DEVELOPMENT OF PRE-TUNING SYSTEM FOR 972 MHZ 9-CELL SUPERCONDUCTING CAVITIES

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Abstract

A pre-tuning system for 972MHz 9-cell SC cavities in the high intensity proton linac was developed. The initial pre-tuning was carried out with two Nb and a Cu 9-cell cavities. Details of this system and performances are reported.

INTRODUCTION

In the KEK-JAERI joint project named J-PARC (Japan Proton Accelerator Research Complex), a superconducting linac is used for the energy range from 400MeV to 600MeV of the proton beam. A prototype cryomodule containing two 972MHz 9-cell niobium cavities of β=0.725 (424MeV) is now under construction for an R&D work and is shown in Fig. 1, [1]. The pre-tuning system for the 972 MHz 9-cell cavities was developed in order to make the field profile of an accelerating mode flat and adjust the resonant frequency to an operating frequency.

PRE-TUNING SYSTEM

The pre-tuning system consists of two components. One is an RF system, and another is a motor control and data acquisition system. Configuration of a field profile measurement system is shown in Fig. 2. Block diagram of a motor control and data acquisition system is shown in Fig. 3. Figure 4 shows the tuning equipment with a 9-cell cavity, and clamping pads driven by stepping motors are shown in Fig. 5. The whole control system for pre-tuning is shown in Fig. 6. The mechanical device for deformation is made of stainless steel, and the gross weight is 400kg. Two 9-cell Nb cavities are called 126R (Right) and 126L (Left) respectively, since it has 126mm diameters of the beam pipe of an input coupler side. Deformation of a cell-shape is performed to stretch or squash a cell with the clamping pads set on an iris part. Other two types of pads were prepared for end cells with different beam pipe size (126 and 90mm). The stepping motors made by Oriental Motor (VEXTA PH533 and PK596) are used to move the bead for field distribution measurements and to drive the clamping pads for deformation of the cell-shape. The hardwares for controlling the motors and measuring the field distribution consist of a PXI-chassis with a PC controller

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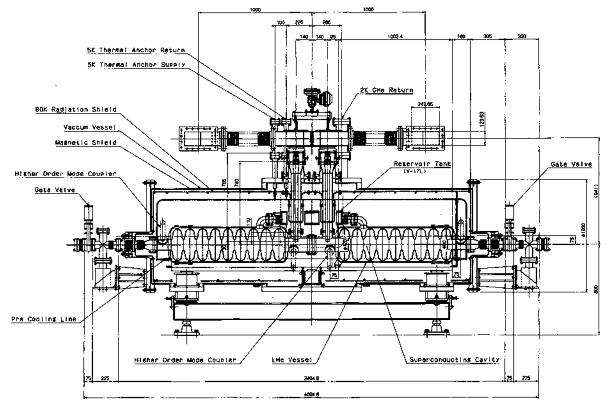

Figure 1: Prototype cryomodule for proton accelerator

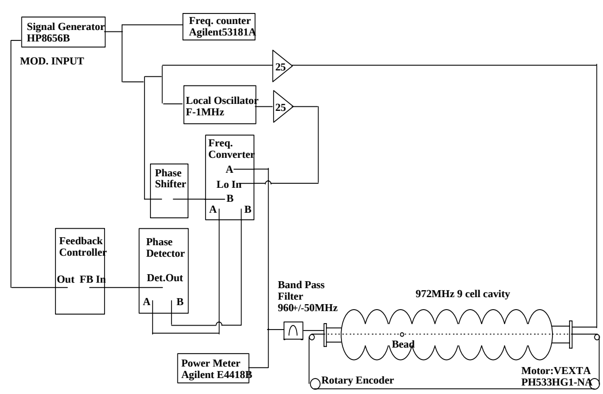

Figure 2: Configuration of field profile measurement

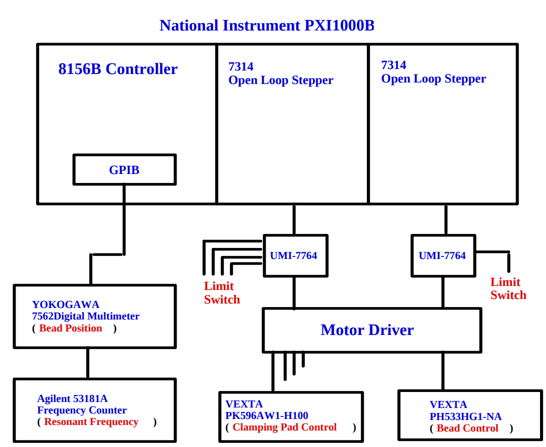

Figure 3: Block diagram of a control system controlling

(products of National Instruments), two motion controllers and two universal motion interfaces. The softwares consist of WindowsOS, LabVIEW and Motion. A speed of the bead and an amount of squeezing/pulling of the clamping pads can be chosen arbitrarily. In the present pre-tuning, a speed of the bead was at 5mm/s, and the clamping pads were moved by 0.1mm per step. An example of the field distribution measurement is shown in Fig. 7.

PRE-TUNING METHOD

The block diagram of the system for electric field distribution measurement is shown in Fig. 2. Phase lock loop (PLL) follows the resonant condition while the bead is moving on the beam axis. Data of the bead position and the resonant frequency are transferred to the computer. The relative distribution of the electric field is obtained by $\sqrt{\Delta f}$, where Δf is a change of the resonant frequency caused by the perturbation by the bead. Then the cell to be deformed and the amount of deformation are determined. The clamping pads are put on the cell, squeeze/pull the cell, and are taken off from the cell. The field distribution is measured again until the required field flatness is obtained. Since the amount of squeezing/pulling to get the required permanent deformation depends on the material parameter, thickness and cell-shape, we have to learn this relation in the first place. It took 3 days to complete the pre-tuning of the first niobium cavity, but it will be much reduced by installing this relation to the computer together with the calculation model, [3][4].

RESULTS OF PRE-TUNING

The first pre-tuning was performed on a 9-cell copper model cavity for training and to check the system. The results are shown in Fig. 8. The results of field distribution measurements on 126R and 126L at the different stages are shown in Fig. 9 and Fig. 10, respectively. Initial measurement is for the cavity as received, then cavities were barrel-polished and electro-polished by about 100µm. The change of the field distribution after electropolishing (E.P.) of the 126L cavity is provably because of miss handling of the cavity. Annealing at 800°C looks having no effect on the field distribution. The field flatness of better than 98% was achieved in the final pre-tuning of both cavities, as shown in Fig. 11. The resonant frequencies at each stage are summarized in Table 1. The full length and frequency change of each cavity are shown in Table 2. The difference of the full length between before and after the pre-tuning was about 3mm in both cavities.

Figure 4: Pre-tuning equipment and a 9-cell Nb cavity

Figure 5: Clamping pads and stepping motors

Figure 6: RF and motor control system

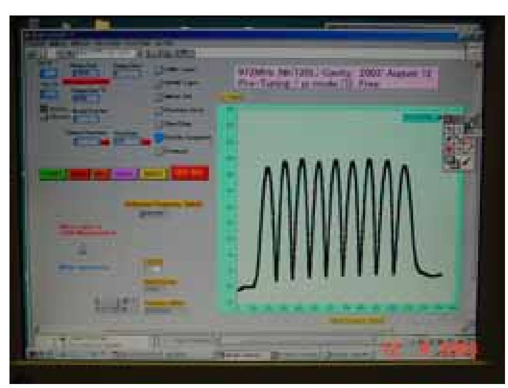

Figure 7: Display of a measured field distribution

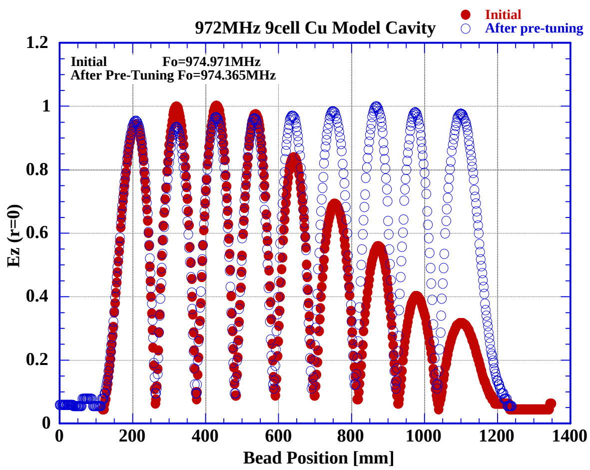

Figure 8: Pre-tuning results of a Cu model cavity

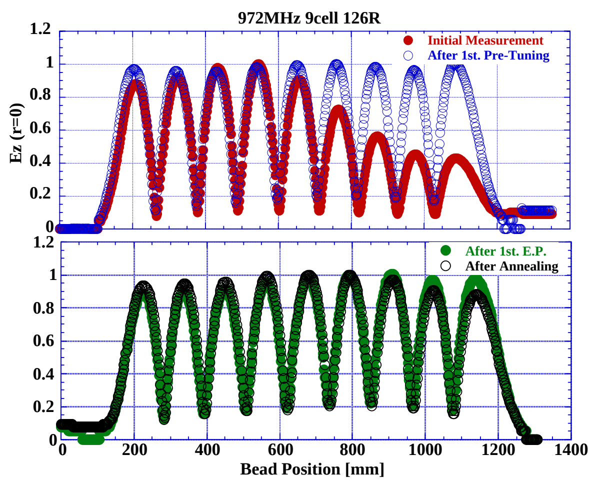

Figure 9: Change of field distributions in the 126R cavity

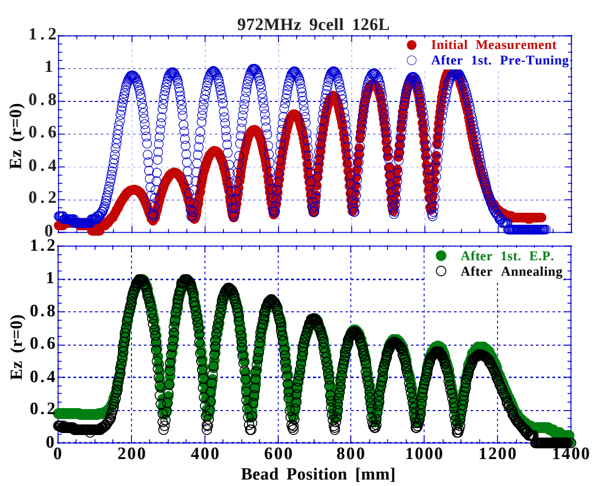

Figure 10: Change of field distributions in the 126L cavity

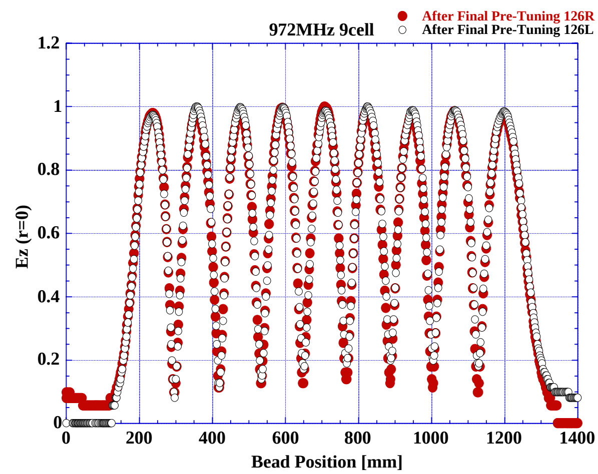

Figure 11: Field distribution after final pre-tuning

Table 1: Resonant frequency (field flatness) in each stage

	126R [MHz]	126L [MHz]
As received	969.27 (45%)	969.52 (25%)
After 1st pre-tuning	969.99 (95%)	969.82 (95%)
After 1st electropolishing	969.62 (88%)	969.35 (60%)
After anneal	969.61 (89%)	969.43 (55%)
Final state	969.57 (98%)	969.62 (98%)
Cold test at 4.2K	971.35	971.25
Cold test at 2K	971.36	971.27

Table 2: Full length and frequency change of each cavity

	Cu cavity [mm]	126R [mm]	126L [mm]
As received	1388.	1395.	1395.
After pre-tuning	1389.	1398.5	1398.
Δf	-600kHz	+720kHz	+300kHz

SUMMARY

The pre-tuning system for 9-cell cavities, which will be used for the J-PARC proton linac, was developed. The field flatness of better than 98% has been satisfactorily attained in two 9-cell niobium cavities.

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