TUNING SYSTEM FOR CAPACITIVELY LOADED 1/4 ACCELERATING CAVITY

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Introduction

The Brookhaven National Laboratory NSLS X-ray and VUV rings currently use capacitively loaded 1/4 RF accelerating cavities. These cavities are manufactured from copper clad plate steel and require a tuning system with a considerable range. Three separate tuning systems are provided, each having its own specific problems and interactions occur between the three systems. A single capacitive tuning system is proposed which will vary the capacitance loading of the cavity directly. The system employs a vacuum balance mechanically driven diaphragm. The control system allows 6 mm of motion at a maximum slewing rate of 1.0 mm per sec. and yields a dynamic tuning range of 480 KHz. Design and fabrication details will be presented together with early testing and operating experience.

The NSLS X-ray and VUV storage rings currently use capacitively loaded 1/4 resonators as the accelerating cavities. These cavities require a tuning system with a considerable dynamic range. The X-ray cavities are run at a power level of 3 KW during the beam fill cycle and are ramped to 50 KW during the acceleration cycle to 2.4 GeV. Although the center electrode cooling water temperature is controlled, the rise in the dissipated power in the center electrode results in an increase in the mean operating temperature. This increase in temperature causes an increase in the center electrode stem length and changes the accelerating gap capacitance.

Fig. 1 Diaphragm Tuner and Cover

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Currently, the cavities are tuned by three separate tuning systems. The center electrode cooling water temperature is controlled and attempts to maintain the stem length at a constant value. Adjustment of the cooling water temperature causes the stem length to change and hence tunes the gap capacitance. The center electrode stem is mounted into the back wall of the cavity and this back wall is made to deflect by a pair of hydraulic rams. This deflection again tunes the gap capacitance. The counting system for these hydraulic rams is called the "Crusher" tuner. A piston tuner is mounted in the cylindrical wall of the cavity as an H field displacer.

While the piston tuner is used to tune the cavity, high levels of multipactoring have been observed during large penetrations of the piston.

Fig. 2 Diaphragm Tuner Control System

The usual operating practice is therefore to minimize the penetration of this tuner. The center electrode cooling water temperature is used for tuning the cavity but due to the large thermal mass, the response of the system is slow. Frequency measurements have shown that the stem mean operating temperature increased by some 15°C during a cavity power ramp. As the cavity is placed under vacuum, the end wall of the cavity deflects by 0.17 mm. Once under vacuum, the crusher tuner hydraulic system is pressurized to produce an additional deflection of 0.4 cm. Thereafter, the cavity tune is changed by variations in the crusher tuner hydraulic pressure. Due to the stiffening ribs on the outside wall of the cover an "oil can" effect has been observed. This results in a rapid change of end wall deflection with very little change of hydraulic circuit pressure. During normal operation, the cavity is tuned by variation of the center electrode cooling water temperature with the crusher tuner set at the mid-range position. Some small adjustments are made of the piston tuner. During the power ramp, water temperature changes are made but any rapid corrections of tune are arranged with the crusher tuner.

Fig. 3 Alternate Inner Slide Contact

Diaphragm Tuner

The X-ray cavities have run for some 1500 hours at a power level of 50 KW. While the VUV cavity has run for a much larger period at 10 KW, the continual deflection of the end wall during cavity tuning operations could lead to fatigue cracking of the end wall welds and vacuum failure. A diaphragm tuner is therefore proposed and is shown in Fig. 1. A replacement cover for the existing cavities is shown and contains a vacuum balanced diaphragm. This diaphragm is connected to the cover wall with a frictionless hinge at its outer circumference and a slide contact to the inside of the cover beam pipe. Drive motion is arranged by three worm-driven, backlash eliminated nuts and screws with a stepper motor drive. The proposed lead screw and worm driven nut has a reduction ratio such that one revolution of the stepper motor will produce 0.25 mm motion of the diaphragm. The stepper motor control circuit will be similar to that used to control the hydraulic pressure in the existing crusher tuner and is shown in Fig. 2. The control circuit detects a phase error signal in the transmission line which is converted to a voltage. This voltage is fed to a D to A converter which provides signals to a clockwise and counter-clockwise bus pair. The three buffered translators are connected in parallel to provide a step count to the three stepper motors. Cooling water is passed through the cover to make a direct circuit of the diaphragm. A position transducer will also be fitted but will be used for position indication only and will not be part of the control circuit.

In storage rings, the beamline impedance is always a concern, therefore the diaphragm inner slide contact may be changed. An alternative design is shown in Fig. 3; other designs are under consideration.

Conclusion

The design of this diaphragm tuner system is proceeding and shop drawings are available. Fabrication of the first unit will start shortly.

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