588 Series Pulse Generator
Operating Manual

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1. Introduction

This manual is a reference designed to familiarize you with the BNC 588 series pulse generator and is arranged so that you can easily find the information you're looking for. Generally, each topic has its own section and no section assumes that you've read anything else in the manual.

Technical Support

For questions or comments about operating the 588 our technical staff can be reached via one of the following methods:

- Phone - (415) 453-9955
- Fax - (415) 453-9956
- Internet - www.berkeleynucleonics.com

Warranty

In addition to a 30-day money back guarantee, the 588 has a two-year limited warranty from the date of delivery. This warranty covers defects in materials and workmanship. BNC will repair or replace any defective unit. Contact us for information on obtaining warranty service.

Package Contents

The box you receive should contain the following:

- 588 Pulse Generator
- AC Power Cord*
- User's Manual on Disk

Contact BNC (415) 453-9955 if any parts are missing.

*Note: AC Power Cord for Model 588 only (not intended for any other use)

2. Safety Issues

Normal use of test equipment presents a certain amount of danger due to electrical shock because it may be necessary for testing to be performed where voltage is exposed.

An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 VDC or 35 V_{RMS} AC should be considered dangerous and hazardous, as it can produce a lethal current under certain conditions. Higher voltages pose an even greater threat because such voltage can easily produce a lethal current. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage and steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

- If possible, familiarize yourself with the equipment being tested and the location of its high-voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.

- Do not expose high voltage needlessly. Remove housing and covers only when necessary. Turn off equipment while making test connections in high- voltage circuits. Discharge high-voltage capacitors after shutting down power.

- When testing AC powered equipment, remember that AC line voltage is usually present on power input circuits, such as the on-off switch, fuses, power transformer, etc.

- Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment. Make certain such surfaces are not damp or wet.

- Use the time-proven “one hand in the pocket” technique while handling an instrument probe. Be particularly careful to avoid contact with metal objects that could provide a good ground return path.

- Never work alone. Someone should always be nearby to render aid if necessary. Training in CPR first aid is highly recommended.

3. Front Panel Overview

588 Front Panel

Display Layout and Indicators

A 4 line x 20 character vacuum fluorescent display module displays parameters and status information. The status information is located in the upper-left corner of the display, between the two brackets. There are four enunciators:

- Vertical Arrow — Indicates there are additional pages to the current menu.
- Blinking Light — Indicated the unit is actively generating pulses, or armed and waiting for an external trigger.
- Question Mark — In external PLL oscillator operation mode, this indicates the internal PLL is not yet locked with the external clock source.
- "p" — A "p" will appear when the system clock is in external PLL mode and has locked on to the source signal.
- "e" — An "e" will appear when the system clock is in external mode, but not when in external with PLL.

The upper-right side of the display contains the title of the currently displayed menu. The rest of the display is used for system parameters. The display brightness may be adjusted, allowing the instrument to be used under various lighting conditions.

Description of Front-Panel Area

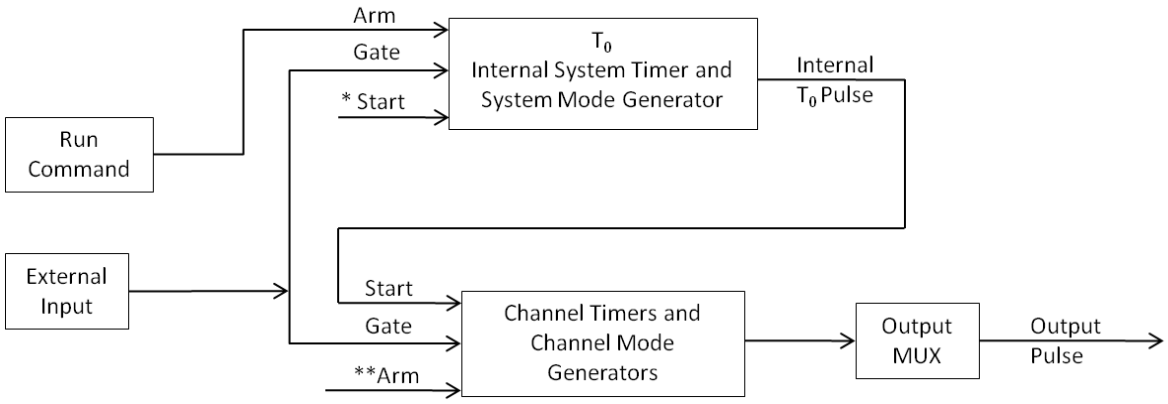
Keypads

Two keypad areas provide fast access to various menus and easy editing of system parameters.

- Menu Keypad — Provides one touch access to the channel, trigger, gate, and system menus for setting up the appropriate parameters. The Page button will allow you to page through the multiple levels of a menu, if multiple levels exist.
- Arrow Keypad — The up/down arrows are used to increment/decrement the current cursor parameter (indicated by the blinking cursor). The position of the cursor controls the step size for each increment. The right/left arrows move the cursor to different positions within the current parameter. The NEXT key selects the next parameter in the currently displayed menu.

4. Pulse Concepts and Pulse Generator Operations

Counter Architecture Overview



*Start source is: RUN button in Internal Modes
External input in External Trigger modes
*TRG command via Serial access

**Channels are armed by the RUN button. In single shot and burst modes channels may be rearmed by pressing the RUN button again.

System Timer Functions

The System Timer functions as a non-retriggerable, multi-vibrator pulse generator. This means that once started, depending on the mode, the timer will produce pulses continuously. Before pulses can be generated, the timer must be armed and then receive a start pulse. Arming the counter is done by pressing the Run/Stop key. With external trigger disabled, the Run/Stop key also generates the start command for the counter. With external trigger enabled, the external trigger provides the start pulse. In either case, once started, the counter operation is determined by the System Mode Generator. Standard modes include:

- Continuous — Once started T_0 pulses are generated continuously.
- Single Shot — One T_0 pulse is generated for each start command.
- Burst — 'N' T_0 pulses are generated for each start command.
- Duty Cycle — Once started T_0 pulses cycle on and off continuously.

The T_0 pulse is distributed to all of the start inputs of the Channel Timers and Mode Generators.

Channel Timer Functions

The Channel Timer functions as a non-retriggerable, delayed, one shot pulse generator. This means that the timer will only generate one delayed pulse for every start pulse received. Once the channel timer has started counting, additional start pulses will be ignored until the pulse has been completed (non-retriggerable). The start pulse for each channel is provided by the internal T_0 pulse generated by the internal system timer. Whether or not a pulse is generated for each T_0 pulse is determined by the Channel Mode Generator. Standard modes include:

- Normal — A pulse is generated for each T_0 pulse.
- Single Shot — One pulse is generated for the first T_0 pulse, after which the output is inhibited.
- Burst — 'N' number of pulses are generated for the first T_0 pulse, after which the output is inhibited.
- Duty Cycle — 'N' number of pulses are generated for each T_0 pulse after which the output is inhibited for 'M' number of pulses. The cycle is then repeated for each subsequent T_0 pulse.

Different modes may be selected for each output, allowing a wide variety of output combinations. Each output may also be independently disabled or gated (using the external gate input).

Digital Output Multiplexer

The outputs of each of the Channel Timers is routed to a set of multiplexers. This allows routing of any or all Channel Timers to any or all of the units' outputs. In the normal mode of operation, the output of the n^{th} Channel Timer is routed to the n^{th} output connector. As an example, if a double pulse is required on Channel A, one can multiplex the Channel A timer with the Channel B timer, then adjust each timer to provide the necessary pulses.

Dependent & Independent Timing Events

The 588 allows the user to control the relationship between the Channel Timers by setting the sync source for each timer. Independent events are all timed relative to the internal T_0 start pulse. Dependent events may be linked together by setting the sync source to the controlling event. This allows the instrument to match the timed events and adjustments can be made in one event without detuning the timing between it and the dependent event.

Navigating the 588 Front Panel

Selecting Menus

Parameters are grouped in menus, selectable by using the function keys. To select the output channel parameters press the letter key corresponding to the desired channel. Menus may include a number of different pages, each page containing up to four parameters. The status block in the upper-left corner of the display shows a vertical arrow if the current menu contains additional pages. Press the Page button to select the next page. There may be multiple channel menus depending on the model. Secondary or advanced menus can be accessed by pressing the letter key of that channel a second time.

There are also individual menu keys for the gate (GATE), trigger (TRIG), and system (MENU) menus. Depending on the model, each of these menus may have multiple pages, accessed by pressing the Page button, or secondary menus, accessed by pressing that particular function key a second time.

Selecting Menu Items

Within a menu, the blinking cursor indicates the current menu item for editing. The NEXT key will select a different menu item.

Numeric Input Mode

When the current item is numeric, the system enters the Numeric Input Mode. In this mode data may be edited using the arrow keypad. The Left and Right arrow keys are used to select a digit to edit. The selected digit blinks to identify itself as the active digit. The Up and Down arrow keys are then used to increment or decrement this digit.

Entering Non-Numeric Parameters

When the current item is non-numeric, the Up and Down arrow keys are used to select among different options for the parameter. If the item is an on-off toggle, the Up arrow enables the item and the Down arrow disables the item.

Enabling System Output

The Run/Stop key is used to arm the system. With external trigger disabled, the key will arm and start pulse output. With external trigger enabled, the key will arm the pulse generator. Pulse outputs then starts after the first valid trigger input. Pressing the Run/Stop key a second time disables the pulse generator.

Enable/Disable Channel Output

At the top of each channel menu page is a parameter to enable or disable the output of the channel. Each channel may be individually enabled or disabled.

Rearming the Channel Timers

If there are channels currently running in normal mode, single shot and burst mode channels can be re-armed without affecting the timing on normal mode channels. The rearming page is located under the System Menu. Once on the rearming page, pressing the up arrow will rearm the channel timers.

Setting Pulse Timing Parameters

Pulses are defined by a delay, from their sync or start pulse to the active edge, and a width.

Wid:	Sets the width of the active portion of the pulse.
Dly:	Sets the delay from the sync source to the rising edge of the pulse.

**NOTE: If Wid + Dly + 75ns (the hardware reset time) > T0 period the correct pulse width will be generated, but at a slower rate.*

Setting Pulse Output Parameters

There are two basic types of outputs available on the 588:

a) TTL/CMOS compatible outputs.

b) Adjustable amplitude outputs.

Out:	Selects between TTL/CMOS mode and Adjustable mode when both are available on a single output.
Pol:	Sets the voltage polarity of the pulse, active high or active low. **Note: All outputs are positive voltage as negative voltages are not supported*
Ampl:	In Adjustable mode the unloaded output voltage is set. The actual output voltage will depend on the load impedance. For example: If the load is 50Ω the output will be 50% of the stated voltage.

Using the Output Multiplexer

Each output channel includes a multiplexer which allows routing of any or all of the timer outputs to the physical output. This allows double pulses and other complex pulse trains to be generated.

	-HGFEDCBA-
MUX:	-00000101-

The multiplexer is represented by an "n" bit binary number as shown above. "n" is the number of channels. Each bit represents a channel timer, which is enabled by setting the bit to one. In the above example, timers A and C are combined on the current output.

Setting System Internal Rate Parameters

The internal T_0 period controls the fundamental output frequency of the system. Each channel may be operated at submultiples of the fundamental frequency by using the channel duty cycle mode.

Source:	Sets the reference source for the internal T_0 period.
Per:	Sets the internal T_0 period.

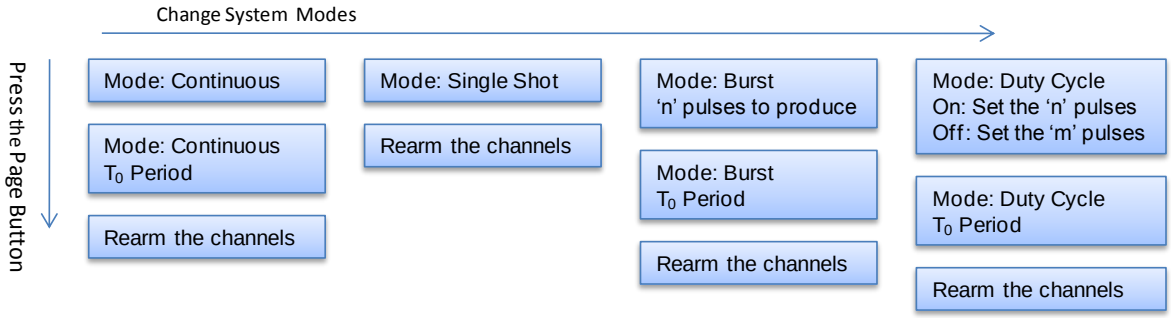
To set the system Internal Rate press the Menu key, then use the arrow keys to specify the T_0 period.

5. 588 Menus

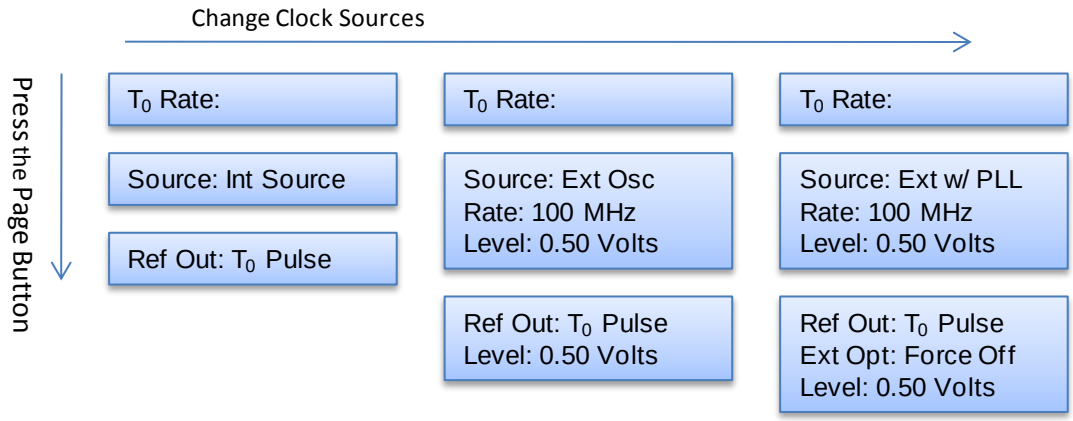
588 Main Menu Structure

The following menus can be accessed by pressing the menu button. The first menu will be the System Mode Menu. By pressing the menu button again the Clock/Rate Menu will come up. As the menu button is pressed again the next menus will be entered in the order seen below. Once the last menu is reached pressing the menu button will start the menus over at the System Mode Menu. All of the values in the fields below are the defaults; this is what the menus will look like when the system is first powered up, or if a recall 0 command is entered.

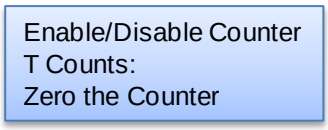
System Mode Menu



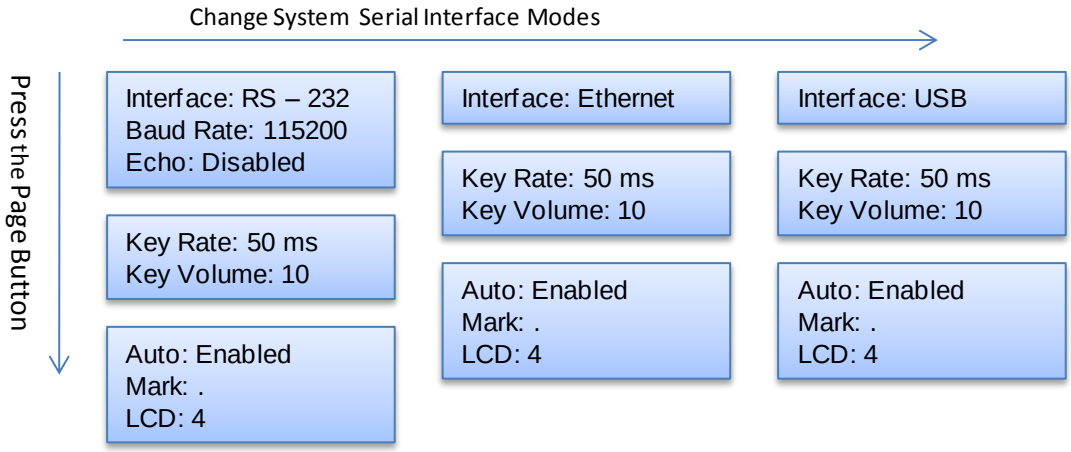
Clock/Rate Menu



Counter Menu



System Configuration Menu



Store Menu

Store#: Choose the location to store the current settings
Name: The name associated with the current location
The action needed to Store the information

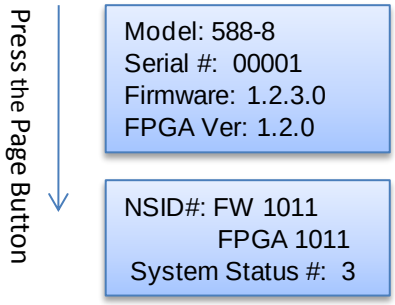
Recall Menu

Recall#: Choose the location to restore the settings from
Name: The name associated with the current location
The action needed to Recall the information

Auxiliary Menu

Screen to let the user know that there maybe updateds on the BNC website for their unit

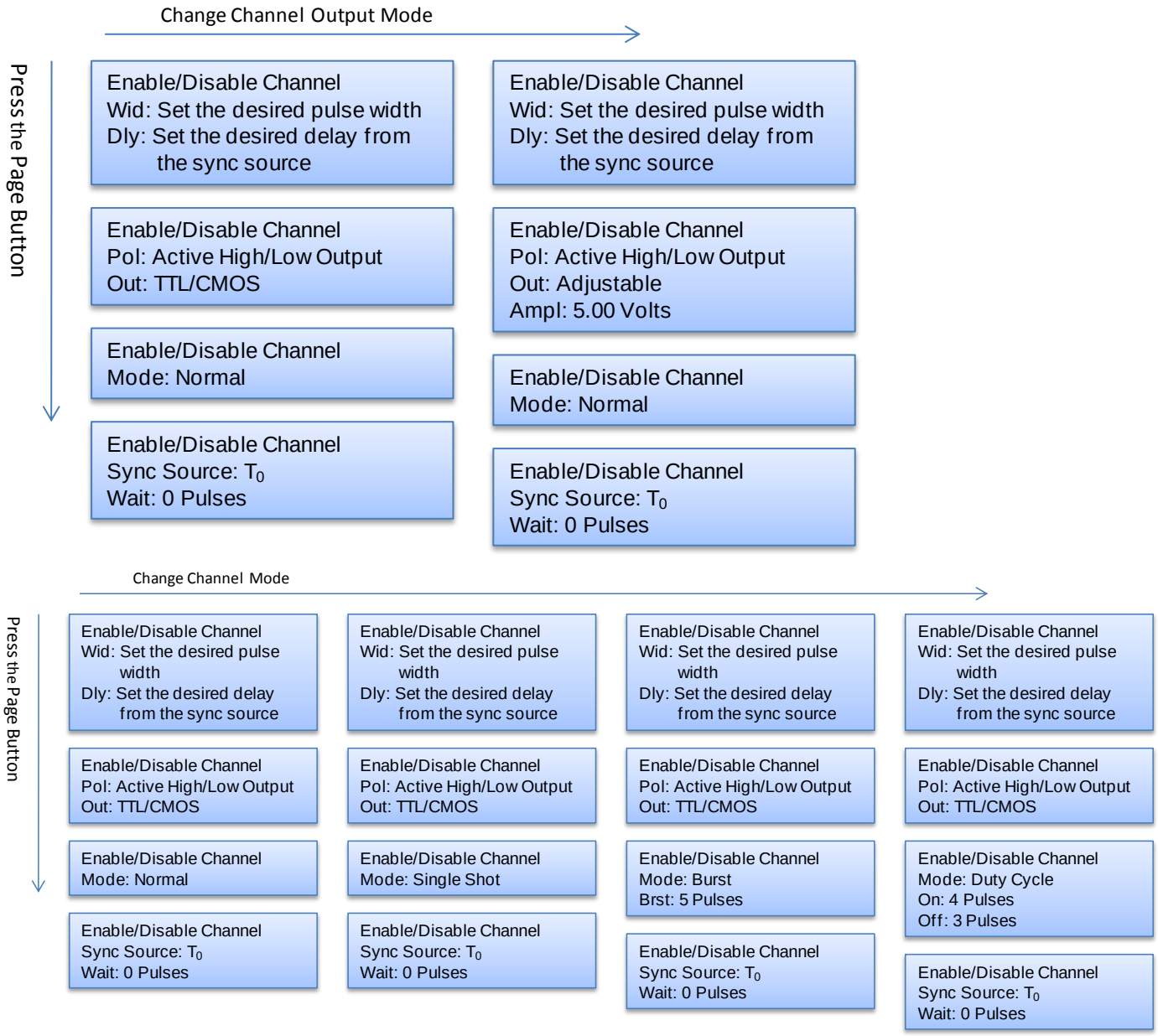
System Information Menu



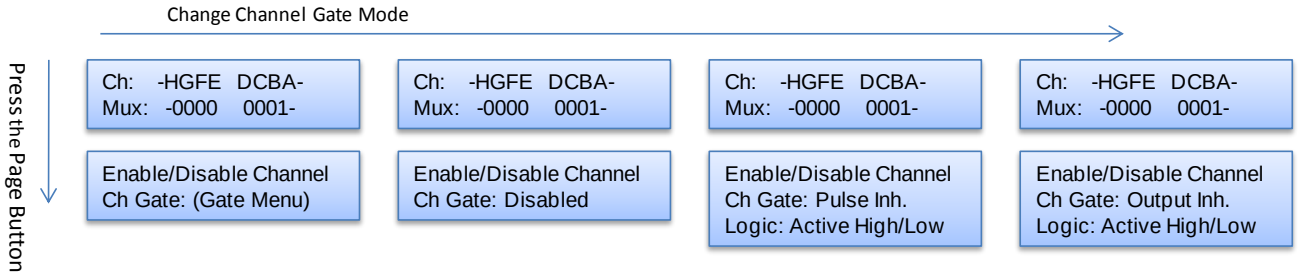
588 Channel Menu Structure

The following menus can be accessed by pressing the button marked for the desired channel. The first menu will be the Channel Menu. By pressing the button marked for the desired channel again the channels' advanced menu will be entered. As the channel button is pressed again the original channel menu will be revisited.

Channel Menu



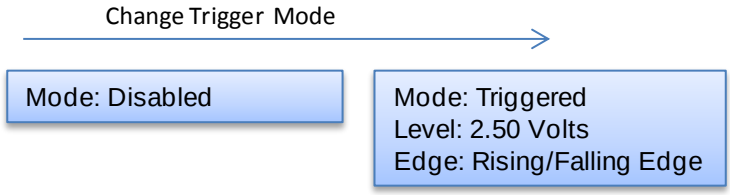
Channel Advanced Menu



Trigger Menu

By pressing the Trigger button the trigger menu will be entered.

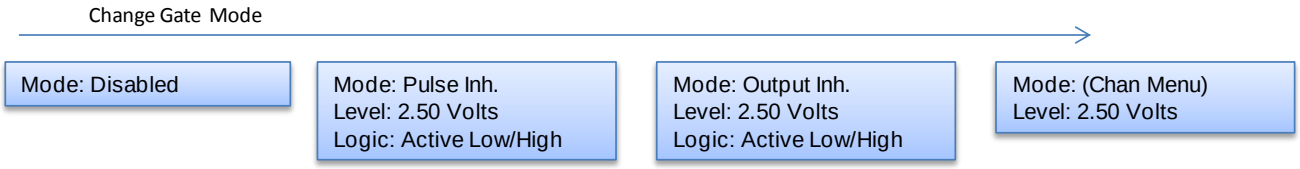
Trigger Menu



Gate Menu

By pressing the Gate button the gate menu will be entered.

Gate Menu



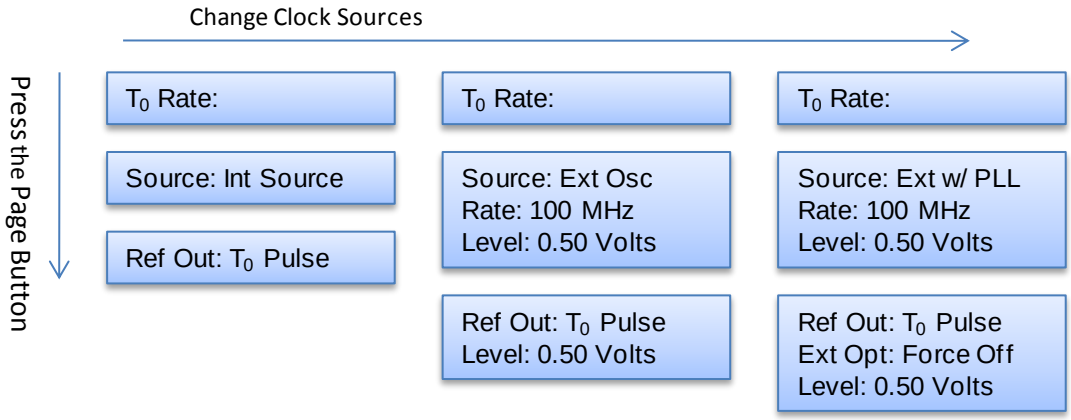
Setting System Mode of Operation

By pressing the Menu button the system mode menu can be accessed. The system Mode menu sets the T_0 system timer mode. The mode may be changed by setting the cursor on the mode row and pressing the up and down key. By pressing the next button while in this menu will allow the user to change between setting the mode or the parameter. The menu will show the extra set of parameters (Brst, On & Off) only when they are applicable.

T_0 Mode:	**Parameters:**	
Continuous	N/A	
Single Shot	N/A	
Burst	Brst:	'N' number of pulses to generated for each T_0 pulse
Duty Cycle	On/Off:	'N' number of pulses to generated for each T_0 pulse / 'M' number of pulses to inhibit for each T_0 pulse

**NOTE: Any mode may be started by either the RUN/STOP key in the internal trigger mode or armed by the RUN/STOP key and started by an external trigger in the external trigger mode. In the single shot and burst modes, (internally triggered) the unit disarms itself at the end of the pulse train. Pressing the RUN/STOP key after the unit has been disarmed will generate a new pulse train.*

Clock/Rate Menu



Setting the Clock Source and Rate

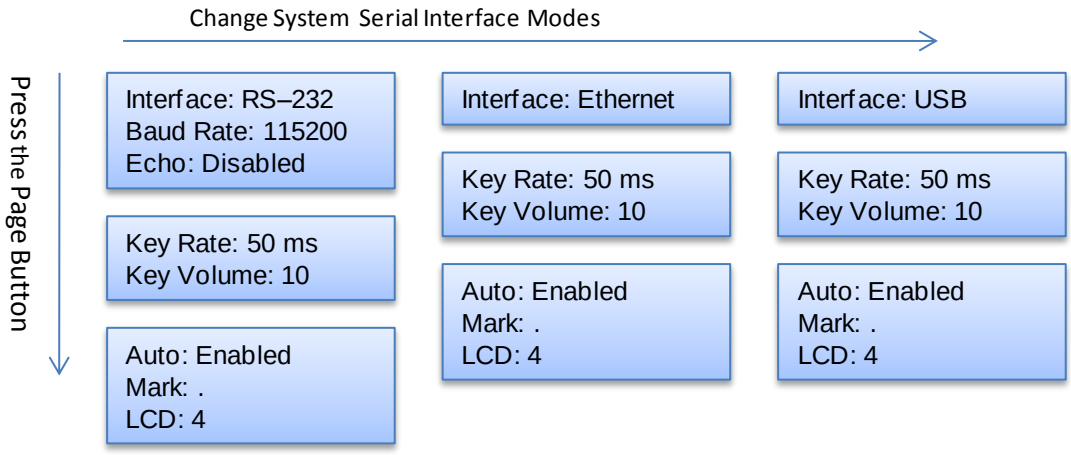
The System Clock Parameters can be accessed and changed by entering the Clock/Rate Menu by pressing the Menu button until that screen is entered. The 588 has the ability to be synced to either the internal clock T_0 or from an external clock source. When the system is in internal mode the frequency is set by changing the T_0rate. When the system is in external mode the source can either be with or without PLL, and in either case the input level and frequency must be set.

Source:	Selects the between the internal or external clock source from which the unit will operate.
Rate:	Sets the T_0 period which determines the fundamental output frequency of the unit.
Level:	When in external mode the level sets the triggering threshold for the input clock source.

Setting the Output Reference

Ref Out:	Selects the source and frequency of the output reference for synchronizing with the external system components.

System Configuration Menu



Setting System Communication Parameters

The System Communications Parameters can be accessed and changed by entering the System Configurations Menu by pressing the Menu button until that screen is entered. The 588 comes with a standard Ethernet, USB, and RS-232 serial ports. The unit will not respond to computer commands unless these ports are properly configured. The default Baud Rates for these interfaces are:

- RS-232 115200
- USB 38400
- Ethernet 115200

The RS–232 and USB interfaces are Plug-n-Play capable, but the Ethernet requires third party software to be utilized (see Appendix D).

When in the System Configuration menu only the RS–232 baud rate can be changed, the USB rate must be varied using the SCPI commands via one of the serial interfaces.

Interface:	RS–232, Ethernet, or USB
Baud Rate:	Selects the baud rate for the RS–232 serial interface.
Echo:	Selects whether the unit will echo characters back to the host computer or not.

Setting Keypad Parameters

The keypad parameters can be set be entering the system configuration menu, and pressing the Page button. The rate at which a key will repeat itself when held down may be set. This can be used to provide a controlled rate at which a parameter is incremented. In addition, the volume of the beep can be controlled for the keypad.

Key Rate:	Sets the rate at which the keys will repeat when held down.
Key Vol:	Sets the beep volume for the keypad.

Setting the Auto Start Mode

The auto start feature can be set be entering the system configuration menu, and pressing the Page button twice. The unit may be configured to automatically start generating pulses after power up.

Setting the Display Decimal Mark

The display mark feature can be changed be entering the system configuration menu, and pressing the Page button twice. The unit may be configured to show either a "." or a "," when the parameters need separation like in the width menus.

Mark:	Selects the format of the decimal mark to either a "." or a ","

Setting the Display Brightness

The display brightness feature can be changed be entering the system configuration menu, and pressing the Page button twice. The unit may be configured to illuminate the display to varying brightness. Also with a command that can be found in the SCPI command section the display can be turned off entirely.

LCD:	Adjusts the display brightness.

Store Menu

Store#: Choose the location to store the current settings
Name: The name associated with the current location
The action needed to Store the information

Storing a System Configuration

The store menu can be accessed by pressing the menu button until that screen is entered. Use the following procedure to store a complete system configuration:

- Set all parameters to the desired value.
- Select a configuration number and/or a configuration name.
  **NOTE: You cannot store to the zero location, as that contains the factory default values.*
- Label the configuration as desired.
- From the Store Menu, press the store button (PAGE) or from one of the serial interfaces type the save command.

Recall Menu

Recall#: Choose the location to restore the settings from
Name: The name associated with the current location
The action needed to Recall the information

Recalling System Configurations

The recall menu can be accessed by pressing the menu button until that screen is entered. Use the following procedure to recall a stored or default system configuration:

- Enter the Recall Menu.
- Select a configuration number.
- From the Recall Menu, press the recall button (PAGE) or from one of the serial interfaces type the recall command.
  **Note: Configuration 0 is the factory default settings.*

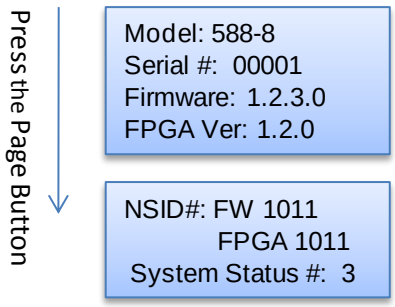
Counter Menu

Enable/Disable Counter
T Counts:
Zero the Counter

Using the Counter Function

The counter menu can be found by pressing the menu button until “Cntr” screen is entered. The Counter function counts the number of T_0 pulses output by the system clock. When the system is in single shot, Burst, or Duty Cycle mode, the T_0 count reflects the number of pulses output by the unit.

System Information Menu

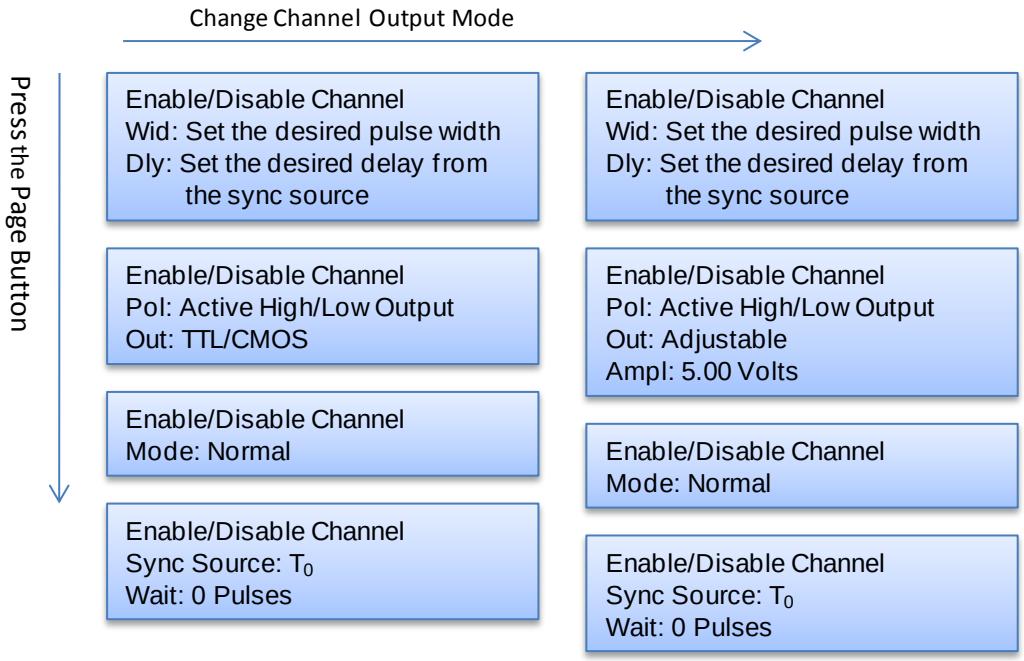


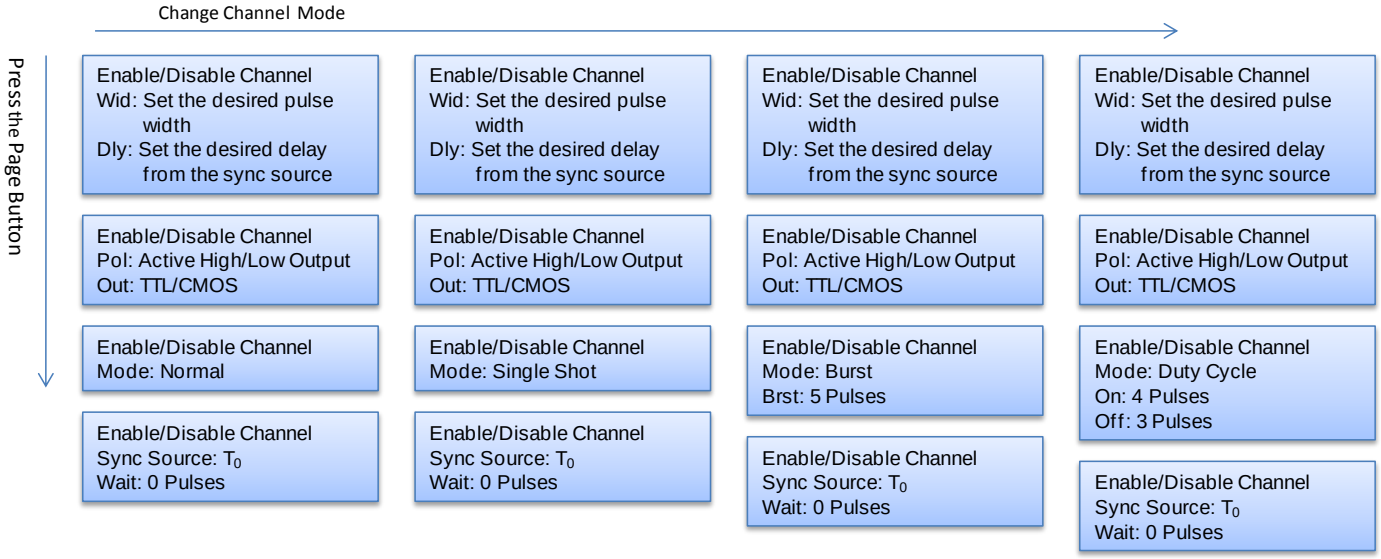
Using the System Information Menu

The information menu can be found by pressing the menu button until the information screen is found. The Information Menu provides all of the pertinent version numbers and serial numbers for the unit. This information should be readily available when contacting customer service for troubleshooting help.

Setting Channel Mode of Operation

Channel Menu





Enabling Channel Output

The channel menu can be found by pressing the desired channel button. At the top of each of the channel menu page is a parameter to enable or disable the channel. Each channel may be individually controlled.

Setting the Channel Timing Parameters

To define a pulse requires two parameters: the delay to the active edge and the width of the pulse.

Wid:	Sets the channel pulse width.
Dly:	Sets the channel delay until the active edge

Setting Pulse Output Configuration

The channel output configuration parameters can be changed by entering the channel menu and pressing the page button to find the output screen. The 588 supports two types of outputs: a high speed TTL/CMOS compatible output, and for applications which require different voltage levels or higher current, an adjustable voltage output. The pulses can also be defined to be active high or active low.

Pol:	Sets the pulse polarity, active high or active low
Out:	Selects the output mode, TTL/CMOS or Adjustable
Ampl:	Sets the output voltage when the channel is in Adjustable mode.

**Note: All outputs are positive, Active low is a negative going signal not a negative voltage*

Setting Channel of Operation

To change the channel output modes enter the channel menu and press the page button until the output mode screen is entered. Each channel may be set independently to operate in one of four modes: normal, burst, single shot or duty cycle:

Mode:	Selects the mode for the current channel. Additional parameters are provided for the burst and duty cycle modes.
Brst:	Sets the number of pulses in the burst mode to generate before inhibiting output.
On:	Sets the number of pulses to generate before inhibiting the output in Duty Cycle Mode.
Off:	Sets the number of pulses to inhibit before repeating the on cycle in Duty Cycle Mode.

Delaying the Start of Channel Output

To change the optional wait parameter, enter the channel menu and press the page button until the source screen is entered. Within any channel mode, the output of the channel can be delayed using the wait parameter (within the Channel menu):

Wait:	Sets the number of T_0 pulses to wait until enabling the channel output.

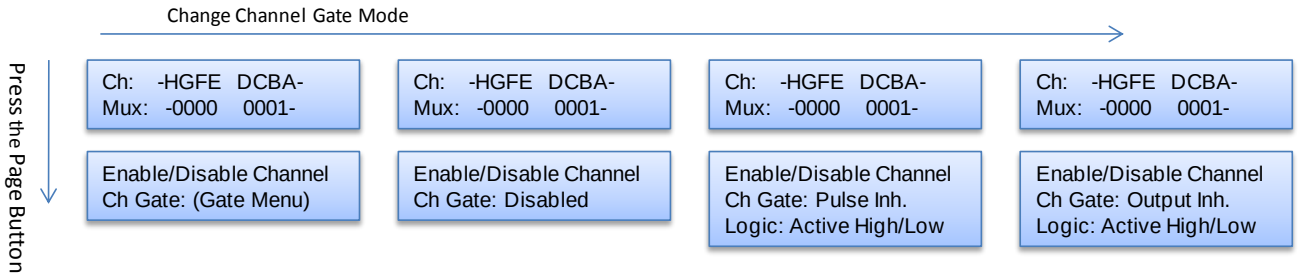
Setting the Sync Source

To change the sync source, enter the channel menu and press the page button until the source screen is entered. Although each channel receives its start pulse from the internal T_0 pulse, logically the start pulse can be assigned such that the delay entered is relative to the T_0 pulse or any other channel pulse. This allows dependent events to link. The unit will not allow a circular chain of sync sources that would result in a channel triggering itself. The delay entered is relative to the selected sync source.

Sync Source:	Selects the channel sync source.

Channel Advanced Menu

The channel Advanced Menu can be entered by pressing the desired channel button twice.



Configuring the Channel Multiplexer

To define which outputs are fed into the channel multiplexer, the corresponding bit for the desired channel to add should be set to 1. All desired omitted channels should have the corresponding bit set to 0.

MUX:	Enable/Disable the bit field.

Setting Channel Gate Control

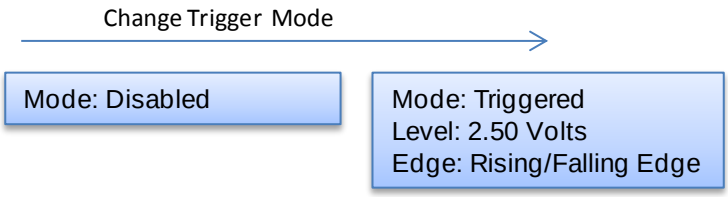
The channel gate menu can be entered by pressing the page button when in the channel advanced menu. When the global gate is set to Chan Menu, the channel can then use the gate input with independent behavior from other channels.

Gate:	Enables the Gate input for the channel by setting the method of output control used with the gating function.
Logic:	Sets the logic level used with the gating function, either active high or active low.

"Pulse Inhibit" method – the gate prevents the channel from being triggered by the channel's trigger source pulse. If a pulse has already started when the gate disables the channel, the pulse will continue normal output but will not restart on the next trigger pulse.

"Output Inhibit" method – the gate leaves the base triggering alone and enables/disables the output directly. If a pulse has already started when the gate disables the output, the pulse will be cut off.

Trigger Menu

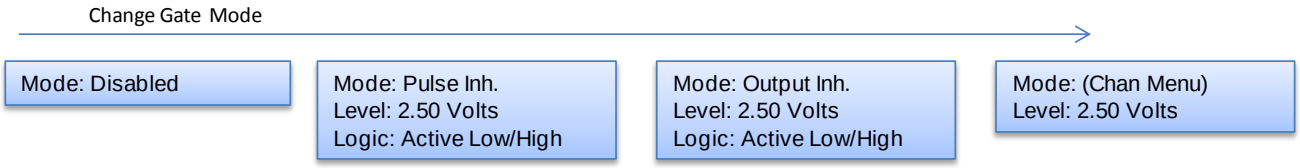


Enabling System Trigger

The trigger menu can be entered by pressing the Trig button. Enable the use of the Trigger input by the system timer as a trigger source.

Mode:	Selects between disabling/enabling the trigger mode(s).
Level:	Sets the trigger threshold.
Edge:	Selects between rising edge or falling edge as the trigger source when the trigger mode is enabled.

Gate Menu



Enabling System Gates

The gate menu can be entered by pressing the Gate button. To enable the use of the gate input trigger inhibit or output control for all channels simultaneously, or on a per channel basis set the following parameters in the gate menu:

Mode:	Selects between disabling the Gate inputs and method of output control.
Level:	Sets the gating threshold.
Logic:	Sets the active logic level.

6. Operating the 588

Quick Start - Normal Internal Rate Generator Operation

The 588 has a powerful set of functions providing a number of modes of operation for the internal or "System" rate generator (T_0). Most of these functions can be ignored if a simple continuous stream of pluses is required. Starting from the default settings, which can be restored by recalling configuration 0, the following parameters need to be set:

Pulse Width and Delay	Enter the Channel menus by pressing the letter key. Enter the required pulse width and delay. Repeat for each output channel.
T_0 Period	Enter the Rate menu by pressing the menu button. Set the desired pulse period. **Note: In general the pulse delay + the pulse width + 75 ns for a hardware reset for any channel must be less than the T_0 period.*
Start	Press the Run/Stop key to start generating pulses.
Stop	Press the Run/Stop key a second time to stop generating pulses.

Quick Start – Normal External Trigger Operation

To generate a single pulse for every external trigger event, based on the default configuration 0, the following parameters need to be set:

System Mode	Enter the System Mode menu by pressing the Menu button until the System Mode menu is selected. Select Single Shot mode
Trigger Menu	Enter the Trigger Menu by pressing the Trig button. Select Triggered.
Level	Press the Next key until the Level parameter is highlighted. Set the trigger threshold voltage to approximately 50% of the trigger signal amplitude. **Note: If the threshold is not set correctly the 588 will have trouble syncing with the trigger source.*
Edge	Press the Next key until the Edge parameter is highlighted. Set the unit to trigger off the rising or falling edge as desired.
Pulse Width and Delay	Enter the Channel menus by pressing the letter key. Enter the required pulse width and delay. Repeat for each output channel.
Start	Press the Run/Stop key to start generating pulses.
Stop	Press the Run/Stop key a second time to stop generating pulses.

System Timer Overview

For internal operation, the 588 contains a timer and mode generator which generates an internal T_0 clock that is used to trigger all the channel timers. System modes are controlled via the Mode menu.

Using Continuous Mode

The Run/Stop button starts and stops a continuous pulse stream at the rate specified by the Rate menu. This corresponds to the normal output mode for most pulse generators. To generate a continuous stream of pulses:

- Within the System Mode menu select Continuous mode.
- Within the Rate menu:
  - Select the system oscillator or external clock in frequency.
  - Set the desired frequency

Pressing the Run/Stop key will now generate a stream of T_0 pulses at a rate specified by the period parameter.

Using Single Shot Mode

To generate a single pulse with every press of the Run/Stop key:

- Within the System Mode menu select Single Shot mode.

Pressing the Run/Stop key will now generate one pulse.

Using System Burst Mode Function

The Run/Stop button generates a stream of 'N' T_0 pulses, where the 'N' is specified by the Burst parameter. The rate is specified in the Rate menu. Pressing the Run/Stop button while in the burst is in process will stop the output. After the burst has been completed, pressing the Run/Stop button will generate another burst. To generate a burst of pulses set:

- Within the System Mode menu:
  - Select mode to be Burst
  - Set the Burst parameter to produce the number of pulses desired

Using the System Duty Cycle Function

The Run/Stop button starts a continuous stream of T_0 pulses, which oscillates on for 'N' pulses and off for 'M' pulses, where 'N' and 'M' are specified by the On/Off parameters respectively. The rate at which the pulses are generated is controlled in the Rate menu. To generate a stream of pulses which will oscillate on for 'N' pulses and off for 'M' pulses set:

- Within the System Mode menu:
  - Set the mode to Duty Cycle.
  - Set the On parameter to the number of pulses to produce during the on cycle ('N').
  - Set the Off parameter to the number of pulses to suppress during the off cycle ('M').
- Within the Rate menu:
  - Set the Source to either the systems internal oscillator or to external mode.
  - Set the desired frequency.

Channel Timer Overview

The output of each channel is controlled by two timers to generate the pulse width and the delay timing. All channels are simultaneously triggered, depending on the system mode, by the internal T_0 pulse, the external trigger, or a trigger provided by a CPU. A given channel may or may not generate a pulse depending on its own channel mode as described below.

Using Channel Normal Function

The Normal mode generates a continuous string of pulses once the Run/Stop key is pressed. To use channel normal mode set:

- Within the Channel menu:
  - Enable the channel output
  - Set the delay desired.
  - Set the pulse width desired.
  - Set the mode to Normal.

Pressing the Run/Stop button key will now generate a continuous stream of pulses.

Using Channel Single Shot Function

The Single Shot mode generates a single pulse every time the Run/Stop key is pressed. To use the channels' single shot mode set:

- Within the Channel menu:
  - Enable the channel output.
  - Set the delay desired.
  - Set the pulse width desired.
  - Set the mode to Single Shot.

Using the Channel Burst Mode

The burst mode generates a burst of pulses every time the Run/Stop key is pressed. To use the channels' burst mode set:

- Within the Channel menu:
  - Enable the channel output.
  - Set the delay desired.
  - Set the pulse width desired.
  - Set the mode to Burst.
  - Set the Brst parameter to the number of pulses to produce during the on cycle ('N').

Using the Channel Duty Cycle Mode

The channel duty cycle mode will generate a stream of pulses on the channel level which will oscillate on for 'N' pulses and off or 'M' pulses. To generate the stated sequence of pulses set:

- Within the Channel menu:
  - Enable the channel output.
  - Set the delay desired.
  - Set the pulse width desired.
  - Set the mode to Duty Cycle.

- Set the On parameter to the number of pulses to produce during the on cycle (‘N’).
- Set the Off parameter to the number of pulses to suppress during the off cycle (‘M’).

**Note: Older BNC pulse generators had a divide-by-’N’ function. The duty cycle mode is a more general case of this operation. To reproduce the divide-by-’N’ function set the on cycle to 1 and set the off cycle to ‘N’-1, where ‘N’ is the divide by factor.*

External Input Overview

The external inputs may be used to trigger the unit, gate the system timer, or to gate the channel timers. When using the trigger input the external input acts s a system start pulse. Depending on the system mode, the result of a trigger input can be a single pulse, a burst of pulses, or the start of a stream of pulses.

Using the External Gate to Control the System

The external gate may be used to control the output of the unit. To gate the internal system timer with an external source set:

- Within the Gate menu:
  - Choose either Pulse or Channel Inhibit.
  - Set the threshold level to ~50% of the incoming gate signal.
  - Choose either active High or Low.
- Within the System Mode menu select the desired mode.

Pressing the Run/Stop button will arm the unit. Once the unit is armed it will start generating pulses once the external gate is in the active state. Pressing the Run/Stop key again will disarm the unit.

Using the Channel Gating Function

Each channel may use the external input to gate or control its output. The gate controls the triggering of the channel. To use the channel gate set the following parameters:

- Within the Gate menu:
  - Set the mode to Chan Menu.
- Within the Advanced Channel menu:
  - Set the channel gate parameter to either Pulse Inhibit or Output Inhibit.
  - Set the gate logic to either Active High or Active Low.

In Pulse Inhibit mode the gate prevents the channel from being triggered by the channels’ trigger source. When in Pulse Inhibit mode if a pulse has already started when the gate disables the channel the pulse will continue normal output, but the output will not restart on the next trigger pulse. In Output Inhibit mode the gate leaves the base triggering alone and will enable/disable the output directly. When in Output Inhibit mode if a pulse has already started when the gate disables the channel the pulse will be immediately cease.

Generate a Pulse on Every Trigger Input

To generate a pulse on every trigger input set the following parameters:

- Within the System Mode menu set the mode to Single Shot mode.
- Within the Trigger menu:

    - Select the Triggered mode.
    - Set the trigger threshold level to ~50% of the incoming signal.
    - Select either rising or falling edge for the unit to trigger on.

Pressing the Run/Stop key will arm the unit. Once the unit is armed it will generate a T_0 pulse for every external trigger received. Pressing the Run/Stop button again will disarm the unit. This mode corresponds to the normal external trigger mode found on most other pulse generators.

Generate a Burst of Pulses on Every Trigger Input

To generate a burst of pulses on every trigger input set the following parameters:

- Within the System Mode menu:
    - Set the mode to Burst.
    - Set the number of pulses that is desired for each input signal.
    - Press the Page button and set the T_0 pulse to the period desired between pulses.
- Within the Trigger menu:
    - Select the Triggered mode.
    - Set the trigger threshold level to ~50% of the incoming signal.
    - Select either rising or falling edge for the unit to trigger on.

Pressing the Run/Stop button will arm the unit. Once the unit is armed it will generate a set of pulses for every external trigger received. The units' timer is reset at the end of a burst and will generate another set of pulses upon receiving a new trigger. Triggers that occur in the middle of a burst will be ignored. Pressing the Run/Stop key again will disarm the unit.

Start a Continuous Stream of Pulses Using the External Trigger

The external trigger may be used to cause the unit to start generating pulses by setting:

- Within the System Mode menu select Continuous mode.
- Within the Trigger menu:
    - Select the Triggered mode.
    - Set the trigger threshold level to ~50% of the incoming signal.
    - Select either rising or falling edge for the unit to trigger on.

Pressing the Run/Stop button will arm the unit. Once the unit is armed it will start generating pulses after an external trigger is received. Triggers that occur after the initial trigger will be ignored. Pressing the Run/Stop key again will disarm the unit.

7. Programming the 588

Personal Computer to Pulse Generator Communication

The 588 has three standard interfaces which are RS-232, USB, and an Ethernet port. All menu settings can be set and retrieved over the computer interface using a simple command language. The command set is structured to be consistent with the Standard Commands for Programmable Instruments (SCPI). Although due to the high number of special features found in the 588, many of the commands are not included in the specification. The syntax is the same for all interfaces. The amount of time required to receive, process, and respond to a command at a Baud rate of 115200 is 10 ms. Sending commands faster than 10 ms may cause the unit to not respond properly. It is advised to wait until a response from the previous command is received before sending the next command.

WARNING: When communicating with the unit (USB, Serial or Ethernet), avoid sending any commands that include the "*" character as the unit is booting up. This may result in an undesired lockup of the instrument.

RS-232 Interface Overview

The serial port is located on the back of the 588 and uses a 9-pin D-type connector with the following pinout (as viewed from the back of the unit):

1	No Connection
2	Tx - Transmit (to computer)
3	Rx - Receive (from computer)
4	DTR - Connected to pin 6
5	Ground
6	DSR - Connected to pin 4
7	RTS - Connected to pin 8
8	CTS - Connected to pin 7
9	No Connection

The serial port parameters should be set as follows:

Baud Rate	4800, 9600 19200, 38400, 57600, 115200*
Data Bits	8
Parity	None
Stop Bits	1

**Note: The default baud rate for the RS-232 is 115200.*

USB Interface Overview

The USB interface is standard on the 588. The interface is a Plug-n-Play capable interface. USB communication is achieved by using a mapped (virtual) COM port on the PC. The driver installation executable will obtain an unused COM port number, install the USB drivers, and make that COM port number available for typical RS-232 communication to the pulse generator. HyperTerminal or other common software may be used.

When communicating through the mapped COM port over USB, the baud rate for the communication port used by the USB chip must match the baud rate for the COM port on the PC. Access to the USB port baud rate is done using the SCPI command :SYSTem:COMMunicate:SERial:USB "n" command; where "n" is the desired communication speed. This parameter can be accessed via any communication method. The default baud rate for USB is 38400.

USB communication notes:

- The correct drivers must be installed on the on the personal computer before communication can be accomplished via USB.
- The Baud Rates on the PC and the pulse generator must match for successful communication.
- The USB port's Baud Rate on the pulse generator can be set using the SCPI command SYSTem:COMMunicate:SERial:USB "n", where "n" can be: 4800, 9600 19200, 38400, 57600, or 115200.
- USB 2.0 specification is used. The USB cable can be removed without "ejecting" the device in the operating system environment.

Ethernet Interface Overview

An Ethernet interface is also standard on the 588. Refer to Appendix C included at the end of this manual for more information about the Ethernet Interface and Operation.

Programming Command Types and Format

The 588 Pulse Generator uses two types of programming commands: IEEE 488.2 Common Commands and Standard Commands for Programmable Instruments (SCPI). The format is the same for all interfaces. HyperTerminal (in Windows) or any other generic terminal program may be used to interactively test the commands using the RS-232 interface. The format of each type is described in the following paragraphs.

Line Termination

The pulse generator uses text-style line terminations. When a command is sent to the unit, the firmware is programmed to read characters from a communication port until it reads the line termination sequence.

The command string is parsed and executed after reading these characters. These characters are the "carriage return" and "linefeed". They are ASCII character set values 13 and 10 respectively (hex 0x0D and 0x0A). All command strings need to have these characters appended.

When the pulse generator responds to a command, whether it is a query or a parameter change, it also appends its return strings with these characters. Coded applications could use this behavior to know when to stop reading from the unit. However, if the "echo" parameter is enabled, there will be two sets of line terminators, one following the echoed command string, and one following the pulse generator's response.

**Note: The pulse generator will echo commands on the RS-232 serial port only.*

The pulse generator responds to every communication string. If the communication string is a query, the unit responds with the queried response (or error code) followed by the line terminators. If the communication string is a parameter change, the response is "ok" (or error code) followed by the line terminators. For this reason, it is not recommended that multiple commands be stacked together into single strings as is common with some other types of instruments. It is recommended that the coded application send a single command in a string and follow immediately by reading the response from the unit. Repeat this sequence for multiple commands.

IEEE 488.2 Common Command Format

The IEEE 488.2 Common Commands control and manage generic system functions such as reset, configuration storage and identification. Common commands always begin with the asterisk (*) character and may include parameters. The parameters are separated from the command pneumonic by a space character. For Example:

*RST <cr><lf>
*RCL 1 <cr><lf>
*IDN? <cr><lf>

SCPI Command Keywords

The commands are shown as a mixture of upper and lower case letters. The upper case letters indicate the abbreviated spelling for the command. You may send either the abbreviated version or the entire keyword. Upper and/or lower case characters are acceptable.

For example, if the command keyword is given as POLarity, then POL and POLARITY are both acceptable forms; truncated forms such as POLAR will generate an error; polarity, pol, and PolAriTy are all acceptable as the pulse generator is not case sensitive.

**Note: The unit by default is not case sensitive, but if it is wished to have the system only respond to capitalized commands see the command list below.*

SCPI Command Format

SCPI commands control and set instrument specific functions such as setting the pulse width, delay, and period. SCPI commands have a hierarchical structure composed of functional elements that include a header or keywords separated with a colon, data parameters, and terminators. For example:

SCPI Format

:PULSE1:STATE ON <cr> <lf>
:PULSe1:WIDTh 0.000120 <cr> <lf>
:PULSe:POL NORMal <cr> <lf>

Any parameter may be queried by sending the command with a question mark appended. For example:

SCPI Query Format

:PULSE1:STATE? <cr><lf>
Will return 1<cr><lf>
:PULSE1:WIDTH? <cr><lf>
Will return 0.000120000 <cr><lf>
:PULSE1:POL? <cr><lf>
Will return NORM <cr><lf>

SCPI Keyword Separator

A colon (:) must always separate one keyword from the next lower-level keyword. A space must be used to separate the keyword header from the first parameter.

SCPI Optional Keywords

Optional keywords and/or parameters appear in square brackets ([ ]) in the command syntax. Note that the brackets are not part of the command and should not be sent to the pulse generator. When sending a second level key word without the optional keyword, the pulse generator assumes that you intend to use the optional keyword and responds as if it had been sent.

SCPI Specific and Implied Channel

Some commands, such as PULSe, allow specifying a channel with an optional numeric keyword suffix. The suffix will be shown in square brackets [1 / 2]. The brackets are not part of command and are not to be sent to the pulse generator. The numeric parameters correspond to the following channels: 0 = T_0, 1 = ChA, 2 = ChB, etc. Only one channel may be specified at a time.

If you do not specify the channel number, the implied channel is specified by the :INSTrument:SELect command or the last referenced channel.

After power-up or reset (*RST) the instrument will default to channel #1.

SCPI Parameter Types

The following parameter types are used:

<Numeric Value>	Accepts all commonly used decimal representation of numbers including optional signs, decimal points, and scientific notation: For Example: 123, 123e2, -123, -1.23e2, .123, 1.23e-2, 1.2300E-01
<Boolean Value>	Represents a single binary condition that is either true or false. True is represented by a 1 or ON; false is represented by a 0 or OFF. Queries return 1 or 0.
<Identifier>	Selects from a finite number of predefined strings.

Error Codes

The unit responds to all commands with either:

ok <cr><lf> or ?”n “<cr><lf>

Where "n" is one of the following error codes:

1. Incorrect prefix, i.e. no colon or * to start command.
2. Missing command keyword.
3. Invalid command keyword.
4. Missing parameter.
5. Invalid parameter.
6. Query only, command needs a question mark.
7. Invalid query, command does not have a query form.
8. Command unavailable in current system state.

Programming Examples

Example 1)

20 ms pulse width, 2.3 ms delay, 10 Hz internal trigger, and continuous operation.

:PULSE1:STATE ON <cr> <lf>	enables channel A
:PULSE1:POL NORM <cr> <lf>	sets polarity to active high
:PULSE:WIDT 0.020 <cr> <lf>	sets pulse width to 20 ms
:PULSE1:DELAY 0.0023 <cr> <lf>	sets delay to 2.3 ms
:PULSE0:MODE NORM <cr> <lf>	sets system mode to continuous
:PULSE0:PER 0.1 <cr> <lf>	sets period to 100 ms (10 Hz)
:PULSE0:TRIG:MODE DIS <cr> <lf>	disables the external trigger

To start the pulses use either of the following commands:

:PULSE0:STATE ON <cr> <lf>	starts the pulses
:INST:STATE ON <cr> <lf>	alternate form to start pulses

Example 2)

25µs pulse width, 0 delay, external trigger, and one pulse for every trigger.

:PULSE1:STATE ON <cr> <lf>	enables channel A
:PULSE1:POL NORM <cr> <lf>	sets polarity to active high
:PULSE:WIDT 0.000025 <cr> <lf>	sets pulse width to 25µs
:PULSE1:DELAY 0 <cr> <lf>	sets delay to 0
:PULSE0:MODE SING <cr> <lf>	sets system mode to single shot
:PULSE:TRIG:MODE TRIG <cr> <lf>	sets system to external trigger
:PULS:TRIG:LEV 2.5 <cr> <lf>	sets trigger level to 2.5 volts
:PULS:TRIG:EDGE RIS <cr> <lf>	set to trigger on rising edge

To arm the instrument in external gate mode, use either of the following commands:

:PULSE0:STATE ON <cr> <lf>	Arms the instrument
:INST:STATE ON <cr> <lf>	Alternate form if T_0 is currently selected.

A software generated external trigger can be generated by using the following command:

*TRG <cr> <lf>	Generates a software external trigger

588 SCPI Command Summary

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:INSTrument				The units' upper level command keyword.
	:CATalog		?	Returns a comma separated list of the names of all channels. Example: A two channel unit would return T_0, CHA, CHB
	:FULL		?	Returns a comma-separated list of the names of all the channels and their associated number. Example: a two channel unit would return T_0, 0, CHA, 1, CHB, 2
	:COMMands		?	Returns an indentured list of all valid SCPI commands
	:NSELect		0 - 8	Selects a channel using the numeric value
	:SELect		T_0 / CH[A-H]	Selects a channel using the identifier
	:STATe		0/1 or OFF/ON	Enables/Disables the selected channel output. If no channel has been selected the command is applied to T_0. If T_0 is selected all outputs are affected. Enabling T_0 is the same as pressing the RUN button.

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:DISPlay				Command to change the units' display settings.
	:ENABle		0/1 or OFF/ON	Enables/Disables the display, also locks the keypad. Once the system is rebooted the display will default to the on state.
	:MODe		0/1 or OFF/ON	Command to enable/disable the automatic display update function. Setting to 1 will force a display update when a command is received via serial communications. Setting to 0 will turn this feature off. The default setting is 0 **Note: Using this feature will slow down the communication response.*
	:BRIGhtness		1 - 8	Command to change the display brightness. 8 is the brightest setting.
	:UPDate		?	Query only. Will force the display to be updated with the current parameters. This command will only update the display once for every time the command is sent.

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:PULSe[0]				Command to change the units' global settings, this is the same as using the :SPULse command
	:COUNter			Subsystem. Contains commands to define the Counter function.
		:STATe	0/1 or OFF/ON	Enables/Disables the counter function
		:Clear	TCNTS/GTNTS	Clears the active counter **Note: Standard units only have the trigger counter.*
		:COUNt?	TCNTS/GTNTS	Reports the clock pulses output except in single shot mode, in this case the trigger pulses input on the channel will be displayed **Note: GCNTS will only work on units that have the dual trigger option and the ? must be included in the Sub-Command.*
	:STATe		0/1 or OFF/ON	Enables/Disables the output for all channels. This command is the same as pressing the Run/Stop button.
	:PERiod		50[ns] – 5000[s]	Sets the T_0 period. The command should be sent without units. If for example 50ns is desired the parameter sent should be 50e-9, or the decimal equivalent.
	:MODe		NORMal/SINGle/ BURSt/DCYCle	Changes the system output mode.
	:BCOunter		1-1,000,000	Changes the number of pulses to output when the system is in burst mode. **Note: The commas should be omitted.*
	:PCOunter		1-1,000,000	Changes the number of on pulses to output when the system is in Duty Cycle mode. **Note: The commas should be omitted.*
	:OCOunter		1-1,000,000	Changes the number of off pulses to suppress when the system is in Duty Cycle mode. **Note: The commas should be omitted.*
	:ICLock			Submenu for selecting the clock source
		:MODe	INT / EXT / XPL	Changes the source and type of the system clock. INT is internal, EXT is external, and XPL is external with phase-locked-loop.
		:RATe	10–100[MHz]	Changes the frequency of input clock signal the unit should expect, has a 1MHz resolution **Note: This menu is only active in EXT mode.*
		:LEVel	.02 - 2.5[V]	Choose the input level threshold to trigger on ~ 50% of the input potential. **Note: If the triggering threshold is not set correctly the unit responses are undetermined.*
		:OPTion	FORCE / LAST	Allows the user to set the behavior of the instrument when synchronization to the external clock is lost and resync'd. "Force" will cause the unit to disable the channels as soon as the lock is lost, and "Last" will cause the unit to resume with whatever the last mode was when resync'd. **Note: Only applies when ICLock is XPL mode*

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:PULSe[0]				Command to change the units' global settings, this is the same as using the :SPULse command
	:OCLock		T_0 / RATE / CHAN / AUX1-4 / DIS	Allows the user to select the clock source to output: When ICLock is INT: T_0 is the user defined period. Rate = N/A CHAN = N/A AUX1 = 40 MHz AUX2 = 20 MHz AUX3 = 10 MHz AUX4 = 5 MHz When ICLock is in EXT: T_0 is disabled RATE = f_{output} will be f_{input} CHAN = f_{output} will be 2x f_{input} AUX1 = 2x EXT PLL AUX2 = 1x EXT PLL AUX3 = 1/2 EXT PLL AUX4 = 1/2 EXT
	:GATe			Command to change the units' global gate settings.
		:MODe	DIS / PULS / OUTP / CHAN	Sets the global gate mode for the unit: When in pulse inhibit mode if the pulse has started before the gate is seen the output pulse will finish, but any further pulses will be prevented, In output inhibit mode if a pulse has started it will be truncated as soon as the gate signal is seen and will prevent any further pulses, and when in channel mode each channel can be setup individually (be aware of insertion delay for each mode, this is listed in the appendix)
		:LOGic	LOW / HIGH	Choose active Low (will allow pulses when low) or active High (will allow pulses when high)
		:EDGe	RISing / FALLing	Choose the edge of the incoming pulse to trigger on. (Only used when the option for the gate to be a second trigger input is enabled)
		:LEVel	.20 – 15[V]	Choose the gate level threshold to trigger on, this should be set to ~ 50% of the input potential
	:TRIGger			Command to change the units' global trigger settings.
		:MODe	DIS / TRIG / DUAL	Sets the global trigger mode for the unit: When the unit is set to single pulse each trigger input will produce a output pulse, When in burst mode each trigger input will produce a burst of output pulses, and when in continuous or duty cycle mode the trigger input will start the pulses (the trigger will function the same as pressing the Run/Stop button) **Note: When in dual trigger mode each channel will have the option to select which trigger to use.*
		:EDGe	RISing / FALLing	Choose the edge of the incoming pulse to trigger on.
		:LEVel	.20 – 15[V]	Choose the gate level threshold to trigger on, this should be set to ~ 50% of the input potential.

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:PULSe[1/2/n]				Command to change the units' channel specific settings.
	:STATe		0/1 or OFF/ON	Enables/Disables output pulse for selected channel.
	:WIDTh		10[ns] - 999.99999999975[s]	Sets the pulse width for the selected channel. The command should be sent without units. If for example 50ns is desired the parameter sent should be 50e-9, or the decimal equivalent.
	:DELay		-99.99999999975[s] to 999.99999999975[s]	Sets the delay from the timing reference to when the pulse is created. The command should be sent without units. If for example 50ns is desired the parameter sent should be 50e-9, or the decimal equivalent.
	:SYNC		T0,CHA,CHB-CHH	Allows the user to select the timing reference for each channel. **Note: When in external clock input mode T_0 will be the clock input.*
	:MUX		0-255	Decimal representation of an 8 bit binary number (example: 255 = 1111 1111)
	:POLarity		NORMal / COMPlement / INVerted	Normal is active HIGH, Inverted and Complement are active LOW.
	:OUTPut			Command to change the channels' output parameters.
		:MODe	TTL / ADJustable	Allows the user to select either TTL logic mode or Adjustable voltage output mode.
		:AMPLitude	2.0 to 20[V]	Allows the user to select the voltage potential for Adjustable output mode.
	:CMODe		NORMal / SINGle / BURSt / DCYCle	Allows the user to select the pattern of outputs to use on the channel level.
	:BCOunter		1 to 1,000,000	When the channel is in Burst mode will allow user to select the number of pulses to output with each input clock pulse. **Note: The commas should be omitted.*
	:PCOunter		1 to 1,000,000	When the channel is in duty cycle mode will allow the user to select the number of pulses to create with each input clock pulse. **Note: The commas should be omitted.*
	:OCOunter		1 to 1,000,000	When the channel is in duty cycle mode will allow the user to select the number of pulses to suppress with each input clock pulse. **Note: The commas should be omitted.*
	:WCOunter		0 to 1,000,000	Allows the user to select how many clock cycles to wait until the channel should start creating an output pulse. **Note: The commas should be omitted.*
	:CTRIg		TRIG / GATE	Sets the Trigger source for the channel selected. **Note: For the gate to be used as a trigger source the unit must have the dual trigger option.*

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:PULSe[1/2/n]				Command to change the units' channel specific settings.
	:CGATe		DIS / PULS / OUTP	Sets the channel gate mode to Disabled, Pulse Inhibit mode, or Output Inhibit mode. **Note: The system global gate mode must be set to CHAN for this command.*
	:CLOGic		LOW / HIGH	Set the channel gate to active LOW or active HIGH. **Note: The system global gate mode must be set to CHAN for this command to work.*

Keyword:	Command:	Sub-Command:	Sub-Command:	Parameter Range:	Notes:
:SYSTem					Command to change the units' system settings.
	:STATe			?	Query Only Command
	:BEEPer				Command to change the units' beeper settings.
		:STATe		0/1 or OFF/ON	Command to turn on or off the systems' beeper.
		:VOLume		0 - 100	Command to change the units' beeper volume.
	:COMMunicate				Command to set the communication settings.
		:SERial			Sub-Command to set the serial interface parameters.
			:BAUD	4800 / 9600 / 19200 / 38400 / 57600 / 115200	Command to change the baud rate for the RS-232 interface.
			:USB	4800 / 9600 / 19200 / 38400 / 57600 / 115200	Command to change the baud rate for the USB interface.
			:ECHo	0/1 or OFF/ON	Command to Enable/Disable the echo function on the RS-232 interface. The Echo function will cause the unit to repeat the command received to the PC.
	:KLOCk			0/1 or OFF/ON	Command to lock-out the keypad.
	:AUTorun			0/1 or OFF/ON	When the unit is powered up, if this command is enabled, the unit will start pulsing automatically.
	:VERSion			?	Query only. Returns SCPI version number in the form YYYY.V for ex. 1999.0
	:SERNumber			?	Query only. Returns the serial number of the unit. The format returned will be "SER# xxxxx".

	:INFOrmation			?	Query only. Returns model, serial number, firmware version, and FPGA version numbers. The same as the *IDN? Command.
	:NSID			?	Query only. Returns firmware and FPGA identification numbers.
	:CAPS			0/1 or OFF/ON	The default value is 1, which means the unit is not case sensitive. 0 means the commands sent to the unit must be capitalized. **Note: To change this parameter the unit must be power cycled before the command will take effect.*

IEEE 488.2 Common Commands

Command:	Parameter Range:	Notes:
*IDN	?	Query only. Returns model, serial number, firmware version, and FPGA version numbers.
*RCL	1 - 24	RECALL
*RST		RESET. Resets parameters only same as *RCL 0
*SAV	1 - 24	SAVE
*TRG		Creates a soft trigger input.
*TTG		Creates a soft trigger for the trigger input only. Used when the dual trigger option is enabled.
*GTG		Creates a soft trigger for the gate input only. This command is only active when the dual trigger option is enabled.
*LBL	?	Used to query the label of the last saved or recalled configuration.
	String Value	Command to attach a string label to the current settings. The string must be in double quotes and no longer than 14 characters. Command must be followed by a *sav [1/2/n] command to take effect. **Note: To see the label on the screen a display update or reboot must take place.*
*ARM	0/1 or OFF/ON	Resets all channel counters simultaneously when the channels are in either single shot or burst mode. **Note: The system must be in continuous mode (this command is functionally the same as pressing the Run/Stop button).*
*PUC		Saves the system settings. Acts like pressing the front panel power button.

8. Appendix A – Specifications

588 Specifications

INTERNAL RATE GENERATOR

RATE (T_0 period)	0.0002 Hz to 10.000 MHz
RESOLUTION	10 ns
ACCURACY	1 ns + .0001 x period
JITTER	< 50 ps RMS
SETTLING	1 period
BURST MODE	1 to 1,000,000 pulses
TIMEBASE	100 MHz, low jitter PLL
OSCILLATOR	50 MHz, 25ppm
SYSTEM OUTPUT MODES	Single pulse, burst, duty cycle, external gate/trigger
PULSE CONTROL MODES	Internal rate generator, external trigger/gate

PROGRAMMABLE TIMING GENERATOR

CHANNEL OUTPUT MODES	Single shot, burst, duty cycle, normal
CONTROL MODES	Internally triggered, externally triggered and external gate. Each channel may be independently set to any of the modes.
OUTPUT MULTIPLEXER	Timing of any/all channels may be multiplexed to any/all outputs.
WAIT FUNCTION	0 to 1,000,000 pulses
TIMEBASE	Same as internal rate generator

DELAYS

RANGE	0-1000 s
ACCURACY	1 ns + 0.0001 x Delay
RESOLUTION	250 ps
PULSE INHIBIT DELAY	< 120 ns typical
OUTPUT INHIBIT DELAY	< 50 ns typical

SYSTEM EXTERNAL TRIGGER/GATE INPUT(S)

TRIGGER INPUT	
FUNCTION	Generate individual pulses, start a burst or continuous stream
RATE	DC to 1/ (200 ns + longest active pulse). Maximum of 5 MHz
SLOPE	Rising or Falling

GATE INPUT	
MODE	Pulse inhibit or output inhibit
POLARITY	Active high/active low

MODULE SPECIFICATIONS

TTL/ADJUSTABLE DUAL CHANNEL OUTPUT MODULE (Standard)

OUTPUT IMPEDANCE	50 ohm

TTL/CMOS MODE

OUTPUT LEVEL	4.0 V typ into 1 kohm
RISE TIME	3 ns typ (10% - 90%)
SLEW RAT	> 0.5 V/ns
JITTER	50 ps RMS channel to channel

ADJUSTABLE MODE

OUTPUT LEVEL	2.0 to 20 VDC into 1 k ohm 1.0 to 10.0 VDC into 50 ohm
OUTPUT RESOLUTION	10 mV
CURRENT	200 mA typical, 400 mA (short pulses)
RISE TIME	15 ns typ @ 20V (high imp) 25 ns typ @ 10V (50 ohms) (10% - 90%)
SLEW RATE	>0.1 V/ns
OVERSHOOT	<100 mV + 10% of pulse amplitude

TRIGGER/GATE DUAL INPUT MODULE (Standard)

Standard dual channel input module, providing one trigger input and one gate input. May be used with the dual trigger firmware option to provide two independent trigger sources.

THRESHOLD	0.2 to 15 VDC
MAXIMUM INPUT VOLT.	60 V Peak
IMPEDANCE	1.5 K ohm + 40 pF
RESOLUTION	10 mV

TRIGGER INPUT

SLOPE	Rising or Falling
JITTER	800 ps RMS
INSERTION DELAY	<180 ns
MINIMUM PULSE WIDTH	2 ns

GATE INPUT

POLARITY	Active High/Active Low
FUNCTION	Pulse Inhibit or Output Inhibit
CHANNEL BEHAVIOR	Global w/Individual Channel
PULSE INHIBIT DELAY	120 ns
OUTPUT INHIBIT DELAY	50 ns

STANDARD FEATURES

COMMUNICATIONS	USB/RS232
EXTERNAL CLOCK IN	10 to 100 MHz in 1 MHz increments
EXTERNAL CLOCK OUT	T_0, Rate, Chan, 2x ExtPLL, 1 ExtPLL, ½ ExtPLL, ½ Ext, 40 MHz, 20 MHz, 10 MHz, 5 MHz, and Disabled

GENERAL

STORAGE	24 storage bins
DIMENSIONS	19” x 10” x 1.75”
WEIGHT	8 lbs
POWER	100 - 240 VAC 50/60 Hz <3 A
FUSE	(Qty 2) 630 mA, 250 V Time-lag

9. Appendix B - Safety Symbols

Safety Marking Symbols

Technical specifications including electrical ratings and weight are included within the manual. See the Table of Contents to locate the specifications and other product information. The following classifications are standard across all QC products:

- Indoor use only
- Ordinary Protection: This product is NOT protected against the harmful ingress of moisture.
- Class 1 Equipment (grounded type)
- Main supply voltage fluctuations are not to exceed ±10% of the nominal supply voltage.
- Pollution Degree 2
- Installation (overvoltage) Category II for transient overvoltage's
- Maximum Relative Humidity: <80% RH, non-condensing
- Operating temperature range of 0° C to 40° C
- Storage and transportation temperature of -40° C to 70° C
- Maximum altitude: 3000 m (9843 ft.)
- This equipment is suitable for continuous operation.

This section provides a description of the safety marking symbols that appear on the instrument. These symbols provide information about potentially dangerous situations which can result in death, injury, or damage to the instrument and other components.

Symbol	Publication	Description/Comment
	IEC 417, No. 5031	**Direct current**. Vdc may be used on rating labels.
	IEC 417, No. 5032	**Alternating current**. For rating labels, the symbol is typically replaced by V and Hz as in 230V, 50Hz. DO NOT USE **Vac**.
	IEC 417, No. 5033	**Both** direct and alternating current
	IEC 617-2 No. 02-02-06	**Three-phase alternating current**
	IEC 417, No. 5017	**Earth (ground) terminal**. Primarily used for functional earth terminals which are generally associated with test and measurement circuits. These terminals are not for safety earthing purposes but provide an earth reference point.
	IEC 417, No. 5019	**Protective conductor terminal**. This symbol is specifically reserved for the protective conductor terminal and no other. It is placed at the equipment earthing point and is mandatory for all grounded equipment

	IEC 417, No. 5020	**Frame or chassis terminal**. Used for points other than protective conductor and functional earth terminals where there is a connection to accessible conductive terminals to advise the user of a chassis connection.
	IEC 417, No. 5021	**Equipotentiality** Used in applications where it is important to indicate to the operator that two or more accessible functional earth terminals or points are equipotential. More for functional rather than for safety purposes
	IEC 417, No. 5007	**On** (Supply) Note that this symbol is a bar, normally applied in the vertical orientation. It is not the number 1.
	IEC 417, No. 5008	**Off** (Supply) Note that this symbol is a true circle. It is not the number 0 or the letter O.
	IEC 417, No. 5172	**Equipment protected by** double insulation or reinforced insulation **(equivalent to Class II if IEC 60536)**
	ISO 3864, No. B.3.6 Background color - yellow; symbol and outline - black	**Caution, risk of electric shock** Generally used only for voltages in excess of 1000 V. It is permissible to use it to indicate lower voltages if an explanation is provided in the manual. Color requirements do not apply to markings on equipment if the symbol is molded or engraved to a depth or raised height of 0.5 mm, or that the symbol and outline are contrasting in color with the background.
	IEC 417, No. 5041 Background color - yellow; symbol and outline - black	**Caution, hot surface** Color requirements do not apply to markings on equipment if the symbol is molded or engraved to a depth or raised height of 0.5 mm, or that the symbol and outline are contrasting in color with the background.
	ISO 3864, No. B.3.1 Background color - yellow; symbol and outline - black	**Caution (refer to accompanying documents)** used to direct the user to the instruction manual where it is necessary to follow certain specified instructions where safety is involved. Color requirements do not apply to markings on equipment if the symbol is molded or engraved to a depth or raised height of 0.5 mm, or that the symbol and outline are contrasting in color with the background.
	IEC 417, No. 5268-a	**In-position of bistable push control**
	IEC 417, No. 5269-a	**Out-position of bistable push control**

10. Appendix C - COM

Ethernet Interface Overview

**Note: See also Appendix D for more on the Ethernet interface*

The Ethernet module used is a "Digi Connect ME" module supplied by Digi Connectware, Inc. There are several ways to successfully communicate with the pulse generator over Ethernet. The two most popular methods are raw TCP/IP (such as Labview or programming with VISA libraries) and by mapping a PC COM port using the Digi Connectware's "Realport Drivers".

Whatever method of Ethernet communication is ultimately desired, the utilities supplied by Digi Connectware (included on the CD shipped with the Pulse Generator) will be critical to implementing the communications. Please install the following utilities:

Ethernet Communication Notes:

- The Digi Connectware's "Digi Device Discovery" can be used to determine what IP address was assigned by the local DHCP server (if any).
- "Digi Device Discovery" can also be used to open a web interface to the Ethernet module. Simply double-click on the IP address that is displayed in the Digi Device Discovery utility.
    - Username: "root"
    - Password: "dbps"
- If a mapped COM port is the desired communication method, the Digi Connectware's "Realport Drivers" setup must be used to install the COM port on the PC. The virtual COM port is then local to the computer it was installed on. Please refer to the Digi Connectware documentation supplied on the CD, or call BNC Technical Support.
- The pulse generator's SCPI default baud rate on the Ethernet port is 115200 and should not be changed for communication, whether or not a mapped COM port is used. The virtual COM port on the PC should be set to a baud rate of 115200.
- Echo functionality is not available on the Ethernet port.

11. Appendix D - Ethernet Connectivity

The Ethernet module used in BNC's pulse generators is a "Digi Connect ME" device manufactured by Digi International, Inc. It supports virtually all practical Ethernet communication methods. A set of utilities and documentation by Digi is included on the CD shipped with the pulse generator.
This discussion assumes that the Digi utilities included with your pulse generator and National Instruments VISA (version 3.3 in this procedure, see National Instruments' website) are installed. The procedures discussed have been prepared using Windows XP service pack 2.

Determining IP address

The Digi module has been reset to factory defaults before it left the manufacturing facility. In this mode, it is ready to be assigned an IP address by the local DHCP server. If a crossover cable is being used, the Ethernet device will assume a default IP address.
The Digi utility "Digi Device Discovery" can be used to determine the IP address that is currently assigned to the Ethernet module. Hit "Start, All Programs, Digi Connect, Digi Device Discovery". When the utility opens, it scans the LAN looking for Digi Ethernet modules. It may take a minute after plugging in or powering the Ethernet module before the LAN negotiates the connection with the Digi module. Hit "Refresh View" in the left column after a minute or so if the utility fails to see the unit when you start it. When the utility sees the Digi device, it will display it in the list (Figure 1).

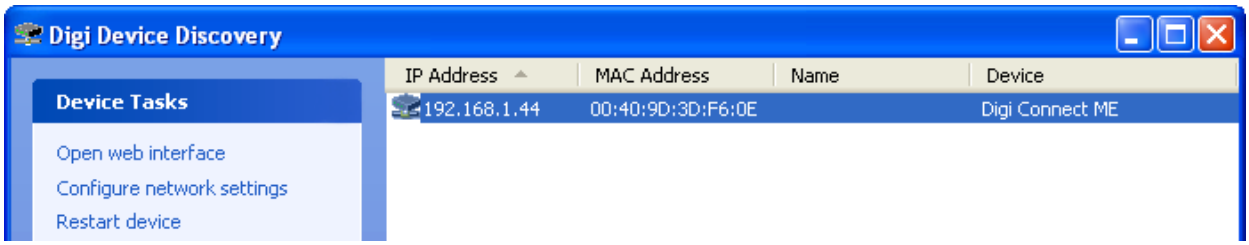


Figure 1: Digi Device Discovery utility displaying Digi module discovered on the LAN

Note the IP address for use later. A static IP address can be set using the "Configure network settings" link in the left hand column. From this point, a web interface can be opened, allowing access to configuration options for the Digi module. Select "Open web interface" under the device tasks on the left hand column of the Digi Device Discovery software.
You will be required to enter the following username and password:

- Username: "root"
- Password: "dbps"

The Digi Connect ME Configuration and Management home page will be displayed (Figure 2).

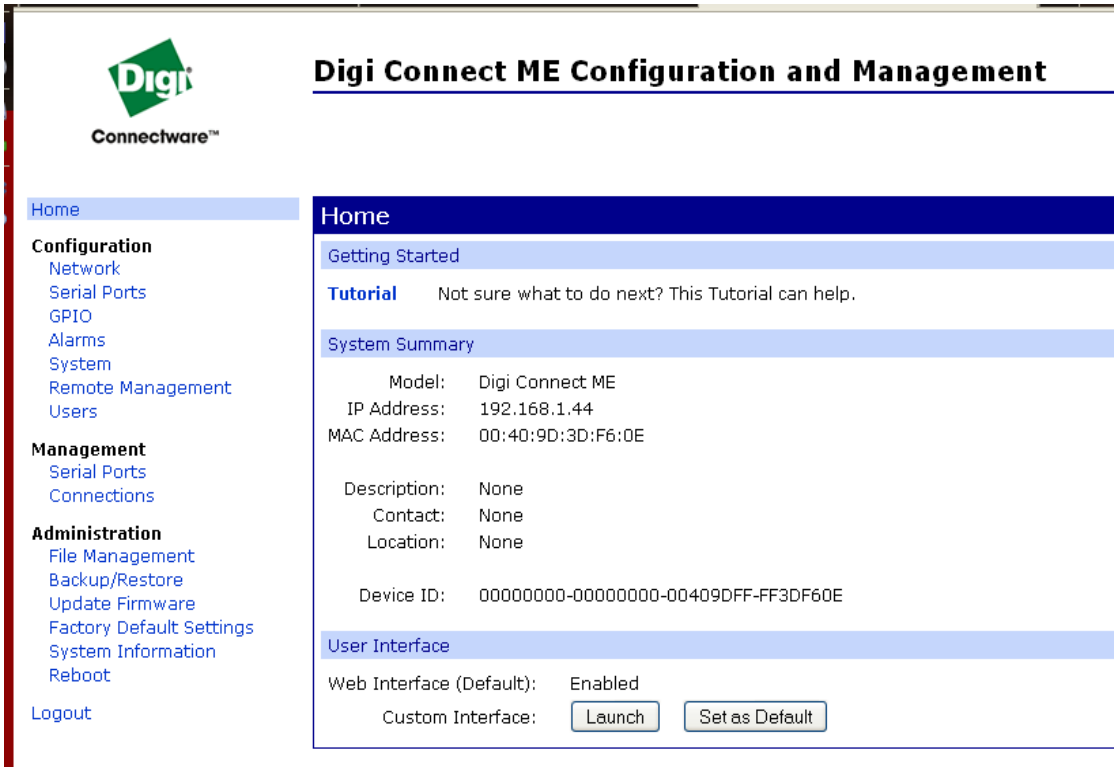


Figure 2: Configuration Home page

From the home page select “Serial Ports” on the left hand side. The serial port configuration page will be displayed (Figure 3).

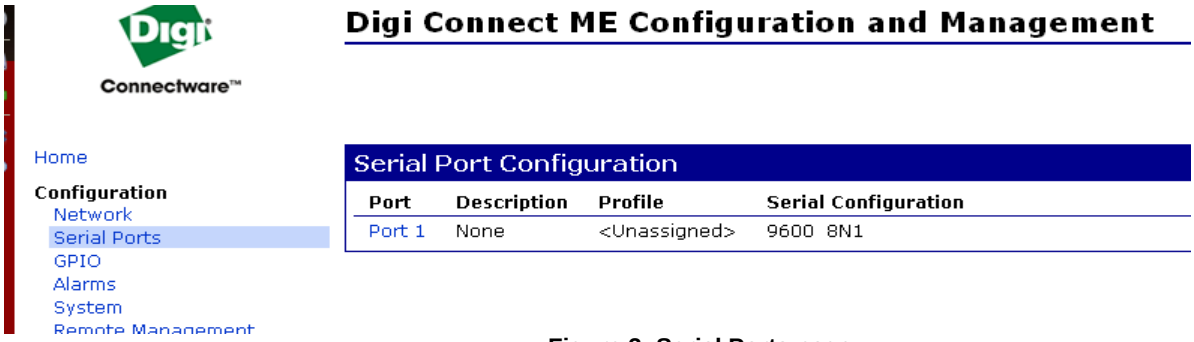


Figure 3: Serial Ports page

Select Port 1 from the list of ports. Select TCP Sockets from the list of available profiles and click on apply at the bottom of the page. The TCP Sockets profile settings will then be displayed. Be sure that the box next to “Enable Raw TCP access using TCP Port:” is selected and note the port number. By default the port number is 2101. If any settings were changed click on apply at the bottom of the Port Profile Settings section. Next, select the “Basic Serial Settings” section located below the “Port Profile Settings” section. If the product is a 9500+ select 9600 as the baud rate, all other models need to be set to a baud rate of 115200 (Figure 4).

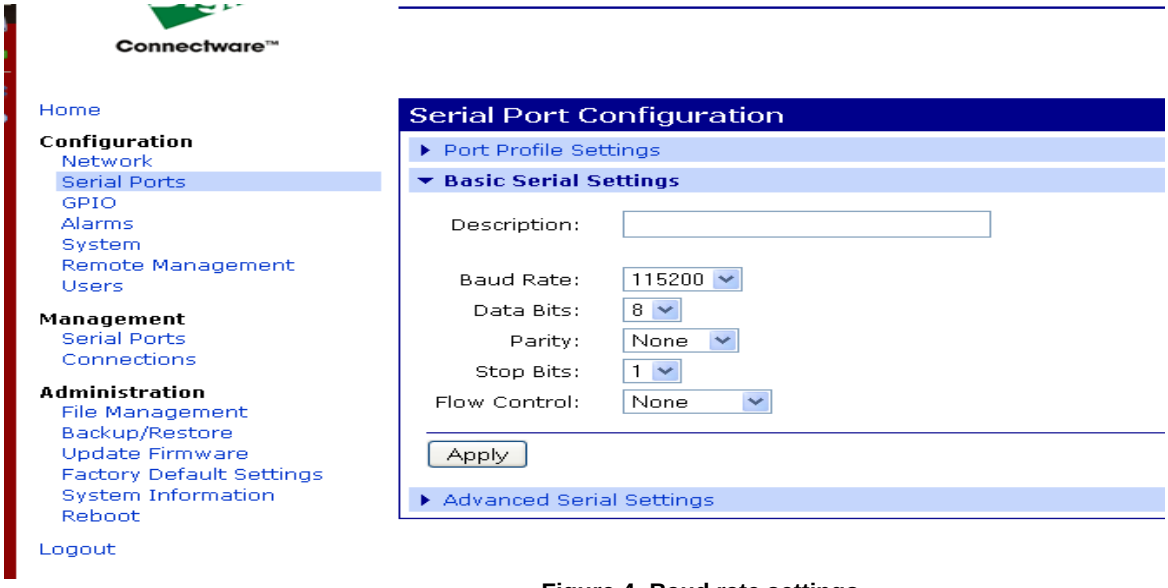


Figure 4: Baud rate settings

Click on apply after changing the baud rate. Select “Logout” from the bottom of the left hand column. After logging out power cycle the instrument. Use the Digi Device Discovery software to see if the IP address of the unit appears again. Once the unit has been identified the unit is ready for communication.

Testing Ethernet Communication

Ethernet communication to the pulse generator can be tested using a utility that is installed with National Instruments’ (current) VISA libraries.
After determine the IP address for the unit, “VISA Interactive Control” can be used to send and receive command strings to and from the pulse generator. Hit “Start, All Programs, National Instruments, VISA, VISA Interactive Control” (Figure 5).

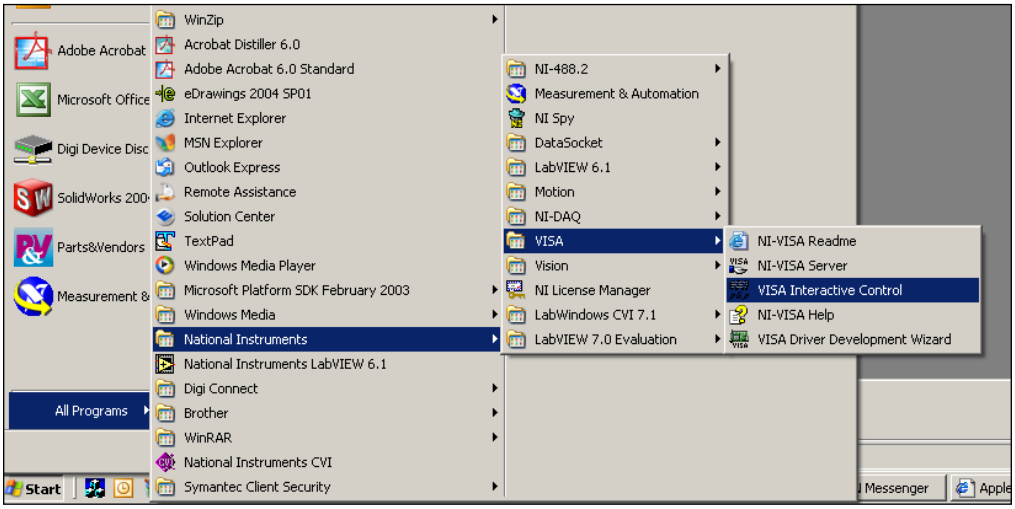


Figure 5: Typical path to VISA Interactive Control utility

When this utility opens, it displays local resources found. TCPIP resources are typically not shown in this window. However, the resource string can be successfully entered manually in the "Resource to Open" field (Figure 6). The resource string for Digi Connect Ethernet Modules in BNC pulse generators needs to be formatted as follows:
TCPIP0::<IP address>::2101::SOCKET

Or, for example:
TCPIP0::192.168.1.44::2101::SOCKET

A session window will open allowing access to communication parameters and read and write buffer access and control (Figure 6). BNC pulse generators support SCPI formatted command strings. For these units, command strings and responses are both terminated with text-style line terminations, a carriage return and linefeed pair. These are ASCII characters number 13 and 10 respectively. They are represented in this utility (and in many other contexts) as "\r\n".

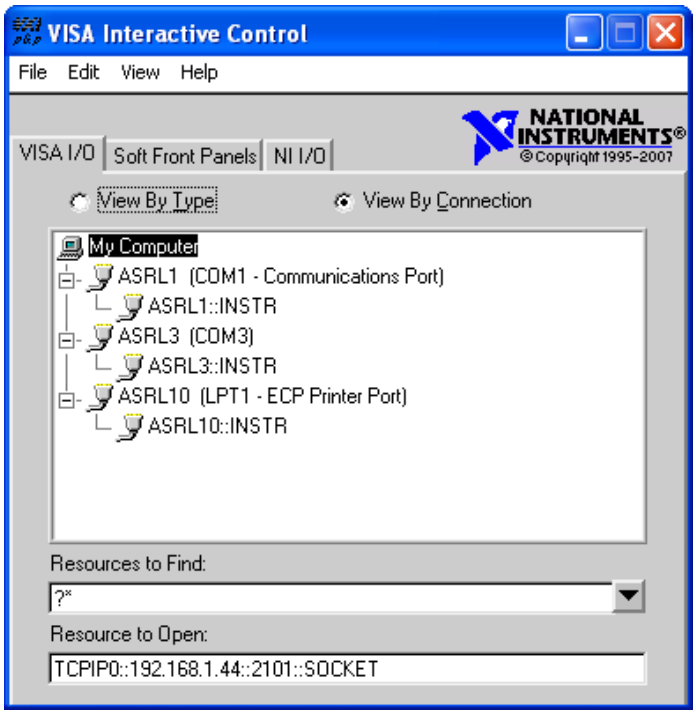


Figure 6: Session window for TCPIP resource

In hexidecimal, these are represented as "0x0D" and "0x0A", respectively. When sending command strings to the pulse generator, strings need to be terminated with a carriage return and linefeed pair. Without this line termination, the pulse generator will not execute commands, but continue to wait for more characters until it sees this string termination sequence.

Tab over to the "Write" tab (Figure 7).

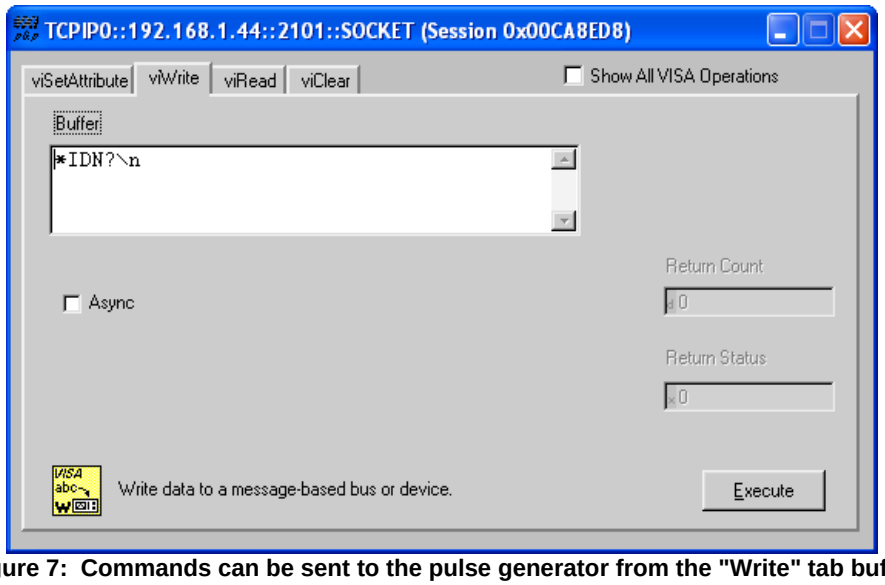


Figure 7: Commands can be sent to the pulse generator from the "Write" tab buffer

The “Buffer” field can be edited to send any valid command to the pulse generator. Hit “Execute” to send the “*IDN?” command. Now tab over to the “Read” dialog (Figure 8).

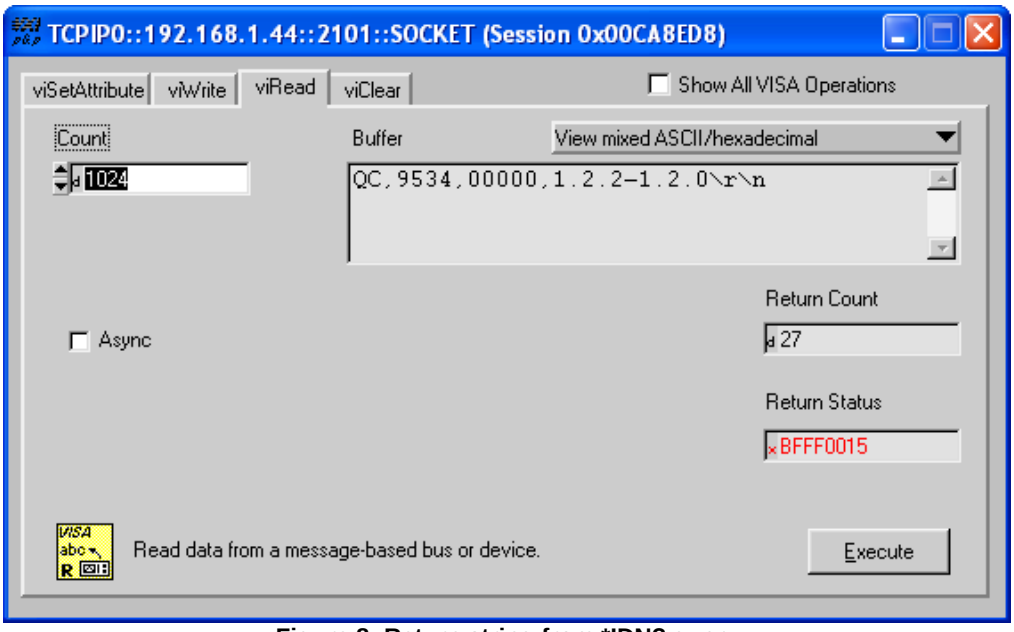


Figure 8: Return string from *IDN? query

Successive iterations between “Write” and “Read” operations can be accomplished from here. Keep in mind that it is always best to follow each “Write” command immediately with a “Read” command, whether the commands are generated from a utility such as this, or from a more complex coded application. The pulse generator is designed to respond to every command line with either the result of a query (ie, “:pulse1:width?\r\n” could return “0.000100000”), or a simple “ok\r\n” to acknowledge a successful parameter change. If a “Read” command does not follow each “Write” command, the read (output) buffer in the pulse generator can overfill and become corrupt.

Many applications may need a communication mechanism no more sophisticated than what can be achieved with this simple utility. At the very least, this tool can be used to verify that the pulse generator and communication hardware are functioning properly. From here, a specific application in whatever preferred programming language can be built.

Although BNC cannot support all programming languages, we do have extensive experience with many languages, and strive to provide whatever assistance we can. Contact QC technical support for the latest information on what assistance may be available for your application.

12. Appendix E - Dual Trigger Input

DT15 Dual Trigger Module

**Note: Dual Trigger Mode and Incrementing mode are mutually exclusive.*

This module option allows the "Gate" input to function as a second trigger input. For consistency, the enabling menu for this option is located under the "Trig" menu structure. Once the dual trigger mode is enabled, both the "Gate" and "Trig" inputs can act as trigger inputs.

Adjustments for the "Gate" functioning as a trigger input are located under the "Gate" menu structure. The voltage threshold level and trigger edge for the "Gate" input can be adjusted from this menu. The "Gate" trigger edge choice is only available when in dual trigger mode.

Once dual trigger functionality is enabled on the unit, each channel can be assigned to either of the trigger inputs. The default trigger source for each channel is the "Trig" input. The trigger source selection is accessed in the secondary channel menus. To access this menu, press the button for the channel of interest twice. Continue to press then the Page button until the menu page with "Ch Gate:" and "TrigSrc:" appears. Use the "Next" button to place the cursor on the "TrigSrc" line and use the up/down arrows to change to the desired trigger source.

588 SCPI Dual Trigger Command Summary

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:PULSe[0]				Command to change the units' global settings, this is the same as using the :SPULse command
	:TRIGger			Command to change the units' global trigger settings.
		:MODe	DIS / TRIG / DUAL	Sets the unit to dual trigger mode.
:PULSe[1/2/n]				Command to change the units' channel specific settings.
	:CTRIGger	GATE/TRIG		Sets which input is assigned to the channel trigger

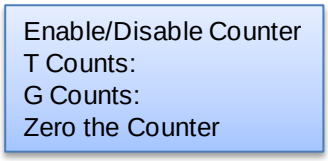
IEEE 488.2 Common Commands

Command:	Parameter Range:	Notes:
*TTG	Trigger-Trigger Input	Generates a software trigger pulse for the TRIG input only. Operation is the same a receiving an external trigger pulse.
*GTG	Trigger-Gate Input	Generates a software trigger pulse for the GATE input only. Operation is the same a receiving an external trigger pulse.

Changes in Menu Structure Caused by Enabling the Dual Trigger Function

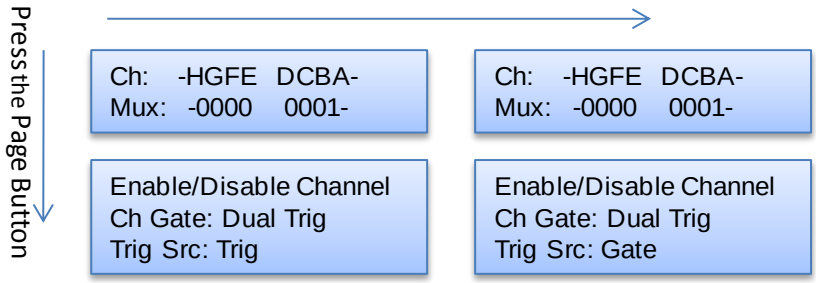
Counter Menu

The counter Menu now shows the option to track the counter counts on the Gate input when functioning as a trigger.



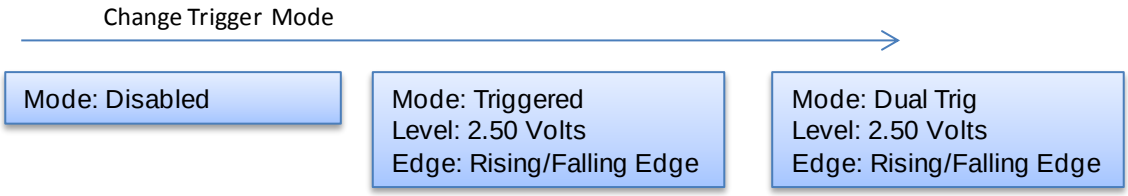
Channel Advanced Menu

The Channel Advanced menu now shows that the gate is used in the dual trigger mode and only lets the user select to enable/disable the channel and choose which trigger source to use for that channel.



Trigger Menu

The Trigger menu now has a third mode selection, Dual Trigger.



Gate Menu

When the Dual Trigger option is evoked under the Trigger menu the Gate menu changes to allow the user to only change the level and edge parameters.

13. Appendix F – Impedance Matching Outputs

TZ50 Impedance Matching Output Module

This module option allows a user to have a 50 Ω load on the output while maintaining output amplitude of at least 4 Volts while in the TTL/CMOS mode. All other functionality of the module is the same as the AT20 modules, including output while using the Adjustable Mode Function of the channels.

TTL/ADJUSTABLE OUTPUTS

TTL/CMOS Mode

Output Level	4.0 Volts typical into 50 Ω
Rise Time	3 ns
Slew Rate	>0.5 V/ns
Jitter – Channel to Channel	<50 ps RMS

Adjustable Mode

Output Resolution	10 mV
Current	200 mA typical, 400 mA max (short pulses)
Slew Rate	>0.1 V/ns

**Note: The TZ50 module has significant overshoot and ringing through high impedance (see figure).*

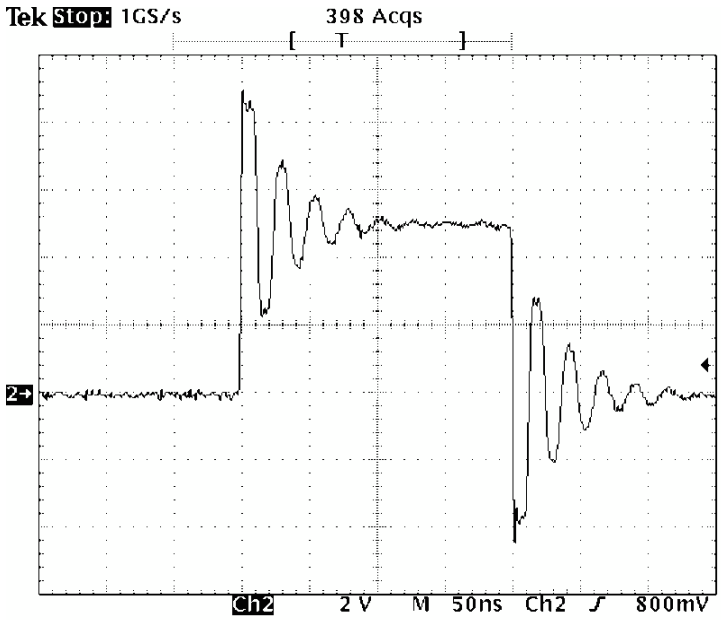


Figure 9: Overshoot on the Output of TZ50 Module

14. Appendix G - Increment Mode

Using the Increment System Mode

**Note: Dual Trigger Mode and Incrementing mode are mutually exclusive.*
Also to get the first incremented pulse the :PULSe0:IRESet 1 command must be sent, otherwise the pulse will not get incremented.

The System Increment modes are a pair of special modes, which allow the delay and width of each channel to be incremented at the end of a burst of pulses. Each channel is independent and each may be set with different initial values and different values for the step size for both the delay and the pulse width.

There are two incrementing modes, Burst Increment and Duty Cycle Increment. In the Burst Increment mode, each start command or external trigger produces a burst of pulses. At the end of the burst the appropriate delays and pulse widths are incremented and the instrument is armed for the next start command. In the DC Increment (Duty Cycle) mode the output is started as with the normal duty cycle mode. At the end of each cycle the delays and pulse widths are incremented. This continues for the number of cycles defined by the Cycle parameters. The modes are selected from the system mode menu. The step sizes are specified in the advanced channel menus.

588 SCPI Increment Command Summary

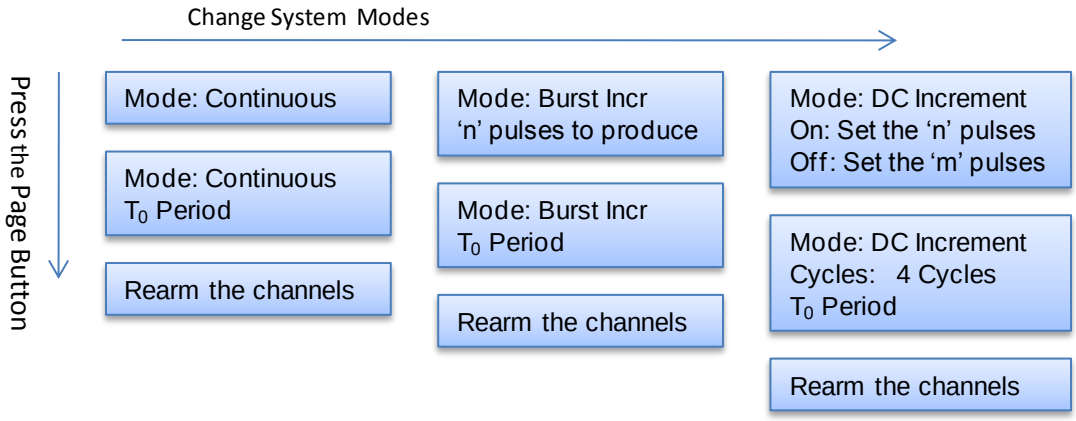
Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:PULSe[0]				Command to change the units' global settings, this is the same as using the :SPULse command
	:MODe	BINCRement/ DCINCRement/ NORMal/ SINGle/ BURSt/ DCYCle		Sets the T_0 mode. Added parameter for Burst Increment and Duty Cycle Increment mode.
	:CYCLe		1 - 100	Sets the number of cycles to generate in Duty Cycle Increment mode.
	:IRESet		1	Resets the width and delay increment parameters on all channels.
:PULSe[1/2/n]				Command to change the units' channel specific settings.
	:IWIDth	GATE/TRIG	-1.000,000,000,00 to 1.000,000,000,00	Sets the pulse width in 10ns increment step sizes. **Note: The commas should be omitted.*
	:IDELay		-1.000,000,000,00 to 1.000,000,000,00	Sets the delay in 10ns increment step sizes. **Note: The commas should be omitted.*

**Note: The update rate for increment mode is:*
10 µs + 30 µs per active channel (1 Ch @ 25 KHz to 8 Ch @ 4 KHz)

Changes in Menu Structure Caused by Enabling the Incrementing Function

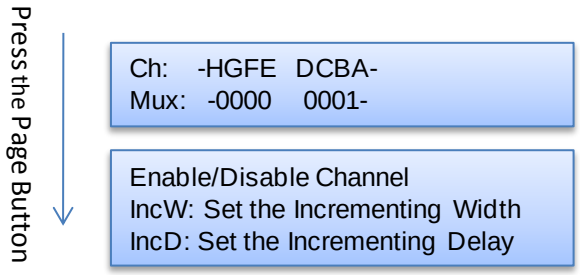
System Mode Menu

The System Mode menu now shows two more options, one is Burst Increment and the other is Duty Cycle Increment. The menus below are in addition to the normal menus under the System Mode.



Channel Advanced Menu

The Channel Advanced menu now has a page where the user can set the Incrementing Width and Delay for each channel.



Using the Duty Cycle Increment Function

- In the System Mode menu:
  - Set the mode to DCIncrement mode.
  - Set the number of on and off pulses that are desired.
  - Press the Page button and set the number of cycles to run.
  - Set the T_0 period.
- In the Channel menu:
  - Set the desired pulse width and delay.
  - Set the desired Channel Mode.
- In the Channel Advanced menu:
  - Set the desired width increment step size.
  - Set the desired delay increment step size.
- Via a serial interface send the :PULSe0:IRESet 1 command to initialize the incrementing mode

Once the Run/Stop button is pressed the unit will generate one set of pulses, ‘N’ on and ‘M’ off. Pressing the Run/Stop button again will generate a second set of pulses with the width and delay adjusted by the increments set in the Channel Advanced menu. To reset the width and delay increments the :PULSe0:IRESet 1 command must be sent to the unit using HyperTerminal.

Using the Burst Increment Function

- In the System Mode menu:
  - Set the mode to BurstIncrement mode.
  - Set the desired number of pulses.
  - Press the Page button and set the T_0 period.
- In the Channel menu:
  - Set the desired pulse width and delay.
  - Set the desired Channel Mode.
- In the Channel Advanced menu:
  - Set the desired width increment step size.
  - Set the desired delay increment step size.
- Via a serial interface send the :PULSe0:IRESet 1 command to initialize the incrementing mode

Once the Run/Stop button is pressed the unit will generate one set of pulses. Pressing the Run/Stop button again will generate a second set of pulses with the width and delay adjusted by the increments set in the Channel Advanced menu. To reset the width and delay increments the :PULSe0:IRESet 1 command must be sent to the unit using HyperTerminal.

15. Appendix H - External Clock

588 External Clock Operation

The 588 pulse generator has a special external clock circuit that allows for external clock synchronization when using clock sources that have very narrow pulse widths and amplitudes.

Parameter:	Minimum	Maximum
Pulse Width	100 ps	-
Pulse Amplitude	50 mV	2.5 Volts Peak
Frequency	10 MHz	100 MHz
Insertion Delay	-	10 ns

Using the external clock function:

- Enter the clock source menu by pressing the page button until the clock source page is reached.
- Select the source to External Osc or External PLL.
- Adjust the threshold level appropriate for the amplitude of the external clock source.
- Adjust the rate to match the frequency of the external clock source.
- When the source is set to External Osc a lower case e will appear in the bracketed area of the screen (Figure 10).
- A "?" will appear if the system does not lock onto the external clock source when in External PLL mode. Once the system is locked on the external clock signal the "?" will change to a "p". If the "p" never appears or is sporadic possible problems are:
  - Threshold level not adjusted correctly.
  - External clock source not present.
  - External clock has excessive jitter.
  - Amplitude of external clock is changing.

Figure 10: System Display Screen Shot