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 200 ps in order to fill only the selected buckets. The pulsed magnets have to be synchronized 500 μs in advance because of their risetime. Their jitter must be smaller than 3 ns [2]. The most critical part of the timing system described below is the Gun Trigger module. Semicustom 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.

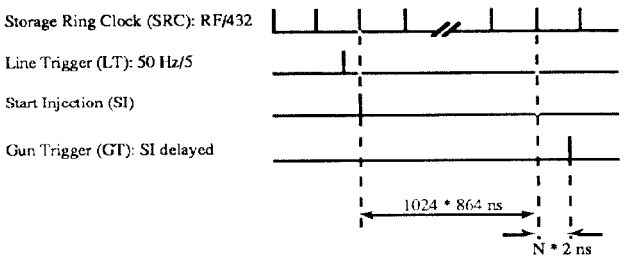

Figure 1. Injection Timing: the Gun Trigger is delayed by 884.7 μs (1024*864 ns) from SI. One more adjustable delay in 2 ns step is used to fill any bucket of the storage ring. Other triggers can be derived from SI in order to provide any pretrigger required.

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.

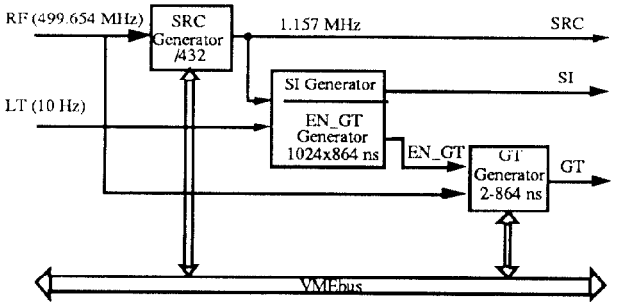

Figure 2. Logic block diagram. SI is the first SRC count after LT. EN_GT is the ripple carry after 1024 SRC counts and enables the GT counter.

Two Gun Trigger Module must be used. The first one will generate the triggers shown in figure 1. The second one will generate the triggers for the FEL mode: a repetition from 30 to 50 ns will be used instead of GT. This repetition is realized using the SRC generator of the second board.

The board is a four layer VMEbus compatible board: one ground plane, one power plane and two signal planes. It is developed in ECL technology except for the VMEbus interface which uses TTL technology.

The 50 Ohm input has a probe to test the input radi o frequency signal. A 100114 line receiver drives the input signal to the 500 MHz counters through a 50 Ohm microstrip line. The input circuit accepts amplitude from -10 dBm to 10 dBm. The output signals are at the NIM standard (-14 to -18 mA on 50 Ohm).

The SI and EN_GT generators are implemented with two ECL PALs (Programmable Array Logic): 1016RD8 from National Semiconductor. The clock is SRC. The Enable is the 10 Hz trigger, the Reset is GT. The 10 Hz trigger starts the counting and GT resets the counter. SI is generated at the first SRC pulse after the Enable, EN_GT at the last count.

The same IC is used for both the SRC Generator and for the GT Generator: the SH100CK1133, a semi-custom chip from Siemens. It is a 16 bit programmable counter which can work up to 750 MHz. This choice reduces the complexity of the board [figure 3], the power consumption, and the space respect to other solutions.

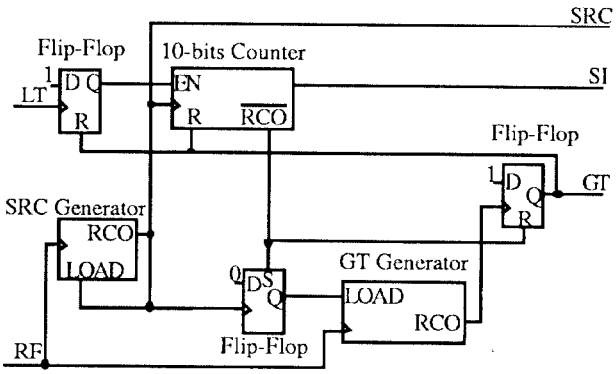

Figure 3. Schematics of the logic which realizes the timing. Only six chips are used.

The -5.2 V for powering the ECL devices comes from an external power supply through a connector on the front panel to give full VMEbus compatibility. The ECL logic levels and the -2 V level for the signal pulldowns are derived from the -5.2 V. The total power consumption is about 4 A on the -5.2 V and 2 A on the +5 V.

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.

Three Gun Trigger Module boards have been built. Their characteristics satisfy the initial requirements. Two of these boards will be used for the ELETTRA timing system.

V. REFERENCES

[1] G.R. Aiello and A. Carniel, "Timing System Project", Sincrotrone Trieste ST/M-89/11, July 1989.

[2] D. Tommasini, "Determination and Design of Septa Magnets for ELETTRA", Sincrotrone Trieste ST/M-TN-90/16, August 1990.