BUNCHER IN THE BEAM LINE FROM ECR TO SFC

J.Z.Jiang, X.H.Zhou, Q.Wang, F.Wang, W.M.Jiang
IMP,Academia Sinica,P.O. Box 31, LanZhou,730000, China

ABSTRACT

A buncher was used to produce the required bunched beams at the entrance of SFC. The buncher consists of two parallel mash plates. It is excited by an RF voltage with a saw-tooth waveform produced directly from a waveform convertor without combining RF sine wave with different higher harmonics. There are significant advantages for using waveform convertor at the lower operating frequencies. The peak-to-peak amplitude of the saw-tooth wave is about 800v. The stabilities of the voltage amplitude and the phase are less than $\pm 1\times 10^{-3}$ and $\pm 0.5^0$ respectively.The maximum reguired RF power is 500 W.

1. INTRODUCTION

To achieve high energy resolution of the output beam from HIRFL. The beam injected into SSC must be bunched to three degrees in RF phase. This corresponds to 1.3 ns to 0.6 ns bunches for the 6.5 to 14 MHz frequency range of SSC RF and this exacting requirements must be established at the injection orbit by the external bunching system. The bunching system consists of a buncher B_0 and two rebunchers B_1, B_2 (rebuncher is not described in this paper), see Fig.1.

The new ECR ion source was installed and tested in the injection beam line. It is able to provide variant beams with continuons microwave into SFC. But the RF accelerating phase is about only few degrees in the injector SFC accelerating gap. Most of beams must be lost if the continuous beams are injected derectly into SFC from ECR ion source. The buncher was designed and constructed to modulate the continuous beams from the ECR ion source and to match the RF accelerating phase with SFC in RF phase.

2. BUNCHER

The single gap buncher consists of two parallel mesh plates. The two electrodes with hexagonal mesh are made of copper plates by photo etching and are insulated with ceramics. The size of hexagon is 2 mm. Both width and thickness of the mesh are 0.1 mm. The gap between two electrodes is 5 mm and the diameter of the mesh section is 60 mm. Aligning the meshes of the two electrodes may increase the beam transmission of the two grids almost to that of a single grid. The efficiency of beam transmission is more than 83%.

The buncher is excited by an RF voltage with sawtooth-like waveform as indicated in Fig.2, it is produced directly by a waveform convertor without combining RF sine wave with different higher harmonics. There are significant advantages for using the waveform convertor to produce the sawtooth waveform at the lower operating frequencies.

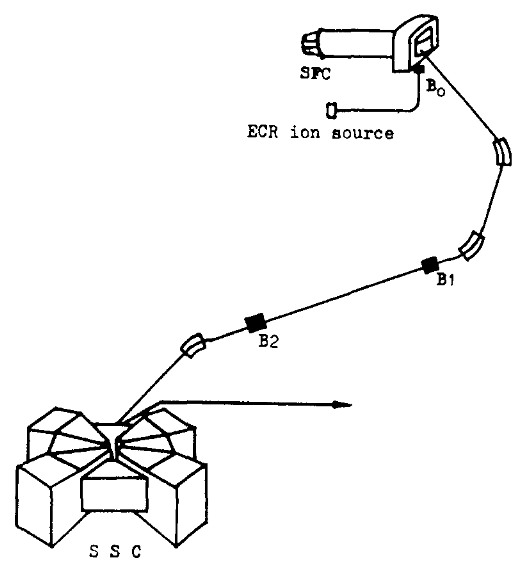

Fig.1 Schematic layout of the buncher B_0 and the rebunchers B_1, B_2

3. WAVEFORM CONVERTOR

Combination with higher sine wave harmonics is a normal way to produce the sawtooth wave. For example, using fundamental and second, third harmonics with the

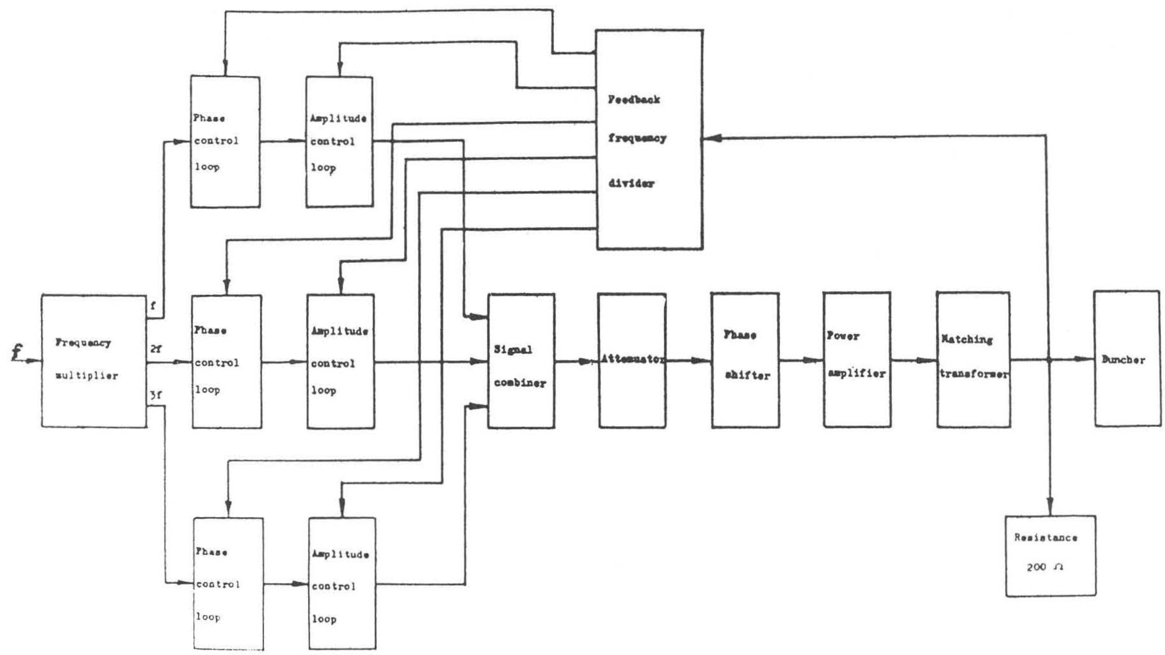

Fig.3 Block diagram of the buncher circuit for the sawtooth waveform.it produced by combining RF sine wave with the first three harmonics.

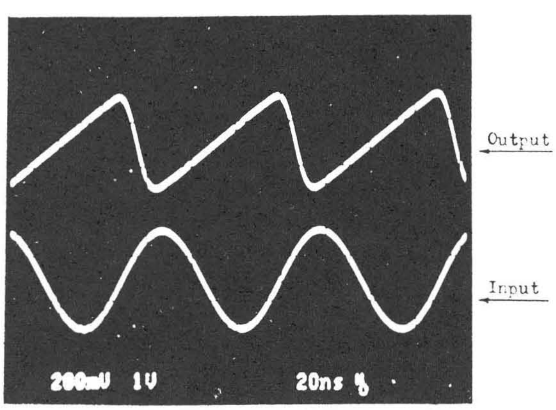

Fig.2 Sawtooth waveform convertor as seen on oscilloscope in control room

definite amplitude and phase relationship can combine sawtooth waveform, as shown in Fig.3. The shape of the sawtooth waveform depends on how many harmonics were joined to combine. Although increasing the number of the higher sine wave harmonics may get the ideal sawtooth waveform, the respective phase and amplitude control loops for every frequency must be built, and the many filters in the frequency multiplier and feedback divider are also difficult to make for wide band operating frequencies. In this case, the whole system is very complicated and expensive.

A waveform convertor was designed and constructed in order to improve the technique of the combining sawtooth waveform in the bunching system in HIRFL. Figure 4 shows the block diagram of the waveform convertor and the waveform at the different points. The narrow pulses with width τ were formed by "shaper–differentiator–shaper" circuits at the plus crossing points of the input sine wave. T is the period of the input sine wave. The capacitor C is charged with constant current I when $U_d = 0$. The capacitor C is discharged quickly during the narrow pulses occur. As a result the sawtooth waveform was formed directly. There are only one amplitude and one phase control loops in whole system and without any filters. $(T - \tau)/T$ is used to evaluate the bunching efficiency of the sawtooth wave. This value is about 70 % for combining sawtooth waveform with three harmonics and without regard to the frequency (see Fig. 5). But the $(T - \tau)/T$ value is from 91 % to 73 % correspondent frequencies from 6 to 18 MHz for the sawtooth waveform produced by the waveform convertor as shown in Fig.2. Here τ is 15 ns and this is compromise consideration. Although the smaller τ is, the better, the sawtooth waveform contains rich high harmonics with minimal τ value. It is difficult to amplify such sawtooth wave with rich harmonics. It needs more wide band power amplifier and better matching, but these are more difficult problems.

Obviously, using waveform convertor are more simple and much cheaper than combining to produce the sawtooth waveform voltage. The shape of the sawtooth waveform is better than it is combined.

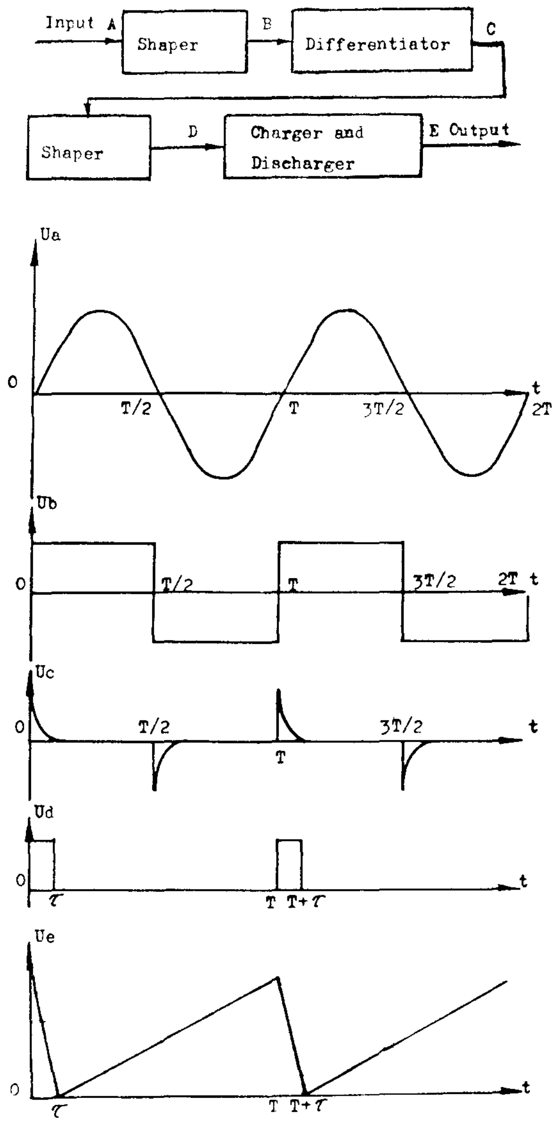

Fig.4 Block diagram of the waveform convertor and waveforms at the different points.

4. RF SYSTEM OF THE BUNCHER

Figure 6 shows the block diagram of the buncher RF system. The RF signal from synthesizer is split into the waveform convertor in which the sawtooth wave is produced with the RF frequency range as same as the injector SFC drive frequencies (6–18 MHz). The RF signal with sawtooth waveform is amplified by a 500 W wide band power amplifier and passes through a matching transformer to one of the two electrodes to which a resistance of 200Ω is connected in parallel.

The peak–to–peak amplitude of the sawtooth waveform in the accelerating gap is about 800 V. The gap voltage is monitored by a resistance divider. The amplitude stability of the voltage is less than $\pm 1 \times 10^{-3}$. The relative phase between the mesh signal and the reference signal is stable to better than 0.5 degree.

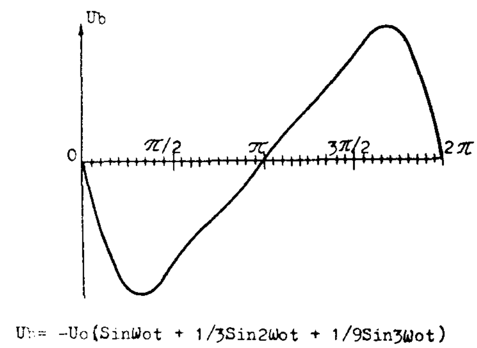

Fig.5 Sawtooth waveform produced by combining RF sine waves with fundemental, second and third harmonic frequencies

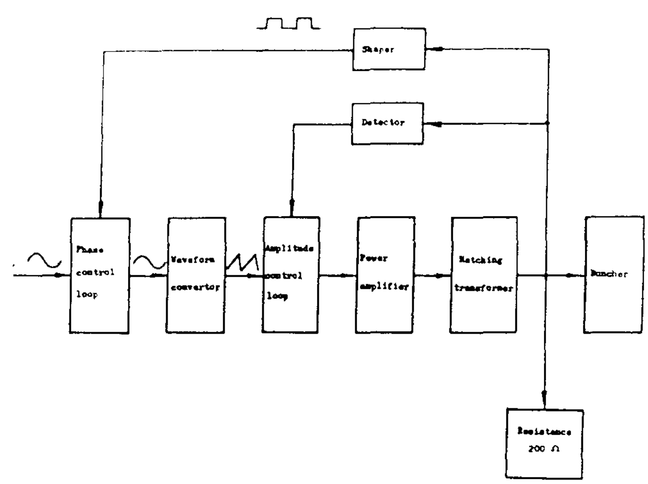

Fig.6. Block diagram of the buncher circuit for the sawtooth waveform produced by a waveform convertor