Test Results of the RF Reference System for the RAON SCL3

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1. Introduction

The heavy-ion accelerator of the Rare Isotope Science Project (RISP) in Korea has been developed [1-2]. The RF reference distribution system must deliver a phase reference signals to all low-level RF (LLRF) systems and BPM systems with low phase noise and low phase drift. The frequencies of RISP linac are 81.25MHz, 162.5MHz and 325MHz, and there are 130 LLRF systems and 60 BPMs for the superconducting linac#3 (SCL3), and 210 LLRF systems and 60 BPMs for the superconducting linac#2 (SCL2). 81.25 MHz signal is chosen as a reference frequency, and 1-5/8" rigid coaxial line is installed with temperature control of heating tape. The RF system for SCL3 was constructed and has been commissioned. This paper describes the test results of the RF reference distribution system for the SCL3.

2. RF reference distribution

2.1 Design and Installation

As coaxial-cable-based distribution and optical-fiber-based distribution are the two most commonly used solutions for RF reference distribution in Linac [3-5]. For a linac with multiple RF systems, a bus-like topology is preferred with a main cable line running the RF power and many tap points along the line delivering required signals to each of LLRF systems [6-7]. The bus-like topology distribution has the advantage of less volume, less power attenuation and easier to implement compared to star topology.

The requirements of the RF phase stability is ±1° in RF control system, and phase stability in RF reference should be within ±0.3° commonly to satisfy the requirements. The frequencies of RISP linac are 81.25MHz, 162.5MHz and 325MHz. 81.25 MHz signal is chosen as the reference frequency, and 1-5/8" rigid coaxial line is installed with temperature control.

Fig.1 shows the schematic layout of the RF reference line for RISP Linac. To minimize the temperature related phase change, the reference clock is fed from the center of the SCL2 tunnel into three RF distribution lines through a 4-way splitter, which are Ref.line#1, Ref.line#2 and Ref.line#3. The construction of SCL1 (Ref.line#4) was pended. Exception for extension in the SCL2, each RF reference line is about 120m. In addition, low loss, temperature-controlled 1-5/8" rigid coaxial line is selected for the RF reference lines. Phase change due to temperature change was calculated for each of the cavity along the linac, as shown in Fig.2. Foam polyethylene instead of Teflon is used as the insulating material in the cable to avoid the so-called teflon "knee" induced phase instability problem [8].

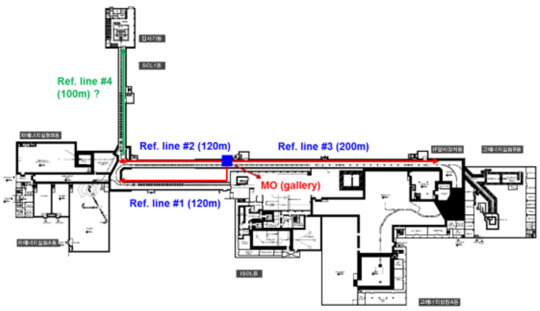

Fig. 1. Schematic layout of the RF reference lines and the reference-feed in the linac tunnel

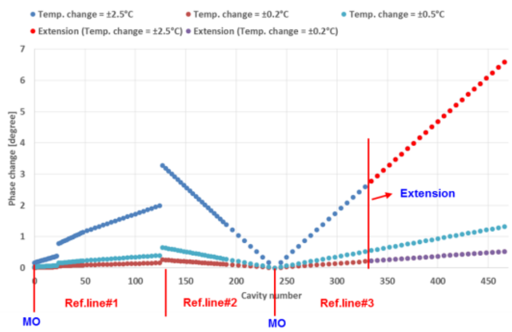

Fig. 2. Phase change ("degree" corresponds to the cavity RF frequency) due to temperature change for each of the cavity along the linac.

The RF reference rigid line for the SCL3 was installed in the tunnel and the master oscillator was installed in the gallery, as shown in Fig. 3.

Fig. 3. RF reference line and Master oscillator for the SCL3

2.2 Test Results for SCL3

Stability of temperature and phase on the RF reference rigid line was measured as shown in Fig.4 and Fig5. Temperature control results were within 40±0.1 ℃, and phase stability was within ±0.1°.

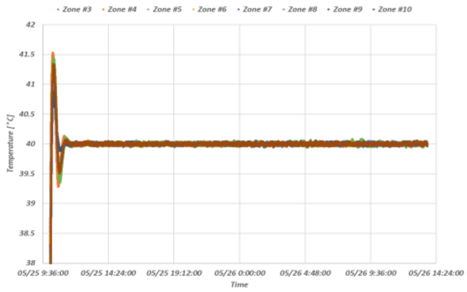

Fig. 4. Temperature control results on the RF reference line (Test results: < *40±0.1 ℃)*

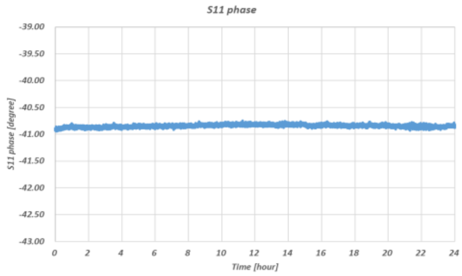

Fig. 5 phase stability on the RF reference line (< ±*0.1 °)*

Phase noise and power level of the master oscillator were measured as shown in Fig.6 and Fig.7. RMS jitter and phase error can be calculated through the measured phase noise. The RMS jitter of the LNA output was about 588 fs, and phase error was 0.0172°. All components of the master oscillator are installed in a constant temperature and humidity rack. Fig.8 shows the power level on each tap of the RF reference line, which is for LLRFs and BPMs.

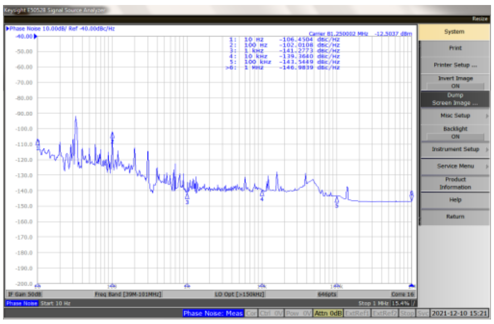

Fig. 6. Measured phase noise of the 81.25 MHz reference (Calculated jitter: 588fs, Calculated phase error: 0.0172°)

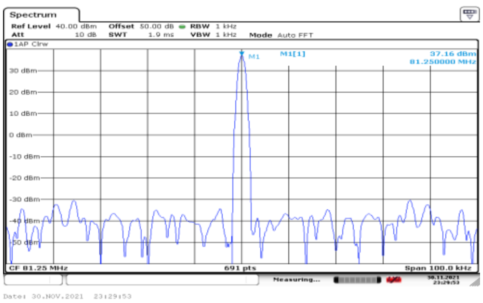

Fig. 7. Power level of the master oscillator

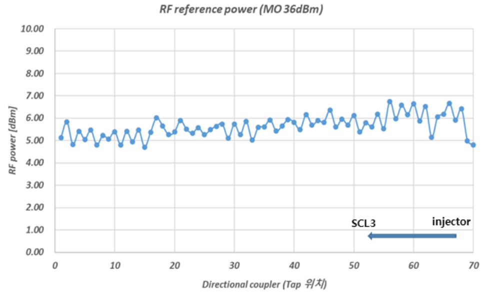

Fig. 8. Power level for LLRFs and BPMs on each tap of the RF reference line

3. Conclusions

The RF reference distribution system for RISP Linac has been developed. The RF reference line and the master oscillator for the SCL3 was constructed and has been commissioned. The RF reference line was 1-5/8" rigid coaxial line with heating tape for temperature control. The temperature control and phase stability on the RF reference line was tested. Temperature control results were within 40±0.1 ℃, and phase stability was within ±0.1°. Phase noise and power levels of the master oscillator were measured. Through the measurements, the RMS jitter was about 588 fs and phase error was 0.0172°. The test results satisfy the requirements.

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