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Notes on tuning the CERN HOM dampers

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HOM DAMPERS

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Introduction

Each of the storage cavities received from CERN has two higher order mode (HOM) dampers, fig. 1. A HOM damper consists of a coupling loop connected to a transmission line in series with a notch filter[1]. The filter is a shorted $\lambda/4$ line which is resonant at the fundamental frequency.

The HOM dampers are tuned to the SPS frequency of 200.39 MHz. To be used on RHIC the dampers will have to be tuned to 196.1 MHz. This note shows why it is necessary to tune the dampers, the tuning methods that have been considered, and the method which we are going to try first. One damper will be tuned and tested at full cavity voltage before modifications are made on others.

Damper measurements

A small loop antenna is mounted close to the coupling loop and the transmission between the antenna and the N-connector on the damper is measured with a network analyzer, fig. 2. The notch is over 40 dB deep at the fundamental. As figure 2 shows, the rejection at a frequency 4 MHz below the notch frequency is down 20 dB from the bottom of the notch.

One damper was placed on a storage cavity tuned to 196 MHz. With the damper not terminated the cavity Q was measured to be 49,600. When the damper was terminated with 50Ω, the Q dropped to 45,900. The test stand cavity has achieved a gap voltage of 1.02 MV with input power of 56 kW. The power necessary to maintain a given gap voltage is inversely proportional to the cavity Q. Thus with this damper installed in the cavity at full voltage the damper resister would absorb 4.5 kW of the fundamental. If the damper is tuned to 196 MHz, the power drops by 20 dB to 45 W.

SUPERFISH results

A SUPERFISH file created using the cavity dimensions on the drawings from CERN gives a filter frequency of 200.40 MHz. Approaches to tuning the cavity were studied using this file. The obvious thing to try first is a simple mechanical deformation of the cavity. This can be done by pressing against the cylindrical conductor to push the bottom of the cavity out. A deformation of the bottom of the cavity by ±0.25 cm tunes the filter by ±300 kHz, fig. 3. This is the method used at CERN to fine tune the damper but it is not sufficient for the initial tuning of 4 MHz.

A 4 MHz shift can be accomplished by increasing the cavity capacitance either by placing a metal insert into part of the cylindrical gap or by increasing the outer diameter of the cylindrical conductor. Loading the gap with dielectric does not give a large enough frequency shift and presents difficult cooling problems.

An insert will have to be built in two pieces and assembled below the loop. Also it will have to make good thermal and electrical contact with the damper metal, and it will have to be mounted so that its position cannot change. This makes it difficult to place a sleeve over the outside of the cylindrical conductor. An insert has been built which consists of a cylindrical sleeve attached to a flange and split in half, fig. 4. Low power tests show this will give the needed frequency shift without changing the broad band transmission, fig.5.

Increasing the outer diameter of the cylindrical conductor by 0.0317 cm will change the frequency by 4.3 MHz, fig. 6. To do this the conductor would be removed by machining and either built up by electroforming or replaced by a new conductor. The conductor would be remounted into the damper by e-beam welding.

Experimental plan

We are receiving one spare HOM damper that will be used for experiments. First a metal insert will be built for high power tests. This will have spring-finger stock in the high current areas to carry the current and conduct heat. It will be attached by screws into tapped holes in the face of the damper.

This modified damper will be tested on a cavity to determine the exact bench frequency corresponding to minimum coupling of the fundamental. The frequency measured on the bench is slightly different than the one measured in the cavity because of effects like loop-to-cavity capacitance.

If high-power tests reveal a problem with electrical or thermal conduction from the insert, then the spare damper will be machined open and the diameter of the cylindrical conductor increased. The tapped holes in the face of the damper will have no effect on its rf properties if the insert proves not to be a suitable fix.

Reference

1. F. Caspers, G. Dome, and H. P. Kindermann, "A New Type of Broadband, Higher Order Mode Coupler Using Parallel Ridged Waveguide in Comparison with a Coaxial Filter Version," Proc. 1987 IEEE PAC conference.

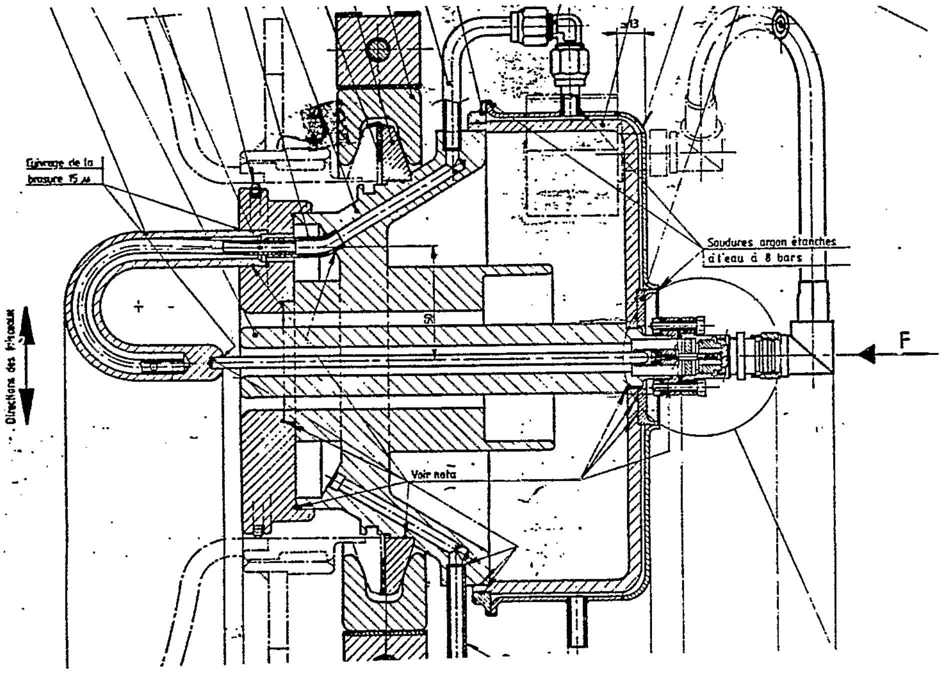

Figure 1. Cross section of HOM damper.

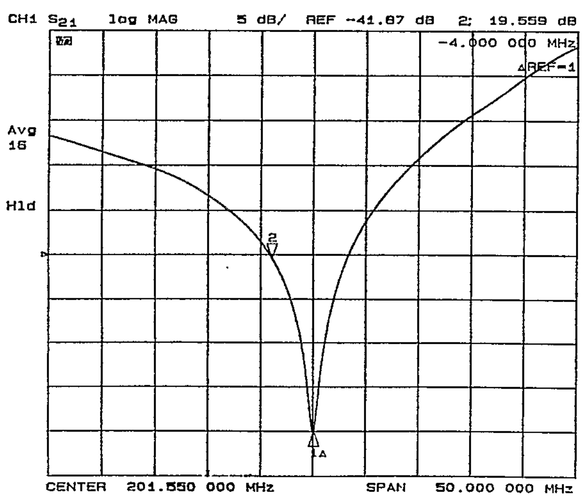

Figure 2. Transmission of filter at fundamental. Marker 2 is 4 MHz below notch.

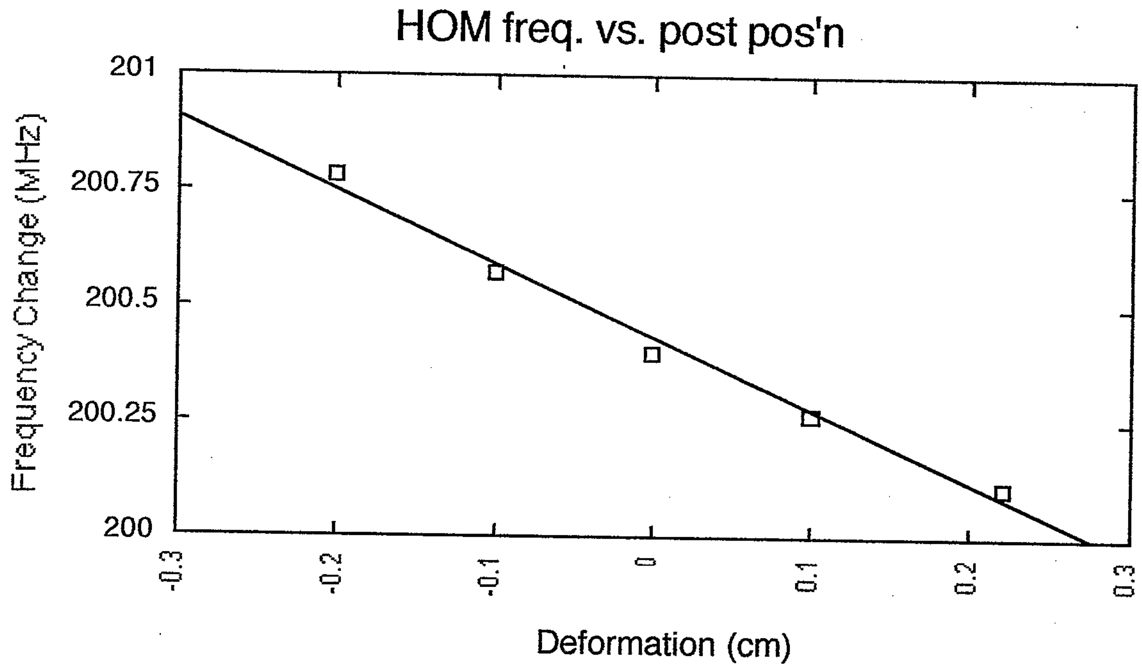

Figure 3. Calculated frequency shift of filter as a function of the deformation of the cavity bottom.

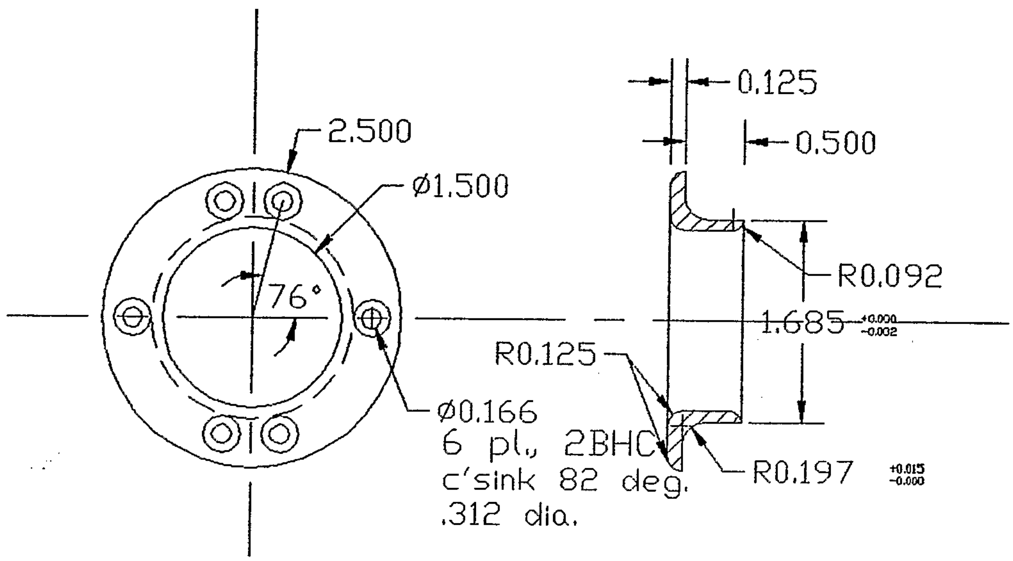

Figure 4. Capacitive insert that has been used for low-level tests.

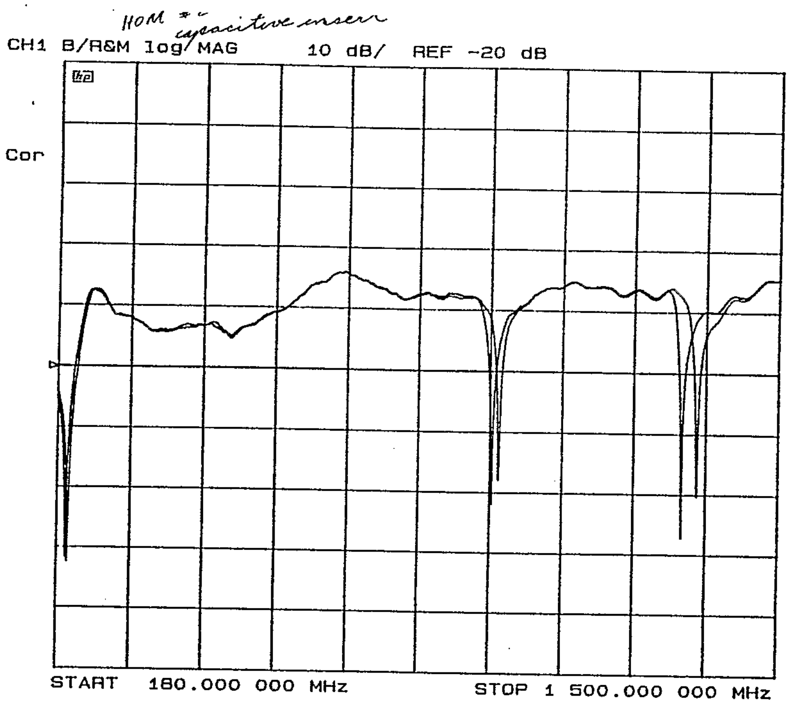

Figure 5. Broadband transmission through a damper with and without the capacitive tuning insert. The insert only shifts the resonances to lower frequencies.

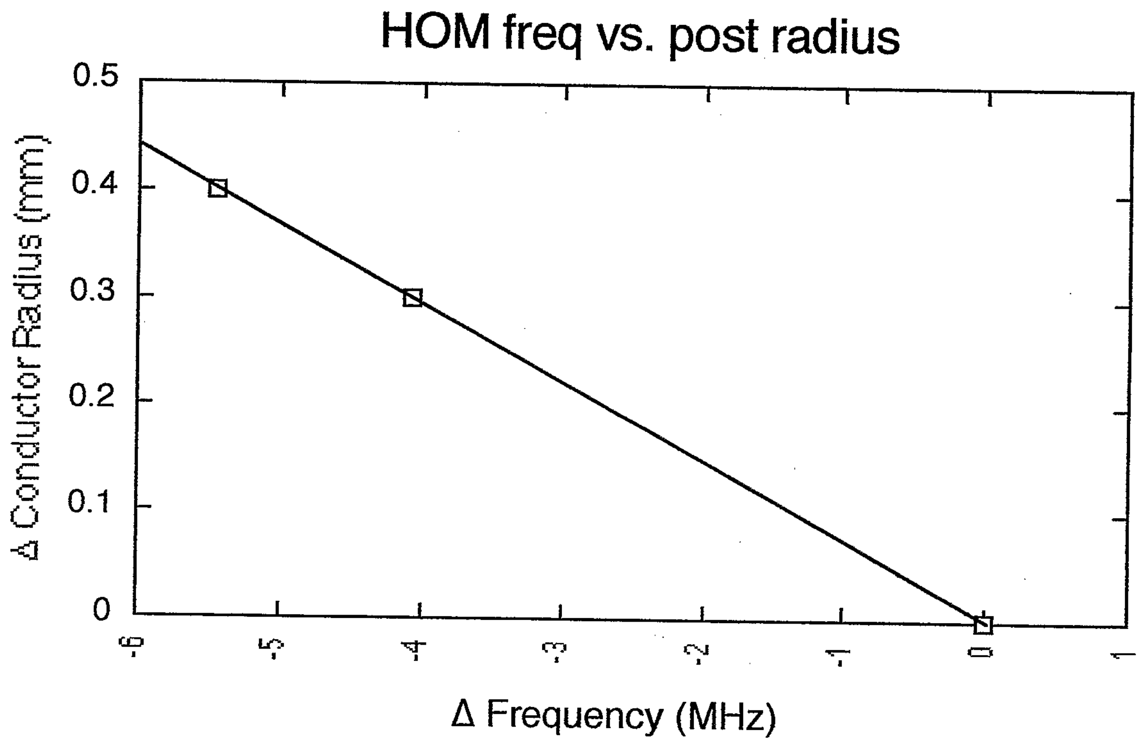

Figure 6. Calculated change in frequency produced by a change in radius of cylindrical conductor.