PXIE MEBT Kicker, 200 Ohm version
Technical Specifications Requirements

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Revision History

Revision	Date	Section No.	Revision Description
0	10/17/2013	All	Initial Release.

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1. Introduction

The PXIE Medium Energy Beam Transport (MEBT, [1]) kicker is a part of the MEBT chopping system, which will prepare a pre-specified bunch structure of the 2.1 MeV H- beam. For at least 80% of the time, bunches are directed to the absorber, and the remaining part (1 mA) of initially 5 mA, 162.5 MHz CW beam is sent to the linac.
The PXIE MEBT beam optics scheme assumes 2 travelling-wave kicker assemblies working in sync. The kicker electric field is generated by applying equal and opposite polarity voltage to the two opposing electrodes of each kicker assembly. The kick is in the vertical direction. These requirements describe the mechanical parameters of the 200 Ohm version of the kicker.

2. Scope

Functional Specification Requirements (FRS) for the MEBT kicker are presented in Ref. [2]. Following to an electromagnetic design that satisfies the FRS, this document specifies the kicker parameters for the mechanical design of the kicker prototype.

3. Kicker requirements

The 200 Ohm kicker assembly consists of a vacuum vessel, two identical helical travelling-wave structures with electrodes attached, protection electrodes located on both ends of the helixes, transmission lines, and feedthroughs. Both helices are mounted to one plate. 200 Ohm microstrip transmission lines interconnect the helix at both ends to vacuum feedthroughs mounted to the plate.

1.1 Helix dimensions

The design of the helical structure ("helix") is based on the prototype shown in Fig.1. The helix consists of the central copper tube serving as the pulsed voltage signal return, a wire of a rectangular cross section wound around the tube in a helical shape, and electrodes attached to the wire. The position of the wire above the copper tube is determined by 4 ceramic spacers.
At both ends of the helix, the central tube OD is decreased ("stepped down") as shown in Fig.2. Cross section of the helical structure (Fig. 3) is a 200 Ohm microstrip line. Parameters of the helix and transmission line are listed in Table 1.

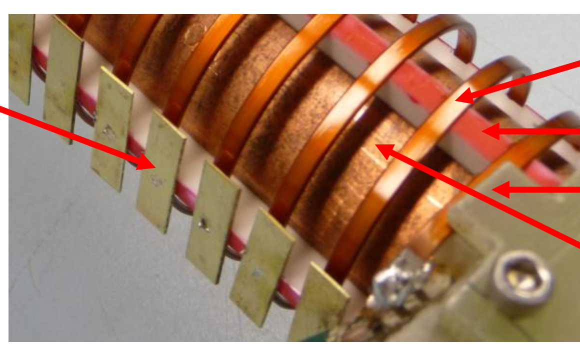

Figure 1. Helical kicker structure. Note: this helix does not have a stepped-end as shown in Fig. 2.

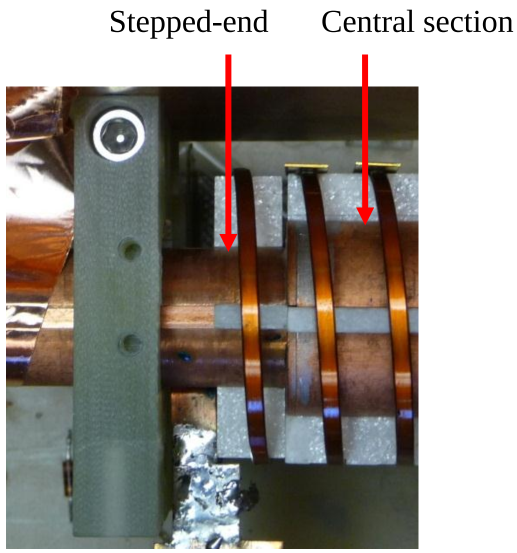

Figure 2. Copper tube, stepped-end and central section. Both tube ends are to step down to a smaller diameter than the central tube section.

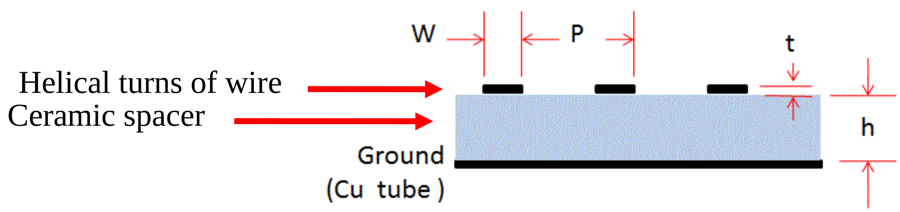

Figure 3. Cross section of the helical structure.

Table 1. Dimensions of the helix and transmission line. Notation in Italic refers to Fig. 3.

Item	Parameter	Value	Units
	Helix		
1	#13 flat magnet wire dimensions, nom. (*W* x *t*)	.105 x .042	inches
2	Pitch (*P*). Tolerance of each turn location is with respect to the reference (one end of the ceramic spacer).	.376 ±.002 (9.500 ±.050)	inches (mm)
3	Helix wire height above ground in the central section (*h*)	.218 ±.002 (5.537 ±.05)	inches (mm)
4	Copper tube central section OD (the helix "ground")	1.116 ±.003 (28.35 ±.1)	inches (mm)
5	Central section tube length having the OD value stated in item 4	18.988 ±.01 (48.23 ±.03)	inches (cm)
6	Copper tube stepped-end OD at both ends, see item 4 in Section 1.2 and Figure 2	.800 ±.002 (20.32 ±.050)	inches (mm)

7	Helix length, measured between wire centers where wire is clamped at both ends (52.5 turns)	19.74 (501.4)	inches (mm)
8	Approximate Microstrip wire total length, 52.5 turns	263 (6.68)	inches (m)
9	Helix diameter, microstrip wire center-to-center	1.594	inches
10	Electrode dimensions (copper or bronze)	.240 ±.002 x .7874 ±.002 x .020 (6.096 ±.05 x 20 ±.05 x .508)	inches (mm)
11	Ceramic spacer thickness, approx. (thickness is 1/8 in. nom.)	.135	inches
12	Ceramic spacer dielectric constant	5.5 ±.2	
13	Ceramic spacer thermal conductivity, minimum	50	W/m/K
14	Space between facing helix electrode surfaces of the two parallel helices	.630 ±.02 (16 ±.5)	inches (mm)
15	Minimum space between helix wire and enclosure surface—top, bottom and sides	2.5 (63.5)	inches (mm)
200 Ohm Interconnecting Microstrip Transmission Lines			
16	Signal wire size	#16 solid round wire (dia. = .051 in.)	
17	Signal wire height above ground, wire center to ground surface	.350 ±.005 (8.89 ±.12)	inches (mm)
18	Ground strip, copper shim stock; width x thickness	.75 ±.01 x .010 (19 ±.12 x .254)	inches (mm)
19	Minimum space between microstrip signal wire and enclosure wall	1.0 (25.4)	inches (mm)

1.2 Other mechanical requirements

1. Two helical structures composing the kicker are mounted on one flange parallel to each other. Positioning of the parallel helices with respect to each other is determined by the gap dimension between opposing electrode surfaces given in Table 1, item 14.
2. The helix wire is to be wound around the copper tube on a mandrel to form the wire in a uniformly round helix.
3. The two helices are to be wound in opposite directions of each other.
4. The wound helix wire is to pass over the stepped-end for one complete turn at both ends of the copper tube. See Fig. 2.

5. The ceramic spacers holding up the helical wire are to be equally spaced around the copper tube.
6. Ceramic spacer material is trade name PV2, machinable AlN, provided by Ceramic Products, Inc.
7. Each vacuum feedthrough shall be located such that the feedthrough center is lined up with the center of the helix wire at the point perpendicular to where the helix wire is clamped.
8. The interconnecting 200 Ohm microstrip transmission lines, at both ends of the helix, connect to the helix such that the transmission line ground is connected to the helix ground tube, and the transmission line wire is connected to the helix wire. The helix to transmission line wire and ground connections can be made either by soldering or spot welding.
9. The interconnecting 200 Ohm microstrip transmission lines will have one large-radius curve as it interconnects the helix wire with the vacuum feedthroughs and be perpendicular to the mounting plate as it connects to the feed through. The height of the signal wire above its ground as given in Table 1, item 17, shall be maintained around the curve. The radius of curvature radius shall not be less than the value in item 19, Table 1.
10. Electrically insulating supports shall physically hold the transmission signal wire in place very close to the point of connection with the feedthroughs. The ground of the microstrip line shall be soldered or welded to the feedthrough ground. The microstrip line signal wire shall connect to a socket that connects to the feedthrough center conductor pin by means of a small, short, stranded wire, soldered or welded.
11. The length of the vacuum vessel is 650 mm flange-to-flange.

1.3 Electrical, Thermal and Vacuum Requirements

1. Maximum electrode voltage with respect to the ground is 550 V.
2. Thermal analysis shall consider each helix dissipates 6 W of electrical power and 40 W steady-state beam absorption (assume even distribution along the length).
3. The copper tube shall be water cooled. Also, the structure shall be designed so as to conduct the ~46 W through the ceramic spacers to the copper tube. The use of adhesives between the copper wire and ground tube and the ceramic spacers is allowable.
4. The helix wire should be clamped with respect to the ground tube at both ends to allow a gradual routing of the connecting 200 Ohm microstrip transmission lines. Both microstrip lines connect vacuum feed throughs located close to their respective helix ends.
5. The first as well as the last turns of the helix wire shall not have electrodes attached. (These locations are as the wire passes over the stepped-ends.)
6. The kicker electrodes should withstand an accidental loss of 20 J evenly distributed between all electrodes of the helix.
7. The kicker structure should not deteriorate from a steady-state radiation by 20 μA tails of the H- beam.

8. All components should be high-vacuum compatible including the case with irradiation by H- beam.
9. Vacuum without the beam should be <100 nTorr.

1.4 Protection Electrodes

The kicker assembly should incorporate two pairs of electrically isolated plates (protection electrodes) for protecting the kicker from accidental beam scraping. The beam current coming to plates will be measured, and the value of the plate current will be used as an indication of possible beam loss to the helix electrodes. Each pair is mounted near the ends of the helix so that creates a horizontal slit.

1. Slit height is 13 mm. The slit sides and the helix electrodes should be aligned so that the offset seen by the beam (16-13)/2= 1.5 mm is within ±0.2 mm.
2. The minimum plate width is 40 mm.
3. Each plate should withstand a steady-state heat load from the beam of 40W and an accidental loss of 20 J.

4. References

Documents with reference numbers listed are in the Project X DocDB: http://projectx-docdb.fnal.gov

[1] PXIE MEBT Functional Requirements Specification
Document #: Project-X-doc-938

[2] PXIE MEBT kicker functional requirements specification
Document #: Project-X-doc-977