Cilex-Apollon Synchronization and Security System*

Mickael PINA, Jean-Luc PAILLARD
LULI, CNRS, Ecole Polytechnique, CEA, UPMC, 91128 Palaiseau, FRANCE

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Cilex-Apollon is a high intensity laser facility delivering at least 5 PW pulses on targets at one shot per minute, to study physics such as laser plasma electron or ion accelerator and laser plasma X-Ray sources. Under construction, Apollon is a four beam laser installation with two target areas. Apollon control system is based on Tango. The Synchronization and Security System (SSS) is the heart of this control system and has two main functions. First one is to deliver triggering signals to lasers sources and diagnostics and the second one is to ensure machine protection to guarantee optical component integrity by avoiding damages caused by abnormal operational modes. The SSS is composed of two distributed systems. Machine protection system is based on a distributed I/O system running a Labview real time application and the synchronization part is based on the distributed Greenfield Technology system. The SSS also delivers shots to the experiment areas through programmed sequences. The SSS are interfaced to Tango bus. The article presents the architecture, functionality, interfaces to others processes, performances and feedback from a first deployment on a demonstrator.

SYNCHRONISATION SYSTEM

Synchronization system principle

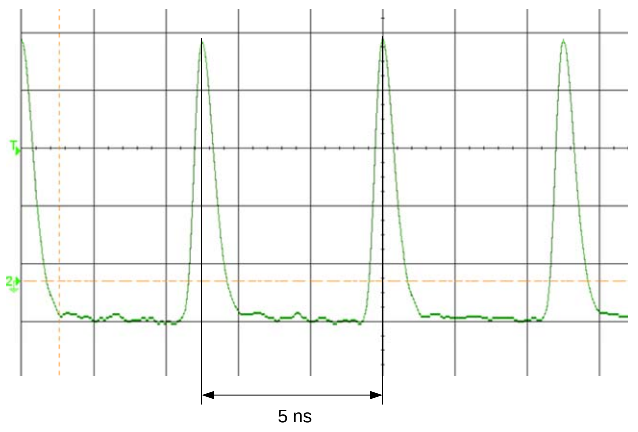

Figure 1 : Laser source's RF signal

The role of the synchronization system is to trigger devices synchronous to the laser. To be synchronous to the laser, the system receives an external clock delivered by the laser source (Figure 1). The devices need to be triggered with different amplitude signal, on different edges and with different performances.

To meet the requirements, the synchronization system has to:

1. be triggered by an external RF signal at 80MHz
2. be distributed (to provide signals throughout the facility)
3. be configured channel by channel (set amplitude, width, delay, trigger, trigger edge)
4. deliver at least 5 different frequencies
5. be scalable to evolve with the facility
6. deliver shot sequences

Apollon synchronization system

The Greenfield Technology system, after some evolutions, satisfies these requirements. The master clock is synchronized to the laser and delivers a data stream, through an optical fiber, to the slave modules.

Each channel parameters of each module can be configured by the supervision. The master manages simultaneously 2 shot sequences. To trigger all kinds of device the system is equipped by 2 kinds of delay generator : high performance delay generators and TTL delay generators. The table 1 shows the differences between the two generators.

Specifications	Type 1	Type 2 (TTL)
Amplitude	2,5V to 10V	2,5V to 5V
Pulse duration	100 ns to 10 ms	100 ns to 1 s
Jitter	< 20 ps rms	< 100 ps rms
Used delay range	< 5 ms	< 1 s
Delay resolution	1 ps	100 ps
Inverted signal	No	Yes

Table 1 : delay generators performances

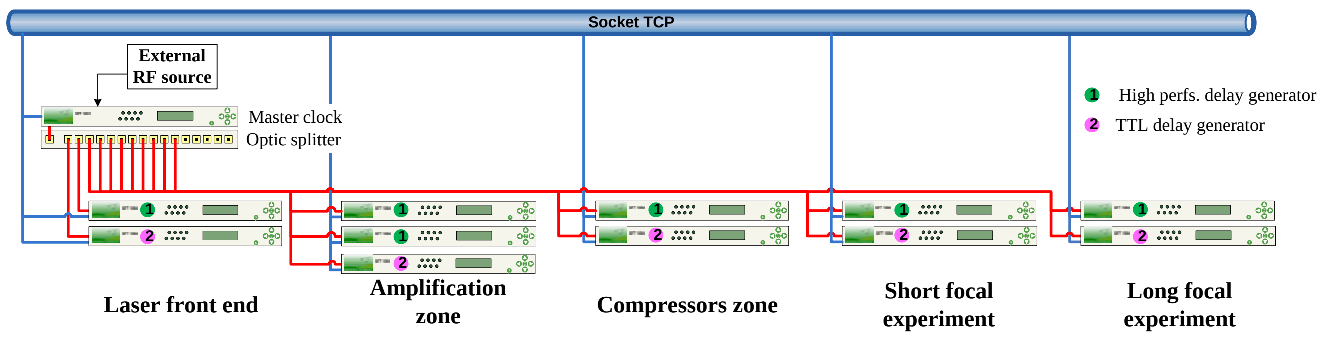

Figure 2 : Apollon synchronization system architecture

SECURITY SYSTEM

Technical requirements and equipments

The main function of the security system is to protect devices of the laser chain. It controls other kind of devices like; a changing energy device, the pump laser power supply, or exchange information with the other subsystems like the Personel Safety System (see the poster Cilex-*Apollon personel safety system*). Like the synchronization system, due to the size of the facility, the security system needs to be distributed. To build this system we chose an architecture based on a NI PXI master and remote I/O (see figure 4). The master runs a real time loop to control slaves and each module (master and slaves) is equiped of an FPGA board to control their I/O. To adapt to the different devices the system offers many kinds of I/O (5V, 24V, analog, relay outputs). The Figure 3 shows the architecture of the master.

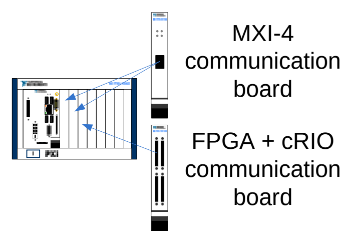

Figure 3 : The master architecture

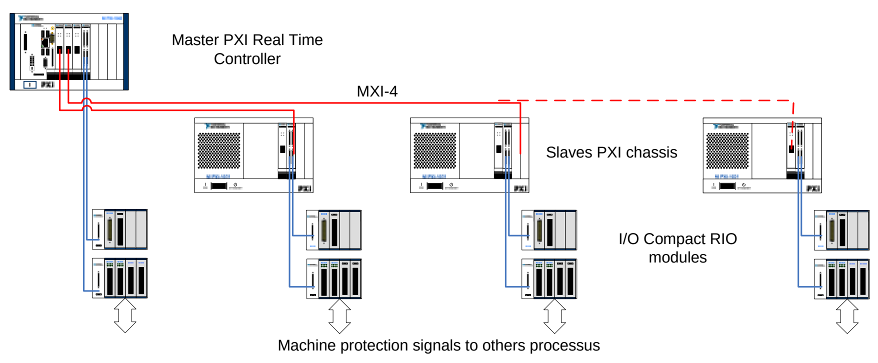

Figure 4 : The hardware architecture

Software architecture

The master runs 3 loops :
- an RT loop to control slaves
- an FPGA loop to control I/Os
- a TCP loop to communicate with the TANGO device server.

Slaves run only one FPGA loop

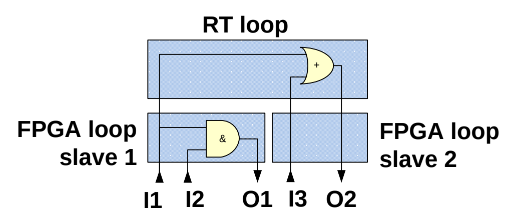

Figure 5 : I/Os management

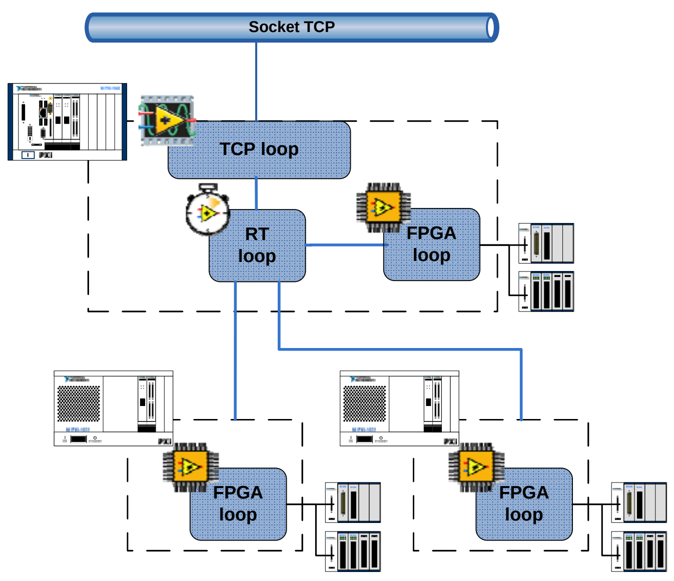

Figure 6 : Security system software architecture

This architecture permits to do some simple calculations on the module I/O in a very short time. The interface between I/O slaves is done by the RT loop. The TCP loop plus the RT loop link all I/Os of the system to the TANGO bus.

With this architecture the security system activates a security in less than 20µs if the calculation is done by the FPGA (Figure 5 output O1) and in less than 10ms if the calculation is done by the RT target (Figure 5 output O2)

SYNCHRONIZATION AND SECURITY SYSTEM ARCHITECTURE

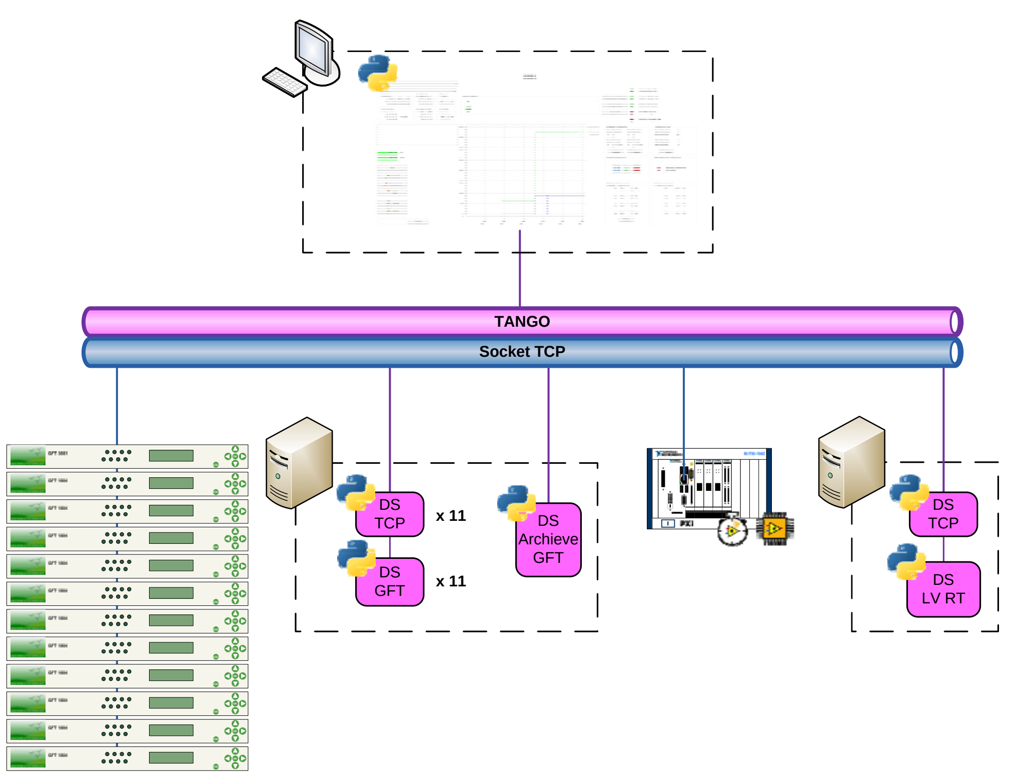

Figure 7 : general software architecture

The security system is part of the global Cilex-Apollon command control system, so it is interfaced to TANGO. To integrate the security system in TANGO we use a TCP device server to establish the communication between RT target and its driver. The same architecture is used to control each delay generator. An archiver permits to save the configuration of the synchronization system (see Figure 7).

To resume, the synchronization and security system delivers different signals to trigger the devices of the facility, to control security devices asynchronous or sychrounous to the laser or shots sequence (synchronous channels are security channels triggered by the synchronization system) (see Figure 8).

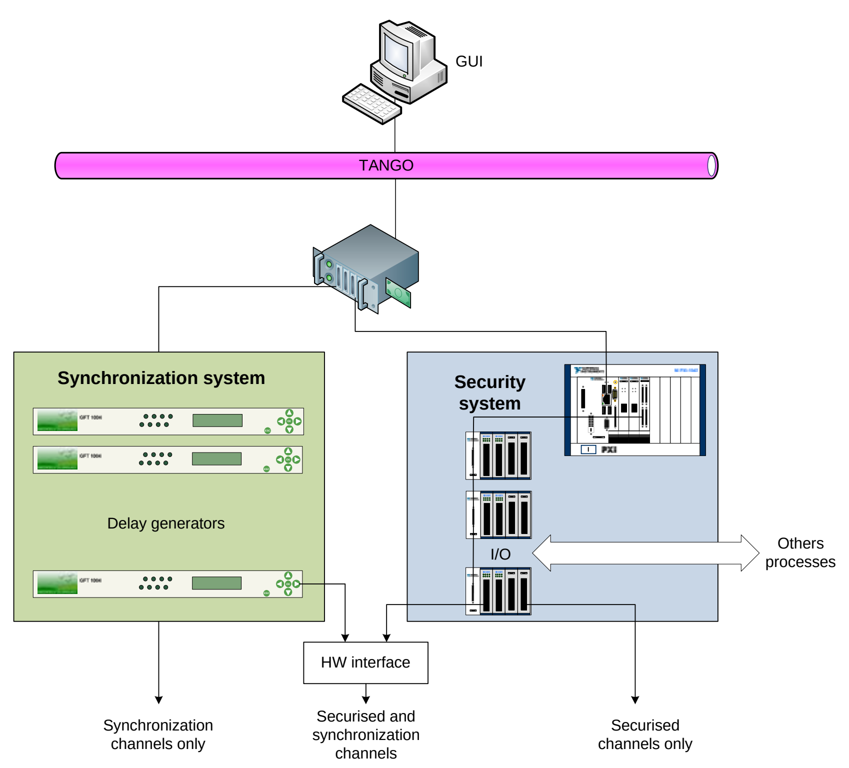

Figure 8 : The synchronization and security system channels

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