# CLS Design Specification
# Timing System

7.4.39.2 Rev. 2

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**REVISION HISTORY**

| Revision. | Date | Description | By |
| --- | --- | --- | --- |
| 1 | 2000-01-24 | Draft | J.M. Vogt |
| 2 | 2001-01-30 | Replace electrical fan-outs with optical fan-outs, new document number | J.M. Vogt |

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# 1. INTRODUCTION

## 1.1 Purpose

This document specifies the timing system of the Canadian Light Source facility.

## 1.2 Scope

This specification describes the system design of the timing system, identifies commercially available components used in the timing system, outlines the requirements of components that need to be custom-built, and defines the interface to the devices triggered by the timing system as well as the reference signals sent to the users.

## 1.3 Background

The pulse from the electron gun is chopped into bunches at a frequency of 500 MHz. Each bunch is accelerated in one of 171 buckets in the booster and then injected into one of 285 buckets in the main ring. By adjusting the width of the LINAC pulse, the number of bunches can be selected from 1 to >70. The position(s) of the bucket(s) in the main ring, that are to be filled, can be selected by adjusting the timing of the extraction of the electron bunches from the booster.

The CLS timing system provides all trigger signals to initiate the operations associated with an injection of current into the main ring. These operations include firing the LINAC (gun, modulators, RF) and triggering the booster injection kicker and injection septum. After the booster has ramped up, the booster extraction kicker and extraction septum are triggered, as well as the main ring injection septum and injection kicker.

## 1.4 Definitions and Abbreviations

IOC: Input/output controller.

PDU: Programmable delay unit.

TGM: Trigger generator module.

# 2. REQUIREMENTS

## 2.1 Function

The CLS timing system provides the signals to control the operations associated with an injection of current into the main ring. An injection is initiated when the timing system generates a Booster Start signal, which causes the booster to start ramping up.

When the booster magnets reach the injection field values, the timing system generates the following trigger signals:

- 7 LINAC modulator triggers.
- LINAC RF trigger.
- 2 LINAC gun triggers.
- 2 LINAC video deflector triggers.
- 2 chopper triggers.
- Booster injection septum trigger.
- Booster injection kicker trigger.
- 16 diagnostic signals.

When the booster magnets reach the extraction field values, the timing system generates the following trigger signals:

- Booster extraction septum trigger (for 1 or 2 septa).
- Booster extraction kicker trigger.
- Main injection septum trigger (for 2 septa).
- Main injection kicker trigger.
- Bump magnet trigger (optional).
- 7 diagnostic signals.

The following signals are generated independent of the fields of the booster magnets. They are used to trigger diagnostic devices and will also be made available to the users on demand:

- Booster synchronous trigger.
- Main ring synchronous trigger.
- Booster / main ring coincidence trigger.

The trigger system also generates an inhibit signal that is distributed to the users.

### 2.1.1 Components

Fig. 1 shows a block diagram of the timing system. The Trigger Generator Module, described in detail in section 2.1.2, is the centrepiece of the system. It generates various trigger signals, which are distributed to the LINAC, the booster, the main ring, and various diagnostic devices via optical fibre cable. Programmable Delay Units (PDU, see section 2.1.3) and optical fan-out modules (see section 2.1.4) are used to delay and split these trigger signals. The inhibit logic (see section 2.1.5) generates a master inhibit signal that is distributed to the user stations via fan-out modules (see section 2.1.6). The Trigger Generator Module and the Programmable Delay Units are housed in a C-size VXI mainframe, connected to the IOC through a GPIB interface (see section 2.1.7).

The timing system is located in the experimental area, near the booster.

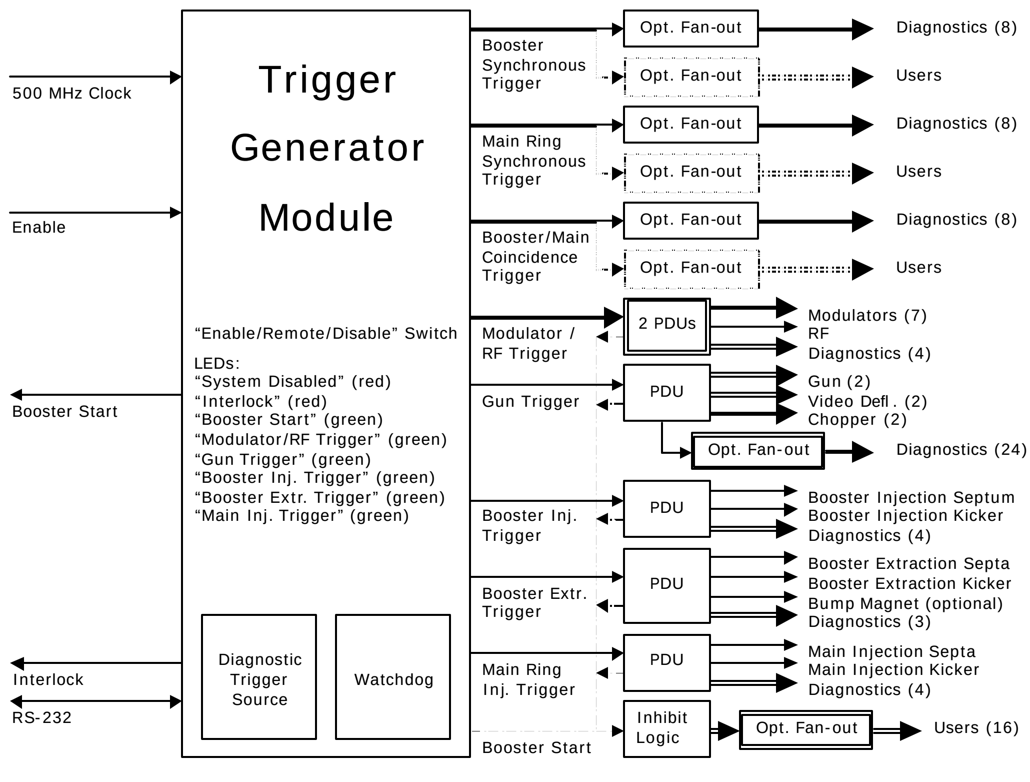


Fig. 1: Block diagram of the timing system.

### 2.1.2 Trigger Generator Module

The Trigger Generator Module (TGM) is a double-wide or triple-wide C-size VXI module, which will be designed at the CLS. The width of the module will be chosen to allow a convenient layout of the front panel. The TGM is the centrepiece of the timing electronics. It generates all required trigger signals, synchronized with the 500 MHz master clock, and it checks the status of the timing system and the 500 MHz clock for interlock conditions. The TGM is controlled by an on-board microprocessor with an RS-232 line for communication.

#### 2.1.2.1 Trigger Signals

The TGM generates the following trigger signals:

- Booster synchronous trigger: Continuous at a rate of 500 MHz ÷ 171.
- Main ring synchronous trigger: Continuous at a rate of 500 MHz ÷ 285.
- Booster / main coincidence trigger: Continuous at a rate of 500 MHz ÷ 855.
- Booster start, modulator / RF trigger, gun trigger, booster injection trigger, booster extraction trigger, main ring injection trigger: Generated by the on-board microprocessor at

a rate controlled by a serial line command, every 100 ms to 65535 ms. Each signal in this group of triggers can be disabled individually.

#### 2.1.2.2 Interlocks

The microprocessor monitors the status of the TGM for the following interlock conditions:

- Loss of 500 MHz clock.
- Enable input FALSE.
- Loss of RS-232 communication for more than 25 s.
- Microprocessor fault.

In the first case, the interlock condition can be checked via the RS-232 line. In all cases, the interlock is reported on the interlock output.

#### 2.1.2.3 Inputs

- 500 MHz clock: 0 dBm to 10 dBm sine wave, AC-coupled, SMA connector.
- Enable: Opto-isolated, FALSE = 0V, TRUE = 5-24V, insulated Lemo connector.

#### 2.1.2.4 Outputs

- Booster synchronous trigger: 2 identical outputs, Lemo connectors, NIM signal levels.
- Main ring synchronous trigger: 2 identical outputs, Lemo connectors, NIM signal levels.
- Booster / main coincidence trigger: 2 identical outputs, Lemo connectors, NIM signal levels.
- Booster start: 2 identical electrical outputs, Lemo connectors, NIM signal levels. 1 optical output, 820 nm LED, ST connector.
- Modulator / RF trigger: 2 identical outputs, Lemo connectors, NIM signal levels.
- Gun trigger: 2 identical outputs, Lemo connectors, NIM signal levels.
- Booster injection trigger: 2 identical outputs, Lemo connectors, NIM signal levels.
- Booster extraction trigger: 2 identical outputs, Lemo connectors, NIM signal levels.
- Main ring injection trigger: 2 identical outputs, Lemo connectors, NIM signal levels.
- Interlock: Solid state relay, isolated BNC connector. The relay opens to indicate any of the interlock conditions described in section 2.1.2.2. The relay is also open when the TGM is not powered up.

#### 2.1.2.5 Enable Switch

The TGM has a 3-position front panel switch “Enable / Remote / Disable”, which is mechanically locked. During normal operation, the switch is in the “Remote” position and the enable/disable-status of the module is determined by the logic level at the enable input.

When the TGM is disabled, the on-board microprocessor is reset and all trigger signals are inhibited except the booster synchronous trigger, the main ring synchronous trigger, and the booster / main coincidence trigger.

#### 2.1.2.6 Indicators

The TGM has the following front panel indicators:

- "System Disabled" (red LED): Indicates that the enable switch (see 2.1.2.5) is in the "Disabled" position, or the switch is in the "Remote" position and the logic level at the enable input is "false".
- "Interlock" (red LED): Indicates any of the interlock conditions described in 2.1.2.2.
- "Booster start" (green LED): ¼ s flash indicates a booster start signal.
- "Modulator / RF trigger" (green LED): ¼ s flash indicates modulator / RF trigger signal.
- "Gun trigger" (green LED): ¼ s flash indicates gun trigger signal.
- "Booster injection trigger" (green LED): ¼ s flash indicates booster injection trigger signal.
- "Booster extraction trigger" (green LED): ¼ s flash indicates booster extraction trigger signal.
- "Main ring injection trigger" (green LED): ¼ s flash indicates main ring injection trigger signal.

### 2.1.3 Programmable Delay Units

The Programmable Delay Units (PDU) are Highland Technology V951 C-size VXI modules (see attached spec sheet) with electrical and optical outputs (850 nm laser into 62/125 µm multimode fibre using ST connectors).

### 2.1.4 Optical Fan-out

The optical fan-outs are single-width NIM modules, which will be designed at the CLS. They have electrical inputs (NIM levels, Lemo connectors) and optical outputs using Hewlett Packard HFBR-1414 or HFBR-1414T drivers (820 nm LEDs with ST connectors). Each module has two channels with one input and eight outputs. The two channels can be combined into a 1×16 configuration by switching a front panel switch.

### 2.1.5 Inhibit Logic

The inhibit logic generates a master inhibit signal for distribution to the users. The purpose is to inhibit the user electronics during times of electrical noise (possibly during booster ramping or while the LINAC RF is on) or unstable beam (immediately after injection). The requirements for the master inhibit signal will have to be determined experimentally and will depend on the actual electric noise in the experimental areas, and the beam stability after injection.

The following signals are available as input signals to the inhibit logic:

- Booster start
- Modulator / RF trigger
- Gun trigger
- Booster injection trigger
- Booster extraction trigger
- Main ring injection trigger

The inhibit logic will consist of commercially available NIM modules using NIM signal levels. A sufficient supply of these modules should be available from the SAL nuclear physics electronics pool. The actual circuit will be determined when the requirements are known.

### 2.1.6 User Fan-out

Two optical Fan-outs (see 2.1.4) are used initially to distribute the master inhibit signals to 16 experimental areas. More modules can be added later, when the demand for inhibit signals increases. Fiber optic receivers, such as the Fiber Optic Oscilloscope Probe (see CLS document 2.1.73) or similar, will be made available to the users to convert the fiber optic signals to electrical signals.

### 2.1.7 VXI Mainframe and GPIB Interface

The VXI modules are housed in a C-size 13-slot VXI mainframe. The VXI is connected to the IOC through a GPIB-VXI/C interface.

## 2.2 Performance

The critical timing path (gun trigger output of TGM to video deflectors) has a jitter of less than ±500 ps.

## 2.3 Safety and Environmental

Not applicable.

## 2.4 Applicable Codes, Standards and Procedures

VXI: IEEE standard 1155.

NIM: DOE/ER-0457.

## 2.5 Quality Assurance

Not applicable.

## 2.6 Inspection, Testing and Commissioning

Not applicable.

## 2.7 Reliability and Maintainability

The air filters of the VXI mainframe and the NIM bin have to be cleaned routinely.

Spares will be kept for all modules, the VXI power supply, and the VXI fan unit. The MTTR for any of these units is of the order of a few minutes.

## 2.8 Layout

Not applicable.

## 2.9 Vibration and Acoustic Noise

Not applicable.

## 2.10 Services

120V AC, 30A.

### 2.11 Other Requirements and Constraints

Not applicable.

## 3. REFERENCES

Highland Technology V951 spec sheet.