MODIFIED BUNCH FILLING SCHEME FOR INDUS-2

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Abstract

Currently Indus-2 is operated with all bunches filled mode. It may be required to fill the ring with different bunch filling patterns in future as per requirements of the users and also to mitigate the problems of ion trapping and beam instabilities. In Indus-2 one can store beam current in maximum of 291 bunches. A bunch-filling scheme has been evolved in which, it is possible to fill Indus-2 with different filling patterns. In the earlier scheme [1], three patterns of bunch filling are proposed namely all bunches, three symmetric bunches and a single bunch. In this scheme there is problem of bunch overlapping in the buckets, if more than one bunch is extracted from the booster. In the new scheme, a formulation has been derive to avoid the overlapping of bunches.

INTRODUCTION

Booster is used as an injector to Indus-2 which is a 2.5 GeV storage ring. In the booster, the beam is accelerated from 20MeV to the 550MeV. During the acceleration process in the booster, the RF voltage creates three bunches. With the triggering of the booster extraction kicker, these bunches are extracted from the booster and fills the RF buckets of Indus-2. There are maximum 291 RF buckets in Indus-2 and the filling of any of them by the booster bunches, depends on the triggering time of the booster extraction kicker magnet. A systematic triggering of the extraction kicker fills required selective RF buckets of Indus-2 resulting in a unique beam-filling pattern.

In this paper, we propose the bunch-filling scheme controlled by proper extraction kicker delays. For this purpose the time correlations between the booster pulses and Indus-2 RF buckets are used.

SELECTION OF INDUS-2 RF BUCKET

The parameters of the booster and the Indus-2 are given in Table: 1.

Table 1: Parameters of the booster and the Indus-2

Parameters (Unit)	**Booster**	**Indus-2 ring**
RF Frequency(MHz)	31.613	505.808
Harmonic number	3	291
RF time period (ns)	~31.632	~1.977
Revolution Time (ns)	~94.89	~575.31

During filling of the Indus-2, a master trigger provides a trigger pulse ‘p’ at ~1Hz rate, for initiating the timing system of the beam formation in microtron, injection, acceleration and extraction from the booster etc. During the filling of storage ring, this pulse number ‘p’, is advanced every second, starting from ‘p=1’.

According to the RF frequencies of the booster & Indus-2 storage-ring, the same RF buckets of both the rings will match after every 97 turns of the booster i.e. after every 291(=97×3) RF time periods in the booster. This time is called ‘coincidence-time’ i.e. ~9.205µs. so there will be a chain of such coincidence events.

For the filling of q^{th} bucket of Indus-2, with the p^{th} pulse after coincidence, let RF buckets of both the rings run and assume that after passing of ‘291m+q’ RF time periods of Indus-2, (‘m’ is complete revolutions of Indus-2 & ‘291’ is harmonic no. of Indus-2) any one bunch of the booster comes against the ‘q^{th}’ RF bucket of Indus-2. During this time period suppose ‘n’ RF time periods of the booster are completed. Taking into account the ratio of RF periods of the booster to Indus-2 is 16, thus

$$n = \left(\frac{291 \times m + q}{16} \right) \tag{1}$$

And using ‘m=5q’,

$$n = 91 \times q \tag{2}$$

Thus for pulse ‘p’ and after the next coincidence event, a delay of ‘91q’ RF buckets of the booster, is provided to fill the desired ‘q^{th}’ bucket of Indus-2. This is illustrated in figure 1.

To generate a desired bunch-filling pattern, following relationship between the bucket q and the pulse p is used.

$$\mathrm{q} = \mathrm{remainder}\left\{ \frac{\left(g - \frac{16 \times e}{b} \right) \times \mathrm{remainder}\left(\frac{p-1}{b} \right) + \left(\frac{16 \times e}{b} \right) \times \mathrm{remainder}\left(\frac{p-1}{b \times s} \right)}{291} \right\} \tag{3}$$

Where, e is the total extracted number of bunches from the booster, g is the required gap between two successive filled buckets, b is the number of buckets to be filled, s is the number of repetitions of the group of b buckets. If a bunch train consists of more than one set of repetition, then ‘b×g ≤16’ must be satisfied to avoid overlapping of the buckets.

BOOSTER EXTRACTION KICKER TIMING

If the time of the one booster RF period is ‘$T_{booster\text{-}(RF)}$’, then for ‘p^{th}’ pulse, the delay time (in seconds) of the

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extraction kicker after coincidence event is calculated as follows.

$$\text{Kicker. Trig. delay Time} = 91 \times q \times T_{\text{booster-(RF)}} \quad (4)$$

In the above calculation, the jitter in the extraction kicker pulse as well as beam travel time from the extraction kicker to the injection point of the Indus-2, is not taken into consideration. Based on the above formulations, some bunch-filling patterns, which can be generated, are shown in figure 2.

CONCLUSION

With this bunch filling scheme, different bunch filling patterns such as single bunch, bunch-trains, and also Cam-shaft pattern etc. can be generated.

REFERENCE

[1] D. Angal-Kalinin and G. Singh, "Schemes for filling of buckets and beam lifetimes in INDUS-2", CAT/2001-13.

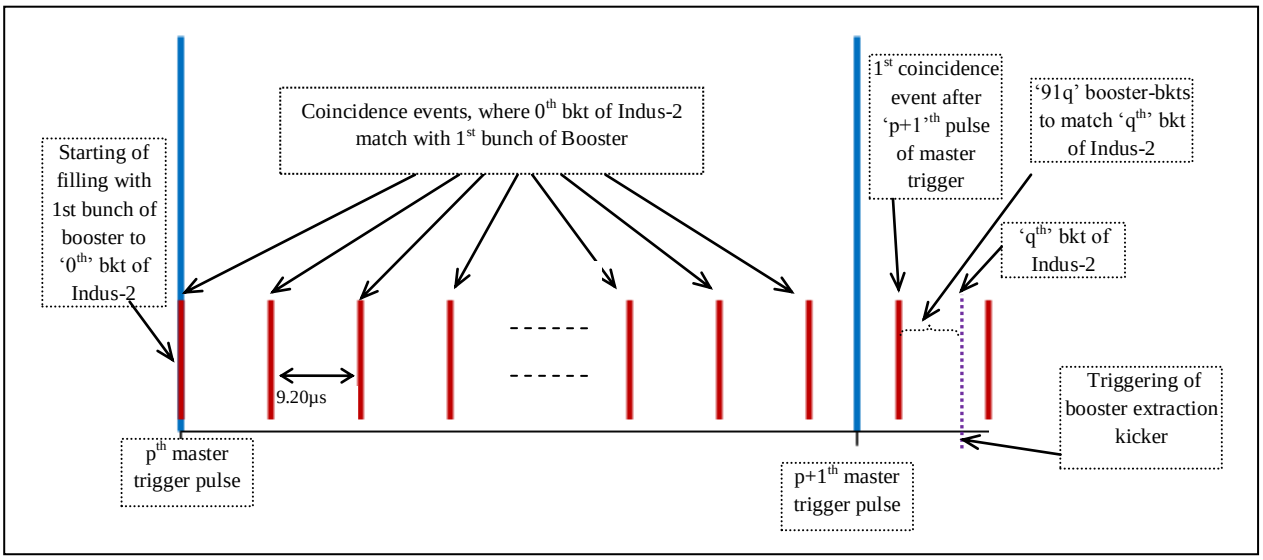

Figure 1: Proposed timing scheme of bunch filling patterns of Indus-2

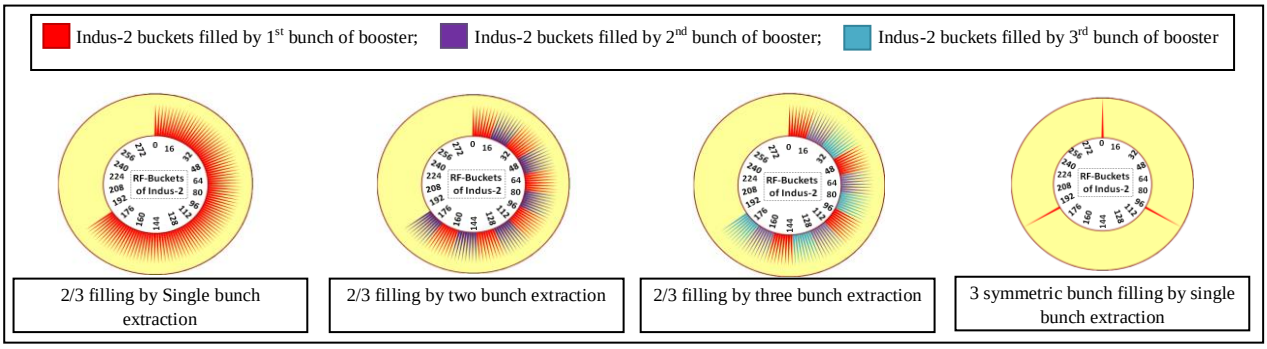

Figure 2: Bunch filling patterns for Indus-2