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RF system of SPring-8 Linac

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Abstract

The construction of the SPring-8 linac (2856 MHz, 60 pps) was started in 1991 March. In 1993, we modified the design of Linac RF system. We choose new 80 MW klystrons, instead of 35 MW klystrons. With this situation, RF power from one klystron is led to two accelerating structures, instead of one accelerating structure. This linac is composed of 13 high power klystrons and 2 medium power klystrons with 26 accelerating structures.

I. INTRODUCTION

The 2856 MHz RF system of SPring-8 linac is shown in Fig. 1. This system is composed of three systems. One is the injector (buncher and pre-bunchers) line and the driver system of main klystrons by the booster klystron. The injector line is already completed and tested in Tokai establishment of JAERI [1]. This system ware transferred from Tokai to Harima in summer 1995. Next is the phase measurement system with the reference line. Last is the high power RF system with wave guide circuit. There are required the phase stability of 2 degrees on the beam line.

II. BOOSTER KLYSTRON AND DRIVE LINE

The 2856 MHz low-level CW output of a highly stable master oscillator is divided into two signal lines. One is provided for the booster klystron through a pulse modulator and a 300 W TWT amplifier. The other provides for the reference line through the 1 W CW amplifier to the phase measurement system.

The output of the booster klystron is fed into the injector line (two prebuncher and buncher). Drive line is divided by a 6-dB directional coupler from injector line. The injector line is filled with 2 kg/cm^2 SF6 gas. In the drive line, about an 1 MW RF power that controlled by DRϕA with SF6 gas is provided in plesured dry air at 2 kg/cm^2. Each fo these klystrons are driven by RF (about 1 kW), branched by directional coupler, from the drive line with IϕA (Isolator, Phase shifter, Attenuator).

III. PHASE MEASUREMENT SYSTEM

For high stability beam control, the RF system needs phase measurement and feedback system. The drive line consists of an 120 m length copper wave guide. The phase of the drive line for last klystron drifts by 11.2 degree/°C. For correction of the phase drift, ϕCMP detects a phase drift by comparing with the standard phase of the reference line.

The reference line is the phase stabilized coaxial cable (Mitsubishi Cable). Electrical length of this cable is stabilized at 2 PPM/°C (0.5 degree/°C at 140 m). The standard phase of the reference line is picked up from the long pulse beam (or the monitor directional coupler of the buncher). The beam phase after H0 accelerating structure is detected by a waveguide type pickup cavity (only long pulse mode). It is the duplicated reference line through phase shifter after the CW amplifier. The phase drift that is detected by ϕCMP is corrected by VME controlled IϕA before each klystron. This system will be available within 2 degree phase drift.

The ϕCMP is composed by phase discriminator (Anaren 2A0756) and phase shifter. The phase discriminators compares with the output of the forward acceleration structure of main klystron and the standard phase of the refarence line. After beam tuning (beam is on the best phase), phase shifter adjust to zero-cross point for avoiding the effect of RF power strength. When the input RF phase of acceleration structure is drift, the phase discriminator detect the phase shift. Output of the phase discriminator after sample hold is fed the VME analogue modules. The VME control the IϕA of the klystron input of the drive line.

When the linac was driven in the long pulse (1 μs beam width) mode, the beam phase with the pickup cavity can duplicate to the refarence line using the phase shifter after the CW AMP in Fig.1. On the shortpulse or single pulse mode, we will use the

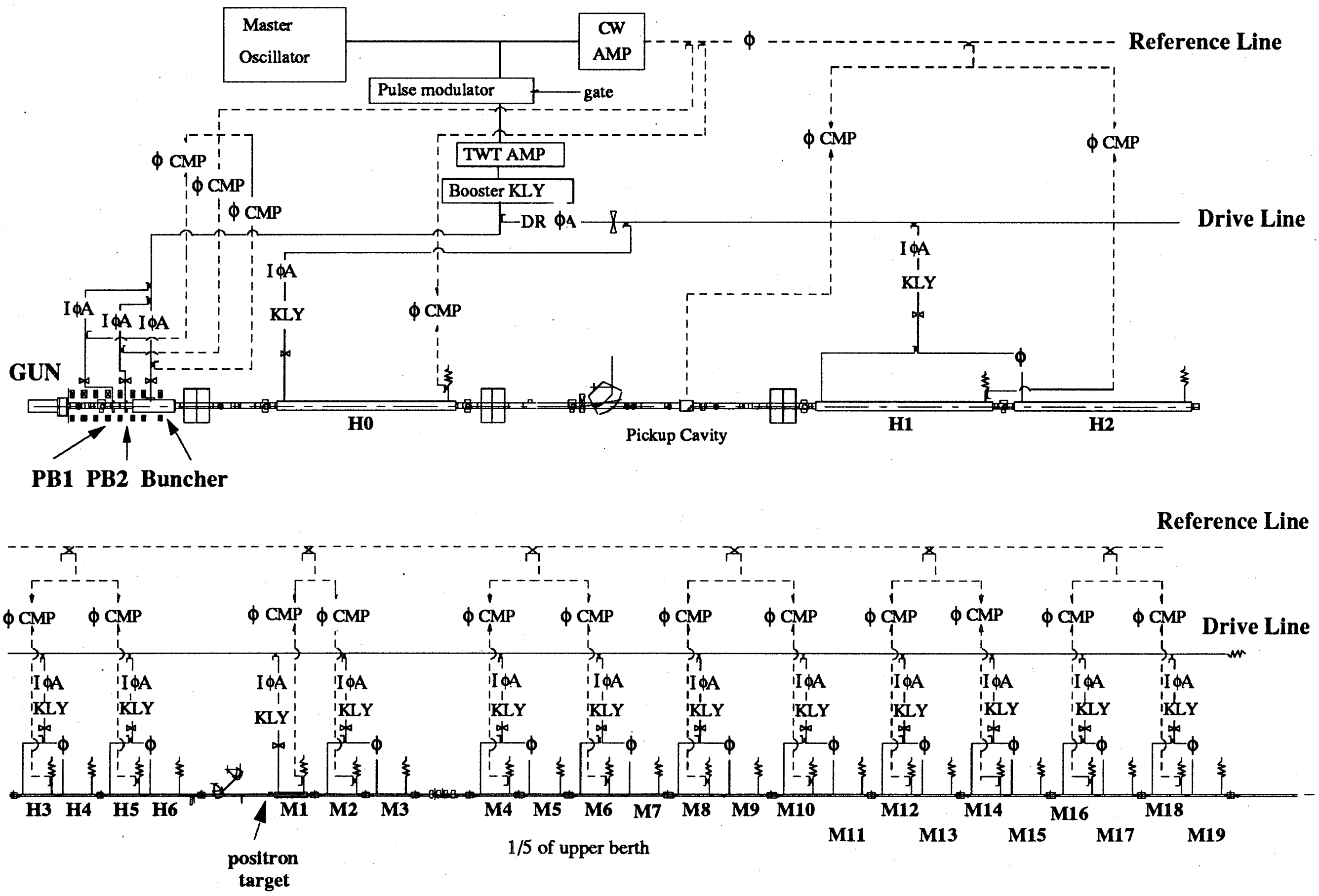

Fig. 1. **RF system of SPring-8 Linac**

Solid line is high power line. Dashed line is monitor line.
H0~M19 : number of accelerating structure, KLY : klystron, ⋈ : RF window
ϕ : phase shifter, DRϕA : phase shifter and Attenuator for drive line
IϕA : isolator, phase shifter and Attenuator, ϕCMP : phase drift detector

buncher input phase instead of the pickup cavity.

IV. HIGH POWER RF SYSTEM

The first accelerating structure (H0 accelerating structure in Fig. 1) is powered by one 80 MW klystron (Toshiba E3712). After the second accelerating structure, the RF power from one 80 MW klystron is divided by a 3 dB directional coupler, and fed to two accelerating structures exclude the e^+/e^- converter section. It is important to control optimized phase and power for the positron converter section [2]. The accelerator structure of the converter section (M1 section in Fig. 1) is driven by the 35 MW klystron (MELCO PV3035) as 1:1 drive.

For a 1.15 GeV electron beam, the RF power of 26 MW is fed into all accelerating structures that produce an electric field gradient of about 16 MeV/m. As we have some margin when one or two klystrons faults, we should keep the linac energy for injection by the rest klystron.

Each klystron is driven by traditional a 190 MW pulse modulator [3] with a flat top of 2 μs within the voltage fluctuation of ±0.5 % at 60 pps. This modulator output will be lead to main klystron with the 1:16 pulse transformer. The voltage stability of PFN charging is achieved of ±0.5 % using the De-Q'ing method.

Wave guide circuits is composed of RF windows, 3 dB directional couplers, vacuum pumps and phase shifters. As the wave guide is fevered by about 50 °C increment at 80 MW without cooling, it is cooled by water of the ordinary water cooling system. En one side route to behind the 3 dB directional coupler, a high power phase shifter is prepared. By this, each phase of accelerating structure can be controlled.

Recently, the high power test of the wave guide circuit was carried out by Toshiba Co'. The result and the photograph are shown in Fig 2 and Fig 3 [4]. A large RF power up to 80 MW-4 μs-60 pps shall pass through the wave guide system. Critical components

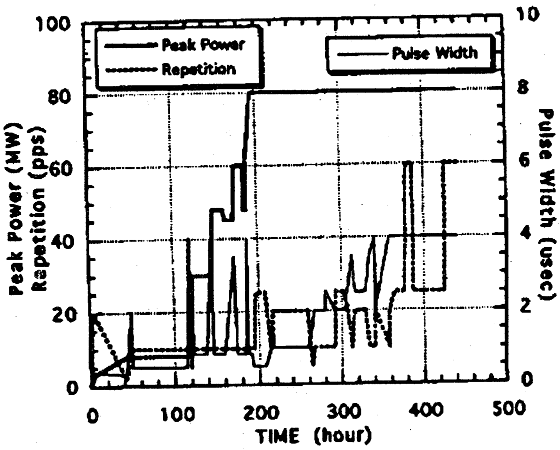

Fig. 2. **Result of high power test**

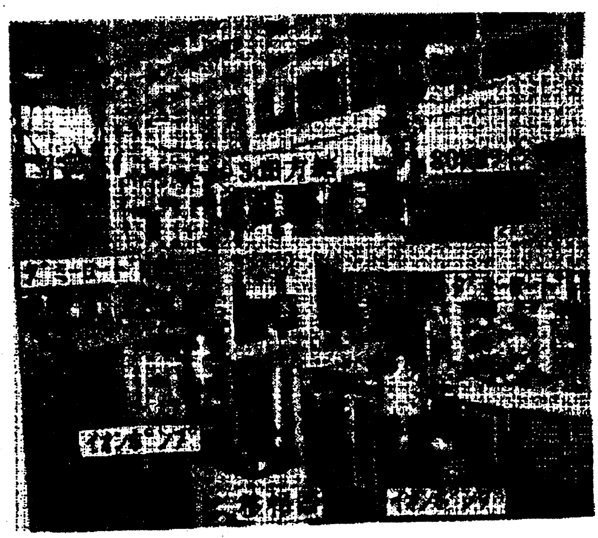

Fig. 3. **Photo of high power test**

such as ceramic-RF-window and a phase shifter are adopted in this high power system. After 420 hours aging process a stable operation with the maximum RF power was realized. Especially, the high power phase shifter was operated in the full RF power without breakdown.

V. CONCLUSION

The installation of the linac is started in May, 1995 in Harima. RF system will be started to install in October, 1995. The aging of the waveguide circuits will be started in April, 1996. And the first beam commissioninng of this linac will start at the first of August 1996.

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