THE STUDY ON MICROPHONICS OF LOW BETA HWR CAVITY AT IMP

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Abstract

The superconducting linac of China Accelerator-Driven System Injector II will operate at CW-mode. The mechanical vibrations of the superconducting cavity, also known as microphonics, cause shifts in the resonant frequency of the cavity. The microphonics is the main disturbance source of cavity frequency shifts when the cavity running in CW mode. In order to understand the effects, microphonics measurements were performed on the half-wave superconducting cavities when they were operated in the cryostat. And the experimental modal test was also performed to identify noise source and improve the cavity structure optimization. The measurement method and results will be shown and analyzed in this paper.

INTRODUCTION

The superconducting half-wave resonator operated at 162.5 MHz, the geometry parameters and RF parameters were described in ref [1]. And the cavity operating temperature was 4.4 K, the test cryostat design detail can be found in the ref [2]. The test cryo-module was built to verify the performance of cryogenic system and LLRF system, it only contain one HWR cavity which didn't be weld with reinforcing ribs. The cryo-module 6 (CM6) had been installed and operated on the beam line, 6 HWR cavities were assembled in this module, the 6 cavities were weld with reinforcing ribs on the outer surface of the region of electric field to minimize df/dp, which means that the mechanical structure of those cavities is more stable.

THE MICROPHONICS MEASUREMENT

A new digital cavity resonance monitor was developed at Institute of Modern Physics (IMP) [3], which utilizes the NI intermediate frequency transceiver to digitize RF signal and process the digital signal, the IF transceiver contains digital down converter (DDC) and a Virtex-5 field programmable gate array (FPGA), the performance test result indicated that the new measurement system is adequate for measuring microphonics of low beta cavity.

The Measurement Scheme

The experimental measurement scheme of the measurement system with cavity installed in the test cryo-module is shown in Figure 1. The frequency of cavity was tracked by the VCO-PLL loop, the down-converted IF signal was input to the IF transceiver, the ADC in the IF transceiver outputs digitized data stream to FPGA for digital signal processing.

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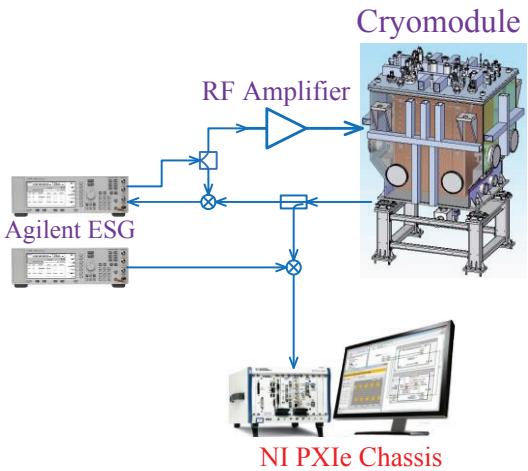

Figure 1: The microphonics measurement setup.

The Experimental Result of Test Cryomodule

The measurement results were shown in Figure 2 and Figure 3, the cavity frequency changed about 25 Hz (peak to peak value) to take no account of the helium pressure fluctuation.

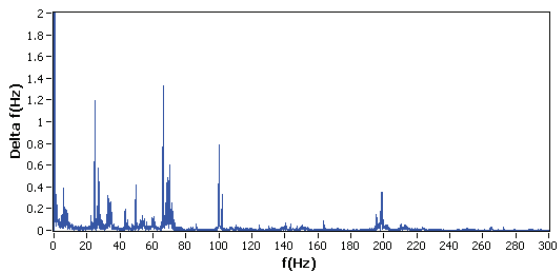

Figure 2: The spectrum of cavity vibration.

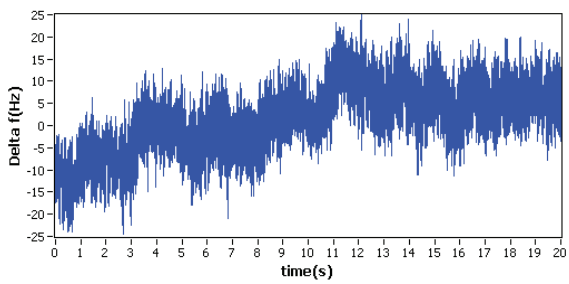

Figure 3: The time domain waveform of cavity frequency shift.

The Microphonics Test Result of CM6

The superconducting cavities in the CM6 were controlled by the LLRF systems which operated in self-excited mode, the function of the self-excited mode is same as VCO-PLL. The measured peak to peak frequency shift of 6 # HWR is about 11.5 Hz as shown in Figure 4, the peak vibration frequency 40 Hz can be found in Figure 5.

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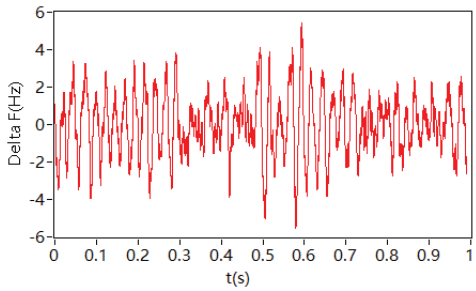

Figure 4: The 6 # HWR cavity frequency shift as a function of time.

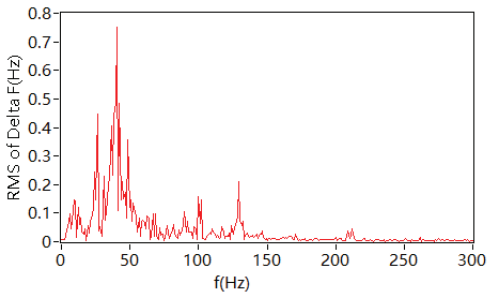

Figure 5: The 6 # HWR cavity vibration frequency spectrum.

A lot of data were acquired to analyze the cavity frequency shift over a long period of time, as the Figure 6 shown, the cavity frequency shifts histogram shown as a Gaussian distribution.

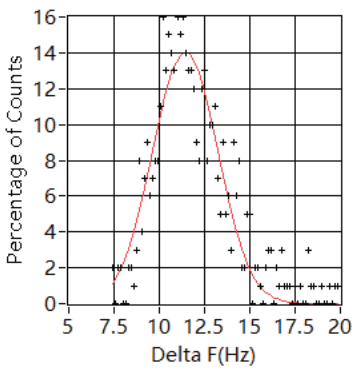

Figure 6: The histogram of cavity frequency shift.

The amplitude of vibration changed over time as the Figure 7 shown, the 26 Hz, 40 Hz, 50 Hz can be obviously identified from the intensity graph which is shown in Figure 8, the three fixed frequency vibration are always there, it's suspected that they are the resonant modes or external vibrations.

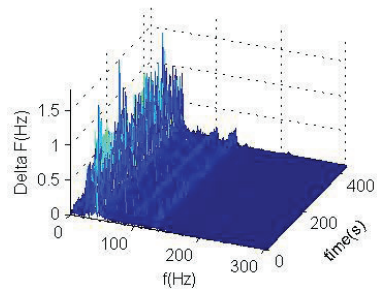

Figure 7: The 3D time-frequency graph of vibration spectrum.

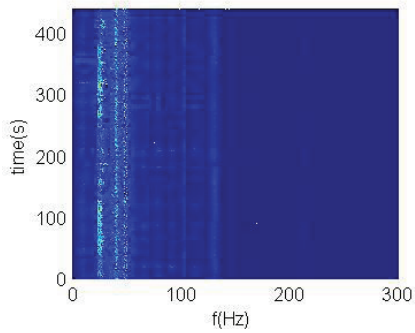

Figure 8: The time-frequency intensity graph.

THE CAVITY STRUCTURE MODAL ANALYSIS

The modal test was performed on the copper model cavity, the pulse hammer excitation method was used to analyze the cavity vibration characteristics, the peak amplitude frequency response is above 200 Hz (as Figure 9 and Figure 10 shown). Though the preliminary test was done, the measurement program and setup need to be improved before testing the niobium cavity.

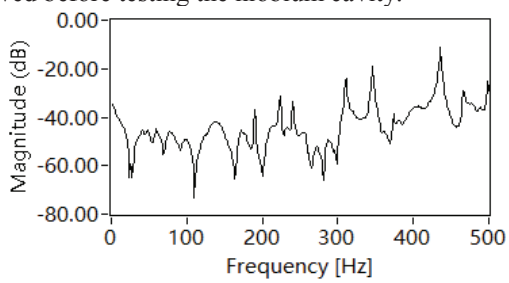

Figure 9: The amplitude frequency response of transfer function.

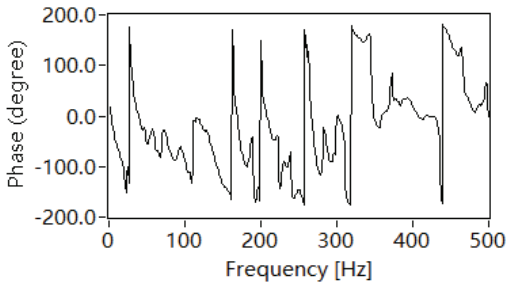

Figure 10: The phase frequency response of transfer function.

SUMMARY

The microphonics of test cryo-module and CM6 were measured by use of the new measurement method, the test results show that the HWR cavity mechanical structure of CM6 is more stable after welding the reinforcing ribs, the frequency shift caused by microphonics decreased about 50% with compare to the cavity in the test cryo-module. It's necessary to further identify the noise source.

ACKNOWLEDGMENT

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REFERENCES

[1] W.M. Yue et al., Development of superconducting half wave resonator for injector II in C-ADS, 2013 SRF Workshop.

[2] L. Wang et al., Design of a test cryomodule for IMP ADS-Injector II, Proceeding of IPAC2013.

[3] Z. Gao et al., A new microphonics measurement method for superconducting RF cavities, Nuclear Instruments and Methods in Physics Research A 767 (2014) 212–217.

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