The ELETTRA Gun Trigger Module

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Abstract

The ELETTRA injector is a full energy Linac. The Linac and the pulsed magnets need to be synchronized with the beam in the storage ring in order to fill it with the proper bunch pattern. Most of the triggers for the timing system are generated by a module which is named Gun Trigger module. The gun is triggered in synchronism with a reference bucket of the storage ring. It can be programmed with a delay between 2 and 864 ns, a range which covers one revolution period of the storage ring, so any arbitrary bucket of the ring can be filled. The module generates also the gun trigger for working in FEL mode, which needs a repetition from 30 to 50 ns in a 10 µs window. The jitter of all these triggers is less than 50 ps. The Gun Trigger module is developed in VMEbus standard, using TTL and ECL technology. It is remotely programmable through the ELETTRA control system. The general architecture of the ELETTRA timing system is also described in the paper.

I. INTRODUCTION

The timing system generates pulses with fixed and variable delay, required to trigger the injection and the beam diagnostics [1]. The Linac and the pulsed magnets need to be synchronized with the beam in the storage ring in order to fill it with the proper bunch pattern. The Linac works at 10, 5, 2 or 1 Hz. The trigger which gives the injection rate is the Line Trigger (LT); it is derived by dividing the 50 Hz line frequency. The timing system must allow different modes of operation: Single Bunch, Multi-Bunch, and FEL. In Single Bunch mode only one bucket of the storage ring must be filled; in Multi Bunch mode the buckets of the storage ring must be uniformly filled; in FEL mode a trigger repetition from 30 ns to 50 ns must fire the gun of the Linac. The jitter of the gun trigger must be smaller than 3 ns [2]. The most critical part of the timing system described below is the Gun Trigger module. Semi-custom ECL integrated circuits from Siemens are used: 16 bits programmable counters which can work up to 750 MHz. This choice has been allowed to realize all the trigger generators in only one VMEbus board, reducing the space, the complexity and the power consumption with respect to other solutions.

II. TIMING SYSTEM ARCHITECTURE

Most of the synchronization problems come from the Single Bunch working mode. The gun needs to be synchronized to the bucket to fill in the storage ring at a 10 Hz injection rate.

Storage Ring Clock (SRC): RF/432
Line Trigger (LT): 50 Hz/5
Start Injection (SI)
Gun Trigger (GT): SI delayed

Figure 1. Injection Timing: the Gun Trigger is delayed by 884.7 µs (1024*864 ns) from SI. One more adjustable delay in 2 ns step is used to fill any bucket of the storage ring. Other triggers can be derived from SI in order to provide any pretrigger required.

In order to realize this timing, the Gun Trigger Module generates the following triggers [figure 1]:
- Storage Ring Clock [SRC]. Synchronized to the reference bucket of the storage ring, it is obtained by dividing the radio frequency [RF] by the harmonic number of the storage ring (432); its frequency is 499.654 MHz / 432 = 1.157 MHz.
- Start Injection [SI]: It is synchronized to SRC and its period is that of the Line Trigger; 10 Hz phased with the line frequency.
- Gun Trigger [GT]: It is delayed by 884.7 µs (1024 * 864 ns) from SI. An additional programmable delay in 2 ns steps is used for synchronizing that to the required bucket of the storage ring.

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The modulator and pulsed magnets triggers are generated by delaying SI. A 4 ns step programmable delay module is used for this purpose.

**III. DESCRIPTION OF THE MODULE**

The Gun Trigger Module contains the SRC, GT and SI generators [figure 2]. The SRC generator is a 16-bit programmable counter always enabled. The whole programming range gives frequencies from 33.3 MHz down to 7.6 KHz, but it is used here to obtain 1.157 MHz. The SI Generator is a 10-bit counter and SRC is its clock. It starts counting at the arrival of the 10 Hz Line Trigger and its first pulse is SI. When it finishes counting, it generates its ripple carry [EN_GT]: this trigger occurs 884.7 μs (1024 x 864 ns) after SI.

The GT generator is also a 16-bit programmable counter. EN_GT enables the counting. This delay can be programmed from 10 ns to 131 μs, but only delays from 864 ns to 1728 ns (864 ns + 864 ns) are used: it allows synchronization of GT to each bucket of the storage ring. All the generators are remote controlled from the VMEbus.

**IV. CONCLUSIONS**

The Gun Trigger module allows to delay the pulse which fires the gun up to 864 ns in 2 ns steps with respect to the Storage Ring Clock, a signal synchronized to a reference bucket of the storage ring. The jitter measured from these triggers is less than 50 ps. Two Gun Trigger Module boards will be used for the ELETTRA timing system.

**V. REFERENCES**