EXPERIENCE OF DRIVING THREE RF CAVITIES BY A SINGLE KLYSTRON IN THE PHOTON FACTORY ADVANCED RING (PF-AR)

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Abstract

In order to evade a problem in one of the rf cavities for the Photon Factory Advanced Ring (PF-AR), we constructed a unique rf distribution system in which three cavities are driven by a single klystron. In order to split the high rf power into three equal parts, we used the combination of an asymmetric power divider and a conventional magic-T. This rf distribution system worked well. We report on our operational experience concerning this three-way rf distribution system.

INTRODUCTION

The PF-AR [1] is a 6.5-GeV synchrotron-light source at the High Energy Accelerator Research Organization (KEK). Through a large upgrade in 2001, the PF-AR has been supplying intense pulsed X-rays for many users. The accelerating system [2] for the PF-AR comprises six 11-cell cavities, two 1-MW klystron and rf distribution networks. Two and the four rf cavities are located in the east and west straight sections, respectively.

After vacuum trouble in one (No. W-1) of the four cavities in the west rf section, a problem occurred with another cavity (No. W-3) in April, 2003. Although this cavity showed no problem under rf conditioning of up to 190 kW/cavity, it experienced frequent trips after acceleration from 3 to 6.5 GeV under beam operation. Due to a limited time to fix this problem, we decided to detune this cavity and to drive the remaining three cavities by a single klystron in the west rf station. For this purpose, we constructed a unique rf distribution system in which the rf power is divided into three equal parts.

THREE-WAY RF DISTRIBUTION SYSTEM

RF Distribution System

Figure 1 shows the original rf system in the west rf station, where rf power is supplied to four cavities. In order to drive three of the cavities while detuning the troubled one, we reconstructed the rf distribution system, as shown in Fig. 2. The first magic-T was replaced by an asymmetric (1:2) power divider [3], which had been developed previously. One of the second magic-T's was replaced by an H-corner waveguide; the waveguide for the troubled cavity was terminated by a dummy load. A slight phase change was compensated by inserting a pair of short lines of 50 mm in total. Using this system, a high rf power generated by the klystron could be divided into three equal parts.

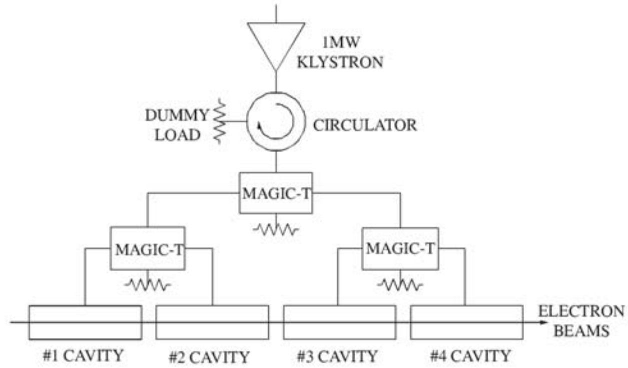

Figure 1: Original rf system of the PF-AR west rf station.

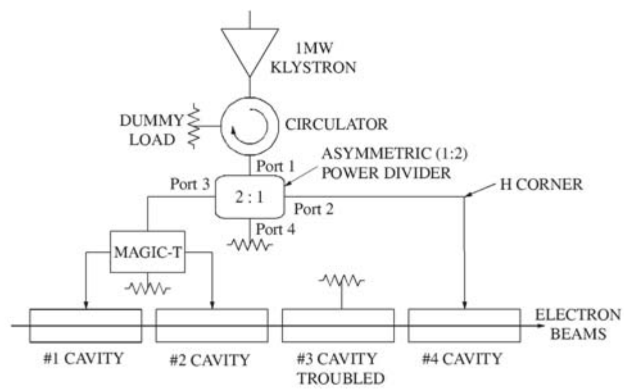

Figure 2: Modified rf system for operating three cavities.

Asymmetric Power Divider

An asymmetric power divider (see Fig. 3) can split high rf power by a ratio of 1:2 at an operating frequency of about 508.57 MHz. It has four WR1500 waveguide ports. An incident TE_{10} wave from port 1 is split into two waves, and goes out from ports 2 and 3 by a power ratio of 1:2. A post, a rod and an iris in this structure are used to adjust the rf characteristics. In order to avoid any unwanted coupling between the cavities, this divider was designed so that ports 2 and 3 are isolated well from each other. In addition, all of the ports are matched well; ports 1 and 4 are also isolated from each other. The measured S-matrix of this divider is given by

$$S=\begin{bmatrix} 0.066\angle{\approx}10^\circ & 0.570\angle 151^\circ & 0.820\angle 127^\circ & 0.014\angle{-1^\circ} \\ 0.570\angle 151^\circ & 0.055\angle{\approx}160^\circ & 0.046\angle{-10^\circ} & 0.820\angle{-31^\circ} \\ 0.821\angle 127^\circ & 0.046\angle{-10^\circ} & 0.056\angle{\approx}30^\circ & 0.568\angle 126^\circ \\ 0.014\angle{-1^\circ} & 0.820\angle{-31^\circ} & 0.569\angle 126^\circ & 0.081\angle{\approx}{-50^\circ} \end{bmatrix},$$

where each matrix element is represented by its magnitude and its phase in degrees, respectively.

Figure 4 shows a photograph taken while installing the asymmetric power divider.

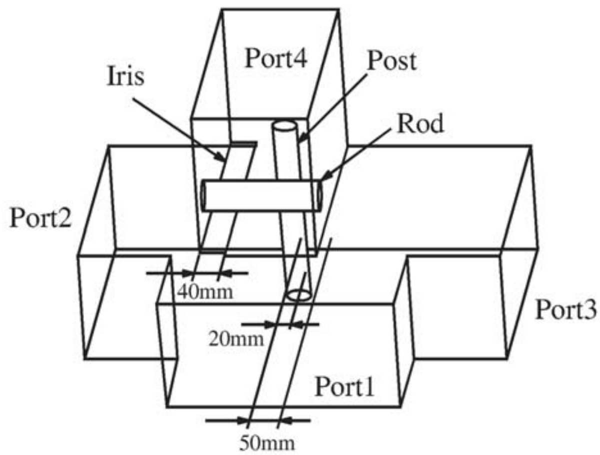

Figure 3: Structure of asymmetric power divider.

Figure 4: Installation of the asymmetric power divider.

OPERATION

We smoothly started operation of this system in April, 2003. We could then store single-bunch beams of about 55 mA, a current comparable to those of the previous user runs. Typical operation parameters of the west rf station are given in Table 1. This system has been working very well for about 5000 hours under a power level of about 600 kW.

Table 1: Typical parameter of the west rf station under three-cavity operation.

Operation frequency	508.57 Hz
Beam Current	54 mA
Beam Energy	6.5 GeV
Klystron output power	628 kW
Reflection from 1:2 power divider	< 5 kW
Power from port 5 of 1:2 divider	4.1 kW
Input power / cavity	~ 200 kW
Reflection from one cavity	~ 5 kW

CONCLUSIONS

Upon the occasion of our cavity problem, we reconstructed our rf distribution network so that three cavities are driven by a single 1-MW klystron. This three-way distribution system has been working fine for a long time under a power level of about 600 kW. We have established through this experience an rf distribution technique by which a single klystron drives three accelerating cavities. This technique will be useful for some accelerator applications where three or six cavities are needed.

ACKNOWLEDGMENT

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