# RF System of the SPring-8 Linac

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## 1. Introduction

The SPring-8 Linac is driven with a 2856 MHz RF. In 1993, we modified the design of the Linac RF system. We choose new 80 MW klystrons, instead of 35 MW klystrons. Then the 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.

## 2. Overview of RF System

The 2856 MHz RF system is shown in Fig. 1. This system is composed of three systems, two driver systems of a booster klystron and main klystrons and the phase measurement system with the reference line and the high power RF system.

## 3. 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 PIN-diode pulse modulator and a 300W TWT amplifier. The other provides for the reference line through a few-watts 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 dry air atmosphere. 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).

## 4. 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/℃. 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/℃ (0.5 degree/℃ 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.

## 5. High Power RF System

The first accelerating structure 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. 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. The performance of the high-power klystron E3712 and our typical operation parameters are shown in Table 1.

Each klystron is driven by traditional a 190 MW pulse modulator 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 ℃ 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

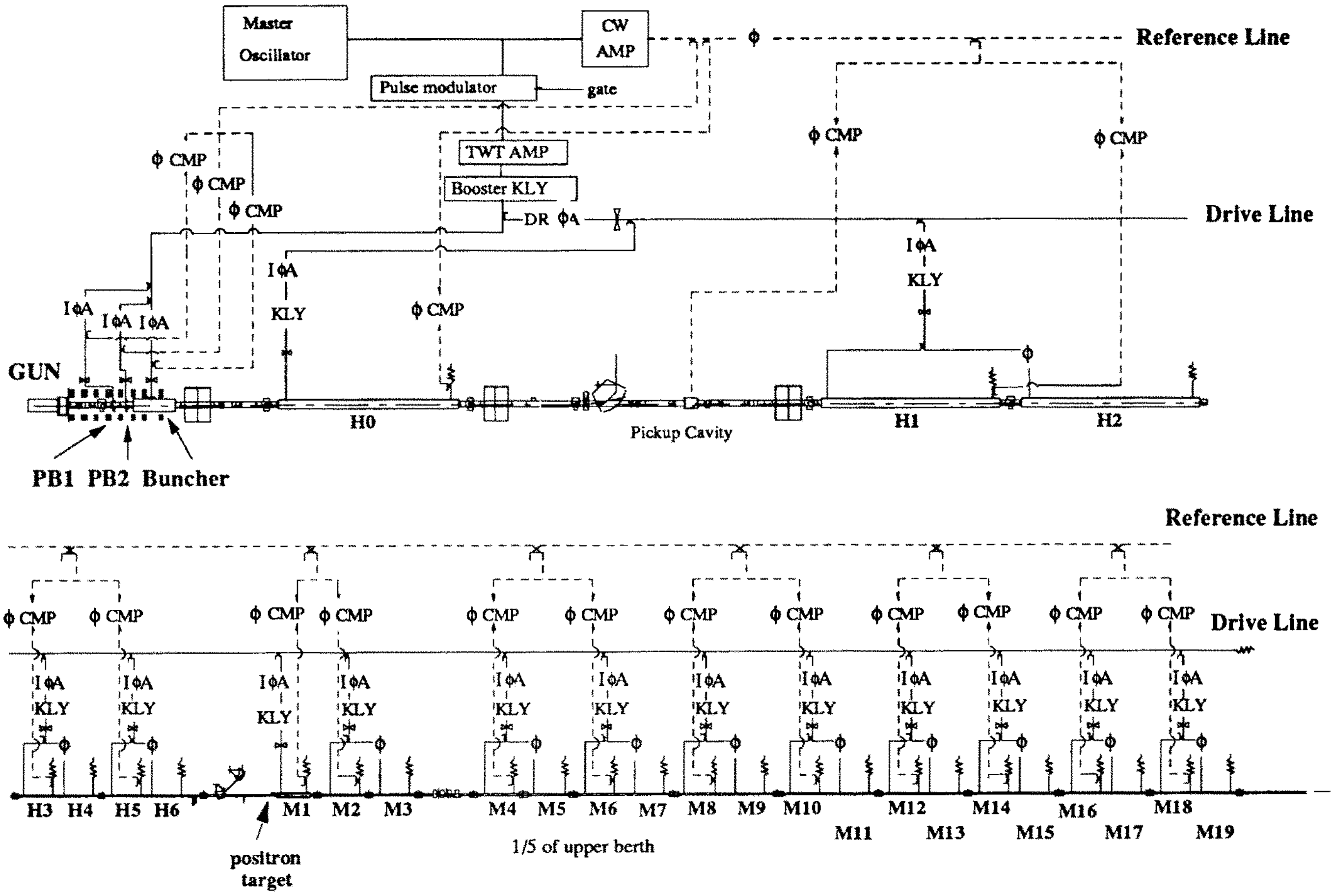


Fig. 1. **RF system of SPring-8 Linac**

Solid line is high power line. Dashed line is monitor line.
H0~M19 : number of accelerating structure, KLY : klystron, ⋈ : RF window
$\phi$ : phase shifter, DR$\phi$A : phase shifter and Attenuator for drive line
I$\phi$A : isolator, phase shifter and Attenuator, $\phi$CMP : phase drift detector

Table 1. E3712 klystron tube parameters

| | typical | max. | |
|---|---|---|---|
| Frequency | 2856 | | MHz |
| Peak Beam Voltage | 391 | | kV |
| Peak Beam Current | 474 | | A |
| Peak Output Power | | 80 | MW |
| Efficiency | 44 | | % |
| Drive Power | 255 | 500 | W |
| Pulse Width (Beam) | 5 | 6.2 | μs |
| Pulse Width (RF) | 2 | 4 | μs |
| Pulse Repetition | 60 | | pps |

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 was satisfied. Especially, the high power phase shifter was operated in the full RF power.