9th Edit. of the Mech. Eng. Des. of Synchrotron Radiat. Equip. and Instrum. Conf. MEDSI2016, Barcelona, Spain JACoW Publishing
ISBN: 978-3-95450-188-5 doi:10.18429/JACoW-MEDSI2016-TUPE29

INTEGRATION OF A STRIPLINE KICKER PROTOTYPE FOR CLIC PROJECT INTO ALBA STORAGE RING

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Abstract

The Compact Linear Collider (CLIC) project is an international collaboration working on the development of a high-energy and high-luminosity machine which will accelerate and collide electrons and positrons at energies between 0.5 and 5 TeV. The extraction system for the Damping Rings of CLIC shall follow very tight requirements in order to maintain the ultra-low emittance of the extracted bunches. A first prototype of the extraction kicker based on stripline technologies has been built and characterized at CERN without beam. The stripline will be shortly installed in the ALBA Synchrotron to be tested under beam. In situ measurements of the impedance, transversal field homogeneity and flat-top ripple aims to complete its characterization. This contribution presents the design of the set up for the integration of the stripline in one of the medium straight sections of ALBA storage ring.

INTRODUCTION

The CLIC project is an international collaboration working on the development of a high-energy and high-luminosity machine which will accelerate and collide electrons and positrons at energies between 0.5 and 5 TeV. The Pre-Damping Rings (PDR) and Damping Rings (DR) are required for reducing the emittance of the beams before being injected into the main linac. The injection and extraction from the PDR and DR are performed by kicker systems based on stripline technologies which allow to maintain a low beam coupling impedance and acceptable broadband impedance matching to the electrical circuit [1].

A first prototype of the extraction kicker for the CLIC DR has been designed, built and studied without beam in previous works from C. Belver-Aguilar et al. [1, 2, 3]. In order to complete its characterization, the stripline kicker will be shortly installed in the ALBA Synchrotron to be tested under beam. The results of the in situ tests and measurements of the beam coupling impedance, transversal field homogeneity and flat-top ripple will be compared to the simulations to validate the final design.

This contribution presents the design of the measurement set up for the integration of the stripline kicker into the ALBA storage ring.

LAYOUT INTEGRATION

ALBA Synchrotron was elected for the kicker testing under beam due to the similarity of characteristics in terms of beam energy and low emittance. Figure 1 and Table 1 shows the accelerator layout and main parameters of ALBA machine respectively.

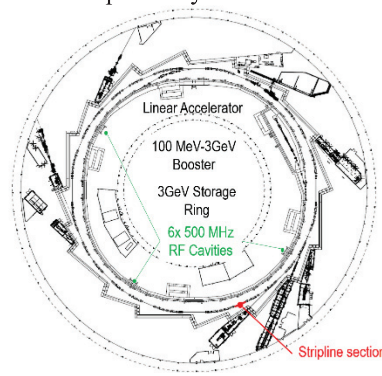

Figure 1: Location of the stripline installation.

Table 1: ALBA Machine Main Parameters

Energy	3 GeV
Design Current	400 mA
Circumference	268.8 m
Horizontal Emittance	4.58 nm·rad

The kicker chamber will be installed in a medium straight section of 3200 mm length, between Sector 07 and Sector 08 of ALBA storage ring. The adjacent vacuum chambers and absorbers have been designed in order to not disturb the beam performance and to protect the stripline from the synchrotron radiation. Figure 2 shows the general layout of the final assembly.

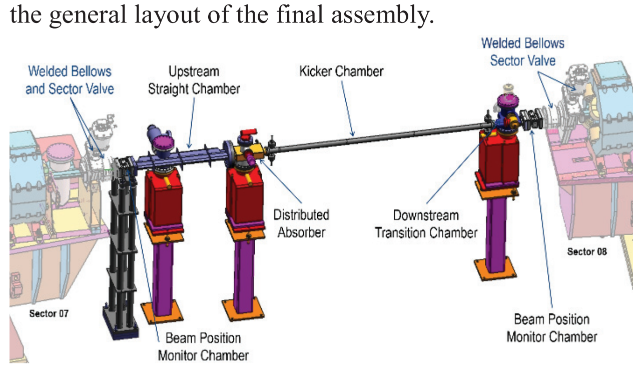

Figure 2: General assembly of stripline section.

Ray Tracing Study

To avoid the incidence of synchrotron radiation over the new elements of the section, ray tracing calculations have been performed. A safety margin of 1 mm has been considered between the inner part of the kicker chamber's ring supports and the x-ray fan. The position and dimensions of the distributed absorber were optimized taking into account the available space of the section, the dis-

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ISBN: 978-3-95450-188-5 doi:10.18429/JACoW-MEDSI2016-TUPE29

tance to the electron beam and ensuring that the last ray coming from the edge of the absorbing surface ends up in the next crotch absorber installed in Sector 08. Figure 3 shows the fan radiation coming from the previous bending magnet till the edge of the distributed absorber.

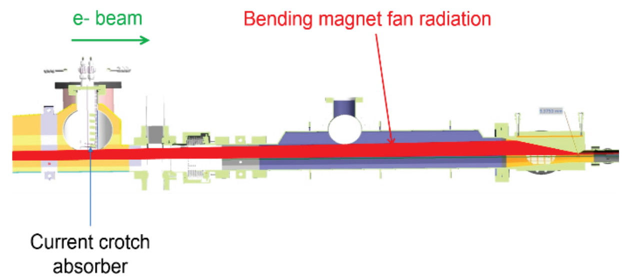

Figure 3: Ray tracing of the first section of the assembly.

CHAMBERS DESIGN

Stripline Kicker

The stripline kicker consists of two half-moon shaped electrodes enclosured along a cylinder vacuum chamber as shown in Fig. 4. Each of the electrodes is driven by an equal but opposite polarity pulse. Its geometry has been optimized to achieve an excellent field homogeneity, good power transmission and very low beam coupling impedance [1].

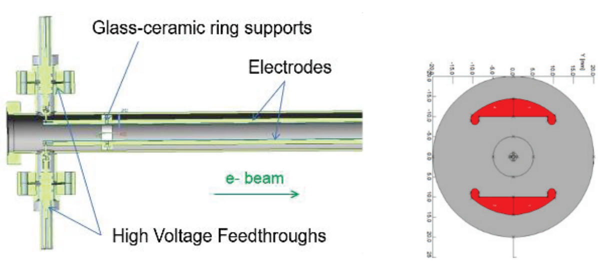

Figure 4: Kicker chamber cross section.

The kicker will be installed 90° rotated to avoid the synchrotron radiation incidence over the electrodes.

Beam Position Monitor (BPM)

Two BPMs will be installed at the beginning and end of the assembly. The downstream BPM will be fixed in a bracket and referenced to the girder as the rest of the BPM net. On the other hand, the upstream BPM will be installed in a fixed position acting as a global reference respect to the floor. For this purpose, a standalone FeNi36 support has been designed for keeping a beam orbit stability of 10% of the beam size and restricting the vertical deformation to a submicron level. Figure 5 shows the results for the vibrational analysis with a first resonance mode of 65 Hz and a deformation of 3.8 calculated for the vertical Z direction.

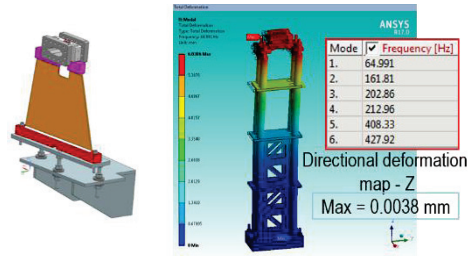

Figure 5: Downstream BPM bracket and upstream BPM support static and vibrational analysis.

Upstream Straight Chamber

The upstream straight chamber showed in Fig. 6 connects the first BPM with the distributed absorber. As the rest of storage ring standard chambers, it is designed in AISI 316 LN stainless steel with a “key-hole” cross section. The electron beam circulates through the main chamber and the photon beam channel, as antechamber, allows the synchrotron radiation to be delivered to the front ends or to be stopped in the absorbers. Static calculations were performed to validate the design ensuring that no stress due to the vacuum forces exceeds 100 MPa.

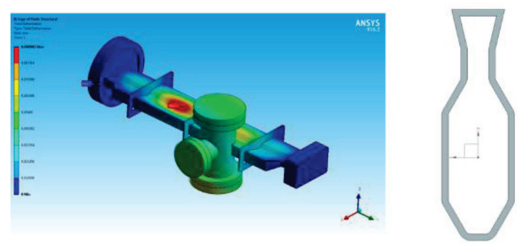

Figure 6: Straight chamber calculations and cross section

Distributed Absorber

The distributed absorber is installed before the stripline kicker and protects the rest of the assembly elements from the photon radiation. Figure 7 shows the cross section, which is tapered from the standard profile of ALBA storage ring to a circular opening of 40 mm diameter. The main block is made of oxygen free high conductivity (OFHC) copper brazed to the stainless steel flanges and auxiliary ports.

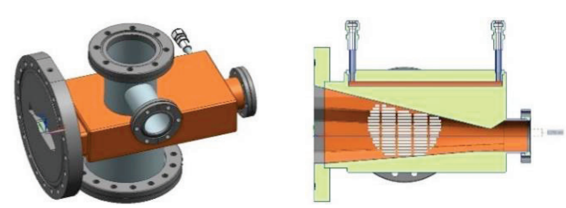

Figure 7: OFHC distributed absorber and cross section.

Static calculations were performed to validate the design ensuring that no stress due to the vacuum forces exceeds 100 MPa. Below Fig. 8 shows part of the

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thermal-mechanical studies carried out in order to optimize the inner dimensions of the absorbing surface and the cooling channel.

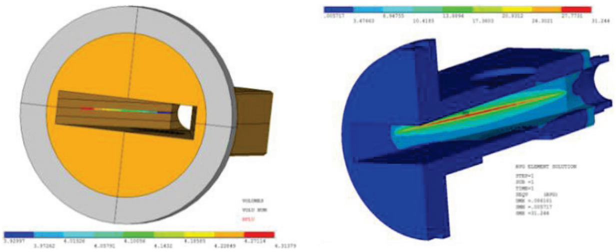

Figure 8: Power density and stress distribution of absorber

Table 2 shows the results of the analysis for the power density distribution, stress and strain distribution, water convective heat transfer coefficient and temperature distribution along the absorbing surface.

Table 2: Thermal-Mechanical Results of Absorber

Power density distribution (Beam current=400 mA)	$P_{a,max}$=4.3 W/mm^2
Stress	S_{max}=31.2 MPa
Strain	Smax=0.027 %
Water convective heat transfer coefficient	h=13625 W/m^2 T_{water}=24 °C
Temperature distribution	T_{max}=58.5 °C

Downstream Transition Chamber

Figure 9 shows the downstream transition chamber, which is made in AISI 316 LN stainless steel and connects the stripline kicker with the downstream BPM. In the same way as the distributed absorber, it has a transitional cross section with a smooth tapering from the ALBA standard profile to a circular opening. A pattern of holes is placed over the pumping ports to prevent any disturbance of the electron beam and to ease the evacuation of the chamber.

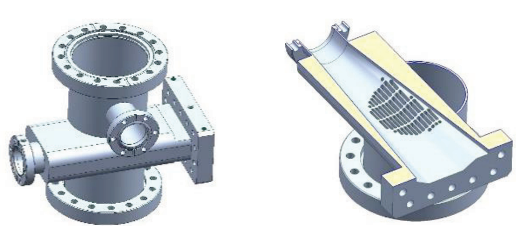

Figure 9: The downstream chamber and cross section.

Static calculations were performed to validate the design ensuring that no stress due to the vacuum forces exceeds 100 MPa.

INSTALLATION AND COMMISSIONING

Before being installed into ALBA machine, the complete assembly of the vacuum chambers will be mounted and baked in a dedicated clean area.

The mechanical supports will be placed in its final position to allow the installation and connection of the assembly. All the chambers, excepting the stripline kicker, have fiducial holes to ease the subsequent alignment of the components. After instrumentation and cabling installation, the logic of the Equipment Protection System (EPS) for the vacuum and temperature signals will be checked.

The commissioning will be finished with the functional tests of the kicker and BPM tests with beam.

The final testing with beam will include measurements for the beam coupling impedance, transversal field homogeneity and flat-top ripple.

CONCLUSION

In summary, the integration of a stripline kicker prototype for CLIC DR into ALBA storage ring is presented. The layout, design and result of calculations of the assembly chambers is described. Finally, it is outlined a list of the installation and commissioning tasks prior to the final tests with beam.

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