CONTINUOUS CIRCUMFERENCE CONTROL AND TIMING SYSTEM FOR SIMULTANEOUS ELECTRON-POSITRON INJECTION AT THE KEKB

Masaaki Suetake, Yukiyoshi Ohnishi, Haruyo Koiso, Katsunobu Oide
KEK, Tsukuba, Ibaraki 305-0801 JAPAN.

Abstract

We have continuously controlled ring circumference with a new method of synthesizer control at the KEKB. The new method stands for continuous controlling of reference frequency of synthesizers. Due to the new circumference control, we stabilized the KEKB circumference within about 6 micrometers. In Fall 2006, KEKB will introduce simultaneous electron-positron injection scheme. We have to change the timing system of KEKB to control the injection phase with pulse-to-pulse injection. We show the plan of the new timing system due to the simultaneous injection scheme.

SUBMISSION OF PAPERS

KEKB timing system is a little complicated due to having many reference frequencies. Because KEKB has used many former TRISTAN resources: klystrons, circulators, waveguides, low-level control system, Linac injector and so on, we were not able to select simple relation between ring RF Fr and Linac RF frequency Fl. We adopted finally the relation ratio as 49/275 with having the greatest common denominator F0, i.e.

$$Fr = 49 * F0 \quad (1)$$
$$Fl = 275 * F0 \quad (2)$$

Synthesizers of both of Linac frequency Fl and ring frequency Fr are generated by common reference frequency Fc. So far we have tuned Fr and Fl independently, we can simultaneously and continuously change both of Fr and Fl by controlling of common Fc.

FORMER SYSTEM

Multi-synthesizer

There are two types of multi-synthesizer that are developed for KEKB. We now introduce one type of synthesizer. Fig.1 shows block diagram of the synthesizer. Source of the synthesizer is 571.2 MHz that is used with subharmonic buncher in Linac. The 571.2 MHz is multiplied by 5 and generates 2856 MHz that is used as Linac RF frequency Fl. Simultaneously, the 571 MHz is divided by 5 and generates 114.2 MHz frequency, which is also used with another subharmonic buncher. The 114.2 MHz frequency is divided by 11 and generates 10.385 MHz frequency, which is the common denominator F0 of ring RF Fr and Linac RF Fl. The common denominator frequency is multiplied by 6 and mixed with 571.2 MHz frequency and finally generates 508.887 MHz frequency that is ring RF frequency Fr. All frequencies are connected and locked with the common denominator frequency 10.585 MHz F0. All frequencies are listed in Table 1.

Table 1: The reference frequencies used in KEKB ring and Linac injector

KEKB ring reference	LINAC reference
	Fl 2856 MHz
	571.2 MHz
Fr 508.887 MHz	508.887 MHz
	114.2 MHz
F0 10.385 MHz	F0 10.385 MHz

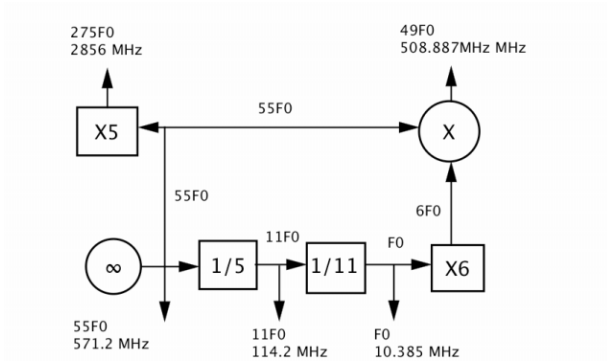

Figure 1: Multi-synthesizer generates many reference frequencies.

Injection Phase and Collision Phase

We can match the phase between KEKB RF bucket and Linac beam with changing KEKB reference frequency phase. The phase between electron and positron collision timing at intersection region can be adjusted by changing LER RF phase. Fig.2 shows timing system for KEKB.

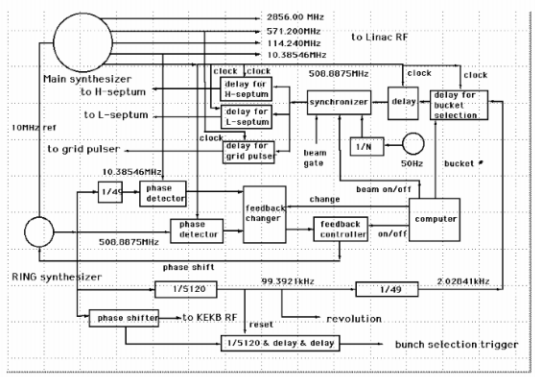

Figure 2: Timing Block Diagram

Frequency Shift and Phase Lock to Linac Synthesizer

At injection, ring RF frequency Fr and Linac frequency Fl are locked with the common denominator frequency 10.385 MHz. After injection, ring RF frequency can be changed in order to measure dispersion and chromaticity parameters. When ring RF frequency is changed, the frequency lock system with Linac frequency is temporally killed. At next injection, we first lock ring 10.385 MHz frequency with Linac 10.385 MHz frequency and secondly lock the ring 508.887 MHz frequency with Linac 508.887 MHz frequency. So we can continuously add KEKB ring beams ever after frequency changing. The Linac 508.887 MHz frequency and the Linac 2856 MHz frequency are always locked with the Linac 10.385 MHz frequency.

NEW SYSTEM

Ring Energy Difference

We measure the ring energy difference dP/P0 with inner product of orbit displacement vector D times dispersion vector η:

$$dP/P_0 = (D-D_0) \bullet \eta \qquad (3)$$

where D_0 is displacement offset (we say golden orbit). Chicane magnets tune LER circumference. Since HER circumference has however no chicane magnets, RF frequency should tune ring circumference.

Common Reference Frequency

After introducing continuous injection mode, KEKB ring beams are almost all time injected. Then we need to change ring frequency even when beams are injected. Since we have two synthesizers that are ring RF synthesizer and Linac RF synthesizer, we change the common reference frequency as shown in Fig.3. When the common reference frequency shift, the two synthesizers' frequencies are simultaneously shifted.

Injection Phase

Injection phase and collision phase are also changed ring RF phase to match Linac beam phase and collision phase.

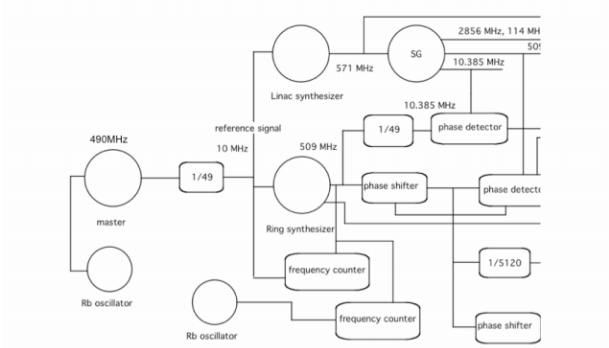

Figure 3: Common reference frequency tunes both synthesizer frequencies

RESULTS

So far, we tuned ring circumference whenever circumference exceeded some threshold. Then the ring circumference appeared saw-toothed edge. After controlling continuously, the circumference is fixed within several microns as shown in Fig. 4.

Earthquakes and Tide

After tuning continuously, the compensated RF frequency shows precise crustal disturbance as show in Fig. 5. We have sensed even very tiny earthquake from 8,000 km away as shown in Fig. 6. Tidal force from the Moon and the Sun also clearly appears as shown in Fig. 7.

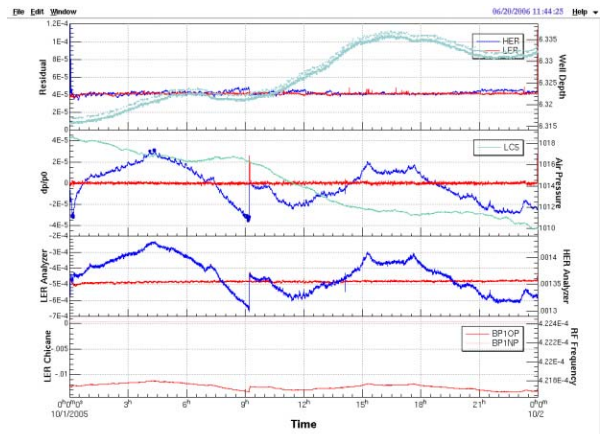

Figure 4: Ring energy difference before the continuous circumference control.

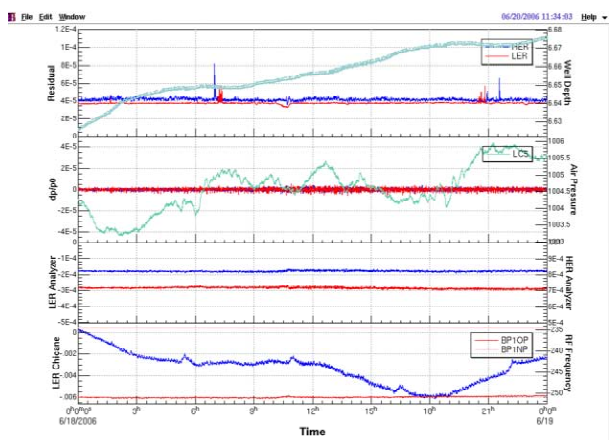

Figure 5: Ring Energy difference after the continuous circumference control.

TIMING SYSTEM FOR SIMULTANEOUS INJECTION

Injection Phase

In order to introduce simultaneous injection, we have to change injection phase within 20msec. Since it is danger that the ring beam moves fast, we change Linac beam phase within 20 msec.

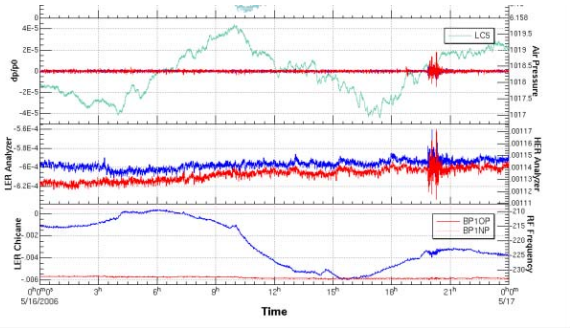

Figure 6: KEKB sensed very tiny earthquake far from 8,000 km away.

Phase Lock to Linac Synthesizer

Because ring RF and Linac RF is locked by PLL, when Linac RF has trouble, ring RF is also downed. To protect against going under together, we have to stop PLL and tune injection phase offset to adjust ring RF and Linac RF phase.

SUMMARY

We have successfully controlled ring circumference with a new method of synthesizer control. Due to the new circumference control, we stabilized the KEKB circumference within about 6 micrometers. After tuning continuously, the compensated RF frequency shows crustal disturbance and Tidal force from the Moon and the Sun. Simultaneous Injection system is also sophisticated successfully.

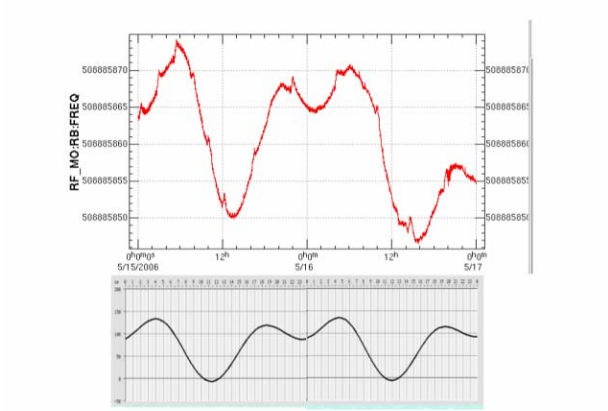

Figure 7: Tidal force from the Moon and the Sun is seen with compensated RF frequency. Lower graph shows sea level nearest coast.

REFERENCES

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