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Supplement to the Resonance Correction Scheme for LEB

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1. Introduction

The lattice of LEB was changed recently. The main change is reducing the vertical tune from 16.75 to 10.75. The main advantages of new lattice, I think, are the reduction of the machine natural chromaticities from -25.15/-25.16 to -21.88/-15.64 and avoicing some strong depolarizing resonances.

The resonance correction scheme for new lattice of LEB was completed. The method used here is the same as that in reference[1]. For the new lattice of LEB we need to correct: (1) the quadrupole resonances 2vx=33 and 2vy=21; (2) the skew quadrupole resonances vx+vy=27 and vx-vy=6; (3) the sextupole third integer resonances 3vx=50, vx+2vy=38 and 3vx=49, vx+2vy=37; (4) the skew sextupole third integer resonances 3vy=32, vy+2vx=44 and 3vy=31, vy+2vx=43.

In order to cancel the resonance strengths excited by the random errors some correctors are placed. Their positions are periodic with the same superperiods as the lattice. Their strengths are different in different superperiod because of the demand of producing the desired harmonic terms (e.g. 33, 21, 27, 6, 50, 38, 49, 37, 44, 43 etc.).

The relationships among the strengths of the corresponding correctors in different superperiod are shown as following:

Superperiod	Quadrupole Corrector	Skew Quadrupole Correctors
1	(Q1, Q2, Q3, Q4)	(SQ1, SQ2)
2	-(Q1, Q2, Q3, Q4)	(SQ3, SQ4)
3	the same as superperiod 1	
4	the same as superperiod 2	
5	the same as superperiod 1	
6	the same as superperiod 2	

Superperiod	Sextupole Corrector	Skew Sextupole Correctors
1	(S1, S2, S3, S4)	(SS1, SS2, SS3, SS4)
2	-0.5* (S5, S6, S7, S8)	-0.5* (SS5, SS6, SS7, SS8)
3	-0.5* (S1, S2, S3, S4)	-0.5* (SS1, SS2, SS3, SS4)
4	(S5, S6, S7, S8)	(SS5, SS6, SS7, SS8)
5	the same as superperiod 3	
6	the same as superperiod 2	

There are 48 quadrupole correctors with four power supplies, 24 skew quadrupole correctors with four power supplies, 48 sextupole correctors with eight power supplies and 48 skew sextupole correctors with eight power supplies in the machine. The correctors would be placed next to some (not all!) main quadrupoles. The detailed positions and the strengths of the different kind of correctors will be given seperately.

2. Quadrupole Resonance Correction

Here the correctors are used to correct the resonances 2vx=33, 2vy=21.

The following random errors are considered:
1) horizontal displacement (σ = 1 mm) of the eddy current sextupole (B"= 0.24 T/M) in dipole;
2) horizontal displacement (σ= 1 mm) of the sextupole (b2=0.12 @ 1cm) in dipole;
3) horizontal displacement (σ= 1 mm) of the main sextupole;
4) error (σ= 0.06%) in the strengths of QF,QD

The positions and the strengths of 8 quadrupole correctors in the first superperiod are shown as following.

S (M, position)	strength
0.40	Q1
5.40	Q2
20.40	Q3
25.40	Q4
40.40	-Q1
45.40	-Q2
60.40	-Q3
65.40	-Q4

The maximum strength of the correctors for 20 random cases is 0.00126 M^{-1}.

3. Skew Quadrupole Corrector

Here the correctors are used to correct the resonances vx+vy=27 and vx-vy=6.

The following random errors are considered:
1) vertical displacement (σ= 1 mm) of the eddy current sextupole (B"= 0.24 T/M) in dipole;
2) vertical displacement (σ= 1 mm) of the sextupole (a2=0.06 @ 1cm) in dipole;
3) vertical displacement (σ= 1 mm) of the main sextupole;
4) rotation error (σ= 0.6 mrad) of QF,QD

The positions and the strengths of 4 skew quadrupole correctors in the first superperiod are shown as following.

S (M, position)	strength
0.40	SQ1
15.40	SQ2
50.40	-SQ1
65.40	-SQ2

The maximum strength of the skew quadrupole correctors for 20 random cases is 0.0024 M^{-1}.

4. Sextupole Corrector

Here the correctors are used to correct the resonances 3vx=50, vx+2vy=38 and 3vx=49, vx+2vy=37.

The following random errors are considered:
1) random sextupole (b2=0.12 @ 1cm) in dipole;
2) error (σ= 0.1%) in the strength of the main sextupole;
3) variation (σ=10%) on the systematic value of the eddy current sextupole (B"=0.24T/M) in dipole.

The positions and the strengths of 8 sextupole correctors in the first superperiod are shown as following.

S (M, position)	strength
0.40	S1
5.40	S2
30.40	S3
35.40	S4
50.40	-S1
55.40	-S2
80.40	-S3
85.40	-S4

The maximum strength of the correctors for 20 random cases is 0.0113 M^{-2}.

5. Skew Sextupole Corrector

Here the correctors are used to correct the resonances 3vy=32, vy+2vx=44 and 3vy=31, vy+2vx=43.

The following random errors are considered:
1) random skew sextupole (a2=0.06 @ 1cm) in dipole;
2) rotation error (σ = 0.65 mrad.) of the main sextupole.

The positions and the strengths of 8 skew sextupole correctors in the first superperiod are shown as following.

S (M, position)	strength
0.40	SS1
5.40	SS2
20.40	SS3
25.40	SS4
50.40	SS1
55.40	SS2
70.40	SS3
75.40	SS4

The maximum strength of the correctors for 20 random cases is 0.0082 M^{-2}.

6. Summary

Considering a safe factor of 2, the results can be summaried shown in the following table:

LEB Corrector Parameters

	Quad. Cor.	Skew Quad. Cor.	Sext. Cor.	Skew Sext. Cor.
No. required	48	24	48	48
Position	shown above			
Legnth(assumed)	0.2M	0.2M	0.1M	0.1M
Strength	0.50 T/M	0.96 T/M	9.2 T/M^2	6.6 T/M^2

Reference

[1] L.K. Chen, "The Resonance Correction Scheme For the Low Energy Booster", SSC-N-687, Dec., 1989