HPRF System for Injector Section of RAON SCL3

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1. Introduction

The development of facilities for the rare isotope accelerator complex for on-line experiments (RAON) has been done, focusing on the construction of a heavy-ion accelerator facility to support a variety of scientific programs [1-3]. Beam commissioning of the low-energy superconducting linear accelerator (SCL3), which includes an injector section, quarter-wave resonators, and half-wave resonators, has been conducted and beam is also being provided to selected users.

In the injector section, a 160-kW solid-state power amplifier (SSPA) for a radio-frequency quadrupole (RFQ) cavity and four SSPAs for rebunchers of a medium energy beam transport (MEBT), which are normal conducting cavities, have been operated during beam commissioning of the SCL3. This paper presents the high-power RF (HPRF) SSPA system for the injector of the SCL3.

2. HPRF SSPA for Injector

Figure 1 shows the injector section for RAON low-energy superconducting linac (SCL3). The injector consists of two ECRIS (Electron cyclotron resonance ion source), a LEBT (Low-energy beam transport), an RFQ, and four rebunchers for an MEBT, employing normal conducting cavities. The block diagram of RF system for the injector is shown in Fig. 2. SSPA was chosen as high-power amplifiers, and RF power rating is 160 kW for the RFQ and 20 kW, 4kW, 4 kW, and 15 kW, respectively, for the four rebunchers, operating at a frequency of 81.25 MHz [4, 5].

Figure 3 shows the configuration of the 160-kW SSPA. It is equipped with two 80-kW solid-state amplifiers, with their outputs connected to the power input couplers of the RFQ. Each 80-kW solid-state amplifier is constructed from four 20-kW amplifiers, where RF power is combined using hybrid combiners. A single 20-kW amplifier comprises four 5-kW power amplifier units, four 5-kW circulators, a 4-way combiner, and a power distribution unit. Each 5-kW power amplifier unit incorporates eight LDMOS FETs (MRFE6VP61K25H) of 850 W. The solid-state amplifier unit is assembled with a basic combination of a power amplifier unit and a circulator of 5 kW. The configuration of high-power RF system for the four rebunchers is similar that of the RFQ.

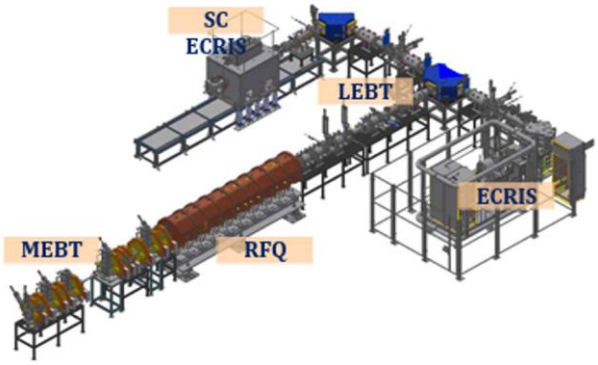

Fig. 1. Injector section for the low-energy superconducting linac (SCL3)

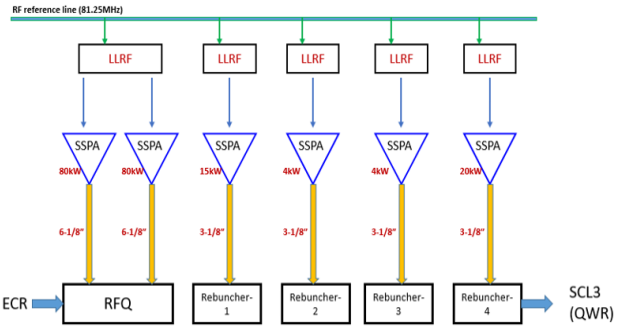

Fig. 2. Block diagram of RF system for the injector section

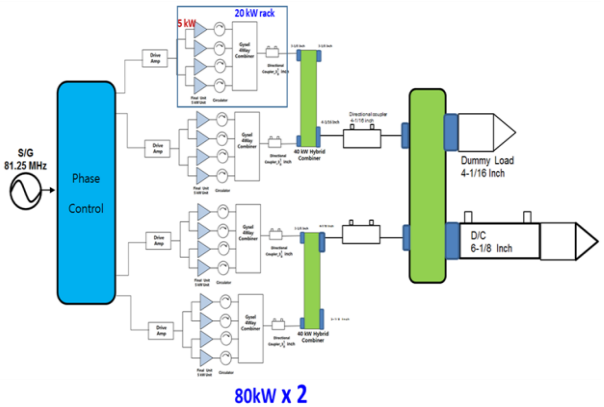

Fig. 3. Configuration of 160-kW SSPA for RFQ

The HPRF system was installed in the injector gallery, as shown in Fig. 4. 6-1/8" rigid coaxial lines were employed to deliver RF power into the RFQ, while 3-1/8" lines were used for the rebunchers. An operator interface (OPI) based on the EPICS control has been

implemented for monitoring and control of the high-power SSPA [6], as shown in Fig. 5.

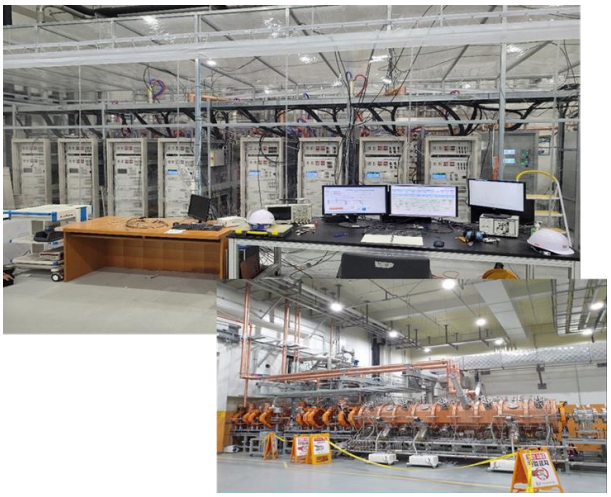

Fig. 4. HPRF SSPA system for the RFQ

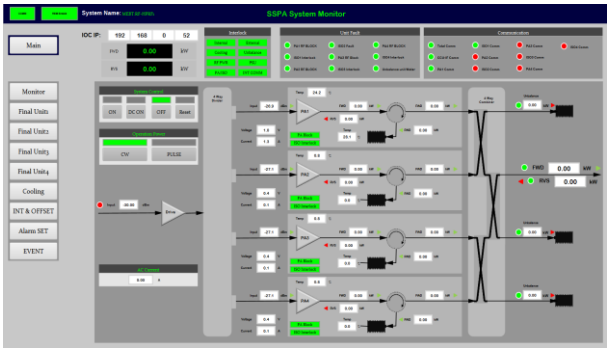

Fig. 5 phase stability on the RF reference line (< ±*0.1* °)

3. Summary

Beam commissioning of the RAON low-energy superconducting linear accelerator (SCL3) has been performed. In the injector section, a 160-kW solid-state power amplifier dedicated to the RFQ and four additional power amplifies designed for the MEBT rebunchers, which utilize normal conducting cavities, have been installed and put into operation. These amplifiers played a crucial role during the beam commissioning of both the injector and the subsequent low-energy superconducting linac (SCL3). The SSPA for the RFQ has been in production for over a decade and has experienced various issues during operation. A new, performance-improved SSPA of 160 kW is being developed to ensure stable beam operation of the SCL3.

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