LBL--25978

DE89 016349

Advanced Light Source Storage Ring RF System

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Paper presented at the 1989 Particle Accelerator Conference in Chicago, Illinois,
March 20 to 23, 1989

This work was supported by the Director, Office of Energy Research, Office of Basic Energy Sciences, Materials Sciences Division of the U. S. Department of Energy under Contract No. DE-AC03-76SF00098

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Introduction

The short electron bunch length (30ps design target) of the Advanced Light Source(ALS) stored beam is capable of exciting a wide spectrum of higher order mode(HOM) frequencies. Further, the small aperture and low cut off frequency of the beam enveloping components does not allow for transmission and consequent attenuation of the lower frequency HOM components.

The small cross section and divergence of the high brightness electron beam will allow for more sophisticated high resolution experiments by synchrotron radiation users. A more stringent requirement on beam position stability results however. In this area transmitted mechanical vibration becomes a problem.

The ALS RF system splits 300kW of CW 500MHz power between two single cell cavities. Compared to past practice this power rating is high. The use of only two cavities however has some advantages, it simplifies the waveguide feed system and releases room in straight sections for insertion devices, more important it reduces HOM and beam impedance problems.

General Arrangement of the RF System

Figure 1 shows the basic RF system in diagrammatic form. Table 1 lists the important parameters. Apart from the cavities and the special waveguide components, associated with HOM countermeasures, all components are conventional catalog items. Conventional cavity tuning servos and amplitude feedback systems will be fitted.

Beam Energy(GeV)	1.5	1.9
Frequency(MHz)	499.654	499.654
Beam Current(mA)	400.0	400.0
Two Cavity System Totals		
Transit Time Factor(T)	0.683	0.683
Peak Effective Volts, VpT(MV)	1.5	1.5
Shunt Impedance, 2ZT²L(Mohms)	16.0	16.0
Dissipation(kW)	140.0	140.0
Power Through Windows(kW)	210.0	286.0
Waveguide Losses(dB)	0.3	0.3
Circulator Loss(dB)	0.1	0.1
Radiated Power		
Bending Magnets(kW)	37.0	94.0
8 Undulators, 2 Wigglers(kW)	30.0	50.0
Parasitic Mode Loss(kW)	2.0	2.0
Required Amplifier Power(kW)	221.0	302.0

Table 1, Storage Ring RF Parameters

As yet the 300kW amplifier tube has not been specified in detail, these items are available from a number of sources. The klystron solutions to this need would employ a tube basically designed for higher power, 600-800kW. These tubes could therefore be supplied to operate at a higher beam voltage than is strictly necessary to produce 300kW. An exercise will be undertaken to weigh the higher conversion efficiency, and consequent lower running costs, of operating at higher voltage, against tube and power supply costs.

The RF Cavities and Windows

Four identical single cell RF cavities are in process of construction for the ALS. One cavity for the booster synchrotron, two for the storage ring and one spare cavity. Prior to the final assembly of the storage ring cavities the design will be tested with a power source capable of 40kW CW or 60kW long pulse (500ms at 50 percent duty cycle).

The single cell toroidal cavities [1] will be fabricated from components precision machined from solid copper and joined by vacuum brazing. Cooling passages, needed to remove the dissipated 70kW of power without generation of significant mechanical vibration will employ electroformed profiles.

An aperture type waveguide to cavity power input feed has been chosen for the cavity rather than the more usual loop coupler. The large unobstructed aperture of 15cm diameter provides beneficial wideband coupling out of the cavity for HOM energy.

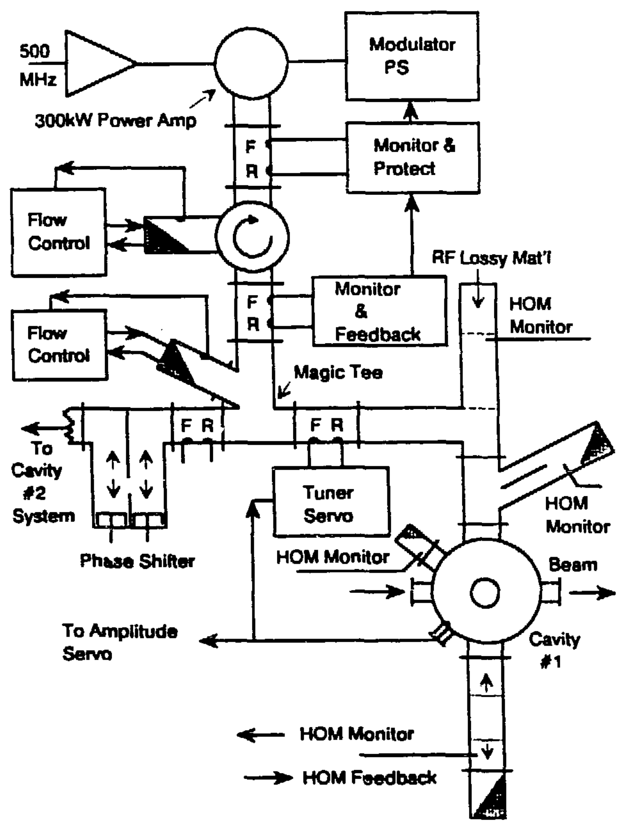

Figure 1, ALS Storage Ring RF System

In order to reduce the electric field in the ceramic due to the cavity contribution, a cylindrical window will be used; this arrangement also has the merit of placing the ceramic largely out of line of sight of the electron beam.

Initially a titanium coated window will be tested, provision has been made, however, to provide a metal blacked window [2].

500Mhz Water Load for Circulator and Magic Tee

For the majority of time when a storage ring is functioning correctly the power dissipated in the waveguide circulator or

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isolator and the magic tee balance loads is very small. The loads are required to protect the system against high VSWR under fault or test conditions.

It is normal practice to employ coaxial type loads and to continually circulate a high volume of water at high pressure, irrespective of the actual RF input to these loads. During normal stored beam conditions the mechanical vibration noise from these systems can be a nuisance to experimenters. Running large pumps continually is expensive in terms of power and maintenance costs.

The ALS water load systems are being designed to operate on a demand cooling system in which circulation or full circulation is triggered by detection of a significant power input or water temperature rise. A demand for increased load dissipation will almost certainly coincide with a "no beam" or "beam lost" situation, experimenters will thus not be inconvenienced. The preliminary design is based on the use of water wedge WR1800 waveguide loads.

Due to the substantial volume of water held in the load under static condition ample time is available to establish the flow. Indications are that the waveguide load system is cheaper than the coaxial equivalent, this price difference may, however, be neutralized by more complex waveguide connections to the loads which have limitations on orientation.

Higher Order Mode Countermeasures

The philosophy of the ALS RF system HOM countermeasures is initially to provide:

1. Good comprehensive diagnostic facilities.

2. Effective wideband HOM absorbtive systems on each cavity.

3. Effective HOM absorbtive filters in the waveguide connections between cavities.

4. An overall system of waveguide assembly which facilitates experiment and change, once HOM problems and solutions are determined, by beaming the systems. Such modification could include tuned HOM damping devices and the injection of active feedback.

The system for one cavity is shown in figure 2, the basic system was pioneered at the Daresbury SRS [3]. The absorber arms of the H plane and E plane tee filters and the HOM transparent cavity matcher bucket all employ the same principle. A standard section of WR1800 waveguide has a central bifurcating conducting sheet, this short circuits the normal waveguide E field, and transforms the single waveguide into two 9 inch by 9 inch guides.

This arrangement looks to the connecting WR1800 waveguide like a short circuit at 500Mhz. Higher frequencies, not beyond cutoff are, however, transmitted.

In the system of figure 1 it will be noted that the coupling path between the two cavities is attenuated by two sets of E plane and H plane filters.

A volume arranged behind the two 9 inch by 9 inch waveguides remote from the point of 500Mhz reflection provides and ideal HOM monitoring, absorbing, or controlled reflection point. Isolation from the 500Mhz power at this point will also allow rf power to be injected to excite cavity higher order resonances for feedback purposes. (e.g. (c) in Figure 2)

The volume behind the bifurcated bucket of the cavity matcher is of particular convenience, and in the ALS design bolt-on variations of terminating devices will be facilitated.

Figure 2 illustrates some possible variations of these attachments.

(a) Is the normal resistive absorbing termination.

(b) Allows for the controlled reflection of all components and therefore optimization of power transfer from the cavity of a single selected HOM component or band of components.

(c) Allows optimization of the coupling out from the cavity of two components of differing frequencies.

(d) Is designed to sweep the resonant frequencies of the waveguide termination, thereby "pulling" the coupled cavity resonances to "spoil" the buildup of instabilities.

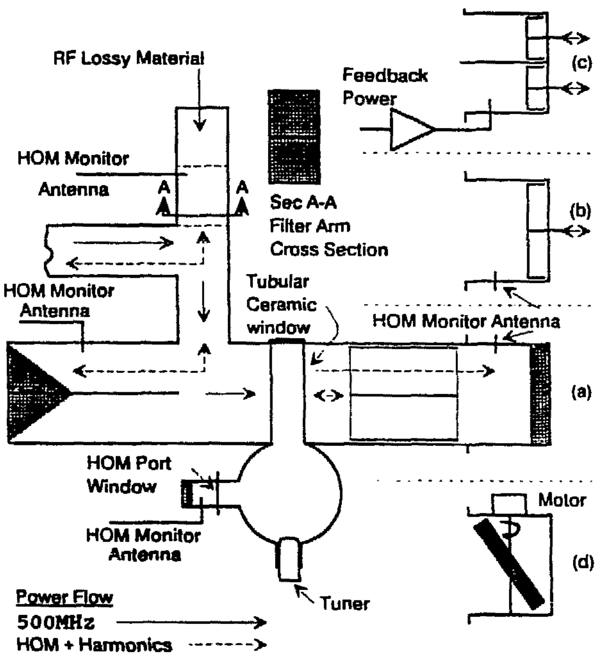

Figure 2, ALS Cavities HOM Approach

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