

MAGNET DIVISION NOTES

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Revised Harmonics for W6733 for the wide inner and thinner outer cables

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The width of the cable used in the inner layer and the thickness of the cable used in the outer layer has been revised from that used in the original coil cross section W6733, described in reference 1. The width of the inner cable is now 0.486 inch (12.34 mm) changed from 0.477 inch. The thickness of the outer cable is now 0.0455 inch (1.156 mm) changed from 0.0459 inch. These changes affect the low field harmonics. In table 1 we describe the harmonics in various revisions of cross section W6733. We also list the new position of the conductors. Beside these changes every thing else in the various cross sections should be the same as described in reference 1.

W6733 is the original coil cross section. For reference purposes, in table 1, we list the harmonics in that case also. W6733A is for the wider inner cable. The cross section was revised such that the outer radius of the inner layer did not change; only the inner coil radius became 9 mil smaller. This changes the minimum thickness of the wedges in the inner layer. The insulated thickness of the wedge closest to the midplane is now 17.7 mil as against 21.9 in the original design. The minimum thickness of the other two wedges is now 75.8 mil as against 77.4.

W6733B is a design in which the wedge sizes have been reoptimized to bring back the original harmonics. The details of it will not be discussed in here. The only reason to bring it up in this note is to show the degree of flexibility available in the W6733 cross section. This may be needed in the future to correct the harmonics when the measured values do not agree with the design values. To evaluate the effects of correcting b_2 and b_4 on higher harmonics, the cross section W6733A and W6733B should be compared to each other.

W6733C is for the thinner outer cable in addition to the wider inner. In this case we have retained the original cable insulation of 3.45 mil on the top and bottom side of the cable and also retained the wedges of W6733A. Therefore, 0.4 mil reduction in the thickness of each cable will produce an overall change of 10.4 mil in the pole angle of the outer layer since there are 26 turns in it. This 10.4 mil space will be taken up by extra assembly shim. This is the present thinking at BNL to deal with the change in cable

thickness in order to retain the normal coil curing process. The harmonics for this case is highlighted with bold face letters in table 1. The coordinates of the insulated turns in the inner and outer layers are given in table 2 and table 3 respectively.

In W6733D, the insulated cable thickness is retained by increasing the amount of cable insulations by 0.4 mil in the form of added epoxy². This would change the insulation at the top and at the bottom side of the cable from 3.45 mil to 3.65 mil. This was the original thinking at FNAL² to retain the magnetic properties of the design.

In W6733E, we discuss an alternate possibility. In this case the cable insulation will be 3.55 mil on each side and the shim (or the added metal in the pole) will be 5.2 mil thick. From b_2 considerations alone, this is better than W6733C and W6733D. This is the way of incorporating the cable thickness change which will be used in the FNAL² coil cross section. It may be pointed out here that the FNAL iron cross section does not have a pole notch and, therefore, the low field harmonics associated with it. Because of this reason the coil should not have -0.28 unit of b_2 as required in the BNL cross section to cancel the effect of the pole notch.

Table 1: The field harmonics in the various versions of coil cross section W6733.

Coil Cross section	T.F. T/kA	b'_2 10^{-4}	b'_4 10^{-4}	b'_6 10^{-4}	b'_8 10^{-4}	b'_{10} 10^{-4}
W6733	1.04522	-0.280	0.009	-0.004	0.044	0.014
W6733A	1.04645	-0.955	0.062	-0.017	0.043	0.015
W6733B	1.04686	-0.282	0.005	-0.024	0.043	0.015
W6733C	1.04769	1.286	0.080	-0.024	0.043	0.015
W6733D	1.04645	-0.955	0.062	-0.017	0.043	0.015
W6733E	1.04707	0.164	0.071	-0.021	0.043	0.015

References

1. R.C. Gupta, S.A. Kahn and G.H. Morgan, "DSX201/W6733 - Coil and Iron Design for SSC 50 mm Dipole Magnet with wider cables", SSC Tech Note No. 88 (SSCL-N-699), June 28, 1990.
2. Jim Strait, "Private communication".

Table 2: Coordinates of the four corners of each conductor in the inner layer. The cable includes 6.5 mil radial insulation and 3.3 mil azimuthal insulation on it.

Turn No.	x_1 inch	y_1 inch	x_2 inch	y_2 inch	x_3 inch	y_3 inch	x_4 inch	y_4 inch
1	0.9755	0.00400	0.975	0.063	1.474	0.073	1.474	0.004
2	0.9729	0.06250	0.971	0.121	1.470	0.142	1.472	0.073
3	0.9673	0.12090	0.964	0.179	1.462	0.211	1.466	0.142
4	0.9586	0.17910	0.954	0.237	1.451	0.280	1.457	0.211
5	0.9469	0.23680	0.941	0.295	1.438	0.348	1.444	0.279
6	0.9322	0.29420	0.925	0.352	1.420	0.416	1.428	0.347
7	0.9168	0.36800	0.883	0.416	1.291	0.704	1.330	0.647
8	0.8901	0.42090	0.856	0.468	1.257	0.765	1.298	0.709
9	0.8608	0.47200	0.825	0.519	1.220	0.824	1.262	0.769
10	0.8290	0.52150	0.793	0.567	1.181	0.881	1.224	0.827
11	0.7947	0.56910	0.757	0.614	1.139	0.936	1.183	0.883
12	0.7581	0.61490	0.720	0.659	1.094	0.989	1.140	0.937
13	0.7192	0.65870	0.680	0.702	1.047	1.040	1.094	0.988
14	0.6235	0.75280	0.576	0.787	0.863	1.195	0.919	1.155
15	0.5765	0.78770	0.528	0.821	0.806	1.235	0.863	1.196
16	0.5277	0.82010	0.479	0.852	0.748	1.272	0.806	1.235
17	0.4112	0.88680	0.356	0.908	0.530	1.376	0.595	1.351
18	0.3568	0.90850	0.302	0.928	0.465	1.400	0.530	1.377
19	0.3014	0.92750	0.246	0.946	0.399	1.421	0.465	1.399

Table 3: Coordinates of the four corners of each conductor in the outer layer. The cable includes 6.5 mil radial insulation and 3.45 mil azimuthal insulation on it.

Turn No.	x_1 inch	y_1 inch	x_2 inch	y_2 inch	x_3 inch	y_3 inch	x_4 inch	y_4 inch
1	1.4836	0.00400	1.483	0.052	1.957	0.060	1.957	0.004
2	1.4824	0.05230	1.481	0.101	1.954	0.117	1.956	0.060
3	1.4798	0.10050	1.478	0.149	1.951	0.173	1.953	0.117
4	1.4756	0.14860	1.473	0.197	1.945	0.230	1.949	0.173
5	1.4699	0.19660	1.466	0.245	1.938	0.286	1.942	0.229
6	1.4628	0.24450	1.458	0.292	1.929	0.342	1.935	0.286
7	1.4542	0.29210	1.449	0.340	1.919	0.398	1.925	0.341
8	1.4441	0.33950	1.438	0.387	1.907	0.453	1.914	0.397
9	1.4325	0.38670	1.425	0.434	1.893	0.508	1.901	0.452
10	1.4194	0.43350	1.411	0.481	1.878	0.563	1.887	0.507
11	1.4049	0.48000	1.396	0.527	1.861	0.617	1.871	0.562
12	1.3793	0.54890	1.360	0.593	1.791	0.789	1.814	0.738
13	1.3603	0.59330	1.340	0.637	1.768	0.841	1.791	0.789
14	1.3400	0.63710	1.319	0.680	1.743	0.891	1.768	0.841
15	1.3183	0.68020	1.296	0.723	1.717	0.942	1.742	0.891
16	1.2952	0.72270	1.273	0.765	1.689	0.991	1.715	0.941
17	1.2709	0.76440	1.247	0.807	1.660	1.039	1.687	0.990
18	1.2453	0.80540	1.221	0.847	1.630	1.087	1.658	1.038
19	1.2184	0.84560	1.194	0.887	1.598	1.134	1.627	1.086
20	1.1903	0.88500	1.165	0.926	1.564	1.180	1.594	1.132
21	1.1609	0.92350	1.135	0.964	1.530	1.225	1.561	1.178
22	1.1303	0.96120	1.103	1.001	1.494	1.269	1.526	1.222
23	1.0985	0.99790	1.071	1.038	1.457	1.312	1.489	1.266
24	1.0655	1.03370	1.037	1.073	1.418	1.354	1.452	1.308
25	1.0314	1.06850	1.002	1.107	1.379	1.395	1.413	1.350
26	0.9961	1.10230	0.966	1.140	1.338	1.435	1.372	1.390