# MODEL 745-T

# FOUR CHANNEL DIGITAL DELAY/ PULSE GENERATOR



The MODEL 745-T

Four high resolution delay channels
    0.25ps delay resolution
    <25ps RMS jitter max (5ps for short delay)
    20s delay range (relative/absolute reference)
Three trigger sources: external, internal or command
Positive or Negative trigger slope
Single, Repetitive or Burst trigger mode
Gate mode
External trigger prescaler (pulse picking)
Tunable output (magnitude 2-5V, width 100ns-10µs)
50 Ω load
T0 reference output
Clock output
Gate input
High precision internal clock (OCXO 50ppb)
USB
Ethernet interface (Web page)

Options:
4 auxiliary high resolution delay channels (1.25ns, 2 to 5V Amplitude but common tuning)

The MODEL 745-T digital delay generator provides four independent high resolution digital delay channels. The rms jitter between the trigger and any outputs is 25ps + delay x $10^{-8}$ max. which ensures a high performance delay. The device can be triggered by different ways: External trigger via a BNC input, Internal trigger and Software command trigger, each one with repetitive, single and burst trigger modes.

# CONTENT

**EDITION**

| Ed. | Date | Description |
|-----|------|-------------|
| 1 | 07/09/2015 | Creation |
| 2 | 04/11/2015 | Modification: channels T1-T8 become channels  A-H |
|   |   |   |
|   |   |   |

# 1- GENERAL INFORMATION

The MODEL 745-T device provides four high precision independent delay channels. Access to these four outputs (A-D) is given by four BNC connectors on the front panel. The achieved delay resolution is about 0.25ps, and trigger-to-channel jitter is less than 25ps (Annex B). A-D can deliver up to 5V, 2ns rise time max (9-Annex A), into 50Ω. Amplitude and width are adjustable on each output channel either programmed from the front panel or via Ethernet.
A T0 output pulse is also available. It gives a time reference for each generated delayed output.
This high accuracy and precision device is suitable for system/experiment in science or industry that requires reliable timing solution.

The MODEL 745-T also provides four optional delay channels to front panel E-H with a delay resolution of 1.25ns, trigger-to-channel jitter less than 50ps with a common 2 to 5V tunable amplitude.
The internal timebase reference is a OCXO with a stability of 50ppb.

The device offers three operating trigger modes, repetitive (internal or external source), single shot (internal, external or asynchronous source) and a burst mode (internal, external or asynchronous source).
A Web page (accessed via Ethernet link) provides a simple method to configure the settings for each channel, amplitude, width, trigger source, trigger mode and to control operation. You can save and recall settings.
A serial communication is also available via an USB port.

Instrument Options

| 745-4C-GOC | Standard device |
|---|---|
| 745-8C-GOC | Extension to 8 channels (4 optional channels with 1.25ns resolution) |

Package Contents
The box you receive should contain the following:
- MODEL 745-T Digital Delay Generator
- PDF user manual and Labview VIs can be downloaded at:
- http://www.berkeleynucleonics.com/support
- Certificate of calibration

BNC product:
For more information about BNC product see our web site: http://www.berkeleynucleonics.com/.

## What do you need to get started

To set up and use the MOD745, you need the following items:
- MODEL 745-T Digital Delay Generator,
- MODEL 745-T user manual

## Unpacking Caution

The MODEL 745-T is shipped in an antistatic package to prevent electrostatic damage to the device. Electrostatic discharge (ESD) can damage several components on the device. Remove the device from the package and inspect the device for loose components or any sign of damage. Notify BNC if the device appears damaged in any way.

*Caution*:

Before device plug in, be sure to set the right voltage with the line voltage selector. It operates from 90V to 240 V.

Do not apply any voltage to either the shields or the output BNCs.

## Operating temperature

The MODEL 745-T can be operated where the ambient air temperature is 10°C to 35°C and can be stored in ambient temperature from - 10°C to + 60°C. The MODEL 745-T is cooled by air circulation.

## Self-test

The unit model, firmware version, serial numbers and the result of self-test procedure will be displayed one minute after power on. After 30s if the test is good then "self-test" disappears and the device can be used. If the test is not ok then "self-test" stays displayed and the device is locked.

## The device software

Labview Vi's are provided with the MODEL 745-T device. They allow users to control and/or configure the equipment as planned. These Vis can be integrated in a top-level Vi where several devices are controlled.

The communication is done with an Ethernet connection.

## Power fuses

The MODEL 745-T is protected against short circuit by means of one fuse according to nameplate of the power supply (F2.5H250V).

## RAM with battery back up

The MODEL 745-T has a RAM with battery backup in which settings of the instrument can be stored (Lithium battery ref 2032).

# 2- SPECIFICATIONS

**Delays**

| | |
|---|---|
| Channels | 4 independent delay outputs |
| Range | 0 to 20 seconds |
| Resolution | 0.25 ps |
| Jitter | 25ps RMS + delay x $10^{-8}$ (external trigger to any output) Annex |
| | 20ps RMS + delay x $10^{-8}$ (Channel to channel) Annex |
| | < 5ps RMS for short delay (Channel to channel) |
| Accuracy | < 250ps + delay x $10^{-8}$ |
| Time base | 200 MHz, 50 ppb |

**Trigger source**

| | |
|---|---|
| Internal | 2 Timers tunable in Hz or ns |
| | 1Hz to 1MHz, 1Hz resolution |
| | 1µs to 4s, 5ns resolution |
| External | Repetition rate < 1MHz |
| | Prescaler : 1 to $2^{16}$-1 |
| | Trigger level, from 0.1 to 5V, |
| | Internal load: 50Ω |
| | Positive or negative slope |
| | Minimum trigger delay < 60ns |

**Trigger mode**

Single, repetitive or burst

| | |
|---|---|
| Burst specs. | Pulse number: 2 to $2^{16}$-1 |
| | Period: 1000ns to 1s |

**Gate Mode**

| | |
|---|---|
| 2 settings: | General or Individual |
| Gate source | Active high, Rep rate <100kHz |

**Output A-D (T1-T4)** BNC connector

| | |
|---|---|
| Amplitude | 2 to 5V, 0.1V resolution |
| Width | 100ns to 10 µs, 5 ns resolution |
| Load | 50 Ω |
| Rise time | < 2ns max, 900ps typical |
| Fall time | < 5ns max, 2ns typical |

**Clock Input**

| | |
|---|---|
| Frequency | 10 or 80 MHz, 50% duty cycle. Ask factory for custom clock frequency. |

**Clock Output**

| | |
|---|---|
| Frequency | 10 or 80MHz (directly related to the input clock) |
| Signal | +/- 1 V, square |

**USB Port**

| | |
|---|---|
| Communication | serial, baudrate 38400 |

**User Memory**

Up to 4 sets of MODEL 745-T parameters can be stored/recalled via Front Panel or Telnet

**General specifications**

| | |
|---|---|
| Size | 215 x 245 x 135 mm |
| Power | 50 W – 110 to 240 V |
| LEDs | Orange: Trigger on |

**Software**

Control panel Web page from embedded web server for IE, Firefox or Chrome

**Options**

745-8C: 4-auxiliary delay output extension

> Delay
>
> Channels: 4 independent delay outputs
>
> Range: 0 to 20 seconds
>
> Resolution:  1.25ns
>
> Jitter: 50ps RMS + delay x $10^{-8}$
>
> (External trigger to any output)
>
> Accuracy: < 1ns + delay x $10^{-8}$

Output E to H (T5 to T8)

> Amplitude: 2 to 5V
>
> Width: 100 ns to 10ms; 5ns resolution
>
> Load: 50Ω
>
> Rise and Fall time < 5 ns
>
> Connector: BNC on front panel

# 3- FRONT PANEL OVERVIEW

The MODEL 745-T front panel is composed of several kinds of elements: the user interface which consists of a keyboard and an LCD display that allows the user to program various settings and to interact with the device in local mode, 4 status LEDs, BNC connectors.



**Figure - 1.        Front panel**

## LCD screen
The screen is a 4.3" touch screen.

## RUN/STOP Button
Global RUN/STOP. It enables to RUN or STOP all output channels.

## BNCs
One input Trigger, one Gate input and 4 independent output channels (A – D) are available. The output voltage is tunable from 2 to 5V for each output independently and each one has to be terminated in 50Ω.
The input Trigger BNC connector provides a trigger signal operating up to 50 kHz.

## Optional BNC
The four optional output (E – H) connectors are 50Ω impedance with adjustable amplitude, delay and width.

## 4- REAR PANEL OVERVIEW

All optional output connectors/modules appear on that side of the device. The other features are listed below.



Figure - 2.        Rear panel

### Power Switch
The unit is turned on by depressing the Power button. The MODEL 745-T can be operated from 100 to 240V at a line frequency of 50-60Hz.

### T0 output
A reference pulse output is available. It delivers a fixed amplitude pulse with adjustable width. Terminated in 50$\Omega$.

### Clock BNCs
Clock input and clock output connectors are available. The CLK IN connector accepts either 10MHz or 80MHz (or custom frequency) clock frequency. The clock output (CLK OUT) comes from the CLK IN connector or from the internal oscillator – if clock in signal not present.

### AUX BNCs
The AUX connector is not used so far.

### Ethernet Port
A RJ45 Ethernet connector is available to control the MODEL 745-T with a computer. See § 8-.

### USB Port
A female USB connector can be available allowing serial communication with the MODEL 745-T. See Chapter 8 – Programming for command syntax.

## 5- MENU STRUCTURE (NAVIGATING THE MODEL 745-T)

A three level Menu is available:
- A main menu to display settings
- Sub-Menus to select the parameter to set
- Keyboard to set the new parameter value

**With 8 channel option**
Here is given a presentation of the display menu for a 8 Channel Unit.

From the main menu (Figure - 3) the user can access every MODEL 745-T settings by pressing the selected parameter zone.
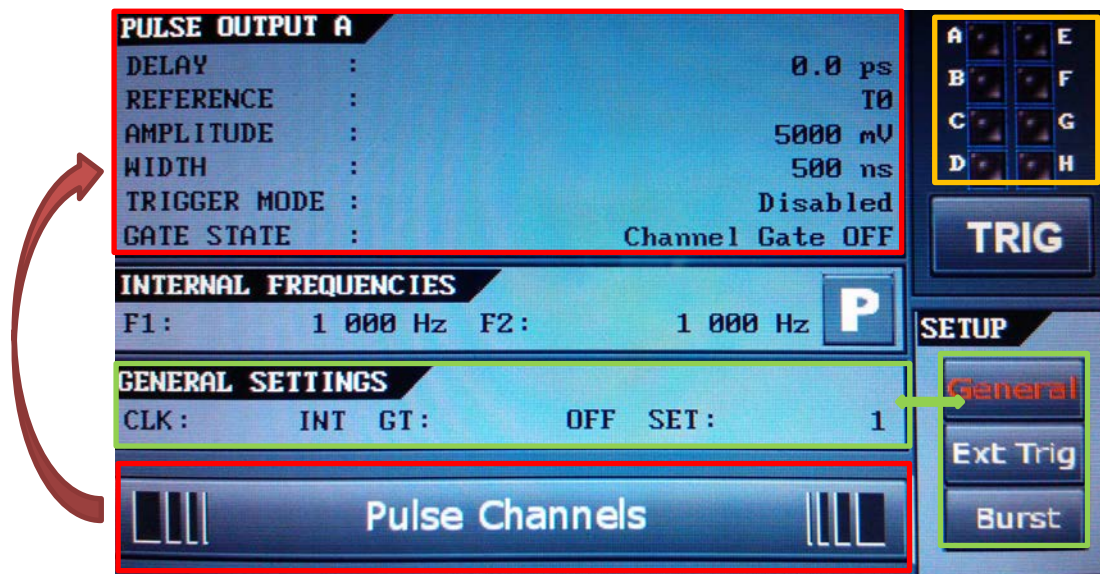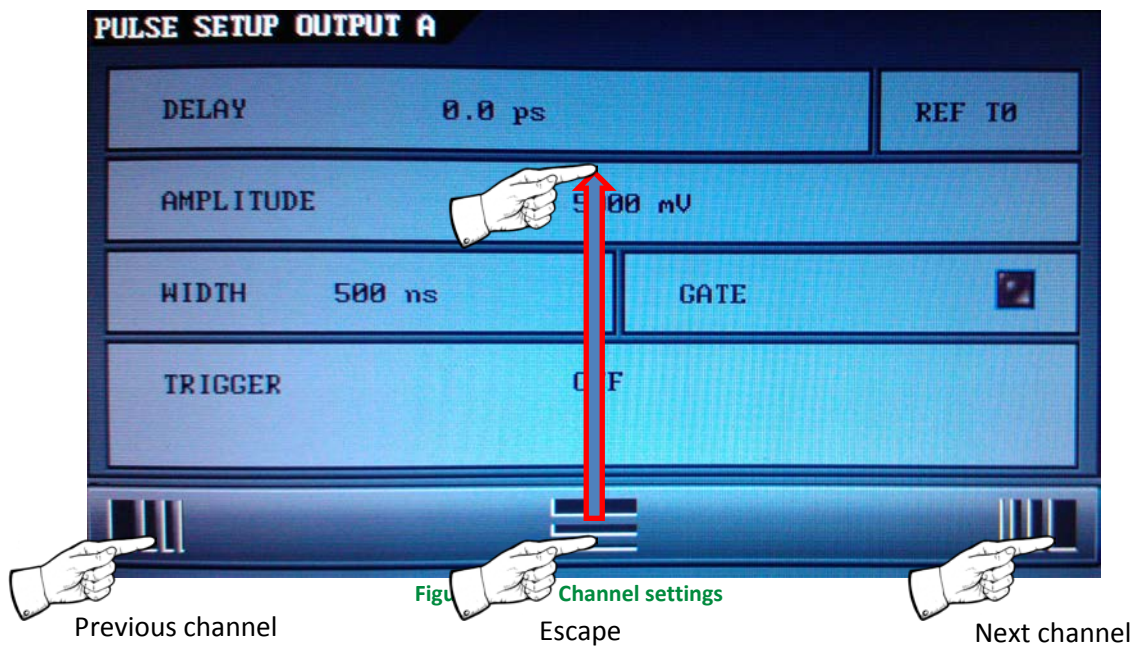


Figure - 3.        Main Display

**Main Display**

| Settings name | Description | Special |
|---|---|---|
| Pulse Output | Channel settings: trigger, amplitude, width, delay, reference, gate | Use the Pulse Channels bar to change the displayed channel |
| Internal Frequencies | Frequency or Period settings of internal trigger generator 1 & 2 | Press the P button to display period settings |
| General | Clock, gate, store/recall and network settings | Press General in the Setup box to display the menu |
| External trigger | Trigger settings: threshold, slope and prescaler | Press Ext Trig in the Setup box to display the menu |
| Burst | Input clock setting: 10 or 80MHz. | Press Burst in the Setup box to display the menu |
| Trigger | Manual trigger button | |
| Channel status | Display the current channl status | Press the zone to clear channel status |

### Channel Setting Display

Channel Tx can be channel A to H.

| Displayed name | Description and settings | |
|---|---|---|
| TX TRIG= | To select Trigger source | OFF= Trigger signal is inhibited<br>IN1= Trigger signal coming from internal frequency 1<br>IN2= Trigger signal coming from internal frequency 2<br>EXT= Trigger signal coming from the front panel (TRIG IN)<br>SS1= Single Shot trigger synchronous with internal freq. 1<br>SS2 = Single Shot trigger synchronous with internal freq. 2<br>SSE= Single Shot trigger synchronous with trigger input<br>LSS = Software Single Shot trigger<br>BST = Pulse train Trigger sync. With internal freq. or trigger input |
| TX RET= | To select the channel delay reference: T0 and A to H | |
| TX Delay= | To adjust Output pulse delay of channel (A to D 1ps resolution display, E to H 1.25ns resolution display). | |
| TX Ampl= | To adjust Output pulse amplitude of channel A to H. | |
| TX Width= | To adjust Output pulse width of channel TX | |
| TX Gate | To set Channel Gate mode On or Off (available if general Gate mode is set to "Channel Gate") of Channel A to H | |
| RETURN MENU | To Return to main menu | |



Figure - 4  Channel settings

Previous channel          Escape          Next channel

*Note*:
To escape from a submenu and go back to the main menu (RETURN MENU item in tables), the user has to touch the bottom bar center and slide up his finger (see Figure - 4).
To generate a pulse with a Single Shot setting (SS1, SS2, SSE or LSS), the user has to press the TRIG button displayed on the general menu.

*__Internal Frequency Display__*

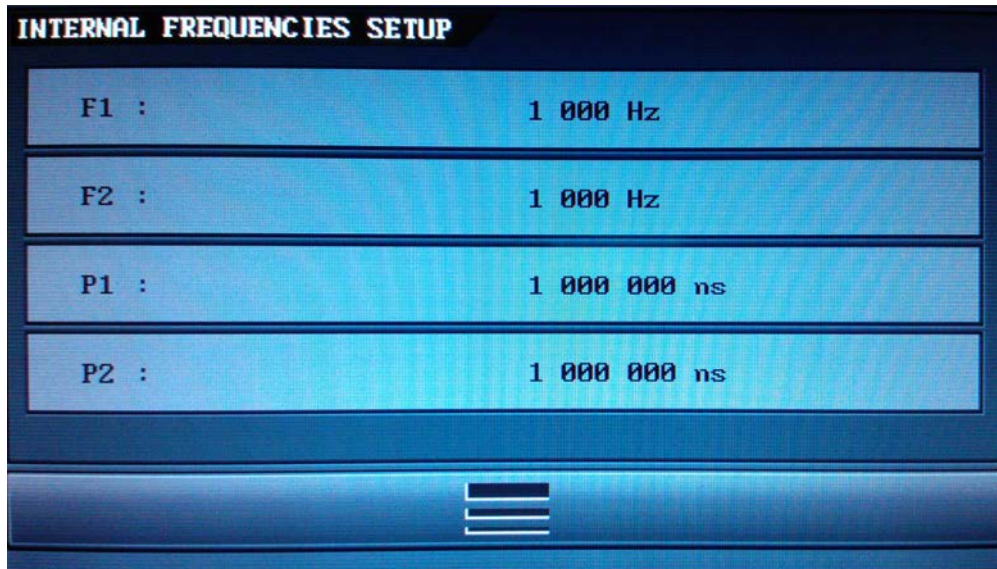| Displayed name | Description and settings |
|---|---|
| Frequency 1 | Frequency of internal trigger generator 1. |
| Frequency 2 | Frequency of internal trigger generator 2. |
| Period 1 | Period of internal trigger generator 1. |
| Period 2 | Period of internal trigger generator 2. |
| RETURN MENU | To return to main menu |



**Figure - 5.     Frequency settings**

Note:

Changing a frequency setting will change automatically the associated period setting and conversely.

*__General settings__*

| Displayed name | Description and settings | |
|---|---|---|
| Ext Clock | Input clock setting: 10 or 80MHz. | |
| Gate Mode | To select the Gate mode | General gate: to aim every outputs<br>Channel gate: to set individual behavior for each channels (independent Gate modes set in each Tx sub-menu) |
| Store x | To store current MODEL 745-T configuration in conf x (x=1 to 4) | |
| Recall x | To recall conf x MODEL 745-T configuration | |
| RETURN MENU | To return to main menu | |

**Figure - 6.**     **General settings 1**

*Note*:
To access to the Ethernet parameters the user has to press the item on the right end of the bottom bar.

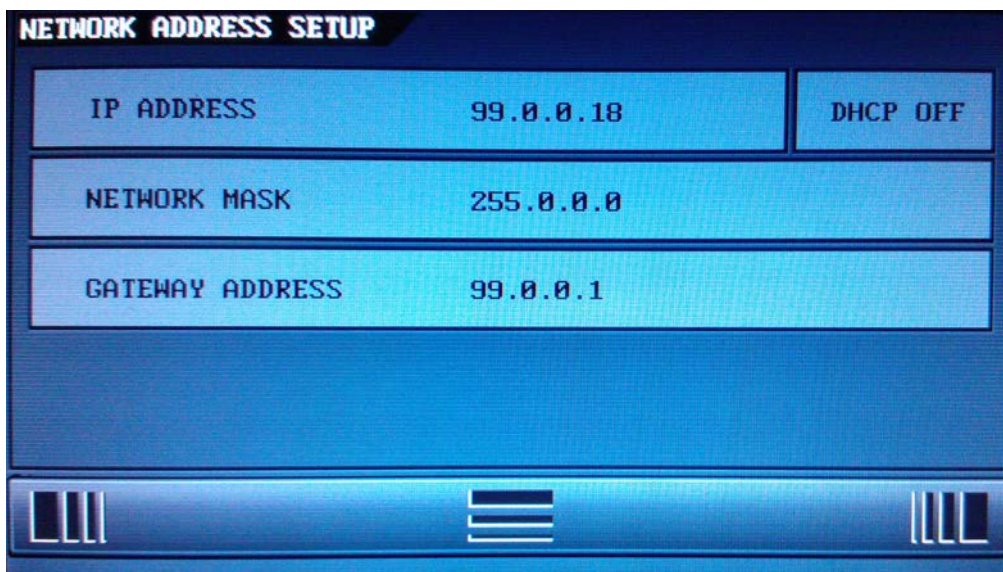| Displayed name | Description and settings |
|---|---|
| IP ADRESS | Set the instrument's IP address |
| NET MASK | Set the instrument's IP mask |
| GATEWAY ADRESS | Set the instrument's IP gateway |
| USE DHCP | YES (automatic IP address assignment) or NO (for manual IP assignment) |
| LANGUAGE | Select French or English language for menu |
| RETURN MENU | To Return to main menu |



**Figure - 7.**     **General settings 2 - Network**

### External Trigger settings

| Displayed name | Description and settings |
|---|---|
| Polarity | To trig on rising edge or on falling edge value of the Trig Ext input |
| Threshold | To adjust the threshold value of the Trig Ext input |
| Prescaler | To prescale the Trig Ext input frequency by a factor N (N = 1 to $2^{16}$-1) |
| RETURN MENU | To return to main menu |
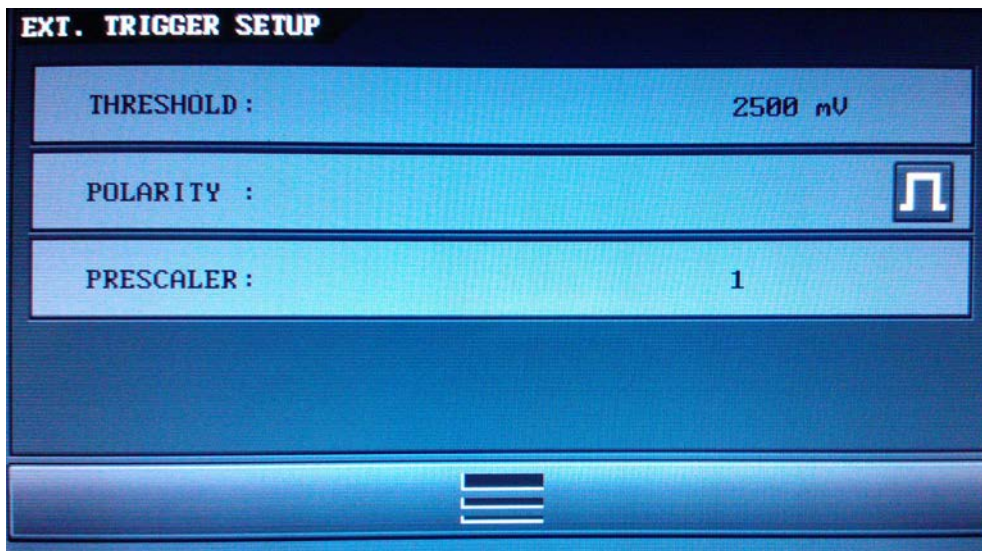


**Figure - 8.        External trigger settings**

### Burst Mode Settings

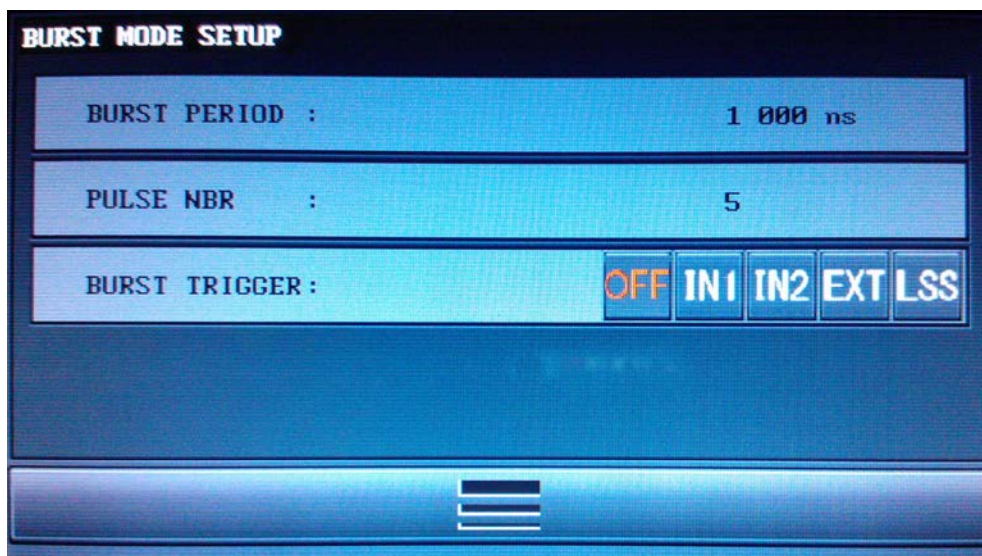| Displayed name | Description and settings |
|---|---|
| Burst Trigger | To select the trigger source : Int, Ext or manual |
| Pulse Number | To select the pulse number in each burst to generate (from 2 to $2^{16}$-1) |
| Pulse Period | To select the period between burst pulses (from 1000ns to 1s) |
| RETURN MENU | To return to main menu |



**Figure - 9.        Burst mode settings**

## 6- OPERATING INFORMATION

### Operating Principles

The principle of the programmable delay generator is described in the figure below:
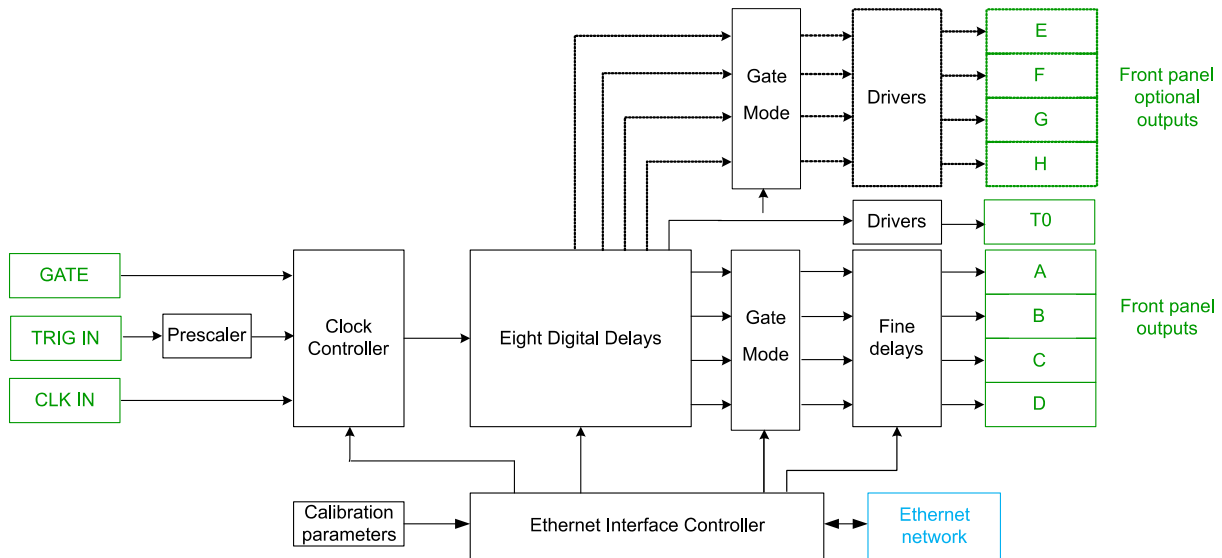


**Figure - 10.     Principle**

Trigger source can be provided by the TRIG IN input, by an internal trigger, by a software command trigger. Repetitive, single shot trigger and burst modes are available with internal and external sources. An asynchronous single shot and burst mode are also available.

#### *Repetitive triggers*

When the external trigger source is selected a rising edge on "TRIG IN" starts a delay sequence. The sequence is depicted on Figure - 12. It has to be noticed that a Prescaler value can be used to divide the Trig Ext input signal frequency.
To get this feature, the user has to select 'EXT' as trigger source on the device via the front panel or via remote control (web page, Ethernet link).

If the internal trigger source is selected, the user can specify the needed trigger source via the front panel or via remote control (web page, Ethernet link). 2 frequency generators derived from input clock can be used as repetitive triggers: IN1 and IN2 corresponding to programmable Frequency 1 and 2. The use of internal trigger is depicted on Figure - 14. Frequency generation restarts when a push on the ESC button is detected while Frequency/Period menu is displayed.
<u>Note</u>: The internal period P1 et P2 can only be increment by step of 5ns.

#### *Single Shot triggers*

3 single shot modes are available: one synchronous to the external source (SSE), one to an internal source (SS1 synchronous to Frequency 1, SS2 synchronous to Frequency 2) and the last, an asynchronous one (LSS).
Each single shot mode is triggered by a software command. Software trigger command is available either via remote control or via front panel.
Single shots synchronous to external source is depicted on Figure - 12. The same principle can be applied to any of the internal sources.

### Burst mode

The Burst mode is defined by its trigger source (internal, external, software / single shot or repetitive), its pulse number in each burst and the period between pulses. A pulse train can be independently set and defined on each channel: amplitude, width and delay are defined in the corresponding channel menu. An example of Burst mode is depicted on Figure - 15.

To generate a burst on a specified channel, first, the user has to configure the Burst mode itself (trigger, pulse number and pulse period) and then select "Burst (BST)" in the trigger source selection of the concerned channel.

### Output channels

A T0 output pulse is the time reference of the delay output. It is generated for each selected trigger.

Each output delayed pulse values A to D can be independently tuned in level, absolute or relative delay and width. All values (delay, delay reference, level, width, gate) are saved in memory except the trigger source.

Each output delayed pulse values E to H can be independently tuned in absolute or relative delay and width. All values (delay, delay reference, width, gate) are saved in memory except the trigger source. Calibration parameters are saved onboard.

After the power on, all trigger sources are off.

It has to be noticed that several output channels can only be triggered by the same source, that is to say an internal OR external source.

### Gate mode

Each channel can be independently or simultaneously "gated" by the Gate in input signal. A Gate menu is available in the main menu of the MODEL 745-T device and in each Tx sub-menu. 2 different modes can be selected in the general Gate menu:

- 1 "GENERAL" mode to gate simultaneously all channels,
- 1 "CHANNEL" mode to gate independently each channel by setting in each Tx sub-menu the desired Gate state ('1' active, '0' inactive).

### Configuration summary

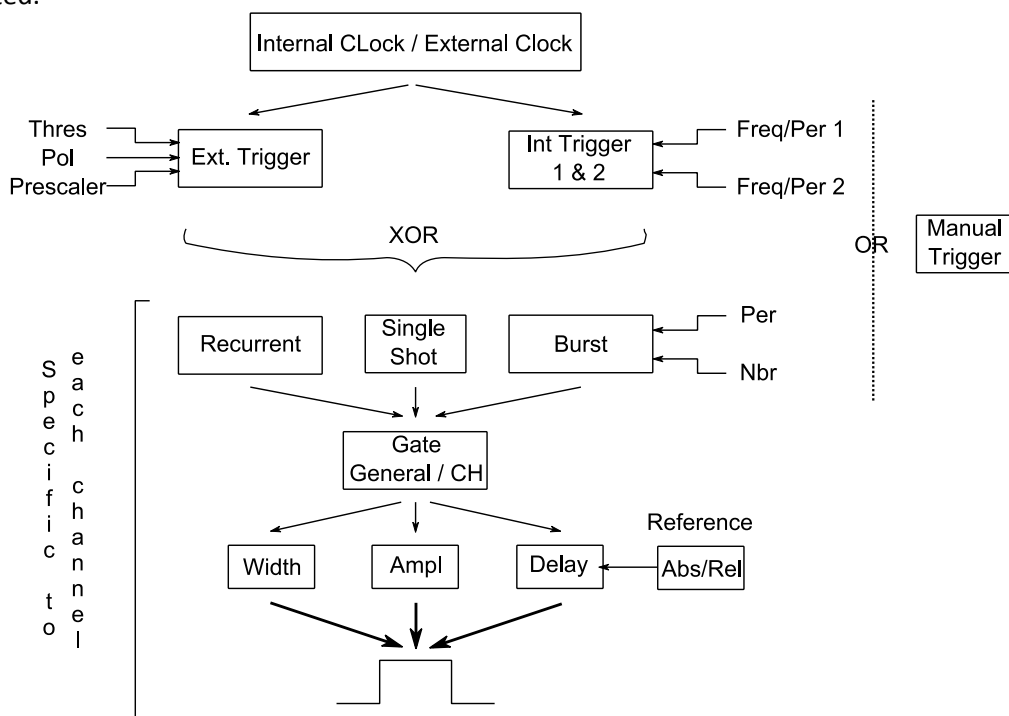On Figure - 11 is presented a functional diagram of the device. The different operation modes are illustrated.



**Figure - 11.    Functional Diagram**

## Timing principle using external trigger

When the device is in a rest state (no current output signals), a rising edge on a trigger starts a delay sequence. The trigger comes from TRIG IN, or from a software command trigger (depending on the selected channel source).

The sequence includes two external trigger phases:

- After an insertion delay (<65ns), a pulse appears on each channel after a specified delay
- At the end of sequence, after the last delayed pulse, the delay generator is ready for repetitive trigger mode.

When a sequence is in progress, the instrument does not respond to a trigger event.

The MODEL 745-T must be configured (trigger, delay, etc.) before starting any sequences.
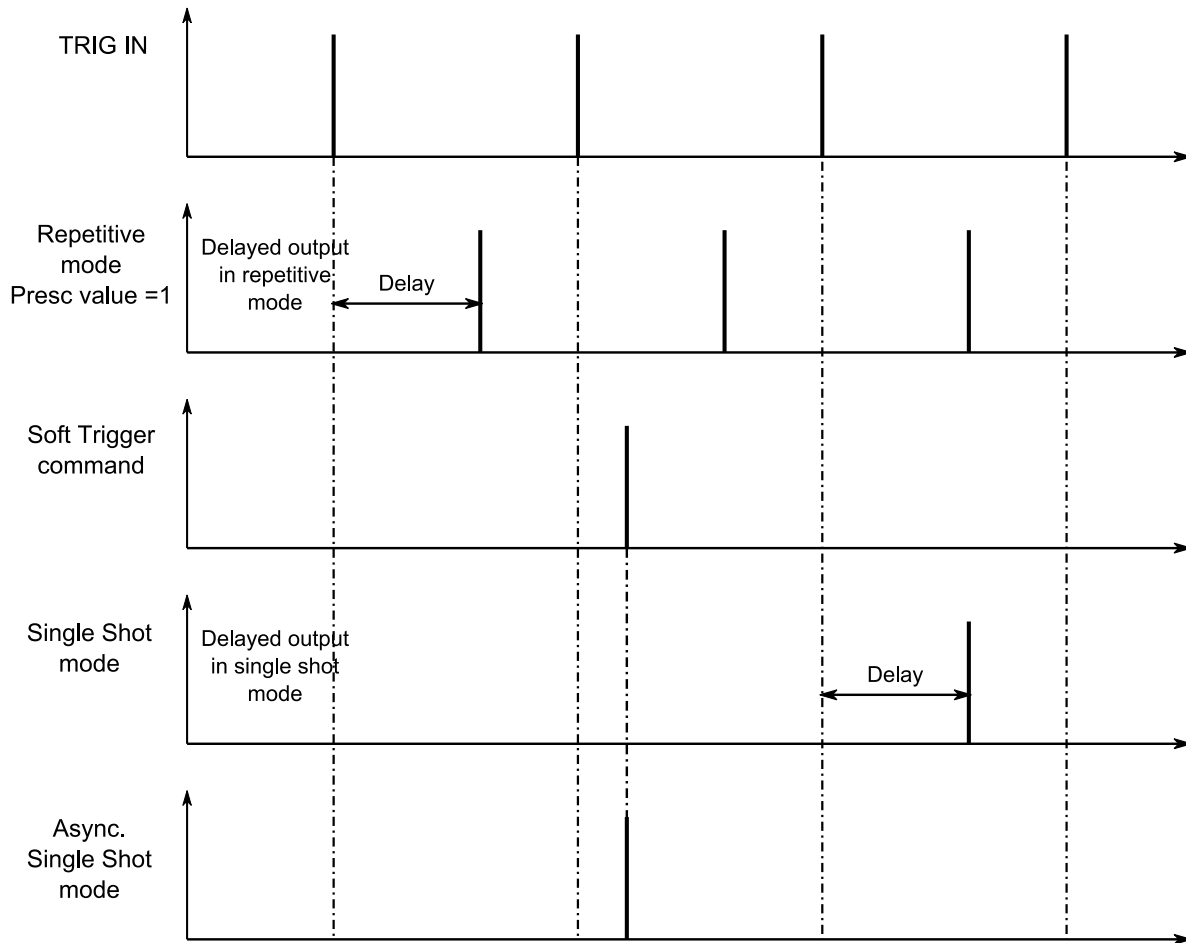


Figure - 12.      External Trigger Timing

In response to an input pulse the device can generate a single delayed output (single shot) or repetitive delayed output (repetitive mode with a Trig In prescaler value = 1). As explain before, the single shot pulse is conditioned by the soft trigger command.

The use of the Prescaler value is depicted on Figure - 13. A Channel trigger source is set to external trigger.
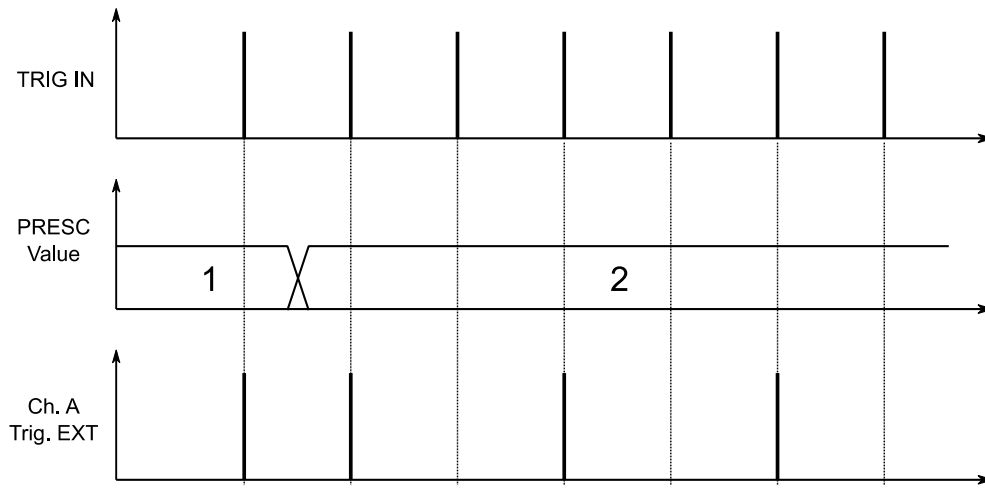
Figure - 13.        Prescaler value

## Timing principle using internal trigger
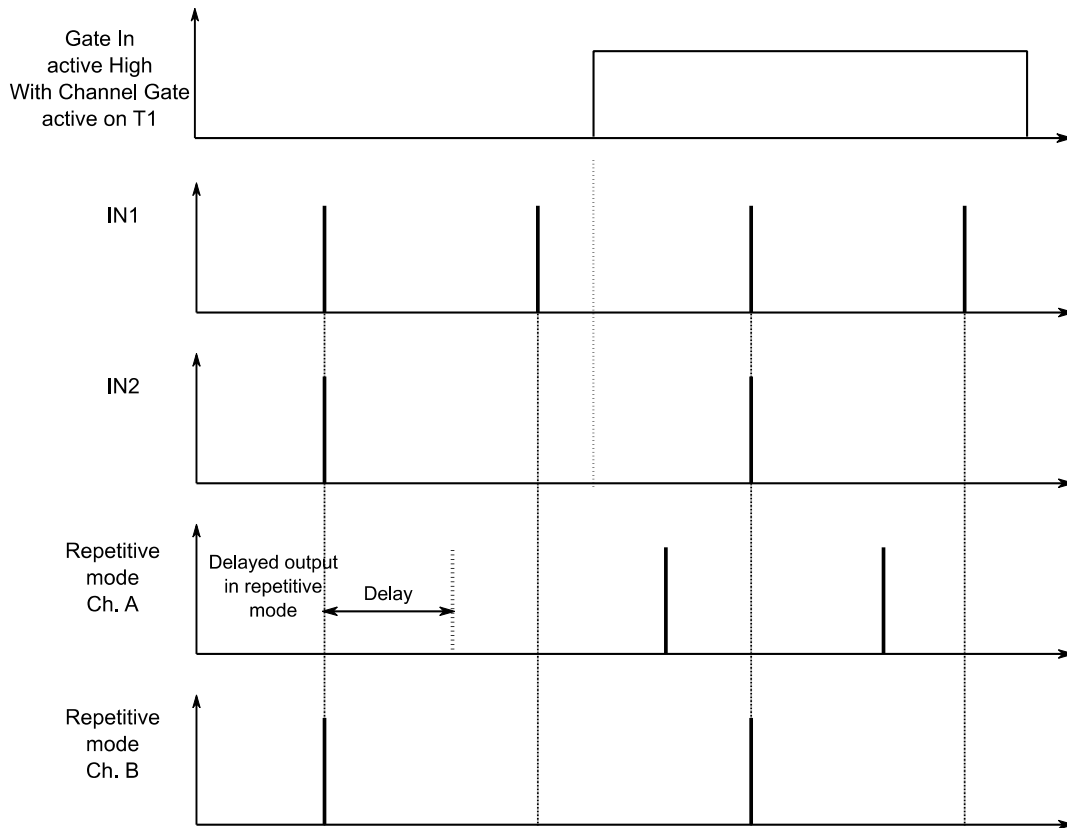


Figure - 14.       Internal Trigger Timing

In Internal trigger mode, two tunable frequencies are available (IN1 and IN2). On Figure - 14, T1 output uses IN1 trigger with a specified delay of 0ps and B output uses IN2 trigger with a non-null delay.

The MODEL 745-T must be configured (trigger, delay, etc.) before starting any sequences. The individual Channel Gate Mode is also depicted on Figure - 14. It is obtained by setting general Gate Mode to "CHANNEL" and channel A Gate mode to "ON". The result is that the Gate In signal allows the pulse output of the channel A.

The width parameter doesn't appear on these two Figures (Figure - 12, Figure - 14). It has to be noticed that the frequency $f$ used as repetitive input trigger (internal or external) and the maximum width of a corresponding output channel $Tx$ are linked by:

$$MaxWidth\,Tx = \frac{1}{4f}$$

## Timing principle using Burst mode

Each Channel can be independently set to Burst mode. In the following example Burst trigger has been set to IN1, Burst pulse number to 5 and Burst period to TB



**Figure - 15.        Burst Mode Timing**

The minimal burst period value is 1000ns. But it has to be noticed that this value depends on the Burst trigger period value and on the Burst pulse number.
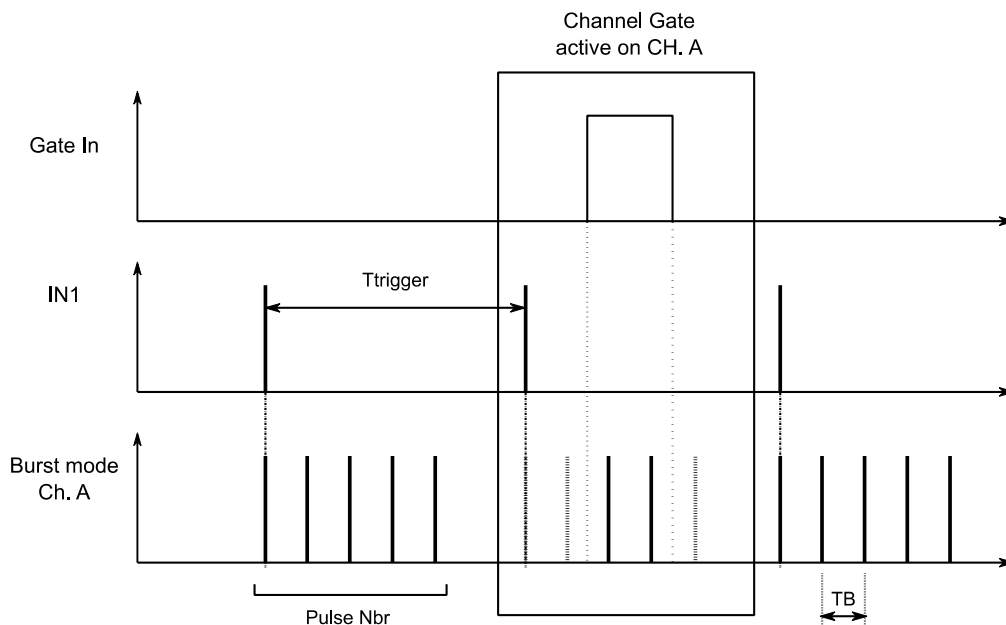
$$TBmin = \frac{T_{trigger}\,min}{Pulse\ Nbr}$$

So, to get a TBmin = 1000ns we can configure the device as follows:
- Pulse nbr max = 5
- $T_{trigger}$ min = 5000ns

As depicted on Figure - 15, in the case of a generation of pulse train (Burst Mode) on a channel, the Gate In signal can allow some pulses among the pulse train.

It has to be noticed that when a delay D is specified on a channel using Burst mode as trigger mode, the MODEL 745-T manages the delay generation according to that rule:
- If delay $D > TB - 15ns$, the delay generation is shared between the delay register specific to the channel ($D_{chan} = TB - 15ns$) and the delay register associated to the burst trigger generation ($D_{BST} = D - TB + 15ns$).
- If delay $D \leq TB - 15ns$, the delay generation is managed as usual, that is to say by using the selected channel delay register.

To summarize: $D = D_{chan} + D_{BST}$ when $D > TB - 15ns$.

When several channels are using Burst mode as trigger mode and one of the delay specified leads to the $D_{BST}$ register use ($D > TB - 15ns$), the $D_{BST}$ value will be ignored (each channel will be delayed by $D_{BST}$).

## 7- OPERATING EXAMPLE

### Default value
These values are the one stored by default:
- IP: 99.0.0.18
- Gateway: 99.0.0.01
- NetMask: 255.0.0.0
- Frequency1: 1000Hz
- Frequency2: 1000Hz
- TX Level: 5V, Width: 200ns.

### Initial setup
Turn on the Model 745T with the rear panel power switch.
After 30 seconds, the following information are displayed:
MOD745     Sn xxxxx,4 V1
SELF TEST

### Setting up the instrument (Recurrent mode)
The aim is to set a repetitive frequency of 1000Hz to output pulse A, with an amplitude of 4V and a width of 1µs. Use the touch screen to configure the settings as following:
- Go to the internal frequency display
- Set Freq 1 to 1000Hz and return to the main menu
- Go the channel setting display and select channel A
- Set amplitude to 4V and width to 1µs
- Select IN1 as trigger source.

As soon as A is set to IN1, the main display LED of A will be on indicating that there is an output signal on A connector.
With an oscilloscope you can check the channel A.
Measurement should be:
Rectangular shape with repetitive frequency =1000 Hz, Amplitude= 4.0V, Width = 1.0 µs.

### Setting up the instrument (Single shot mode)
The procedure explained before can be followed up to the trigger choice. 3 single shot modes (external: SSEXT, internal: SS1 and SS2, asynchronous: LSS) can be set. Once the single shot trigger mode is set, the user has to send a software command to trigger the single shot output pulse. To send this software command, 3 ways are available:
- Via the front panel: in the general menu, by pressing the TRIG button
- Via a telnet command, by sending the 'RUN' command to the device
- Via the web page, by pressing the 'manual trigger' button in the Trigger menu

### Setting up the instrument (Burst Mode)
The aim is to set channel A in Burst mode to get:
- a 5V, 200ns width, 0ns delay pulse
- 100Hz IN1 trigger source
- Burst period 100000ns, pulse number = 10

First the user has to configure the F1 frequency to 100 Hz and then the Burst Mode itself. That is to say, set in the Burst Mode menu:
- Burst Trigger: IN1
- Burst Period: 100000

- Burst pulse number: 10

Once this has been done, the user has to set the width, delay and trigger source (BURST) in the A channel sub-menu.

The device will start to generate the requested pulse train.

## Stop the generator

To stop the generation of that repetitive pulse, you have to set A trigger to OFF value. This will switch off the corresponding LED.

With an oscilloscope you can check if the output signal is switch off.

# 8- PROGRAMMING

## Serial communication (USB port)

### Generality

To access to MODEL 745-T via USB port, you have to configure the connection as follows:
- Baud rate: 38400
- Data bits: 8
- Stop Bit: 1
- Parity: None
- Flow control: None

## Ethernet connection/communication

### Generality

For connection over a LAN, you have to do the following:
- Connect the instrument to the LAN physically,
- In the graphical user interface, specify the LAN address,
- On the control PC, enter the instrument's IP address,
- After the connection has been established, the following commands can be used to modify the settings:
  - o Set's the instrument's IP address with: IP XXX.XXX.XXX.XXX
  - o Query's the instrument's IP address with: IP? $\Rightarrow$ :IP XXX.XXX.XXX.XXX
  - o Set's the instrument's IP mask with: NM XXX.XXX.XXX.XXX
  - o Query's the instrument's IP mask with: NM? $\Rightarrow$ :NM XXX.XXX.XXX.XXX
  - o Set's the instrument's IP gateway: GW XXX.XXX.XXX.XXX
  - o Query's the instrument's IP gateway with: GW? $\Rightarrow$ :GW XXX.XXX.XXX.XXX

### About Telnet Ports

3 ports can be used to configure the communication link and/or the µcontroller used to communicate.
- Port 4000: general communication port
- Port 4001: re-initialization communication port. Used to reinitialize the communication between µC and PC. Used in case of frozen device.
- Port 4002: force reset the µC. Used in case of frozen device.

## Command structure (Ethernet and USB connection)

Each command description is composed at least of some of the following items (all commands are used in a telnet prompt):
- Full command syntax,
- Form Set / Query,
- Brief description,
- Parameters,
- RST value,
- Specified limits.
- Example.

*Note*: in the following commands, instead of using A to H channel syntax, the user will use T1 to T8 syntax. To address a command to the channel A, the user will specify T1 instead of A in the command.

### *IDN?

|  |  |
|---|---|
| Syntax: | *IDN? |
| Form: | Query |
| Description: | Queries instrument identification. Answer gives instrument model, serial number and firmware version. |
| Parameter: | - |
| RST value | - |
| Example: | BNC,MODEL 745,53901/F,V1.1 |
|  | Instrument model: MOD745 |
|  | Serial number: 53901, |
|  | Channel number: F => 4 active channels (FF => 8 active channels) |
|  | Software version: 1.1 |

### BURST TRIG

|  |  |
|---|---|
| Syntax: | BTRIG Source |
|  | BTRIG? source |
| Form: | Set & Query |
| Description: | Trigger source for Burst mode: internal, external or local |
| Parameter: | Source: IN1, IN2, EXT, SSL |
| RST value | - |
| Example: | Set external trigger source: BTRIG EXT |
|  | Query: BTRIG?  => :BTRIG EXT |

### BURST PULSE PERIOD

|  |  |
|---|---|
| Syntax: | PERIOD PB, T |
|  | PERIOD? PB |
| Form: | Set & Query |
| Description: | Set Burst period |
| Parameter: | PB |
|  | T: period in ns (5ns resolution) |
| RST value | - |
| Specified limit | 1000 ns to 1s |
| Example: | PERIOD PB, 1000 |
|  | PERIOD? PB=> :PER 1000 |

### BURST PULSE NUMBER

|  |  |
|---|---|
| Syntax: | BPULSE N |
|  | BPULSE? |
| Form: | Set & Query |
| Description: | Set the number of pulses in a burst |
| Parameter: | N : Number of pulses |
| RST value | - |
| Specified limit | 2 to $2^{16}$-1 (depending on trigger source period and Burst period) |
| Example: | BPULSE 1000 |
|  | BPULSE? => :BPULSE 1000 |

### GENERAL GATE MODE

| | |
|---|---|
| Syntax: | GGLOBAL mode |
| | GGLOBAL? |
| Form: | Set & Query |
| Description: | General Gate mode status |
| Parameter: | mode: OFF, ON and CH |
| RST value | - |
| Example: | Set : inhibit all outputs : GGLOBAL ON |
| | Query: GGLOBAL? => :GGLOBAL ON |

### CHANNEL GATE MODE

| | |
|---|---|
| Syntax: | GCHAN Tx, value |
| | GCHAN? Tx |
| Form: | Set & Query |
| Description: | Individual channel Gate mode status |
| Parameter: | Tx: T1 to T4 (or 1 to 8 for 8 channel) |
| | Value: ON, OFF |
| RST value | - |
| Example: | Set : T1 channel mode On : GCHAN T1, ON (GENERAL GATE MODE has to be set to CH to activate this setting) |
| | Query: GCHAN? T1 => :GCHAN T1, ON |

### RELATIVE DELAY

| | |
|---|---|
| Syntax: | DELAY Tx,Ti, *delaytime* |
| | DELAY? Tx |
| Form: | Set & Query |
| Description: | Delay time of channel Tx relative to channel Ti (reference channel) is set to *delaytime* picosecond |
| Parameter: | Tx: channel number 1 to 4 (or 1 to 8 for 8 channel) |
| | Ti: channel number 0 to 4 (or 0 to 8 for 8 channel) |
| | Tn and Ti have to be different |
| | *delaytime*: picosecond delay |
| RST value | - |
| Specified limit | 0 to 19 999 999 999 999 picoseconds |
| Example: | Set : program 1ns to channel 2 relative to channel 1 : DELAY T2, T1, 1000.75 |
| | Query: DELAY? T2 => :DELAY T2, T1, 1000.75 |
| | |
| | ***Note*** : By using the Web page or Telnet command to configure the device, user can specify delay with 0.25ps resolution. |

### ABSOLUTE DELAY

| | |
|---|---|
| Syntax: | ABSDELAY? Tx |
| Form: | Query |
| Description: | Absolute delay time of channel Tx in ps |
| Parameter: | Tx: channel number 1 to 4 (or 1 to 8 for 8 channel) |
| RST value | - |
| Specified limit | - |
| Example: | Query: ABSDELAY? T2 => :DELAY T2, 5000.75 |

### TRIG

| | |
|---|---|
| Syntax: | TRIG Tx,DEC |
| | TRIG? Tx |
| Form: | Set & Query |
| Description: | Tx trigger mode selection: set trigger mode to internal, external, manual or off. |
| Parameter: | Tx: channel number 1 to 4 (or 1 to 8 for 8 channel) |
| | DEC: trigger mode : IN1, IN2, EXT, SS1, SS2, SSE, LSS, BST, OFF |
| RST value | off |
| Example: | Internal mode to channel 2 : TRIG T2,IN1 |
| | Query mode to channel 2: TRIG? T2 => :TRIG T2,IN1 |

### AMPLITUDE

| | |
|---|---|
| Syntax: | AMPL Tx, mV |
| | AMPL? Tx |
| Form: | Set & Query |
| Description: | Tx channel voltage level setting |
| Parameter: | Tx: channel number 1 to 4 (or 1 to 8 for 8 channel) |
| | mV: Volt Amplitude in milliVolt |
| RST value | - |
| Specified limit | 2000 to 5 000 mV |
| Example: | 2.5 V to channel 4: AMPL T4,2500 |
| | Query mode to channel 4: AMPL? T4 => :TRIG T4,2500 |

### WIDTH

| | |
|---|---|
| Syntax: | WIDTH Tx,W |
| | WIDTH? Tx |
| Form: | Set & Query |
| Description: | Channel Tx width setting |
| Parameter: | Tx: channel number 1 to 4 |
| | W: width ns |
| RST value | - |
| Specified limit | Channel T0 to T4 : 100 to 10 000 ns |
| | Channel T5 to T8 : 100 to 10 000 000ns |
| Example: | 250 ns to channel 4: WIDTH T4,250 |
| | Query mode to channel 4: WIDTH? T4 => :WIDTH T4,250 |

### EXT TRIG THRESHOLD

| | |
|---|---|
| Syntax: | STRIG mV |
| | STRIG? |
| Form: | Set & Query |
| Description: | Set and Query trigger threshold voltage |
| Parameter: | mV: Threshold level in milliVolt |
| RST value | - |
| Specified limit | 100 to 5 000 mV |
| Example: | 2.5 V: STRIG 2500 |
| | Query mode: STRIG? => : 2500 |

### EXT TRIG POLARITY

| | |
|---|---|
| Syntax: | POLAR Edge |
| | POLAR? |
| Form: | Set & Query |
| Description: | Edge: Rising Edge or Falling Edge |
| Parameter: | Edge: R_E or F_E |
| RST value | - |
| Specified limit | R_E or F_E parameters |
| Example: | Falling Edge: POLAR F_E |
| | Query mode: POLAR? :F_E |

### EXT TRIG PRESCALER

| | |
|---|---|
| Syntax: | TPRESC Value |
| | TPRESC?? |
| Form: | Set & Query |
| Description: | Set prescaler value to divide Trig In source frequency |
| Parameter: | Value: Trig In prescaler value |
| RST value | - |
| Specified limit | from 1 to $2^{16}$-1 |
| Example: | 4: TPRESC 4 |
| | Query mode: TPRESC? :4 |

### FREQUENCY

| | |
|---|---|
| Syntax: | FREQ Fx, F |
| | FREQ? Fx |
| Form: | Set & Query |
| Description: | Set internal mode frequency |
| Parameter: | Fx : F1, F2 |
| | F: frequency Hz |
| RST value | - |
| Specified limit | 1 Hz to 1 MHz |
| Example: | FREQ F1, 1000 |
| | FREQ? F1=> :FREQ 1000 |

### PERIOD

| | |
|---|---|
| Syntax: | PERIOD Px, T |
| | PERIOD? Px |
| Form: | Set & Query |
| Description: | Set internal mode period |
| Parameter: | Px : P1, P2 |
| | T: period in ns (5ns resolution) |
| RST value | - |
| Specified limit | 1000ns to 4s |
| Example: | PERIOD P1, 1000 |
| | PERIOD? P1=> :PER 1000 |

*CLKEXT*

| | |
|---|---|
| Syntax: | CLKEXT F |
| | CLKEXT? F |
| Form: | Set & Query |
| Description: | Set external PLL frequency |
| Parameter: | F: external PLL frequency: CLK10, CLK80 |
| RST value | - |
| Specified limit | - |
| Example: | CLKEXT CLK10 |
| | CLKEXT? => :CLKEXT: CLK10 |

*RUN*

| | |
|---|---|
| Syntax: | RUN |
| Form: | Set |
| Description: | Software trigger |
| Parameter: | - |
| RST value | - |
| Example: | RUN |

*STORE*

| | |
|---|---|
| Syntax: | STORE n |
| Form: | Set |
| Description: | To store MODEL 745-T current configuration |
| Parameter: | n: configuration number |
| RST value | - |
| Specified limit | 0 to 3 |
| Example: | STORE 1 |

*RECALL*

| | |
|---|---|
| Syntax: | RECALL n |
| Form: | Set |
| Description: | To recall a MODEL 745-T configuration previously stored |
| Parameter: | n: configuration number |
| RST value | - |
| Specified limit | 0 to 3 |
| Example: | RECALL 1 |

### STAT

| | |
|---|---|
| Syntax: | STAT CLEAR |
| | STAT? xxx |
| Form: | Set & Query |
| Description: | Equipment information |
| Parameter: | CLK: INTERNAL / EXTERNAL |
| | TRIG: trigger channel 1 to 4 states |
| | PLL: PLL oscillator state |
| | OSC: gated oscillator state |
| RST value | Off |
| Example: | STAT CLEAR : clear the information |

STAT? CLK => :STAT CLK,INTERNAL
STAT? TRIG => :STAT TRIG,1,0,0,1 Channel 1 and 4 trig on mode internal, external or manual
STAT? PLL => PLL oscillator default,
STAT? OSC => gated oscillator default

### IP address

| | |
|---|---|
| Syntax: | IP x.x.x.x |
| | IP? |
| Form: | Set & Query |
| Description: | IP Adress |
| Parameter: | x.x.x.x : IP address |
| RST value | Off |
| Example: | IP 172.17.23.6 |
| | IP? => :IP 172.17.23.6 |

### Net mask address

| | |
|---|---|
| Syntax: | NM x.x.x.x |
| | NM? |
| Form: | Set & Query |
| Description: | Net mask Address |
| Parameter: | x.x.x.x : NW address |
| RST value | Off |
| Example: | NW 255.255.0.0 |
| | NW? => :NW 255.255.0.0 |

### GW address

| | |
|---|---|
| Syntax: | GW x.x.x.x |
| | GW? |
| Form: | Set & Query |
| Description: | GW Address |
| Parameter: | x.x.x.x : GW address |
| RST value | Off |
| Example: | GW 172.17.23.6 |
| | GW? => :GW 172.17.23.6 |

## Web Page control/communication

The user can open a web page to control the MODEL 745-T device via Internet Explorer, Firefox or Chrome (last versions supported). To access the web page, the IP address of the device has to be typed in the navigator address field. Once that is done, the user should access to the following page.
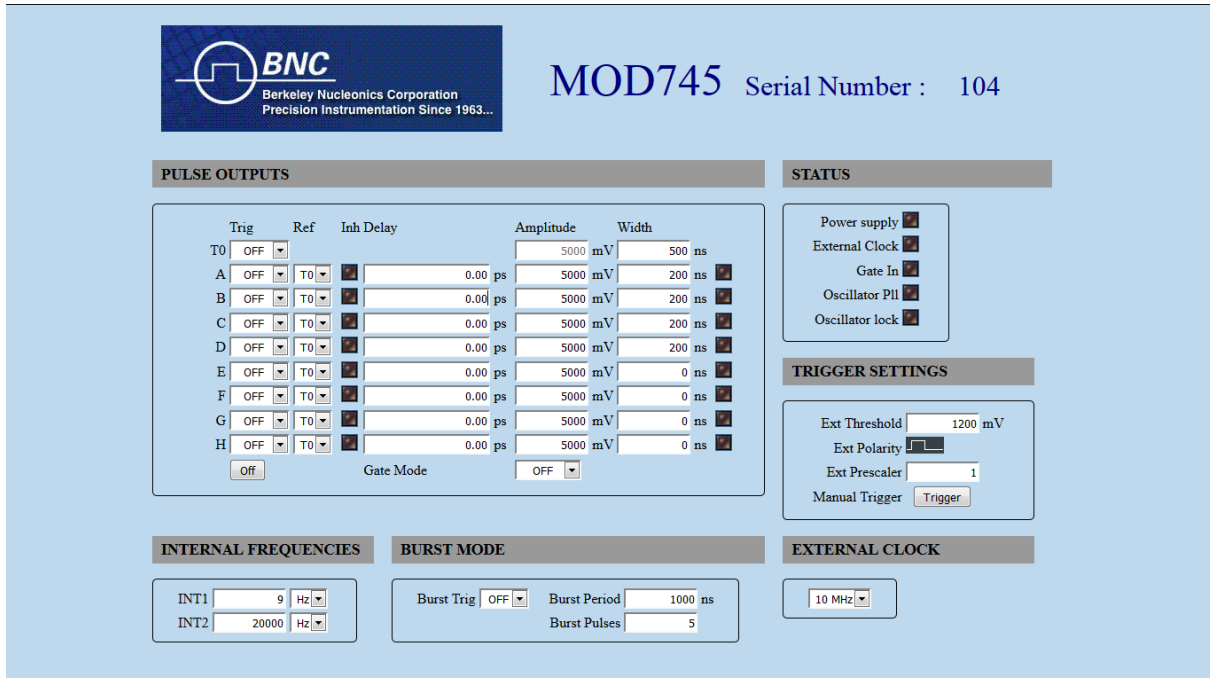


**Figure - 16.      Configuration page**

From that page, the user can configure each output pulse (amplitude, width, trigger, delay, inhibit and delay reference), trigger settings, internal frequencies, external clock and burst mode.
On the first setting change, the user will be asked for Login and Password (Default Login: BNC, Default password: bnc).
Status LEDs indicate which outputs are active or not and Fault LEDs warn the user in case of errors.
To refresh led status, the user has to click on one off these LEDs.
The "manual trigger button" is used to trigger a channel sets to SS1, SS2 or LSS (Single shot 1 & 2 and Local Single Shot)
And at last, the user can access to the password setting page by typing in the address field: "Device IP/passwd.htm".
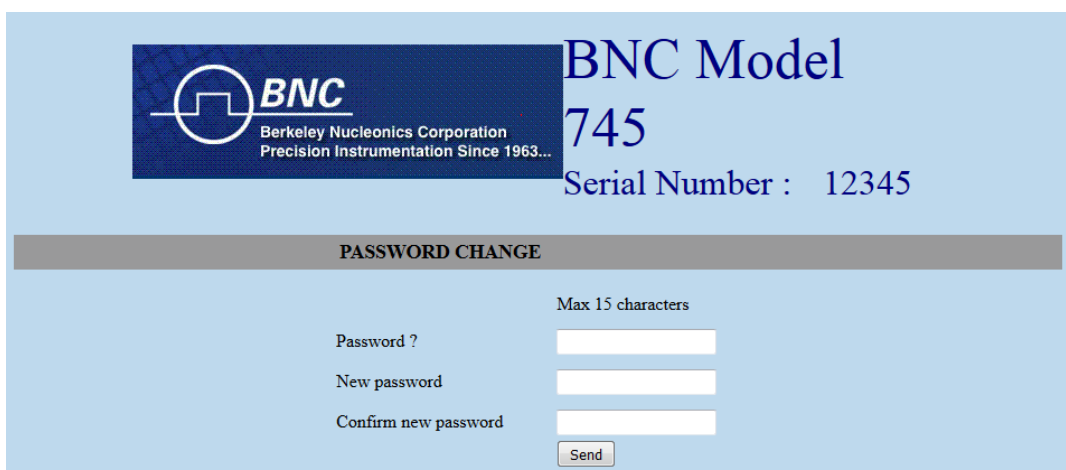


**Figure - 17.      Password page**

# 9- ANNEX A

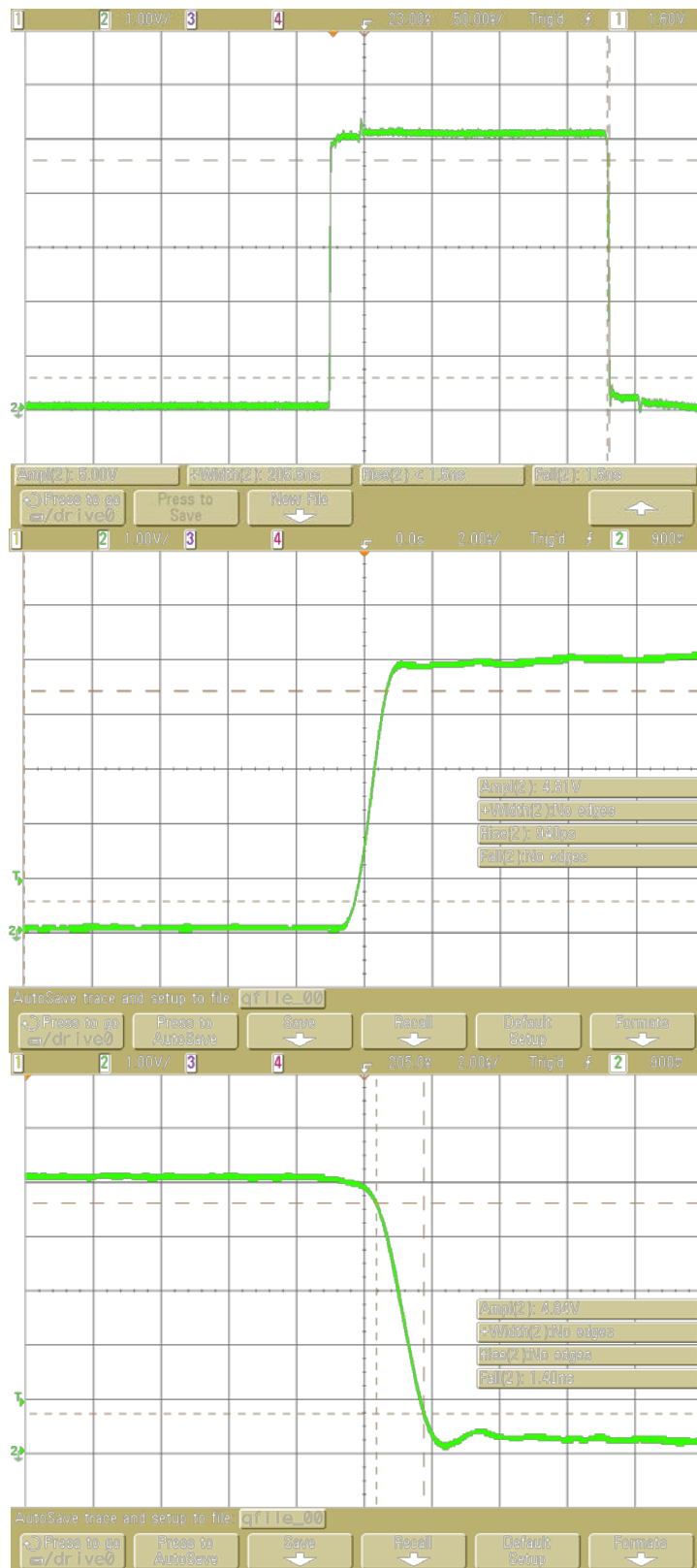High precision and auxiliary pulse results appear on the following figures.
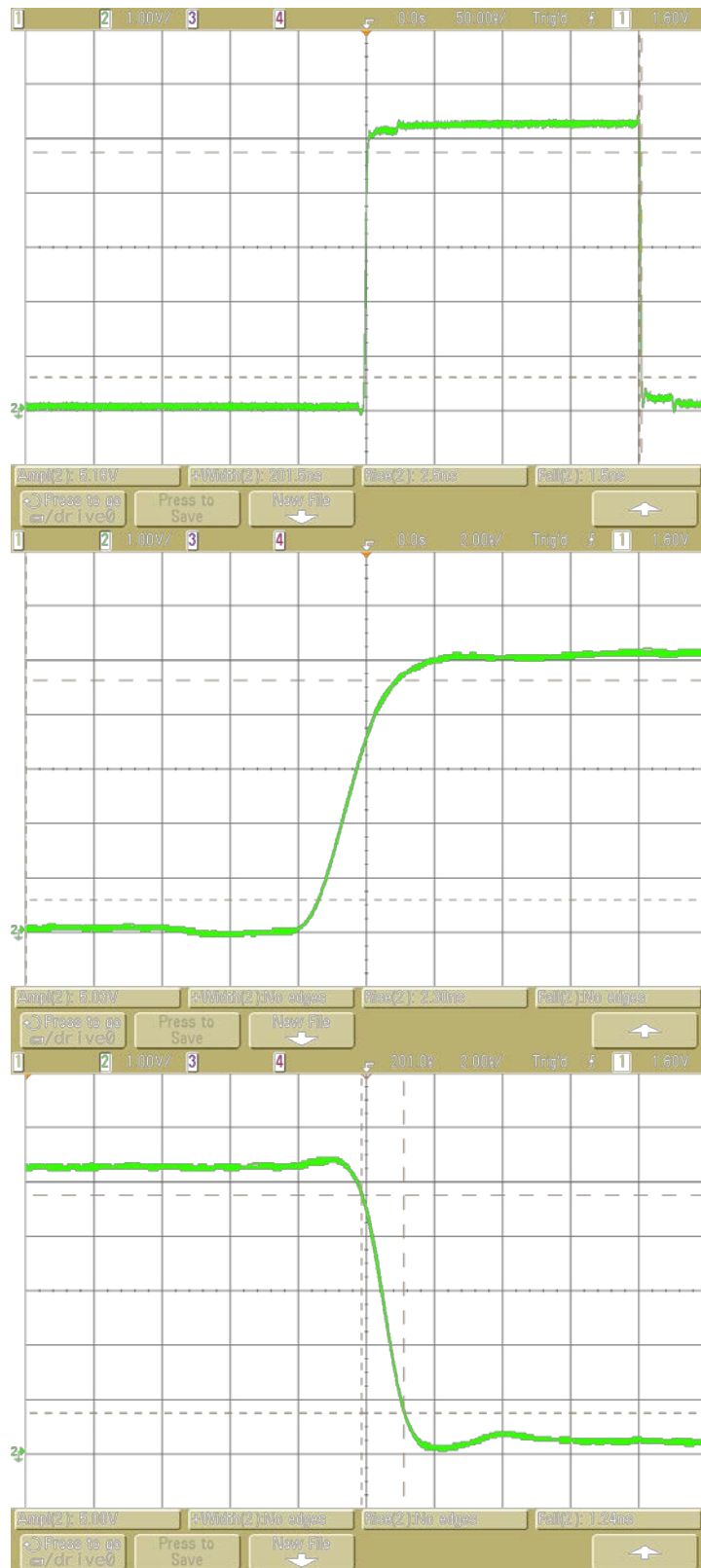


Figure - 18.        Main pulse (channels A to D)

**Figure - 19.**        **Auxiliary pulse (channels E to H)**

# 10-  ANNEX B

The rms jitter for Internal and External source are depicted on figure 11 and 12. It is given for different delay values.
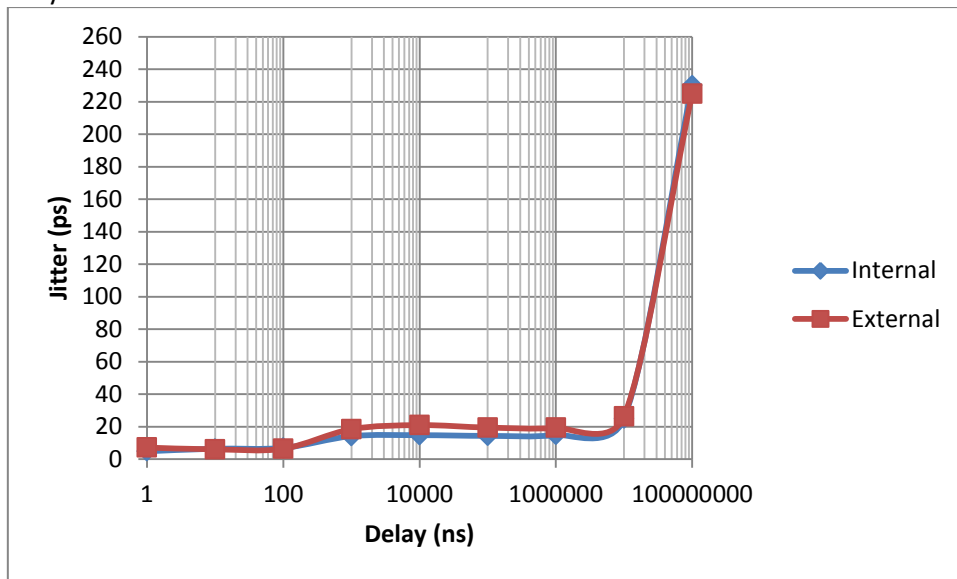


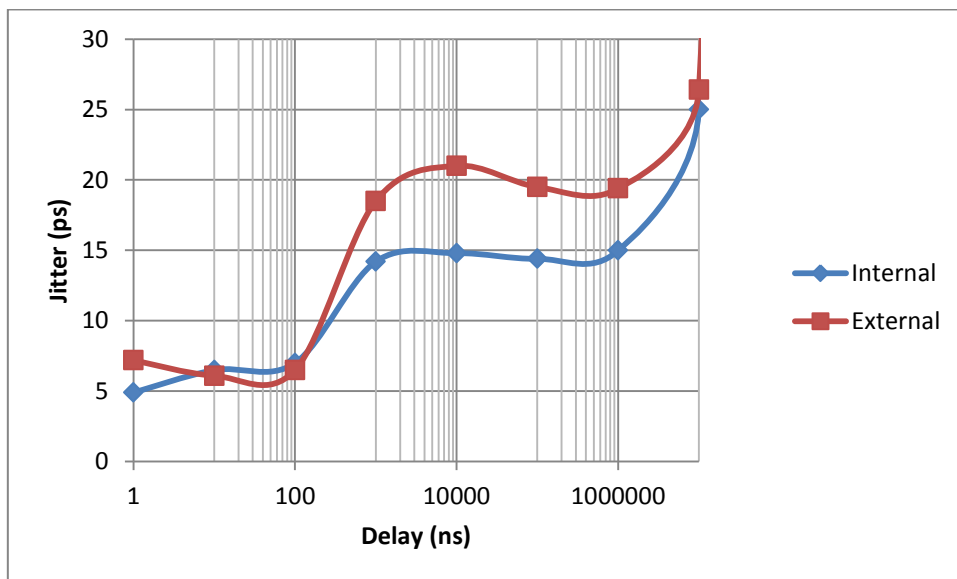**Figure - 20.      Internal and External delay Jitter**



**Figure - 21.      Zoom on delay jitter**

# BNC Product Information for People's Republic of China

This document provides product information as required by the People's Republic of China Electronic Industry Standard SJ/T11364–2006, *Marking for Control of Pollution Caused by Electronic Information Products*.

Table 1 lists toxic or hazardous substances or elements contained in Berkeley Nucleonics' electronic information products (EIPs), including subassemblies, that exceed limits specified in SJ/T11363–2006.

Table 1. Example Toxic or Hazardous Substances and Elements Contained in Product

| Component Name | Toxic or Hazardous Substances and Elements | | | | | |
|---|---|---|---|---|---|---|
| | Lead (Pb) | Mercury (Hg) | Cadmium (Cd) | Hexavalent chromium (Cr$^{6+}$) | Polybrominated biphenyls (PBB) | Polybrominated diphenylethers (PBDE) |
| Printed circuit card assembly | X | O | O | O | O | O |
| Metal enclosure | X | O | O | X | O | O |
| **O**: Indicates that the toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit required in SJ/T 11363-2006.<br><br>**X**: Indicates that the toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T 11363-2006. | | | | | | |

## *Product Marking Explanations*

In accordance with the requirements specified in SJ/T 11324-2006, all BNC EIPs sold in the People's Republic of China are marked with pollution control marking. The following marking applies to BNC products.



This marking indicates that some homogeneous substance within the EIP contains toxic or hazardous substances or elements above the requirements listed in SJ/T11363–2006. These substances are identified in Table 1.

The size or function of some products may prevent them from being directly marked. These products still meet SJ/T11364–2006 requirements, and their marking information is covered by this document.

**Environmentally Friendly Use Period**
The number in the marking, shown as 40 in the illustration above, refers to the EIP's environmentally friendly use period (EFUP). The EFUP is the number of years from the date of manufacture that toxic

or hazardous substances or elements contained in EIPs will not leak or mutate under the normal operating conditions described in the EIP user documentation, resulting in any environmental pollution, bodily injury, or damage to assets.

### *Original Equipment Manufactured (OEM) EIP*

SJ/T11364–2006 specifies that OEM EIPs shipped by BNC should include hazardous substance information and EFUP markings. Table 1 applies to products that do not supply OEM product information

### *Manufacture Date*

Manufacture dates of all BNC products are encoded into the product serial number. Contact your local sales office to obtain the manufacture date for your product.

### *Packaging Recycling Marks*

EIP packaging is marked in accordance with the needs and requirements for recycling, reuse, and regeneration, as defined in standard GB 18455–2001, *Packaging Recycling Marks*. As specified in SJ/T11364–2006, the following packaging information may be used for instances in which it is not possible to provide recycling marks on the packaging material.
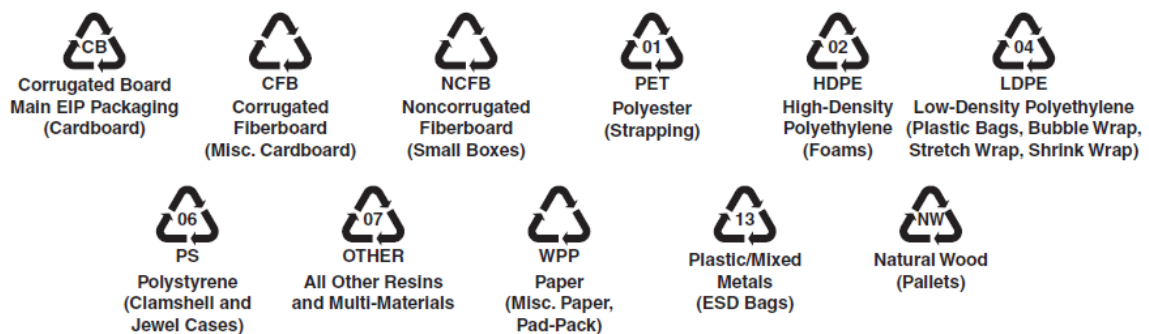


# Waste Electrical and Electronic Equipment (WEEE)

**EU Customers** At the end of the product life cycle, all products must be sent to a WEEE recycling center.

# Restriction of Hazardous Substance (RoHS)