HIGH POWER RF TESTS ON FUNDAMENTAL POWER COUPLERS FOR THE SNS PROJECT*

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Abstract

The SNS is an accelerator-based spallation neutron source being built in Oak Ridge, Tennessee, in a partnership of six DOE laboratories. TJNAF has the responsibility for the superconducting linac, which will be built with medium (0.61) and high (0.81) beta cavities. A 50 ohm coaxial line with planar ceramic window was implemented. High power RF tests have been performed on the prototype couplers in a dedicated RF stand to verify that their specifications are met.

This paper summarizes our results obtained so far at room temperature. After RF conditioning, the SNS fundamental power coupler prototypes have successfully passed RF levels well above the specifications.

The couplers were operated in traveling wave at 750 kW with 1.3 ms duration at 60 Hz, and at 2 MW with 0.65 ms at 60 Hz.

1 INTRODUCTION

The SNS power coupler is one of the challenges for the SNS project, which has a high-energy superconducting (SC) section spanning 210 – 1030 MeV [1], [2]. A large amount of pulsed RF power (machine operation asks for 550 kW, 1.3 ms at 60 Hz repetition rate) must be transmitted through these couplers to the SC cavities.

The 805 MHz fundamental power coupler for the SNS project is scaled down in frequency from the KEK 508 MHz coupler that successfully transmitted 320 kW to a beam. [3], [4], [5]. The layout of the fundamental power coupler for SNS is illustrated Fig.1. On the vacuum side of the coupler, the alumina ceramic disk is TiN coated. The inner conductor and the copper-plated double-walled outer conductor (cooled with He gas) form a 50 ohm coaxial line. Vacuum seal between the window assembly and the outer conductor is made with Conflat® flanges and a modified Copper gasket. Instrumentation ports for vacuum, electron pick-up probe, and arc detectors are located in the vicinity of the vacuum side of the ceramic widow. The air side of the coupler is also a 50 ohm coaxial line (with a water-cooled inner conductor extension) and is connected to the klystron or to the terminating RF load via WR 975 waveguides and optimized waveguide-doorknob transformer. The contact area between the inner conductor extension and the doorknob was separated with two turns of Kapton® foil used as a capacitor for d.c. bias. More details of design of the SNS fundamental power coupler are given in [6], [7].

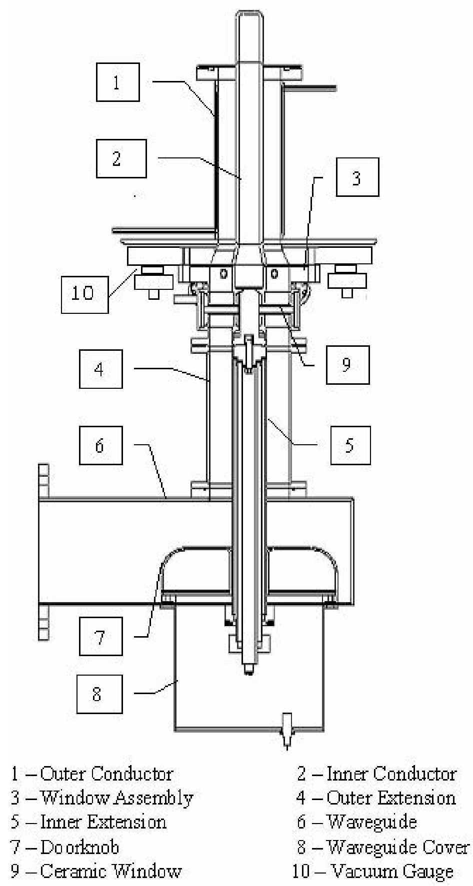

Fig. 1 Fundamental power coupler for the SNS project

2 CONDITIONING AND POWER TESTS

High-RF power tests have been performed using a specially built test cart [8] that allows baking followed by RF conditioning of two couplers under ultra high vacuum. The first six SNS fundamental power couplers prototypes have been tested with high RF power at LANL [9], [10]. In this setup, the RF power is transmitted from one coupler, through a stainless steel connecting waveguide to a second coupler and then to a water-cooled high-power RF terminating load or to a variable short circuit.

At JLAB, a recently commissioned 1 MW 805-MHz pulsed RF power stand (Fig. 2) allows performing highRF power tests in (1) traveling or (2) standing wave modes and two other pairs of couplers have been tested.

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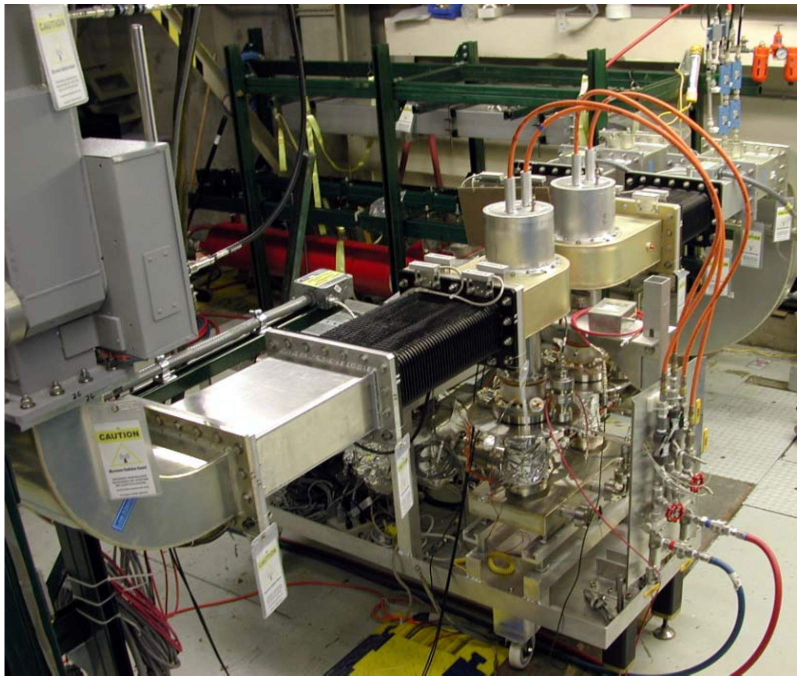


Figure 2 Room temperature tests stand for conditioning and high-power RF testing at Jefferson Laboratory

The two couplers and the connecting waveguide were matched to provide maximum RF transmission power [8], this arrangement allowing for RF conditioning and testing couplers at power levels higher than the values required for normal machine operation.

Before RF conditioning and testing, the components of the couplers were cleaned using a procedure developed at JLAB [9], [10].

RF conditioning was assisted by a fast RF feedback loop [4] which controls the RF pulse amplitude if vacuum events exceed a predetermined threshold (Fig No.3)

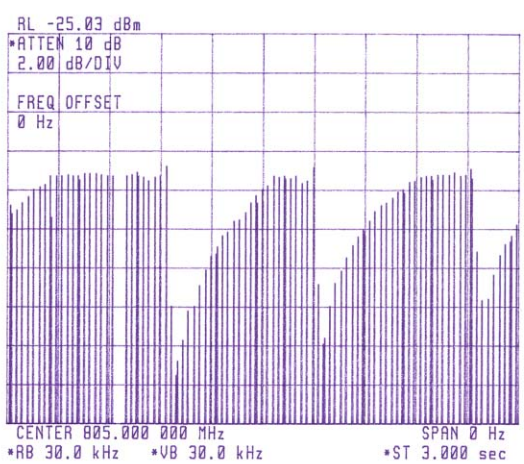


Figure 3. Vacuum induced modulation in RF pulse amplitude with the feedback loop.

A fast interlock system on the vacuum controller's analog output switches RF OFF if the coupler vacuum is higher than 5 10^{-7} mbar. RF permit is obtained after the vacuum pressure is better than 2 10^{-7} mbar.

These conditions allow obtaining optimum RF conditioning and minimize arcing events near the ceramic window. Real-time LabView software provides the operator interface to a data acquisition system that allows changing RF pulse characteristics and control of conditioning or RF testing.

2.1 High RF power tests in traveling wave mode

In this test modality, RF power was transmitted through the couplers into the RF load. With the feedback loop, the vacuum base line was kept below 3 10^{-7} mbar while power levels above 2 MW were reached after about 30 hours of RF processing (See Fig 4) without arcing, vacuum or high electron activity events.

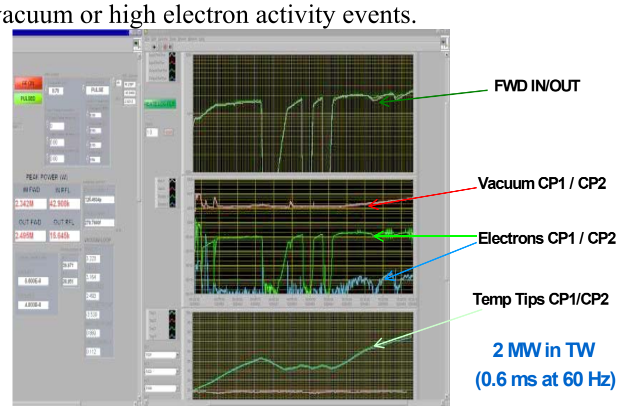


Figure 4. No special vacuum or electron events while passing 2 MW

At different power levels (pulse duration 1.3 ms, 30 Hz repetition rate), calorimetric estimation of absorbed power in the terminating load was measured. The results are synthesized in Table 1.

Table 1: Calorimetric estimation of transmitted RF power

P_{pulse} (kW) powermeter	Delta T(°C)	Flow (gal/min)	P_{ave}(kW)	P_{pulse} (kW) calorimetric
103	1.19	8.8	2.76	91.23
211	3.25	8.8	7.55	249.16
302	3.62	8.8	8.41	227.53
408	5.28	8.8	12.27	404.79
510 - 520	7.19	8.8	16.7	551.23
603 - 607	7.8	8.8	18.12	598
695 - 705	9.8	8.8	22.77	751.32
707 - 712	9.64	8.8	22.4	739.06

The efficiency of d.c bias in controlling multipacting at different RF power levels was tested while cycling the pulse amplitude between 10 kW and 700 kW as shown in Figure 5.

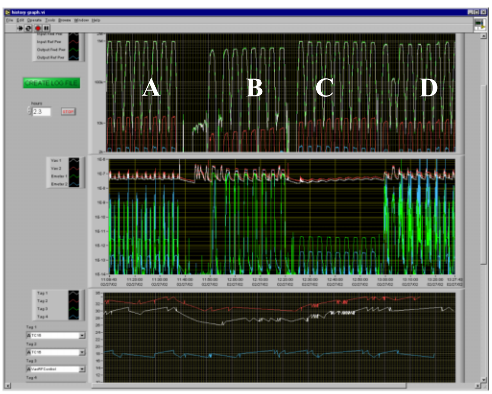
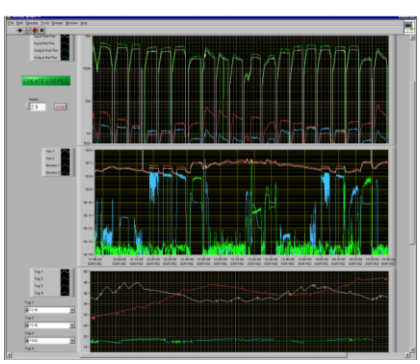


Figure 5. d.c bias efficiency: a) vacuum and electron spikes while cycling pulse amplitude, b) same conditions of cycling but with d.c. bias –2.5 kV, c) vacuum and electron activities are controlled with +2.5 kV, d) cycling again without d.c. bias

2.2 High RF power tests in standing wave mode

Two series of tests in standing wave mode were performed at forward power levels in excess of 600 kW for different positions of the short circuit (moved in steps of 8 mm from 0 to 260 mm – see Fig 6). For some positions of the short circuit, vacuum and electron events triggered by high local peak power occurred.



High RF power tests in SW mode, changing position of the short circuit in steps of 8 mm.

At maximum RF power level permitted by vacuum (4x10^{-7} mbar), a soak time of 5 minutes.

Test done with 1 ms pulse duration at 60 Hz.

Figure 6. Local peak powers in 2.5 MW range in standing wave mode for different positions of the short circuit.

3 SUMMARIES AND CONCLUSIONS

We have demonstrated at LANL, and at JLAB, that the SNS fundamental power coupler can be conditioned and sustain RF power in excess of machine specification, d.c. bias was effective in controlling multipacting. Initial results were obtained at the end of May 2002 on the first SNS cryomodule prototype: cavity fields in excess of 15 mV/m at incident RF power of 350 kW [7]. Extensive tests of the SNS fundamental power couplers at room temperature, as well as on a prototype cryomodule, are scheduled for the near future.

4 ACKNOLWDGEMENTS

This work reflects the sustained efforts of working teams from JLAB, LANL and ORNL, which, in a very short period of time, have managed to surpass inherent difficulties and prove by high RF power tests that the prototype SNS fundamental couplers fulfill the design requirements.

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