MODEL 745-T
FOUR CHANNEL DIGITAL DELAY/ PULSE GENERATOR
User Manual

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.

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)
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## EDITION

<table>
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<tr>
<th>Ed.</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>07/09/2015</td>
<td>Creation</td>
</tr>
<tr>
<td>2</td>
<td>04/11/2015</td>
<td>Modification: channels T1-T8 become channels A-H</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>745-4C-GOC</th>
<th>Standard device</th>
</tr>
</thead>
<tbody>
<tr>
<td>745-8C-GOC</td>
<td>Extension to 8 channels (4 optional channels with 1.25ns resolution)</td>
</tr>
</tbody>
</table>

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](http://www.berkeleynucleonics.com/support)
- Certificate of calibration

BNC product:
For more information about BNC product see our web site: [http://www.berkeleynucleonics.com/](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**: 25 ps RMS + delay x $10^{-8}$ (external trigger to any output) Annex
  
  20 ps RMS + delay x $10^{-8}$ (channel to channel) Annex
  
  < 5 ps RMS for short delay (channel to channel)
- **Accuracy**: < 250 ps + delay x $10^{-8}$
- **Time base**: 200 MHz, 50 ppb

### Trigger source

- **Internal**: 2 timers tunable in Hz or ns
  
  1 Hz to 1 MHz, 1 Hz resolution
  
  1 µs to 4 s, 5 ns resolution

- **External**: Repetition rate < 1 MHz
  
  Prescaler: 1 to $2^{16}$ - 1
  
  Trigger level, from 0.1 to 5 V,
  
  Internal load: 50 Ω
  
  Positive or negative slope
  
  Minimum trigger delay < 60 ns

### Trigger mode

- **Single, repetitive or burst**
  
  Burst specs.
  
  Pulse number: 2 to $2^{16}$ - 1
  
  Period: 1000 ns to 1 s

### Gate Mode

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

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

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

### Clock Input

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

### Clock Output

- **Frequency**: 10 or 80 MHz (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: 1.25 ns
  
  Jitter: 50 ps RMS + delay x $10^{-8}$
  
  (External trigger to any output)
  
  Accuracy: < 1 ns + delay x $10^{-8}$

- **Output E to H (T5 to T8)**
  
  Amplitude: 2 to 5 V
  
  Width: 100 ns to 10 ms; 5 ns resolution
  
  Load: 50 Ω
  
  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.

![Rear panel](image)

**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 50Ω.

**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.

![Main Display](image)

**Figure - 3. Main Display**

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

Channel Tx can be channel A to H.

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

**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.