THE RF SYSTEM OF SIAM PHOTON AT NSRC IN THAILAND

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ABSTRACT

A modeling of the rf cavity of the storage ring of Siam Photon at National Synchrotron Research Center (NSRC) in Thailand is presented here. Monopole and dipole modes in the cavities have been investigated, and the possibility of coupled-bunch-mode instabilities due to these modes is discussed. A modification of the storage ring cavity for the purpose of reduction of these instabilities was carried out and the properties of the modified cavity is presented. This work has been carried out in collaboration with the Photon Factory at KEK.

1 INTRODUCTION

The National Synchrotron Research Center (NSRC) in Thailand maintains the synchrotron facility that was operated by the former SORTEC Corporation in Tsukuba, Japan. It operated at a beam energy of 1 GeV and 200 mA beam current. After SORTEC was closed down, the machine was donated to Thailand, where it is scheduled to be reopened and upgraded in the next future. For details about the operation of the former SORTEC ring see [1, 2].

2 THE CAVITY OF THE STORAGE RING

The parts of the beam duct of the storage ring that are connected to the cavity have a rectangular shape, with its short planes replaced by semi cylinders. The cut-off frequencies of this guide have been calculated with the computer code MAFIA [3].

ν_c *(GHz)*	*Type*	*Coupled cavity mode*
1.522	TE_{10}	*v*-type dipole mode
2.969	TE_{20}	*TE* monopole mode
4.103	TE_{01}	*h*-type dipole mode
4.207	TM_{11}	*TM* monopole mode

Table 1 Propagation modes of the beam duct

For the modeling of the cavity, the ports have been ignored, and the sharp edges have been replaced by some small curvatures, which are more likely to be present in the real cavity. Because of the non cylindrical shape of the beam duct, the modeling had to be carried out for monopole modes, *v*-type and *h*-type dipole modes separately, while the beam duct was replaced by cylinder symmetrical ducts with cut-off frequency according to the values in table 1. In this way, the real cavity was approximated by a perfectly cylinder symmetric cavity, which is expected to have the same properties.

NR.	ν *(MHz)*	*Q-value*	R_s *(KΩ)*
1	121.40	24926	4313.65
2	499.27	34917	110.47
3	766.32	49257	99.02
4	907.02	39179	70.13
5	991.39	50581	52.10
6	1243.23	45733	50.76

Table 2 Monopole modes of the cavity

Mode Nr.1 is the fundamental mode that accelerates the electron beam. The resonance frequency given by the manufacturer Mitsubishi is 118 MHz. The difference might be caused by the assumptions about the curvature.

NR.	ν *(MHz)*	*Q-value*	R_t *(KΩ/m)*
		h-type	
1	504.17	30591	3566.60
2	642.01	17149	7559.79
3	800.54	45632	3331.59
		v-type	
1	504.15	30557	3503.67
2	641.87	17125	7471.47
3	800.50	45620	3331.63

Table 3 Dipole modes of the cavity

3 BUNCH-MODE INSTABILITIES

Electron bunches circulating in a storage ring establish properties of coupled harmonic oscillators. Higher order monopole modes cause a complex frequency shift $\Delta\omega$ of the longitudinal bunch oscillation, which is described by $e^{i(\omega+\Delta\omega)t}$. The growth rate $1/\tau_g$ is defined as $1/\tau_g=-\mathrm{Im}(\Delta\omega)$ [4]. On the other hand, emission of synchrotron radiation causes radiation damping, and a spread in synchrotron frequency causes so called "Landau damping" of the coupled-bunch-modes. A mode is considered as unstable, if its growth rate is higher than its damping rate. The threshold current is defined as the current, for which growth rate and damping rate are equal. The calculations of the growth rates were carried out with the computer code ZAP [5]. The obtained values, which are given in table 4, are the maximum growth rates, which were found by shifting the rf frequency to the closest bunch mode frequency. The parameter a describes the characteristic of the motion in synchrotron phase space.

Mode NR	a	$1/\tau_g$ (s^{-1})	I_{tr} (mA)
2	1	64 839	3.94
	2	48 682	6.71
3	1	27 937	9.15
	2	49 962	6.54
4	1	10 753	23.77
	2	26 611	12.28
	3	1 949	185.99
5	1	5 032	50.79
	2	14 909	21.92
6	2	4 139	78.97

Table 4 Growth rates and threshold currents for longitudinal coupled-bunch-mode instabilities

NR.	*A*	$1/\tau_g$ (s^{-1})	I_{tr} (mA)	$1/\tau_g$ (s^{-1})	I_{tr} (mA)
		h-type		*v*-type	
1	0	2 703	7.72	2 609	8.00
	1	2 843	82.56	2 754	85.22
2	0	3 174	6.58	3 095	6.75
	1	5 211	45.04	5 083	46.17
	2	3 805	80.42	3 709	82.50
3	0	607	34.39	603	34.62
	1	1 510	155.43	1 490	157.52
	2	1 657	184.66	1 635	187.14

Table 5 Growth rates and threshold currents for transverse coupled-bunch-mode instabilities

Transverse instabilities are caused by dipole modes of the rf cavity. In this case, the value $a=0$ is also possible.

4 REDESIGN OF THE CAVITY

By using high resistive *SiC* inside the duct, higher order monopole and dipole modes can be absorbed [6]. For this, the shape of the beam duct must be adjusted in a way that a region inside the duct is generated, where fields of the undesired modes are present, while the field intensity due to the fundamental mode is negligible. This can be achieved by an enlargement of the beam duct. The inner radius of the duct was therefor changed from 55 mm to 86 mm and the outer radius was adjusted to 124 mm to keep the frequency of the fundamental mode constant. The material of the tapered section of the beam duct was replaced by *SiC*, and the shape of this part was changed to increase the effectiveness of the *SiC* material and to "smooth out" the duct. Limits of the rf input power [2] due to a reduction of the shunt impedance of the fundamental mode were taken into account by this procedure.

4. 1 MODES OF THE REDESIGNED CAVITY

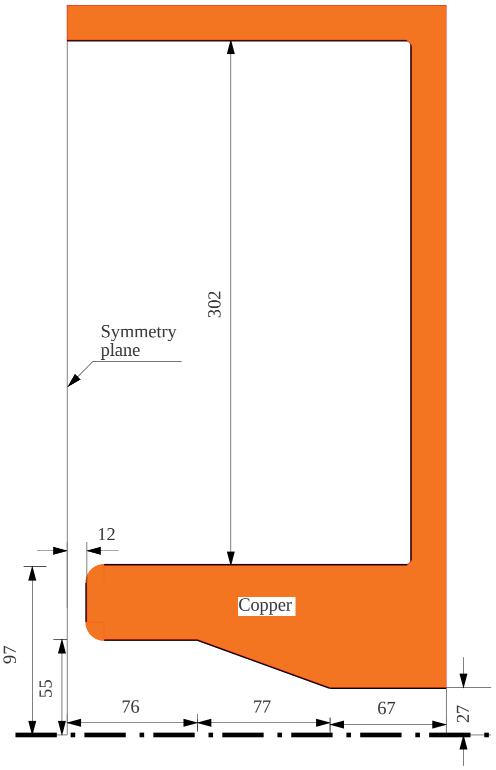
NR.	ν (MHz)	*Q-value*	R_s ($K\Omega$)	R_s/R_{sorig}
1	117.78	21644	3024.70	0.70
2	547.26	29708	57.82	0.52
3	765.16	27009	45.32	0.46
4	933.53	14040	22.13	0.32
5	1084.35	12456	8.51	0.16
6	1309.00	629	0.84	0.02

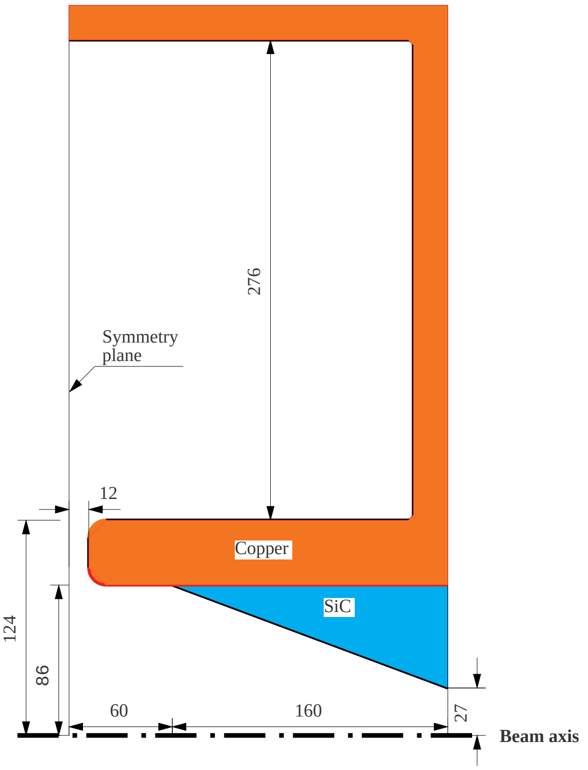
Table 6 Monopole modes of the modified cavity

NR.	ν (MHz)	*Q*	R_t ($K\Omega/m$)	R_t/R_{torig}
			h-type	
1	457.83	406	156.63	0.04
2	595.14	1910	140.98	0.02
3	789.68	5808	100.65	0.03
			v-type	
1	457.05	577	214.11	0.06
2	594.90	2553	179.73	0.02
3	789.56	6592	110.94	0.03

Table 7 Dipole modes of the modified cavity

The use of *SiC* inside the beam duct gives rise to Joule heat of 353 W that must be absorbed by cooling channels inside the cavity walls.





4. 2 BUNCH MODE INSTABILITIES OF THE REDESIGNED CAVITY

NR	*a*	$1/\tau_g$ (s^{-1})	I_{tr} (mA)	$I_{tr} / I_{tr\ orig}$
2	1	31 497	8.11	2.06
	2	28 203	11.59	1.73
3	1	12 581	20.31	2.22
	2	22 774	14.35	2.19
4	1	2 961	86.32	3.63
	2	7 759	42.13	3.43
	3	3 485	110.15	0.59

Table 8 Growth rates and threshold currents for longitudinal instabilities of the modified cavity

The results for the transverse case established that transverse coupled bunch mode instabilities are not at all expected to be present in the modified cavity.

5 DISCUSSION

Because it is almost impossible to detune all 11 modes simultaneously, instabilities might occur during the operation of the ring, which may cause problems in the case of an upgrading of the ring for example to higher beam energies, higher currents or lower emittances. For this case, a modification of the cavity according to section 4 may be useful. In the modified cavity, only three monopole modes may cause coupled bunch mode instabilities, which can be detuned easily by appropriate adjustment of the cavity tuners. On the other hand, this improvement requires a 43% higher input power, and technical limitations due to this fact should be taken into account.

6 REFERENCES

[1] Kodaira, N. Awaji, T. Kishimoto, O. Asai and M. Haraguchi, Performance of SORTEC 1 GeV Synchrotron radiation source facility and future plan Contributed to EPAC 92 Berlin

[2] N. Awaji, M. Kodaira, T. Kishimoto, T. Iida, Y. Kijima and H. Tsuchidate High current beam storage experiments in SORTEC SR source Contributed to EPAC 92 Berlin

[3] MAFIA Cooperation Copyright T. Weiland, 64285 Darmstadt, Germany, 1993

[4] A. Zichichi, K. Johnsen and M. H. Blewett, Theoretical aspects of the behavior of beams in accelerators and storage rings CERN 77 - 13 (1977)

[5] Zisman S. Chattopadhay and J. Bisogano, ZAP Computer code, Lawrence Berkeley Laboratory, University of California, Berkeley, CA, 94720

[6] T Koseki, M. Izawa and Y. Kamiya, 4th European particle accelerator conference, London 1994, pp. 2152