Developments and Upgrades of Linac

Laser Driven RF Signal Generation for Photocathode RF Gun

Precise synchronization between an RF signal and a laser pulse is essential for the pump-and-prove experiments using photocathode RF guns. The electron beam bunch lengths of less than hundreds femtoseconds have recently been utilized, and thus, the RF and laser synchronization has to be controlled so that its timing jitter becomes less than 100 fs. For this purpose, we developed an amplitude-stabilized RF signal generator driven by laser pulses generated by laser oscillator [20].

Circuit

The laser oscillator is simply synchronized with a 2856 MHz reference oscillator at the frequency of 89.25 MHz, 1/32 of 2856 MHz, by applying a PLL technique, as shown in the upper block of Fig. 25. The laser oscillator with a piezo-controlled mirror works as a voltage controlled oscillator in the PLL feedback. The measured timing jitters between the laser pulses and reference RF waves were 300-400 fs with this PLL feedback system. For further high-precision synchronization, we developed a laser-driven RF regeneration as follows.

A fast photodiode detects the 89.25 MHz laser pulses and generates electric pulses of the same frequency, as shown at the upper left of the bottom block in Fig. 25. The next stage circuit filters the pulse signal and picks up only the 2856 MHz waves from among the higher harmonics. Thus, the RF signal of 2856 MHz can be regenerated from the 89.25 MHz laser pulses.

To reduce the RF variation caused by the laser power fluctuation, we designed an amplitude-stabilized RF generator employing the following two key components: a limiter amplifier (GigOptix, iT3011E) stabilizes the RF signals from the photodiode, and a comb generator (Herotec, Inc., GC100) produces narrow pulses with a fast rise-time resulting in intense higher harmonics. The following cavity type BPF passes only the 32nd harmonics, 2856 MHz.

Performance

The output power variation of the amplitude-stabilized RF generator was kept within 1.5% when the 89.25 MHz pulse signal varied in the power range of 10 dB. The short-term (<1 min) amplitude stability for the stabilized RF generator was decreased to 0.20% (RMS), while that for the unstabilized one was 0.27% (RMS). According to these results, we have confirmed that the amplitude stabilization effectively worked against not only the long-term drift, but the short-term fluctuation of the laser power.

The short-term (< 1 s) jitter was about 160 fs for the stabilized RF generator, which is almost the minimum resolution of the measurement system, while that of the unstabilized one was about 270 fs. This result shows that the stabilized generator has an advantage in the timing synchronization compared with the unstabilized one.

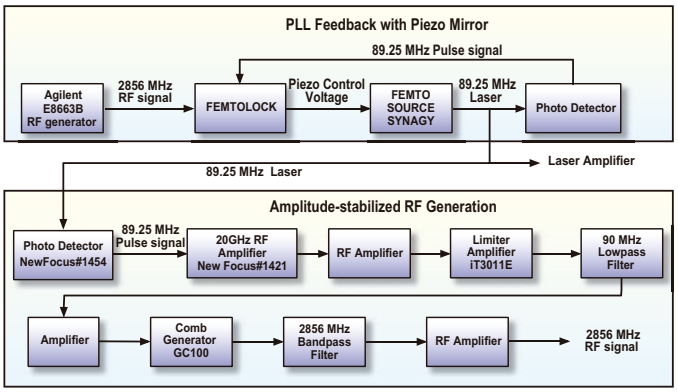

Fig. 25. Block diagram of amplitude-stabilized laser-driven rf generator.

Haruo Ohkuma*, Hiroto Yonehara and Hirofumi Hanaki

SPring-8/JASRI

*E-mail: ohkuma@spring8.or.jp

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