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DEVELOPMENT OF 81.25 MHz 20 kW SSPA FOR RAON ACCELERATOR

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Abstract

A heavy ion accelerator, RAON is under development in Daejeon, Korea by Rare Isotope Science Project (RISP).In this accelerator, 81.25 MHz Radio Frequency Quadrupole (RFQ) will be used for the acceleration of various ions from several tens of keV/u to about half MeV/u [1]. For this system two 80 kW RF power sources are planned and RISP will develop them with a solid state power amplifier (SSPA) architecture. As a first step, a 20 kW SSPA was developed and the performance was tested. In this presentation the current status of developed SSPA and the test results will be presented.

INTRODUCTION

A SSPA system is used to supply RF to RFQ cavity in RAON. It consists of PSU, drive unit, final unit (4EA), circulator, combiner, and directional coupler. The power supply unit (PSU) is a device that supplies power to the drive and final amp. The purpose of the drive amplifier is to deliver power to the final amplifiers. Also, in the drive amplifier, the output of the same phase is divided into four and transmitted to each of the final amplifier inputs. The final amplifier is a device that can obtain high power by using LDMOS transistor [2]. And in order to cool the heat generated from the LDMOS transistor, a water cooling system is necessary. Circulator is a protective device for the SSPA by blocking the flow of the reflected RF to the SSPA and dumping it to the water cooled dummy load. The combiner is a device used to synthesize the power of final amplifiers in order to obtain the high power. The dual directional coupler is a device to monitor the forward power and reflected power of the SSPA. Fig. 1 shows the structure of the HPRF system for RFQ cavity in RAON.

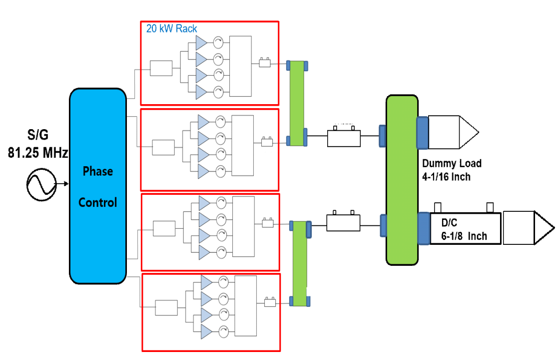

Figure 1: HPRF system for RFQ cavity in RAON.

The HPRF system of RFQ was to generate 20kW power per one rack. Inside the Rack, there are of 4 final amplifiers, and Fig. 2 is the internal structure of the final amplifier.

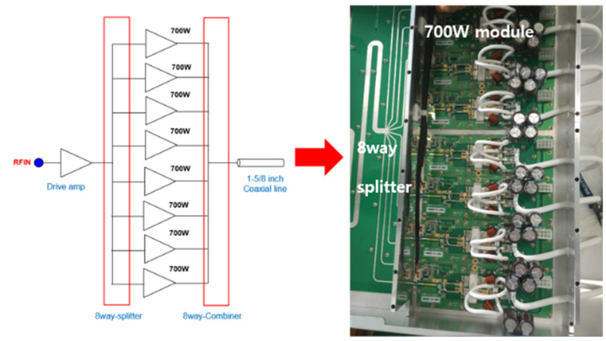

Figure 2: Block diagram of the final amplifier in 20kW rack.

We used 8-way splitter and combiner based on PCB. Internal transistor adopts LDMOS technology, and it has advantages such as the high efficiency, and the operation with mismatched power well. Each final amplifier is equipped with a circulator for protection from reflected power. We also install a high power combiner for synthesizing high power from four final amplifiers.

FULL POWER TEST OF 5 kW UNIT

In the 19-inch rack, a 5 kW final amplifier was mounted with a circulator and a full power test was performed. Fig. 3 shows 5 kW full power test bench.

Figure 3: 5 kW Full power test bench.

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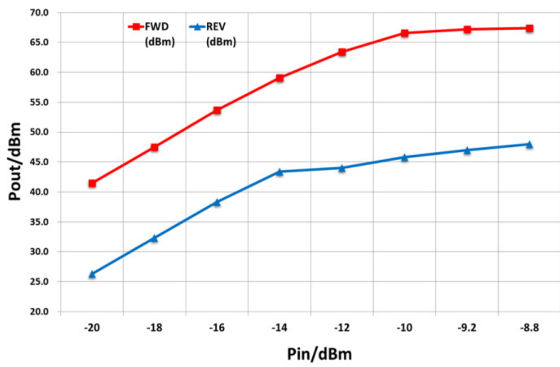

Figure 4: 5 kW full power test (temperature of the coolant in the SSPA unit is 20 ℃).

The temperature of the cooling water entering the SSPA unit and the circulator was set between 16 and 20 °C for the 5 kW full power test. We used a dual directional coupler to monitor power and a commercial dummy load to dump the RF power. As a result of the full power test, the output power of the circulator input power is about 0.2 ~ 0.3 dB, which is the circulator loss [3]. SSPA unit power was measured as 67dBm at 8.8dBm input power as shown in Fig. 4. In a 19-inch rack, four 5 kW units were installed, and the full power test was performed for the remaining units on the same test bench.

ACCEPTANCE TEST OF 5 kW SSPA

In order to check if the SSPA can work under full reflection condition in RF cavity, an acceptance test is required in the HPRF system. In the RAON project, we manufactured a movable short device to change the impedance for the acceptance test. The structure of the movable short device is shown in Fig. 5.

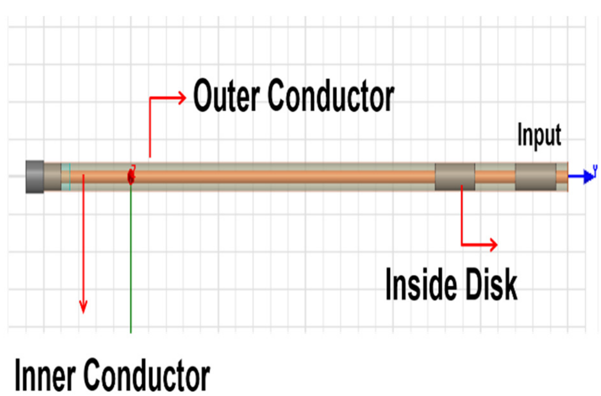

Figure 5: Structure of movable short device.

With the movable short device we can adjust the inner disk to generate open, short and miss matched impedance conditions. Figure 6 shows the impedance on the VNA(vector network analyzer) with adjusting the steering wheel to check if the impedance changes.

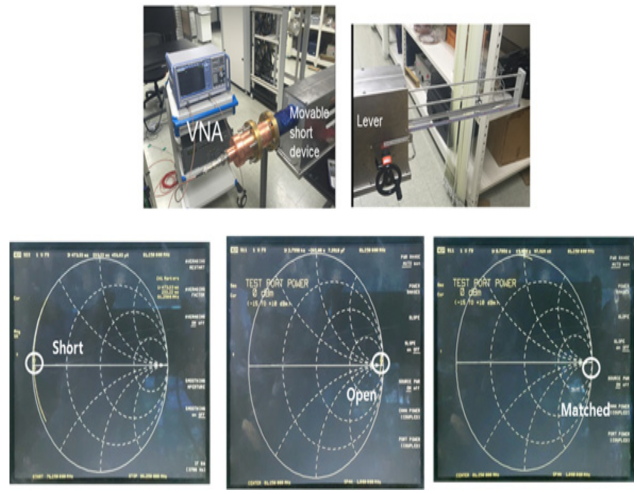

Figure 6: Variable impedance generated by adjusting the movable short device.

After attaching movable short device to circulator output stage, arbitrary impedance, and the acceptance test was carried out with changing the impedance. The Fig. 7 shows the setup of test bench for acceptance test.

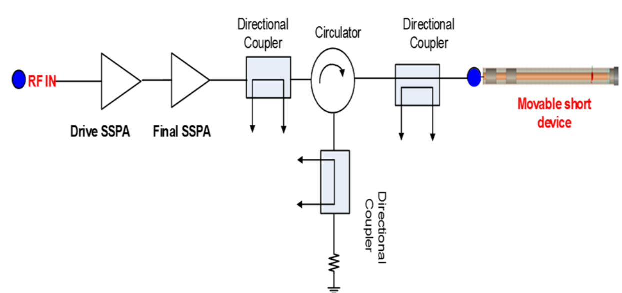

Figure 7 : Figure of the acceptance test bench.

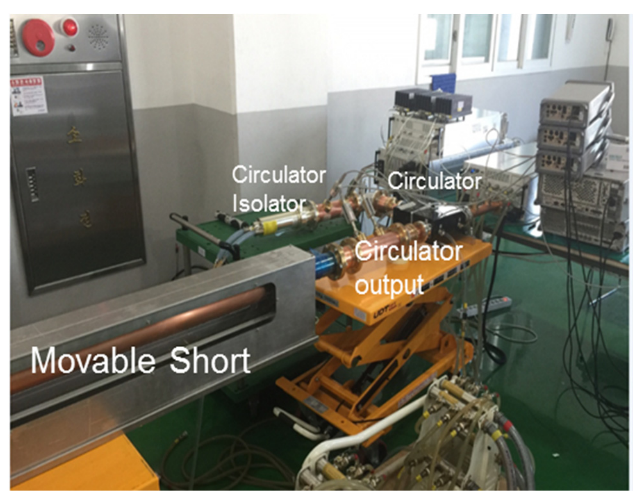

Figure 8: Acceptance test setup.

Figure 8 shows a setup of the acceptance test. Under the open, short, and mismatched impedance conditions with movable short device, we performed a full power test. The following Table 1 summarize the results of acceptance test under various impedance conditions.

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Table 1: Acceptance Test with Various Impedance

Impedance	**Circulator out** (dBm)	**Circulator isolator**(dBm)
Load(50Ω)	67.26 dBm	48.20 dBm
Open(∞)	67.87 dBm	65.37 dBm
Short(0Ω)	65.16 dBm	66.28 dBm
Mismatched	65.08 dBm	65.71 dBm

We performed a full power test with four different impedance conditions. Full power was totally reflected with some impedance conditions, and the reflected power was dumped to the circulator dummy load. It was confirmed by the power from directional coupler. Six hours long term full power acceptance test was performed. We confirmed that it totally dumps the total reflected power towards the circulator isolator in the circulator.

20 kW FULL POWER TEST

In order to synthesize RFQ (81.25 MHz) 20 kW power, four*5 kW final amplifiers are required. In order to protect reflected power, we installed a circulator between 20 kW combiner and 5 kW final amplifier [4]. 20 kW combiner output port is 3 1/8 inch coaxial line which can withstand 20 kW or more at 81.25 MHz. A dual directional coupler was attached to the combiner output stage. The forward and reverse power of 20 kW high power amplifier output could be monitored. We designed and installed manifold system to supply cooling water to HPRF system. Figure 9 shows a test bench for the 20 kW full power test.

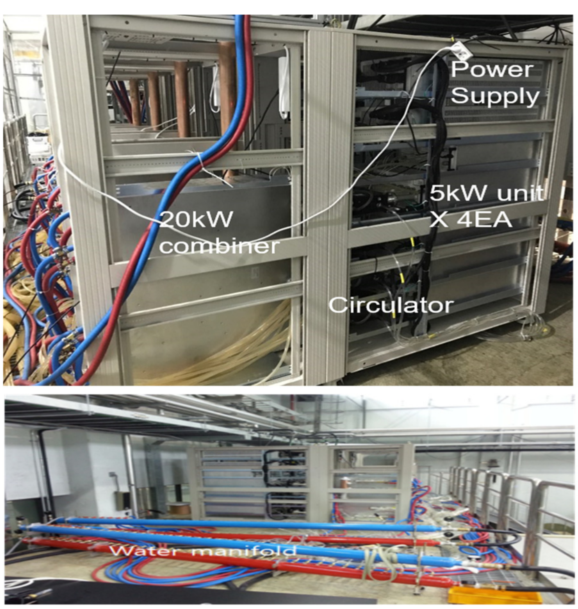

Figure 9: 20 kW full power test bench and manifold system.

1ea Drive unit, 4ea 5 kW unit and power supply for 20 kW power synthesis are installed in a 19-inch rack A cooling water line was connected and the temperature was set between 16 and 20 ° C. Figure 10 shows the measured RF power during 20 kW full power test.

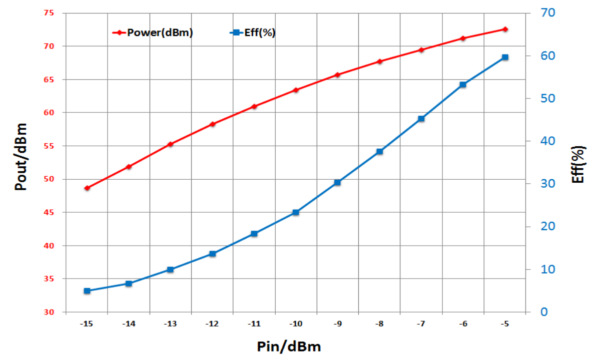

Figure 10: 20 kW full power test result.

When the input level was -5 dBm, the output power was of 73 dBm and, the efficiency was about 59%.

CONCLUSION

A 20kW SSPA system for RAON RFQ was developed and tested. It consists of 4*5kW amplifiers, drive unit, DC power supply unit, and combiner. Every 5kW final amplifier was tested with full power. Also a movable short device was used to check the amplifiers with various operation condition such as full reflection. Finally, 20 kW full power test was performed by using Gysel combiner. As a next step, development of 80kW system by combining the 4*20kW amplifiers is planned.

ACKNOWLEDGEMENT

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