

# COMMISSIONING OF RF POWER COUPLER FOR BISOL R&D RESEARCH

Feng Zhu<sup>#</sup>, Z. Q. Yao, S.W. Quan

Institute of Heavy Ion Physics & State Key Laboratory of Nuclear Physics and Technology,  
 Peking University, Beijing, 100871, China

## Abstract

RF power coupler is a key component of superconducting accelerating system. For the pre-research of BISOL, we designed a 162.5 MHz RF power coupler which can transmit CW 20 kW power for HWR cavities. It can also transmit 1-5 kW 81.25MHz power for QWR cavity horizontal test study. Two prototype couplers have been fabricated and proceeded the high power conditioning.

## INTRODUCTION

Beijing isotope separation on line type rare ion beam facility (BISOL) is a proposed facility which has an intense deuteron driver superconducting linac and a post-accelerator [1]. For the first stage of BISOL, the beam load reaches 10 mA of 162.5MHz HWR cavities for deuteron beams and 0.4 uA of 81.25MHz QWR cavities for secondary heavy ion beams. For the pre-research of BISOL, a cryomodule which can provide the horizontal test of both 81.25 MHz QWR for the post-accelerator and 162.5 MHz HWR for the driver accelerator with the proper external quality factor was designed and fabricated under the collaboration between Peking University (PKU) and China Institute of Atomic Energy (CIAE). In order to reduce expenses, we designed a RF power coupler which could transmit both CW 20 kW 162.5MHz for HWR cavities and 1-5 kW 81.25MHz power for QWR cavities [2].

Figure 1 shows the cross section of the coupler. The parameters of coupler are listed in Table 1. The coupler consists of two cylindrical ceramic windows, adjusting bellows, coaxial lines and T-box. Although T-box has frequency selectivity, we can adjust the size of outside box and the position of short-circuit face to guarantee the impedance matching for the whole coupler transmitting both 162.5MHz and 81.25MHz frequency.

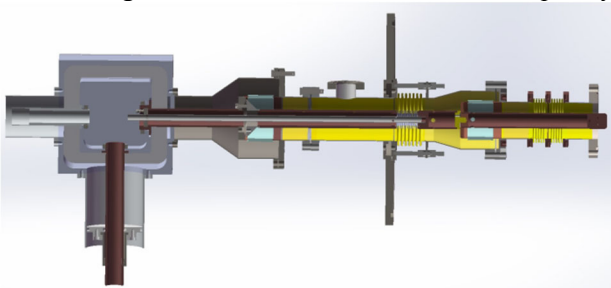


Figure 1: Cross section of the coupler.

Table 1: Parameters of the Coupler

Parameter	Value
Frequency	162.5MHz/81.25MHz
Impedance	50ohm
Structure type	Coaxial
Window type	Double, cylinder ceramic
Coupling method	Antenna coupling
Power level	20kW@162.5MHz, 1kW@81.25MHz

## FABRICATION AND ASSEMBLY

The outer conductor is made of SS316L and the surface is coated with about 15 μm copper. The inner conductor is oxygen free copper or stainless steel coated with 50 μm copper. The ceramic windows are made of Al<sub>2</sub>O<sub>3</sub> with purity of 97.6%.

A nitrogen air pipe inserted inside the inner conductor to cool the inner part of the coupler. Polyimide film is used to isolate the inner conductor and the inner part of the T-box. We fabricated two prototype couplers. Figure 2 shows the parts of the couplers. After ultrasonic cleaned, all the parts were assembled in the class 100 clean room and the two couplers had leak check.

The commissioning of the couplers was done at Institute of High Energy Physics (IHEP). They have a 166MHz 50kW cw amplifier and the test stand. It can provide at least 20kW 162.5 MHz power. To do the commissioning of the couplers, a connecting cavity is used. Figure 3 shows the structure of the connecting cavity with flanges of 100 mm diameter. For the impedance matching, we designed and fabricated two transition parts to connect the cavity and the two couplers. The antenna length was optimized to get the right coupling between the connecting cavity and the coupler at 162.5 MHz.



Figure 2: Parts of the coupler.

<sup>#</sup>zhufeng7726@pku.edu.cn

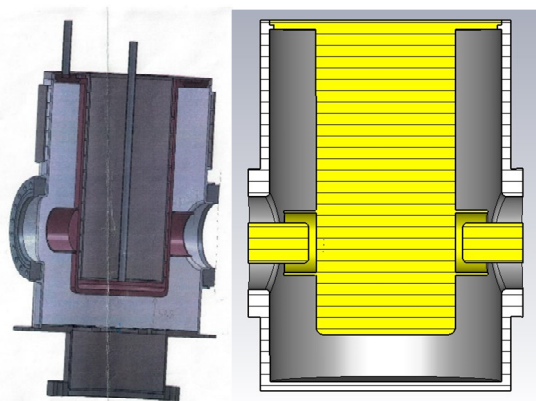


Figure 3: The connecting cavity of the IHEP 166MHz coupler test stand.

### COMMISSIONING OF THE COUPLERS

The two couplers and the connecting cavity were assembled in the class 10000 clean room and pumped. They were baked for 66 hours at 110°C. After baking, the vacuum of the couplers and the connecting cavity was lower than  $3 \times 10^{-6}$  Pa. Then they were connected to the amplifier and the load. Figure 4 shows the coupler commissioning test stand.



Figure 4: Commissioning test stand of the coupler at IHEP.

We measured the transmission properties of the two couplers and the connecting cavity at 162.5 MHz. S parameters were measured by the vector network analyzer.  $S_{11}=-27.5864\text{dB}$ ,  $S_{22}=-31.2513\text{dB}$ , and  $S_{21}=-0.2159\text{dB}$ .

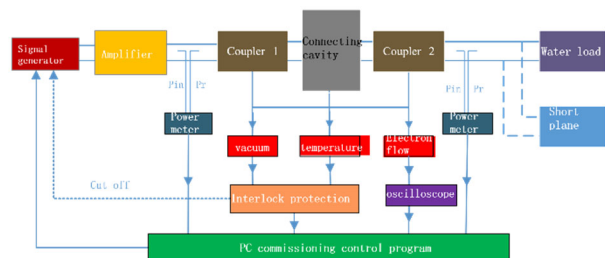


Figure 5: Diagram of the commissioning system.

Figure 5 gives the diagram of the commissioning system. It contains the high power phase shifter, solid

state power source, couplers and connecting cavity, load vacuum system, inspection system and the interlock control system. The inspection system needs to monitor the temperature, pressure and the electron flow caused by the emitters. When these values were higher than the set parameters, the interlock control system would reduce or stop the input forward power in several microsecond to protect the ceramic windows. During the commissioning process, pulsed mode and cw mode were used alternately. For the first run, the repetition rate was 10 Hz and the pulse width was  $10 \mu\text{s} \sim 1 \text{ms}$  and the power from 0 to 20 kW. Then the repetition rate raised to 1 kHz and the pulsed width was  $20 \mu\text{s}$  to 1s. When the duty factor was high, the inner conductor was cooled by nitrogen gas and the cold window areas were cooled by fans. The power reached 20 kW and retained for at least 10 minutes for every pulse mode run. To have a better effect, bias voltage was not applied to the couplers during the commissioning process.

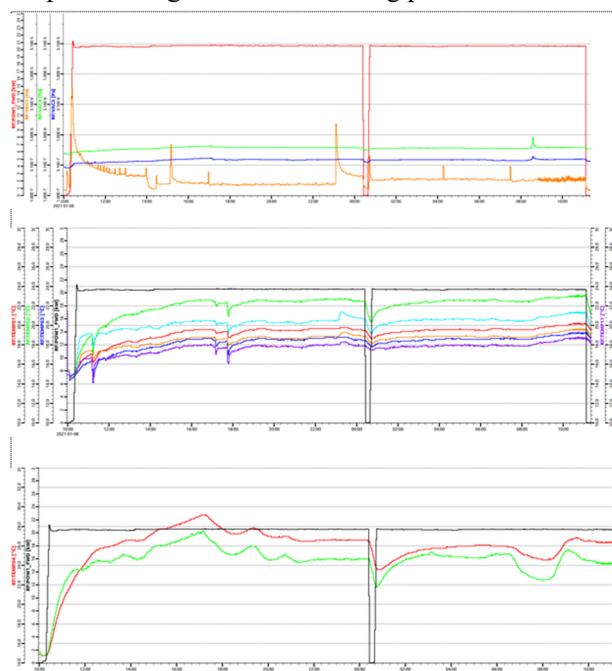


Figure 6: Pressure (the top figure), temperature near cold window area (the middle figure) and temperature near warm window area (the bottom figure) of the couplers during the cw 20 kW power test.

After the commissioning process, the couplers were tested at 20 kW. For the long time test, +1 kV and +1.5 kV bias voltage was applied to the inner conductors of the two couplers separately. Figure 6 gives the vacuum and temperature curve change as the time. The test lasted for 24 hours. Because there was something wrong with one temperature sensor, there is one break during the test. There was no electron flow during the test. There was several little vacuum vibration of coupler I. The base pressure was lower than  $5 \times 10^{-7}$  Pa. The temperatures of the couplers were about 20-35 °C. Limited by the 166 MHz power source, the long time test of the couplers was done only at cw 20 kW 162.5 MHz power. We also did half an hour test on 25-30 kW,

and the inspection parameters were stable. It means the couplers could transmit higher power than 20 kW.

Considering the real situation of total power reflection, the couplers also did standing wave commissioning. Because the high field at antinodes may destroy the ceramic windows, the standing wave test was necessary. Limited by the IHEP feeder tubes, the maximum power for the standing wave commissioning was 9 kW. Table 2 gives the standing wave commissioning result of the two couplers. Both couplers was applied +1 kV bias voltage. The short planes was set at 10 different positons. The pressure of the couplers did get worse or have vibration. There was no unusual increase of the temperature and there was no electron flow during the standing wave power test. The couplers could transmit stably cw 9.1 kW power at standing wave mode.

Table 2: Standing Wave Power Test of the Couplers at cw 9.1 kW.

Short plane position (mm)	Duration (min)	pressure (Pa)		Cold window temperature		Temperature at warm bellow		warm window temperature		Temperature at T-box	
		CPL I	CPL II	I	II	I	II	I	II	I	II
374	60	<1.4×10 <sup>4</sup>	<5×10 <sup>3</sup>	25.4	23.2	<22	27.3	27.1	23.5	31.6	29.8
466	60	<7×10 <sup>3</sup>	<6×10 <sup>3</sup>	22.8	21.8	<20	27.4	25.8	24.8	32.4	33.2
558	50	<1.7×10 <sup>4</sup>	<5×10 <sup>3</sup>	22.1	22.5	<21	27.5	29.0	27.5	32.8	31.5
650	50	<1.2×10 <sup>4</sup>	<5×10 <sup>3</sup>	22.8	22.9	22.5	25.6	30.6	28.3	33.4	28.8
742	60	<1.1×10 <sup>4</sup>	<5×10 <sup>3</sup>	22.1	22.2	25.0	23.5	30.2	29.2	31.0	24.1
834	60	<7.0×10 <sup>4</sup>	<5×10 <sup>3</sup>	22.0	22.2	27.1	<22	24.8	25.8	25.6	21.6
926	50	<1.0×10 <sup>4</sup>	<5×10 <sup>3</sup>	22.5	22.6	27.9	<21	24.8	28.5	39.2	32.8
1018	96	<1.0×10 <sup>4</sup>	<5×10 <sup>3</sup>	24.9	22.7	29.0	<22	25.0	23.4	31.8	25.5
1110	50	<1.3×10 <sup>4</sup>	<5×10 <sup>3</sup>	26.3	23.8	28.0	22.2	25.8	25.5	37.4	29.7
1202	22	<4.6×10 <sup>4</sup>	<9×10 <sup>3</sup>	26.6	24.2	25.0	24.9	26.2	25.1	43.8	38.5

## CONCLUSION

Two prototype input power couplers which can transmit both 162.5MHz and 81.25MHz frequency power to SRF HWR cavity or QWR cavity have been designed and fabricated. The high power commissioning of the couplers was done at 162.5MHz at IHEP. Both couplers could transmit cw power higher than 20 kW at traveling wave mode and 9 kW at standing wave mode. Because of the lack of 81.25 MHz power source, the commissioning of the couplers at 81.25 MHz will be done later.

## ACKNOWLEDGEMENT

The commissioning work of the couplers was done at IHEP. We would thank the colleagues at IHEP, especially for the help of T. M. Huang, Q. Ma and H. Y. Lin.

## REFERENCES

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