Random Error Multipoles Generated by the Trim Correction Coils

SSC-N-239
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The alignment and mechanical error tolerance of the trim correction coils are specified by Pat Thompson.[1] We assume the specifications reached by "technology level I" of Ref.1, i.e.

coil displacement	0.25 mm
coil rotation	0.9 deg.
gap	0.9 deg.
elliptical deformation	0.25 mm
wire rms	0.125 mm
block rms	0.125 mm.

Reference 1. P. A. Thompson, SSC-N-226, August 1986.

Assuming Thompson's error matircies, the random multipole errors can be obtained by adding the above contributions in quadrature. The result for the b_2 trim coil are (relative to the field strength due to b_2, measured at 1 cm radius)*

* assuming the values of b_4 and b_5 due to elliptical distortion in Table 1 of Ref.1 are mistakenly switched.

a_0 = 0.52%	b_0 = 3.32%
a_1 = 5.11%	b_1 = 5.11%
a_2 = 5.27%	b_2 ----
a_3 = 0.25%	b_3 = 0.62%
a_4 = 0.17%	b_4 = 0.59%
a_5 = 0.07%	b_5 = 0.02%
a_6 = 0.04%	b_6 = 0.00%
a_7 = 0.02%	b_7 = 0.02%
a_8 = 0.00%	b_8 = 0.02%

Similarly for b_3 trim coil, the rms random multipoles are (relative to b_3 field strength at 1 cm radius)

a_0 = 0.71%	b_0 = 0.35%
a_1 = 1.13%	b_1 = 6.60%
a_2 = 7.65%	b_2 = 7.65%
a_3 = 6.92%	b_3 ----
a_4 = 0.32%	b_4 = 0.75%
a_5 = 0.11%	b_5 = 0.68%
a_6 = 0.07%	b_6 = 0.07%
a_7 = 0.04%	b_7 = 0.02%
a_8 = 0.02%	b_8 = 0.00%
a_9 = 0.02%	b_9 = 0.00%

For b_4 trim coil, the rms random multipoles are (relative to b_4 field strength at 1 cm radius)

a_0 = 0.95%	b_0 = 0.71%
a_1 = 1.22%	b_1 = 0.88%
a_2 = 1.27%	b_2 = 9.94%
a_3 = 10.18%	b_3 = 10.18%
a_4 = 8.52%	b_4 ----
a_5 = 0.05%	b_5 = 0.90%
a_6 = 0.09%	b_6 = 0.78%
a_7 = 0.07%	b_7 = 0.09%
a_8 = 0.04%	b_8 = 0.04%
a_9 = 0.02%	b_9 = 0.02%
a_{10} = 0.02%	b_{10} = 0.00%

During injection, the trim correctors are used to compensate for the persistent current effects. Taking b_2=-4.7, b_4=0.3 (for 5 μm filament in the dipoles) and, somewhat arbitrarily, b_3=0.1, the rms of the combined multipole errors are given below (all coefficients in the usual $10^{-4}cm^{-n}$ units):

a_0 = 0.025	b_0 = 0.156
a_1 = 0.240	b_1 = 0.240
a_2 = 0.248	b_2 = 0.031
a_3 = 0.033	b_3 = 0.042
a_4 = 0.027	b_4 = 0.028
a_5 = 0.003	b_5 = 0.003
a_6 = 0.002	b_6 = 0.002
a_7 = 0.001	b_7 = 0.001

The random a_1 and b_1 components mainly come from the feeddown of the b_2-coil displacements. These values are about 1/3 of the expected 0.7 units of the random a_1 and b_1 of the main dipole field. The random a_2 comes mainly from the rotational misalignment of the b_2-coils. It is to be compared with the 0.6 units of the random a_2 of the main dipole fields.

We thus iterate the conclusion made in Ref. I that the random multipoles due to alignment and mechanical errors (technology I) of the trim coils, especially the b_2-coils, are about at the acceptable level. In addition, we remind the reader the conclusion made in SSC-N-185 (Peterson) that the present arrangement of single-layer b_2, b_3 and b_4 trims requires an rms orbit displacement to be less than 1 mm, assuming 5 μm filament in the main dipole magnets.