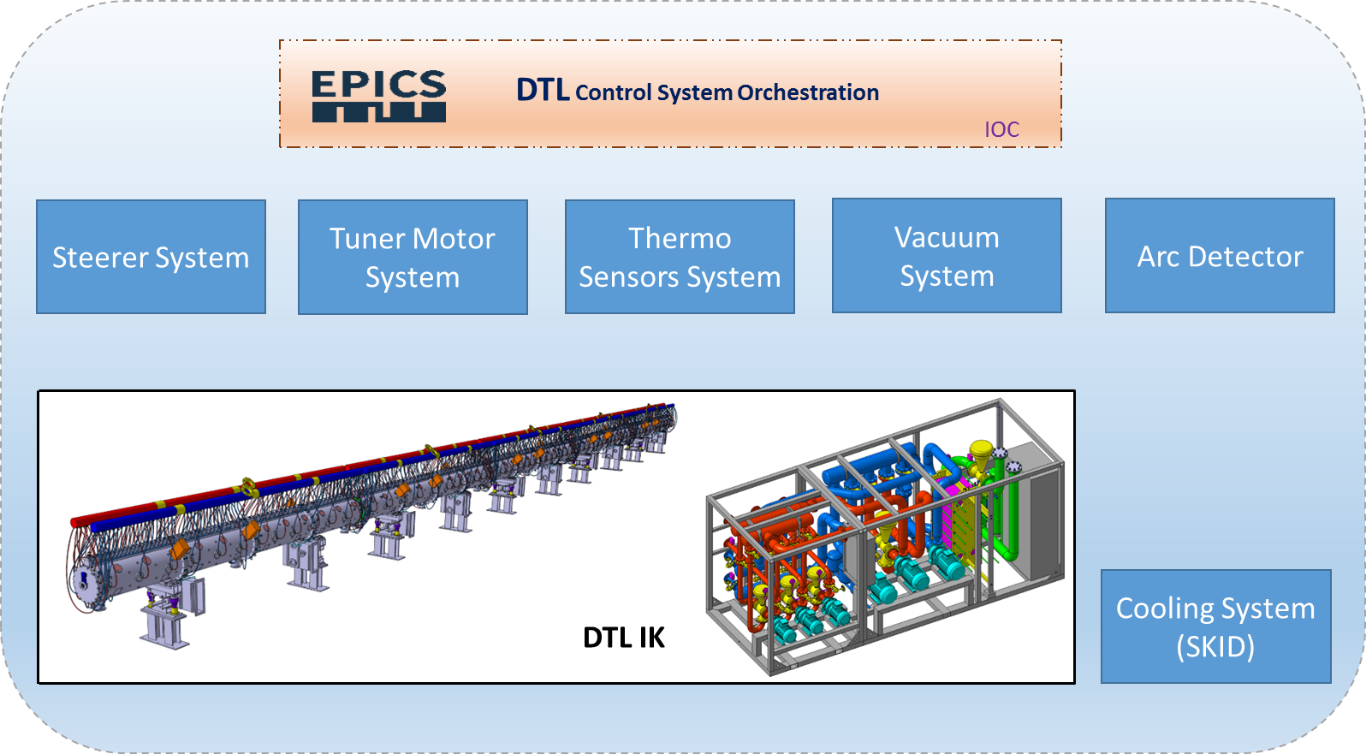


Figure 3 - A schematic picture of sub-systems composing the DTL apparatus’ interfaces.

DTL is a system interfaced (directly or indirectly) with other different apparatus composing the Normal Conducting Linac and transversal systems and services, such as vacuum and RF system, Machine Protection System and Personal Protection System, required to operate the accelerator in safety. Because of the complexity of the Project and the number of persons involved at different layers, the DTL control system design and implementation must follow precise strategies and solutions. This approach can optimise costs and time during the stages of the installation campaign.

The first step required to design the control system is to define the concepts of how DTL will operate and the different information and data exchanged with other sub-systems. Through this analysis and the usage of the Project’s documentation, the design of a control system architecture is possible.

# Control System Requirements

According to the procedures required to operate the machine in different configuration, technical requirements are divided into these categories:

* Functional Requirements
* Constraint Requirements
* Environmental Requirements
* Conventional Safety Requirements
* Radiation Safety Requirements
* Interface Requirements

**Note**: the common understanding used to evaluate the level of analogic input variable (from high to low) is the following:

* High range limit;
* HI Interlock;
* HIHI alarm – high severity;
* HIGH alarm – low severity;
* LOW alarm – low severity;
* LOLO alarm – high severity;
* LO Interlock;
* Low range limit;
* Hysteresis (of interlock thresholds);

Alarms are related to notifications to the operator and optionally trigger automatic controls, while interlocks are connected to protection systems devoted to prevent dangerous situations for the DTL apparatus.

## Functional Requirements

### Temperature Monitoring

#### Control Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.TH.CR.01 | Temperature system shall acquire 178 Pt100 temperature signals from the field |
| DTL.CTRL.TH.CR.02 | Temperature system shall have temperature precision ≤± 0.1°C |
| DTL.CTRL.TH.CR.03 | Temperature system shall provide HI interlock and hysteresis values for each of the 178 sensors |
| DTL.CTRL.TH.CR.04 | Temperature system shall verify sensor status (single or multiple temperature sensors broken) |
| DTL.CTRL.TH.CR.05 | Temperature system shall provide the possibility to bypass one or more temperature sensors |
| DTL.CTRL.TH.CR.06 | Temperature values should have low priority alarms (LO and HI) configured |
| DTL.CTRL.TH.CR.07 | Temperature system shall shut down the proper steerer power supply in case of HI interlock |
| DTL.CTRL.TH.CR.08 | Temperature system shall provide OK stat to RFLPS to enable RF power (one per DTL tank) |
| DTL.CTRL.TH.CR.09 | OK stat to RFLPS combined (AND logic) with cooling system OK Stat (DTL.CTRL.COL.CR.05) |

#### Monitoring and Graphical User Interface Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.TH.MR.01 | Control panel (CSS OPI) shall display all the 178 temperature signals |
| DTL.CTRL.TH.MR.02 | Control panel (CSS OPI) shall display alarm and interlock informations if temperature value is out of the limits |
| DTL.CTRL.TH.MR.03 | Control panel (CSS OPI) shall display a map of the geographical temperature distribution |
| DTL.CTRL.TH.MR.04 | Control panel (CSS OPI) shall indicated the status of sensor if broken |
| DTL.CTRL.TH.MR.05 | Control panel (CSS OPI) shall visualise bypass status for one or more temperature sensors |

#### Data Acquisition, Archiving and Alarm Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.TH.DAR.01 | ESS-ERIC archiver appliance shall acquire all 178 temperature value (scalar values). |
| DTL.CTRL.TH.DAR.02 | ESS-ERIC archiver appliance shall acquire alarm/interlock status. |
| DTL.CTRL.TH.DAR.03 | ESS-ERIC archiver appliance shall acquire temperature sensor bypass status. |
| DTL.CTRL.TH.DAR.04 | ESS-ERIC BEAST Alarm service shall show alarms/interlocks related to temperature. |

### Sterrer Magnet Power Supply

#### Control Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.STR.CR.01 | Steerer System shall control power supplies in current with range [-15, +15]A. |
| DTL.CTRL.STR.CR.02 | Steerer System shall enable/disable power supplies by remote through CSS OPI. |
| DTL.CTRL.STR.CR.03 | Steerer System shall provide current and voltage read backs. |
| DTL.CTRL.STR.CR.04 | Steerer System shall provide power supplies enable status read back. |
| DTL.CTRL.STR.CR.05 | Steerer System shall set current range limits(one for each steerer). |
| DTL.CTRL.STR.CR.06 | Steerer System shall provide enable inputs to operate with steerers. |
| DTL.CTRL.STR.CR.07 | Steerer System shall provide manual operation or automatic mode via DTL core control system. |
| DTL.CTRL.STR.CR.08 | Steerer System shall provide a “OK state” checking steerers thermal switches and power supply units. |

#### Monitoring and Graphical User Interface Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.STR.MR.01 | Control panel (CSS OPI) shall display all the power supplies distributed along the tanks. |
| DTL.CTRL.STR.MR.02 | Control panel (CSS OPI) shall display current and voltage read back for each power supply. |
| DTL.CTRL.STR.MR.03 | Control panel (CSS OPI) shall display current set-point and enable commands for each power supply. |
| DTL.CTRL.STR.MR.04 | Control panel (CSS OPI) shall display the manual\automatic command from DTL core control system. |
| DTL.CTRL.STR.MR.05 | Control panel (CSS OPI) shall display the state “OK State” information. |

#### Data Acquisition, Archiving and Alarm Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.STR.DAR.01 | ESS-ERIC Archiver Appliance shall archive all magnets current set point, PS enable, current, voltage, read backs. |
| DTL.CTRL.STR.DAR.02 | ESS-ERIC Archiver Appliance shall archive current/voltage ratio related to temperature “out of range”. |
| DTL.CTRL.STR.DAR.03 | ESS-ERIC Archiver Appliance shall archive steerer system “OK state”. |
| DTL.CTRL.STR.DAR.04 | ESS-ERIC BEAST alarm service shall show an alarm in case of operation without steerer system “OK state” |

### Vacuum

Vacuum System HW parts (pumps, valves, gauges) and the relative I/O integration up to EPICS PVs level are in charge of ESS Vacuum group [5]. Control requirements in charge of ESS Vacuum group are shown in section 5.1. The tasks in charge of DTL core control system concern mainly high level logic (e.g. coordination of vacuum with DTL Core control), here the relative requirements.

Note: this requirement has to be verified at SAT stage.

#### Control Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.VAC.CR.01 | Vacuum System shall provide warning and alarm in case of pressure out of the low severity and high severity limits (defined during DTL tests) |
| DTL.CTRL.VAC.CR.02 | Vacuum System shall raise and alarm in case of pump failure. |
| DTL.CTRL.VAC.CR.03 | Vacuum System shall raise a warning In case of gauge damage |

#### Monitoring and Graphical User Interface Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.VAC.MR.01 | Control panel (CSS OPI) shall display all the pressures along the DTL, one for each sensor. |
| DTL.CTRL.VAC.MR.02 | Control panel (CSS OPI) shall display control panel must display all pumps statuses. |
| DTL.CTRL.VAC.MR.03 | Control panel (CSS OPI) shall display all valve statuses. |
| DTL.CTRL.VAC.MR.04 | Control panel (CSS OPI) shall disable valve’s control when pressure is above alarm limits. |
| DTL.CTRL.VAC.MR.05 | Control panel (CSS OPI) shall display commands and status of the DTL vacuum automation. |

#### Data Acquisition, Archiving and Alarm Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.VAC.DAR.01 | ESS-ERIC Archiver Appliance shall archive all pressures, one for each vacuum gauge |
| DTL.CTRL.VAC.DAR.02 | ESS-ERIC Archiver Appliance shall archive all pumps and valve status (open/close or enabled/disabled) |
| DTL.CTRL.VAC.DAR.03 | ESS-ERIC Archiver Appliance shall archive vacuum alarms in case of pressure above the limit |
| DTL.CTRL.VAC.DAR.04 | ESS-ERIC BEAST alarm service shall show an alarm in case of pressure above alarm limit |

### Tuner Motors System

#### Control Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.TUN.CR.01 | Tuners System shall provide operation in closed loop with frequency detuning coming from LLRF system. |
| DTL.CTRL.TUN.CR.02 | In tuners System, 3 tuners per tank shall operate simultaneously in closed loop [6] |
| DTL.CTRL.TUN.CR.03 | Tuners System shall operate with feedback loop speed response ≥0.3kHz/s [6][7] |
| DTL.CTRL.TUN.CR.04 | Tuners System shall operate with a precision of at least 2.5kHz for the tuner system [6][7] |
| DTL.CTRL.TUN.CR.05 | Tuners System shall correct frequency detuning in range [-125, +125] kHz [6][7] |
| DTL.CTRL.TUN.CR.06 | Tuners System shall control motors in absolute position. |
| DTL.CTRL.TUN.CR.07 | Tuners System shall use linear potentiometers sensors to read tuner’s position. |
| DTL.CTRL.TUN.CR.08 | Tuners System shall use limit switches to perform path and homing functions. |
| DLT.CTRL.TUN.CR.09 | Tuners System shall receive an enable to operate command via EPICS from DTL core control system. |
| DTL.CTRL.TUN.CR.10 | Tuner System shall operate in automatic (frequency detuning close loop), manual and test mode. |

#### Monitoring and Graphical User Interface Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.TUN.MR.01 | Control panel (CSS OPI) shall display the map of tuners along the DTL. |
| DTL.CTRL.TUN.MR.02 | Control panel (CSS OPI) shall display, for each tuner, position read back, frequency detuning, limit switches status and stepper motor specific controls (jogging, homing, etc.). |
| DTL.CTRL.TUN.MR.03 | Control panel (CSS OPI) shall display “enable to operate movable tuners” status. |
| DTL.CTRL.TUN.MR.04 | Control panel (CSS OPI) shall display a warning, in case of tuner motors system failure (KO State). |
| DTL.CTRL.TUN.MR.05 | Control panel (CSS OPI) shall disable start commands if tuners are not enabled to operate. |
| DTL.CTRL.TUN.MR.06 | Control panel (CSS OPI) shall display, for each tuner, the closed loop control parameters. |

#### Data Acquisition, Archiving and Alarm Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.TUN.DAR.01 | ESS-ERIC Archiver Appliance shall archive all tuner positions. |
| DTL.CTRL.TUN.DAR.02 | ESS-ERIC Archiver Appliance shall archive all limit switch statuses. |
| DTL.CTRL.TUN.DAR.03 | ESS-ERIC Archiver Appliance shall archive all closed loop parameters (with low priority) |
| DTL.CTRL.TUN.DAR.04 | ESS-ERIC BEAST Alarm service shall provide an alarm in case of tuner motors system failure (KO State). |

### Cooling System (SKID)

#### Control Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.COL.CR.01 | Cooling System shall acquire temperatures with precision ≤±0.1°C. |
| DTL.CTRL.COL.CR.02 | Cooling System temperature sensors shall operate in range [0, +80]°. |
| DTL.CTRL.COL.CR.03 | Cooling System water pressure shall operate in range [0, +8] bar. |
| DTL.CTRL.COL.CR.04 | Cooling System shall operate in temperature close loop with response time in terms of minutes. (The DTL cooling system detuning parameter is: -10kHz/°C) [6] |
| DTL.CTRL.COL.CR.05 | Cooling System shall provide an “OK state” to enable RF operation (one per DTL tank). |
| DTL.CTRL.COL.CR.06 | Cooling System temperature shall provide alarm, interlock and hysteresis values. |
| DTL.CTRL.COL.CR.07 | Cooling System flow sensors shall provide alarm, interlock and hysteresis values. |
| DTL.CTRL.COL.CR.08 | Cooling System pressure sensors shall provide alarm, interlock and hysteresis values. |

#### Monitoring and Graphical User Interface Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.COL.MR.01 | Control panel (CSS OPI) shall display all temperatures. |
| DTL.CTRL.COL.MR.02 | Control panel (CSS OPI) shall display all fluxes. |
| DTL.CTRL.COL.MR.03 | Control panel (CSS OPI) shall display all pressures. |
| DTL.CTRL.COL.MR.04 | Control panel (CSS OPI) shall display all water pumps status. |
| DTL.CTRL.COL.MR.05 | Control panel (CSS OPI) shall display a warning in case of water pump failure (KO state). |
| DTL.CTRL.COL.MR.06 | Control panel (CSS OPI) shall display the operational state machine. |
| DTL.CTRL.COL.MR.07 | Control panel (CSS OPI) shall display the PLC communication status. |
| DTL.CTRL.COL.MR.08 | Control panel (CSS OPI) shall display a warning in case of water flux exceeds the alarm limits. |
| DTL.CTRL.COL.MR.09 | Control panel (CSS OPI) shall display a warning in case of water temperature exceeds the alarm limits. |

#### Data Acquisition, Archiving and Alarm Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.COL.DAR.01 | ESS-ERIC Archiver Appliance shall archive all temperatures, fluxes, pressures, PH, conductivities and pump statuses. |
| DTL.CTRL.COL.DAR.02 | ESS-ERIC BEAST alarm service shall show an alarm in case of pump failure. |
| DTL.CTRL.COL.DAR.03 | ESS-ERIC BEAST alarm service shall show and alarm in case of flux exceeds the alarm limits. |
| DTL.CTRL.COL.DAR.04 | ESS-ERIC BEAST alarm service shall show and alarm in case of water temperature exceeds the alarm limits. |

### Arc Detector

Due to the functionality tightly connected with the RF system, installation and integration of the arc detector systems (provided by INFN) is charge of the RF system. Arc detection systems (one per DTL tank) includes 4 Arc Detection Modules (ADMs), one per each arc detection point and the Arc Test Transmitter (ATT), one each DTL tank. The ADMs will be directly connected (hard wired) with the RFLPS, to receive the interlocks, monitor the status and sent the command to execute the ADM internal test. INFN-LNL provided information about technical requirements for the correct integration.

The arc detector test transmitter board will provide a light signal, which will be coupled to the arc detector optical fibre, to check the working condition of the arc detector whole system (optical-fibre and AMD). The ADTT will be remote command by the DTL control system. More details are shown Section 5 and in Appendix.

Note: this requirement has to be verified at SAT stage.

#### Control Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.AD.CR.01 | Arc Detector System shall provide the signal Arc OK State (One signal per each DTL tank) in case of no arc detection. |
| DTL.CTRL.AD.CR.02 | Arc OK State signal (normally high level) shall fall for 100µs in case of arc detection (ADM Automatic reset), response time ≤ 7µs. |
| DTL.CTRL.AD.CR.03 | Arc Detector Test Transmitter (ADTT) shall provide a complete test of ADM and optical-fibre via proper electronic board. |
| DTL.CTRL.AD.CR.04 | Arc Detector Test Transmitter (ADTT), installed in the RF racks, shall be remote command by the DTL control system. |
| DTL.CTRL.AD.CR.05 | DTL core control system shall provide Arc Detector interlock thresholds and rearming configurations to RF system. |
| DTL.CTRL.AD.CR.06 | DTL core control system shall retrieve Arc Detector System information (status, counting, arc event) from RFLPS system. |

#### Monitoring and Graphical User Interface Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.AD.MR.01 | Control panel (CSS OPI) shall display number of arcs events and arcs frequency per each arc detection point. |
| DTL.CTRL.AD.MR.02 | Control panel (CSS OPI) shall display the position and timestamp of an arc event. |

#### Data Acquisition, Arching and Alarm Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.AD.DAR.01 | ESS-ERIC Archiver Appliance shall archive all arc counters. |
| DTL.CTRL.COL.DAR.02 | ESS-ERIC Archiver Appliance shall archive arc interlock configurations. |
| DTL.CTRL.COL.DAR.03 | ESS-ERIC Archiver Appliance shall archive all arc test command. |
| DTL.CTRL.COL.DAR.04 | ESS-ERIC BEAST Alarm service shall raise an alarm in case of arc event of arc frequency out of limits. |

## Constraint Requirements

ICS Standards for hardware are outlined in References [2] and [3].

## Environmental Requirements

No environmental requirements have been expressed for the DTL CS.

## Conventional Safety Requirements

No conventional safety requirements have been expressed for the DTL CS.

## Radiation Safety Requirements

No radiation safety and security requirements related to the DTL CS.

## Interface Requirements

These interfaces are detailed in the Interface Control Document in Reference [4].

### Interlock Signals

For each DTL Tank:

One single signal combining Temperature status & Cooling OK status.

### Enable Signals

To be defined.

# Requirements on Other Systems

## Vacuum

The interface between vacuum control system and DTL control system is located at EPICS level. Therefore the following signals are “soft” EPICS variables not hard-wired connections. These shall not substitute in any case what is defined in [5] but aims to clarify the interface information.

**Note:** this requirement has to be verified at SAT stage.

### Control Requirements

| Id | | Text |
| --- | --- | --- |
| DTL.CTRL.VAC.CR.01 | | Vacuum System shall provide DTL pressure (vacuum) status, one for each gauge meter. |
| DTL.CTRL.VAC.CR.02 | | Vacuum System shall provide pumps status read back. |
| DTL.CTRL.VAC.CR.03 | | Vacuum System shall provide pumps enable/disable commands. |
| DTL.CTRL.VAC.CR.04 | | Vacuum System shall provide open/close status read back of vacuum valves at DTL begging, DTL end and intertank. |
| DTL.CTRL.VAC.CR.05 | | Vacuum System shall provide DTL’s valves open/close commands. |
| DTL.CTRL.VAC.CR.06 | Vacuum System shall provide gauges status read back. | |
| DTL.CTRL.VAC.CR.07 | Vacuum System shall provide pressure alarm, interlock and hysteresis values per each gauges. | |
| DTL.CTRL.VAC.CR.08 | Vacuum System shall provide OK stat to RFLPS to enable RF power (hard wired, one per DTL tank). | |

## RF System

### Control Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.RF.CR.01 | RF system shall foresee the possibility to permit beam transport when a tank is in *No Beam Acceleration* status. |
| DTL.CTRL.RF.CR.02 | RF system shall provide via EPICS PV the frequency detuning. |

## Interlocks to RF Local Protection System

### Arc Detectors Control Requirements

The RF LPS of each DTL tank – see Reference [5] will be connected by hard-wired signal to the 4 Arc Detector Modules and provides test internal commands to check internal status of the ADM. Further detail is available in appendix (xxx).

| Id | Text |
| --- | --- |
| DTL.CTRL.ADL.CR.01 | RFLPS shall receive the signal ARC OK state (high level) to enable RF power injection in the correspondent DTL tank. |
| DTL.CTRL.AD.CR.02 | During RF conditioning with pulse width ≥1ms, in case of an arc interlock (ARC OK state low level for 100 µs) the RF system shall provide the possibility of restart RF injection within the same pulse (when this is feasible ). |
| DTL.CTRL.AD.CR.03 | In case of an arc interlock (ARC OK state low level for 100 µs) the RF system shall provide the possibility of restart RF injection at the next pulse (automatic restart next pulse). |
| DTL.CTRL.AD.CR.04 | In case of an arc interlock (ARC OK state low level for 100 µs) the RF system shall provide the possibility of restart RF injection after an adjustable delay from the arc interlock expiration (automatic restart with delay). |
| DTL.CTRL.AD.CR.05 | RFLPS System shall identify arc events, indicating “where” (which of the 4 ADM per tank) and “when” (RF pulse ID or time stamp). |
| DTL.CTRL.AD.CR.06 | RFLPS shall count the total number of arcs detected per each detection point (ADM). |
| DTL.CTRL.AD.CR.07 | RFLPS shall provide a reset command per each arc counter. |
| DTL.CTRL.AD.CR.08 | RFLPS shall stop RF if Arcs frequency > configurable thresholds (arc number, Δtime). |
| DTL.CTRL.AD.CR.09 | In case of arc frequency interlock, the RF system shall provide the possibility of restart RF injection at the next pulse (automatic restart next pulse). |
| DTL.CTRL.AD.CR.10 | In case of arc frequency interlock, the RF system shall provide the possibility of restart RF after an adjustable delay from the arc frequency interlock expiration (automatic restart with delay). |
| DTL.CTRL.AD.CR.11 | In case of arc frequency interlock, the RF system shall provide the possibility of restart RF after a RESET command (restart after RESET). |
| DTL.CTRL.AD.CR.12 | RFLPS shall provide test reset commands to the ADM.  This command shall be available via EPICS for the DTL Control system. |
| DTL.CTRL.AD.CR.13 | RFLPS shall not count arcs in case of ADM test or complete test via ADTT. |
| DTL.CTRL.AD.CR.14 | Arc Detector interlock thresholds and rearm configuration (used by RF system) shall be set-up by DTL core control system. |

**Note:** restart means that interlock signal (related to the arc event or arc frequency) is reset in each one of the involved systems; RF power injection in DTL is resumed (if there are no other interlock conditions which prevent it).

### Temperature and Cooling Requirements

RF LPS of each tank receives an “OK status” signal which is a logical AND combination of temperature monitoring and cooling system OK status (DTL.CTRL.TH.CR.01)

|  |  |
| --- | --- |
| DTL.CTRL.TH.CR.01 | OK stat to RFLPS combined (AND logic) with cooling system OK Stat (DTL.CTRL.COL.CR.05) |

### RF Conditioning Requirements

Part of the DTL conditioning can be automated, saving time and reducing the human intervention. This possibility should be foreseen by RF system, otherwise control parameter should be editable by a dedicated procedure included in the DTL Core Control system. These parameters are at least the ones reported in [9], in particular Pulse period and width, forward power level. (DTL.CTRL.TH.CR.09).

|  |  |
| --- | --- |
| DTL.CTRL.RF.CR.01 | RF system should implement the automatic conditioning procedure, or it shall provide the SW interfaces to implement it. |

## ESS Linac Control System

In order to operate properly and automate particular routines, the main ESS Linac Control System (ECS) has to provide the following information.

### Control Requirements

| Id | Text |
| --- | --- |
| DTL.CTRL.ECS.CR.01 | ESS Linac Control System shall provide a EPICS PVs containing the working configurations to the DTL Control System (e.g. RF Conditioning, No Beam Operation, Ready for operation). |
| DTL.CTRL.ECS.CR.02 | ESS Linac Control System shall provide a EPICS PVs containing the set-points for steerers coming from simulations. |

# references

1. ICS Handbook [ESS-0067637]
2. Control System Hardware Platforms [ESS-0037909]
3. ESS Standardised PLC Equipment [ESS-0101132]
4. DTL Interface Control Document
5. Proton Beam Vacuum Control System – System Requirement Specification [ESS-0090064]
6. DTL ESS Start up Procedure [ESS-0177688]
7. Requirements for the DTL [ESS-0050110]
8. RF Local Protection System [ESS-0153980]
9. ESS DTL LCS SW Interfaces

Document Revision history

| Revision | Reason for and description of change | Author | Date |
| --- | --- | --- | --- |
| 1 | First upload following Critical Design Review of System | INFN Legnaro + ESS Lund | 2019-06-27 |
|  |  |  |  |

# Appendix

## 2017-11-06 Arc Detector Interlock Signal to RF LPS

invited:

Rafael Montano , Anders J Johansson , Annika Nordt , Enric Bargalló , Francesco Grespan , Loris Antoniazzi

Topics:

• Requirements to RFLPS

• Reaction to arcs

• Integration of arc frequency evaluation

• Consequences for MPS

• Consequences for LLRF

Notes:

restart the RF after an interlock event within the same RF pulse

• During RF conditioning (without beam), it would be interesting to be able to get RF back into the cavity as quick as possible after an interlock event. => this accounts for a ater stage of the conditioning, when we are at a longer nominal RF pulse length already (1-4 ms)

• in normal operation, we plan to restart the RF with the next pulse (depending on the MPS set-up for automatic restarts)

• The AFT system itself needs a time of 100 micro sec to be able to detect another arc again

• The reaction time of the RFLPS between an arc detected in the AFT modul and the stop of the RF is 200 micro sec (measured in RFLPS test stand)

• As soon as a solution allows to rearm the RF within 200 -1000 micro sec after an interlock, it is interesting to have this function in order to safe time during the conditioning

• Rafael Montano finds out, what is the time that could be achievale to rearm the RF again based on an EPICS solution. The aim is not to change anything on the hardware level of the RFLPS.

arc counter to evaluate the arc frequecy

• the arc frequency is used to inhibit an automatic restart of the RF after an arc.

• The time window to evaluate the frequency needs to be adjustable. In particular during RF conditioning and normal operation, we will use very differnt time windows (some multiple of the RF rearming time up to ~1h).

• The RFLPS would have variables related to arcs on the DTLs: 1) arc signal itself => interlock of RF 2) arc frequence => switch between automatic OR manual restart

• Rafael Montano verifies an EPICS based implementation of this function. This is preferred in comparison to a separate counting unit

arc detection system tests

• automatic functionality tests will be preformed on the arc detectors during conditioning and operation

• the RFLPS uses the DB9 interface on the AFT arc detector modules to send test and reset commands. This tests the functionality of the arc detector modules in the crate.

• INFN is planning to have AFT test boards in the arc detector crates (one board per two arc detectors), which are used to test the detector chain between the arc module and the view port on the cavity.

• Loris Antoniazzi checks with AFT, how the communication with the test board works and if there is any connection needed between the test board and the arc detector module.

• Janet Schmidt chechs with ICS (Wojtek Fabianowski), which options for diagnostic modules are avaliable to perform such system tests.

Material:

NCLPR-9 - DTL cavity arc detector integration Done

2017-10-26 Round table meeting: DTL controls (@LNL) (see slides of arc detector presentation)

### JIRA Ticket

|  |  |
| --- | --- |
| [**DTL arc detectors**](https://jira.esss.lu.se/browse/NCLPR-4) ([NCLPR-4](https://jira.esss.lu.se/browse/NCLPR-4)) [NCLPR-9] [DTL cavity arc detector integration](https://jira.esss.lu.se/browse/NCLPR-9) Created: 2017-Oct-09  Updated: 2018-Mar-16  Resolved: 2018-Mar-08 | |
| **Status:** | Done |
| **Project:** | [Normal Conducting Linac Preparation](https://jira.esss.lu.se/secure/BrowseProject.jspa?id=24814) |
| **Component/s:** | [DTL](https://jira.esss.lu.se/issues/?jql=project%3D24814%20AND%20%22component%22%3D19534%20ORDER%20BY%20priority%20ASC) |
| **Affects Version/s:** | None |
| **Fix Version/s:** | None |

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| --- | --- | --- | --- |
| **Type:** | Sub-task | **Priority:** | Normal |
| **Reporter:** | [Janet Schmidt](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=janetschmidt) | **Assignee:** | [Loris Antoniazzi](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=lorisantoniazzi) |
| **Resolution:** | Done | **Votes:** | 0 |
| **Labels:** | Arc\_detector, DTL, RF, preparation | | |
| **Remaining Estimate:** | Not Specified | | |
| **Time Spent:** | Not Specified | | |
| **Original Estimate:** | Not Specified | | |

|  |  |
| --- | --- |
| **Attachments:** | 09\_Part 3 AFT tech Spec Manual Arc4.pdf     17-10-24\_DTL\_arcDetectorRequirements.pptx     2017\_10\_26\_ESS\_DTL\_Arc\_Detectors.pptx     2017\_11\_03\_ESS\_DTL\_Arc\_Detectors\_Requirment From INFN.pptx     P000237237(A000009162).pdf     arcDetectorLogic.pptx |
| **Issue Links:** | |  |  |  |  | | --- | --- | --- | --- | | **Relates** | | | | | relates to | [NCLPR-12](https://jira.esss.lu.se/browse/NCLPR-12) | Test of DTL arc detectors interlocks | To Do | | relates to | [NCLPR-6](https://jira.esss.lu.se/browse/NCLPR-6) | DTL (WP3) rack population | In Progress | |
| **Start Date:** | 2017-Oct-09 |
| **End Date:** | 2018-Mar-08 |
| **Additional Team Members:** | Bruno Lagoguez, Francesco Grespan, Janet Schmidt, Loris Antoniazzi, Morten Rostrup Forup Jensen, Rafael Montano, Stevo Calic |

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| **Description** |  |

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| TOPIC: the 4 arc detectors for each DTL cavity (5 cavities in total) will be delivered by INFN. In this task, we should define the spacial and fuctional integration into the RF system. |

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| **Comments** |  |

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| --- |
| Comment by [Janet Schmidt](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=janetschmidt) [ 2017-Oct-09 ] |
| Next meeting regarding this topic: 17-10-12 |
| Comment by [Janet Schmidt](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=janetschmidt) [ 2017-Oct-24 ] |
| Dear all,  [Loris Antoniazzi](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=lorisantoniazzi), [Francesco Grespan](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=francescogrespan), can you please have a look at the requirements that I have summarized?  [Rafael Montano](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=rafaelmontano), is this what you need from us? Please let us know, if something is missing.  Cheers, Janet |
| Comment by [Loris Antoniazzi](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=lorisantoniazzi) [ 2017-Oct-24 ] |
| Note that ATF ARC4 Standard Interface Board return only one GLBARC signal which is OR function of the selected inputs; while ATF ARC4 Signal Selectable Logic interface Board return only one (from datasheet, I'm checking with AFT) GLBARC signal which is combination of up to 4 input channels. By this the crate population Option 2 should contain more than one Interface Board.   * AFT arc 4 system will include for each channel all the necessary to check the arc detector status, simulating an arc by remote command (test view port, test board and optical fiber) * frequency of single arc events > threshold (EPICS setting, password protected): stop RF, restart manually after check, or restart automatically after an adjustable time delay   Arc Counting, Frequency evaluation and limit should include for each channel:   * total number arcs, * reset of the arcs count amount (to restore the total after arc test) * set of the arcs count amount to a different value (to restore the total after arc test) * arc frequency should be evaluated in a configurable period (10ms - 1s)  and the relative interlock intervention should be guaranteed in the same time. * Arc frequency for each period should be available at EPICS level at least as postmortem in case of threshold overcoming. |
| Comment by [Janet Schmidt](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=janetschmidt) [ 2017-Oct-25 ] |
| Hi [Loris Antoniazzi](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=lorisantoniazzi),  from what I saw in the AFT data sheet, the DB15 interface can provide either the global arc signal or single channel information. Also, it looked to me like the interface board can handle twice a OR evaluation of 8 inputs each. This is, what is reflected in the population option2. Of course, I never used the system, so please correct me, if I'm wrong. The remote command can be done via the DB9 connector.  Thank you for the additional information about the frequency counting function. This will help to determine, if the function can be implemented by [Rafael Montano](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=rafaelmontano) in the module for the RFLPS. He will join us tomorrow morning via conference call.  Please (if it's still enough time) have a look in the "requirements" documentation for the open points that I marked on the last slide. And also at the RF rack distribiution.  See you tomorrow, Janet |
| Comment by [Janet Schmidt](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=janetschmidt) [ 2017-Nov-06 ] |
| Hi [Loris Antoniazzi](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=lorisantoniazzi),  can you please tell me, which arc detector modules are included in the two crates in the rack layout in your slide 8 of "2017\_11\_03\_ESS\_DTL\_Arc\_Detectors\_Requirement From INFN"?  Thank you, Janet |
| Comment by [Loris Antoniazzi](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=lorisantoniazzi) [ 2017-Nov-06 ] |
| Hi [Janet Schmidt](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=janetschmidt),  the AFT ARC4 module at slide 8 of "2017\_11\_03\_ESS\_DTL\_Arc\_Detectors\_Requirement From INFN"? are inside the racks DTL-030ROW:CNPW-U-002 and are related to the arc detector of the couplers of the tanks 3, 4, 5. Take into account that I prepared this presentation before being informed from AFT of the new Arc detector product version.  Regards  Loris |
| Comment by [Janet Schmidt](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=janetschmidt) [ 2018-Mar-07 ] |
| HI [Loris Antoniazzi](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=lorisantoniazzi),  do you agree to close this topic? Is there anything open?  Cheers, janet |
| Comment by [Loris Antoniazzi](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=lorisantoniazzi) [ 2018-Mar-08 ] |
| Hi [Janet Schmidt](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=janetschmidt),  I think that everything is clear and you can close.  I just would like to test together with the RFLPS group the functions related to arc counting and arc frequency interlock when these will be ready.  Best Regards,  Loris |
| Comment by [Janet Schmidt](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=janetschmidt) [ 2018-Mar-08 ] |
| Hi [Loris Antoniazzi](https://jira.esss.lu.se/secure/ViewProfile.jspa?name=lorisantoniazzi),  I have created a separate issue for the tests: [DTL-21](https://jira.esss.lu.se/browse/NCLPR-12)  I will close this topic here now |

Generated at Thu Oct 11 17:02:53 CEST 2018 by Maurizio Montis using JIRA 7.7.2#77003-sha1:2241faf4520a2d3eba4691b355732c8fd7579144.

### Power Point – DTL Arct Detector requirements from INFN-LNL

