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DESIGN AND TEST OF DOUBLE SPOKE SUPERCONDUCTING CAVITY TUNER FOR CSNS-II *

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Abstract

The China Spallation Neutron Source phase II (CSNS-II) upgrade design will increase the total beam power from 100 kW to 500 kW and boost the beam energy from 80 MeV to 300 MeV in the linac by adding a superconducting linear accelerator to the existing accelerator complex. The double spoke resonator is used in the energy range of 80 MeV to 165 MeV. To compensate the frequency change due to manufacturing uncertainty, Lorentz force, beam loading, He pressure and microphonics, a new type tuner is designed for the double spoke superconducting cavity. The tuner is mounted on the side of the cavity, and each module contains two tuner systems. In this paper, the structure and working principle of the tuner are designed and analysed, also the testing result of the tuner with the double spoke Resonator and cryomodule prototypes are introduced.

INTRODUCTION

The baseline and main parameters for upgrade SRF system of CSNS-II have been public [1, 2]. IHEP is developing 324 MHz double superconducting RF cavities for CSNS-II, the structure is shown in Fig. 1. In order to increase the beam power from 80 MeV to 165 MeV, and also with the beam peak current increase from 15 mA to 50 mA, twenty double Spoke superconducting cavities with β0=0.5 are used, as the scheme shown in Fig. 2. Each cryomodule contains two 324 MHz superconducting cavities, for a total of ten this cryomodules. The spoke cavity operates in pulse mode and is mainly affected by Lorentz force, to adjust the cavity resonance frequency to the accelerator frequency during operation is essential to the RF system stable and have a perfect transmission of the radiofrequency power to the beam, also reduce reflection power. The cavity parameters as shown in Table 1, to meet the requirements of 324 MHz double Spoke cavities, newly tuner system is designed. Two type tuners have been designed and test for the performance verification. Due to the lever tuner are widely used for SRF cavity to tuning frequency for install and maintains easily, lever tuner has been chosen as the basic structure. And adopts the structure of motor tuner (slow tuning) and piezo tuner (fast tuning). Assembled the two type tuners and cavity in the cryostat, and completed the warm temperature (300 K) test and cold test (2 K). The research objectives include verify the tuner's design and overall structure, evaluate its performance at different temperatures, and assess its effectiveness in achieving the desired tuning capabilities

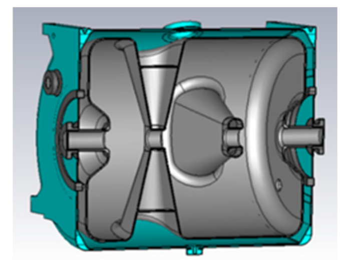

Figure 1: 324 MHz double spoke cavity 3D model.

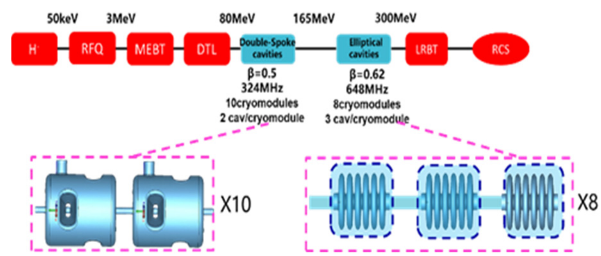

Figure 2: CSNS -II linear accelerator upgrade scheme.

Table 1: Parameters of Double Spoke Cavity

Parameters	Value	Units
Frequency	324	MHz
Aperture	50	mm
Operating temperature	2	K
Β 0	0.5	--
Ep/Eacc	4.1	--
Bp/Eacc	9.2	mT/(MV/m)
G	120	Ω
R/Q	410	Ω
Operating gradient	7.3	MV/m
Operating frequency	25	Hz
Cavity stiffness	~10	N/um
Tuning sensitivity	100	kHz/mm
Kl (tow beam pipe free)	-12.54	Hz/(MV/m)2
Kl(one beam pipe free)	-10.47	Hz/(MV/m)2
df/dp	-0.773	Hz/mbar
Frequency	324	MHz

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THE LEVER TUNER DESIGN

Table 2 is the main tuning parameters of lever tuner for 324 MHz double spoke cavity according the tuning requirements.

Table 2: Main Parameters of Lever Tuner

Parameters	Value	Units
Motor tuning range	100	kHz
Motor stroke	~1	mm
Motor resolution	<5	Hz
Motor tuner stiffness@2K	>20	N/um
Operating temperature	5~35	K
Piezo tuner tuning range	1	kHz
Piezo tuner resolution	1	Hz
Piezo stroke@2K	~10	um
Piezo operating temperature	5~35	K
Piezo tuner response time	~1	ms

Structure

The new type lever tuner for 324 MHz double spoke cavity installed at one end of the helium vessel, as Fig. 3 shown. The two end of the lever tuner fixed with the helium vessel, installed along the up-down direction. The middle part of the tuner arm connects with the ring-pull through two screws. With the lever tuner to tuning the cavity frequency after cooling down, and the Piezo to compensate the frequency change due to the He pressure, microphonics and Lorentz force. Figure 4 (a) is the trans-mission part of lever tuner for the 324 MHz cavity. One low temperature motor with two Piezo working together. The Piezo are installed in the sliding base of the tuner. The tuner pulls the cavity during working.

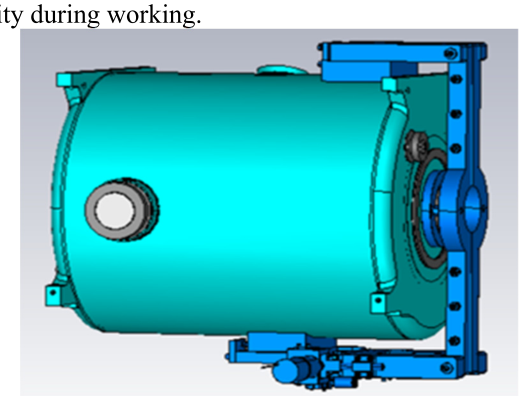
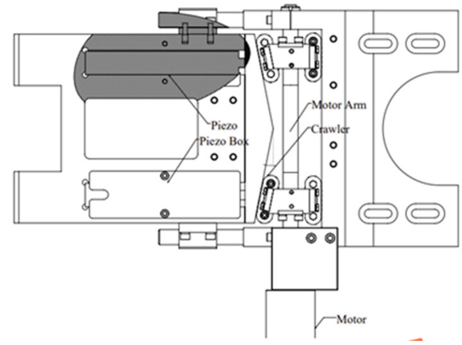
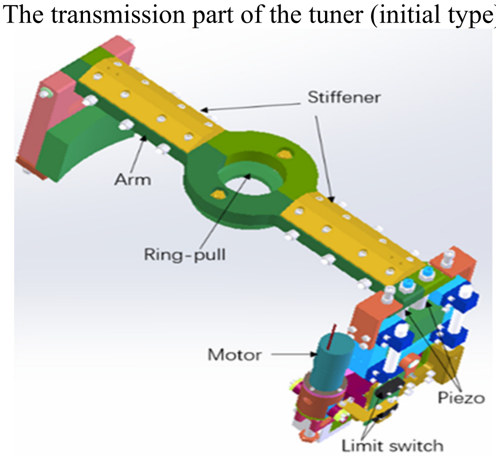


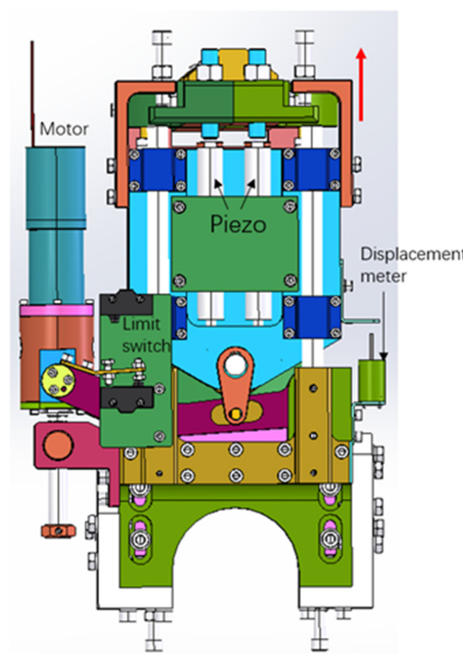
Figure 3: Overview of the cavity with tuner 3D model (initial type).



(a) The transmission part of the tuner (initial type).



(b) The improved tuner.



(c) The transmission part of the tuner (improved type).

Figure 4: Overview of the lever tuner.

Due to the tuner installed in the up-down direction, the transmission part of the initial type tuner is difficult and also the test results cannot meet the design value. So, redesign the tuner and improved the transmission part, as shown in Figure 4 (b) and (c). Replace the slider structure

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with a lever arm and add stiffeners to the tuner arm, make the installed and adjust simply [3, 4].

INTEGRATED WITH CAVITY AND TEST

In order to verify the performance of the whole equipment, a prototype of the cryomodule is developed, as shown in Fig. 5.

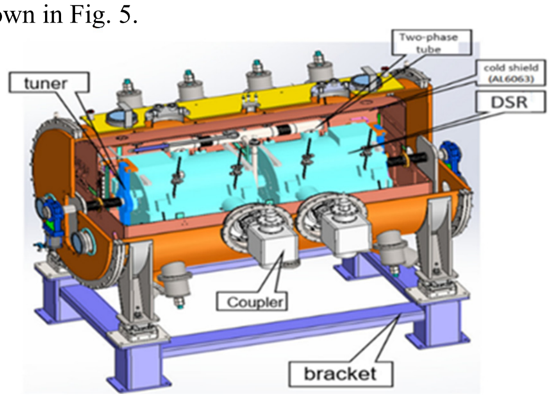

Figure 5: Prototype of the 324 MHz cryomodule.

The tuners assemble with two double spoke cavities after the cavity string out from clean room, as shown in Fig.6. During installed the tuner, needs monitor the cavity frequency using Vector network analyser, and test the motor tuner and piezo at room temperature, as shown in Fig. 7.

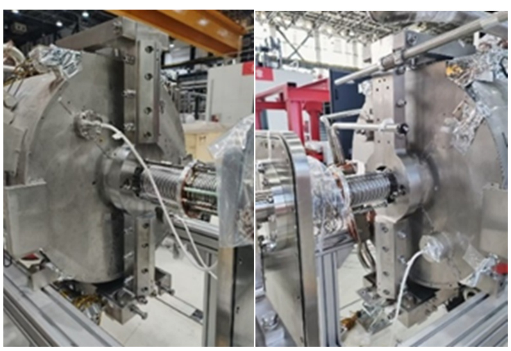

Figure 6: The tuner assembling with cavity.

Figure 7: The tuner test at room temperature.

Test Results

In order to make sure the performance meets the design value, test the tuner at different stage during the cryomodule assemble, and monitor the frequency change during cooling down, as shown in Fig. 8. As shown in Table 3 is the tuner test results.

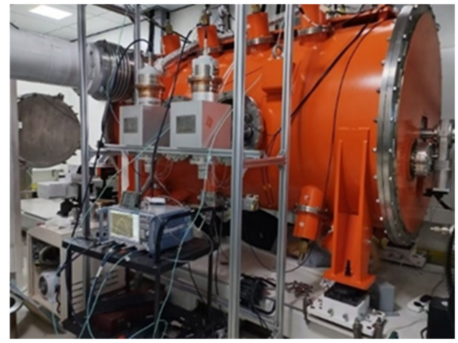

Figure 8: The tuner test in cryomodule.

Table 3: Tuner Test Results

Parameters	Value	Units
Motor tuning range	>100	kHz
Motor resolution	<1	Hz
Motor tuner operating temperature	~35	K
Piezo tuner tuning range	> 1.2	kHz
Piezo tuner resolution	<1	Hz
Piezo tuner operating temperature	~35	K
Piezo tuner response time	~1	ms

CONCLUSION

The new type of tuner has been designed for the CSNS-II 324 MHz double spoke cavities. The tuner performance is validated in the cryomodule warm and low temperature test. The next step will be to further optimize the tuner for mass manufacturing.

ACKNOWLEDGEMNET

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