NUT 063 Ed. 2.2

September 2015

User's Manual

MODEL 745-20C

20 CHANNELS DIGITAL DELAY GENERATOR

- 20 independent delay channels
- 100 ps delay resolution (1 ps option)
- 10 seconds delay range
- Adjustable output level, polarity and width

Number of pages: 31

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Edition

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Edition	Date	Description
1	January 2014	Creation
2	October 2014	Operating description updates
2.1	April 2015	Minor correction
2.2	September 2015	Add some informations
2.3	August 2016	Correct some mistake

1. GENERAL INFORMATION

1.1. Overview

The MODEL 745-20C Digital Delay Generator provides twenty independent delayed output pulses.

Delays up to 10 seconds may be programmed with 100ps resolution (1ps optional) and a channel to channel jitter of less than 50 ps RMS.

BNC outputs deliver delayed pulses with adjustable level (3 to 6V) and width into 50Ω load. A polarity control allows to have inverted pulses.

A trigger output signal (T0) is provided as the temporal reference for the delayed outputs.

The MODEL 745-20C may be remote controlled via Ethernet interface (10/100Mb/s) (basic commands or Web page interface).

Instrument Options

Option 1	Clock output
Option 2	2.5 to 10 V channels, 1 ns rise time, positive polarity
Option 3	Amplitude up to 20 V, adjustable
Option 4	Maximum amplitude up to 32V (fixed)
Option 5	1 ps resolution
Option 6	Front panel for local control (touchscreen)
Other	Trigger source saved after shut down, Immediate modification of output pulse without validation, specific options available upon request.

Package contents

The box you receive should contain the following:

- MODEL 745-20C instrument,
- Power cable,
- User's manual,
- CD containing DLL and Labview driver.

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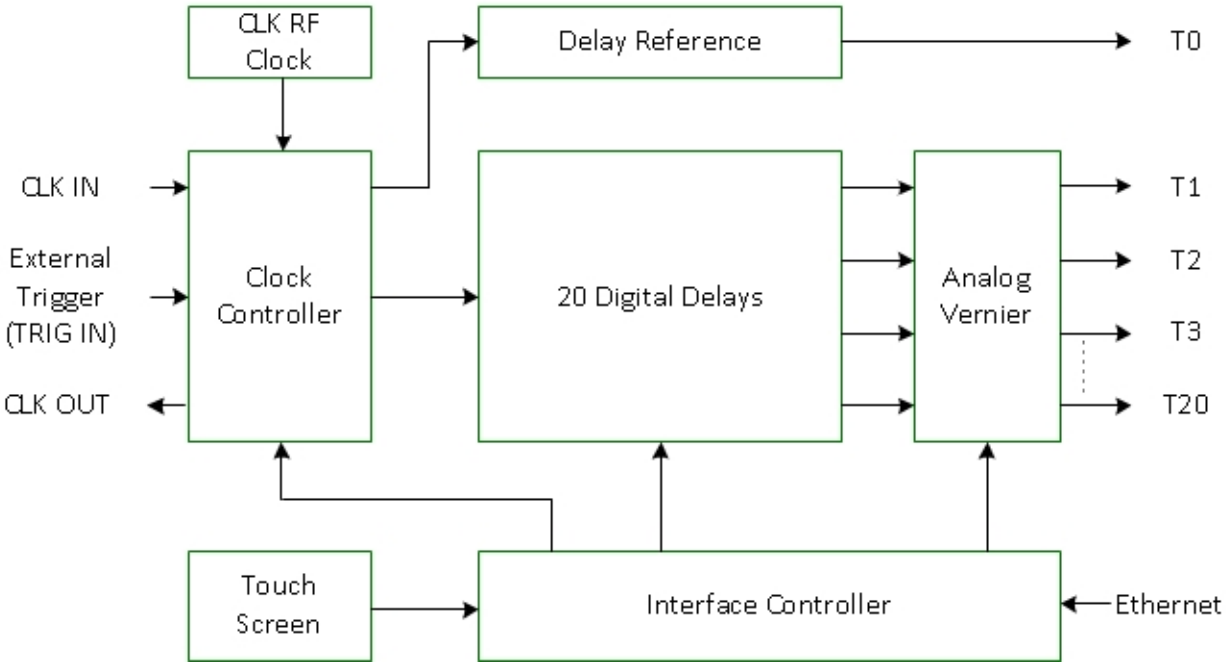
www.BerkeleyNucleonics.com

1.2. Principle – Block diagram

The principle of the MODEL 745-20C programmable delay generator is described in the figure bellow.



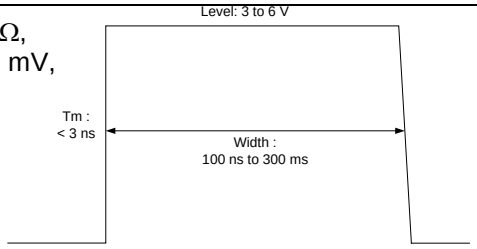
The sequence follows 3 phases:

1) After an insertion delay, a reference pulse appear at the “T0” output,
2) Following the reference, a pulse is generated on each channel after the specified delay,
3) At the end of the sequence, after last delayed pulse outputs, the delay generators are initiate.

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

Each channel T1 to T20 can be independently set in level, width, delay, polarity and trigger source. All these values are saving when the equipment is shut down, except the trigger source (option). After the power on, all trigger sources are set to OFF (INH).

2. SPECIFICATIONS

Delays	
Channels	20 independent delay channels
Range	0 to 10 seconds
Resolution	100 ps (1 ps option)
RMS Jitter	< 25 ps + delay x 10^{-7} rms
Internal time base	
Frequency	CLK RF
Stability	10^{-8}
Trigger	
Single shot source SS1 and SS2	SS1 synchronous with the first occurrence of F3 and SS2 with the second occurrence of F3.
Synchronous repetitive triggers	3 frequencies: F1> F2 > F3 in 1, 2 , 5 sequence F1: 1000, 500, 200, 100, 50, 20, 10, 5, 2 Hz F2: 200, 100, 50, 20, 10, 5, 2, 1, 0.5 Hz F3: 50, 20, 10, 5, 2, 1, 0.5, 0.2, 0.1 Hz
Outputs	
Delayed output (T1 to T20)	Positive or negative pulse into 50 Ω, Amplitude 3 to 6 V , resolution: 10 mV, Rise time : < 5 ns, Fall time: < 10 ns, Width: 100 ns to 300 ms Connector type BNC, 
Reference output (T0)	Positive pulse into 50 Ω, amplitude 3 to 6V, resolution 10 mV Rise time < 5 ns, fall time < 10 ns, width 100ns to 300 ms Connector type BNC
CLK RF / 2 (output option)	Frequency: CLK RF / 2, > 1V / 50 Ω, Connector type BNC
Interface	
Front panel (option), Ethernet 10/100 Mb/s, Internet (Web page)	
General	
Power Required	90 – 220 V / 50 – 60 Hz / 1 A.
Weight	Net: < 10 kg
Dimensions	19'', 2 U, 320 mm without handles

Outputs (option 2)	
Delayed output (T1 to T20)	Positive pulse into 50 Ω, Amplitude 2.5 to 10 V , resolution: 10 mV, Rise time : < 1 ns, Fall time: < 5 ns, Width: 100 ns to 10 ms Connector type BNC,
Outputs (option 3)	
Delayed output (T1 to T20)	Positive pulse into 50 Ω, Amplitude 5 to 20 V , resolution: 10 mV, Rise time : < 5 ns, Fall time: < 10 ns, Width: 100 ns to 1 µs Connector type BNC,
Outputs (option 4)	
Delayed output (T1 to T20)	Positive pulse into 50 Ω, Amplitude 32 V , Rise time : < 10 ns, Fall time: < 10 ns, Width: 100 ns to 1 µs Connector type BNC,

3. INSTALLATION

3.1.1. Power source

The MODEL 745-20C can be operated from 90 VAC to 240 VAC nominal supply source.

The maximum power consumption of the MODEL 745-20C is 80 W.

3.1.2. Power cord

The MODEL 745-20C comes with a removable power cord for US operation. It has a three contact plug for connection to both the power source and protective ground.

3.2. Operating temperature

The MODEL 745-20C can be operated where the ambient air temperature is 0°C to 35°C and can be stored in ambient temperature from - 10°C to + 60°C. The MODEL 745-20C is cooled by air circulation. To prevent instrument damage a clearance of 2 inches on the side and 1 inch on the rear must be maintained for proper cooling.

3.3. Rack mounting information

The MODEL 745-20C will fit a 19 inch rack.

3.4. Self-test

The model, firmware version, serial numbers of the equipment and self-test will be displayed for a certain duration after the start up, depending on the ambient temperature. The self-test should not exceed 1 minute.

3.5. Optimal performance

To ensure optimal performance, it is recommended to wait 1 hour after the equipment's switching on.

4. INTERFACES DESCRIPTION

4.1. Front panel

The MODEL 745-20C front panel is depicted in the following figure.

4.1.1. Local interface

The MODEL 745-20C is equipped with a touch screen (option) on the front panel for local operation.

4.1.2. AUX 1 to 3

The three BNC connectors located on the front panel are used for extension to 40 channels. They are unused in the MODEL 745-20C version.

4.2. Rear panel

All input/output connections on the MODEL 745-20C are located on the rear panel depicted in the following figure.

4.2.1. Power switch

The unit is turned ON by switching the red button located above the mains connector.

The MODEL 745-20C can be operated from 90 to 240 V at a line frequency of 50 – 60 Hz.

4.2.2. Ethernet port (LAN)

The “LAN” RJ45 rear panel connector is used to remote control the MODEL 745-20C with TCP/IP protocol.

4.2.3. Trigger input (TRIG IN)

The “TRIG IN” BNC connector is used for application of the trigger input signal that generates the single shot sequence.

4.2.4. Trigger ouptut (T0)

The “T0” BNC connector is used as the output temporal reference for delayed outputs. This should be terminated in 50Ω if used.

4.2.5. Clock output (CLK OUT)

The “CLK OUT” BNC connector (option) is used to monitor the internal frequency reference divided by 2. This signal is synchronous with the other outputs. This should be terminated in 50 Ω if used.

4.2.6. Clock input (CLK IN)

The “CLK IN” BNC connector is used to add an external frequency reference.

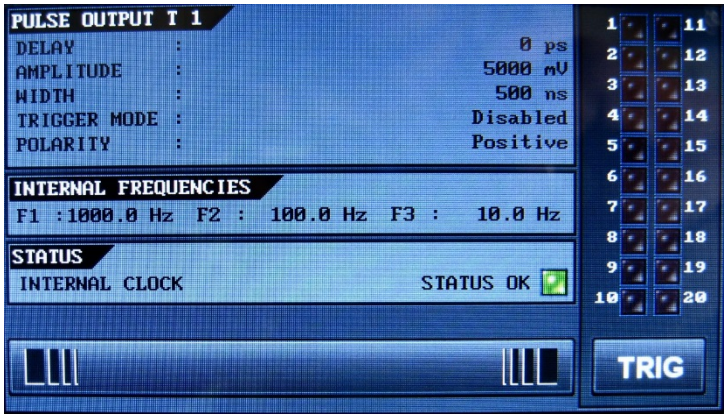
4.2.7. Delayed output (T1 to T20)

“T1” to “T20” BNC connectors are the 20 delayed outputs. They should be terminated in 50 Ω if used.

5. LOCAL OPERATION

5.1. Main menu

After power on, the main menu appears on the touch screen as depicted below.



PULSE OUTPUT displays the settings of each channel T0 to T20.

INTERNAL FREQUENCIES displays the actual set of frequencies F1, F2 and F3.

STATUS displays the status of the equipment (internal or external clock and status).

1 to **20** indicators light up in green when the corresponding channel has been triggered.

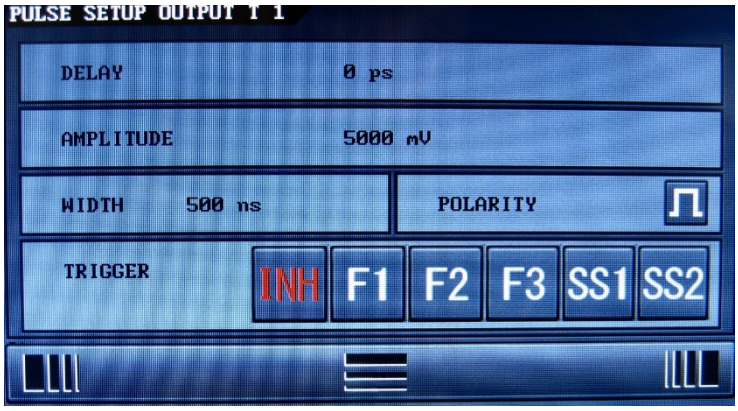
TRIG runs a unique single shot sequence.

Notes:

- The displayed channel in PULSE OUTPUT window is set with the scroll bar at the bottom of the screen.
- The STATUS OK indicator turns red when the equipment is in a default state.
- The 1 to 20 trigger status indicators turn green if the channel has delivered at least one pulse.
- Tapping on the 1 to 20 trigger status indicators will reset them until next trigger.

5.2. Sub-menu “PULSE SETUP OUTPUT”

Tapping in the “PULSE OUTPUT” window on the main menu will open a sub-menu with the channel settings depicted in the following figure.



DELAY parameter is the delay of the channel, relative to T0, in ps.

AMPLITUDE parameter is the voltage level of the channel, in mV.

WIDTH parameter is the width of the channel, in ns.

POLARITY parameter is the quiescent level of the channel.

TRIGGER parameter is the trigger source of the channel.

Notes:

- At power on, all channels trigger are set to INH (disabled).
- To set delay, amplitude or width, tap on the corresponding window to open the sub-menu.
- To change polarity, tap on the button in the polarity window ( ).
- To change the trigger source tap on the corresponding source button.
- The displayed channel can be changed with the scroll bar at the bottom of the screen (left or right) directly in this sub-menu.
- The sub-menu can be closed by taping and dragging up the center of the bottom scroll bar.

The following chart described the trigger source, amplitude, width and polarity possible value for each channel.

	T0 to T20
TRIGGER SOURCE	Disabled (INH)
	Repetitive F1 (F1)
	Repetitive F2 (F2)
	Repetitive F3 (F3)
	Single Shot 1 (SS1)
	Single Shot 2 (SS2)
AMPLITUDE	3000 mV to 6000 mV in 10 mV steps
WIDTH	100 ns to 300 ms in CLK RF steps

POLARITY	Positive : quiescent level of the channel is 0V
	Negative : quiescent level of the channel is at amplitude level
T1 to T20	
DELAY	0 to 9 999 999 999 999 ps in 100 ps steps or 1 ps steps (option)

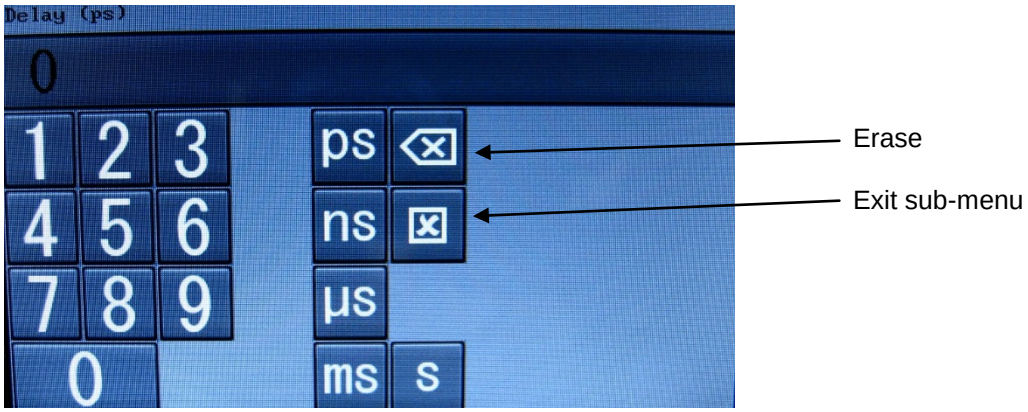
The default values of the equipment are the following:

- IP ADRESS : 99.0.0.18
- GATEWAY ADRESS : 99.0.0.01
- NET MASK : 255.0.0.0
- F1 : 1000 Hz
- F2 : 100 Hz
- F3 : 10 Hz
- Level: 5.00 V
- Width: 500 ns
- Trigger source: INH
- Polarity: Positive

5.1. Sub-menu “Delay”

Tapping in the “DELAY” window on the “PULSE SETUP OUTPUT” sub-menu will open another sub-menu with the delay settings of the channel depicted in the following figure.

To set the channel delay, enter the value with the numbers, then tapping on the unit (ps, ns, µs, ms or s) will validate the setting.

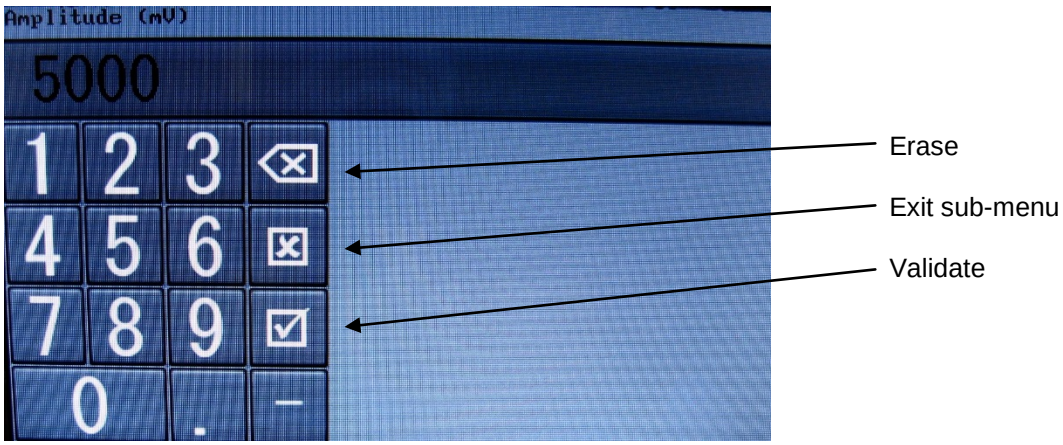


Note: Out of range values are rejected.

5.2. Sub-menu “Amplitude”

Tapping in the “AMPLITUDE” window on the “PULSE SETUP OUTPUT” sub-menu will open another sub-menu with the voltage level settings of the channel depicted in the following figure.

To set the channel level, enter the value with the numbers in millivolts, then tapping on the validate button will send the setting.

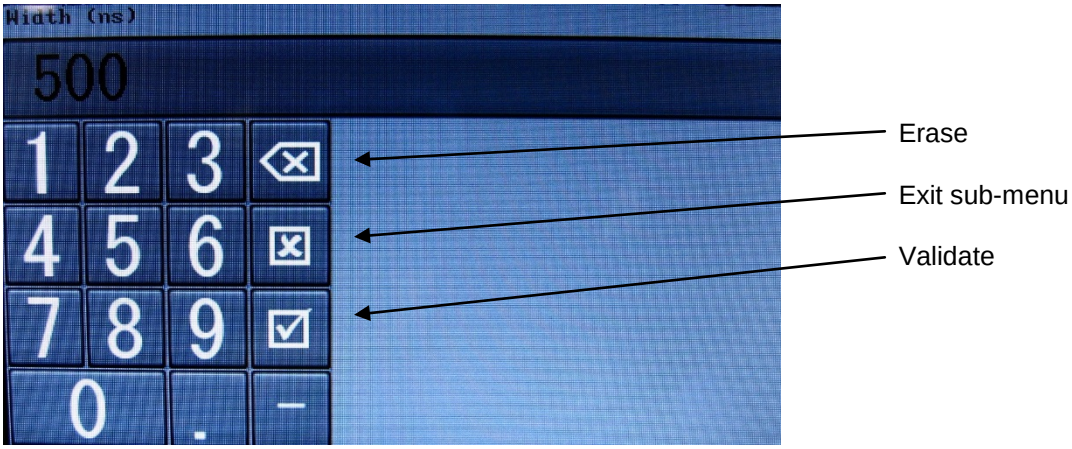


Note: Out of range values are rejected.

5.3. Sub-menu “Width”

Tapping in the “WIDTH” window on the “PULSE SETUP OUTPUT” sub-menu will open another sub-menu with the width settings of the channel depicted in the following figure.

To set the channel width, enter the value with the numbers in nanoseconds, then tapping on the validate button will send the setting.

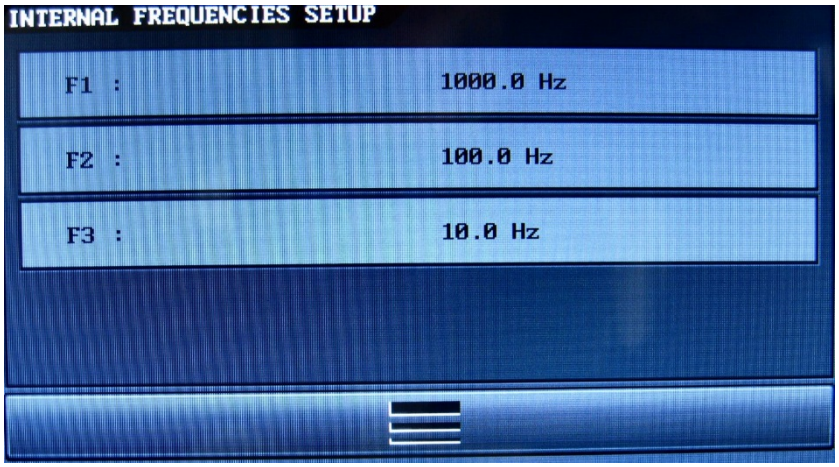


Note: Out of range values are rejected.

5.4. Sub-menu “INTERNAL FREQUENCIES SETUP”

Tapping in the “INTERNAL FREQUENCIES” window on the main menu will open a sub-menu with the internal frequencies settings depicted in the following figure.

To set the frequencies, tap on the window corresponding to the internal frequency to configure.



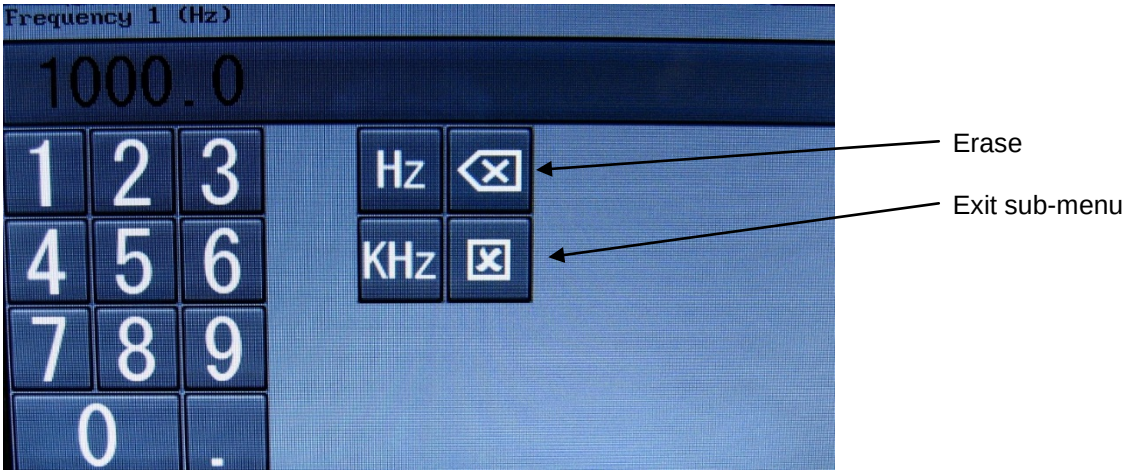
Notes:

- F1 is the highest frequency.
- F3 is the lowest frequency.

5.5. Sub-menu “Frequency”

Tapping in the “F1”, “F2” or “F3” window on the “INTERNAL FREQUENCIES SETUP” sub-menu will open another sub-menu with the corresponding frequency settings depicted in the following figure.

To set the frequency, enter the value with the numbers, then tapping on the unit (Hz or KHz) validate the setting.

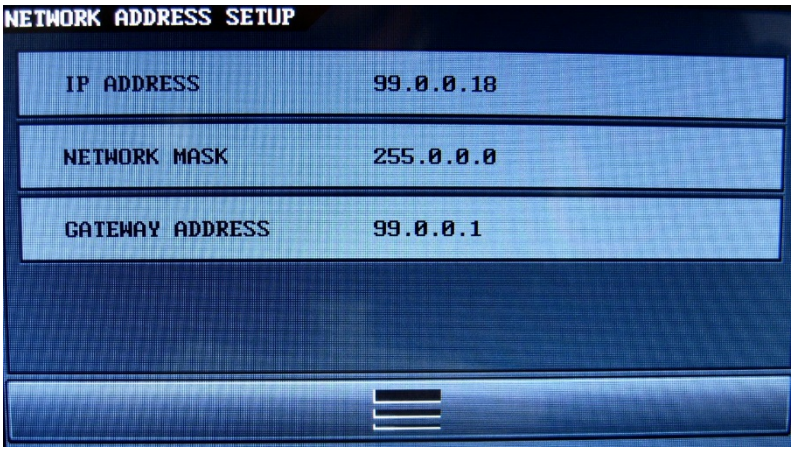


Notes:

- Out of range values are rejected.
- The frequency values can be set in a 1 – 2 – 5 sequence.
- F1 > F2 > F3 and minimum gap of 2 between F1 and F2 or F2 and F3.

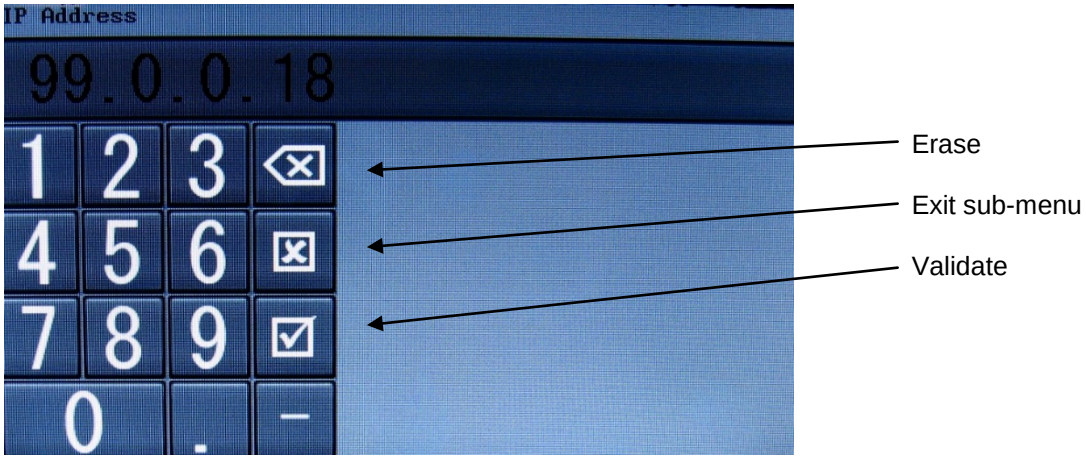
5.6. Sub-menu “NETWORK ADDRESS SETUP”

Tapping in the “STATUS” window on the main menu will open a sub-menu with the network address setup as depicted in the following figure.



5.7. Sub-menu “IP Address”

Tapping in the “IP Address” window in the “NETWORK ADDRESS SETUP” sub-menu will open another sub-menu with the IP address setup as depicted in the following figure.



Notes: Submenus “NETWORK MASK” and “GATEWAY ADDRESS” are identical.

5.8. Front panel “Run/Stop” button

The front panel ‘Run/Stop’ button enables channels programmed with a single shot trigger source (SS1 or SS2) to trigger each time a pulse is present on the rear panel ‘TRIG IN’ input.

Each press of the button will change the state alternately.

When in ‘Run’ state, the led inside the button lights in red.

6. REMOTE CONTROL

6.1. Connection

To connect over the LAN, follow these steps:

- Connect the instrument LAN connector to the remote control computer,
- On the user interface, either specify the LAN address,
- On the remote controlcomputer, enter the instrument's IP address,
- After the connection has been established, the following commands can be used to modify the settings:
    - Set the instrument's IP address with: IP XXX.XXX.XXX.XXX
    - Query the instrument's IP address with: IP? ⇒ :IP XXX.XXX.XXX.XXX
    - Set the instrument's IP mask with: NM XXX.XXX.XXX.XXX
    - Query the instrument's IP mask with: NM? ⇒ :NM XXX.XXX.XXX.XXX
    - Set the instrument's IP gateway: GW XXX.XXX.XXX.XXX
    - Query the instrument's IP gateway with: GW? ⇒ :GW XXX.XXX.XXX.XXX

6.2. Command structure

MODEL 745-20C is compatible with all command of the LIL timing system.

Each command description has at least some of the following items:

- Full command syntax
- Form Set / Query
- Brief description
- Parameters
- RST value
- Specified limits
- Example

6.2.1. IDENTIFICATION

Syntax:	*IDN?
Form:	Query
Description:	Query instrument identification. Response gives instrument model, serial number and firmware version.
Parameter:	-
RST value:	-
Example:	Answer: *GFTy/MIPSI,MODEL 745-20C,SN54001/000000,V1.0*
	Instrument model: MODEL 745-20C
	Serial number: 54001
	Firmware version: 1.0

6.2.2. DELAY

Syntax:	DELAY T<n>,<D>
	DELAY? T<n>
Form:	Set & Query
Description:	Query delay of channel T<n> or set the delay of channel T<n> to <D> picosecond (relative to T0 channel)
Parameter:	<n>: Channel number (1 to 20)
	<D>: Delay value (in picosecond)
RST value:	Last value set
Range:	0 to 9 999 999 999 999 ps
Example:	Set 1 ns delay on channel 2: *DELAY T2,1000*
	Query delay on channel 2: *DELAY? T2* (Answer: *:DELAY T2,1000*)

6.2.3. TRIGGER

Syntax:	TRIG T<n>,<Tg>
	TRIG? T<n>
Form:	Set & Query
Description:	Query trigger mode on channel <n> or set channel <n> trigger mode to Frequency 1 (F1), Frequency 2 (F2), Frequency 3 (F3), Single Shot 1 (SS1), Single Shot 2 (SS2) or Inhibit (INH)
Parameter:	<n>: Channel number (0 to 20)
	<T>: Trigger mode (F1, F2, F3, SS1, SS2 or INH)
RST value:	INH
Example:	Set channel 2 trigger mode to Frequency 1: *TRIG T2,F1*
	Query trigger mode on channel 2: *TRIG? T2* (Answer: *:TRIG T2,F1*)

6.2.4. VOLTAGE LEVEL

Syntax:	AMPL T<n>,<V>
	AMPL? T<n>
Form:	Set & Query
Description:	Query voltage level on channel <n> or set channel <n> to voltage level <V>
Parameter:	<n>: Channel number (0 to 20)
	<V>: Voltage level (in millivolt)
RST value:	Last value set
Range:	3 000 to 6 000 mV
Example:	Set voltage level to 3.5 V on channel 4: *AMPL T4,3500*
	Query voltage level on channel 4: *AMPL? T4* (Answer: *:AMPL T4,3500*)

6.2.5. WIDTH

Syntax:	WIDTH T<n>,<W>
	WIDTH? T<n>
Form:	Set & Query
Description:	Query channel <n> width or set channel <n> at specified <W> width
Parameter:	<n>: Channel number (0 to 20)
	<W>: Width (in nanosecond)
RST value:	Last value set
Range:	100 to 300 000 000 ns
Example:	Set 250 ns width on channel 4: *WIDTH T4,250*
	Query width of channel 4: *WIDTH? T4* (Answer: *:WIDTH T4,2500*)

6.2.6. POLARITY

Syntax:	TTL T<n>,<P>
	TTL? T<n>
Form:	Set & Query
Description:	Query polarity of channel <n> or set channel <n> at specified <P> polarity, positive (POS) or negative (NEG). Not available with option 2, 3 and 4.
	Not available with option 2, 3, 4
Parameter:	<n>: Channel number (0 to 20)
	<P>: Polarity (POS or NEG)
RST value:	POS
Example:	Set negative-going pulses on channel 3: *TTL T3,NEG*
	Query polarity of channel 3: *TTL? T3* (Answer: *:TTL T3,NEG*)

6.2.7. FREQUENCIES

Syntax:	FREQ F<n>,<F>
	FREQ? F<n>
Form:	Set & Query
Description:	Query frequency of internal Frequency <n> or set frequency of internal Frequency <n>
Parameter:	<n>: 1, 2 or 3 (Frequency 1, Frequency 2 or Frequency 3)
	<F>: Frequency (in Hertz)
RST value:	Last value set
Range:	0.1 to 1 000 Hz (in 1, 2, 5 sequence)
Example:	Set internal Frequency 3 to 0.5 Hz: *FREQ F3,0.5*
	Query frequency of internal Frequency 3: *FREQ? F3*
	(Answer: *:FREQ F3,0.5*)

6.2.8. RUN

Syntax:	RUN
Form:	Set
Description:	Run a unique single shot sequence (Same function as the “TRIG” button on the touch screen or “Trigger” light/button on web page)
Parameter:	none
RST value:	-
Example:	Run a single shot sequence: *RUN*

6.2.9. ARM

Syntax:	ARM
	ARM?
Form:	Set & Query
Description:	Query state (enable or disable) of “TRIG IN” input or enable/disable “TRIG IN” input for single shot mode (Same function as the “RUN/STOP” button on the front panel or “Run” light/button on web page)
Parameter:	Set: none (change the actual state to the other)
	Query: 0 => disable (STOP)
	1 => enable (RUN)
RST value:	Disable (STOP)
Example:	Enable “TRIG IN” input: *ARM*
	Query “TRIG IN” state: ARM? (Answer: *:ARM 1*)

6.2.10. STAT

Syntax: STAT CLEAR

STAT? <XXXX>

Form: Set & Query

Description: Query equipment information

Parameter: <XXXX>: TEMP (Temperature in °C)

CLK (Clock source, internal or external)

POW (+6V, -6V, +3.3V, +1.8V, +11V power supply level in V)

TRIG (Trigger feedback for channel 1 to 20. 1 = trigged)

MTRIG (Single shot trigger feedback. 1 = trigged)

RST value: -

Example: Clear information: *STAT CLEAR*

Query temperature: *STAT? TEMP* (Answer: :*STAT TRET,28.30*)

Query clock source: *STAT? CLK* (Answer: :*STAT CLK,INTERNAL*)

Query power supply level: *STAT? POW*

(Answer: :*STAT POW,6.00,-5.99,3.35,1.75,11.45*)

Query trigger feedback: *STAT? TRIG*

(Answer: :*STAT TRIG,1,0,0,1,0,0,0,0,0,0,0,0,0,0,1,1,0,0,0)*

Query single shot trigger feedback: *STAT? MTRIG*

(Answer: *:STAT MTRIG,0*)

6.2.11. IP adress

Syntax:	IP <x.x.x.x>
	IP?
Form:	Set & Query
Description:	Query IP Address or set it
Parameter:	<x.x.x.x>: IP address
RST value:	Last value set
Example:	Set IP address to 172.17.23.6: *IP 172.17.23.6*
	Query IP address: *IP?* (Answer: *:IP 172.17.23.6*)

6.2.12. Netmask adress

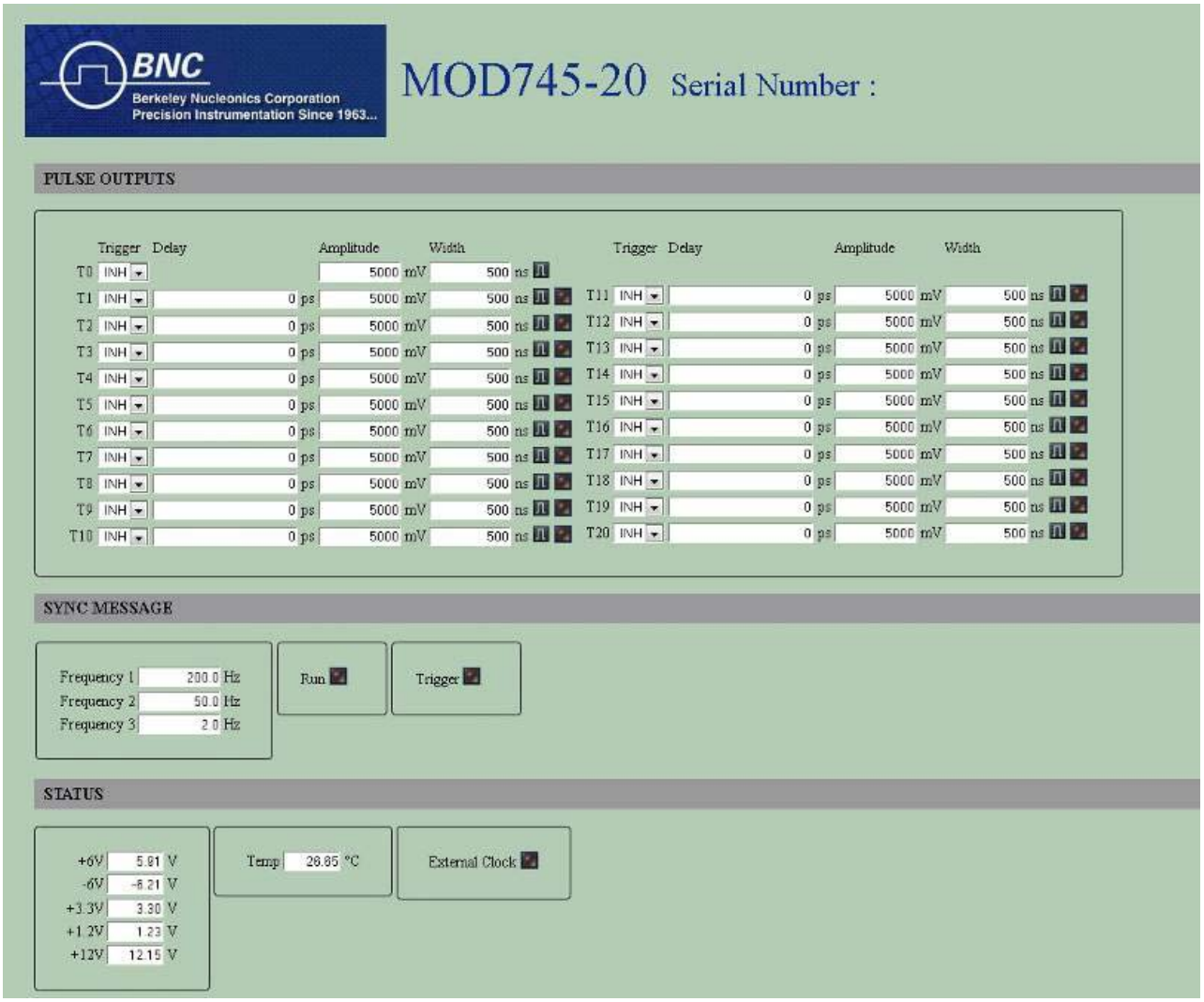
Syntax:	NM <x.x.x.x>
	NM?
Form:	Set & Query
Description:	Query Netmask Address or set it
Parameter:	<x.x.x.x>: NW address
RST value:	Off
Example:	Set Netmask address to 255.255.0.0: *NM 255.255.0.0*
	Query Netmask address: *NM?* (Answer: *:NM 255.255.0.0*)

6.2.13. Gateway adress

Syntax:	GW <x.x.x.x>
	GW?
Form:	Set & Query
Description:	Query Gateway Address or set it
Parameter:	<x.x.x.x>: GW address
RST value:	Last value set
Example:	Set Gateway address to 172.17.23.7: *GW 172.17.23.7*
	Query Gateway address: GW*?* (Answer: *:GW 172.17.23.7*)

6.3. Remote control via web page

With Internet explorer or Firefox, you can open a web page to drive the MODEL 745-20C at the IP address specified:



The “PULSE OUTPUTS” area allows controlling each output from T0 to T20:

- Trigger source (F1, F2, F3, SS1, SS2 or INH)
- Delay in ps
- Amplitude in mV
- Width in ns
- Polarity (positive or negative)

And displays the state of the channels T1 to T20:

- Led lights green : the channel has been triggered
- Led off (black) : the channel has not been triggered

A click on the leds reset all the states of the channels.

The “SYNC MESSAGE” area allows to:

- Change the values of F1 to F3
- Toggle between Run and Stop states (“Run” button lights green when in “Run” state)
- Perform a single shot (“Trigger” button lights green when a single shot occurred, and can be erased by clicking on the state led of the channels)

The “STATUS” area shows:

- The level of the internal power supplies
- The internal temperature of the unit
- The state of the clock (lights in green when external clock)

Notes: When entering a new value, after pressing “Enter” key, the field turns yellow briefly (the new value is sent), then turns white again (the new value has been taken into account). If the new value is out of range, then the field will turn red, until a valid value is entered.

7. SOFTWARE

The MODEL 745-20C comes with DLL drivers for Windows XP or Seven. Our primary objective in designing software drivers is to get the user up and running as quickly as possible.

Software drivers are provides as a Dynamic Link Library (DLL) which is compatible with most 32-bit windows based development software. The main program is written on Labview v11 or later.

The listing of files is the following:

- MODEL 745-20C: main program,
- DLL or vi:
  - *.dll or *.vi : set the value,
  - *_val.dll or *_val.vi : query the value.

Delay
void Delay(LVRefNum *IDConnexionIN, uInt8 Channel, floatExt DelayPs, TD1 *entrEDErreurPasDErreur, LVRefNum *IDDeConnexionOUT, TD1 *errorOut)

Delay_val
void Delay_val(LVRefNum *IDConnexionIN, uInt8 Channel, TD1 *entrEDErreurPasDErreur, LVRefNum *IDDeConnexionOUT, uInt8 *ChannelOut, floatExt *DelayPs, TD1 *errorOut)

Identifiant_val
void Identifiant_val(LVRefNum *IDConnexionIN, TD1 *entrEDErreurPasDErreur, LVRefNum *IDDeConnexionOUT, LStrHandle *dataOut, TD1 *errorOut)

Softtrigger
void Softtrigger(LVRefNum *IDConnexionIN, TD1 *entrEDErreurPasDErreur, LVRefNum *IDDeConnexionOUT, TD1 *errorOut)

Trigger
void Trigger(LVRefNum *IDConnexionIN, uInt8 Channel, uInt16 Trigger2, TD1 *entrEDErreurPasDErreur, LVRefNum *IDDeConnexionOUT, TD1 *errorOut)

trigger_val
void Trigger_val(LVRefNum *IDConnexionIN, uInt8 Channel, TD1 *entrEDErreurPasDErreur, LVRefNum *IDDeConnexionOUT, uInt8 *ChannelOut, uInt16 *TriggerOut, TD1 *errorOut)

sta_val
void Sta_val(LVRefNum *IDConnexionIN, TD1 *entrEDErreurPasDErreur, LVRefNum *IDDeConnexionOUT, TD2Hdl *Surveillance, TD1 *errorOut)

The Labview driver front panel is shown below :