COMMISSIONING OF THE NEW RF SYSTEM WITH THE HOM DAMPED RF CAVITY

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Abstract

A new 178 MHz RF system has been commissioned at Duke Storage Ring. It consists of a 140 kW tetrode transmitter; higher order modes (HOM) damped RF cavity and the necessary frequency and voltage control electronics. The cavity walls are made of copper-on-stainless steel bimetal (8 mm Cu, 7 mm SS). The cavity has a larger beam pipe opening (700 mm in diameter) in the down-stream side, which allows the HOM propagating out of the cavity and being absorbed by the ceramic loads. The design details and the commissioning results are presented in this paper.

INTRODUCTION

About 10 years ago, Budker Institute of Nuclear Physics made an accelerating cavity and control system for the DFELL storage ring, USA.

The RF system has been successfully operated during almost 10 years. However, the RF system limited the maximum stored beam current because of the synchrotron oscillations arising from the interaction of the cavity HOMs with the electron beam. Although the cavity was equipped with two HOM tuners, it was practically impossible to set the cavity HOM frequencies so that they did not affect the beam dynamics at high currents and in multibunch mode.

In 2001, DFELL started a machine upgrade project aiming at the FEL experiments in VUV range [1]. After the upgrade the machine should operate at energy up to 1.2 GeV with average current up to 300 mA and number of bunches from 1 to 64.

The storage ring upgrade called for a new 178.5 MHz RF system with a HOM damped cavity. The required accelerating voltage over the cavity gap is up to 730 kV.

HIGH POWER GENERATOR

The new RF generator (Fig. 1) provides up to 140 kW output power in the frequency range of 178 to 179 MHz.

Figure 1: New DFELL generator.

Table 1: Parameters of bimetal cavities for the fundamental (accelerating) mode

	DFELL Duke-1	DFELL Duke-2
Operation frequency f, MHz	178.5	178.5
Characteristic impedance R_{acc}/Q, Ohm	114	88.6
Transit time factor T	0.919	0.764
Quality factor Q	42000	39000
Shunt impedance R_{acc}, MOhm *	4.77	3.46
Accelerating voltage V_{acc}, kV	640	730

* Shunt impedance is defined as $R_{acc} = V_{acc} / 2P$, where V_{acc} is the accelerating voltage.

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It is a 3 stage power amplifier with an external drive. In the first two stages, GU-92A tetrodes are used. A high power GU-101A tetrode is used in the output stage. The Amplifier is driven by a 100 W solid-state pre-amplifier. The output power is delivered to the cavity via a 75 Ohm rigid coaxial feeder.

In order to increase the reliability of the generator and to extend the lifetime of the tubes, the tubes are operated in a relaxed regime. The voltages of the power supplies and the dissipated powers are slightly reduced in comparison to their specified values by the manufacturer.

BIMETAL CAVITY WITH HOM DAMPING

The cavity for the new DFELL RF system, "Duke-2", was developed on the basis of a "standard" BINP bimetal (copper clad stainless steel) cavity. Parameters for the fundamental mode of the cavity are listed in Table 1. For comparison, parameters of the "old", "Duke-1" cavity [2] are also presented.

The new RF cavity for DFELL is shown on Fig. 2. The cavity is equipped with RF power absorbing load for HOM damping. HOMs are coupled to the RF absorbing load via a large (∅700 mm) beam pipe. The cutoff frequency of the pipe for the accelerating TM_{01} mode is substantially higher than the fundamental mode frequency, so the fundamental mode is trapped inside the cavity, while the HOMs propagate out of the cavity to the absorbing load. The load is 1200 mm away from the cavity, so it does not cause any considerable influence on the Q-factor of the fundamental mode. Power loss in the load at accelerating frequency is 100 W. The large opening in the cavity wall causes a fundamental mode frequency shift. A nose cone at the opposite cavity side wall is needed to bring the frequency down to the design value. Also, the transit time factor decreases due to the field pattern distortion. This leads to higher fields in the cavity at the same accelerating voltage.

Cylindrical shell of the cavity has few ports for connecting various units. Coaxial input coupler with a cylindrical ceramic window is installed on top of the cavity. Two ports are used for fundamental mode tuners (plungers).

The cavity is pumped out by two combined vacuum pumps (each pump includes ion and getter pumps) of PVIG-250/630 type with total pumping speed of 630 *l*/s each. Pumps are attached at the bottom of the tube connecting the cavity to the HOM load. After the manufacturing and assembly the Duke-2 cavity was baked at 300 °C. After an RF processing vacuum in the cavity of $1\cdot10^{-10}$ torr was achieved.

A conducting ceramics KT-30 produced by "Start" company, Fryasino, Russia, is used as an absorbing material for the HOM load. The composition of the ceramics is: TiO_2 – 30 %, A-995 – 70 % (Al_2O_3 – 99.8 %, MgO – 0.2 %). The RF absorber elements are ceramic cylindrical cups ∅32 mm and 45mm high. Each absorber is screwed to the inner wall of the load.

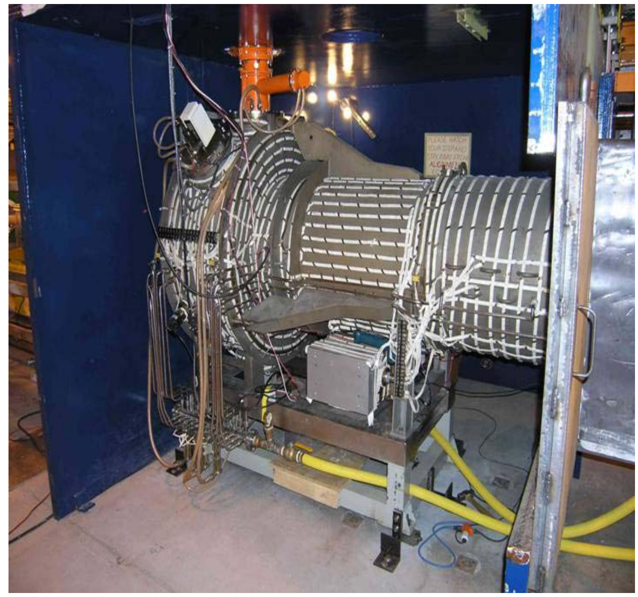

Figure 2: Duke-2 cavity.

The material used and the design of the load are capable to sustain baking of the cavity with the loads at the required temperature.

COMMISSIONING

The whole RF cavity was shipped to the Duke from BINP under vacuum. The high power generator was shipped in cabinets and assembled together locally. The new RF system was tested at Duke during June-August 2004. In August 2004, the new RF system starts its service to the Duke storage ring. Since then, the system works well to support the current mode of daily operation.

The RF signal from the RF cavity sampling loop output has been observed by a HP spectrum Analyzer during the operation with stored beam. Very obviously, all the amplitude of observed higher order modes are much smaller than before with this HOM damped RF cavity. During the daily operation, our machine physicists have noticed that the longitudinal beam instability has been greatly improved. The over all effects of this HOM damped RF cavity to the storage ring performance are still under study.

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