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Informal Report

COS θ DIPOLE OF 12-CM APERTURE

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Abstract

This note summarizes the conductor distribution in a $\cos \theta$ dipole of 12-cm aperture (inner coil diameter). We include calculated field shapes for the case of an infinite- μ iron shield, and examine the multipoles introduced by random as well as systematic errors in conductor location.

Magnet Geometry

A quadrant of the magnet cross section is shown in Fig. 1, which also indicates the spacing of "inert" turns (black) in order to obtain the required ribbon distribution, and the iron shield. There are 87 conductors, each 0.027 in. thick and 3/4 in. wide, arranged in groups of 21, 20, 17, 14, 10 and 5 turns, respectively. The gap between the coils and iron shield is 0.175 in. Conductor locations and sizes are listed in Table I. Here X and Y are the coordinates of the corner closest to the median plane of each conductor, and ϕ is the tilt angle of a conductor with respect to the median plane. In this geometry the midpoint of the base of each conductor, of rectangular shape, is located on a circle of radius 6.0 cm. As usual optimum conductor locations were obtained by small azimuthal displacements of the conductors, thus cancelling the six leading Fourier coefficients in the field distribution in the case of an infinite- μ iron shield (located at a radius of 8.35 cm). Therefore the wedges are not all of the same size, as was also the case in ISA-1 and ISA-2.

Field Distribution

In Fig. 2 are shown normalized fields and first and second field derivatives versus radius on the median plane (again for the case of infinite- μ iron). The region of acceptable field homogeneity, in terms of the criterion proposed by G. Parzen, ranges between 73% of the magnet aperture with respect to the first derivative requirement

$$\left(\frac{1}{B_0} \frac{dB}{dX} \leq 0.6 \times 10^{-3} \text{ in.}^{-1} \right)$$

and 65% with respect to the second derivative requirement

$$\left(\frac{1}{B_0} \frac{d^2 B}{dx^2} \leq 1 \times 10^{-3} \text{ in.}^{-2} \right) .$$

The "load line" for this magnet is 13.423 G/A for $\mu = \infty$; with iron of finite permeability approximately 3300 A are actually required to produce 40 kG.

Effect of Errors in Conductor Location

Sensitivity to random conductor displacements from the ideal positions was investigated by moving all ribbons in a block (and in one quadrant only) a uniform amount, radially or azimuthally, from which field errors due to rms errors in all four quadrants were obtained. The results, in terms of induced multipoles, are shown in Fig. 3 and compared with the corresponding multipoles in the case of dipoles of 8 and 10 cm aperture (CRISP 73-2). These calculated multipoles should probably be regarded as upper limits.

Failure to center the coils in the iron shield was explored by systematically displacing all conductors an equal amount horizontally or vertically. In terms of harmonics, a horizontal displacement does not affect the even harmonics $b_2, b_4, \dots$, but does introduce an odd in-phase quadrupole term b_1 : $b_1 \sim 0.075 \times 10^{-3} \text{ in.}^{-1}$ per mil of displacement; a vertical displacement produces a quadrupole term of the same magnitude but out of phase. Higher induced odd harmonics are negligible.

TABLE I

CONDUCTOR THICKNESS = 0.068878 cm
CONDUCTOR WIDTH = 1.905 cm

X (cm)	Y (cm)	φ°
6.004 044	0.008 912	7.003 420
6.003 147	0.078 198	
6.001 451	0.147 385	
5.998 961	0.216 476	
5.995 678	0.285 467	
5.991 605	0.354 363	
5.986 743	0.423 161	
5.981 094	0.491 863	
5.974 659	0.560 468	
5.967 438	0.628 977	
5.959 432	0.697 389	
5.950 642	0.765 705	
5.941 066	0.833 925	
5.930 705	0.902 048	
5.919 556	0.970 074	
5.907 623	1.038 004	
5.894 900	1.105 837	
5.881 386	1.173 572	
5.867 080	1.241 211	
5.851 979	1.308 731	
5.836 060	1.376 194	
5.830 096	1.434 776	20.744 012
5.812 769	1.501 865	
5.794 688	1.568 670	
5.775 859	1.635 191	
5.756 283	1.701 430	
5.735 961	1.767 386	
5.714 897	1.833 061	
5.693 091	1.898 464	
5.670 545	1.963 568	
5.647 258	2.028 401	
5.598 466	2.157 226	
5.572 960	2.221 219	
5.546 713	2.284 931	
5.519 728	2.348 363	
5.492 000	2.411 514	
5.463 529	2.474 283	
5.434 213	2.536 970	
5.404 350	2.599 275	
5.373 639	2.661 296	
5.342 176	2.723 032	

TABLE I (CONT.)

X (cm)	Y (cm)	φ°
5.254407	2.903506	34.520994
5.220278	2.963629	
5.185490	3.023800	
5.150047	3.082519	
5.113949	3.141288	
5.077197	3.199607	
5.039793	3.257476	
5.001736	3.314900	
4.963026	3.371874	
4.923669	3.428400	
4.883656	3.484478	
4.842995	3.540107	
4.801679	3.595287	
4.759710	3.650016	
4.717086	3.704298	
4.673825	3.758127	
4.629667	3.811504	
4.586747	4.116849	46.236428
4.520804	4.156670	
4.472330	4.215697	
4.423327	4.264232	
4.373796	4.312174	
4.323757	4.359626	
4.273151	4.406288	
3.970394	4.498041	
3.918233	4.543033	
3.865539	4.587436	
3.812319	4.631246	
3.758569	4.674465	
3.704291	4.717091	
3.649462	4.759124	
3.586541	5.116099	62.091105
3.079341	5.151487	
3.019771	5.186174	
2.959829	5.220161	
2.899518	5.253449	
2.777782	5.317923	
2.716361	5.349113	
2.654869	5.379611	
2.592405	5.409405	
2.529570	5.438494	
1.584995	5.767766	76.329254
1.518349	5.805217	
1.451616	5.821680	
1.384496	5.837775	
1.317289	5.852901	

Fig. 1

MULTIPOLE COEFFICIENTS
INTRODUCED BY 0.002" BLOCK
DISPLACEMENTS VS. DIPOLE
APERTURE

FIG. 3