US HL-LHC Accelerator Upgrade Project

MQXFA MAGNET INTERFACE SPECIFICATION

Prepared by:
Giorgio Ambrosio, US HL-LHC AUP MQXFA L2 Manager, FNAL
Maria Baldini, US HL-LHC AUP MQXFA L2 Manager deputy, FNAL
Dan Cheng, US HL-LHC AUP Magnet Assembly L3 Manager deputy, LBNL
Soren Prestemon, US HL-LHC AUP Magnet Assembly L3 Manager, LBNL
Paolo Ferracin, HL-LHC WP3 Lead Engineer, CERN

Reviewed by:
Giorgio Ambrosio, US HL-LHC AUP MQXFA L2 Manager, FNAL
Sandor Feher, US HL-LHC AUP Cryo-assembly L2 Manager, FNAL
Tom Page, US HL-LHC AUP System Integration Manager, FNAL
Ezio Todesco, HL-LHC WP3 Leader, CERN

Approved by:
E. Todesco, HL-LHC WP3 Leader, CERN
Tom Page, US HL-LHC AUP System Integration Manager, FNAL
Giorgio Ambrosio, US HL-LHC AUP MQXFA L2 Manager, FNAL
Sandor Feher, US HL-LHC AUP Cryo-assembly L2 Manager, FNAL
Ruben Carcagno, US HL-LHC AUP Deputy Project Manager, FNAL
Giorgio Apollinari, US HL-LHC AUP Project Manager, FNAL

Revision History

Revision	Date	Section No.	Revision Description
v0	10/2/18	All	Initial Release

TABLE OF CONTENTS

1. Introduction

MQXFA magnets [1,2] are the quadrupole magnetic components of the HL-LHC Q1 and Q3 inner triplet optical elements in front of the interactions points 1 (ATLAS) and 5 (CMS). Two MQXFA magnets are installed in each Q1 or Q3. Since these magnets are identical whether installed in Q1 or Q3, the interface specifications are identical for all MQXFA magnets.

This specification defines the mechanical and electrical interfaces of the MQXFA magnets, which are relevant for the incorporation of these elements into the LMQXFA cold mass assembly, and subsequently into the cryostat which completes the LQXFA/B cryo-assembly.

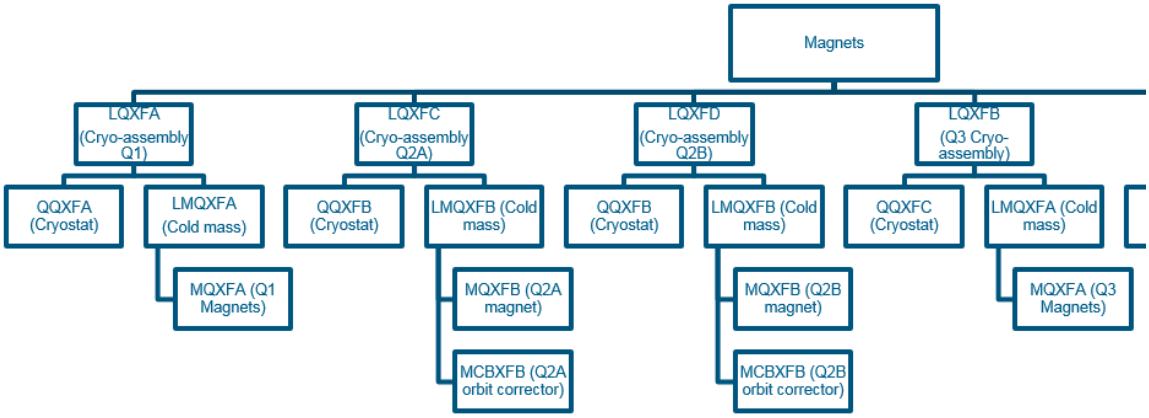

Figure 1: CERN Naming Conventions for HL-LHC Inner Triplets

2. MQXFA interfaces

2.1. Mechanical interfaces

The MQXFA Magnet mechanical interfaces are defined in [3]. This drawing defines:

- The diameter, length and weight of the magnet.
- The longitudinal position of the magnetic center relative to the return end of the yoke.
- The position and aperture of the holes for heat exchangers.
- The position of the slots for tack blocks.
- The features of the slots where the tack blocks will be inserted.
- The positions and features of the alignment slots.
- The envelope of the lead connection blocks (pizza box).
- The orientation of the leads when magnet is in horizontal position.

The bore of the MQXFA magnet has a 146.7 mm inside diameter at room temperature after insertion of coil-bumpers and magnet pre-load, allowing for the insertion of an insulated beam tube.

The OD of the beam tube is 144.7 +0.7/-0.0 mm at room temperature. The beam tube insulation thickness is 0.2 mm.

The iron yoke of the MQXFA magnet has four cooling channels. The two upper channels (wrt. to the orientation shown in Fig 2) will be used for the heat exchangers of the LMQXFA cold mass. The minimum diameter of the MQXFA yoke cooling channels is 77 mm at room temperature.

2.2. Cold Mass Welding

When the two half shells of the LMQXFA cold mass are welded together the weld shrinkage may increase the coil pre-load. This pre-load increase may cause excessive conductor strain if the interference between magnet and cold mass is not limited. Therefore, this interference shall be kept under control and the coil pre-load increase shall not exceed 15 MPa at room temperature.

2.3. Electrical Interfaces

The MQXFA magnet has two 18 kA leads extending from the lead end of the assembly. Each lead is made of two NbTi cables [2]. The leads will be labelled A and B according with the CERN standard [4]. Looking from the lead end, the "A" lead is the lower exiting lead and the "B" lead is the upper exiting lead with the magnet oriented as shown in Figure 2. The leads exiting the splice-connection block are 1.5 m long, such that further routing and splicing can be completed. Vertical testing requires shorter leads, therefore after vertical test the leads are about 0.7 m long from the splice-connection block.

The MQXFA magnet has two CLIQ leads [5] extending from the lead end of the assembly. The leads will be labelled "A" and "B", based on how close they are in the electrical circuit to the A/B current leads. Looking from the lead end, with the magnet oriented as shown in Figure 2, the CLIQ "A" lead is one the left, and the CLIQ "B" lead is on the top. The leads exiting the splice-connection block are 1.5 m long, such that further routing and splicing can be completed.

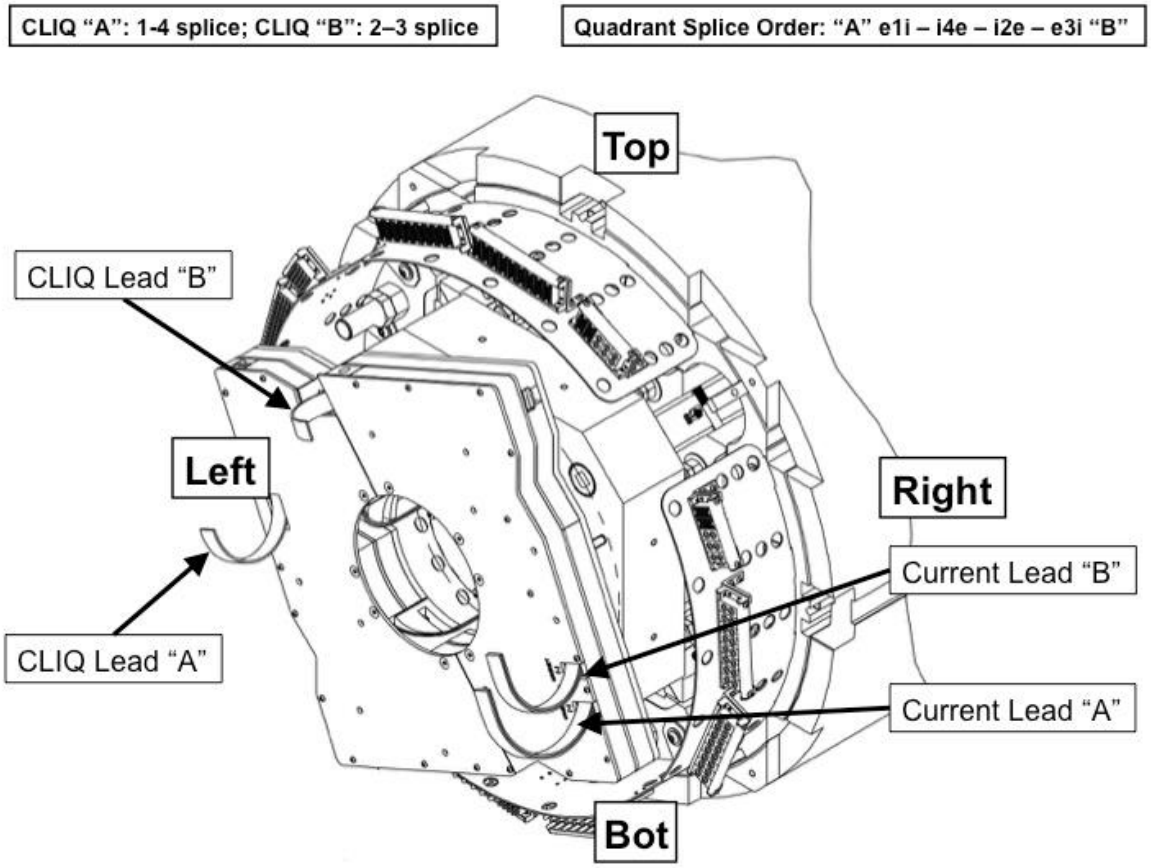

Figure 2: Power leads and CLIQ leads on a completed MQXFA magnet.

The instrumentation wiring required for the MQXFA magnet is listed in Table 1. All voltage tap and quench heater wires exit from the lead end of the magnet. Each wire will be labelled indicating functionality and location according to [6]. The MQXFA Electrical Schematic is shown in Appendix A.

The MQXFA magnet has three quench detection voltage taps located on each magnet lead and at the electrical midpoint of the magnet circuit. Each voltage tap used for quench detection has a redundant voltage tap. Therefore, the total number of wires for quench protection is 6 (3 x 2 for redundancy). The quench protection wires are AWG 26 gauge and ??? m long.

The MQXFA magnet has 2 voltage taps for each internal Nb_3Sn-NbTi splice resulting in 16 wires. The voltage tap wires are AWG 26 gauge in accordance with [6], and each wire is ??? m long when the MQXFA is delivered for cold-mass assembly.

The MQXFA magnet has four outer layer heater strips per coil (one high-field and one low-field strip on each coil side). Pairs of heater strips are connected in series according to [6]. The heater-heater connections are done at magnet return end. Therefore, there is a total of 16 heater wires exiting from the lead end. The heater wires are AWG 18 gauge and are ??? m long.

MQXFA heaters and CLIQ leads are compatible with the HL-LHC Inner Triplet quench protection system [7].

Table I. Instrumentation and heater wires. The lengths are measured from the magnet lead end plate.

Wire	Number	Gauge	Length	Description
Quench detection	6	26	???	AXON HH2619 - LH [8]
Voltage tap	16	26	???	AXON HH2619 - LH [8]
Heater wire	16	18	???	AXON HH1819 - LH [9]

3. References

1. MQXFA Magnets Functional Requirements Specification, EDMS No. 1535430; US-HiLumi-doc-36
2. MQXFA Final Design Report, US-HiLumi-doc-948
3. MQXFA Mechanical Interface Specification Drawing (TBD)
4. LHC MAGNET POLARITIES, CERN Specification LHC-DC-ES-0001.00, rev 1.1, 27 April 1999 (is there a more updated reference?).
5. CLIQ leads drawing, US-HiLumi-doc-998 (Felix may generate a new drawing by the end of September)
6. Triplet Electrical Scheme, US-HiLumi-doc-968 (to be updated and approved)
7. HL-LHC Inner Triplet quench protection system (TBD)
8. Drawing: S515769BB-ENG_DWG; US-HiLumi-doc-1603
9. Drawing: S563483AA_DWG; US-HiLumi-doc-1603

Appendix A – MQXFA Electrical Schematic

Here should go the drawing with MQXFA Electrical Schematic …