KICKER AND MONITOR FOR CTF3 PHASE FEED FORWARD*

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Abstract

In the Compact LInear Collider (CLIC) the synchronization of the Drive Beam and the Main Beam has to be assured in the femtosecond range to avoid luminosity reduction of the collider. The Drive and Main Beams arrival time is measured with longitudinal monitors and the correction is applied changing the path length of one beam with respect to the other in a magnetic chicane by means of two transverse fast stripline kicker. The performance of the feed forward system will be tested in the CLIC Test Facility (CTF3) measuring the phase at the linac exit, correcting in the chicane after the combination rings and comparing the longitudinal position change before the power RF production system. The developed phase monitors and kicker magnets for the test in CTF3 are described.

INTRODUCTION

The two beams acceleration scheme, basic feature of the Compact LInear Collider CLIC, asks for precise synchronization between the Main Beam and the RF power produced by the Drive Beam in order to keep the energy of the Main Beam constant. Drive Beam timing and intensity errors lead to phase and amplitude RF variation in the accelerating structures, with consequent different acceleration gradient. Main Beam energy variations cause collider luminosity reduction. In order to keep the luminosity reduction less than 2% the RF phase jitter should be less than 0.1^{o} (23fs @ 12GHz) [1].

The Main Beam and Drive Beam synchronization has to be assured by a feed-forward system in which the two beams arrival time are compared and the proper correction is applied to the Drive Beam.

A feed forward system, similar to the CLIC one, will be tested in the CLIC Test Facility CTF3 now in operation at CERN [2]. The phase measurement is foreseen at the end of the Drive Beam linac and the correction will be applied in the chicane after the combination rings. The effectiveness of the system will be measured by another phase monitor placed before the RF power production system and by monitoring the RF power production in the decelerating structures.

The basic components of the system are the phase monitors and the correction kickers that are now in the construction phase.

THE PICK-UP DESIGN

The front end of the phase forward system is the monitor that detects the bunch longitudinal position and is characterized by a time resolution of the order of 20 fs [3]. The monitor is an electromagnetic pick-up that interacts with the field induced by the electron beam and sends to the electronics the RF signal containing the beam arrival time information. The beam signal is mixed with a low phase noise local oscillator with than 5 fs integrated timing jitter [4].

The pick-up is composed by four slots, equally distributed on the vacuum chamber, with cut-off frequency above the bunch frequency of 12 GHz: the electromagnetic field at that frequency is evanescent in the slot. The beam signal is coupled out of the beam pipe through waveguides with transitions to 50Ω coaxial lines. Commercial vacuum feedtroughs to SMA standard connectors are placed in the coaxial section. Double ridged design of the waveguide has been chosen in order to optimize the transition frequency response and reduce the cross section.

Two notch filters, realized with bumps in the beam pipe at a distance tuned at the bunch detection frequency, are placed at both the pick up sides, providing a resonant volume for the beam electromagnetic field. The filters provide also the rejection of the RF noise and wake field in the working bandwidth that can induce spurious signals that affect the measurements.

Fig.1 shows one quarter of the phase monitor simulated with HFSS electromagnetic code

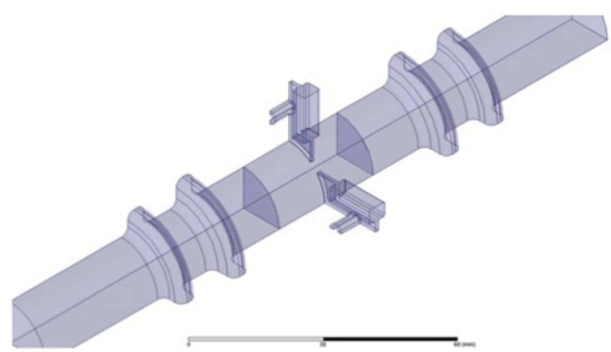

Figure 1: Phase monitor schematic drawing.

The fast response of the monitor is mandatory because after the acquisition of a few bunches of the Drive Beam train the feed forward system must perform the correction of the longitudinal position of the rest of the bunch train. To obtain the monitor fast rise time and to reduce the extraction of power from the beam, both the Q-factor and the shunt impedance value must be reduced. The possibilities are: a) to build the monitor in stainless steel, b) to increase the coupling to the pick-up waveguides and c) to detune the monitor resonant frequency with respect to the bunch frequency.

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Time domain simulations have been performed to characterize the pick up response applying a phase jump in a certain bunch of the train and looking at the signal at the monitor exit. Two examples are reported in Fig. 2: the first is the time response signal, in bunch number, of the monitor precisely tuned at the bunch frequency (output voltage larger than 700V at the nominal current). The second is for the same pick-up with the notch filter with slightly different distance that gives the detuned version (signal of 30V). The response time is approximately 50 bunches on 2100 bunches of the train that is a reasonable value for the feedback.

a)

b)

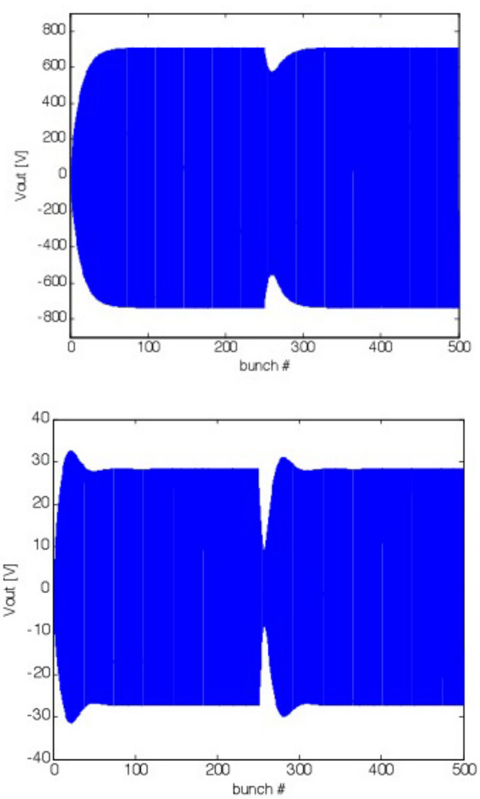

Figure 2: Phase monitor time response: a) tuned and b) detuned version.

The detuned version has been chosen because the signal level is high but compatible with the SMA standard feedthroughs and the coupling impedance is reasonable.

Table 1: Phase Monitor Parameters

Pick up version	"Tuned"	"Detuned"
f_{RF} [GHz]	11.99	11.99
f_{res} [GHz]	11.99	12.22
Charge per bunch [nC]	2.33	2.33
Q value	41	42
V_{out} [V]	710	28

Figure 3 shows the monitor mechanical rendering in which the notch filters are obtained directly machining the beam pipe.

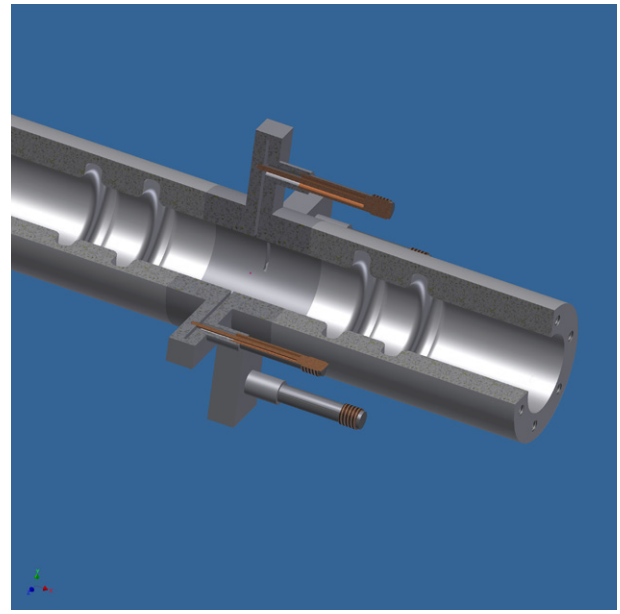

Figure 3: Phase monitor mechanical drawing.

THE KICKER DESIGN

The phase correction is provided by changing the electron beam trajectory in a dispersive region by transversally kicking the bunch with fast kicker magnets: the path length variation due to the trajectory closed bump provides the longitudinal position correction.

A two strip-line kicker structure has been chosen to satisfy the following requirements:

- Fast response to the input pulse signal (few ns):
- High kick efficiency
- 50Ω characteristics impedance to match the high voltage (2kV) pulser avoiding pulse reflection.
- Low longitudinal coupling impedance to limit the energy spread degradation.

A diameter of 40 mm in the stripline region has been chosen to maintain the same beam stay clear aperture of the rest of the pipe. Therefore the strip line surrounding vacuum pipe has an internal diameter of 74 mm to match the 50Ω characteristic impedance. The kickers will be installed in the dog-leg line that connects the Combiner ring to the CLIC experimental area. The maximum available space is 1200 mm including the tapered connection to the rest of the beam pipe. The strip line length is 960 mm and the overall kicker length is 1140 mm.

Both ends of the internal strip are tapered in transverse dimension and distance from the vacuum chamber up to the feedthrough to match the high voltage generator output 50Ω impedance and to reduce the beam coupling impedance.

With this configuration a voltage of 1.4kV applied to each strip, with opposite polarity, provides the requested 1mrad kick angle at the CTF3 beam energy (150 MeV).

Kickers with similar design have been realized for the DAΦNE collider injection [5]. The transfer and coupling impedances have been measured, using the wire method, showing very good agreement with the HFSS simulations. In DAΦNE the high voltage kickers were extensively tested during operation.

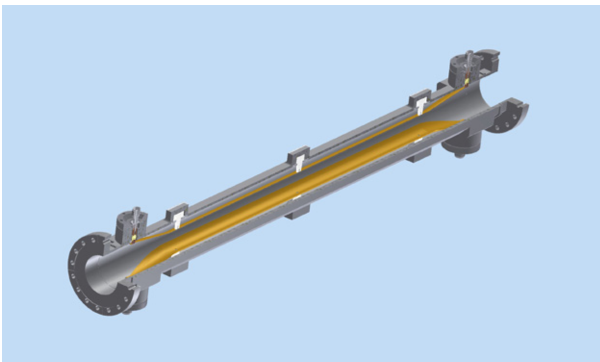

Figure 4: Kicker mechanical design.

CONCLUSIONS

The feed forward scheme that will provide the synchronization between the Main Beam and the Drive Beam in CLIC collider has been studied. The design of the main components is completed and the system will be tested in the CLIC test facility, with the CTF3 parameters, at CERN.

Mechanical design of the phase monitors that provides the high temporal resolution, good noise rejection and low coupling impedance is terminated and the construction started.

The electromagnetic design of the stripline kickers that will provide the phase error correction in the CLIC Test Facility is ready. The mechanical design is now finalized and the tender request has been started. The main features of the kickers are: 50Ω impedance all along the device to match the high voltage pulser impedance to avoid reflections and to provide fast kick rise time; the high transverse impedance to increase the efficiency and, at the same time, low bunch coupling impedance to avoid beam quality degradation.

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