HIGH POWER TEST OF THE RF SYSTEM FOR THE KOMAC MEBT*

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Abstract

A 100 MeV proton linac of the Korea multi-purpose accelerator complex (KOMAC) has been operated for providing a proton beam to users. RF systems of two medium energy beam transports (MEBT) have been designed to improve a beam quality. An operating frequency of the MEBT RF system is 350 MHz, and the required RF power is 44 kW for MEBT-1 and 18 kW for MEBT-2. The RF duty is 9% (1.5 ms, 60 Hz). The RF system includes a low-level RF (LLRF) control system, a solid state RF amplifier (SSPA) as a 60 kW SSPA for MEBT-1 and a 30 kW SSPA for MEBT-2, a coaxial circulator, and 3-1/8" coaxial line components. A RF power test to the MEBT has been performed with 4 kW SSPA before the full power operation. The configuration and high power test results of the MEBT RF system are presented in this paper.

INTRODUCTION

In the 100 MeV proton linear accelerator (Linac) for KOMAC, the RF source will power two-accelerator cavities (an RFQ, a DTL1) operated at a frequency of 350 MHz [1]. The low level RF (LLRF) system for 100 MeV proton linear accelerator provides field control including an RFQ and a DTL at 350 MHz. In our system, an accelerating electric field stability of ± 1% in amplitude and ± 1º in phase is required for the RF system [2, 3]. Now a total of 9 RF systems are being operated. To improve the beam quality, the additional RF system for MEBT (Medium Energy Beam Transport) is needed. An addition of a MEBT RF system will reduce loss of beam quantity caused by gab between 20 MeV DTL tank and 100 MeV DTL tank. To this end, we have developed MEBT RF system.

MEBT RF SYSTEM DESIGN

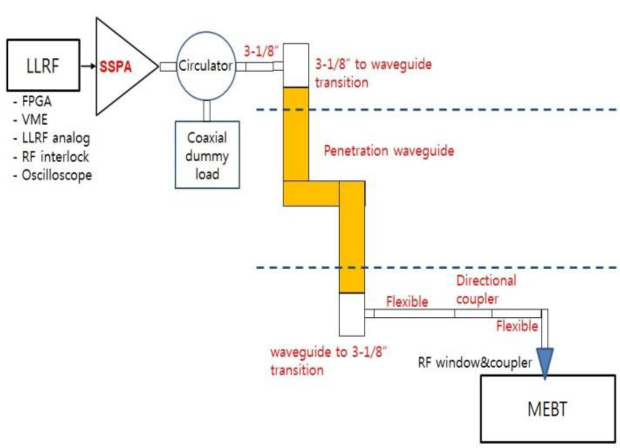

Figure 1: MEBT RF system.

MEBT RF system consists of FPGA controlling RF power amplitude and phase, 60 kW SSPA for MEBT-1, a 30 kW SSPA for MEBT-2 and low-level RF (LLRF) analog chassis performing a clock and RF distribution, an up/down conversion, RF signal processing, and an interlock for the high power RF system protection.

Figure 1 shows the overall system of RF system for MEBT. FPGA, VME, LLRF analog box, RF interlock box, oscilloscope, SSA are included in high frequency control rack for MEBT. High power RF from high frequency control rack goes into MEBT, running through the cable and waveguide. Three main parts of high frequency control rack are FPGA controlling the size and the phase of the high frequency signal, the SSA amplifying signal and sending into the tank, and LLRF analog box, which plays the role of a bridge between FPGA and SSA. FPGA operates at 50 MHz, but the high frequency running into the tank is 350 MHz. The LLRF analog box converts the frequency by the 300 MHz of reference signal and providing the tank with appropriate power.

HIGH POWER RF COMPONENTS DESCRIPTIONS

Figure 2: High power RF components (SSPA, Circulator, Dummy load).

SSPA

SSPAs for MEBT-1 and MEBT-2 were manufactured by Tomco. Each SSPA could deliver RF power up to 30 kW and 60 kW into the load. Max duty is 9 % (1.5 ms, 60 Hz)

Circulator

A 350 MHz Y-junction type circulator, which can deliver 60 kW peak and 6 kW average RF power for forward and reverse direction at any phase, is used to protect the SSPA against the reflected RF power from the cavity. The circulator has been manufactured by Advanced Ferrite Technology (AFT).

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Dummy Load

A 20 kW (CW) at 350 MHz RF dummy load was used. It uses water as a coolant. In the MEBT RF system, the RF dummy load is used as a dummy load not only for SSPA full power test but also for absorbing reflected RF power from MEBT tank through circulator.

RF SYSTEM INSTALLATION AND RF POWER TEST

RF control racks, helix cables and circulator were installed in the klystron gallery. Each RF control rack for MEBT includes FPGA, VME, LLRF analog box, RF interlock box, Oscilloscope and SSPA. After installation is complete, Transmission losses between tunnel and gallery were measured by Sending a signal generator signal from the tunnel to the gallery. Attenuation of the signals passing through helix cables and waveguides were about 2.0 ~ 2.2dB.

Before proceeding with the high power test, conditioning MEBT cavity was conducted using 4 kW SSPA. The operating status was checked for one week on condition of both 1 ms, 10 Hz, output of 4.5 kW. After conditioning, MEBT cavity reverse and pick-up power ripple disappeared. Figure 3 shows conditioning result.

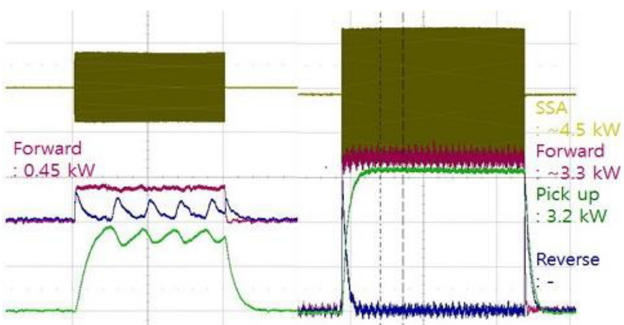

Figure 3: Before and after MEBT cavity conditioning.

Next, 30 kW SSA for the MEBT RF system were tested. First, the output was measured by powermeter as the input in the SSA increased slightly. In this test, the maximum output was 30 kW as seen in the Figure 6. Then the operating status was checked for an hour on condition of both 1.5 ms, 50 Hz, output of 30 kW. The test results are Figure 6.

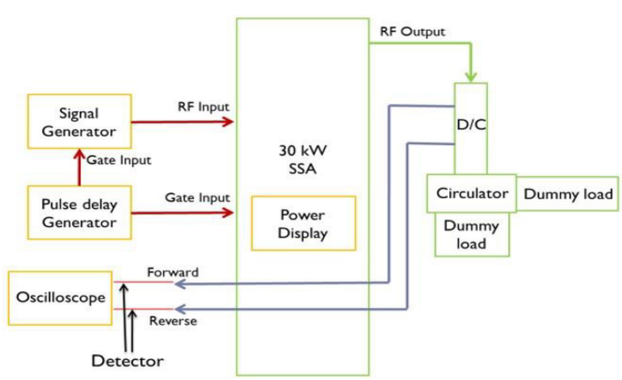

Figure 4: 30 kW SSA test configuration.

Figure 5: 30 kW SSA test environment.

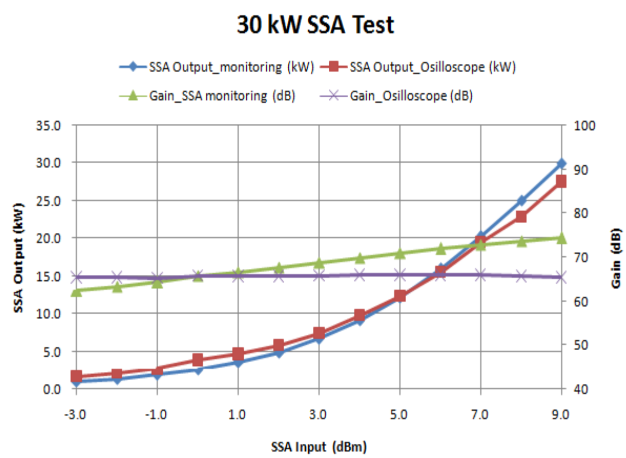

Figure 6: 30 kW solid state amplifier test.

CONCLUSIONS

MEBT RF system including LLRF system, High power RF components (SSPA, Circulator, Dummy load) and the transmission lines from the RF control rack to the MEBT tank were installed. LLRF system and SSPA have been tested. The condition of the test is 350 MHz, 9 % pulse duty (1.5 ms, 60 Hz), 30 kW (peak power). A coupler for MEBT is still in production. After installing the coupler, conditioning and high power test will be performed. Perfecting an RF system of MEBT will reduce loss of beam quantity caused by gab between 20 MeV DTL tank and 100 MeV DTL tank.

ACKNOWLEDGEMENT

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