

Longitudinal and Transverse Impedance of The SPring-8 Storage Ring

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1 Introduction

The result of estimations of the broad-band longitudinal and transverse impedance of the SPring-8 storage ring is shown. The estimation scheme is given in ref.[1].

2 Dimension of Structure of Beam Pipe

Fig.1 ,2,3, Table 1,2 show the shape of discontinuities of the inner wall of the beam pipe of the storage ring[2].

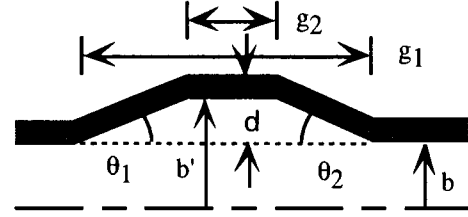


Figure 1. Dimension of two-dimensional models of elements

Table 1. Dimensions of two-dimensional models of elements of the vacuum chamber.

element	dimension [mm, rad]						
	b	b'	d= b'-b	g ₁	g ₂	θ ₁	θ ₂
RF cavity	50	250	200	220	220	90	90
weldments	20	22	2	0.2	0.2	90	90
flanges*	20	23	3	0.5	0	-	90
offsets	20	20.5	0.5	-	0	0	90
ID [†] section	20	5	15	-	-	5	5
transition at RF section	20	50	30	-	-	10	10
absorbers at RF section	50	35	15	-	-	10	10
BPM ^{††}	20	-	-	0.5	0.5	90	90

†: ID is Insertion Device,

††: BPM is Beam Position Monitor,

*:with RF contact finger

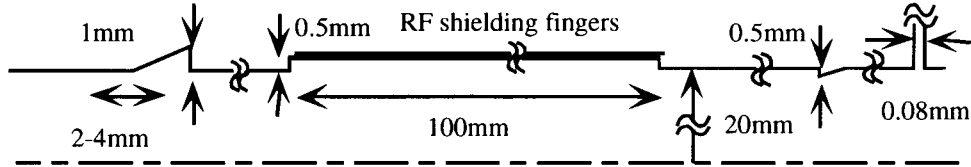


Figure 2. Shape of a valve

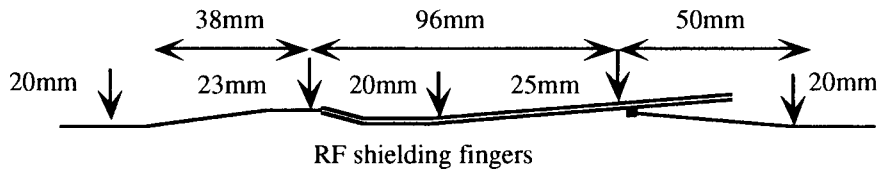


Figure 3. The shape of a bellows.

Table 2. Dimension of slots

slot size[mm]	height	length	depth
between RF contact fingers	1	1~100	1
to antechamber	10~12	-	> 20
to DIP [†]	2	50	4

†: DIP is Distributed Ion Pump

3 Impedance

The impedance of the SPring-8 storage ring is summarized in Table 3.

The total impedance is

$$\frac{Z^{\parallel}}{n} = -0.127i + \frac{400}{n} + 1.3 \times 10^5 \frac{1+i}{n\sqrt{n}} [\Omega]$$

These values are valid at $\omega < c/d$, d is the depth of the grooves[3], such as flanges, weldments and offsets shown in Fig. 1. In our case, $d \sim 2\text{mm}$ and $c/d \sim 150\text{GHz}$.

Table 3. Impedance of the SPring-8 storage ring

Elements	Number of Elements	Total Impedance			d /min.{b,b'} [mm/mm]
		Theory	Simulation		
		$\frac{Z^{\parallel}}{n} \text{ } [\Omega]$	$\frac{Z^{\parallel}}{n} \text{ } [\Omega]$	$Z^{\perp} \text{ } [M\Omega/m]$	
RF cavities	32	$1.5 \times 10^5 \frac{1+i}{n\sqrt{n}}$	$1.3 \times 10^5 \frac{1+i}{n\sqrt{n}}$	$2.8 \times 10^4 \frac{1+i}{n\sqrt{n}}$	50 / 50
weldments	2000	- 0.005 i	- 0.006 i	- 0.007 i	20 / 20
flanges†	700	- 0.005 i	- 0.007 i	- 0.008 i	20 / 20
offsets	2700	- 0.013 i	- 0.020 i	- 0.023 i	20 / 20
bellows†	400	-	- 0.060 i	- 0.068 i	20 / 20
BPMs	300	-	360 / n	410 / n	20 / 20
transitions at RF sections	4 pair	- 0.007 i	- 0.006 i	- 0.007 i	20 / 20
absorbers at RF sections†	8	- 0.007 i	- 0.003 i	- 0.003 i	35 / 35
ID sections	40	- 0.020 i	- 0.020 i	- 0.092 i	10 / 5
valves†	100	-	40 / n - 0.003 i	46 / n - 0.003 i	20 / 20
pumping slots	3000	-	- 2×10 ⁻⁵ i	- 2×10 ⁻⁵ i	(20/√2)/35
slots to antechamber	500	-	- 0.001 i	- 0.001 i	(20/√2)/35
slots between RF fingers	24000	-	- 0.001 i	- 0.001 i	(20/√2)/35
resistive wall (b=20mm)	-	$1.9 \frac{1-i}{\sqrt{n}}$	-	$2.2 \frac{1-i}{\sqrt{n}}$	20 / 20
synchrotron radiation	-	0.026	-	-	-

† : These elements have RF shielding fingers.

Table 4. Loss parameters of a single element

Bunch Length [r.m.s.]	loss parameters [V/C]		
	3 mm	5 mm	10 mm
an RF cavity	8.07E+11	6.43E+11	4.82E+11
a weldment	5.02E+09	2.78E+08	1.88E+07
a flange	6.61E+08	8.09E+07	7.58E+06
an offset	2.81E+09	8.69E+08	1.21E+08
an ID section†	6.93E+10	1.11E+10	1.36E+09
a transition at RF	8.57E+11	1.56E+11	1.16E+10
an absorber at RF	2.56E+11	1.22E+11	3.87E+10
bellows	9.81E+10	4.14E+10	9.57E+09
a valve	1.50E+10	6.04E+09	9.60E+08
a slot opening	9.65E+08	1.08E+08	1.88E+06
Total (One Turn)	8.28E+13	3.69E+13	1.77E+13

The loss parameters and the parasitic loss power caused by them for different bunch length is shown in Table 4,5 , respectively.

The expected natural bunch length is 3.5-5mm[4].

Table 5. Parasitic Loss Power of a single elements at the stored current of 100mA=5mA/bunch×20 bunch

Bunch Length [r.m.s.]	Parasitic Loss Power [W]		
	3 mm	5 mm	10 mm
an RF cavity	1932.75	1539.97	1154.38
a weldment	12.02	0.67	0.05
a flange	1.58	0.19	0.02
an offset	6.73	2.08	0.29
an ID section	165.97	26.58	3.26
a transition at RF	2052.50	373.62	27.78
an absorber at RF	613.11	292.19	92.69
bellows	234.95	99.15	22.92
a valve	35.92	14.47	2.30
a slot opening	2.31	0.26	0.00
Total (One Turn)	1.98E+05	8.84E+04	4.24E+04

References

- [1] T. Nakamura, "Estimation Scheme of Longitudinal and Transverse Impedance," in this report.
- [2] K. Watanabe, et al., Proc. of the 1993 IEEE Particle Accelerator Conference, pp.3845-3847(1993).
- [3] T. Nakamura, "Characteristics of Impedance of Small grooves," in this report.
- [4] T. Nakamura, "The Simulation Study of THE Single bunch instabilities in the SPring-8 Storage Ring," submitted to EPAC96.