BEAM COUPLING IMPEDANCE OF THE NEW BEAM SCREEN OF THE LHC INJECTION KICKER MAGNETS

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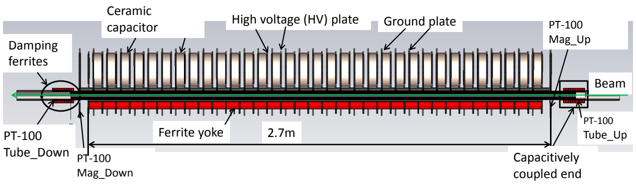

Figure 1: Structure of the injection kicker magnets.

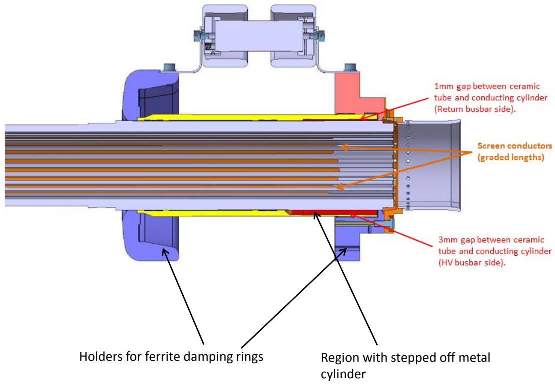

Figure 2: Cross section of the new beam screen design

Abstract

The LHC injection kicker magnets experienced significant beam induced heating of the ferrite yoke, with high intensity beam circulating for many hours, during operation of the LHC in 2011 and 2012. The causes of this beam coupling impedance were studied in depth and an improved beam screen implemented to reduce the impedance. Results of measurements and simulations of the new beam screen design are presented in this paper: these are used to predict power loss and temperature of the ferrite yoke for operation after long shutdown 1 and for proposed HL-LHC operational parameters.

INTRODUCTION

During the 2011 and 2012 runs of the LHC, high temperatures were observed in several devices in the LHC [2], a critical piece being the LHC injection kicker magnets (MKIs) Fig. 1, which were attributed to beam-induced heating due to high power loss from the interaction of the circulating beam with the longitudinal beam coupling impedance. This heating was observed to raise the temperature of the ferrite yoke of one of the MKIs above its Curie point during fills, thereby necessitating waiting times of several hours for the ferrite to cool before safe injection could be carried out [3]. A magnet with an improved beam screen was inserted during technical stop 3 (TS3) (23/09/12-27/09/12), replacing the MKI8D which was measured to have the highest temperature [4]; the replacement magnet was subsequently measured to have the lowest temperature of all magnets.

Building on this success a new design has been proposed to satisfy competing needs of low rates of electrical breakdown during magnet pulsing and a low beam coupling impedance to reduce the power lost into the structure by wakefields; in addition to meeting strict requirements for magnet operation for field rise time and flat top stability [1].

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NEW BEAM SCREEN DESIGN

The new design involves a redesign of the capacitively coupled end of the beam screen, intended to reduce the electrical field due to the induced potentials on the screen conductors during magnet pulsing. This reduced electric field reduces the possibility of surface breakdown on the internal face of the beam screen allowing additional beam screens to be inserted where previously they had been removed due to being located in regions of high electric field Fig. 2 providing complete screening of the ferrite yoke of the magnet. See [6] for more information on behaviour relating to surface flashover.

IMPEDANCE MEASUREMENTS

In order to observe the effect of manufacutring tolerences between magnets and as part of the campaign to characterise the impedance of all devices placed into the LHC each of the MKIs with the new beam screen has it's longitudinal beam coupling impedance measured during assembly. These measurements are carried out using the resonant coaxial wire method [cite], a measurement technique that turns the device under test (DUT) into a coaxial resonator with a weak external coupling. This allows very sensitive measurements of the impedance of the DUT to be made, at the cost of a relatively poor frequency resolution as the measurement is of the Q-factor at the resonant frequencies of the coaxial device.

The real component of the longitudinal beam coupling impedance of an example of the new design as well as for an MKI before LS1 (with 15 screen conductors) and the MKI8D that was replaced in TS3 (with 19 screen conductors) are shown in Fig. 3. It can be seen that the new design has a substantially lower beam coupling impedance over the majority

Figure 3: Real component of the longituidinal beam coupling impedance measured using the resonant coaxial wire method for the new beam screen design, the design with 15 screen conductors as was the case for most magnets prior to LS1 and the upgraded MKI8D, inserted in TS3.

Figure 4

of the frequency range, with the broadband impedance seen in the case of 15 screen conductors becoming resonant in nature with 24 conductors.

POWER LOSS AND FUTURE IMPROVEMENTS

INTRODUCTION

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