PICKUP STRUCTURES FOR THE HESR STOCHASTIC COOLING SYSTEM

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Abstract

The design of the High-Energy Storage Ring (HESR) of the future international Facility for Antiproton and Ion Research (FAIR) at the GSI in Darmstadt includes electron and stochastic cooling. Simulations have shown that the bandwidth of a 2-4 GHz stochastic cooling system is sufficient to achieve the requested beam quality at the internal target. New 2-4 GHz pickup structures have been developed and tested mainly for transversal operation. The printed loop boards have been constructed as a part of a universal modular octagonal structure. Different modes of signal combinations outside the vacuum envelopes will allow to pick up different transversal beam positions as a part e.g. of a core or a halo cooling system. First results of the low-impedance printed loop structures will be presented.

STOCHASTIC COOLING SYSTEM

Many stochastic cooling systems have been or are still in operation worldwide ([1], [2], [3], [4]). Most of them use the well-known λ/4 loop as pickup and kicker structures. To increase the sensitivity of these structures, most systems are moveable even in a cold environment.

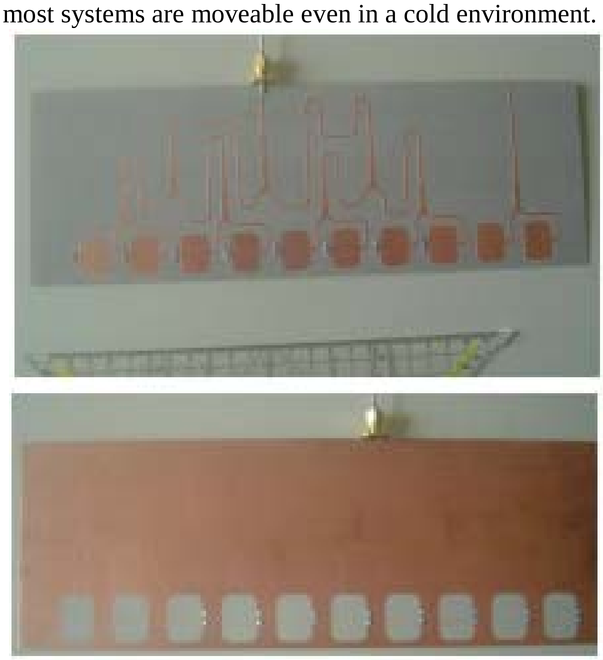

Figure 1: Printed loop couplers (the grid of the ruler is 1cm).

Extensive calculations [5] have been carried out to find the optimum stochastic cooling system for the High-Energy Storage Ring (HESR) of the future international Facility for Antiproton and Ion Research (FAIR) [6]. The model used for the transversal and longitudinal filter cooling is based on λ/4 loops with moveable electrodes to reach a small gap of 25mm. But, the relative low aperture (89mm) of the planned HESR and the need of low-impedance structures suggest structures without movements.

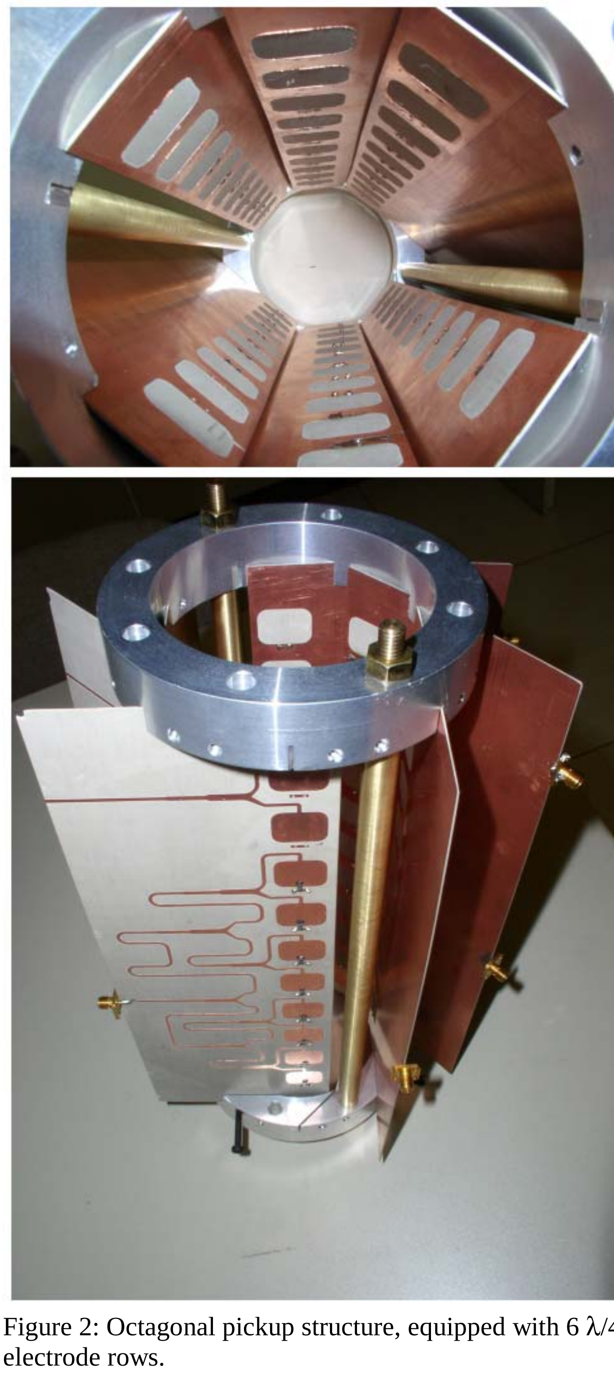

Figure 2: Octagonal pickup structure, equipped with 6 λ/4-electrode rows.

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As a first solution we analysed printed loop couplers similar to those developed at the FNAL [7]. The λ/4 loops of the 2-4GHz system are part of the combiner boards, which simplified the whole structure and minimized the fabrication costs. Top and bottom side of the first λ/4-loop test-board are shown in Fig. 1. The loops are located at the combiner side whereas the coupling is done through the dielectric material of low permittivity (ε_r=3.27). Only simple wireholes are needed for connection of the terminating resistor at the electrodes.

Six of these combiner boards have been arranged to an octagonal structure shown in Fig. 2. The signals of each electrode row will be fed through the vacuum tank and can be combined outside for a usual transversal and longitudinal cooling system.

First tests have been carried out to measure the frequency response of the loops and combiners. A microstrip ring resonator was measured at room-temperature and at 77K to analyze the temperature dependence of the used material.

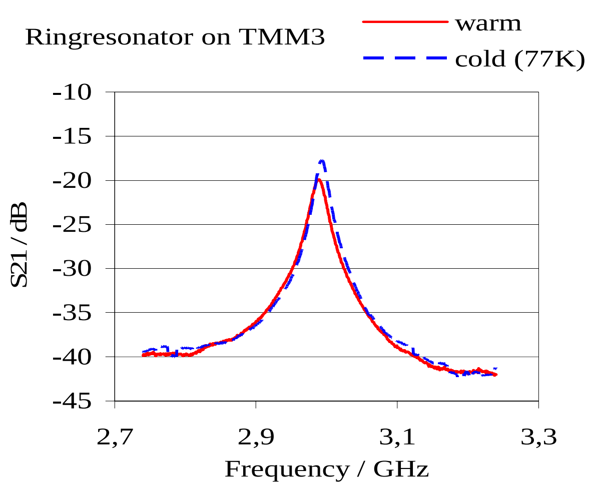

Figure 3: Measured resonance curve of the ring resonator with TMM3 substrate at room temperature and at 77K.

The measured value of the frequency change (Fig. 3) of less than 1.4 $^{0}/_{00}$ shows that the chosen temperature compensated material (TMM3 [8]) can be used at room-temperature as well as at low temperatures with no significant change of the ε_r. A first check at the vacuum test stand has shown that the material is well compatible with the vacuum conditions of the HESR.

PRINTED LOOP COUPLER

The first design of the HESR stochastic cooling pickups uses 50-Ohm printed loop couplers containing rectangular electrodes having rounded corners. Each loop ends at a 50-Ohm SMD resistor.

These loops are combined via several impedance transforming networks. The relative high bandwidth of 2-4 GHz requires at least two-stage transforming networks. Compared to Wilkinson couplers these combiners are a little bit more space consuming but have lower losses. Figure 4 shows the measured and calculated reflections of one combiner including two loops.

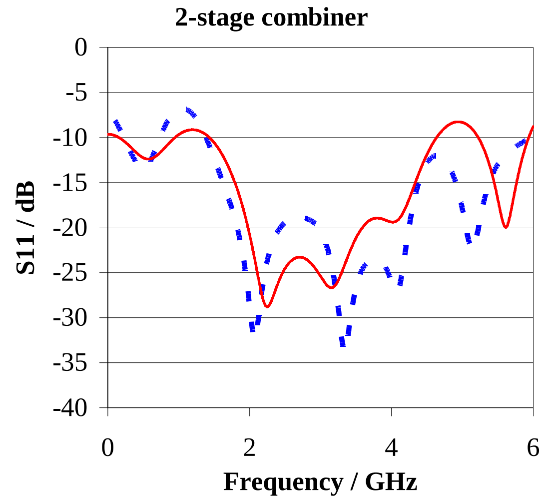

Figure 4: Measured reflection coefficient of one 2-stage combiner including two λ/4-loops (blue) and the corresponding MWS [9] simulation (red).

We compared the transversal sensitivity of the new printed loops to that of the COSY-loop structure of 1.8 to 3 GHz simulating the beam by an air microstripline. The width of the COSY loops is the same as in the first layout of the printed loops. Even the number of combined loop are the same, thus a direct comparison is possible. Fig. 5 shows the cooling pickup structure of COSY [4] which was adapted from the CERN AC structure [1].

Figure 5: COSY cooling structure and test bench. The length in the beam direction reaches about 0,25m (8 electrodes).

The results of the measurements are presented in Fig. 6. Although the printed loops have been optimized for a frequency range of 2-4 GHz the measurements shows that these loops have the same transversal sensitivity as the COSY-loops and can be used even at lower frequencies.

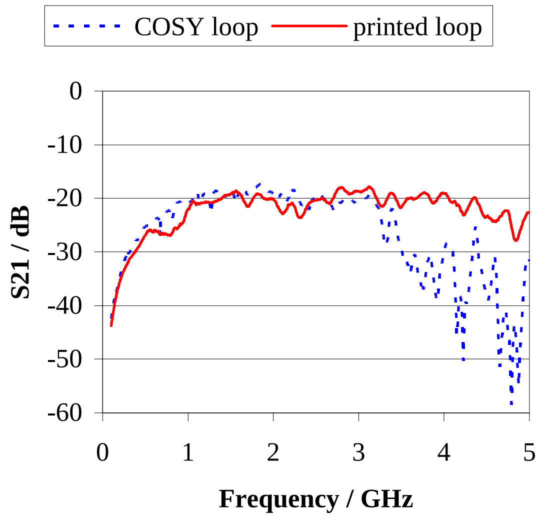

Figure 6: Comparison of COSY-loop and printed loop structures using the test bench of Fig. 5.

The sensitivity of the octagonal structure is sufficient for a transversal stochastic cooling system both as pickup and as kicker structure, but first HFSS [10] simulations [11] show that the sensitivity of the printed loops for longitudinal signals is nearly a factor of two lower than the AC loops.

OUTLOOK

We are going to design a new test-setup that replaces the beam simulating stripline in Fig. 5 to create different field patterns. This setup will also be used to measure the influence of vertical fields for a horizontal connection of the pickup rows.

To increase the sensitivity of the pickup/kicker loops for a longitudinal operation, different methods will be analysed. First of all we are looking for an integration of the AC loops into an octagonal structure. Also we are working out a modification of the printed electrode board that operates as a broad-band accelerating structure. This will have essential higher longitudinal impedance and will serve as the corrector structure of the longitudinal cooling system. We also will perform a comparative study between our structure and the promising GSI planar pickup electrodes [12] scaled to the envisaged frequency band of 2-4GHz.

ACKNOWLEDGEMENT

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