DG-301I-17 Three Channel Delay Generator

User MAnual Rev. F

Soluciones y Tecnologías de Control

Embebido SAPI de CV

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Environmental Specifications

The Pulse Generator device with Programmable Delays, model DG-3O1I-17 is designed to work indoors, according to the following ranges.

- Temperature Range: 10 ° C - 40 ° C
- Maximum Relative Humidity: 80% without condensation and temperature above 31 ° C.
- External Power Supply: 8VDC -12VDC, 2.5W.
- Power Supply from USB bus: 5VDC, 2.5W with electrical isolation[1] .

Feature of Secure USB by Electrical

The equipment, to which the DG-3O1I-17 device is commonly connected, can work with potentials and high voltage signals (~ 10kV), for example laser equipment with active optical switches. Such potentials can, due to installation error or loss of insulation, find a way to low voltage (~ 5V) control lines damaging sensitive equipment. Therefore, the DG-3O1I-17 has a SECURE USB for your computer equipment; for being designed according to industrial techniques and components that provide electrical insulation according to standards.

- UL: 2500 V rms for 1 minute, conforming to UL 1577
- CSA # 5A Component Acceptance Notice
    - IEC 60950-1: 600 V rms
- VDE Certificate of Conformity
    - DIN V VDE V 0884-10 (VDE V 0884-10): 2006-12 VIORM = 560 V peak

Therefore, high voltage pulses that may be applied by mistake to the input or outputs of the DG-3O1I-17, will not be transmitted to the computer equipment or to the external power supply. The protection is in both directions, that is, some damage to the computer or transitory equipment in the power line, nor will it be passed to the DG-3O1I-17 output lines..

[1] If the equipment is powered from the USB bus only, note that the output levels will drop to approximately 4VDC. If the equipment to be synchronized accepts these levels, there is no problem, otherwise, to obtain TTL output levels of 5VDC nominal, use alone or together with the USB the external power supply provided with the equipment.

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Unpacking and Inspection

Unpacking your Delay Generator

Your Delay Generator equipment was packed with great care and the container inspected before shipping, so it leaves our facilities in good condition. Upon receiving your equipment, immediately inspect the exterior of the container. If you find any major damage (box holes, crushed areas, etc.), insist that a shipping company representative be present when unpacking the contents. Carefully inspect and videotape the equipment as you unpack it. If any damage is evident, such as scratches or dents on the chassis, broken glass display, broken or bent connectors, etc., immediately notify the carrier and the seller. Secure the shipping box. If a claim is drawn up, it may be necessary to show the damage and that it was as a result of the shipment. Also, if you need to return the equipment for any update or repair, the original packaging may be useful.

Components included

When you receive your container, verify that at least the following items are present:

1. The Delay Generator DG-3O1I-17
2. Wall eliminator with 9VDC output and 100VAC - 220AC input
3. A commercial invoice or final component list (useful in case of adding an optional accessory to the shipment, such as a power spigot adapter for a region other than America).

Security advice

ATTENTION: It is recommended for safety that before connecting the DG-3O1I-17 equipment to a laser or other external device; the input and outputs of the DG-3O1I-17 are configured in terms of the type of logic, see sections "Equipment Configuration and Control from Touch Screen**" page 11. Additionally, try:**

- **that the laser or other external equipment is turned off or its inputs are disabled during adjustment of the DG-3O1I-17's input and output logic**
- **Before turning off the delay generator, first turn off the laser or external equipment, see section "**Turning the DG-3O1I-17 On and Off**" on page 9**

If a DG-3O1I-17 output is modified in terms of output logic, a level change will occur in it, for example from 0V to 5V and the external laser that is connected to said output can detect the pulse as a command to perform a laser shot, so if the proper precautions are not taken you would inadvertently get a laser shot, with the risks that this implies.

So, know well the levels present in your system to control and if you will modify the output logic or trigger edge of the "hot" input, consider the precautions for laser shots or possible activations of the external system. Changes in delay or width of the output pulses do not affect that the equipment outputs emit pulses.

Technical characteristics

- Model DG-3O1I-17
- Three independent TTL outputs
- The outputs are configurable as to type of logic (positive / negative), width of the output pulse and delay with respect to the input event
- Outputs with protection against external short circuits and surges
- The input can be configured to respond to the rising or falling edge event of a compatible TTL input pulse, but also supports 10V amplitude pulses
- Optional control and power from the USB bus
- Optional external power supply in DC-IN barrel connector: 9VDC - 12VDC
- Maximum consumption of 2.5W
- Delay Range 0.1 us - 6553.5 us
- Delay Resolution: 0.1 us
- Pulse Width Range: 0 us - 65535 us
- Pulse width resolution: 1 us

Introduction

The DG-3O1I-17 delay generator is a device based on an FPGA programmable gate array device. The latter allows to have an input and three really independent output channels. Control of the device is carried out both from its touch screen and from a personal computer or laptop (PC) through a USB serial bus and a computer application running on the PC. The use of a PC is optional, useful for example to operate the DG-3O11-17 as part of an automated installation.

The DG-3O1I-17 can be understood as a device that with one input stimulus pulse generates three output pulses. These output pulses are generated some time after the input stimulus and with the following properties:

1. The delay between the input stimulus and the pulse of a given output is adjustable and independent of any other output
2. The pulse width of an output is adjustable and independent of any other output
3. The digital logic[2] of a given output is adjustable and independent of the logic of any other output

Fig. 1. Delay Generator front panel with input (IN) and outputs (OUT)

The figure above shows the panel with BNC connectors for "IN" input and "OUT" outputs. To the left of each connector there is a light indication that can be yellow or red, depending on whether the voltage is 0V or + 5V, respectively. In this way, when we connect a BNC cable to the input, observing the color of the "IN" light indicator, we can determine the high or low level presented.

[2] In our case, by output with positive [negative] logic we will understand an output whose signal level always remains at "0V" ["5V"] and only goes to high [low] or "5V" ["0V"] during emission of a pulse.

By changing the logic type of an output, the corresponding indicator will also change color. In negative logic, for example, the output will remain high at all times and the indicator light will be red, and will only change to low during the pulse width time that has been configured in said output. For outputs, also consider that for small pulse widths, ~ 1 ms; the change of color of the light indicator during the generation of the pulse, would go unnoticed to the naked eye.

The following figure shows the rear panel of the delay generator, which contains a USB connector for data communication with a PC and / or power supply. To the far right of the rear panel is the 9VDC-12VDC power connector. The device can be powered either from the USB bus (connected to a PC or a cell charger), or from the DC-IN connector of 9VDC-12VDC, or both options at the same time. Internally DC-IN will be chosen to decrease the consumption of the USB bus; but if DC-IN fails or is removed while USB power is present, the device will automatically continue uninterrupted power from the current source.

Fig. 2. Rear panel of the Delay Generator with USB port and 9VDC-12VDC Power input, touch screen is also shown

The figure above also shows the area of the touch display. From the latter, parameters such as:

- The Logic of Entry
- The Output Logic
- The Delay at each Exit
- The pulse width of each output

- The input Pulse counter[3]

Input

The input is based on a 50 Ω impedance BNC connector; TTL type (with extended capacity for pseudo-square pulses and up to 10VDC). The input has over-voltage protection, so momentary input pulses outside the allowed range will be virtually short-circuited to prevent them from entering the rest of the delay device modules.

An input stimulus can be the positive or negative edge of a square, triangular, or square-like pulse, or a packet of input pulses, the amount of which is defined with the input counter option. The input supports TTL pulses with voltages between 0V and 10V. This allows the direct interconnection of a module for detecting short laser pulses, which although the output signal of said photodiode module is analog, for being of short duration (in the order of tens of 10^{-9}s), it is closer to Virtually a square or triangular pulse with a very steep rising and falling edge, so it will be detected by the delay generator without major complexity.

Outputs

Like the input, the outputs are also BNC and TTL type, with a nominal impedance of 50 Ω, protection against short circuits and external overvoltages. They have a current capacity of 80 mA and a maximum output voltage of 5VDC.

Internal Structure of the Delay Pulse Generator

The following figure shows in a simplified way the structure or internal logic of the Pulse Generator with Programmable Delays DG-3O1I-17.

[3] The function of Counting pulses at the input will be detailed later, but basically allows the Device to activate the outputs only when a certain number of pulses have arrived at the input. This is useful, for example, in multipulse lasers, to trigger the spectrometer only with the arrival of the nth laser pulse and not only in the first one. Another use is to activate a spectrometer and a Q-switch every certain number of flash lamp shots, so our laser would maintain a high frequency of flash flicker while the Q-switch and the spectrometer only activate at a submultiple of the flash lamp frequency.

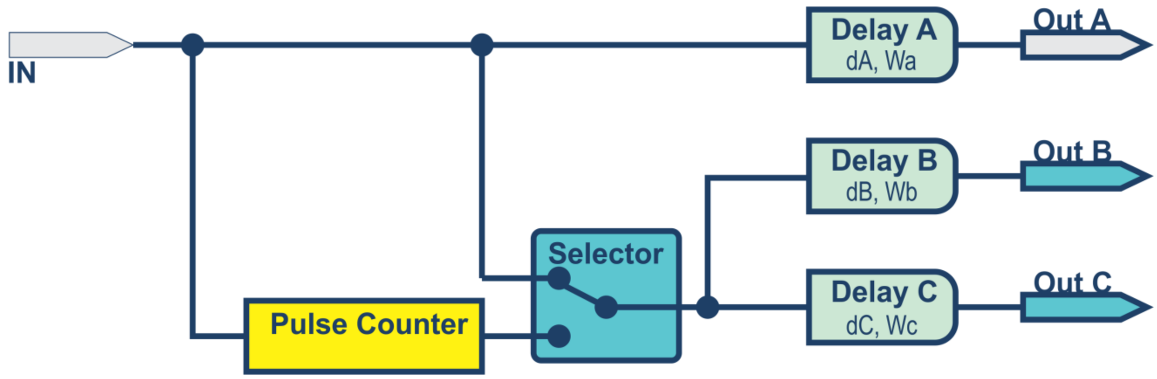

Fig. 3. Structure or internal logic of the delay generator

In the previous figure, we have the following blocks:

- IN: It is the Pulse input to the equipment
- Out A, Out B and Out C: These are the pulse outputs of the equipment
- Pulse Counter: Counter block of the pulses that enter through IN, emits a pulse towards the “Selector” block every time the count programmed by the user is reached from the equipment's touch screen.
- Selector: Block that selects between the “IN” input or the “Pulse Counter” output to connect to the delays of the “Out B” and “Out C” outputs
- Delay A: Block that performs the delay function for the “Out A” output, receives a pulse directly from “IN” and a configurable “dA” time, then emits a pulse in “Out A” with a duration or value width "Wa"
- Delay B: Block that performs the delay function for the “Out B” output, receives a pulse from “IN” or from “Pulse Counter” depending on the position of the “Selector” and a configurable time “dB” then emits a pulse in "Out B" with a duration or width of value "Wb"
- Delay C: Block that performs the delay function for the “Out C” output, receives a pulse from “IN” or from “Pulse Counter” depending on the position of the “Selector” and a configurable “dC” time then emits a pulse in "Out C" with a duration or width of value "Wc"

Note that the "Out A" output differs from "Out B" and "Out C" in that the latter can receive a pulse from the "Pulse Counter" module or directly from "IN", depending on the position of the "Selector" module, but "Out A" only receives pulses directly from "IN" through its "Delay A". Such configuration of outputs allows in those applications where it is necessary to control the firing of a flash lamp from the DG-3O1I-17 uninterruptedly, while an optical switch (Q-switch active) is activated only every certain number or count of shots in the flash lamp. Then, the control of the flash lamp would be taken directly from "Out A" while the active Q-switch would be controlled from "Out B" and a third external component, for example an optical spectrometer, would be controlled from the output "Out C " For the input configuration menu and to activate the counter, you can consult page 12 of this manual.

The following figure shows the behavior of the outputs when the retarder is configured with delays "dA", "dB", "dC" and pulse widths "Wa", "Wb" and "Wc" respectively on the output channels "Out A ",“ Out B ”and“ Out C ”, while the“ IN ”input is configured to use the rising edge of an input pulse as“ zero ”time or reference to start the delays of each output. During the emission of a pulse in some output channel, said channel will not attend to another event in the input channel, and this does not affect neighboring channels.

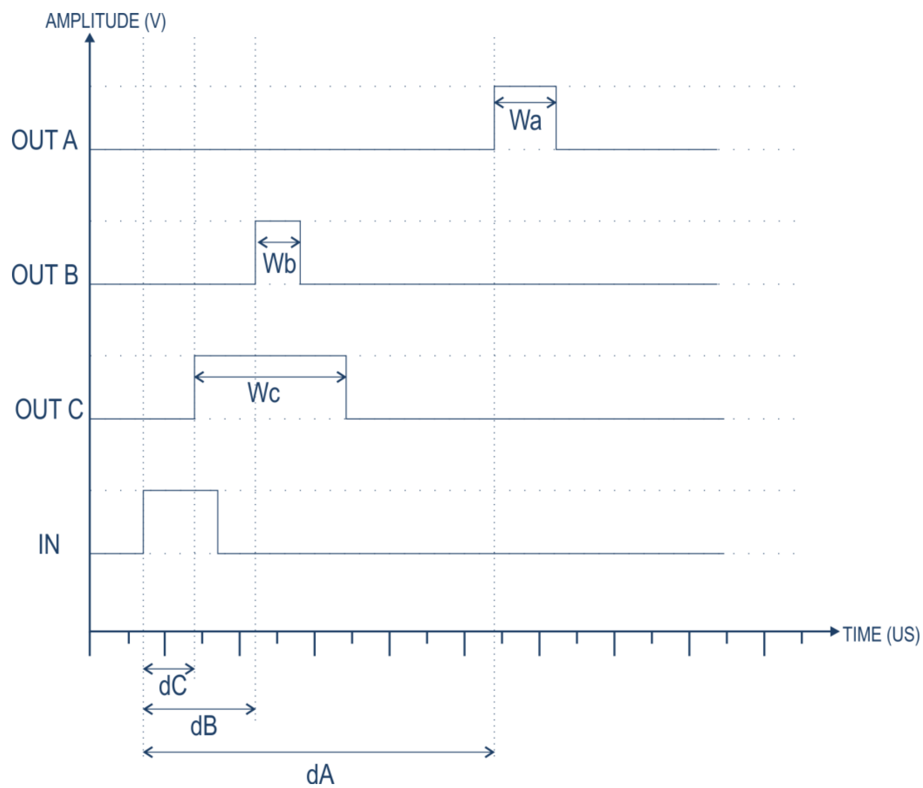

Fig. 4. Behavior of the outputs with respect to an input pulse, pulse counter deactivated

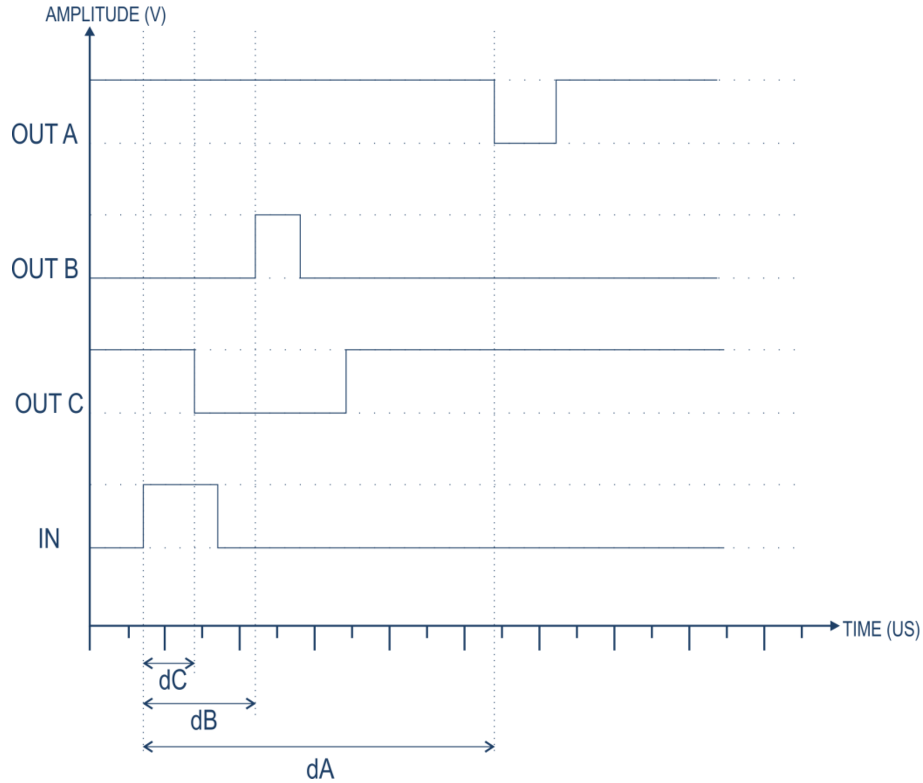

Fig. 5. Behavior of the outputs with respect to an input pulse, pulse counter deactivated and with output channels C and A in negative logic

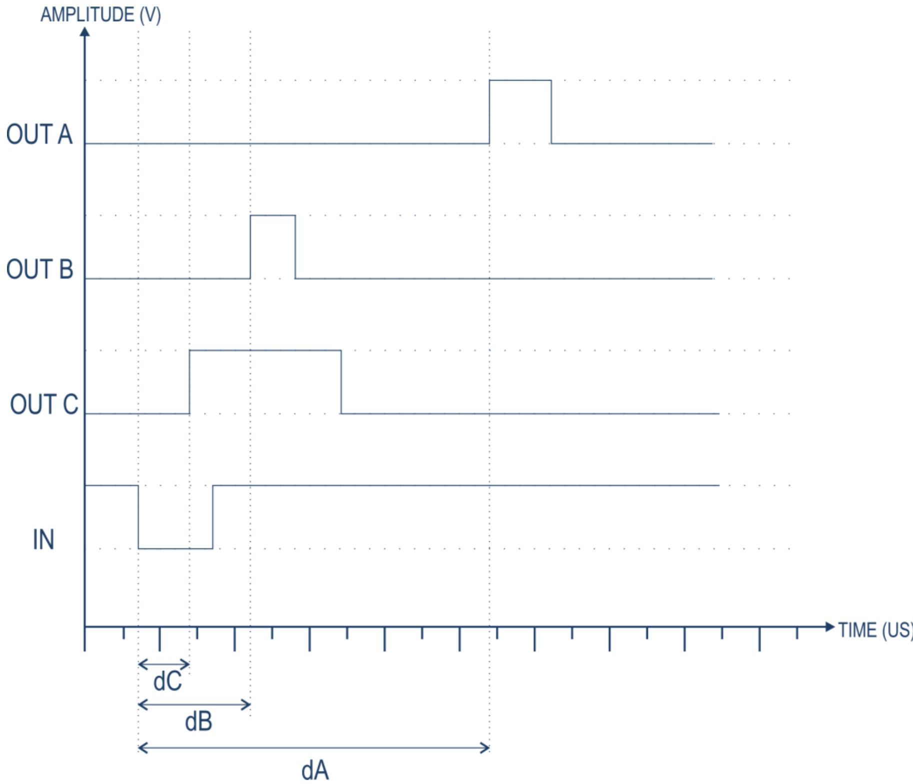

Fig. 6. Behavior of the outputs with respect to a negative logic input pulse, with falling edge detection activated at IN input

Device behavior activating the pulse counter

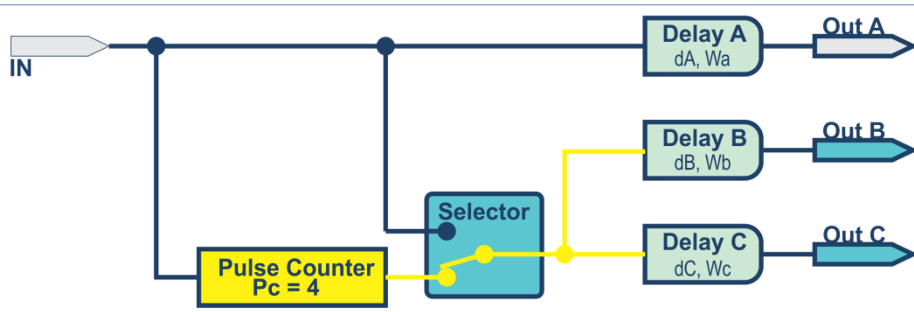

Fig. 7. Structure of the Delay Generator when the Pulse Counter is activated, in the example it was configured to detect 4 rising edges

The following graph shows the behavior of the outputs with respect to successive "IN" input pulses. Note that the output channel "Out A" emits a delay pulse "dA" and width "Wa" for each rising edge detected in "IN", while the outputs "Out B" and "Out C" emit their pulses with delays and widths "dB", "Wb" and "dC", "Wc", respectively when the pulse count configured in the "Pulse Counter" module is reached, in the case of the example it was configured to count four edges of rise at the "IN" entrance.

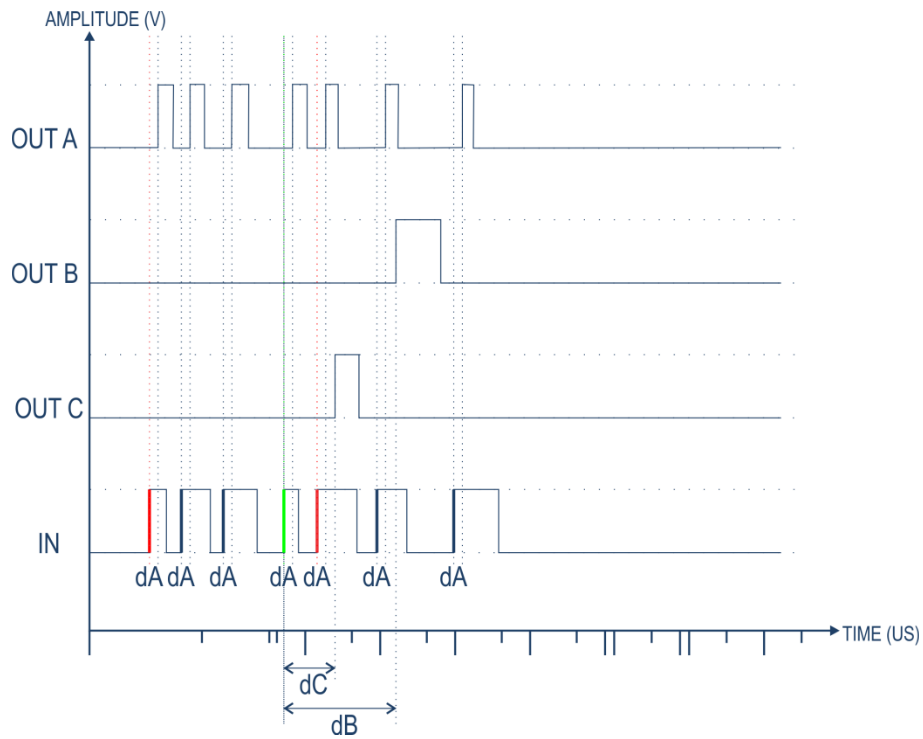

Fig. 8. Behavior of the outputs with the Pulse Counter activated to detect 4 rising edges, regardless of the time variation between input edges

About the input parameter "Wait Time"

It should also be mentioned that in the input configuration “IN” (see page 12), there is a parameter called “wait time” in units of microseconds. This parameter is only used when the pulse counter is activated and defines the time pause to be made after making a total count and before starting the next count. During the wait time the equipment will not consider new pulses.

Using the Delay Generator as a Bounce Filter

It was previously mentioned that during the emission of a pulse in one channel, the latter will not attend to another input event and that this does not affect neighboring channels. This feature can be used by the user to obtain clean “bounce” delay outputs. For example, if you know that two consecutive short pulses are eventually received at the input, but you only want to consider the first one, then you can configure an output with the minimum possible delay and a pulse width in said output greater than the total period of the received pulses. In this way, the Delay Generator will not attend to the second short input pulse and would obtain only one output pulse without the inconvenience of bouncing.

Material and Mechanical Dimensions

- 158.28 mm X 130 mm X 37.4 mm . The housing is made of anodized aluminum.

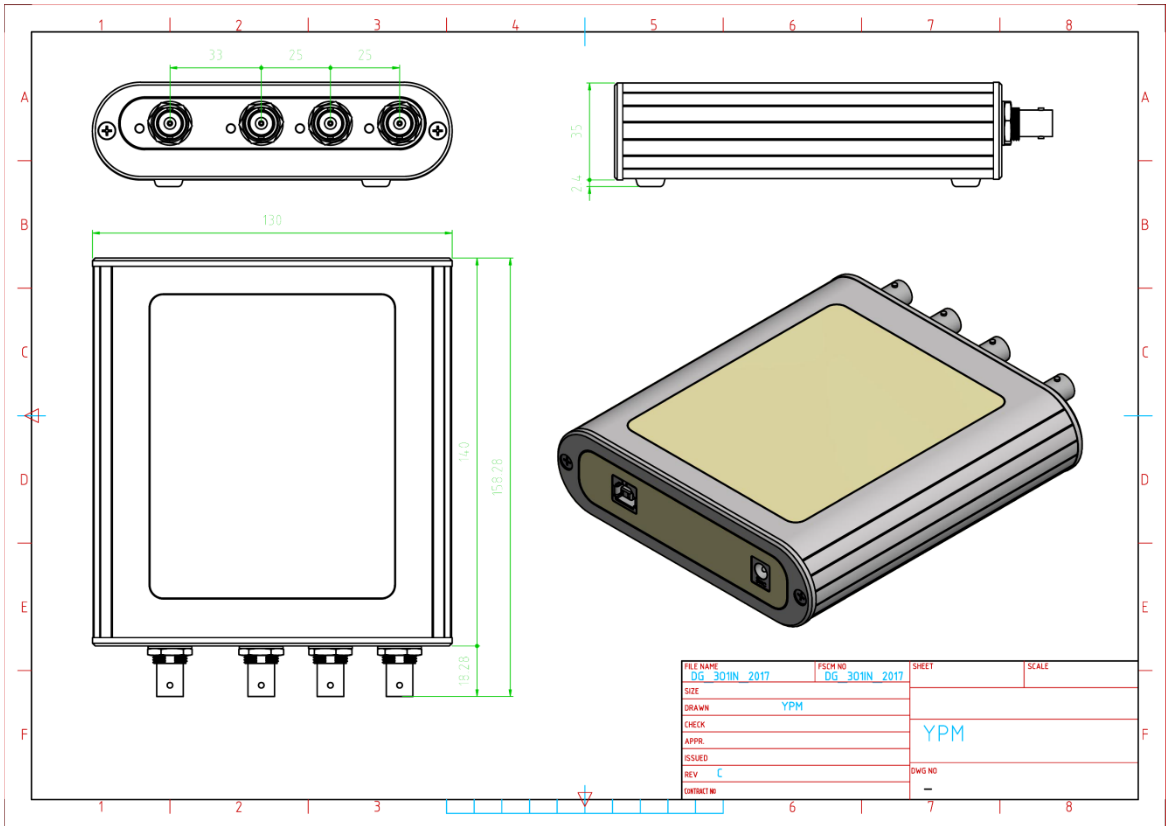

Fig. 9. Delay Generator Dimensions

Turning the DG-3O1I-17 On and Off

The equipment is powered on as soon as the 9VDC-12VDC DC-IN power supply is connected to the DG-3O1I-17, or to the USB bus of a PC or Cell phone charger. The equipment has a low power consumption of 2.5W maximum. At the end of a day, it is recommended to first turn off or disconnect the laser connected to the DG-3O1I-17 and then disconnect the external power supply from the delay generator. In the case of power from the USB bus of a PC, keep in mind that when turning off the PC the USB bus can remove the power from the retarder, and the output lines will remain or go to low level or 0V which could activate processes of shot on the laser or external device.

In summary, it is recommended that the shutdown of the DG-3O1I-17 be performed after securing or disconnecting the laser or equipment connected to the retarder and then switching off the external source, PC or USB charger of the DG-3O1I-17.

Equipment Configuration and Control from Touch Screen

When energizing the DG-3O1I-17 equipment, its inputs and outputs will be automatically configured with the last configuration used. When turning on the equipment, the home screen similar to the one shown in the following figure will appear on the touchscreen.

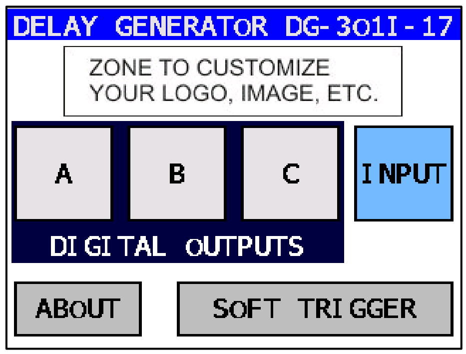

Fig. 10. Delay generator home or main screen

From the home screen you have access to the configuration of the three output channels or "DIGITAL OUTPUTS", called "A", "B" and "C" and which correspond to the BNC connectors marked with the same name on the panel front of the equipment, see Fig. 1 on page 1. Likewise, the touch button called "INPUT" allows access to the input channel parameter configuration window.

The area marked "ZONE TO CUSTOMIZE YOUR LOGO, IMAGE, ETC." is a graphic area for the user to locate the logo of your company or institution or other relevant information. For example, the following image shows this personalized area according to the requirements of the laser laboratory of the La Plata Optical Center[4].

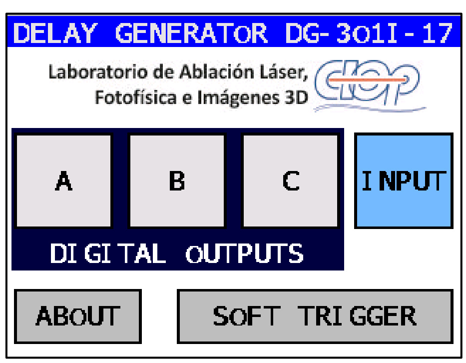

Fig. 11. Home screen with custom zone

[4] https://ciop.conicet.gov.ar/

For the personalization of the home screen, the user can send a file in JPG format with their design, the dimensions must be 270 x 50 pixels. You can also leave the customizable area blank.

In addition to the "DIGITAL OUTPUTS" and "INPUT" buttons, the home screen shows a "SOFT TRIGGER" and "ABOUT" button, these will be described in subsequent sections.

Configuring the Input Channel

By pressing the touch button denoted by “IN” on the main screen (see Fig. 10), you will access the input channel configuration screen, similar to the following figure.

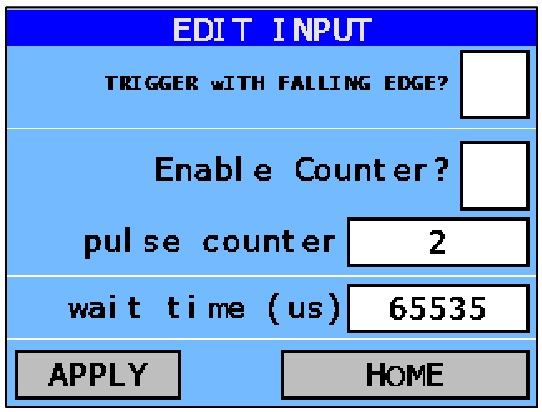

Fig. 12. Pantalla de configuración del canal de Entrada

When accessing a window, the quantities displayed by each control are those currently configured on the equipment. To modify them, press on the control or indicator in question, which will open a numeric keyboard. The input parameter named "wait time" was mentioned on page 8.

Tabla 1. Input Channel Controls Description

Control	Range of Values	Function
“Trigger with falling edge?	Mark/No Mark	Without checking, the output pulses will start their delays with respect to the positive edge of the input pulse, that is, when the input changes from "0V" to a voltage between "2.5V - 10V". If checked, then the equipment will only respond to negative edges of an input signal, that is, when the input is changed from a high potential of "2.5V - 10V" to a lower potential of "2V".

"Enable Counter?"	Mark/No mark	Without checking, the equipment works in normal mode, each input pulse will be followed by pulses at the outputs with their respective programmed delays. If checked, then pulse counting will be enabled and pulses on the output channels will only be output when a certain number of input pulses are counted.
"pulse counter"	1 – 255	This control only takes effect if "Enable Counter?" It is marked. Defines the number of pulses that must arrive at the input before generating delayed pulses at the outputs. If said control is set to a value, for example 3, then it will be the third input pulse that will be used as a reference for the output pulses with their respective delays with respect to said third pulse..
"wait time (us)"	1 us - 65535 us	This control only takes effect if "Enable Counter?" It is marked. It is a time pause. Defines the maximum time that the equipment will pause before restarting its counter after the arrival of a packet of "n" pulses according to "pulse counter". If pulses reach the input during the wait time, they will not be considered for the count. After the waiting time, the internal counter will be ready before a new pulse train.
"APPLY"	-	By pressing this button, the values that have been defined in the previous controls will be applied to the DG-3O1I-17 immediately.
"HOME"	-	Pressing this touch button will return to the main window Fig. 11.

As mentioned in the previous paragraph, to modify a value, simply press on the control to modify on the touch screen. The following figure exemplifies the case in which the user pressed the "pulse counter" control and entered the number 20 to define that the input will wait for the arrival of 20 pulses and in the last received pulse, the delays will be activated. Note that this situation is not identical to introducing a certain delay with respect to the first pulse, since the time between pulse and pulse of the input packet could be random, as it happens in some multipulse lasers with saturable passive type optical switch (Q-Switch passive). Then, to obtain a synchronism always with respect to the same pulse different from the first, the input pulses must be counted and only with respect to the desired pulse emit the delays, thus respecting better synchronization than that possible to maintain only with respect to the first detected pulse[5].

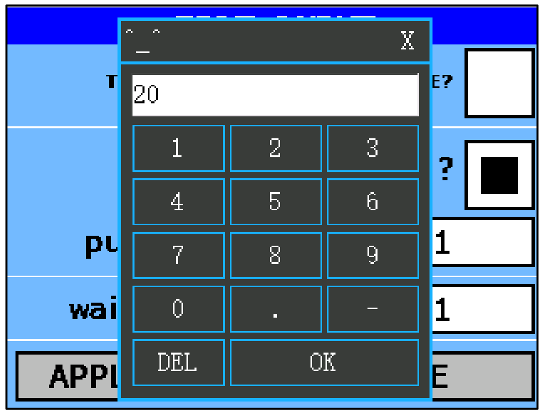

Fig. 13. Numeric keypad Modifying the number of pulses to count on input IN

The numerical keyboard of the previous figure allows deleting the current value using the "Delete" or "DEL" button and with the rest of the keyboard inserting a new value. To finish editing, press the "OK" button and return to the starting window to continue editing other values. The following figure shows the pulse counter once modified from the numeric keypad.

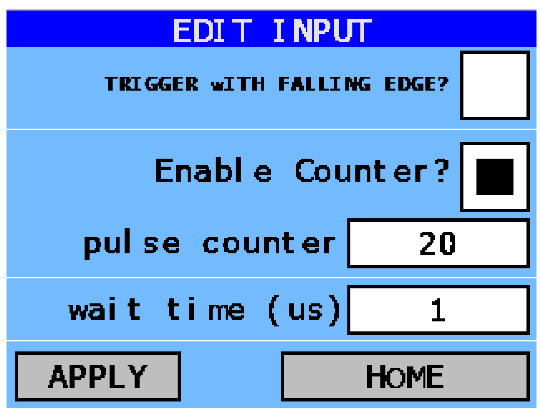

Fig. 14. Pulse counter enabled for 20 rising edges, the pause time before counting again 1us input pulses

When finished editing the input channel parameters, you must press the "APPLY" button so that they are applied and loaded into the unit's memory. You can then return to the home screen (Fig. 10 on page 11) by pressing the "HOME" button.

[5] Patent pending, file Mx / a / 2018/014622.

In the title section “Example of Connection with commercial Quantel USA Laser with Source and Control Type ICE450” on page 27, An application of the pulse counter is described, for the control of the active optical switch (Q-switch active), and thus obtain a low opening frequency of the Q-Switch while the firing frequency of the flash lamp is high, which results in optimal working conditions of the laser head by respecting the lamp frequency and the thermal balance of the laser head.

Configuring Output A

Pressing the touch button denoted by "A" on the main screenl (see Fig. 10), the configuration of output channel “A” will be accessed, as shown in the following figure.

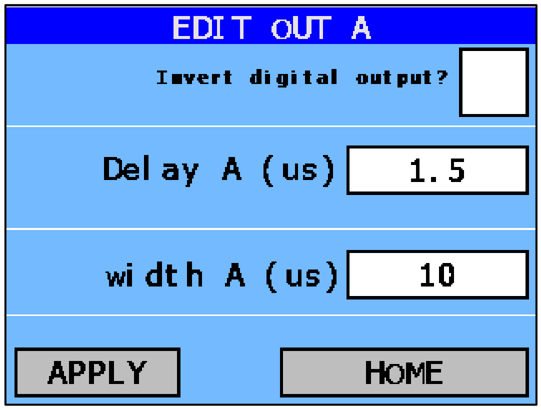

Fig. 15. Configuration screen for output channel "A", with positive logic, with 1.5 us of delay with respect to the input event and the pulse to be generated will have a width or duration of 10 us

The quantities shown in the newly opened window will be those currently configured on the equipment. And to modify them, you must press on the control or indicator in question, to open the numeric keyboard.

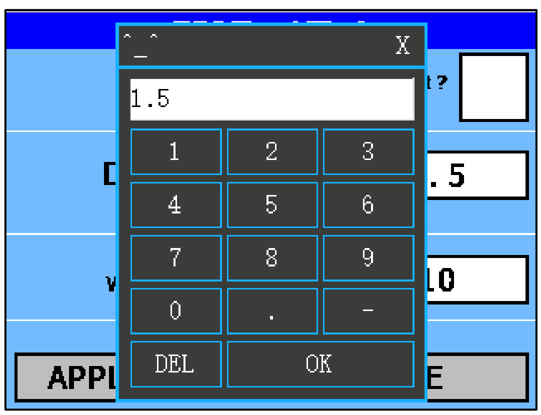

Fig. 16. Configuration screen for output channel “A”, showing numeric keyboard Delay value editor shown when pressing the Delay control

The numerical keyboard of the previous figure allows to delete the current value using the “DEL” button, and with the rest of the keyboard insert a new value. To finish editing, press the "OK" button and return to the starting window to continue editing other values.

When you finish editing the channel parameters, you must press the "APPLY" button so that they are applied and saved to the unit's memory. Then you can return to the home screen by pressing the "HOME" button.

The following table describes the controls present in an output channel window.

Tabla 2. Controls Description of Output Channel A, similar to Channel B and C

Control	Range of Values	Function
“Invert digital output?”	Mark/No mark	Unchecked: the output will be positive logic. With mark: the output will be negative logic. In positive logic, the output is always at “0V” voltage level and only goes to “5V” during pulse emission and for a time given by “width A”. In negative logic, the output will always be at “5V” and will go to “0V” only during the emission of the pulse and for the time “width A”. To change or revert the control, press on the control area.
“Delay A (us)”	0.1 us - 6553.5 us	Defines the time that will elapse from the detection of an input event on channel “IN” and the start of output pulse “A”. To change its value, you must touch the numerical value to open a keyboard.
“width A (us)”	0 – 65535 us	Defines the duration of the output pulse emission. For example, in positive logic, it will be the time that the pulse will be at the “5V” level before returning to the “0V” level. In negative logic, it will be the time that the pulse will be at the “0V” level before returning to the “5V” level. If the width of the pulse is defined as a value of “0”, then virtually the output will not emit any pulse, that is, it will be disabled. To change its value, you must touch the numerical value to open a keyboard.
“APPLY”	-	By pressing this button, the values that have been defined in the previous controls will be applied to the DG-3O1I-17 instantly.
“HOME”	-	Pressing this touch button will return to the main window Fig. 11.

Configurando Salida B

Pressing the touch button denoted by "B" on the main screen (see Fig. 10), the configuration screen for output channel "B" will be accessed, similar to the following figure.

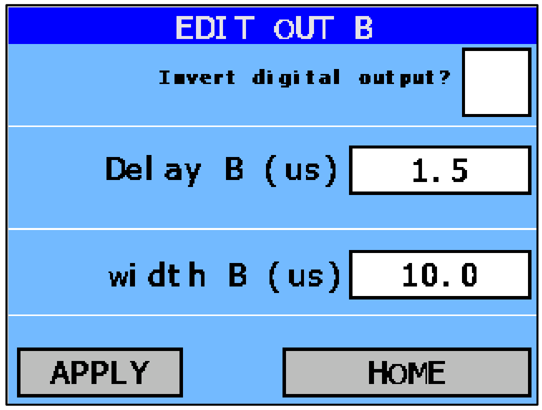

Fig. 17. Configuration screen for output channel "B", with positive logic, with 1.5 us of delay with respect to the input event and the pulse to be generated will have a width or duration of 10 us

The quantities shown in the newly opened window will be those currently configured in the equipment and to modify them, click on the control or indicator in question to open the numeric keypad for editing values, see the following figure.

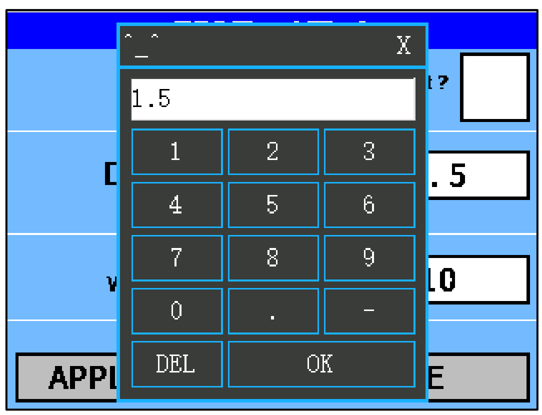

Fig. 18. Configuration screen for output channel "B", showing numeric keyboard Delay value editor shown when pressing the Delay control

The numerical keyboard of the previous figure allows to delete the current value using the "DEL" button and with the rest of the keyboard insert a new value. To finish editing, press the "OK" button and return to the starting window to continue editing other values.

When finished editing the channel parameters, you must press the "APPLY" button so that they are applied and loaded into the unit's memory. You can then return to the home screen by pressing the "HOME" button. The description of the controls present in the editing window for channel B is identical to that presented for channel "A" in the table from the previous page.

Configuring Output C

Pressing the touch button denoted by "C" on the main screen (see Fig. 10), the configuration screen for output channel "C" will be accessed, similar to the following figure.

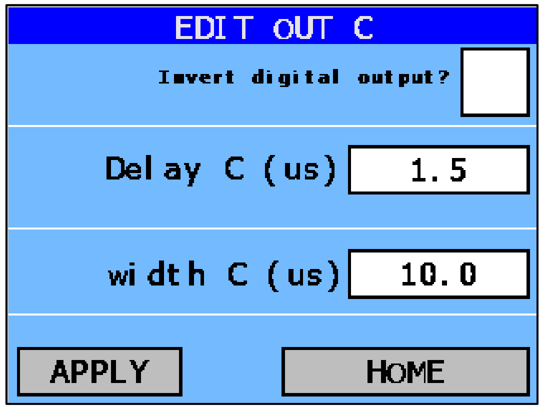

Fig. 19. Configuration screen for output channel "C", with positive logic, with 1.5 us of delay with respect to the input event and the pulse to be generated will have a width or duration of 10 us

The quantities shown in the newly opened window will be those currently configured in the equipment and to modify them, click on the control or indicator in question to open the numeric keypad for editing values, see the following figure.

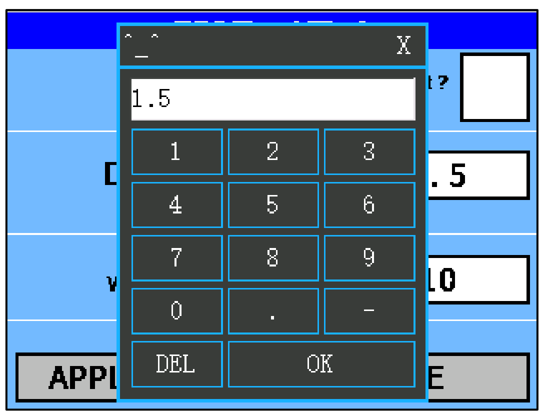

Fig. 20. Configuration screen for output channel "C", showing numeric keyboard Delay value editor displayed when pressing the Delay control

The numerical keyboard of the previous figure allows to delete the current value, using the "DEL" button, and with the rest of the keyboard insert a new value. To finish editing, press the "OK" button and return to the starting window to continue editing other values.

When finished editing the channel parameters, you must press the "APPLY" button so that they are applied and loaded into the unit's memory. You can then return to the home screen by pressing the "HOME" button. The description of the controls present in the edit window for channel C is identical to that presented for channel "A" in Table on page 17.

Manual trigger with touch button "Soft Trigger"

Once the input and output channels have been configured, it is recommended to verify the parameters by manually triggering the outputs. In order not to depend on the arrival of the input pulses, a button called “Soft Trigger” is available in the main window of the touch display, which internally simulates the arrival of an input pulse. The use of the "Soft Trigger" is not affected by the configuration of the input pulse counter, the outputs will automatically be triggered with the delays programmed with respect to the "Soft Trigger" pulse that is simulated internally.

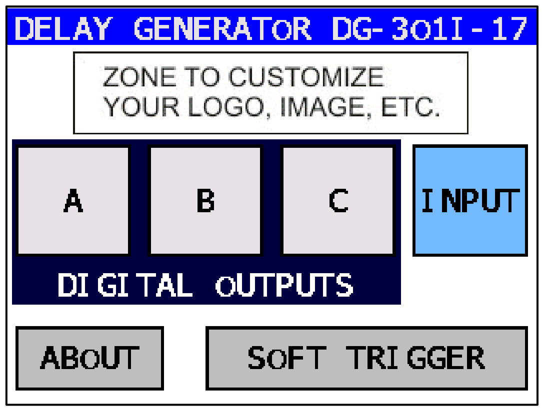

Fig. 21. The "Soft Trigger" button for manual triggering of the output pulses is displayed in the lower right corner of the Home Screen.

Verification of the output pulses can also be done with the use of an oscilloscope; preferably 4 input channels, to display in unison the delays between the edge chosen for the input and the output pulses of each channel.

Display contrast regulation

The “ABOUT” button, present in the lower left corner of the Home Screen, see previous figure, provides access to equipment information, web contact and display contrast regulation, to regulate its brightness level.

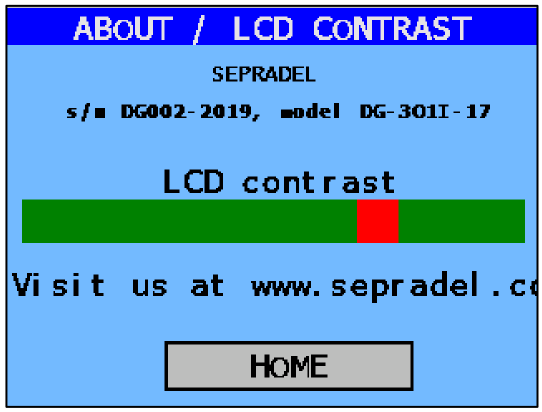

Fig. 22. “ABOUT / LCD CONTRAST” screen with information and horizontal slider to adjust the contrast of the Display

Active Q-Switch Generic Laser Connection Example

Many commercial Solid State lasers, pumped by Flash Lamp and with active Q-Switch (Q-Sw) optical switch, give the investigator the possibility of controlling the activation moment of the flash lamp and the Q-Sw, thus regulating the power laser pulse output.

The following figures show suggestions for interconnection of these commercial lasers with the DG-3O1I-17 delay generator and an optical spectrometer. In such a way that great control flexibility is obtained from both the laser and the spectral reading device. Although the suggested schemes are focused on a particular application which is Laser Induced Plasma Spectroscopy (LIBS), they can also be extrapolated to synchronism in other applications such as laser pulsed thin layer deposition (PLD), among others.

The following figure shows a control scheme in which the laser flash lamp output is used towards the “IN” input of the DG-2O1I-17, to generate delayed control pulses towards the optical spectrometer Output channel “C "And the Q-Switch on output channel" B ".

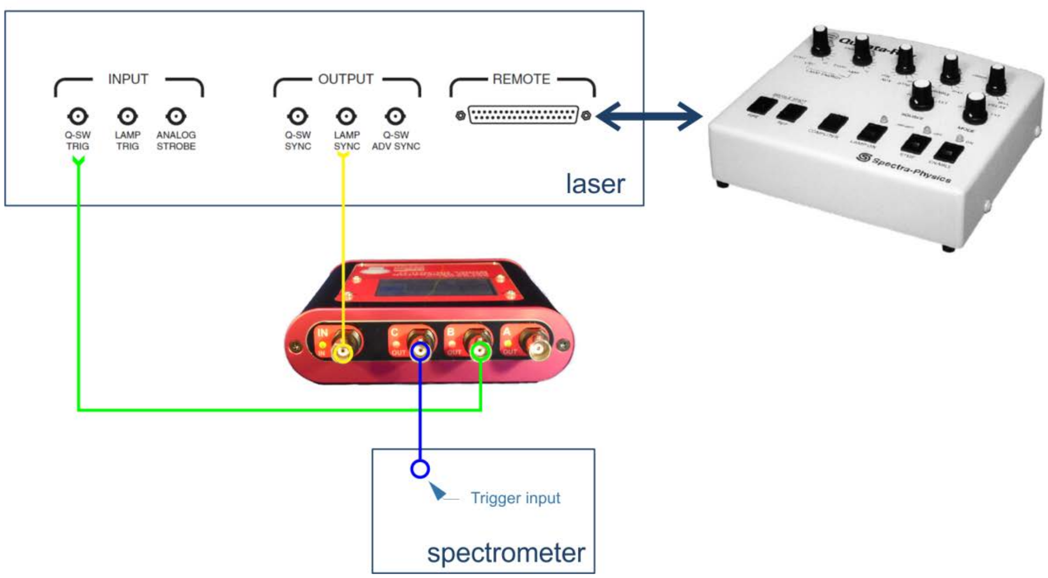

Fig. 23. Synchronism from Q-Switch flash lamp and Spectrometer

In the scheme of the previous figure, the commercial laser must be configured from its control console so that the Q-Switch control is external and the flash lamp is triggered from the laser control itself, whose output TTL pulses will be used by DG-2O1I-17 to initiate delays. Also take into account the characteristics of your commercial laser, to know the optimal delay values between the reception of the lamp pulse and the emission of the Q-Sw pulse. In parallel and independently, you must also set the ideal delay between the sync pulse of the flash lamp and the pulse destined for the spectrometer. As a general rule, it is recommended to first adjust the delay of channel "C" connected to the Q-Sw, until obtaining laser plasma or the desired laser power and then program channel "B" with the same delay found for the Q-Switch and from said value increase or decrease it until optimizing the obtaining of the optical spectrum.

In the following three figures, one of the three possible laser outputs is used as synchronism (some lasers only provide the "LAMP" signal), since the LAMP and Q-Switch control is carried out with the delays characteristic of the laser console.

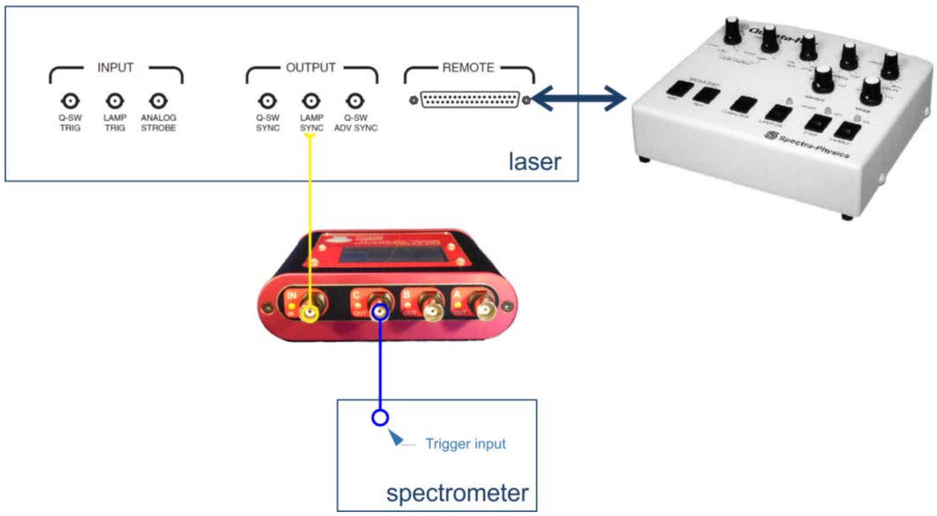

Fig. 24. Synchronism with flash lamp, lamp and Q-Switch controlled by the laser itself

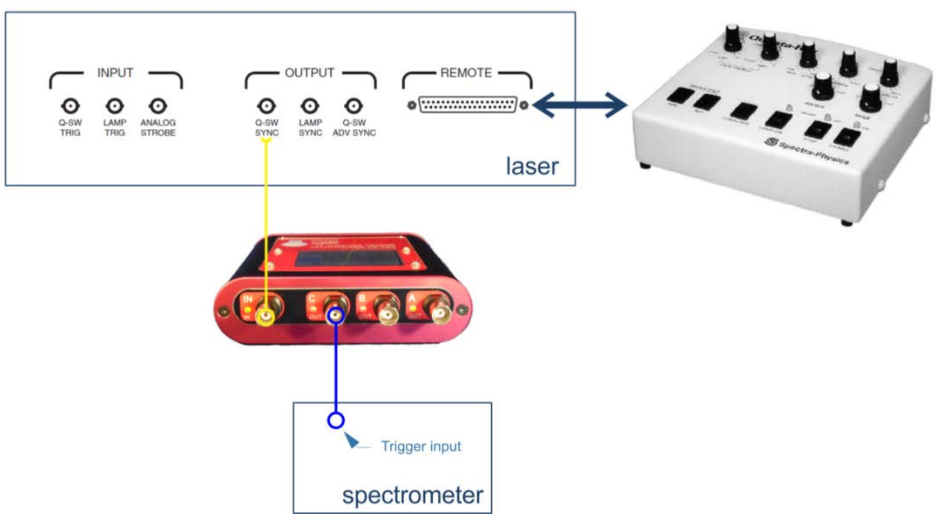

Fig. 25. Synchronism with Q-Switch, flash lamp and Q-Switch Controlled by the laser itself

The following figure allows the optical spectrometer to be triggered using as a reference an "Adv Q-Sw" output (not available on all commercial lasers) that delivers a Q-Switch pulse a time earlier than the true Q-Switch laser pulse.

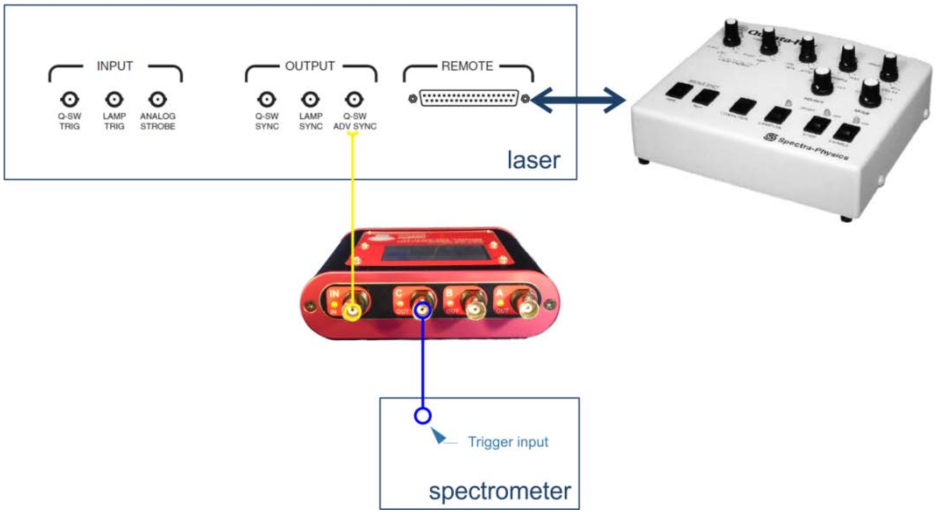

Fig. 26. Synchronism with Q-Switch ADV SYNC, flash lamp and Q-Switch controlled by the laser itself

In another control scheme, the DG-3O1I-17 can take over and delay the LAMP, Q-Switch, and spectrometer. As shown in the following figure. In this scheme, the triggering of the lamp, the Q-Switch and the spectrometer would be carried out from the LCD display itself using the manual trigger button "Soft Trigger", see section on "Manual trigger with touch button "Soft Trigger"", page 20.

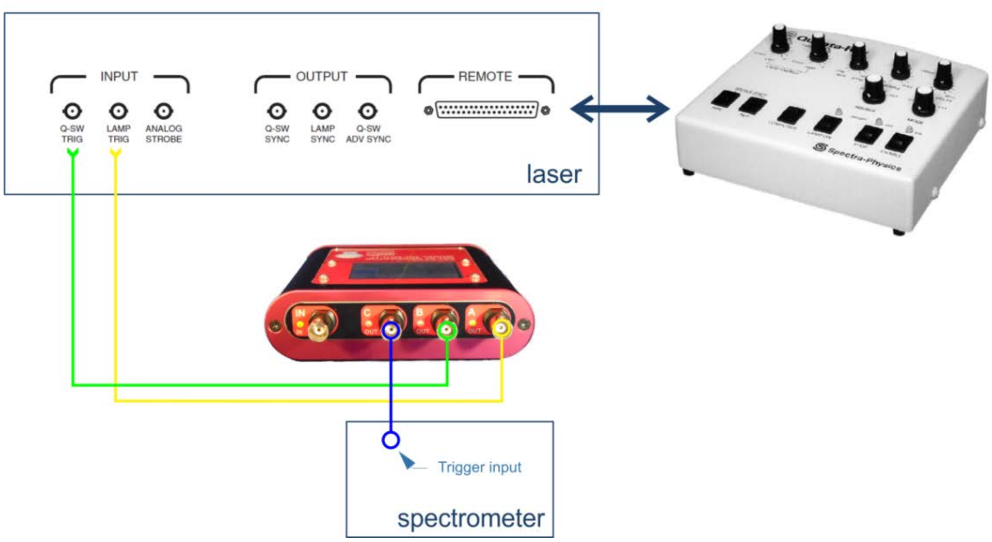

Fig. 27. Lamp control, Q-Switch and spectrometer from the DG-3O1I-17, the shot is made from a button on the touch screen or with a square pulse generator (not shown in the image) that is connected to the IN input

Trigger control via USB

The interconnection of the previous section allows shots to be made at the user's request by activating the "Soft-Trigger" button, but if said shots are to be made repeatedly, with a certain frequency of the flash lamp being triggered, then it may be convenient for the control The DG-3O1I is made from a PC, so that a control program repeatedly sends the trigger command via USB.

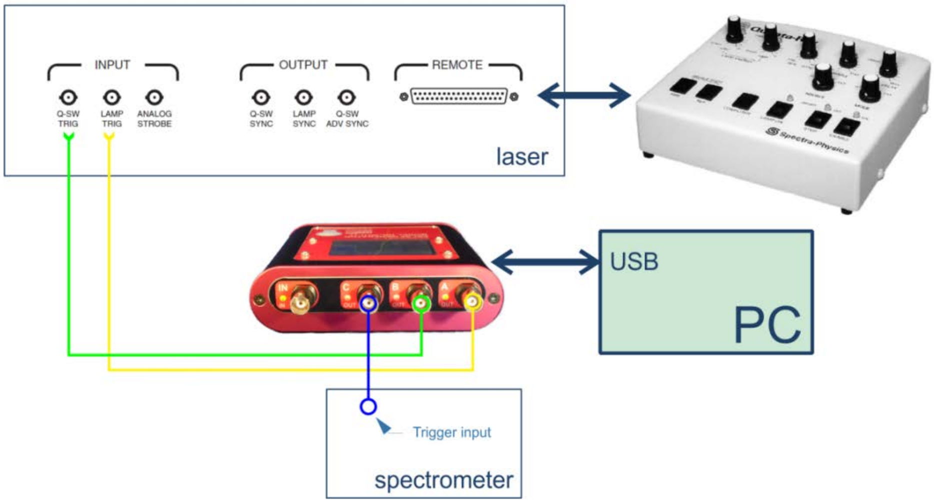

Fig. 28. Lamp control, Q-Switch and spectrometer from DG-3O1I-17 connected to a PC for repetition of the trigger command with programmable frequency

The DG-3O1I-17 equipment is recognized by the PC via the USB bus as a serial port, for example COM3 (the port number may vary and is automatically assigned by the PC).

The serial command (via USB) is to send the DG-3O1I-17 the ASCII character "S" followed by a return character CR (decimal value 13). For example, in LabView, the section of code to send the trigger command would read as follows:

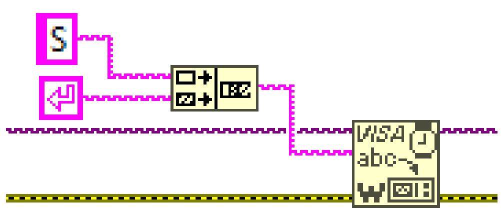

Fig. 29. Serial trigger command formed in LabView

By sending this command repetitively and at regular time intervals, a certain flash lamp and Q-Switch firing frequency could be configured (using the configuration from the equipment's own display). Serial configuration corresponds to a speed of 9600 bps, 8 data bits, no parity and one stop bit.

Example of Connection with commercial Quantel USA Laser with Source and Control Type ICE450

Configure the Quantel USA laser

In the Quantel Laser Control box, access the flash lamp menu and ensure that the line "flash sync" is equal to "INT".

Fig. 30. Quantel Laser Control Box, from there it will configure the lamp and Q-Switch to externally use the retarder

The following image shows the flash lamp setup menu for your Quantel laser. The lamp will be triggered by the laser control itself, so it is correct to configure the lamp trigger menu or "Flash sync" as "INT". The rest of the parameters of the laser lamp menu will depend on the conditions of your experiment, during a set-up it is recommended to use the lowest possible lamp voltage.

Main Menu	←
>flash sync	INT
ct	0000.001.368
cu	0000.001.368
voltage	550V
energy	06.77J
freq.	20.00Hz
power	132W

Fig. 31. Laser flash lamp menu, with internal mode selected

Then access the configuration menu of the optical switch triggering or Q-Sw, to configure it in external mode (EXT), since the Q-Switch will be externally controlled by the DG-3O1I-17. See the following figure in the Q-Switch configuration menu and change the "QS sync" line from "INT" to "EXT".

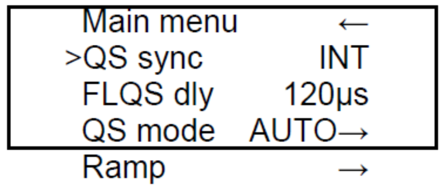

Fig. 32. Quantel laser Q-Switch menu, change timing from INT to EXT

By changing the Q-Switchd to EXT trigger the Quantel laser, we will allow the Q-switch to be manipulated externally by our delay generator DG-3O1I-17.

Configure DG-3O1I-17 Delay Generator

It is recommended to configure the DG-3O1I-17 before connecting it to the commercial laser, to avoid that any change in the outputs during configuration activates an unexpected laser shot, with the risk that this implies.

DG-3O11-17 Input Configuration

The input of the DG-3O1I-17 will later be connected to the BNC connector of the Quantel laser, which is the output of the flash lamp signal and may be marked as "Lamp OUT"

The retarder input can be configured with or without a pulse counter. If you activate the pulse counter for n-input counts, then outputs B and C will activate only with the n-input pulse. If the counter, the outputs B and C of the retarder will work with each of the input pulses.

The following figure shows the input configuration of the retarder to obtain a laser firing frequency of 1 Hz, although internally the laser has its flash lamp activating at 20 Hz. That is, for every 20 flash lamp firings, a Q-Sw activation will be obtained..

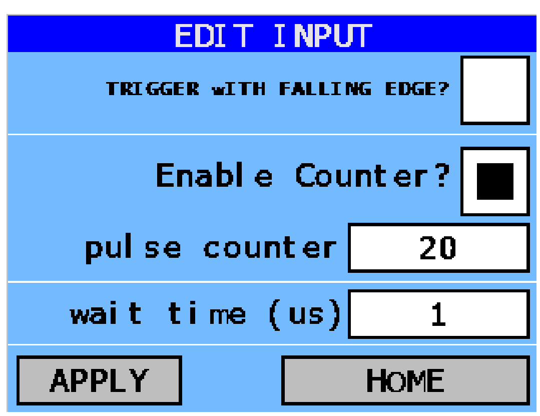

Fig. 33. Set the input menu with counter activated to get lower Q-Switch frequency

Manipulate the "pulse counter" value to obtain other trigger frequencies. For example, at 10 counts, with the Quantel laser flash lamp at 20 Hz, you will get laser shots at 2 Hz.

Configuration of Output B for Q-Switchof the Quantel laser

Output "B" of DG-3O1I-17 will be connected to the Q-Switch In input connector of the Quantel laser. According to page 13 of the consulted manual[6], the pulses for said input must be TTL compatible and with a width of not less than 100 µs. In addition, in the same laser manual it is established that the time or delay between the pulse of the flash lamp and the Q-Switch, can be between 100 µs and 500 µs, so the value that will be shown here of 120 µs will be only as a starting suggestion and in practice it should be adjusted experimentally until the desired firing power is obtained.

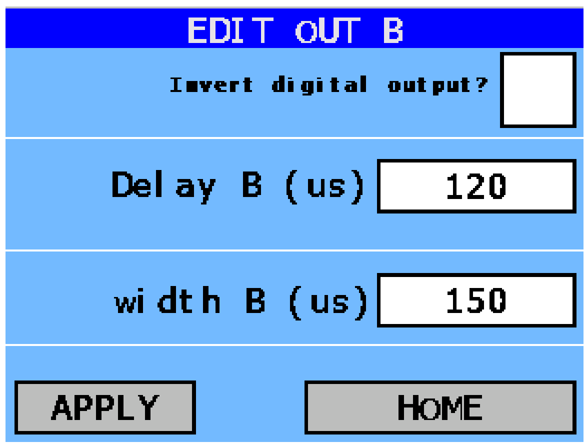

Fig. 34. Set the output B for the Q-Switch of the Quantel laser, the Delay B value of 120 µs is only a suggestion, in practice this value should be adjusted, the minimum width for the Quantel is 100 µs, so 150 µs satisfies said condition of the laser Q-Switch input

Then configure the delay for the optical spectrometer connected to the retarder "C" channel.

Output C Configuration for Optical Spectrometer

Channel "C" of the Digital Retarder will be connected to your optical spectrometer. It is important to consult the manual of the optical spectrometer in question and configure it so that its activation is by edge and not by level. If per level, it will be capturing for as long as the trigger signal is active, while per edge, it will only capture a spectrum each time it detects a pulse edge. Another aspect of your spectrometer to check is the type of logic, negative or positive, of the trigger signal and the minimum time of the trigger pulse so that it can detect it favorably. In the following figure, a

[6] ICE450 User's Manual: DOC00070 Rev. C

spectrometer was assumed whose trigger signal admits TTL voltage levels, with positive logic and that will be activated with rising edge, in addition, it admits a pulse with a minimum width of 10 µs. Thus, the configuration of channel C would be as follows.

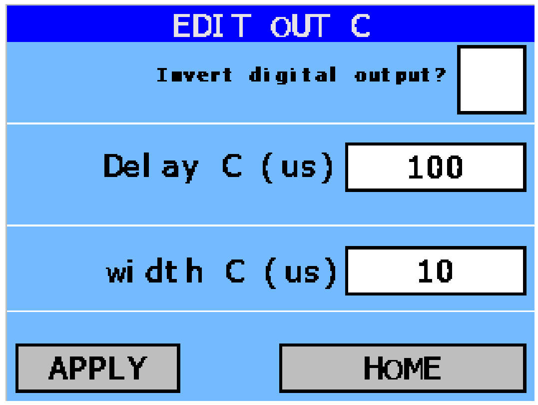

Fig. 35. Set the C output for the trigger of your spectrometer, the Delay C value of 100 µs is only a suggestion, in practice this value should be adjusted until the desired spectrum quality is obtained, for example, until the laser emission line disappear from the spectral capture, likewise, the width pulse C must be adjusted according to the allowed in your spectrometer

In practice, you can adjust the Delay of the spectrometer with respect to the firing of the laser flash lamp, remembering that it is connected to the input of the retarder. One way to carry out said adjustment of the delay of the spectrometer is to increase it to a value where the laser emission line does not appear, so that the integration of the optical sensor will be occurring instantaneously after the laser pulse. As a starting point you can also use the same delay value for the Q-Sw, which in practice will mean that the trigger of the spectrometer will be given at the same time as the laser pulse and from this value decrease or increase the delay C, it will depend on the particular characteristics of the optical spectrometer.

Connect the DG-3O1I-17 to the laser. Note that if you adjust the channel B assigned to the Q-Sw, you may have to readjust the C delay of the spectrometer, since both delays are triggered from the same input signal, and therefore the time difference between channel B and C is what will be effectively regulating the quality of the capture spectra.

Once the retarder and laser have been configured, proceed to connect the coaxial cables (verify that the cables are in good condition and with electrical continuity), according to the following image.

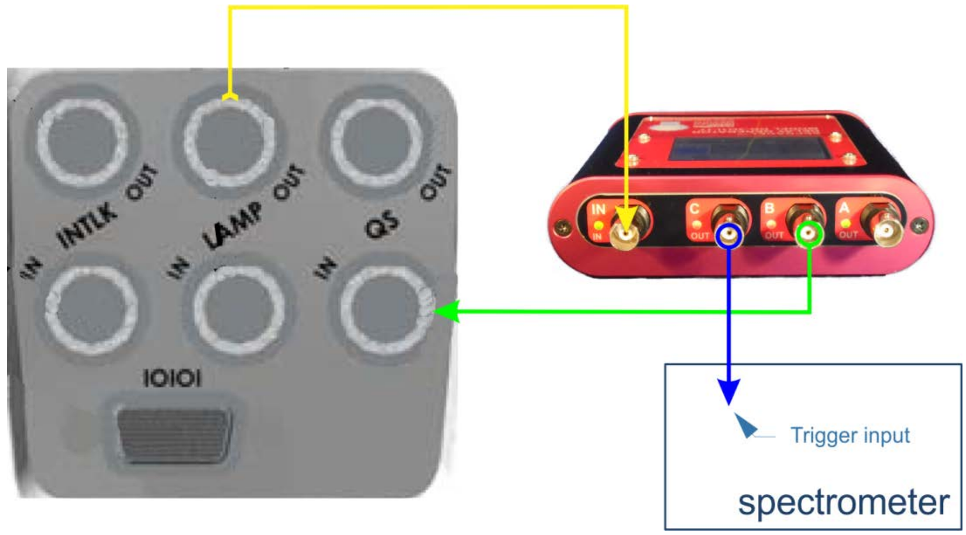

Fig. 36. Interconnection of the retarder with the Quantel laser and the spectrometer, lamp output to the retarder input, channel B of the retarder to the QS input of the Laser, Channel C to the trigger input of the spectrometer

Passive Q-Switch Laser Connection Example

In solid state pulsed lasers with passive Q-Switch optical shutters, we do not have precise control of the laser emission moment. In some models of commercial lasers, they provide a signal of synchronism with respect to the firing of the flash lamp, but in any case the very nature of the passive Q-Switch shutter inserts some type of variability in the instant of emission of the laser pulse, variability that will depend from the pumping energy of the lamp and even from environmental factors such as humidity and temperature. In this case, a solution may be to detect with a high-speed photodiode module the emission of the laser pulse, and use this signal to trigger the spectrometer. It should be noted that the spectrometer must be one with a high response speed between the reception of the trigger signal and the entry into the integration zone of the image sensor they have. As a general rule, spectrometers with high response speed or low latency between the reception of the trigger and the capture of the spectrum are those that have an image sensor, almost always of the charge coupled type (CCD) with shutter-electronic. Therefore, before selecting a spectrometer for this application, ask the supplier if the used sensor enters the integration zone immediately after receiving the trigger signal and it is not only enough to know the value of said time, but also if it is constant between catch. The following figure shows an assembly to trigger an optical spectrometer using the DG-3O1I-17 from the analog signal of a PDA10A type photodiode module from the manufacturer Thorlabs.

Fig. 37. Spectrometer triggering from the optical detection of a laser pulse

The laser pulses with Q-Switch are of short duration, in the order of units or tens of nanoseconds, it will also be the output of the photodiode module, so it can be considered virtually as a very short duration square pulse, which will be detected by the retarder without further complications, thanks to its high-speed FPGA device.

It should be noted that the detection modules generally do not get in the way of the laser beam, due to their high sensitivity they can be oriented laterally towards the plasma area without using any type of approach.

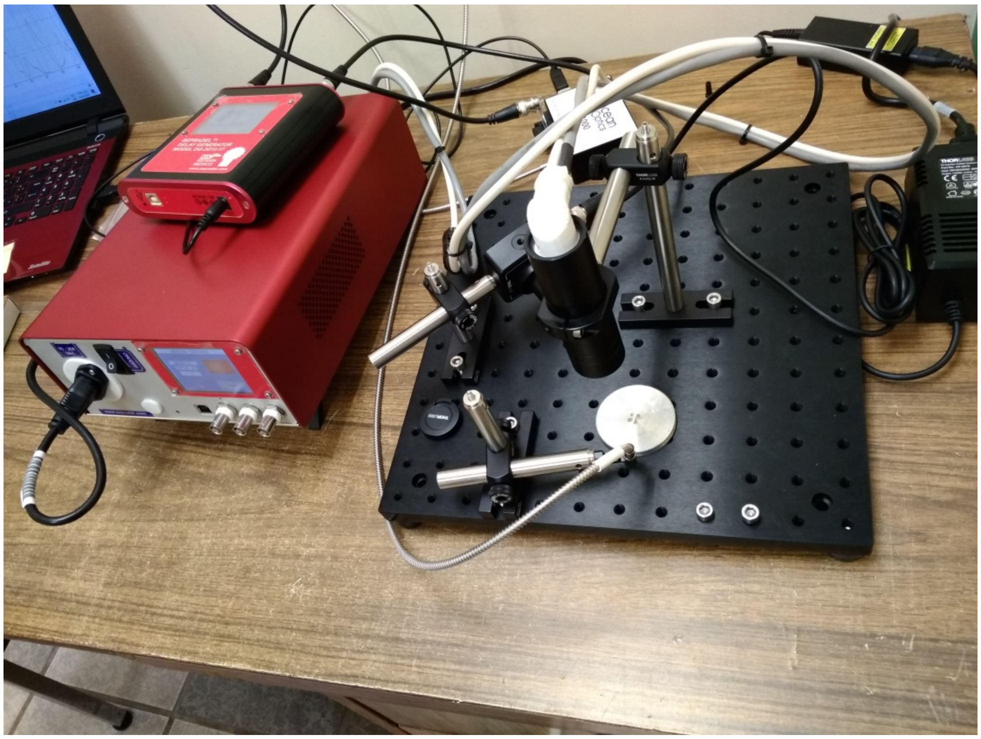

Fig. 38. Example of LIBS experiment with Sepradel Laser with passive Q-Sw, Spectrometer triggering from the optical detection of a laser pulse

Problem resolution

If there are synchronism problems with the external equipment that you are controlling, it is suggested to consider the following points:

- Check continuity and good condition of BNC cables.
- That the type of positive or negative logic is correctly selected according to the application.
- That the input is correctly configured regarding the edge to be detected
- That the delay values are correct
- That the pulse counter is not unnecessarily enabled or disabled for testing
- Preferably, view the input signal and the output signals on an oscilloscope
- If the times displayed on an oscilloscope do not correspond to what is programmed through the display or USB bus, please contact the supplier for a possible update of the product firmware