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Canadian Light Source Main Ring Lattice

CLS DESIGN NOTE – 5.2.69.2 Rev.3

January 13, 2004

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REVISION HISTORY

Revision	*Date*	*Description*	*Author*
B	May 18, 1999	Original Draft	L. O. Dallin
C	October 1, 1999	Update lattice to 500 MHz	same
D	October 18, 1999	Move first S1 sextupole 85 mm	same
0	November 27, 2000	2.9 GeV operation Correct RF voltage Correct pulse length Change file number (was 2.1.15 D)	same
1	December 18, 2000	Change effective length of quadrupoles and sextupoles	same
2	October 16, 2002	Move Q3 quadrupoles 63 mm closer together. Use measured gradient and pole face rotation for the dipole. Include low-β_y parameters	same
3	January 13, 2004	corrected errors in Appendix A	same

1.0 INTRODUCTION

This technical design note provides the characteristics of the CLS main ring lattice.

The parameters for 2.9 GeV operation are given. The RF frequency is 500 MHz and the cavity voltage is taken to be 2.4 MV.

In revision D, the S1 sextupoles are now asymmetrically located in the lattice cell. This allows more room for the vacuum chamber requirements at the end of the first dipole. This shift in the sextupole position results in a small adjustment to the nominal sextupole strengths of both sextupole families, but does not change the maximum field strength requirements.

In revision 2, the Q3 quadrupoles are moved symmetrically closer together by 60 mm. This results in a slight changes in all quadrupole values, but does not change the maximum field strengths required. It also results in a slight decrease in the strengths of the sextupole magnets. Also, for the dipole magnets, the measured gradients and pole face rotations are now used to determine the machine parameters.

Revision 2 also includes a provision for an alternate tune resulting in a decrease in the vertical beta function in the straight sections. For this tune the maximum strength in the Q1 quadrupoles is increased.

The lattice is shown in Figure 1, where one full cell is shown. The new machine parameters are given in Table 1.

Machine parameters are derived from the DIMAD input file given in Appendix A. For more details see reference 1.

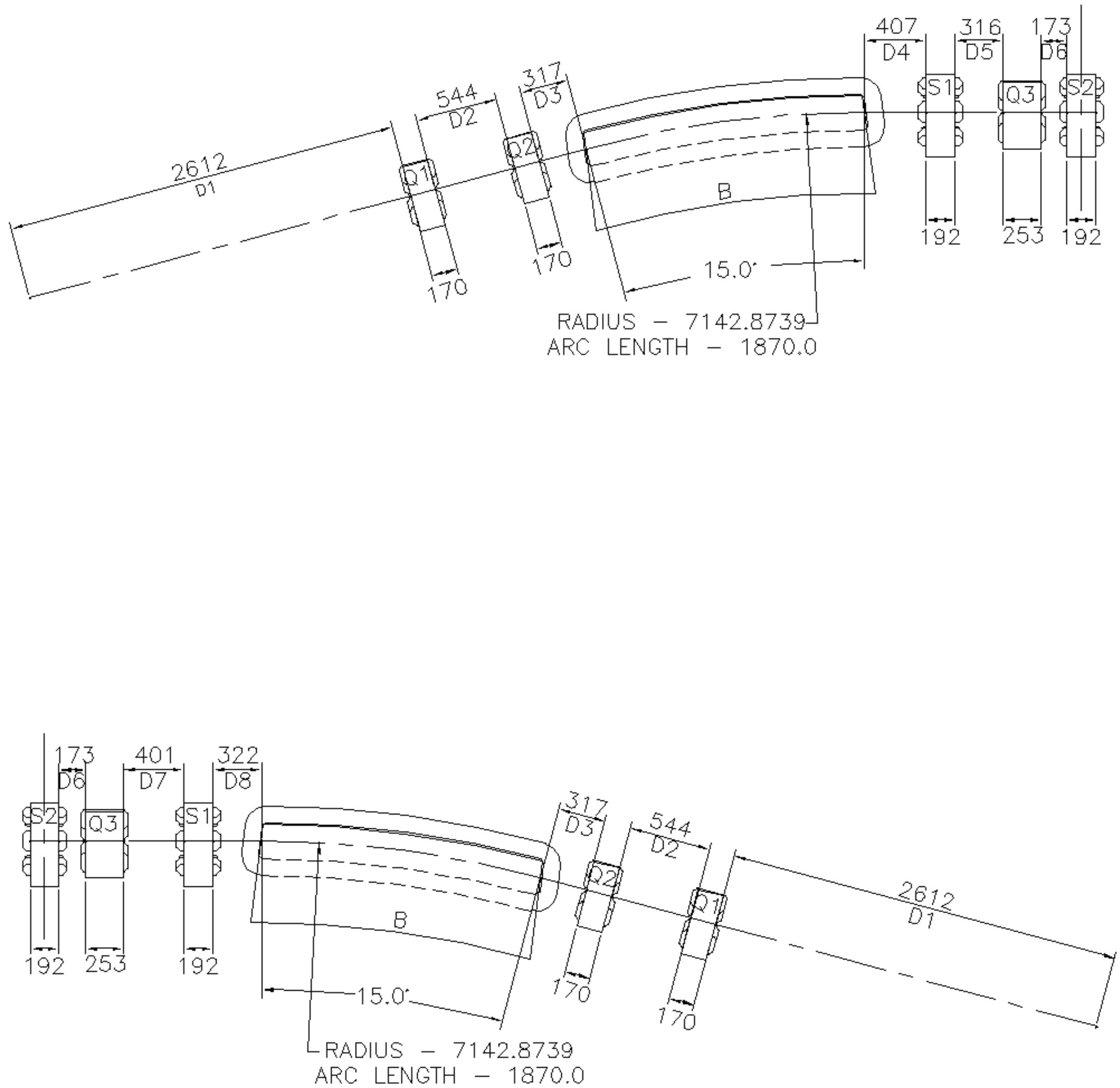

Figure 1. Full cell of the CLS lattice. (Lengths of elements are physical lengths.)

Table 1. Light Source Ring Parameters

Circumference	170.88		m
Periodicity	12		
Optics	nominal	low β_y option	
ν_x (tune)	10.22	10.22	
ν_y	3.26	4.26	
χ_x (natural chromaticity)	–13.7	–14.8	
χ_y	–16.4	–18.3	
momentum compaction	0.0038	0.0038	
Straights	12		
length	5.2		m
β_x	8.1	9.1	m
β_y	4.6	2.7	m
η_x (dispersion)	0.15	0.15	m
RF Cavity			
frequency	500		MHz
voltage	2.4		MV
harmonic number	285		
Dipole field	1.354	1.354	T
Damping times			
τ_x	2.4	2.4	ms
τ_y	3.8	3.8	ms
τ_E	2.7	2.7	ms
Energy loss/turn	0.876	0.876	MeV
Radiated power	438	438	kW @ 500 mA
Radiated power/m in dipoles	9.76	9.76	kW/m
ε_x (emittance)	18.3	17.9	nm-rad
δ (energy spread)	0.111	0.110	%
Energy acceptance	1.54	1.55	%
Full bunch length	65	65	ps

2.0 DIPOLE MAGNETS

The dipole magnets are 1.87 m long and are designed to run at 1.354 T at 2.9 GeV. To supply vertical focusing, the dipoles have a field gradient of -3.867 T/m at 2.9 GeV. This corresponds to an energy independent “k” value of $k_q = -0.400$ m^{-2}. For details of the dipole design see technical design note 5.2.31.2.ReV.0 "Synchrotron Light Source Magnets" (reference 2).

In revision 2 the measured dipole gradient and pole face rotation angle are used. They are $k = -0.3972$ m^{-2} and 0.105 radians, respectively. Also, from the measurements, a small sextupole content is included in the dipoles, $k_s = -0.20$.

3.0 QUADRUPOLE MAGNETS

There are three families of quadrupoles, Q1, Q2 and Q3. The lengths of Q1 and Q2 are the same, while Q3 is somewhat longer. For the nominal tunes, the k values of Q1 and Q2 are kept well below $k_q=2.0$ m^{-2} to allow for tunability when operating at 2.9 GeV. For Q3, the tunability required is small so this magnet has been designed to operate near $k_q=2.1$ m^{-2}. The lengths and strengths of the quadrupole magnets are given in Table 2. More details are given in design note 5.2.31.2.Rev.0 mentioned previously.

Table 2. Quadrupole Parameters at 2.9 GeV

Family	Length		Strength (nominal)		(low β_y)	
	magnetic m	physical m	k_q m^{-2}	B’ T/m	k_q m^{-2}	B’ T/m
Q1	0.180	0.170	1.679	16.23	1.954	18.89
Q2	0.180	0.170	1.883	18.20	1.441	13.93
Q3	0.260	0.253	2.040	19.72	2.045	19.75

4.0 SEXTUPOLE MAGNETS

The sextupoles are required to adjust the chromaticities (χ's) to zero, or to a value slightly greater than zero. The values of the sextupole magnets are given in Table 3 for chromaticities of zero and two. More details are given in design note 5.2.31.2.Rev.0. (Note B'' = E/0.3* k_s and B (x) = B'' * x^2 / 2.)

Table 3. Sextupole Parameters at 2.9 GeV

Family	χ	Length		Strength		low β_y	
		magnetic m	physical m	k_s m^{-3}	B'' T/m^2	k_s m^{-3}	B'' T/m^2
S1	0.0	0.192	0.192	–24.8	–240.	–25.9	–250.
S2	0.0	0.192	0.192	39.1	378.	39.7	384.
S1	2.0			–28.1	–272.	–29.1	–281.
S2	2.0			44.6	431.	44.9	434.

5.0 REFERENCES

1. L.O. Dallin, CLS design note 8.2.69.1 Rev.0, "CLS Lattice Performance Analyses" , 27 Nov., 2000.
2. L.O. Dallin, CLS design note 5.2.31.2 Rev.0, "Synchrotron Light Source Magnets" , 14 Feb., 2001.

References are available at http://www.cls.usask.ca/research/technotes.shtml

APPENDIX A – DIMAD INPUT FILE:

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TITLE
CLS January 2004 (betay=3.26)
D1:DRIFT,L=.25
D1b:DRIFT,L=.357
D2:DRIFT,L=0.534
D3:DRIFT,L=0.312
D4:DRIFT,L=.407
D5:DRIFT,L=.3125
D6:DRIFT,L=.1695
D7:DRIFT,L=.3975
D8:DRIFT,L=.322
Q1:QUADRUPOLE,L=.18,K1=1.67899,APERTURE=.035
Q2:QUADRUPOLE,L=.18,K1=1.88264,APERTURE=.035
Q3:QUADRUPOLE,L=.260,K1=2.03992,APERTURE=.035
S1:SEXTUPOLE,L=.192,K2=-24.7925,APERTURE=.035
S2:SEXTUPOLE,L=.192,K2=39.0518,APERTURE=.035
HC:SBEND,L=1.87,ANGLE=0.2617994,E1=0.105,E2=.105,K1=-.3972, &
HGAP=.025,FINT=0.5,FINTX=0.5,K2=-0.2,H1=0.,H2=0.
CELL:LINE=(9*D1,D1b,Q1,D2,Q2,D3,HC,D4,S1,D5,Q3,D6,S2, &
D6,Q3,D7,S1,D8,HC,D3,Q2,D2,Q1,D1b,9*D1)
RING:LINE=(12*CELL)
USE,RING
DIMAT
MATRIX
2 -1,
HARDWARE
2.9 0. 0. 0. 0. 0. 0. 0. 1. 0,
MACHINE
1.5 2.9  1.4 1 .025 1 1
0 0 0 0 0 0
0;
STOP;
```