THE KEKB TIMING SYSTEM

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Abstract

The KEKB control system required a new timing system to match low longitudinal acceptance due to low alpha machine. This timing system is based on frequency divider/multiply technique and digital delay technique. The KEKB timing system is a little complicated, because KEKB ring RF frequency (508.887MHz) is not a divisor of Linac RF frequency (2856MHz). The KEKB ring frequency and the Linac frequency is locked with a common divisor frequency (10.385MHz). The common divisor frequency determines injection timing. This paper describes the overview of KEKB timing system and RF bucket selection system.

1 Introduction

1.1 The difference of injection schema between TRISTAN and KEKB

At TRISTAN they adopted 5-bunch injection system which means that 5 bunches of Linac beam are merged into a bunch of TRISTAN beam. We can't inject multi-bunch beams in order to match low longitudinal acceptance, for KEKB ring is low alpha machine. Timing jitter between injected beam and RF bucket is allowed less than 30 psec. That of low-level control system is limited within several psec. So we intended to inject single and high current bunch beam. Furthermore we synchronize KEKB RF frequency (508.887MHz) and Linac frequency (2856MHz) so that we can always catch Linac beams at the same phase of KEKB RF frequency.

1.2 2856 MHz and 508.887 MHz

Although KEKB RF frequency is not a divisor of Linac RF frequency, those frequencies have a common divisor frequency (10,385MHz). Because of the existence of common divisor frequency, we can synchronize KEKB RF bucket timing and Linac beams at the common divisor frequency intervals. Linac RF frequency and KEKB RF frequency are locked by common divisor frequency with a newly developed multi-synthesizer.

2 Multi-synthesizer

There are two types of multi-synthesizer that are newly developed for KEKB. We now introduce one type of synthesizer. Fig.1 shows block diagram of synthesizer. Source of the synthesizer is 571.2 MHz that is used with subharmonic buncher in Linac. The frequency 571.2 MHz is multiplied by 5 and generates 2856 MHz that is used as LINAC RF frequency. Simultaneously, the frequency 571.2 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 10.385MHz frequency, which is common divisor frequency. The common divisor frequency is multiplied by 5 and mixed with 571.2 MHz frequency and finally generates 508.558MHz frequency, which is KEKB RF frequency. All frequencies are connected and locked with the common divisor frequency 10.585 MHz. All reference frequencies are listed in Table 1.

Table 1
The reference frequencies used in KEKB ring and LINAC

KEKB ring reference	LINAC reference
	2856 MHz
	571.2 MHz
508.887 MHz	508.887 MHz
	114.2 MHz
10.385 MHz	10.385 MHz

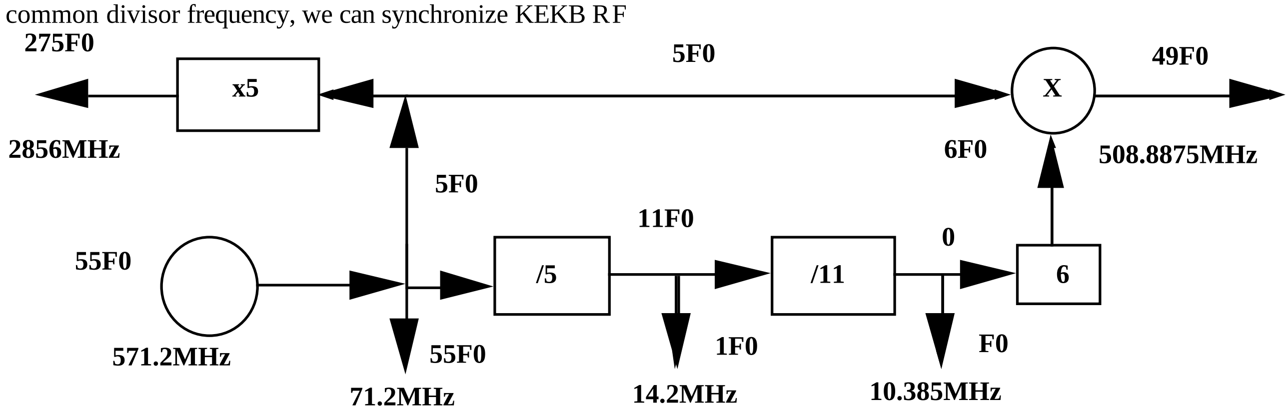

Fig. 1 KEKB Multi-synthesizer

3 Overview of KEKB timing system

3.1 Single Reference Frequency in KEKB machine

Although KEKB machine consists of two rings: HER and LER, it has single reference frequency 508.887 MHz. We can't change the reference frequency of each ring independently. Of course the phase of reference frequency of each ring can be changed independently. We avoided the complication of double reference system. Since we never measure dispersion parameters or chromaticity parameters of both ring simultaneously, no troubles have occurred about single reference system.

3.2 Distributing the reference frequency

The reference frequency is distributed with coaxial cables and optical fiber cables as shown in Fig.2 Main line that is circulated around KEKB ring consists of coaxial cables, which are locked with PLL in phase. The main line has stabilized within 1 degree around KEKB ring. Satellite lines consist of optical fiber cables, of which phase stabilities match less than 0.2 ppm per degree in electrical length. The satellite has line stabilized less than 0.5 degree in total.

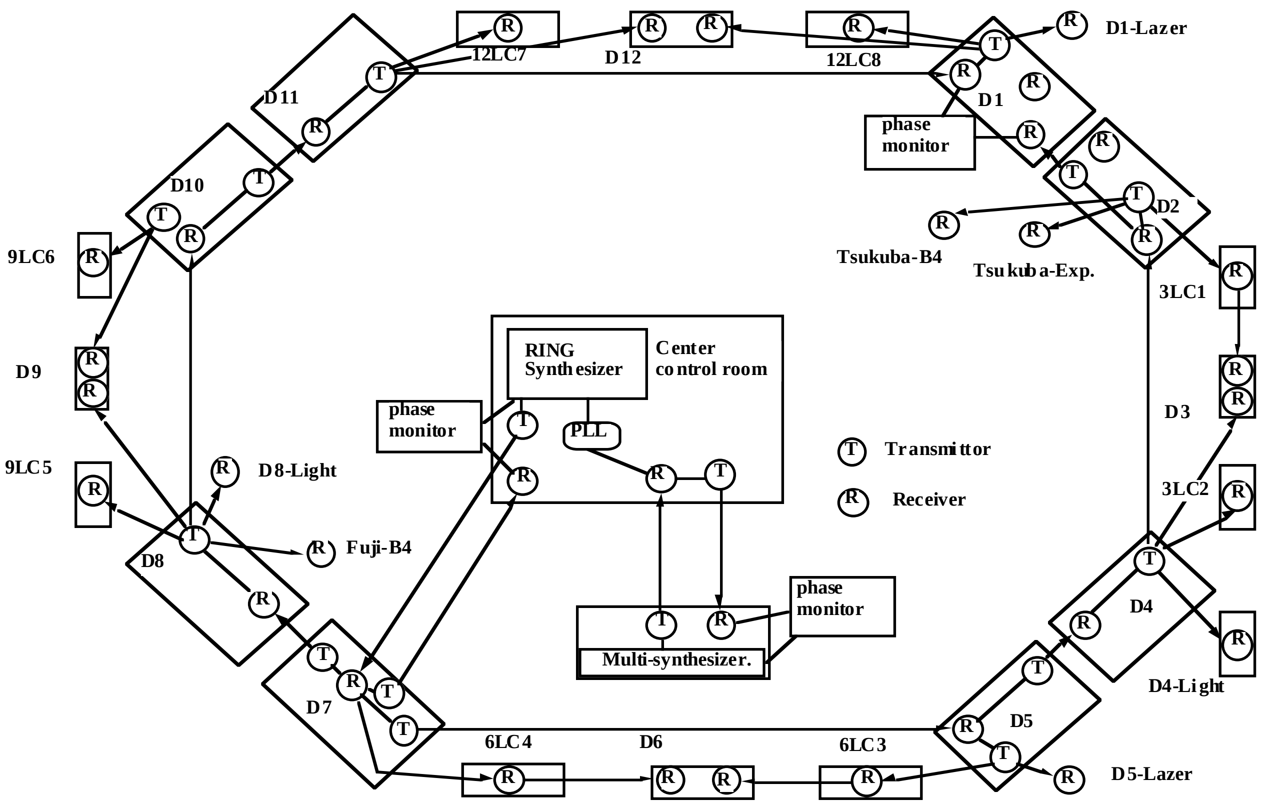

Fig. 2 Reference frequency distribution diagram

4 Bucket Selection Method

4.1 10.385 MHz and 2.028 kHz

Since KEKB RF frequency (508.887MHz) and LINAC frequency (2856MHz) are locked in 10.385 MHz intervals as shown in synthesizer paragraph, we can inject LINAC beams in the intervals. The interval equals 49 bucket spacing in KEKB ring. Since the frequency 10.385 MHz divide by 5120 that is KEKB harmonic number equals 2.028 kHz, we can inject LINAC beams in 2.028 kHz intervals at the same bucket in KEKB ring. So we choose the frequency 2.028 kHz as basic injection frequency. We can choose any buckets with delay timing from the basic frequency in 10.385 MHz interval units that is 49 bucket spacing in KEKB ring. Since the number 49 and the number 5120 have no common divisor, the 10.385 MHz intervals that is 49-bucket spacing times 5120 equals 2.028 kHz interval. So within 2.028 kHz interval we can select any bucket addresses as show the relation:

Address# = mod (delay# x 49, 5120)

In reverse

Delay # = 209 x mod (address#, 49) + int (address# / 49)

4.2 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.

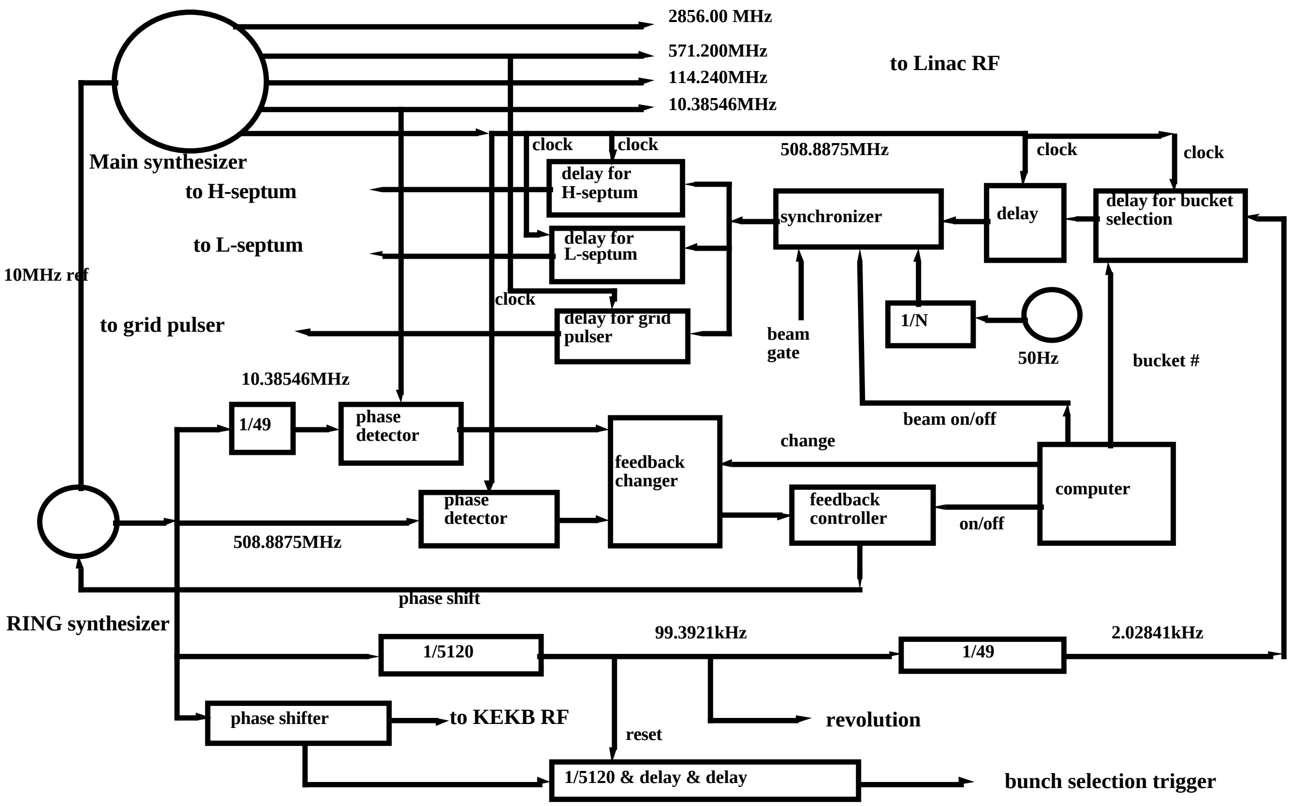

Fig. 3 KEKB Timing diagram

5 Frequency Shift and Phase Lock to Linac synthesizer

At injection timing, KEKB RF frequency and LINAC frequency are locked with the frequency 10.385 MHz. After injection, KEKB RF frequency can be changed in order to adjust ring circumference and in order to measure dispersion and chromaticity parameters. When KEKB RF frequency is changed, the frequency lock system with LINAC frequency is killed. At next injection timing, we first lock KEKB 10.385 MHz frequency with LINAC 10.385 MHz frequency and second lock the KEKB 508.887 MHz frequency with the LINAC 508.887 MHz frequency. So we can continuously add KEKB ring beams even after frequency changing. The LINAC 508 MHz frequency and the LINAC 2856 MHz frequency are always locked with the LINAC 10.385 MHz frequency.

6 Summary

Since we introduce single bunch injection and the frequency lock system between KEKB ring frequency and LINAC frequency, we can inject LINAC beams within several psec jitters. We can select any bucket address in KEKB ring, change ring frequency freely without injection timing and inject LINAC beams continuously next injection timing.