CILEX-APOLLON SYNCHRONIZATION AND SECURITY SYSTEM*

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Abstract

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 an important part of the Apollon control system. The article presents the architecture, functionality, interfaces to others processes, performances and feedback from a first deployment on a demonstrator.

FUNCTIONS OF THE SSS

The SSS has two functions. The 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. Fig. 1 gives the architecture of the SSS. Machine protection system is based on a distributed I/O system running a Labview real time application and the synchronization part is based on a distributed and customized commercial system. The SSS also delivers shots to experimental areas through programmed sequences. The SSS is also interfaced with Tango bus.

GLOBAL ARCHITECTURE

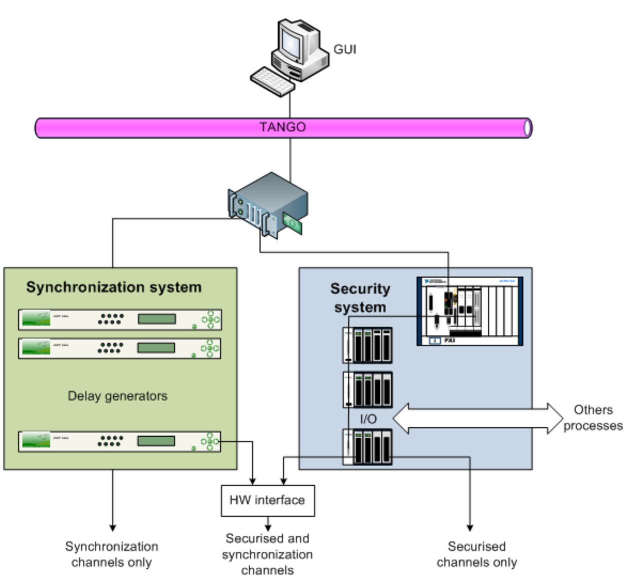

Figure 1: SSS architecture.

The SSS consists in two distributed systems both using a dedicated optic fiber network. The two systems don't communicate to each other but they work together to supply triggering channels with integrated security functions. Fig. 1 gives the three cases of channels encountered on Apollon facility. On the bottom left, the first case is a pure synchronization channel which delivers a trigger signal for a pulse laser for example. On the bottom right is the case of a pure security channel driving a beam shutter for example, and in the middle a mixed channel both driven by a synchronisation channel and validated by a safety output channel. On the right side, we find links with others processes such as laser diagnostics (to ensure machine security when a beam default is detected) and the Personnel Safety System (PSS) [1] of Apollon facility.

Both subsystems are controlling by a front end processors running device server applications to communicate with Tango bus.

SYNCHRONIZATION SUBSYSTEM

Description

Apollon synchronization system consists in a master clock synchronized with an 80 MHz RF signal supplied by a photo detector installed in the laser oscillator source. This pulsed signal is amplified and filtered before injection in the master clock module. Its function is to deliver a serial data stream synchronized with the RF laser signal, to the delay generators despatched all over the facility. The data stream contains time bases made of five frequencies for recurrent trigger signals and top triggers for sequence of shots. In addition, delay generators can generate two other local reference frequencies synchronized with the data stream as well. This system was supplied by Greenfield Technology Company which has customized and optimized characteristics of its system to meet Apollon requirements.

Figure 2 gives an overview of the synchronization system. Red lines are relative to the dedicated optical network, while cyan lines are relatives to Ethernet. The system is scalable and can manage up to 256 delay generators. Distances between the equipment exceed several hundred meters without trouble.

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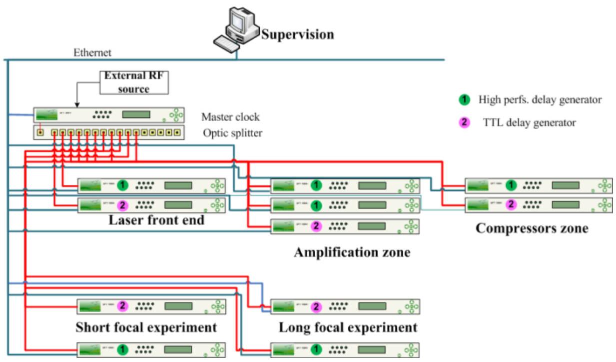

Figure 2: Architecture of the synchronization system.

Delay Generators and Performances

Two models of delay generators can be used in the system. Both can be triggered through the optical network. All of them are equipped with ten outputs which can be programmed through the supervision level GUIs. Delay generators of the first type have optimal performances and can deliver signal of up to ten volts in fifteen ohm with less than 20 ps rms jitter, relative to the RF signal and with a 3 ms delay. Delay generators of the second type deliver TTL signals with 100 ps rms jitter. type 1 applications include precise triggering such as pockels cells, pump lasers, high speed diagnostics such as streak cameras, while type 2 is used for general triggering with the advantage on this type to invert the output signal. The Table 1 resumes delay generator performances.

Table 1: Delay Generator Performances

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

Shot Sequences

Apollon is a facility composed of a laser part and two experimental areas. The laser is designed to provide one shot per minute to a target area at a time. The second target area is in preparation but may take a beam for adjustments occasionally. Target areas use laser beams depending on the type of the target. Most targets are multi-type shots to limit unused time of the facility. Operating laser shots in target areas follow a temporal typology according to a sequence of bursts defined by four parameters: number of bursts, shots per burst, burst period, shot period in each burst.

All functionalities of sequencing are supplied by the synchronization system master clock and are managed with the Tango client software presented below.

MACHINE SECURITY SUBSYSTEM

Architecture

The Apollon machine security system is based on a PXI distributed system using a dedicated fiber optic network. A master PXI real time controller communicates with other slaves PXI dispatched in the three zones of the laser part of the facility. These stations are equipped with FPGA card controlling I/O modules. Fig. 3 gives an idea of the system.

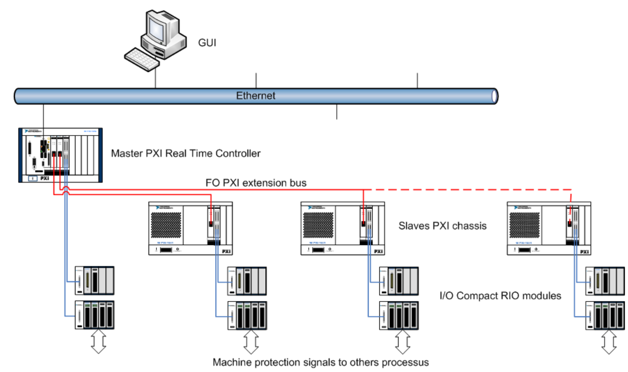

Figure 3: Machine security architecture.

Security functions are divided into two levels. A first level of functions is managed by FPGA cards embedded in each PXI slave. These functions are used when small time reaction is necessary, i.e. less than 10 ms. An upper level of functions are managed by the real time target application in the PXI master chassis. The loop time is adjusted to 10 ms.

The target is a RT Labview application which can access to all the I/O in the slaves of the system. The Tango interface is described in the next section.

Performances in terms of reaction time for an output compared to an input, both localised on different slaves, are : 80 µs for the level 1 including reaction time of output modules equipped with filters, and 10 ms for the level 2.

SOFTWARE

The object oriented distributed system Tango [2] was selected by the LULI software team as the middleware of the Apollon control system. Tango is appreciated for its features, its modernism and in the package a lot of tools to manage the system. The software part of the SSS allows the operator:

- to have an overview of the Apollon facility concerning machine security and synchronization.
- to adjust the parameters of synchronization channels.
- to adjust parameters of the sequence.
- to start, follow, spot, suspend, and restart the sequence.

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Tango Interface

The SSS is interfaced to Tango by custom device server software modules. These two device servers communicate with both subsystems through a TCP socket protocol. On the upper level two dedicated device servers publish objects to the Tango bus. These modules are running on the same front end computer.

Figure 4 gives an overview of the software architecture. All the modules are developed in Python.

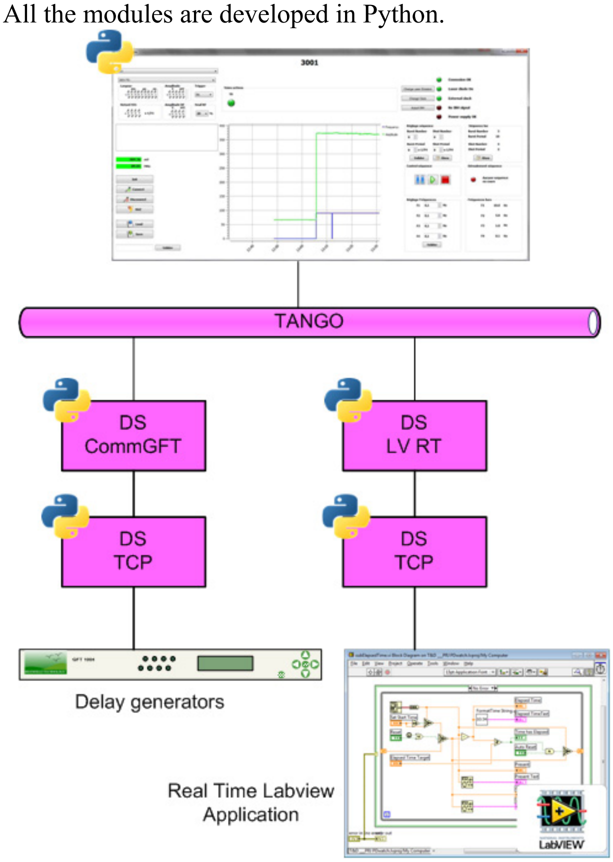

Figure 4: Software architecture.

Graphical User Interface

Among the solutions to make Graphical User Interface with Tango, Apollon chose Python language and Labview. SSS GUI is developed in Python with PyTango and PyQt. Fig. 5 shows the GUI of delay generators.

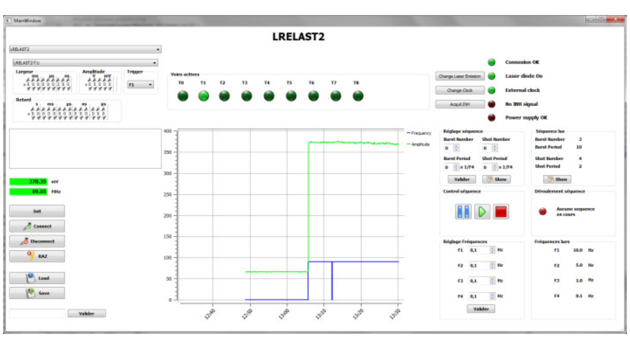

Figure 5: GUI for delay generators.

CONCLUSION

Cilex-Apollon, like others medium and large scale laser facilities, requires a distributed synchronization system. Cilex-Apollon requires also a distributed machine security system. These two systems form the SSS which has been integrated in the distributed control system based on Tango.

REFERENCES

[1] J-L. Veray and al, “Cilex-Apollon Personnel Safety System”, MOPPC044, these proceedings.
[2] TANGO home page: www.tango-controls.org

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