DEVELOPMENT OF RAON QWR CRYOMODULE FOR LINAC DEMONSTRATION*

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Abstract

Quarter-wave resonator (QWR) cryomodule is developed for linac demonstraction. The plan and layout of the linac demonstration are shown. 3D drawing and P&ID are shown for the quarter-wave resonator (QWR) cryomodule. The QWR cryomodule consists of cavity, coupler, tuner, liquid helium reservoir, thermal shield and magnetic shield. PLC rack is fabricated to control the QWR cryomodules. The PLC controls and monitors pumps, heaters, cryogenic valves, solenoid valves, gate valves and temperature sensors.

INTRODUCTION

Superfluid helium fog was studied below the critical temperature of superfluid, 2.172 K [1-3]. Thermal radiation from n-dimension [4] and the size effect of the thermal radiation [5, 6] were investigated. RAON superconducting radio frequency (SRF) test facility was designed [7]. The RAON SRF test facility consists of cryogenic system, cleanroom, cavity test and cryomodule test. The cleanroom is used for cavity processes and assembles. Residual resistivity ratio (RRR) test of niobium was performed and the conditions of e-beam welding (EBW) were studied [8]. A half-wave resonator type 1 (HWR1) cryomodule was test in low temperature [9].

In this research, we develop QWR cryomodule for linac demonstration. Layout of linac demonstration is presented. In order to control the cryomodules, PLC rack is fabricated and PLC program is developed.

LINAC DEMONSTRATION

Superconducting linac (SCL) demonstration consists of ECRIS, LEBT, RFQ, MEBT, QWR cryomodule, warm section, RF system and cryogenic system. Figure 1 shows the layout of the linac demonstration. The linac demonstration is located in RAON SRF test facility. The SRF test facility includes cleanroom, cryogenic system, vertical test bench, horizontal test bench, etc. Oxygen beam having A/q~3 is used initially and then metal ion such as Bismuth having A/q~7.2 will be used in future. ECRIS beam energy is 10 keV/u, RFQ beam energy is 500 keV/u, and QWR beam energy is 530 keV/u.

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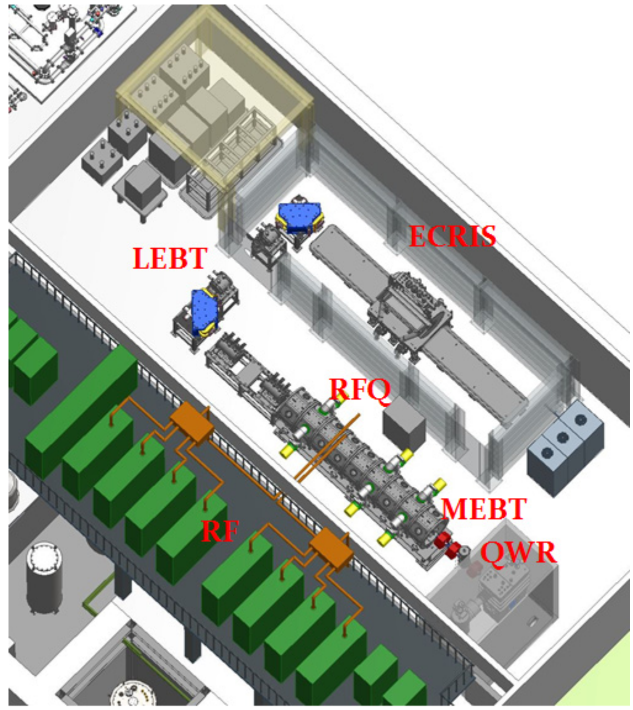

Figure 1: Layout of linac demonstration.

QWR CRYOMODULE

Prototype of QWR cryomdoule was fabricated and the QWR cryomodule is modified for linac demonstration. Figure 2 shows the 3D drawing of the QWR cryomodules. The QWR cryomodule consists of cavity, coupler, tuner, liquid helium reservoir, thermal shield, magnetic shield, etc. The cavity is made of Nb and is operated at the temperature of 4.3 K and the frequency of 81.25 MHz. The Residual resistivity ratio (RRR) value of Nb shows the purity of niobium, which is related to heat transfer during welding process. The RRR degrades during electron beam welding process due to impurity incorporation. Thus, e-beam welding is very important process to fabricate the Nb cavity. In order to improve the quality (Q) factor of Nb cavity, the conditions of e-beam welding which include vacuum level, welding speed, and power were studied [10] and were applied to the cavity fabrication.

SRF test facility has cryoplant, cleanroom, vertical test bench and horizontal test bench. Cleanroom has high pressure rinsing, buffered chemical polishing, ultrasonic cleaning, high vacuum furnace and cavity assemble place. The classes of the cleanroom are 10, 100, 1000, and 10000. The class of cavity assemble place is 10 in which cavity is assembled for QWR cryomodule. Deionized water is produced at the facility and the resistivity of the deionized water is currently about 16 M·ohm·cm which is used for cleaning purpose. The power of the cryoplant is 330 W (4.5 K equivalent), which supplies liquid helium to linac demonstration.

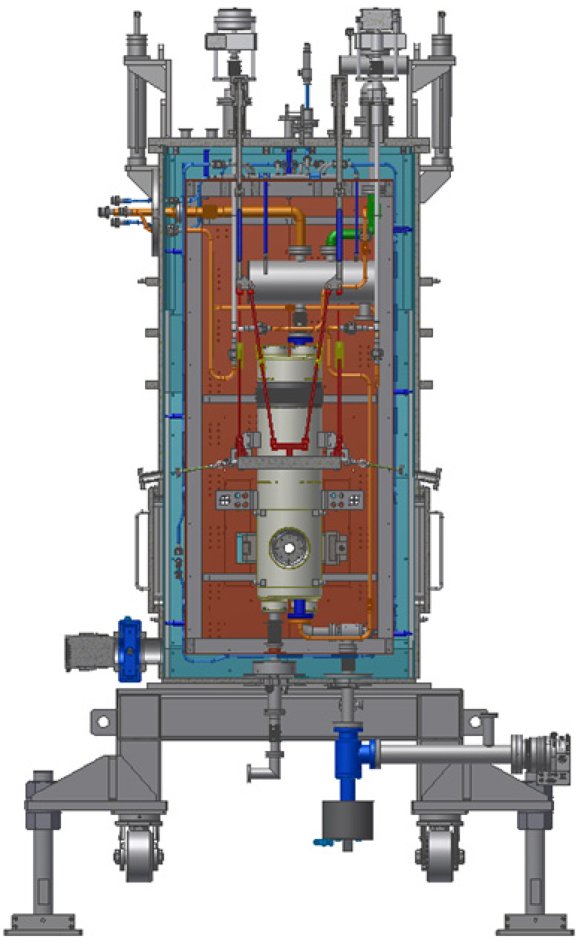

Figure 2: 3D drawing of QWR cryomodule.

Figure 3 shows the P&ID of the QWR cryomodule. Liquid nitrogen is supplied to the thermal shield and liquid helium of 4.5 K is supplied to the helium reservoir whose level is monitored using a helium level meter. Temperatures are monitored in many places as shown in Fig. 3. Cavity and vessel are pumped using dry pump and turbo molecular pump (TMP).

Programmable logic controller (PLC) rack consists of 15 inch touch panel, heater controller, vacuum monitor, dosing control unit (DCU) for TMP, IOC IPC, switching hub, liquid helium level monitor, temperature monitors, etc. The PLC rack of the QWR cryomodule is shown in Fig. 4. IOC IPC is used for EPICS and archiving.

CompactLogix PLC and Studio 5000 software of Rockwell Automation is used for the PLC of the QWR cryomodule. AllenBradley PLC controls pumps, heaters and valves. The valves include gate valves, cryogenic valves, and solenoid valves. Pumps consist of dry pump and TMP for vessel and cavity, respectively. The PLC

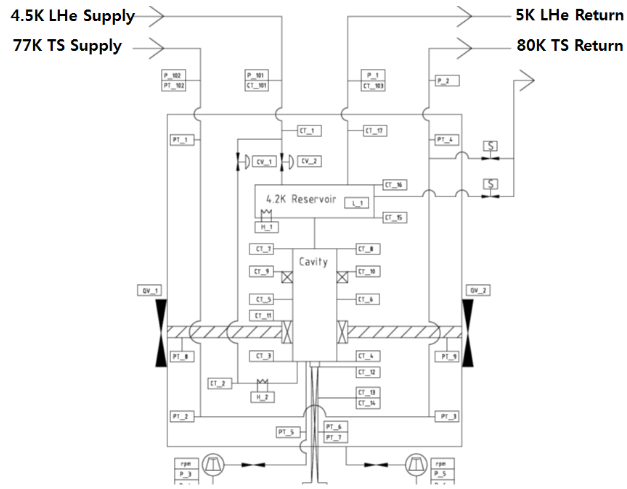

Figure 3: P&ID of QWR cryomodule.

Figure 4: PLC rack of QWR cryomodule.

communicates with temperature monitors through ethernet.

The total number of tag name is about 300 for the cryomodules. The drive frequency for the QWR cryomodule is 81.25 MHz and the cavity is operated at 4.3 K. Temperature, pressure and liquid helium level can be monitored. Monitored pressures are thermal shield and liquid helium reservoir pressure. Monitored vacuum pressures are cavity and vessel vacuum level. Cryogenic valves, pumps and heater powers can be controlled.

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Heaters having 50 ohm are installed below the bottom of the helium reservoir and cavity. A proportional-integral-derivative controller (PID controller) is used to control the liquid helium level at a constant height by controlling a cryogenic valve. PID auto tuning is useful to get the reasonable values of the coefficients for the proportional, integral, and derivative terms, respectively.

EPICS is also developed by mapping PLC tag name to process variable (PV) name. The control screen of EPICS is almost the same as that of PLC. EPICS for the cryomodule consists of control, monitor, parameter set-up, alarm and data browser screen.

SUMMARY

We have developed the quarter-wave resonator (QWR) cryodmoule for linac demonstration. Superconducting linac (SCL) demonstration consists of ECRIS, LEBT, RFQ, MEBT, QWR cryomodule, warm section, RF system and cryogenic system. The QWR cryomodule was modified from the prototype of QWR cryomodule. 3D drawing and P&ID were shown for the QWR cryomodule. The PLC rack for the cryomodule was fabricated and the PLC controls the pumps, heaters, cryogenic valves, solenoid valves, and gate valves and monitors the vacuum pressure and temperatures of the cryodmoule. The QWR cryomodule will be operated with the PLC at RAON SRF test facility.

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