



9420 Series Pulse Generator Operating Manual

Version 00

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2 Introduction

This manual is a reference designed to familiarize you with the Quantum Composers 9420 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 9420 -- our technical staff can be reached via one of the following methods:

- Phone: (406) 582-0227
- Fax: (406) 582-0237
- Online: www.quantumcomposers.com

Warranty

In addition to a 30-day money back guarantee, the 9420 has a two-year limited warranty from the date of delivery. This warranty covers defects in materials and workmanship. Quantum Composers 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:

- 9420 Pulse Generator
- AC Power Cord
- Disc that includes
 - Operating Manual
 - Software Drivers
 - Communication Software

Contact Quantum Composers (406) 582-0227 if any parts are missing.

3 Safety Issues

Normal use of test equipment presents a certain amount of danger from electrical shock because testing must be performed where exposed voltage is present. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 V (DC or RMS AC) should be considered dangerous and hazardous since 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.

4 Front Panel Overview

9420 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:

-  A vertical arrow indicates there are additional pages to the current menu.
-  An alternating hollow and then solid circle indicates the unit is actively generating pulses, or armed and waiting for an external trigger.
-  A musical note indicates the function key has been pressed.
-  In external oscillator operation, a question mark indicates the internal pll is not yet locked with the external clock signal.

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

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

- Channel Keypad Provides one touch access to the menus for setting up the channel parameters. Pressing the appropriate letter will display the parameters for the corresponding channel. Example: Pressing the **A** key will access the Channel A menus.
- Arrow Keypad The up (**UP**) and down (**DOWN**) arrow keys are used to increment/decrement the current parameter (indicated by the blinking cursor). The position of the cursor controls the step size for each increment. The

right (**RIGHT**) and left (**LEFT**) arrow keys moves the cursor to different positions within the current parameter. The **NEXT** key selects the next parameter in the currently displayed menu.

- **Numeric Keypad** Allows numbers and alphanumeric values to be entered. When entering alphanumeric values, pressing a key will display the first letter shown on the key. The yellow **FUNC** key allows the keys to select the yellow functions.

Repeated key presses will toggle through all the letters, both upper and lower case, shown on the keycap. To enter two letters which appear on the same keycap, select the first character, then use the right arrow to shift to the next position and enter the next letter. When data entry is complete the **ENTER** key must be pressed.

Rotary Adjustment Knob

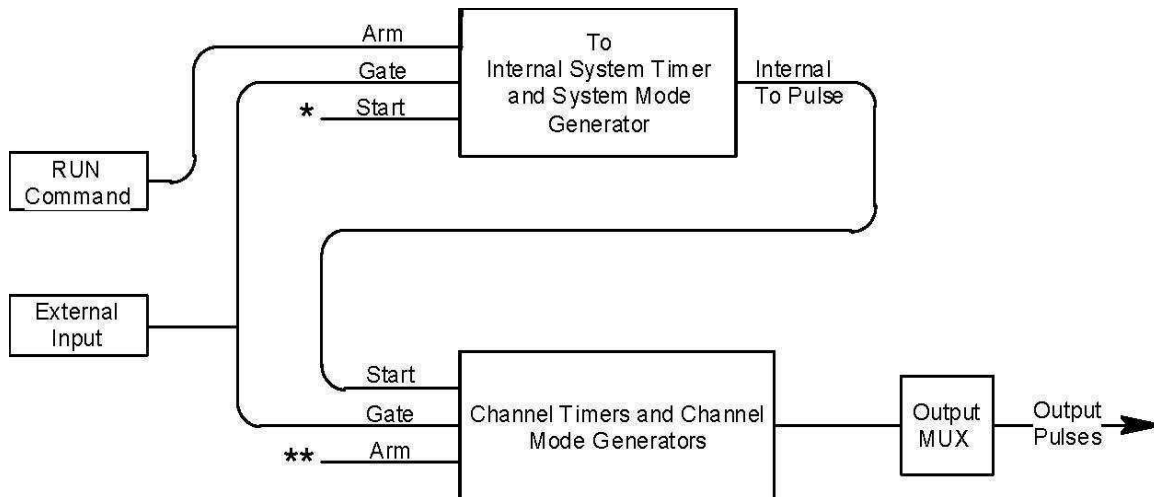
As an alternative to the Arrow Keypad, the Rotary Adjustment Knob may be used to adjust the current parameter. The step size is controlled by the position of the cursor; however turning the knob faster will increase the step size. Pushing the knob will perform functions similar to the **NEXT** key and switch to the next parameter in the currently displayed menu.

Second Level Menus (Function Key)

The second level menus (indicated in yellow above certain keys) are accessed through the use of the yellow function (**FUNC**) key. Pressing the **FUNC** key once and then pressing the desired menu key will display the specified second level menu. Pressing the **FUNC** key twice in succession will put the unit into "Function Lock" mode, where the second level menus can be accessed without repeatedly pressing the **FUNC** key. Pressing the **FUNC** key a third time will exit "Function Lock" mode.

5 Pulse Concepts and Pulse Generator Operations

Counter Architecture Overview



*Start source is: **RUN/STOP** key in Internal Modes
External input in External Trigger modes
*TRG command via Serial/GPIB access

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

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 pulses are 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 at the first T_0 pulse, after which output is inhibited.
- Burst A pulse is generated for each T_0 pulse, 'n' times, after which output is inhibited.
- Duty Cycle 'n' pulses are generated for each T_0 pulse after which the output is inhibited for 'm' times. The cycle is then repeated.

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 the Channel Timers are routed to a set of multiplexers. This allows routing of any or all Channel Timers to any or all of the unit outputs. In the normal mode of operation, the output of the T_n Channel Timer is routed to the T_n output connector. As an example, if a double pulse is required on Channel A output, one can multiplex the Channel A timer with the Channel B timer adjusting each timer to provide the necessary pulses.

Dependent & Independent Timing Events

The 9420 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 a dependent event.

Navigating the 9420 Front Panel

Selecting Menus

Parameters are grouped in menus, selectable using menu keys. To select the output channel parameters press the letter key corresponding to the desired channel. To select second level menu press the **FUNC** key and then the key corresponding to the desired function. To select advanced channel menus press the **FUNC** key followed by the desired channel key. Menus may include a number of different pages with 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. To select the next page, press the channel button again or select the same second level menu by pressing the **FUNC** key and the channel/menu key again.

Selecting Menu Items

Within a menu, the blinking cursor indicates the current menu item for editing. The **NEXT** key or pressing the adjustment knob 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 in one of three ways. Using the arrow keypad, the left (**LEFT**) and right (**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. Alternately, after using the **LEFT** and **RIGHT** arrow keys to select an active digit, the adjustment knob may be used to increment and decrement this digit. The adjustment knob features speed dependent resolution. Slow rotation will increment or decrement the active digit by one. As you increase the speed of rotation, the parameter will be 10 to 1000 times faster depending on the speed.

An additional entry mode is using the numeric keypad. Enter the number, including decimal point using the numeric keypad. Complete the number using the **ENTER** key. To clear number entry and/or start over press the clear key (**CLR**). Pressing the **CLR** key a second time will exit the numeric keypad mode and restore the original number.

The last entry mode is a modified form of scientific notation. The **FUNC** button acts as $10^$ in this case. Type in the value followed by **FUNC** then the number button that represents the power desired. For example 64us is entered as 6, 4, **FUNC**, and then 6.

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. The adjustment knob may also be used to change the selection. If the item is an on-off toggle, the **UP** arrow

(CW adjustment knob) enables the item and the **DOWN** arrow (CCW adjustment knob) disables the item.

Alphanumeric Input Mode

When the current item is alphanumeric, the system enters the Alphanumeric Input Mode. In this mode, data is entered using the alphanumeric keypad. Pressing a key will display the first letter shown on the keypad. Repeated key presses will toggle through all the letters, both upper and lower case, shown on the key cap. To enter two letters which appear on the same key cap, select the first character, then use the right arrow to shift to the next position and enter the next letter. The Left and Right arrow keys may be used to position the cursor to edit any character. When data entry is complete, the **ENTER** key must be pressed. The keys contain the following characters:

- 1 1 2 3 4 5 6 7 8 9 0
- 2 A B C a b c 2
- 3 D E F d e f 3
- 4 G H I g h i 4
- 5 J K L j k l 5
- 6 M N O m n o 6
- 7 P Q R S p q r s 7
- 8 T U V t u v 8
- 9 W X Y Z w x y z 9
- 0 0 1 2 3 4 5 6 7 8 9
- . . , # \$ % & ? • -- + * / space

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 output 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. An illuminated channel key indicates that the channel is enabled.

Rearming the Channel Timers

In the channel single shot mode and burst mode, the Channel Timers may be rearmed after completing the initial output by pressing the **FUNC** key followed by the **RUN/STOP** key. If there are channels currently running in normal mode, single shot and burst channels can be re-armed without affecting the timing on normal mode channels by pressing function **RUN/STOP** button.

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 start of the pulse.

NOTE: If $Wid + Dly + 75ns$ (hardware reset time) $> T_0$ Period, the correct pulse width will be generated but at a slower rate.

Setting Pulse Output Parameters

There are three basic types of outputs available on the 9420: (a) TTL/CMOS compatible outputs; (b) adjustable amplitude outputs; (c) optical 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 - negative voltages are not supported.
Ampl: In adjustable mode, it sets the unloaded output voltage. The actual output voltage will depend on the load impedance. For example: If the load is 50 ohms, the output will be 50% of the stated voltage.

Using the Output Multiplexer

Each output channel includes a multiplexer which allows routing any or all of the timer outputs to the physical output. This allows double pulses and other complex pulse trains to be generated. Only timing parameters are multiplexed together, not amplitudes.

Mux: -HGFEDCBA-
 -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 operate at submultiples of the fundamental frequency using their duty cycle mode.

Per: Sets the internal T Period.

To set the system Internal Rate press the yellow **FUNC** key, then press the **RATE** key, and then use the dial or number pad to specify the T_0 Period.

6 9420 Menu Structure

System Mode Menus (FUNC + MODE key)

MODE:	MODE: Single	MODE: Burst	MODE: Duty
Continuous	Shot		Cycle
			#/On
		#/Burst	#/Off

Setting System Mode of Operation

The **MODE** menu sets the T₀ system timer mode. The menu will show the extra set parameters (Burst, On & Off) only when they are appropriate.

- Mode: Selects the T₀ mode: Continuous, Single Shot, Burst or Duty Cycle mode.
- Burst: Sets the number of pulses to be generated when in Burst mode.
- On: Sets the number of pulses to be generated during each on cycle.
- Off: Sets the number of pulses to skip each during off cycle when in the Duty Cycle mode.

*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.

Channel Menus (A, B, C, D, E, F, G, or H key)

Timing Menu

Channel Enable
Sync Source
Pulse Width
Delay

Output Configuration Menu

Channel Enable	Channel Enable
Output Type:	Output Type:
TTL/CMOS	Adjustable
Polarity	Polarity
	Amplitude

Mode Menu

Channel Enable	Channel Enable	Channel Enable	Channel Enable
Mode: Normal	Mode: Single Shot	Mode: Burst	Mode: Duty Cycle
			#/On Pulses
		#/Burst Pulses	#/Off Pulses

Wait Menu

Channel Enable
#/Wait Pulses

Enabling Channel Output

At the top of each of the channel menu pages is a parameter to enable or disable the channel. Each channel may be individually controlled. When enabled, the channel key will illuminate.

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 Configuration Output Type

The 9420 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.

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

Setting Channel Mode of Operation

Each channel may be set independently to operate in one of four modes: normal, single shot, burst, or duty cycle (within the CHANNEL menus):

Mode: Selects the mode for the current channel. Additional parameters are provided for the burst mode and the duty cycle mode.
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 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

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.

Advanced Channel Menus (FUNC + A, B, C, D, E, F, G or H key)

Multiplexer Menu

-HGFE DCBA-
Multiplexed Channels

Configuring the Channel Multiplexer

To define which channels 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 bit field.

Channel Gate Menu

Channel Enable	Channel Enable	Channel Enable
Ch Gate Mode: (Gate Menu)	Ch Gate Mode: Pulse Inhibit	Ch Gate Mode: Output Inhibit
	Logic Level	Logic Level

Setting the Sync Source

Although each channel receives its start pulse from the internal T_0 pulse, 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.

Setting Channel Gate Control

When the global gate is set (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.

Rate Menu (FUNC + RATE key)

Internal Reference Menu

T ₀ Period

Setting the Rate

To: Sets the T₀ period which determines the fundamental output frequency of the unit.

Trigger Menus (TRIG key)

Mode: Disabled	Mode: Triggered
	Threshold Level
	Trigger Edge

Enabling System Trigger

Enable the use of the TRIG input by the system timer as a trigger source.

Mode: Selects between disabling/enabling the trigger mode.

Level: Sets the trigger threshold. Edge: Selects between rising and falling edges as the trigger source when a trigger mode is enabled.

Gate Menus (GATE key)

Standard Gate Menu

Mode: Disabled	Mode: Pulse Inhibit	Mode: Output Inhibit	Mode: (Chan Menu) *
	Threshold Level	Threshold Level	Threshold Level
	Logic Level	Logic Level	

* Gate Mode is controlled on a per channel basis from the [Advanced Channel Gate Menu](#)

Enabling System Gate

Enables the use of the GATE input as a trigger inhibit or output control for all channels simultaneously, or on a per channel basis.

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

System Configuration Menus (FUNC + SYSTEM key)

Communication Interface Menu

Interface: RS232	Interface: USB	Interface: GPIB
Baud Rate	Baud Rate	Address
Echo	Echo	

Setting System Communication Parameters

The 9420 comes with a standard RS232 serial port, USB port, and GPIB. The unit will not respond to computer commands unless these ports are properly configured.

Interface:	RS232, USB, GPIB
Baud Rate:	Selects the baud rate for the RS232 or USB interface.
Echo:	Selects whether to echo characters back to the host computer or not.
Address:	Sets the GPIB address.

User Options Menu 1

Key Rate
Key Volume
Knob Volume

Setting Keypad Parameters

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 both the keypad and the adjustable knob.

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

User Options Menu 2

Auto Start Mode
Decimal Mark
LCD Brightness

Setting the Auto Start Mode

The unit may be configured to automatically start generating pulses after power up.

Setting the Display Decimal Mark

Mark:	Selects the format of the decimal mark, "." or ",".
-------	---

Setting the Display Brightness

LCD:	Adjusts display brightness.
------	-----------------------------

Store Menu (FUNC + STORE key)

Configuration #
Name
Help Line

Storing a Configuration

Use the following procedure to store a complete system configuration:

- Set all parameters to the desired value.
- Select a configuration number.

*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 sequence (**FUNC + STORE**).

Recall Menu (FUNC + RECALL key)

Configuration #
Name
Help Line

Recalling System Configurations

Use the following procedure to recall a stored or default system configuration:

- Enter the Recall Menu (**FUNC + RECALL**).
- Select a configuration number.
- From the Recall Menu, press the recall key sequence (function + recall).

*Note: Configuration 0 is the factory default setting.

Counter Menu (FUNC + AUX1 key)

Counter Enable
T Counts
Help Line

Using the Counter Function

The Counter function counts the number of T_0 pulses output by the system clock. When the unit is operated in system single shot mode, the T_0 count reflects the number of incoming trigger pulses.

Information Menus (FUNC + 0 key)

Information Menu A

Model Number
Serial Number
Firmware Ver.
FPGA Ver.

Information Menu B

FW ID #
GA ID #
Module IDs
Instr. Options

The Information Menus provide 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.

7 Operating the 9420

Quick Start - Normal Internal Rate Generator Operation

The 9420 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 pulses is required. Starting from the default settings, which can be restored by recalling configuration 0, the following parameters need to be set:

Pulse Width, 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 FUNC key and then the RATE key. Set the desired pulse period. Note that in general, the pulse delay plus the pulse width, plus a 75ns hardware reset constant, 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 FUNC key and then the MODE key. Select Single Shot mode.
Trig	Enter the Trigger menu by pressing the TRIG key. 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.
Edge	Press the NEXT key until the Edge parameter is high-lighted. Set the instrument to trigger off the rising edge or falling edge as desired.

Pulse Width, 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/arm the instrument. The 9420 will now generate a pulse for every valid trigger.
Stop	Press the RUN/STOP key a second time to stop/disarm the instrument (i.e. to stop generating pulses).

System Timer Overview

For internal operation, the 9420 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.

To Use 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
Mode Select Continuous for the system mode.
- within the Rate menu
Period Set the desired period.

Pressing the **RUN/STOP** key will now generate a stream of T_0 pulses at a rate specified by the period parameter.

To Use Single Shot Mode

To generate a single pulse with every press of the **RUN/STOP** key:

- within the system Mode menu
Mode Select Single Shot for the system mode.

Pressing the **RUN/STOP** key will now generate a single pulse.

To Use System Burst Mode Function

The RUN/STOP button generates a stream of “n” T_0 pulses, where “n” is specified by the Burst parameter. The rate is specified in the Rate menu. Pressing the RUN/STOP button while 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:

- within the system Mode menu

Mode: Select the Burst mode.

Burst: Set the number of pulses to produce in the burst.

To Use System Duty Cycle Function

The RUN/STOP button starts a continuous pulse stream which oscillates on for the “n” pulses and off for “m” pulses, where “n” and “m” are specified by the On and Off parameters, respectively. The rate is specified in the Rate Menu. To generate a stream of pulses which oscillates on for ‘n’ pulses and off for ‘m’ pulses:

- within the system Mode menu

Mode: Select the Duty Cycle mode.

On: Set the number of pulses to produce during the on cycle.

Off: Set the number of pulses to skip during the off cycle.

- within the Rate menu

Source: Select the system oscillator or the external clock in frequency.

Period: Set desired Period.

Channel Timer Overview

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

When one channel is generating a continuous stream of pulses, a user can trigger a single shot or burst of pulses on another channel without interrupting the continuous stream by pressing the **FUNC** and the **RUN/STOP** key.

To Use Channel Normal Mode Function

The Normal mode generates a continuous stream of pulses at a rate determined by the system timer:

- within the Channel menus

Enable: Select Enable to enable channel output.

Dly: Set the desired delay.

Wid: Set the desired pulse width.

Mode: Select the Normal mode.

Pressing the **RUN/STOP** key will now generate a continuous stream of pulses.

To Use Channel Single Shot Function

The Single Shot mode generates a single pulse every time the **RUN/STOP** key is pressed. If the unit is in the active state, (i.e. channels which are set to the Normal mode are producing pulses), pressing the **FUNC** key and **RUN/STOP** key will reset the Single Shot counters and generate one pulse in sync with the other channels running in the Normal mode. To use the Single Shot mode:

- within the Channel menus
- Enable: Select "Enabled" to enable channel output.
- Delay: Set the desired delay.
- Width: Set the desired pulse width.
- Mode: Select the Single shot mode.

To Use Channel Burst Mode Function

The Burst mode generates a burst of pulses every time the **RUN/STOP** key is pressed. If the unit is in the active state, (i.e. channels which are set to the Normal mode are producing pulses), pressing the **FUNC - RUN/STOP** key sequence will reset the Burst counters and generate a new set of pulses in sync with the other channels running in the Normal mode. **FUNC - RUN/STOP** will not affect T_0 pulse status. To use the Burst mode:

- within the Channel menus
- Enable: Select "Enabled" to enable channel output.
- Delay: Set the desired delay.
- Width: Set the desired pulse width.
- Mode: Select the Burst mode.
- #/Burst: Set the number of pulses to produce in the burst.

To Use the Channel Duty Cycle Function

To generate a stream of pulses which oscillates on for 'n' pulses and off for 'm' pulses:

- within the Channel menus
- Enable: Select "Enabled" to enable channel output.
- Delay: Set the desired delay.
- Width: Set the desired pulse width.
- Mode: Select the Duty Cycle mode.
- On Cycle: Set the number of pulses to produce during the on cycle.
- Off Cycle: Set the number of pulses to skip during the off cycle.

**Note: Older Quantum Composers pulse generators had a divide-by-n function. The duty cycle mode is a more general case. 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-n factor.

To Use 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 gate, set the following parameters

- within the Channel menu

Mode: In Gate Menu must be set to Channel Menu.

Channel Gate: Select “Pulse Inh” or “Output Inh”.

Logic: Select active high or active low.

In the “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 pulse. In the “Output inhibit” method, the gate leaves the base triggering alone and enables/disables the output directly. Output pulses will immediately cease when the gate signal is removed

External Input Overview

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

To Generate a Pulse on Every Trigger Input

To generate a pulse on every external trigger received, set the following parameters:

- within the Mode menu

Mode: Select the Single Shot mode.

- within the Trigger menu

Mode: Select Triggered mode.

Level: Set the trigger threshold level.

Edge: Select which edge, rising or falling, 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** key will disarm the unit. This mode corresponds to the normal external trigger mode found on most other pulse generators.

To Generate a Burst of Pulses on Every Trigger Input

To generate a burst of pulses for every external trigger received set the following parameters:

- within the Mode menu

Mode: Select the Burst mode.

Burst: Set the number of pulses to generate in each burst.

- within the Rate menu

To: Set the period between pulses.

- within the Rate menu

Source: Select the system oscillator or an external clock in frequency.

To: Set the period between pulses.

- within the Trigger menu

Mode: Select Triggered mode.

Level: Set the trigger threshold level.

Edge: Select which edge, rising or falling, to trigger on.

Pressing the **RUN/STOP** key will arm the unit. Once the unit is armed, it will generate a set of pulses for every external trigger received. The unit 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 are ignored. Pressing the **RUN/STOP** key will disarm the unit.

To Start a Continuous Stream of Pulses Using the External Trigger

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

- within the Mode menu

Mode: Select the Continuous mode.

- within the Rate menu

Source: Select the system oscillator or an external clock in frequency.

To: Set the period between pulses.

- within the Trigger menu

Mode: Select the Trigger mode.

Level: Set the trigger threshold level.

Edge: Select which edge, rising or falling, to trigger on.

Pressing the **RUN/STOP** key will arm the unit. Once the unit is armed, it will begin generating pulses after an external trigger is received. Triggers

that occur after the pulses start are ignored. Pressing the **RUN/STOP** key a second time will disarm the unit.

To use the External Gate to Control the System

The external gate may be used to control the output of the unit. To gate the system timer:

- within the Mode menu

Mode: Select the desired mode.

- within the Rate menu

Source: Select the system oscillator or an external clock in frequency.

Per: Set the period between pulses.

- within the Gate menu

Mode: Select "Pulse Inh" or "Output Inh".

Level: Set the gate threshold level.

Logic: Select active high or active low.

Pressing the **RUN/STOP** key will arm the unit. Once the unit is armed, it will begin generating pulses whenever the external gate input is in the active state. Pressing the **RUN/STOP** key a second time will disarm the unit.

8 Programming the 9420

Personal Computer to Pulse Generator Communication

The 9420 ships standard with an RS232 serial, USB, and GPIB interface. 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. Although due to the high number of special features found in the 9420, 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 approximately 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.

RS232 Interface Overview

The serial port is located on the back of the 9420 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

*The default baud rate for the RS232 is 115200.

USB Interface Overview

The USB interface is standard on the 9420. Before this type of communication can be used, the appropriate drivers must be installed on the personal computer (pc). These drivers are normally installed automatically, but if problems occur the latest version of drivers can be downloaded at

<http://www.ftdichip.com/Drivers/VCP.htm>. Please contact Quantum Composers or visit www.quantumcomposers.com for instructions.

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 RS232 communication to the pulse generator. Communications Terminal (included on shipment CD) 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 <baud rate>” command. This parameter can be accessed via any communication method. The default baud rate for USB is 115200.

USB communication notes:

- The correct drivers must be installed on the personal computer before communication can be accomplished via USB.
- The BAUD rates on the PC and on 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 <baud rate>” where <baud rate> can be:
 - 4800
 - 9600
 - 19200
 - 38400
 - 57600
 - 115200 (default)
- USB 1.0 specification is used. The USB cable can be removed without “unplugging” the device in the operating system environment.

GPIO Interface Overview

Also known as IEEE-488, a GPIO computer interface is standard on the 9420. Before using this interface, the address must be set using the GPIO address menu item.

Programming Command Types and Format

The 9420 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 RS232 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.

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 mnemonic by a space character. For Example:

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

SCPI Command Format

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.

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:

QUERY FORMAT

```
:PULSE1:STATE?<cr><lf>
    Will return:  1<cr><lf>

:PULSE1:WIDT?<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. If more than one parameter is used, you must separate subsequent parameters with a comma.

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 = T₀, 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 default is 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: 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, 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, 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 v
: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
--------------	---------------------------------------

9420 INSTRument Commands (SCPI Command Summary)

Keyword	Parameter	Comments
:INSTrument		Subsystem. Supports treating each channel as a logical instrument.
:CATalog?		Query only. Returns a comma-separated list of the names of all channels. A two channel instrument would return: T ₀ ,CHA,CHB.
:FULL?		Query only. Returns a comma-separated list of the names of all channels and their associated number. A two channel instrument would return: T ₀ , 0, CHA, 1, CHB, 2.
:COMMands?		Query only. Returns an indented list of all SCPI commands.
:NSElect	0-8	Selects a channel using the channel's numeric value. All channel specific commands will refer to the selected channel.
:SElect	T ₀ ,CHA,CHB,CHC,CHD,CHE,CHF,CHG,CHH	Selects a channel using the channel's identifier string. All subsequent channel specific commands will refer to the selected channel.
:STATe	0/1 or OFF/ON	Enables/Disables the selected channel output. If T ₀ is selected all output is affected. Enabling T ₀ is the same as pressing the RUN button.

9420 System PULSe[0] Commands (SCPI Command Summary)

Keyword	Parameter	Comments
:PULSe[0]		Subsystem. Contains commands to control the output pulse generation. Commands without suffix refer to the currently selected logical instrument. See INSTRUMENT subsystem.
:COUNter		Subsystem. Contains commands to define the Counter function.
:STATe	0/1 or OFF/ON	Enables/Disables the counter function.
:CLear	TCNTS	Clears the pulse counter.
:COUNts?	TCNTS	Queries the number of counts for the trigger input.
:STATe	0/1 or OFF/ON	Enables / Disables the output for all channels. Command is the same as pressing the RUN/STOP button.
:PERiod	200ns-5000s	Sets the T_0 period.
:MODE	NORMal / SINGLE / BURSt / DCYCLE	Sets the T_0 mode.
:BCOunter	1-1,000,000	Burst Counter. Number of pulses to generate in the Burst mode.
:PCOunter	1-1,000,000	Pulse Counter. Number of pulses to generate during on cycle of the Duty Cycle mode.
:OCOunter	1-1,000,000	Off Counter. Number of pulses to inhibit output during the off cycle of the Duty Cycle mode.
:GATE		Subsystem. Contains the commands to define the Gate function.
:MODE	DISabled / PULSe / OUTPut / CHANnel	Sets Global Gate Mode. Disable, pulse inhibit, output inhibit, channel.
:LOGic	LOW / HIGH	Sets Channel Gate logic level. Active low or active high.
:LEVel	.20V - 15V	Sets the gate threshold. Value is in volts with a range of .20 to 15 Volts.
:TRIGger		Subsystem. Contains the commands to define the Trigger function.
:MODE	DISabled / TRIGgered	Sets Trigger Mode. Disable or TRIG (enable).
:LOGic	RISing / FALLing	Selects which edge (rising or falling) to use as the trigger signal.
:LEVel	.20V - 15V	Sets the Trigger Threshold. Value is in volts, with a range of .20 to 15 Volts.

9420 Channel PULSe[n] Commands (SCPI Command Summary)

Keyword	Parameter	Comments
:PULSe [1 / 2 / n]		Subsystem. Contains commands to control the output pulse generation. Valid suffix range depends on the number of channels (ChA = 1, ChB = 2, etc). Command without suffix refers to the currently selected logical instrument. See INSTRument subsystem.
:STATe	0/1 or OFF/ON	Enables/Disables the output pulse for selected channel.
:WIDTh	10ns – 1000s	Sets the width or duration of the output pulse.
:DELay	-999.999999999s - 1000s	Sets the time from the start of the T ₀ period to the first edge of the pulse.
:SYNC	TO, CHA, CHB, CHC, CHD, etc.	Selects the Sync source.
:MUX	0-255	Selects which timers are enabled as output for the current channel.
:POLarity	NORMal / COMPliment / INVerted	Sets the polarity of the pulse. For NORMal operation the second nominal state is more positive than the first. COMPliment and INVerted are aliases. For both, the second state is more negative than the first.
:OUTPut		Subsystem. Contains command to control output mode.
:MODE	TTL/ ADJustable/	Selects output Amplitude mode: TTL/CMOS, ADJustable.
:AMPLitude	2.0V to 20V	Sets adjustable output level.
:CMODE	NORMal / SINGLE / BURSt / DCYCLE	Channel Mode. Sets the channel pulse series output mode.
:BCOunter	1-1,000,000	Burst Counter. Sets the number of pulses to generate when channel is in the BURST mode.
:PCOunter	1-1,000,000	Pulse Counter. Sets the number of pulses to generate during the on cycle of the Duty Cycle Mode.
:OCOunter	1-1,000,000	Off Counter. Number of pulses to inhibit output during the off cycle of the Duty Cycle mode.
:WCOunter	1-1,000,000	Sets the number of T ₀ pulses to delay until enabling output.
:CGATe	DIS / PULS / OUTP	Sets Channel Gate Mode. Disable, pulse inhibit, output inhibit. (Global Gate Mode must be set to CHAN for this command to be available).
:CLOGic	LOW / HIGH	Sets Channel Gate Logic level. Active low or active high. (Global Gate Mode must be set to CHAN for this command to be available).

9420 SYSTem Commands (SCPI Command Summary)

Keyword	Parameter	Comments
:SYSTem		
:STATe?		Query only. Returns the state of the machine: returns "1" if the machine is armed and/or generating pulses or "0" if the machine has been disarmed.
:BEEPer		Subsystem. Controls the audible beeper.
:STATe	0/1 or OFF/ON	Enables/disables the beeper.
:VOLume	0 - 100	Range is 0 to 100, Sets the volume of the beeper where 0 is off and 100 is maximum volume.
:COMMunicate		Subsystem. Controls the RS232 and GPIB interfaces.
:GPIB		Subsystem. Controls the physical configuration of the GPIB port.
:ADDRess	1-15	Sets the GPIB of the instrument.
:SERial		Subsystem. Controls the physical configuration of the RS232 port.
:BAUD	4800 / 9600 / 19200 / 38400 / 57600 / 115200	Sets the baud rate for both receiving and transmitting using the DB9 RS232 port. Default value is 115200.
:USB	4800 / 9600 / 19200 / 38400 / 57600 / 115200	Sets the baud rate for communication when using mapped comports for USB communication. Default value is 115200.
:ECHO	0/1 or OFF/ON	Enables/Disables transmission of characters received on the DB9 serial or USB port.
:KLOCK	0/1 or OFF/ON	Locks the keypad.
:AUTorun	0/1 or OFF/ON	After power-up, unit will start generating pulses .automatically
:VERSion?		Query only. Returns SCPI version number in the form: YYYY.V ex. 1999.0
:SERN?		Query only. Returns the serial number.
:INFORmation?		Query only. Returns model, serial number, firmware version, and FPGA version numbers.
:NSID?		Query only. Returns firmware and FPGA identification numbers.
:CAPS	0/1 or OFF/ON	Forces unit to recognize commands only sent in capital letters. 1 turns on the feature - 0 disables the feature.

9420 DISPlay Commands (SCPI Command Summary)

Keyword	Parameter	Comments
:DISPlay		Subsystem. Contains commands to control the display.
:MODE	0/1 or OFF/ON	Enables/Disables automatic display update. When true, front panel display is updated with serial command parameter changes. Setting to false decreases response time.
:UPDate?		Query only. Forces update of display. Use when mode is false.
:BRIGhtness	0-4	Controls intensity of display. Range is 0 to 4, where 0 is off and 4 is full intensity.
:ENABle	0/1 or OFF/ON	Enables/Disables the display and front panel lights. When Disabled the keylock is enabled to prevent parameter changes from the front panel.

IEEE 488.2 Common Commands

Keyword	Parameter	Comments
*IDN?	Identification Query	Queries the Pulse Generator Identification. The ID will be in the following format: manufacturer,model#,serial#,version#
*RCL	0-12	Restores the state of the Pulse Generator from a copy stored in local nonvolatile memory (0 through 12 are valid memory blocks).
*RST	Reset Command	Resets the Pulse Generator to the default state.
*SAV	1-12	Stores the current state of the Pulse Generator in local nonvolatile memory (1 through 12 are valid memory blocks).
*TRG	Trigger	Generates a software trigger pulse. Operation is the same as receiving an external trigger pulse.
*LBL	Setup Label	Query Form returns the label of the last saved or recalled configuration. Command Form sets the label string for the next "*SAV" command. String must be in double quotes, 14 characters max.
*CATalog?	Command Query	Query only. Returns an indented list of all SCPI commands.
*ARM	Channel Trigger Reset	Resets channel triggers when channels are set to single shot or burst mode. Functions like pressing the function then run/stop button.

Appendix A - 9420 Specifications

INTERNAL RATE GENERATOR

RATE (T_0 period)	0.0002 Hz to 5.000 MHz
RESOLUTION	10ns
ACCURACY	1ns + (0.0001 x Period)
JITTER	< 250 ps RMS
SETTLING	1 period
BURST MODE	1 to 1,000,000 pulses
TIMEBASE	100 MHz, low jitter PLL
OSCILLATOR	50 MHz, 20ppm Crystal Oscillator
SYSTEM OUTPUT MODES	Continuous, 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 Each channel may be independently set to any of the modes.
CONTROL MODES	Internally triggered, externally triggered and external gate.
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
WIDTHS	
RANGE	10 ns-1000 s
ACCURACY	1.5 ns + [0.0001 x (width + delay)]
RESOLUTION	1 ns
DELAYS	
RANGE	-999.999999999s - 1000 s
ACCURACY	1.5 ns + (0.0001 x delay)
RESOLUTION	1 ns

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
POLARITY

Pulse inhibit or output inhibit
Active high/active low

MODULE SPECIFICATIONS

TTL/ADJUSTABLE DUAL CHANNEL OUTPUT MODULE

OUTPUT IMPEDANCE 50 ohm

TTL/CMOS MODE

OUTPUT LEVEL 4.0 V typ into 1 kohm
RISE TIME 3 ns typ (10% - 90%)
SLEW RATE > 0.5 V/ns
JITTER <400 ps RMS (channel to channel)
OUTPUT CURRENT 5mA typical (1K Ohm)
 50mA typical (50 Ohm)

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
OUTPUT CURRENT 200 mA typical, 400 mA (short pulses)
RISE TIME (10% - 90%) 15 ns typ @ 20V (high imp)
 25 ns typ @ 10V (50 ohms)
SLEW RATE >0.1 V/ns
OVERSHOOT <100 mV + 10% of pulse amplitude

TRIGGER/GATE DUAL INPUT MODULE

Standard dual channel input module, providing one trigger input and one gate input.

THRESHOLD 0.2 to 15 VDC
MAXIMUM INPUT VOLT. 30 V Peak
IMPEDANCE 1.2K ohm
RESOLUTION 10 mV
TRIGGER ACCURACY ±3% of Threshold Voltage

TRIGGER INPUT

SLOPE Rising or Falling
JITTER <2.5 ns 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

GENERAL

COMMUNICATIONS	USB/RS232/GPIB
STORAGE	12 storage bins
DIMENSIONS	10.5" x 8.25" x 5.5"
WEIGHT	8 lbs
POWER	100 - 240 VAC
	50/60 Hz, <3 A
FUSE	(Qty 2) 3.15 A, 250 V Time-lag

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 overvoltages
- 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.

Symbols	Publications; Descriptions & Comments
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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.
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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 colour - 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. Colour requirements do not apply to markings on equipment if the symbol is moulded or engraved to a depth or raised height of 0.5 mm, or that the symbol and outline are contrasting in colour with the background.



IEC 417, No. 5041

Background colour - yellow; symbol and outline – black

Caution, hot surface - Colour requirements do not apply to markings on equipment if the symbol is moulded or engraved to a depth or raised height of 0.5 mm, or that the symbol and outline are contrasting in colour with the background.



ISO 3864, No. B.3.1

Background colour - 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. Colour requirements do not apply to markings on equipment if the symbol is moulded or engraved to a depth or raised height of 0.5 mm, or that the symbol and outline are contrasting in colour 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.