TEST BENCH FOR THE NICA STOCHASTIC COOLING ELEMENTS

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Abstract

Stochastic cooling is one of the crucial NICA (Nuclotron-based Ion Collider fAcility) subsystems. Cooling efficiency depends on quality of system elements. A new test bench has been created at JINR for incoming control of pickups, kickers and amplifiers, tuning and adjustment of the comb filter etc. The description of the test bench is given. Methodics of the measurements that should be done on the test bench are discussed. The results of the first measurements are given.

INTRODUCTION

Stochastic cooling system (SCS) for NICA collider is under development in JINR [1]. Main equipment for the NICA SCS consist of 6 pickups, 4 kickers and 64 power amplifiers. Supply of the equipment is in progress and to perform incoming quality tests a test bench has been created. A number of measurements should be done for pickups and kickers: shunt impedance dependence on the pickup structure length and azimuthal loop position, electrical centre behaviour as a function of frequency, influence of high-order mode suppressors and ceramic vacuum chamber, kicker standing wave ratios (SWR). Also measurements for the amplifiers are the following: gain dependence on frequency and input power, linearity of gain (intermodulation products) and phase frequency response, group delay deviations from a constant value and reproducibility of all the parameters mentioned above.

TEST BENCH

The test bench consists of of the ring slot coupler type pickup/kicker prototype [2,3] with mechanical support, comb filter, power meter, attenuators and vector network analyser (VNA). The typical measurement scheme is shown in Fig. 1.

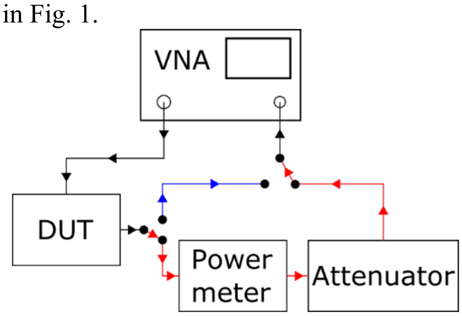

Figure 1: The measurement scheme for devices under test (DUT): red line for active devices, blue – for passive ones.

Passive devices (e.g. pickups/kickers, cables etc.) are measured by direct connection to the VNA. To prevent VNA ports from damage caused by high power from active devices (e.g. amplifiers) the power meter and attenuator are added to the scheme between the output port of the DUT and the input port of the VNA.

All measurements for the test bench are listed in Table 1. Measurements except the influence of intermodulation distortion (IMD) are performed by the scheme presented in Fig. 1. The measurement of IMD is discussed in details in section below.

Table 1: List of Measurements

Pickup/Kicker	***Amplifiers***
Impedance dependence on the azimuthal loop position	Gain vs frequency
Impedance dependence on the longitudinal loop position	Gain vs input power
Electrical center position as a function of frequency	Gain linearity of frequency and power
Influence of High Order Mode suppressors	Phase linearity
Influence of ceramic vacuum chamber	Group delay
Kicker SWR	IMD
Reproducibility	

POWER AMPLIFIER MEASUREMENTS

General Measurements

The total output power of one NICA SCS kicker is estimated to be 500 W. Every kicker will consist of four sections, each of them can dissipate power of 125 W. Every section will be driven by 30 W amplifier units distributed by 4 directions as shown in Fig. 2. This scheme requires precise reproducibility of amplifier performance. The amplifier response should be close to constant gain and linear phase.

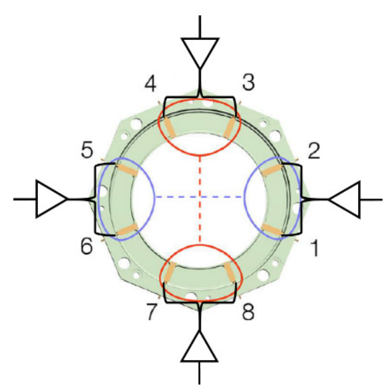

Figure 2: Feed scheme of one kicker section.

The combination of this requirements is unavailable in commercial amplifiers, therefore, research and

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development has been carried out. First four amplifier prototypes have been produced and delivered to JINR. The amplifier requirements that have to be checked during the incoming control are listed in Table 2.

Table 2: Amplifier Requirements

Bandwidth	2 – 4 GHz
Gain	43 ± 2 dB
1 dB compression (at 3 GHz)	Input 0 dBm (1 mW)
Power linearity (IMD)	Notch depth > 30 dB
Phase linearity	5 deg
Group delay variation	200 ps
Reproducibility	

The measurements mentioned in the table above for each of four amplifier prototypes has been carried out. The obtained data are illustrated in Figs. 2 – 6. Gain in the range operating frequencies (2-4 GHz) is shown in Fig. 3. The deviations from the average gain value meet the requirements and are less than 2 dB.

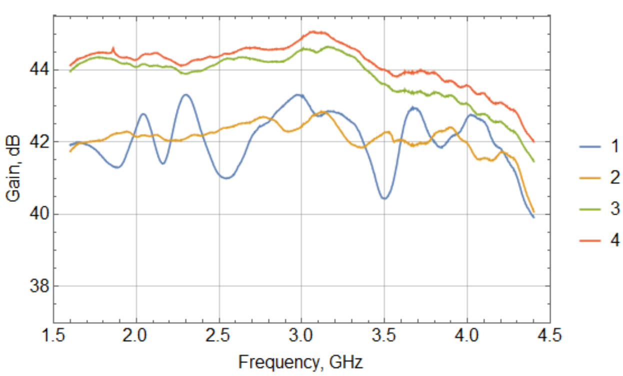

Figure 3: Gain of four power amplifier prototypes as a function of frequency.

Gain dependence of input power is depicted in Fig. 4. The value of 1 dB compression is at the level of input power of 0 dBm which is in accordance with the requirements.

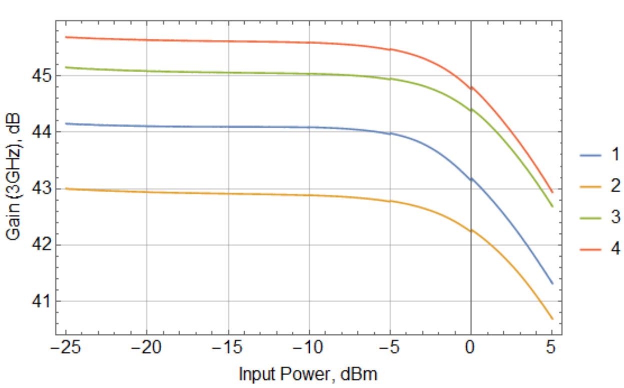

Figure 4: Gain of four power amplifier prototypes as a function of input power.

Group delay dependence of frequency is presented in Fig. 5. The deviations from the average group delay value meet the requirements are less than 200 ps.

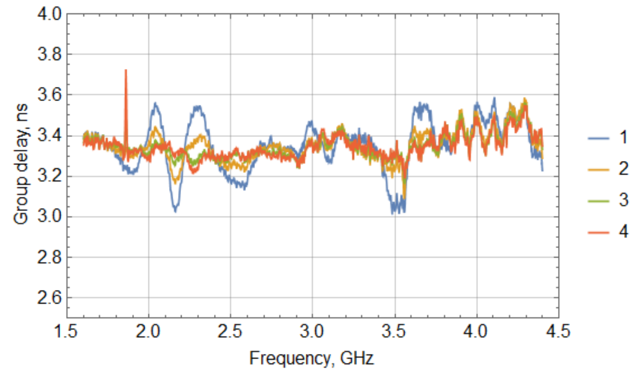

Figure 5: Group delay of four power amplifier prototypes as a function of frequency.

Influence of Intermodulation Distortion

For the start-up configuration of the NICA SCS the filter cooling method is chosen. The key parameter which characterizes quality of the comb filter is the notch depth. It is the difference between maximum and minimum of the amplitude response in the frequency range of a notch. For effective cooling notch depths should be similar in the whole bandwidth and as large as possible. IMD of any amplifier which comes after the comb filter reduces the notch depths of the SCS and therefore cooling efficiency. The Fig. 6 depicts the measurement scheme for influence of the power amplifier intermodulation products.

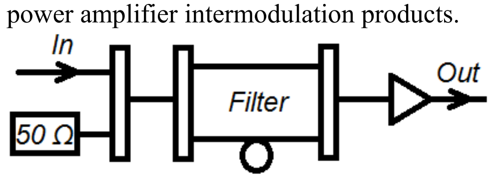

Figure 6: Measurement scheme for the influence of IMD.

As a source of thermal noise the 50 Ohm load at room temperature is used. The noise is coupled with the input signal from the VNA. The signal superposition passes though the comb filter and power amplifier. The VNA indicates the transmission scattering parameter (S_{21}) of the scheme.

The response of the NICA SCS comb filter without amplification is presented on Fig. 7.

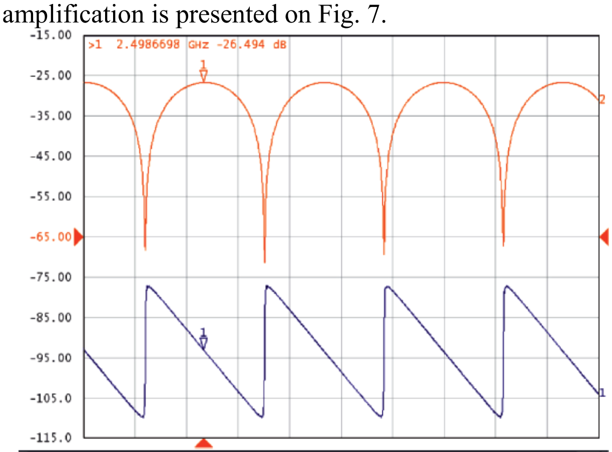

Figure 7: Amplitude (top) and phase (bottom) response of the comb filter at Nuclotron.

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In Fig. 8 the illustration of a notch distorted after amplification is given. The depth of shown notch (41.9 dB) is less than the bandwidth average value of 37.8 dB which is above the minimal acceptable value of 30 dB.

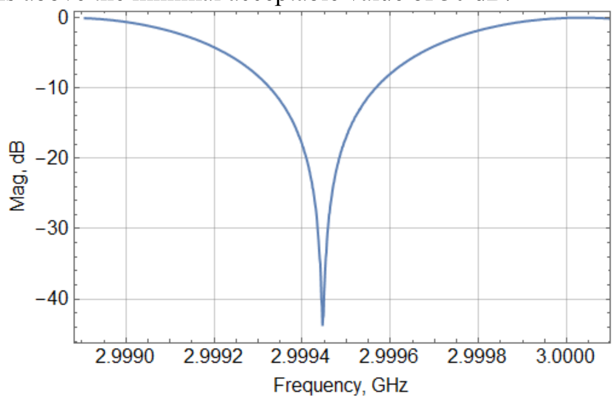

Figure 8: Notch depth in the middle of SCS frequency range (2 – 4 GHz) on the output of power amplifier.

CONCLUSIONS

The test bench for quality control of the NICA SCS elements has been created. Methodics of measurements has been developed. The measurements has been started. Power amplifier prototypes has been successfully produced and fullfill the requrements.

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