11th HL-LHC Technical Committee
2nd September 2014

HL-LHC-IP1 AND IP5-COLD POWERING OF THE MAGNETS IN THE MATCHING SECTIONS

HL-LHC-IP1 AND IP5-COLD POWERING OF THE ARC MAGNETS

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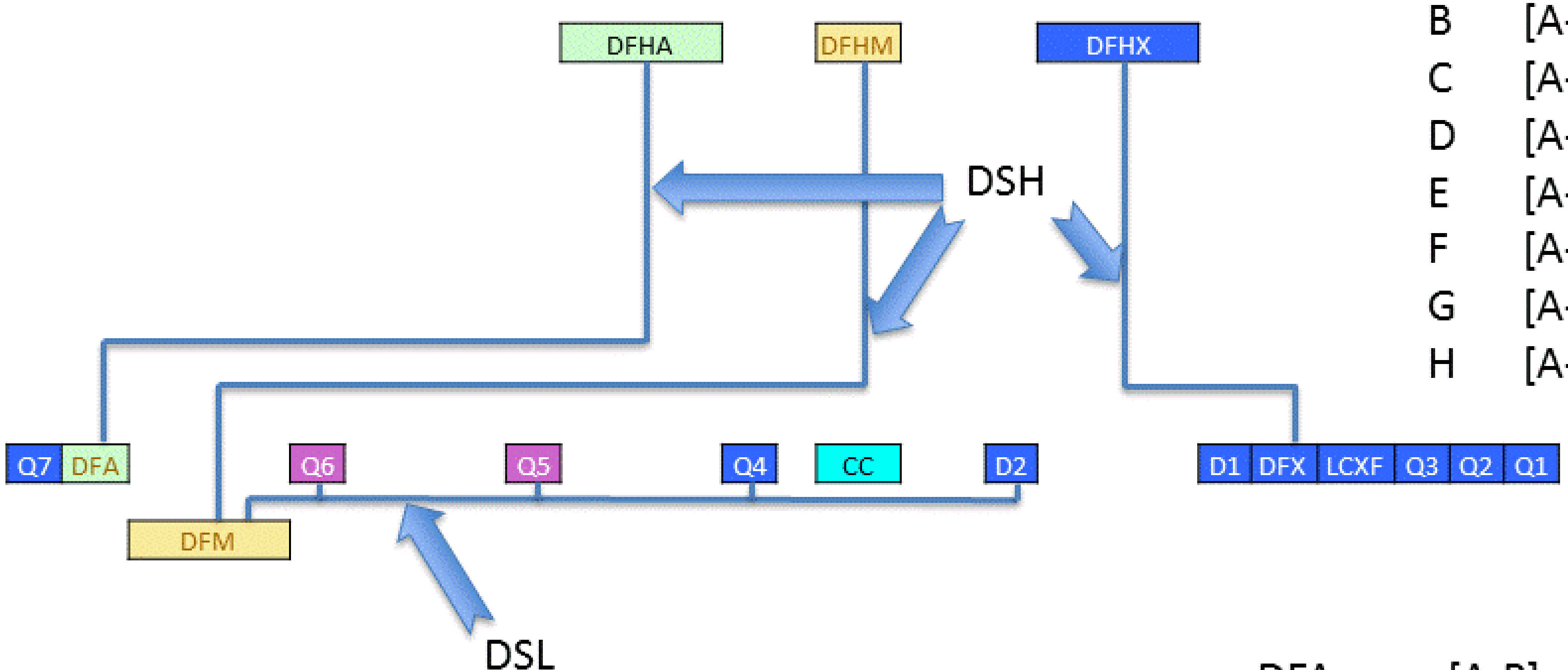
Naming conventions



DSH	A	[A-F]
	B	[A-F]
	C	[A-B]
	D	[A-D]
	E	[A-F]
	F	[A-D]
	G	[A-B]
	H	[A-F]

DFA	[A-P]
DFM	[A-P]
DFX	[A-H]

EDMS NO.	REV.	VALIDITY
1364939	**0.0**	**DRAFT**

REFERENCE : LHC-EQCOD-ES-XXXX

Presented in July 2012

CONCEPTUAL SPECIFICATION

HL-LHC-IP7-COLD POWERING

[HL-LHC EQCOD ACCORDING TO CONFIGURATION MANAGEMENT]

Equipment/system description

The Cold Powering System at LHC Point 7 (P7) is designed to relocate the 600 A power converters, initially installed in the RR73 and RR77, and the Distribution Feedboxes, today in-line with the magnets in the RR73 and RR77, inside the TZ76 gallery in a radiation free environment. The system relies on superconducting links that provide the electrical connection between the magnets in the tunnel and the new Distribution Feedboxes (DFH). The links (DSH) contain MgB_2 and High Temperature Superconducting (HTS) cables cooled by forced flow of helium gas and operated at temperatures of up to 20 K. This specification describes the basic functionality and the design parameters of the Cold Powering System for LHC P7.

Layout Versions	LHC sectors concerned	CDD Drawings root names (drawing storage):
V X.X	S6-7, S7-8, TZ76	Text

TRACEABILITY

Project Engineer in charge of the equipment	WP Leader in charge of the equipment
A. Ballarino, S. Weisz	[Checked by] A. Ballarino

Presented in July 2012

EDMS NO.	REV.	VALIDITY
136493	0.0	DRAFT

REFERENCE : LHC-EQCOD-ES-XXXX

CONCEPTUAL SPECIFICATION

HL-LHC-IP1 AND IP5-COLD POWERING OF THE TRIPLETS

[HL-LHC EQCOD ACCORDING TO CONFIGURATION MANAGEMENT]

Equipment/system description

The Cold Powering System of the Hi-Luminosity Triplets at LHC Point 1 (P1) and Point 5 (P5) is designed to locate power converters, current leads and distribution feedboxes in surface buildings. The system relies on superconducting links that provide the electrical connection between the magnets, in the tunnel, and the new distribution feedboxes (DFH), at the surface. The links (DSH) contain MgB_2 and High Temperature Superconducting (HTS) cables cooled by forced flow of helium gas and operated at temperatures of up to 20 K. This specification describes the basic functionality and the design parameters of the Cold Powering System for the Hi-Luminosity Triplets at LHC P1 and P5.

Layout Versions	LHC sectors concerned	CDD Drawings root names (drawing storage):
V X.X	S1-2, S4-5, S5-6, S8-1	Text

TRACEABILITY

Project Engineer in charge of the equipment	WP Leader in charge of the equipment
[Prepared by] A. Ballarino, S. Weisz	[Checked by] A. Ballarino

New

CONCEPTUAL SPECIFICATION

HL-LHC-IP1 AND IP5-COLD POWERING OF THE MAGNETS IN THE MATCHING SECTIONS

Replacement of LHC DFBL

[HL-LHC EQCOD ACCORDING TO CONFIGURATION MANAGEMENT]

Equipment/system description

The Cold Powering System of the stand-alone magnets in the Matching Sections around LHC Point 1 (P1) and Point 5 (P5) is designed to locate power converters, current leads and distribution feedboxes in surface buildings. The system relies on superconducting links that provide the electrical connection between the magnets, in the tunnel, and the new distribution feedboxes (DFHM), at the surface. The links (DSH) contain MgB_2 and High Temperature Superconducting (HTS) cables cooled by forced flow of helium gas and operated at temperatures of up to 20 K. This specification describes the basic functionality and the design parameters of the Cold Powering System for the magnets in the Matching Sections at LHC P1 and P5.

Layout Versions	LHC sectors concerned	CDD Drawings root names (drawing storage):
V X.X	S1-2, S4-5, S5-6, S8-1	Text

TRACEABILITY

Project Engineer in charge of the equipment	WP Leader in charge of the equipment
[Prepared by] A. Ballarino, S. Weisz	[Checked by] A. Ballarino

Committee/Verification Role	Decision	Date
PLC-HLTC/ Performance and technical parameters	Rejected/Accepted	20YY-MM-DD
Configuration-Integration / Configuration, installation and interface parameters	Rejected/Accepted	20YY-MM-DD

HL-LHC

EDMS NO.	REV.	VALIDITY
*******	0.0	DRAFT

REFERENCE : LHC-EQCOD-ES-XXXX

New CONCEPTUAL SPECIFICATION **Replacement of LHC DFBA**

HL-LHC-IP1 AND IP5-COLD POWERING OF THE ARC MAGNETS

[HL-LHC EQCOD ACCORDING TO CONFIGURATION MANAGEMENT]

Equipment/system description

The Cold Powering System of magnets in the arc at LHC Point 1 (P1) and Point 5 (P5) is designed to locate power converters, current leads and distribution feedboxes in surface buildings. The system relies on superconducting links that provide the electrical connection between the magnets, in the tunnel, and the new distribution feedboxes (DFHA), at the surface. The links (DSH) contain MgB_2 and High Temperature Superconducting (HTS) cables cooled by forced flow of helium gas and operated at temperatures of up to 20 K. This specification describes the basic functionality and the design parameters of the Cold Powering System for the magnets in the arc at LHC P1 and P5.

Layout Versions	LHC sectors concerned	CDD Drawings root names (drawing storage):
V X.X	S1-2, S4-5, S5-6, S8-1	Text

TRACEABILITY

Project Engineer in charge of the equipment	WP Leader in charge of the equipment
[Prepared by] A. Ballarino, S. Weisz	[Checked by] A. Ballarino

Committee/Verification Role	Decision	Date

R2E

Replacement of LHC DFBA and LHC DFBL

Table 4: Preliminary Schedule

Phase	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Requirements definition										
Functional specification										
Engineering specification										
Acquisition Process										
Fabrication, Assembly & Verification										
Installation – Commissioning										

Installation in the tunnel during LS3

Replacement of LHC DFBA

Circuit	Cold powering system current rating (A)	Number of SC cables/Currrent leads
RQT	600	8/8
RQS	600	4/4
RQTL	600	4/4
RSS	600	4/4
ROD	600	4/4
ROF	600	4/4
RQ10	6000	3/3
RQ7	6000	3/3
RQ8	6000	3/3
RQ9	6000	3/3

Table 1: Type of LHC circuits fed by the Cold Powering System at each side of LHC P1 and P5, current rating of the cold powering system, number of superconducting (SC) cables in the link and of current leads in the DFHA located in surface buildings

Replacement of LHC DFBA

2 PRELIMINARY TECHNICAL PARAMETERS

2.1 Assumptions

The technical design of the Cold Powering System at P1 and P5 assumes that:

- The DFBAA and DFBAB at P1 and the DFBAI and DFBAJ at P5 will not be used for the powering of the magnets in the arc. Only the two 13000 A leads connected to the powering extraction system, which is located in the tunnel, will be operational;
- The DFBAA and DFBAB at P1 and the DFBAI and DFBAJ at P5 will be removed;
- The DFA cryostat will be located in the tunnel in the same position where today are the DFBAs. It will house the two 13000 A current leads used for energy extraction and the electrical interconnections between the Nb-Ti bus, coming from the magnets, and the MgB_2 cables in the superconducting link;
- The DFHAs and the current leads will be located at the surface;
- All power converters feeding the circuits listed in Table 1 will be located at the surface;
- The helium required for cooling the Cold Powering System is provided by the present LHC refrigerator cooling the arc;
- Helium for cooling the Cold Powering System is supplied at its coldest temperature from the LHC tunnel, it is transferred inside the superconducting link cryostats, where it cools the MgB_2 and HTS cables, and it is recuperated at ambient temperature at the surface after cooling of the current leads located inside the DFHAs;
- Surface buildings are made available at the surface to host the new DFHAs, the power converters, the warm termination of the DSH and the associated services;
- The connection between the power converters and the current leads will be made at the surface, and the length of the room temperature electrical cables will be kept as short as physically possible.

Replacement of LHC DFBA

2.2 Equipment Technical parameters

The main design parameters of the Cold Powering System are reported in Table 1.

Table 1: Equipment parameters

Characteristics	Units	Value
Number of Cold Powering Systems at LHC P1	-	2
Number of Cold Powering Systems at LHC P5		2
Number of superconducting cables per superconducting link	-	40*
Approximate length of superconducting link	m	300
Operating temperature of superconducting link	K	≤ 20
Temperature of helium supply (superconducting link cold mass)	K	5
Required helium mass flow rate (superconducting link cold mass)	g/s	< 15
Design pressure of cryogenic circuits	MPa	0.35
Temperature of helium recovered from the DFH	-	RT**
Pneumatic test pressure of cryogenic circuits	MPa	0.45
Integral of leak rate of cryogenic and vacuum insulation circuits	$Pa\ m^3\ s^{-1}$	$\leq 10^{-7}$
Minimum bending radius of superconducting link	m	1.5

*Additional spare cables may be integrated inside the link

**Room Temperature

Replacement of LHC DFBL

Circuit	Cold powering system current rating (A)	Number of SC cables/Currrent leads
RCBY	120	12/12
RD2	6000	3/3
RQ5	6000	3/3
RQ6	6000	3/3
RQ4*	16000*	2/2
RD2**	13000	2/2

*Replacement of the LHC RQ4 circuit (3900 A ultimate current) with the Hi-Luminosity Q4 circuit

**Replacement of the LHC D2 circuit (4670 A ultimate current) with the Hi-Luminosity D2 superconducting circuit

Table 1: Type of LHC circuits fed by the Cold Powering System at each side of LHC P1 and P5, current rating of the cold powering system, number of superconducting (SC) cables in the link and of current leads in each of the two the DFHMs located in surface buildings

The Cold Powering System described in this document will electrically feed the magnets in the Matching Sections at P1 and P5, as listed in Table 1.The current rating of the RQ4 and RD2 circuits are in line with the Hi-Luminosity upgrade requirements (https://espace.cern.ch/HiLumi/wp3/SitePages/Home.aspx). On the basis of the today available information, it is assumed that the current rating and the powering scheme of the RCBY, RQ5 and RQ6 circuits will not change with the Hi-Luminosity upgrade.

Replacement of LHC DFBL

2 PRELIMINARY TECHNICAL PARAMETERS

2.1 Assumptions

The technical design of the Cold Powering System at P1 and P5 assumes that:

- The DFBLA and DFBLB at P1 and the DFBLD and DFBLE at P5 will be removed;
- The DFBLA and DFBLB at P1 and the DFBLD and DFBLE at P5 will be replaced with DFM cryostats located at the surface;
- According to the present requirements of the Hi-Luminosity upgrade, the D2 and Q4 superconducting magnets will be individually powered via a pair of current leads and operated at respectively 12050 A and 15650 A (https://espace.cern.ch/HiLumi/wp3/SitePages/Home.aspx), while the number, powering layout and current rating of the other circuits will be unchanged (see Table 1);
- Each DFM cryostat will be located in the tunnel at the location where today are the DFBLs. It will house the electrical interconnections between the Nb-Ti bus, coming from the magnets, and the MgB_2 cables in the superconducting link;
- The DFHMs and the current leads will be located at the surface;
- All power converters feeding the circuits listed in Table 1 will be located at the surface;
- The helium required for cooling the Cold Powering System is provided by the LHC refrigerator cooling the Matching Sections and the High Luminosity Triplets;
- Helium for cooling the Cold Powering System is supplied at its coldest temperature from the LHC tunnel, it is transferred inside the superconducting link cryostats, where it cools the MgB_2 and HTS cables, and it is recuperated at ambient temperature at the surface after cooling of the current leads located inside the DFHMs;
- Surface buildings are made available at the surface to host the new DFHMs, the power converters and the associated services;
- The connection between the power converters and the current leads will be made at the surface, and the length of the room temperature electrical cables will be kept as short as physically possible.

2.2 Equipment Technical parameters

The main design parameters of the Cold Powering System are reported in Table 1.

Table 1: Equipment parameters

Characteristics	Units	Value
Number of Cold Powering Systems at LHC P1	-	2
Number of Cold Powering Systems at LHC P5		2
Number of superconducting cables per superconducting link	-	25*
Approximate length of superconducting link	m	300
Operating temperature of superconducting link	K	≤ 20
Temperature of helium supply (superconducting link cold mass)	K	5
Required helium mass flow rate (superconducting link cold mass)	g/s	< 15
Design pressure of cryogenic circuits	MPa	0.35
Temperature of helium recovered from the DFH	-	RT**
Pneumatic test pressure of cryogenic circuits	MPa	0.45
Integral of leak rate of cryogenic and vacuum insulation circuits	$Pa\ m^3\ s^{-1}$	$\leq 10^{-7}$
Minimum bending radius of superconducting link	m	1.5

* Additional spare cables may be integrated inside the link

**Room Temperature

Table 2: Technical services

Domain	Requirement
Electricity & Power	Required for heating system integrated at the warm end of each current lead and for instrumentation and control racks
Cooling & Ventilation	No known requirements
Cryogenics	Liquid (in the tunnel) and gaseous (in the link and in the DFHM) helium
Control and alarms	Required for operation of the system. They are associated with the instrumentation incorporated in the Cold Powering System.
Vacuum	Technical vacuum, for the thermal insulation of the DSH cryostat, and of the DFHMs and DFMs cryostats
Instrumentation	Vacuum and temperature gauges, voltage taps

Table 3: Installation services

Domain	Requirement
Civil Engineering	Surface buildings for housing the DFHMs, the power converters, and warm termination of the DSH Routing of the DSH from the tunnel to the surface will be done either using existing LHC shafts or via new ducts to be drilled in the most convenient location
Handling	Installation in the tunnel of the equipment. Tooling for transport and integration needs to be developed
Alignment	In-situ alignment of the DFM cryostats