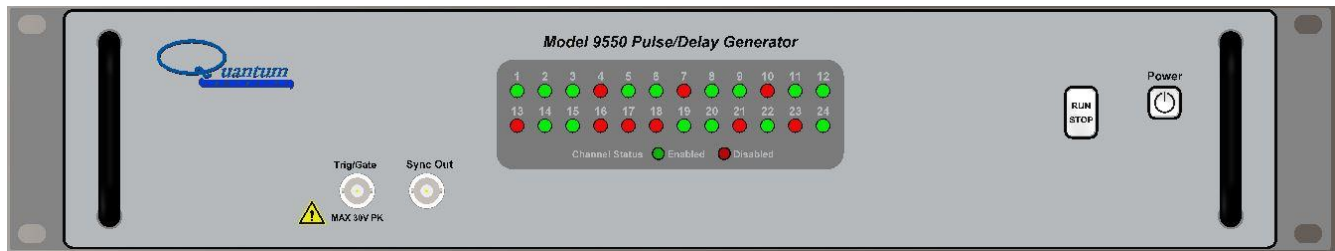# 9550/8550 Series Pulse Generator

Operating Manual

6, 12, 24 & 36 Channel Pulse Generators

Your contact:

Schulz Electronic
Professional Power Supplies

Schulz-Electronic GmbH
Dr.-Rudolf-Eberle-Straße 2
D-76534 Baden-Baden
Fon + 49.7223.9636.0

vertrieb@schulz-electronic.de
www.schulz-electronic.de

QUANTUM COMPOSERS,
INC PO Box 4248
Bozeman, MT 59772
(406)582-0227 phone
www.quantumcomposers.com

Contents

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1. Introduction

This manual is a reference designed to familiarize you with the Quantum Composers 9550 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.

	Rack Mount Models	Board Level Models
6 Channel Units	QC9550-6	QC8550-6
12 Channel Units	QC9550-12	QC8550-12
24 Channel Units	QC9550-24	QC8550-24
36 Channel Units	QC9550-36	QC8550-36

Technical Support

For questions or comments about operating the 9550 our technical staff can be reached via one of the following methods:

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

Warranty

In addition to a 30-day money back guarantee, the 9550 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:

- 9550 Pulse Generator
- AC Power Cord*
- User's Manual and Software on USB Drive

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

*Note: AC Power Cord for Model 9550/8550 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. System Overview

9550 Front Panel
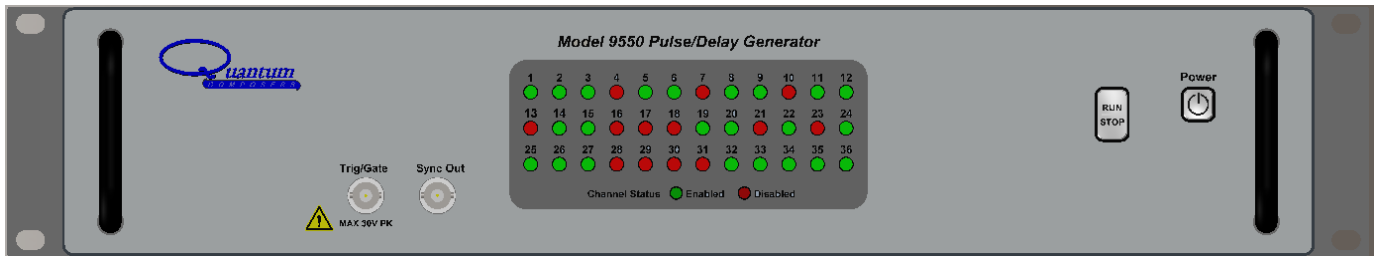
Figure 1 9550 36 Channel Front Panel

Front Panel Layout

An array of LEDs provides channel status, green indicates the channel is enabled, red indicates the channel is disabled. On power up all the LEDs will be green for 1 second and then red for 1 second to confirm operation. Error messages are indicated by blinking LEDs.

The power button and the Run button are on the right side of the front panel. On the left is a general-purpose Trigger / Gate input. The input range is 0.5v to 30v. In addition, a switch closure may be used, allowing the use of a foot switch or safety interlock.

9550 Rear Panel
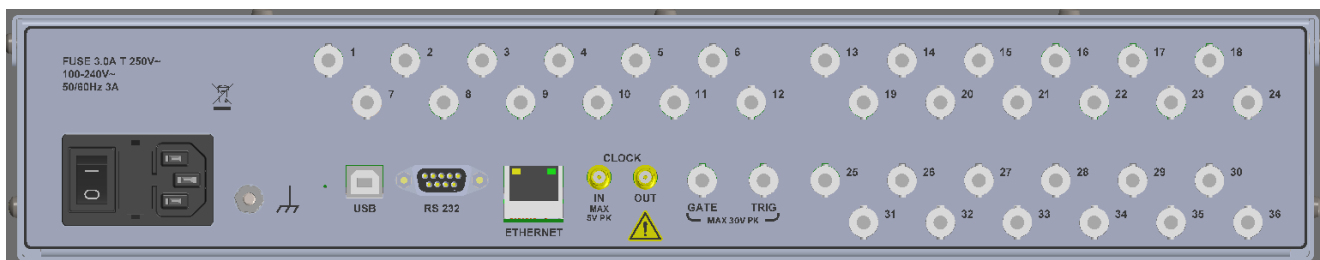
Figure 2 36 Channel Back Panel

Rear Panel Layout

The channel outputs are available from an array of BNCs. There is a BNC trigger input and a BNC Gate input. The input range is 0.5v to 30v for both inputs. In addition, a switch closure may be used, allowing the use of a foot switch or safety interlock. A pair of SMA connectors provide for the input of a reference oscillator and the output of the internal system T0 pulse or a synthesized oscillator output. The unit provides three communication ports: RS232, USB & Ethernet. The power entry module has a power on/off switch and accepts 100 to 240VAC at 50Hz or 60Hz.

4. Pulse Concepts and Pulse Generator Operations

Counter Architecture Overview
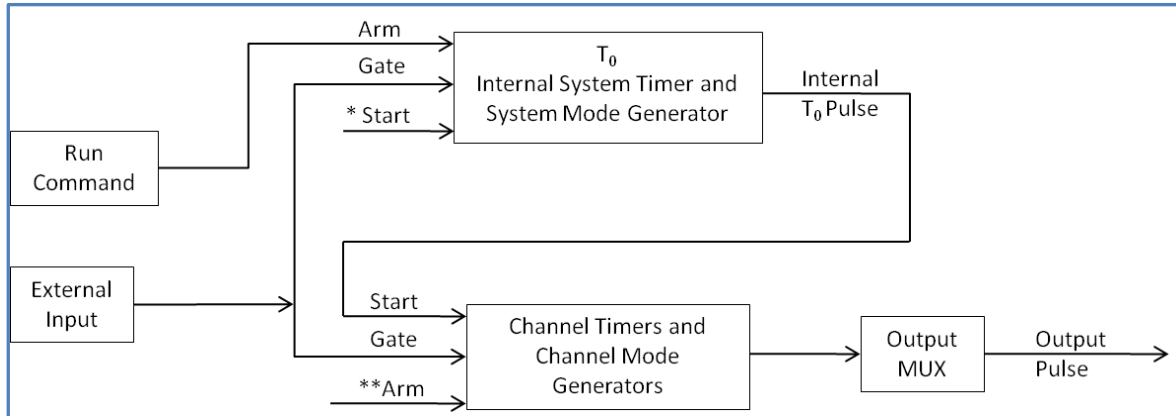
Figure 3 Pulse Generation

*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 generates the internal T0 pulse which is used as the Start pulse for the channel timers. 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 or using the comm commands. 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.
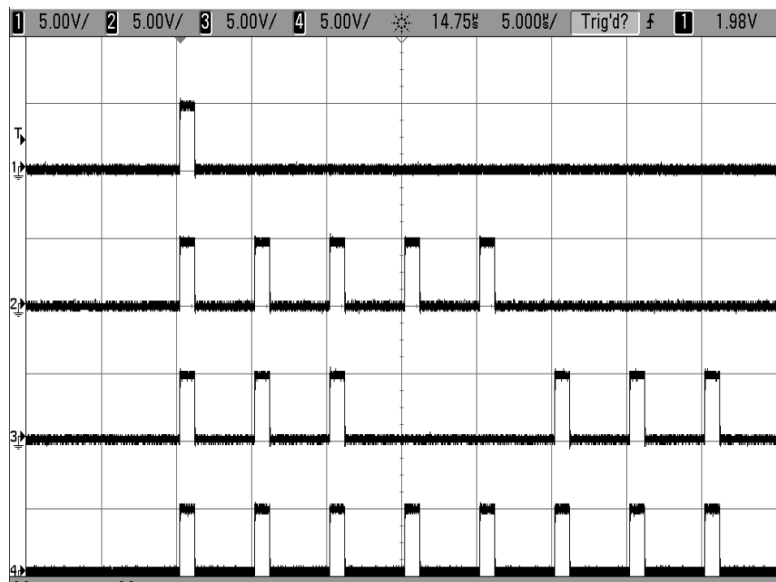
Different modes may be selected for each output, allowing a wide variety of output combinations. Each output may also be independently disabled or gated (using the external gate input).

Scope Ch 1
      Ch 1 - Single Shot

Scope Ch 2
      Ch 2 - Burst Mode
        (5 Pulses)

Scope Ch 3
      Ch 3 – Duty Cycle
        (3 On, 2 Off)

Scope Ch 4
      Ch 4 - Normal Mode

Mode

Digital Output Multiplexer

The outputs of each of the Channel Timers are routed to a set of multiplexers. This allows routing of a number (up to 5) Channel Timers to each of the output ports.

Channel Multiplexer Bit Assignments

Bit	4			3			2	1	0	
Model Number	12	24	36	6 / 12	24	36	all	all	all	
Output Channel 1	12			2			5	3	1	Bank A
Output Channel 2	12			2			6	4	2	
Output Channel 3	12			2			1	5	3	
Output Channel 4	12			2			2	6	4	
Output Channel 5	12			2			3	7	5	
Output Channel 6	12			2			4	2	6	
Output Channel 7	12			2			11	9	7	Bank B
Output Channel 8	12			2			12	10	8	
Output Channel 9	12			2			7	11	9	
Output Channel 10	12			2			8	12	10	
Output Channel 11	12			2			9	13	11	
Output Channel 12	12			2			10	8	12	
24 Channel Units										
Output Channel 13	12	24		2			17	15	13	Bank C
Output Channel 14	12	24		2			18	16	14	
Output Channel 15	12	24		2			13	17	15	
Output Channel 21	12	24		2			14	18	16	
Output Channel 22	12	24		2			15	13	17	
Output Channel 23	12	24		2			16	14	18	
Output Channel 24	12	24		2			23	21	19	Bank D
Output Channel 21	12	24		2			24	22	20	
Output Channel 21	12	24		2			19	23	21	
Output Channel 22	12	24		2			20	24	22	
Output Channel 23	12	24		2			21	19	23	
Output Channel 24	12	24		2			22	20	24	
36 Channel Units										
Output Channel 25	12	24	36	2			29	27	25	Bank E
Output Channel 26	12	24	36	2			30	28	26	
Output Channel 27	12	24	36	2			25	29	27	
Output Channel 33	12	24	36	2			26	30	28	
Output Channel 34	12	24	36	2			27	31	29	
Output Channel 35	12	24	36	2			28	26	30	
Output Channel 34	12	24	36	2			35	33	31	Bank F
Output Channel 35	12	24	36	2			36	34	32	
Output Channel 33	12	24	36	2			31	35	33	
Output Channel 34	12	24	36	2			32	36	34	
Output Channel 35	12	24	36	2			33	31	35	
Output Channel 36	12	24	36	2			34	32	36	

Command: **:PULSEn:MUX 0 to 31** *where 'n' is the channel number .*

The mux value (0 to 31) is determined by the enabled bits: bit 0 = 1, bit 1 = 2, bit 2 = 4, bit 3 = 8, bit 4 = 16

In the normal mode of operation bit 0 is the only bit enabled (bit pattern: 00001, command parameter 1), thus the output of the nth channel timer is routed to the nth output channel connector. Note that the channel routed to bit 3 (parameter = 8) is channel 2 for all outputs and the channel routed to bit 4 (parameter = 16), 12, 24 or 36, depends on the system channel size. Using the MUX function with the channel modes allows a number of complex functions, such as double pulsing, modulating pulsewidths as shown in the following examples:

Ex. 1: Double Pulse – A double pulse waveform can be generated, as shown in the figure, by using the MUX function to combine two channels.

Scope Ch 1: Channel 1 output after combining channel 1 and channel 3 (mux code: 3).

Scope Ch 2: Channel 1 output before combining channel 3 (mux code: 1).

Scope Ch 3: Channel 3 output delayed as necessary to generate the required second pulse (mux code: 1).
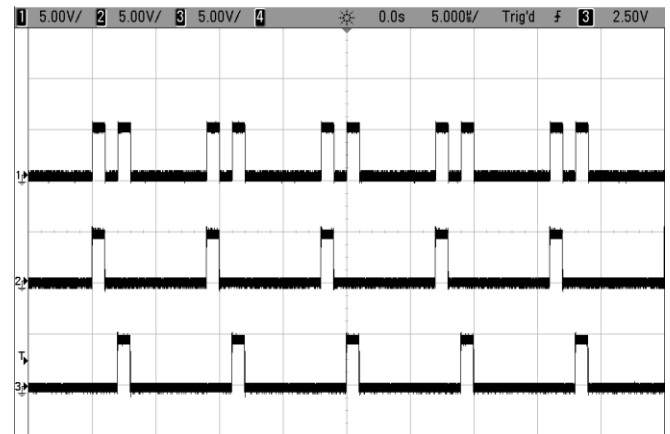
Ex. 2: Alternating Pulsewidth – An extended pulse can be generated every other pulse, as shown in the figure, by using the MUX function to combine two channels.

Scope Ch 1: Channel 2 output after combining channel 2 and channel 4 (mux code: 3).

Scope Ch 2: Channel 2 output before combining channel 4 (mux code: 1).

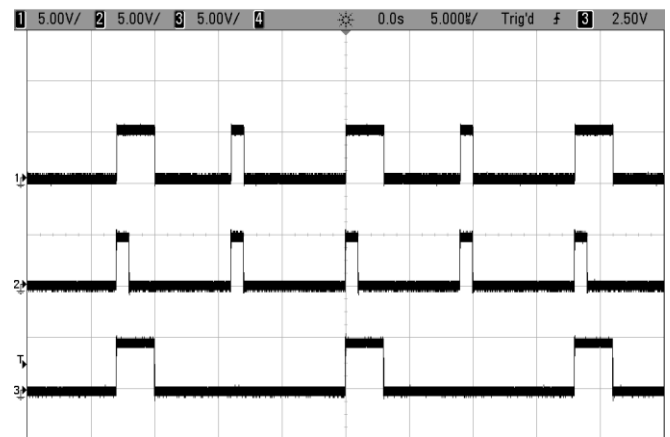Scope Ch 3: Channel 4 output extended as necessary to generate the required second pulse (mux code: 1). The channel is in duty cycle mode (1 on, 1 Off) to generate the alternating pattern.

Channel Gate Function

The outputs of each of the Channels can be gated by one of two channel timers as defined below:

Gate / Inhibit Function	6 / 12	24	36	12	24	36	12	24	36
MODEL #		GATE-A			GATE-B			INHIBIT-B	
6 / 12 Channel Units	4			12			12		
24 Channel Units	4			12	24		12	24	
36 Channel Units	4			12	24	36	12	24	36

Command: **:PULSEn:CONTROL GATA | GATB | INHB**

In the gated mode, output of the gated channels only occurs when the gate is high (active high mode). The gate A timer (4) is common to all channels. The gate B timer (12, 24 or 36) depends on the model, 6/12, 24 or 36 channels, respectively. In the inhibit mode, output of the gated channels is inhibited when the gate is high (active low mode).

Note: *Gate B and Inhibit B are not available in the 6-channel unit.*

Gate A Mode

Scope Ch 1
    Ch 1 – Normal Mode

Scope Ch 2
    Ch 2 – Gate A (GATA) Enabled

Scope Ch 3
    Ch 3 – Gate A (GATA) Enabled

Scope Ch 4
    Ch 4 - Normal Mode
        (extended delay & width)
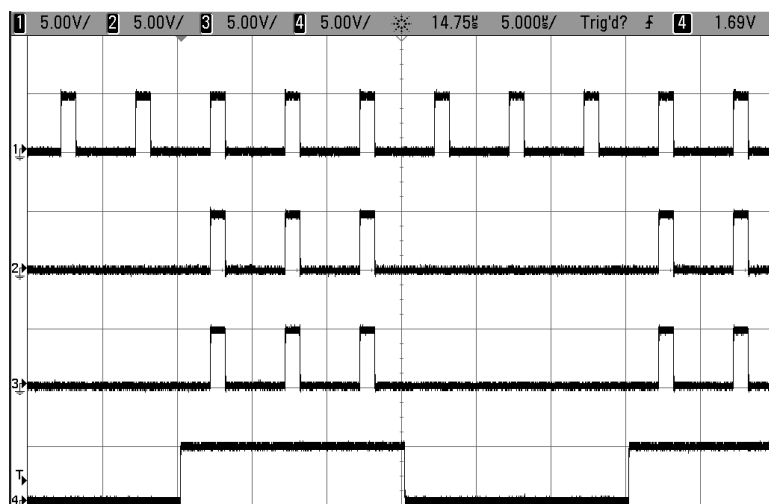
Gate B & INHIBIT B Mode

Scope Ch 1
    Ch 1 – Normal Mode

Scope Ch 2
    Ch 2 – Inhibit B (INHB) Enabled

Scope Ch 3
    Ch 3 – Gate B (GATB) Enabled

Scope Ch 4
    Ch 12 - Normal Mode
        (extended delay & width)
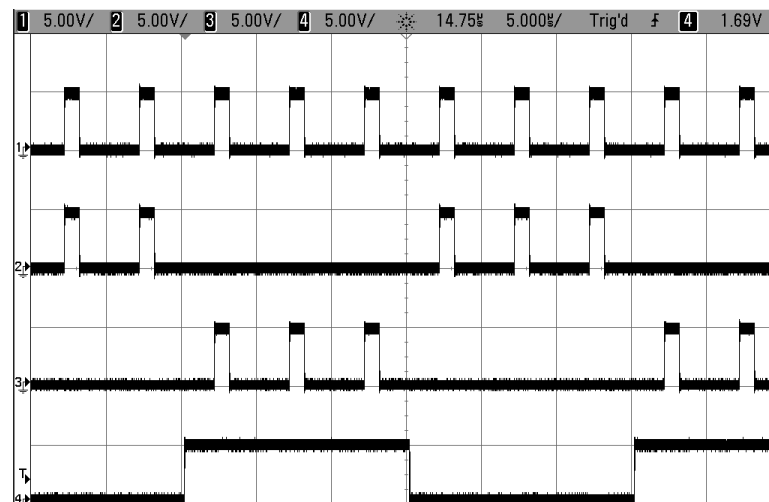
Channel Phase Locking

Normally when rearming a channel, the output will start on the next available T0 pulse. This leads to a random phase relationship with other channels that may be in duty cycle mode, as shown in column 1. The QC9550 channel sync feature can be used to lock the channel relative to the sync pulse, as shown in column 2. Note that when sync is enabled, the Ch3 burst is always locked to start of Ch2 output.

Channel Sync Function	6 / 12	24	36	12	24	36	6 / 12	24	36
MODEL #		SYNC-A			SYNC-B			SYNC-T	
6 / 12 Channel Units	6			12					
24 Channel Units		6		12	24			trigger sync	
36 Channel Units		6		12	24	36			

Command::PULSEn:SYNC SYNA | SYNB | SYNT

Column 1 – Sync Mode Disabled   ## Column 2 – Sync Mode Enabled
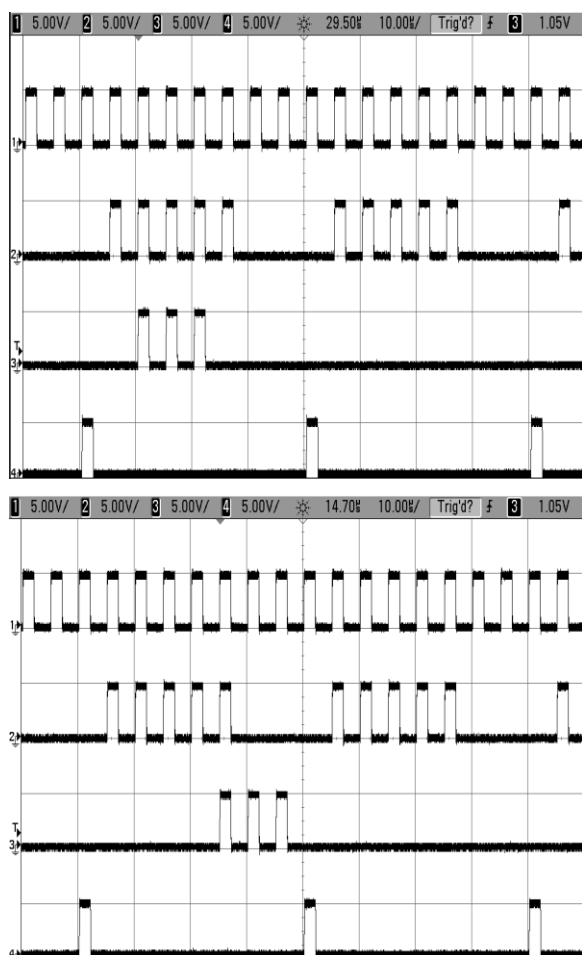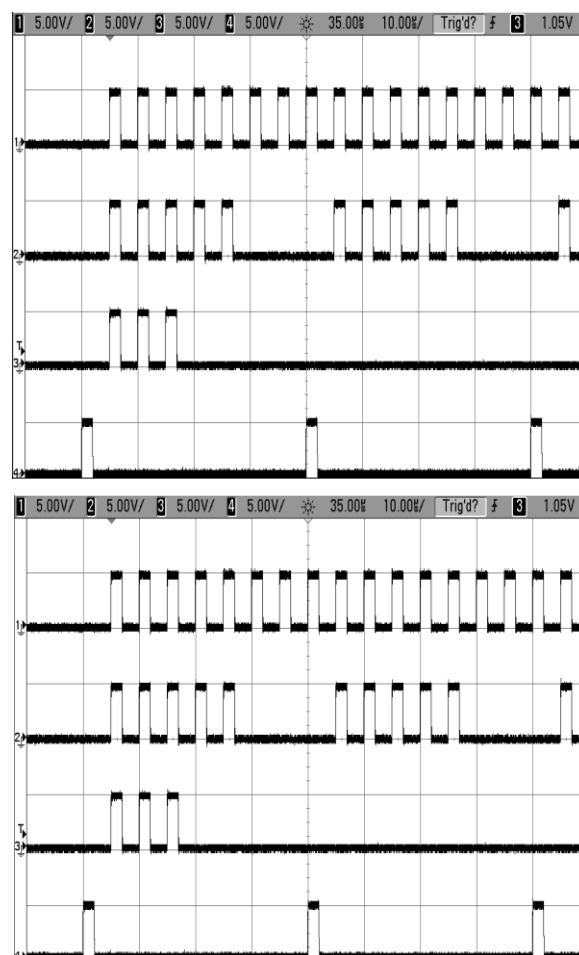
Scope Ch1 – channel 1 - normal mode, wait = 1
Scope Ch2 – channel 2 - duty cycle mode (5 on, 3 off), wait = 1
Scope Ch3 – channel 3 - burst mode (3 pulses), wait = 0
Scope Ch4 – channel 6 - (sync pulse) duty cycle mode (1 on, 7 off), wait = 0.

Operating the 9550/8550

The 9550/8550 has a powerful set of functions providing a number of modes of operation. Both the system timer and the channel timer combine to provide the ability to generate complex waveforms. Configuring the system is done via the QC GUI or using the computer interface command set. The available computer interfaces include a USB port, RS232 port and optional Ethernet port.

Quick Start - Normal Internal Rate Generator Operation

The 9550/8550 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:

T_0 Period	Set the Rate using either the supplied GUI or using the command set on one of the computer interfaces. The system mode should be in Continuous Mode.
Pulse Width and Delay	Set the required pulse width and delay using either the supplied GUI or using the command set on one of the computer interfaces. Enable or Disable the channel as required. The mode will be "normal". Repeat for each output channel.

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 to avoid dropped pulses.

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	Set the System Mode using either the supplied GUI or using the command set on one of the computer interfaces. Select Single Shot mode.
Trigger	Set the Trigger using either the supplied GUI or using the command set on one of the computer interfaces. Select Trigger Enable
Level	Set the Level parameter using either the supplied GUI or using the command set on one of the computer interfaces. Set the trigger threshold voltage to approximately 50% of the trigger signal amplitude.

Note: If the threshold is not set correctly the 9550 will have trouble syncing with the trigger source.

Edge	Set the Edge parameter using either the supplied GUI or using the command set on one of the computer interfaces. Set the unit to trigger off the rising or falling edge as desired.
Pulse Width and Delay	Set the required pulse width and delay using either the supplied GUI or using the command set on one of the computer interfaces. Repeat for each output channel.
Start	Press the Run/Stop key to start generating pulses or use either the supplied GUI or use the command set on one of the computer interfaces.
Stop	Press the Run/Stop key a second time, or use either the supplied GUI or use the command set on one of the computer interfaces, to stop generating pulses.

System Timer Overview

For internal operation, the 9550/8550 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 system Period parameter. This corresponds to the normal output mode for most pulse generators. To generate a continuous stream of pulses:

- System Mode: Continuous mode
- System Period: 10µs

Pressing the front panel Run/Stop key or entering the system State command will now generate a stream of pulses at a rate specified by the period parameter.

Scope Ch 1: Channel 1 set to normal mode.
Scope Ch 2: Channel 2 set to normal mode
Scope Ch 3: Channel 3 set to normal mode
Scope Ch 4: Channel 4 set to normal mode
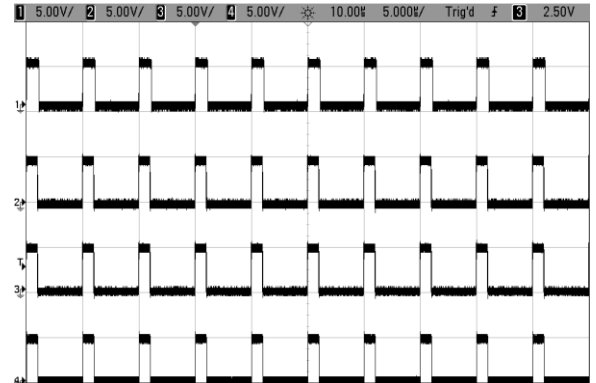
Using Single Shot Mode

To generate a single pulse with every press of the Run/Stop key or the State enable command:

- System Mode: Single Shot mode

Pressing the front panel Run/Stop key or entering the system State command will now generate one pulse.

Scope Ch 1: Channel 1 set to normal mode.
Scope Ch 2: Channel 2 set to normal mode
Scope Ch 3: Channel 3 set to normal mode
Scope Ch 4: Channel 4 set to normal mode
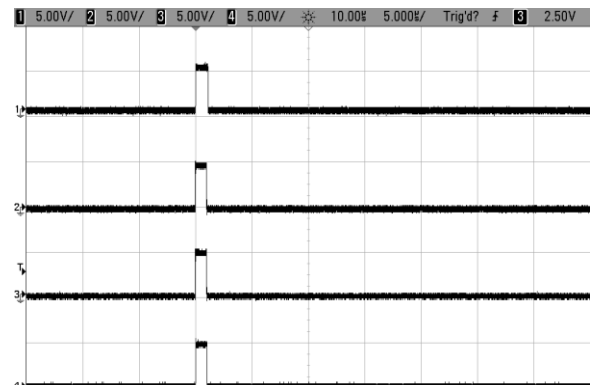
Using System Burst Mode Function

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:

- System Mode: Burst mode
- Burst Count: 5
- System Period: 10µs

Pressing the front panel Run/Stop key or entering the system State command will now generate a burst of the specified number of pulses.

Scope Ch 1: Channel 1 set to normal mode.
Scope Ch 2: Channel 2 set to normal mode
Scope Ch 3: Channel 3 set to normal mode
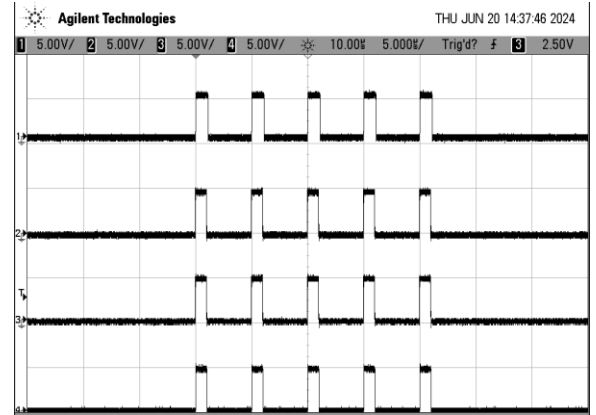Scope Ch 4: Channel 4 set to normal mode

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:

- System Mode: Duty Cycle mode
- On Count: 3
- Off Count: 1
- System Period: 10µs

Pressing the front panel Run/Stop key or entering the system State command will now generate a continuous stream of pulses in bursts as defined by the on/off parameters.
Scope Ch 1: Channel 1 set to normal mode.
Scope Ch 2: Channel 2 set to normal mode
Scope Ch 3: Channel 3 set to normal mode
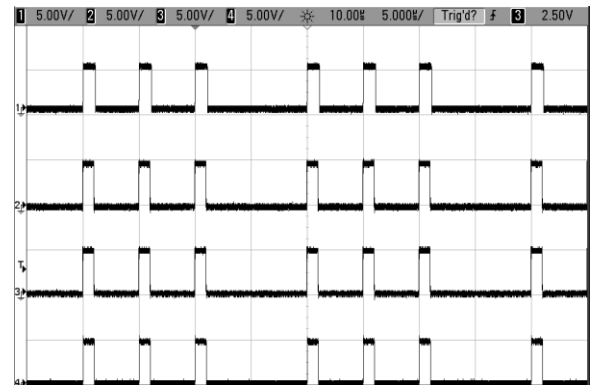Scope Ch 4: Channel 4 set to normal mode

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.
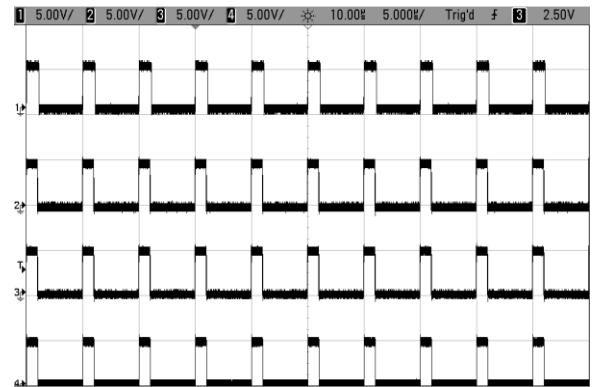
Using Channel Normal Function

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

- System Mode: Continuous mode
- System Period: 10µs

- Set the Channel parameters:
  - Enable the channel output
  - Set the delay desired.
  - Set the pulse width desired.

Pressing the front panel Run/Stop key or entering the system State command will now generate a stream of T_0 pulses at a rate specified by the system period parameter.

> Scope Ch 1: Channel 1 set to normal mode.
> Scope Ch 2: Channel 2 set to normal mode
> Scope Ch 3: Channel 3 set to normal mode
> Scope Ch 4: Channel 4 set to normal mode

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:

- System Mode: Continuous mode
- System Period: 10µs

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

Pressing the front panel Run/Stop key or entering the system State command will now generate one pulse on hannel 1. Other channels can continue to generate pulses depending on the System Mode and/or the channel modes.

> Scope Ch 1: Channel 1 set to single shot mode.
> Scope Ch 2: Channel 2 set to normal mode
> Scope Ch 3: Channel 3 set to normal mode
> Scope Ch 4: Channel 4 set to normal mode
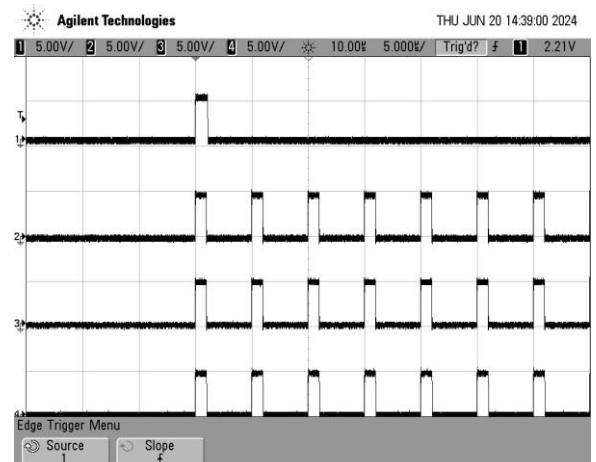
Using the Channel Burst Mode

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

- Set the Channel parameters:
    - 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 in the burst.

Pressing the front panel Run/Stop key or entering the system State command will now generate a burst of pulses. Other channels can continue to generate pulses depending on the System Mode and/or the channel modes.

Scope Ch 1: Channel 1 set to single shot mode.
Scope Ch 2: Channel 2 set to burst (5) mode
Scope Ch 3: Channel 3 set to normal mode
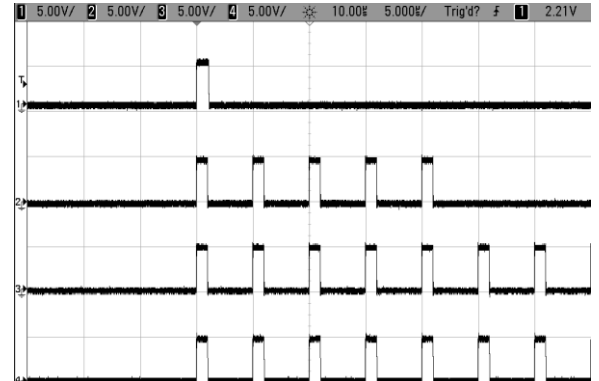Scope Ch 4: Channel 4 set to normal mode

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 required sequence of pulses set:

- Set the Channel parameters:
    - 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').

Pressing the front panel Run/Stop key or entering the system State command will now generate a continuous series of 'N' pulses followed by 'M' suppressed pulses. Other channels can continue to generate pulses depending on the System Mode and/or the channel modes.

Scope Ch 1: Channel 1 set to single shot mode.
Scope Ch 2: Channel 2 set to burst (5) mode
Scope Ch 3: Channel 3 set to duty cycle (3 on, 1 off)
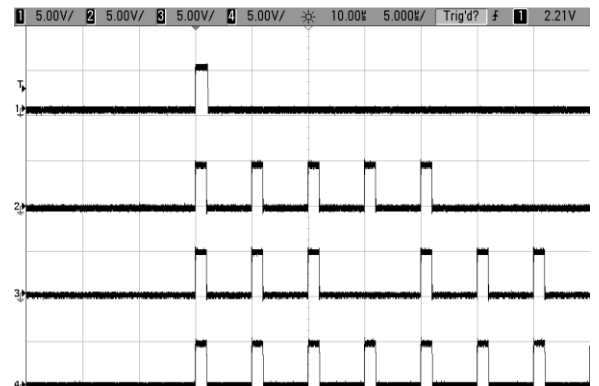Scope Ch 4: Channel 4 set to normal mode

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 as 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. Rear panel contains a trigger input and a gate input. The front panel contains an input that can be used as either a trigger input or a gate input. The trigger input can be either a 2.0v to 30v pulse or a switch closure (foot switch).

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:

- Set the Gate parameters:
  - Choose either Pulse or Output Inhibit.
    - Pulse inhibit will inhibit pulses without truncating the last pulse.
    - Output inhibit will suppress the pulse immediately, potentially truncating the pulse.
  - Set the threshold level to ~50% of the incoming gate signal.
  - Choose either active High or Low.

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:

- Set the Gate parameter:
  - Set the mode to Chan Mode.
- Set the Advanced Channel parameters:
  - 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 immediately stop.

Generate a Pulse on Every Trigger Input

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

- Set the System Mode to Single Shot mode.
- Set the Trigger parameters:
  - 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:

- Set the System parameters:
    - Set the mode to Burst.
    - Set the number of pulses that is desired for each input signal.
    - Set the period desired between pulses.
- Set the Trigger parameters:
    - Set 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:

- Set the System Mode to Continuous mode.
- Set the Trigger parameters:
    - Set the Trigger 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.

5. 9550/8550 Application

Aside from using the SCPI command protocol, the included software application is the primary means of communication with the 9550/8550. This application allows simple control of the 9550/8550 unit via the USB or RS232 communications port. To run the software, simply double click on the application which can be found on the included USB drive. No installation is required. The software can also be copied to your computer and run from any location. The screenshot shows the 9550/8550 application and all of the corresponding default parameters:

Quantum Composers Model 9550-24 SW Version: 0.0.1.20 ComPort: 4 Baud: 115200

File   Storage   Tools   Help

Quantum®
C O M P O S E R S

Run

System Options | External Trig/Gate | Additional Options

System

Pulse Mode
Continuous

Period
0.000,010,000

Burst Count
10

Duty Cycle
On Counts
4

Off Counts
2

Cycle Counts
0

Sync Ouput
T0

☐ Auto Start

Channels

| Ch 1 | Ch 2 | Ch 3 | Ch 4 | Ch 5 | Ch 6 | Ch 7 | Ch 8 | Ch 9 | Ch 10 | Ch 11 | Ch 12 |
| Ch 13 | Ch 14 | Ch 15 | Ch 16 | Ch 17 | Ch 18 | Ch 19 | Ch 20 | Ch 21 | Ch 22 | Ch 23 | Ch 24 |

☑ Enabled

Delay
0.000,000,000,000

Channel Mode
Normal

Sync Source
Disabled

Duty Cycle On
3

Gate Mode
Disabled

Width
0.000,002,000,000

Burst Count
5

Polarity
Normal

Duty Cycle Off
1

Gate Logic
Active Low

Output Mode
TTL/CMOS

Amplitude (V)
5.00

Wait Count
0

Channel Control
Disabled

Multiplexer
☑ 0   ☐ 1   ☐ 2   ☐ 3   ☐ 4

Command Terminal

Send

System Information
Serial Number: 1
Firmware Ver: 9.0.7.0
FPGA Ver: 8.0.4.5

Figure 4 Software Application Window

6. Programming the 9550/8550

Personal Computer to Pulse Generator Communication

The 9550/8550 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 9550/8550, many of the commands are not included in the SCPI 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. All commands return a response and best practices require software to wait until the response from the previous command is received before sending the next command. This will provide fast, reliable communication with the system.

RS-232 Interface Overview

The serial port is located on the back of the 9550 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 9550. 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 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 9550. 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 9550/8550 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)
:TRIG:STATE 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
:TRIG:STATE ENAB <cr> <lf>	sets system to external trigger
:TRIG:LEV 2.5 <cr> <lf>	sets trigger level to 2.5 volts
: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

9550/8550 SCPI Command Summary

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:

:INSTrument				Submenu: Misc. system commands.
	:COMMands		?	Returns an indentured list of all valid SCPI commands
	:NSELect		0 - n	Selects a channel using the numeric value, where 'n' is the channel number.
	:STATe		0/1 or OFF/ON	Enables/Disables the system. This is the same as pressing the RUN button.

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:SPULse :PULSe0				Submenu: Commands to change the system timer settings, this is the same as using the :PULse0.
	: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 100µs is desired the parameter sent should be 0.0001 or using exponential notation i.e. 100e-6.
	:MODe		NORMal / SINGle/ BURSt / DCYCle	Changes the system output mode.
	:BCOunter		1 - 4,000,000,000	Changes the number of pulses to output when the system is in burst mode. *Note: Do not include commas.*
	:PCOunter		1 - 4,000,000,000	Changes the number of on pulses to output when the system is in Duty Cycle mode. *Note: Do not include commas.*
	:OCOunter		1 - 4,000,000,000	Changes the number of off pulses to suppress when the system is in Duty Cycle mode. *Note: Do not include commas.*
	:CYCLe		0 - 10,000,000	Changes the number of cycles to output when the system is in Duty Cycle mode, 0 = continuous cycles. *Note: Do not include commas.*

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:TRIGger[1/2]				Submenu: Commands to change the system trigger functions. Trig1 is the rear panel trigger input and Trig2 is the front panel input.
	:MODe		DISable / TRIGger	Enables 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)
	: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.
	:DEBounce		ENABle / DISable	Enables / disables the circuit. Note: *This will increase the insertion delay and jitter.*

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:GATe[1/2]				Submenu: Commands to change the system gate functions. Gate1 is the rear panel gate input and Gate2 is the front panel input.
	:MODe		DISabled / PULSe / OUTPut / CHANnel	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)
	:LEVel		.20 – 15[V]	Choose the gate level threshold to trigger on, this should be set to ~ 50% of the input potential
	:DEBounce		ENABle / DISable	Enables / disables the circuit. Note: *This will increase the insertion delay and jitter.*

:COUNter				
	:STATe		0/1 or OFF/ON	Enables / disables the counter.
	:CLear		1	Clears the counter. Should be done before starting a count.
	:SELect		To / CH1 / CH2 / CH4 / CH6	Selects channel to count.
	:PULSes		?	Returns the current count.

Keyword:	Command:	Sub-Command:	Parameter Range:	Notes:
:PULSe[1/2/n]				Submenu: Commands to change the channel settings. 'n' is the channel number.
	:STATe		0/1 or OFF/ON	Enables/Disables output pulse for selected channel.
	:DELay		0[s] to 2000[s]	Sets the delay for the selected channel. The command should be sent without units. If for example 25µs is desired the parameter sent should be 0.000025 or using exponential notation i.e. 25e-6.
	:WIDTh		10[ns] – 2000[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 0.00000050 or using exponential notation i.e. 50e-9.
	:MODe		NORMal / SINGle / BURSt / DCYCle	Allows the user to select the pattern of outputs to use on the channel level.
	:BCOunter		1 to 10,000,000	In Burst mode allows user to select the number of pulses to output with each input clock pulse. *Note: Do not include commas.*
	:PCOunter		1 to 10,000,000	In duty cycle mode allows the user to select the number of pulses to create with each input clock pulse. *Note: Do not include commas.*
	:OCOunter		1 to 10,000,000	In duty cycle mode allows the user to select the number of pulses to suppress with each input clock pulse. *Note: Do not include commas.*
	:WCOunter		0 to 10,000,000	Allows the user to select how many To pulses to wait until the channel should start creating a output pulses. *Note: Do not include commas.*
	:OUTPut			Submenu: Commands to change the channels' output parameters.
		:MODe	TTL / ADJustable	Allows the user to select either TTL logic mode or Adjustable voltage output mode.
		:POLarity	NORMal / COMPlement / INVerted	Normal is active HIGH, Inverted and Complement are active LOW.
		:AMPLitude	2.0 to 20[V]	Allows the user to select the voltage potential for Adjustable output mode.
	:MUX		0 to 31	
	:CONTrol		DISable / GATA / GATB / INHB	Enables gate / inhibit function: GATA (ch2) as a global gate. GATB (ch12, 24 or 36) as a bank gate. INHB (ch12, 24 or 36) as a bank inhibit. *Note: GATB and INHB are not available on the 6-channel unit.*
	:SYNC		DISabled / SYNA / SYNB / SYNT	Enables sync function. SYNA (ch6) as a global sync. SYNB (ch12, 24, or 36) as a bank sync. SYNT (trig) as a global sync *Note: SYNB is not available on the 6-channel unit.*
	:CGATe		DISabled / PULSe /	Sets the channel gate mode to Disabled,

				OUTPut	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					Submenu: Commands to change general system settings.
	:STATe			0 / 1 or OFF / ON	Enables/Disables the output for all channels. This command is the same as pressing the Run/Stop button.
	:SYNC			T0 / Ch1 / Ch2 / Ch4 Ch 6 / TRIG / GATE	Selects front panel sync output.
	:ICLOCK			INT / 10 / 20 / 25 / 30 40 / 50 / 60 / 80	Changes the source of the system clock. INT is internal 'n' is the input frequency in MHz
	:OCLOCK			T0 / 10 / 20 / 25 / 30 40 / 50 / 60 / 80	Allows the user to select the clock source to output: When ICLock is INT: T0 is the system sync pulse. 'n' is the input frequency in MHz
	:BEEPer				Submenu: Commands 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				Submenu: Command to set the communication settings.
		: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.
		: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.
		:DPM		COMMA, PERIOD	Selects the decimal mark either a comma or a period
	: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.

IEEE 488.2 Common Commands

Command:	Parameter Range:	Notes:
System Commands		
*BEP	1 to 1000 1 to 100	Generates a beep, first parameter is the volume, second parameter is the number of beeps to produce.
*LOG	0 to 100	Controls the brightness of the front panel logo.
*CAT	?	Query only. Generates an indentured list of all SCPI commands.
*ERS		Resets the ethernet port.
*IDN	?	Query only. Returns model, serial number, firmware version, and FPGA version numbers.
Storage Commands		
*LBL	?	Used to query the label of the last saved or recalled configuration.
*LBL	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.*
*RCL	0 - n	Recall the saved configuration. 'n' depends on the model (6/12 channel units n = 12, 24 channel unit n = 24, 36 channel units n = 36. *RCL 0 loads the system default values.
*SAV	1 - n	Save a configuration. 'n' depends on the model (6/12 channel units n = 12, 24 channel unit n = 24, 36 channel units n = 36.
*RST		Resets the unit to the default values. This is the same as *RCL 0
*PUP	0 - n	PowerUP configuration - Sets the configuration to be loaded on power up. 0 = The configuration that was stored on power down. n = The configuration #
Quick Setup Commands		
*CFG	0 [p1] [p2] …	Provides a more efficient way of loading parameters. *CFG 0 loads the system timer parameters. See description below.
*CFG	n [p1] [p2] … where 'n' is the ch#	Provides a more efficient way of loading parameters. *CFG n, where 'n' is the channel number, loads the channel parameters. See description below.
*CFG	90	Provides a more efficient way of loading parameters. *CFG 90 loads the trigger 1 parameters for the rear trigger input. See description below.
*CFG	91	Provides a more efficient way of loading parameters. *CFG 91 loads the trigger 2 parameters for the front panel input. See description below.
*CFG	92	Provides a more efficient way of loading parameters. *CFG 92 loads the gate 1 parameters for the rear panel gate input. See description below.
*CFG	93	Provides a more efficient way of loading parameters. *CFG 93 loads the gate 2 parameters for the front panel input. See description below.
Trigger Commands		
*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).*
*GTE		Creates a soft trigger for the gate input.
*TRG		Creates a soft trigger for the trigger input.
Counter Commands		
*CTR	0 to 5, 10	n = 0 disables the counter. n > 0 selects a channel, clears the counter & enables counter. n=1 -> T0, n=2 -> Ch1, n=3 -> Ch6, n=4 -> Ch8, n=5 -> Ch10 n=10 renables counter without clearing. Uses current channel for source. *CTR? returns the current counter value.

Config Command (*CFG)

*CFG ch# [parameter 1] [parameter 2] [parameter 3] … [parameter n]

ch# = channel number, 0 = System parameters, 9x = Trigger / Gate parameters

The parameter list (partial list) is terminated by a line feed or a carriage return.

Quick Configuration Commands

System Parameters (*CFG 0)

PARAMETER#	COMMAND	TYPE	RANGE
	SPULse	Subsystem (24)	
1	STATe	Boolean	0 1
2	PERiod	Double	0.000000050 to 5000.000000000
3	MODe	List	CONTinuous SINGle BURSt DCYLe
4	BCOunter	Integer	1 to 4000000000
5	PCOunter	Integer	1 to 4000000000
6	OCOunter	Integer	1 to 4000000000
7	CYCLe	Integer	1 to 10000000

Channel Parameters (*CFG n) (n = 1 to the # of channels)

PARAMETER#	COMMAND	TYPE	RANGE
	PULSe[n]	SubSystem# (12)	
1	STATe	Boolean	0 1
2	DELay	Double	0.00000000000 to 2000.00000000000
3	WIDTh	Double	0.00000001000 to 2000.00000000000
4	CMODe	List	NORMal SINGle BURSt DCYCle
5	BCOunter	Integer	1 to 10000000
6	PCOunter	Integer	1 to 10000000
7	OCOunter	Integer	1 to 10000000
8	WCOunter	Integer	1 to 10000000
	OUTPut	Subsystem	
9	MODe	List	TTL ADJustable
10	POLarity	List	NORMal COMPlement INVerted
11	AMPLitude	Single	2.00 TO 20.00
12	MUX	Integer	0 to 31
13	CONTrol	List	DISable GATA GATB INHB
14	SYNC	List	DISable SYNA SYNB SYNT
15	CGATe	List	DISable PULSe OUTPut
16	CLOGic	List	HIGH LOW

Trigger Parameters (*CFG 90) (rear panel trigger input)   (*CFG 91) (front panel input)

PARAMETER#	COMMAND	TYPE	RANGE
	TRIGger	Subsystem	
1	STATe	List	DISable TRIGger
2	EDGe	List	RISing FALLing
3	LEVel	Single	0.20 to 15.00
4	DEBounce	List	DISable ENABle

Gate Parameters (*CFG 92) (rear panel gate input)   (*CFG 93) (front panel input)

PARAMETER#	COMMAND	TYPE	RANGE
	GATe	Subsystem	
1	STATe	List	DISable ENABle PULSeinh OUTPutinh CHPUlseinh CHOUtputinh
2	LOGic	List	LOW HIGH
3	LEVel	Single	0.20 to 15.00
4	DEBounce	List	DISable ENABle

Figure 5 Quick Configuration Commands

7. Appendix A – Specifications

9550/8550 Specifications

INTERNAL RATE GENERATOR

RATE (T_0 period)	50 ns to 5,000 s (0.0002 Hz to 20 MHz)
RESOLUTION	5 ns
ACCURACY	1 ns + .0001 x period
JITTER	< 50 ps RMS
SETTLING	1 period
BURST MODE COUNTER	1 to 4,000,000,000 pulses
DUTY CYCLE MODE COUNTERS	1 to 4,000,000,000 pulses
CYCLE COUNTER	1 to 10,000,000 cycles
TIMEBASE	200 MHz, low jitter PLL
OSCILLATOR	50 MHz, 25 ppm
SYSTEM OUTPUT MODES	Single pulse, burst, duty cycle, external gate/trigger
PULSE CONTROL MODES	Internal rate generator, external trigger/gate

CHANNEL 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.
BURST MODE COUNTER	1 to 10,000,000 pulses
DUTY CYCLE MODE COUNTERS	1 to 10,000,000 pulses
WAIT FUNCTION COUNTER	0 to 10,000,000 pulses
OUTPUT MULTIPLEXER	Up to five (5) channel timers may be routed to each output channel.
TIMEBASE	Same as internal rate generator

DELAYS

DELAY RANGE	0 - 2,000 s
WIDTH RANGE	10 ns – 2,000 s
ACCURACY	1 ns + 0.0001 x Delay
RESOLUTION	250 ps
PULSE INHIBIT DELAY	< 120 ns typical
OUTPUT INHIBIT DELAY	< 50 ns typical

OUTPUT 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 kohm
                             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 @ 20 V (high imp)
                             25 ns typ @ 10 V (50 ohms)
                             (10% - 90%)
    SLEW RATE   >0.1 V/ns
    OVERSHOOT   <100 mV + 10% of pulse amplitude

SYSTEM EXTERNAL TRIGGER/GATE INPUT(S)

TRIGGER INPUT
TYPE	Pulse 0.5 to 30 V.
FUNCTION	Generate individual pulses, start a burst or continuous
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
CHANNEL BEHAVIOR	Global w/Individual Channel Control

TRIGGER/GATE DUAL INPUT MODULE (Standard)
Standard dual channel input module, providing one trigger input, one gate input and one dual purpose input on the front panel.

THRESHOLD	0.2 to 15 VDC
MAXIMUM INPUT VOLT.	30 V Peak
IMPEDANCE	5.3 kohm + 10 pF
RESOLUTION	10 mV

TRIGGER INPUT
SLOPE	Rising or Falling
JITTER	800 ps RMS
INSERTION DELAY	<160 ns
MINIMUM PULSE WIDTH	10 ns

GATE INPUT
PULSE INHIBIT DELAY	<160 ns
OUTPUT INHIBIT DELAY	<160 ns

STANDARD FEATURES

COMMUNICATIONS	USB / RS232 / Ethernet
EXTERNAL CLOCK IN	10 MHz, 20 MHz, 25 MHz, 30 MHz, 40 MHz, 50 MHz, 60 MHz, 80 MHz
EXTERNAL CLOCK OUT	T_0, 10 MHz, 20 MHz, 25 MHz, 30 MHz, 40 MHz, 50 MHz, 60 MHz, 80 MHz, 100 MHz

GENERAL

STORAGE	6/12 ch = 12 storage bins
	24 ch = 24 storage bins
	36 ch = 36 storage bins
DIMENSIONS	19" x 10" x 1.75" 6/12 ch (standard 1U rack mount)
	19" x 10" x 3.50" 24/36 ch (standard 2U rack mount)
WEIGHT	8 lbs
POWER	100 - 240 VAC
	50/60 Hz <3 A
FUSE	(Qty 2) 630 mA, 250 V Time-lag

9550 Mechanical Dimensions
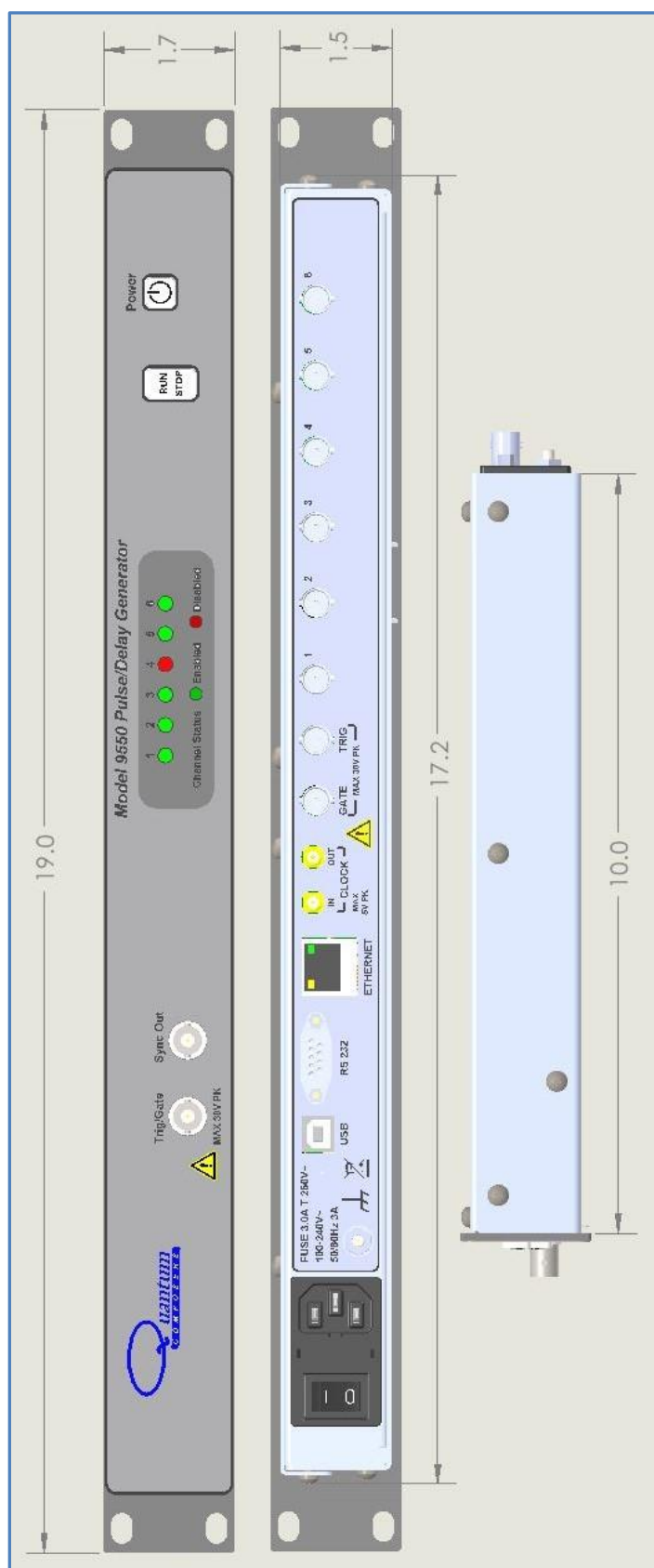
Figure 6 9550 6 Channel Dimensions
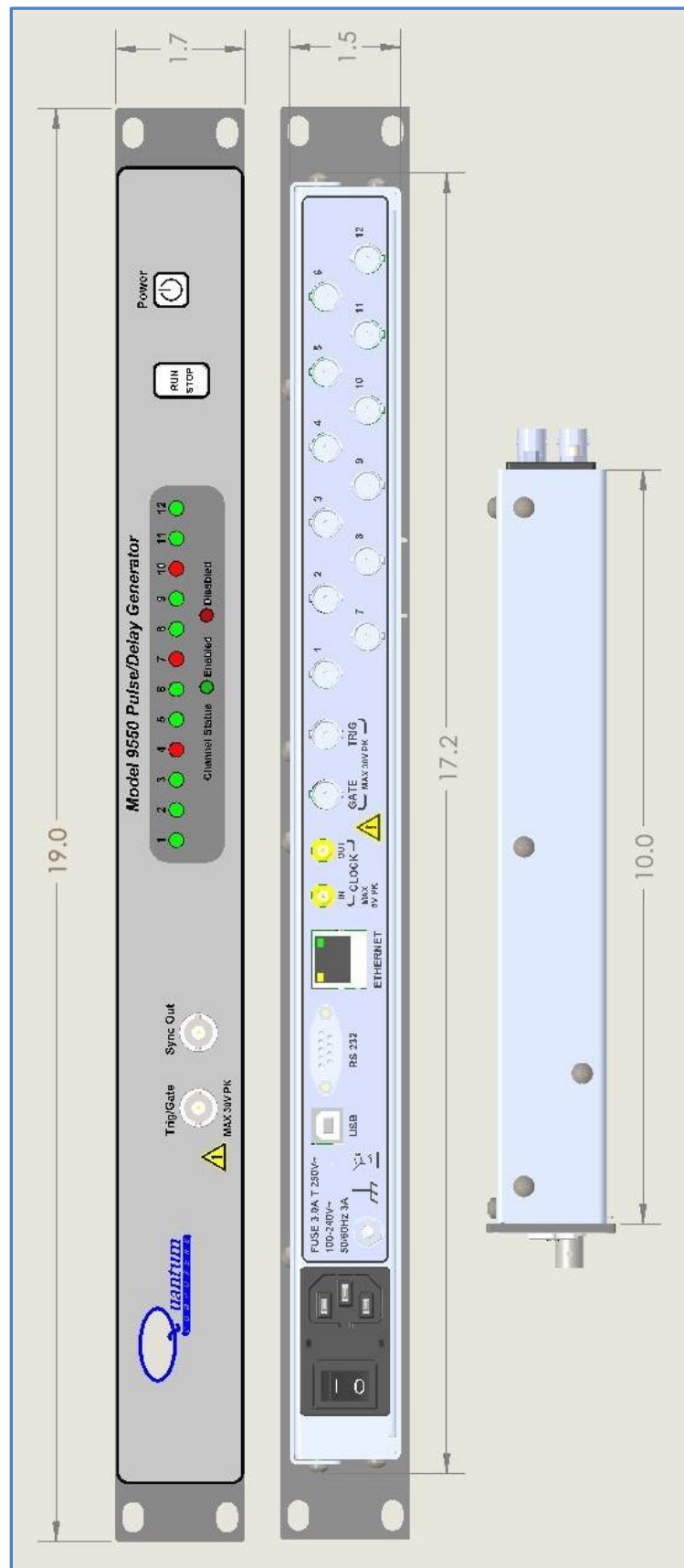
Figure 7 9550 12 Channel Dimensions
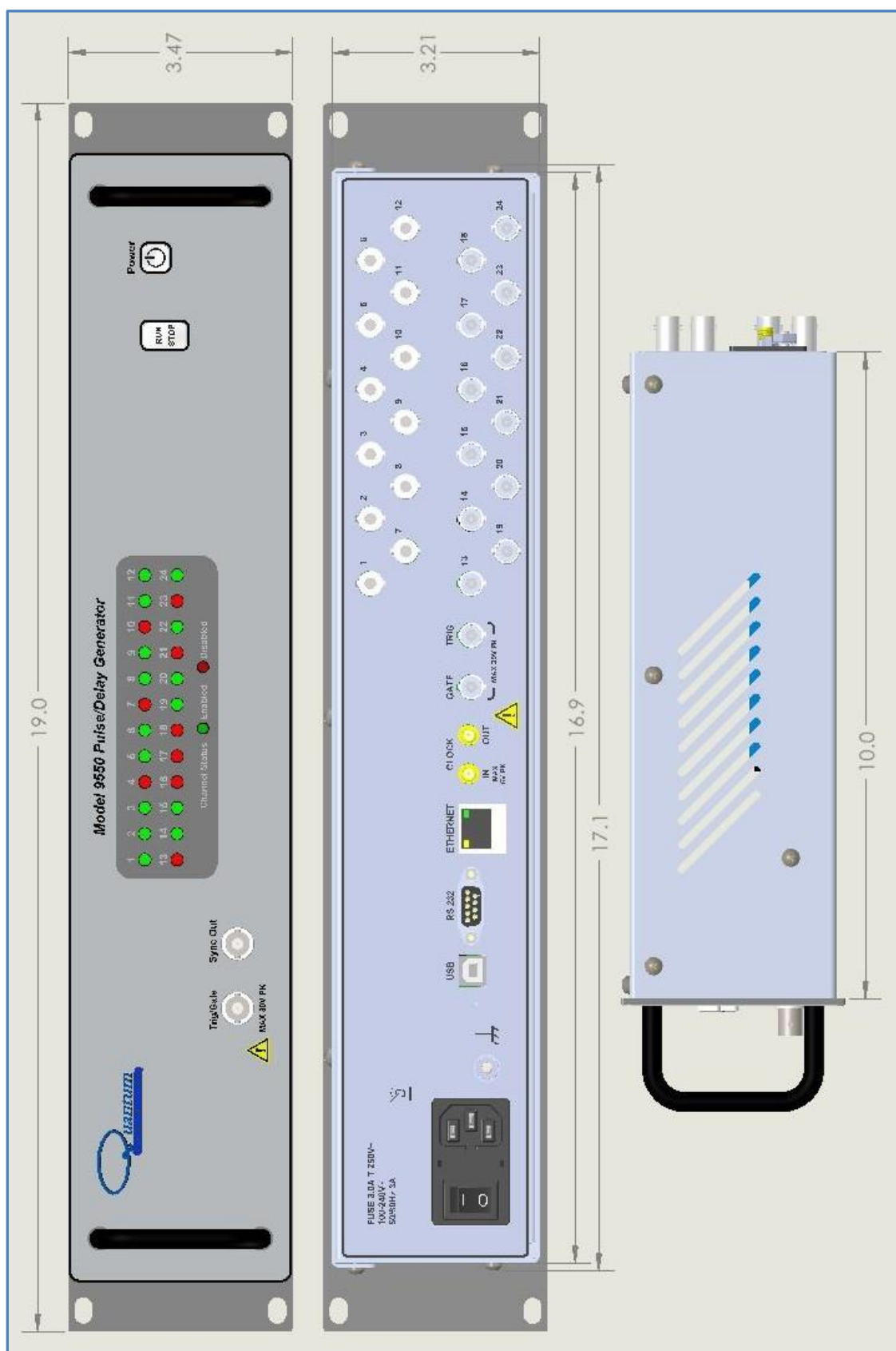
Figure 8 9550 24 Channel Dimensions
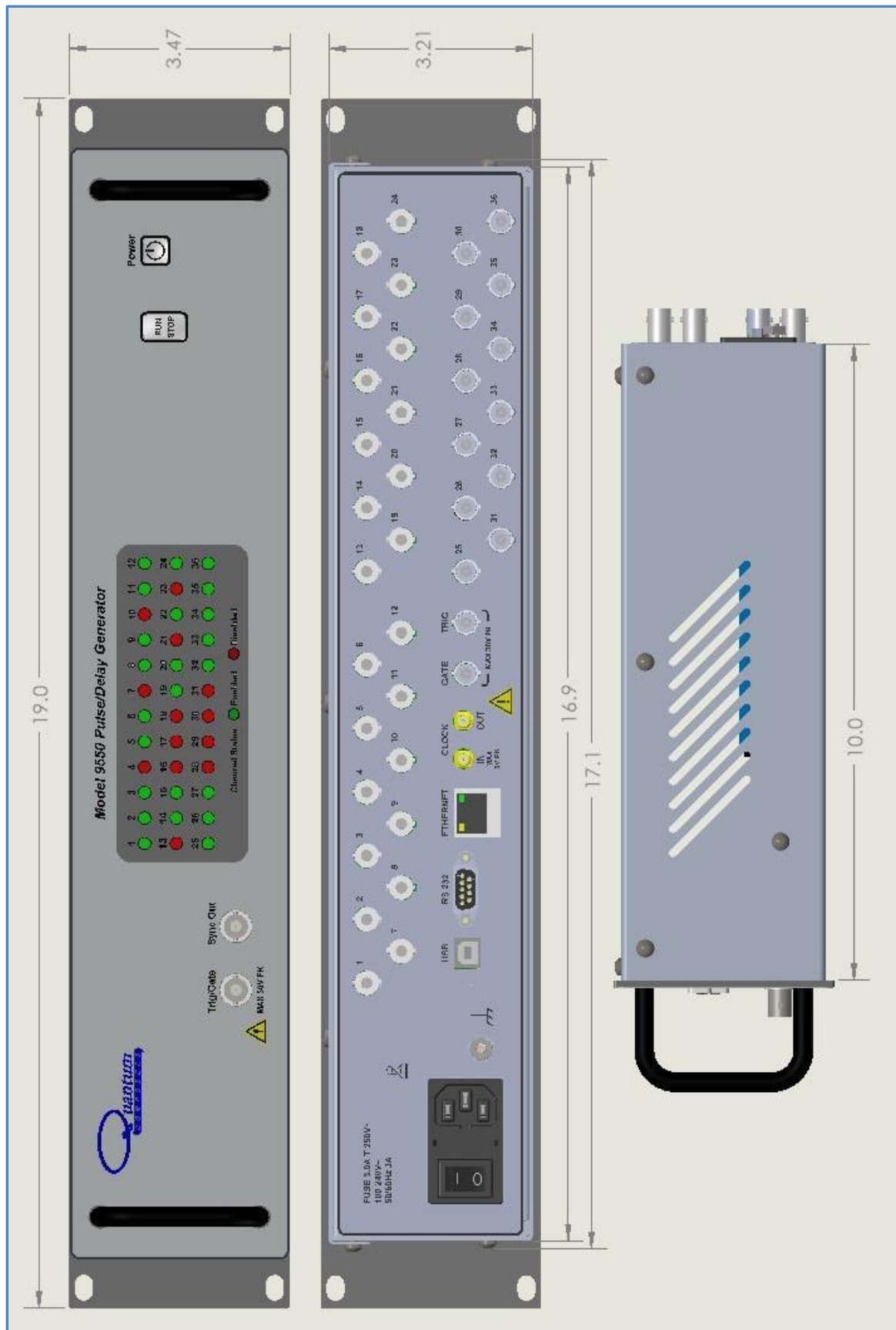
Figure 9 9550 36 Channel Dimensions

8. 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
3∿	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**

9. Appendix D - Ethernet Connectivity

The Ethernet module used in Quantum Composers' pulse and current 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/USB 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.

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 10** (Digi Device Discovery utility displaying Digi module discovered on the LAN)).
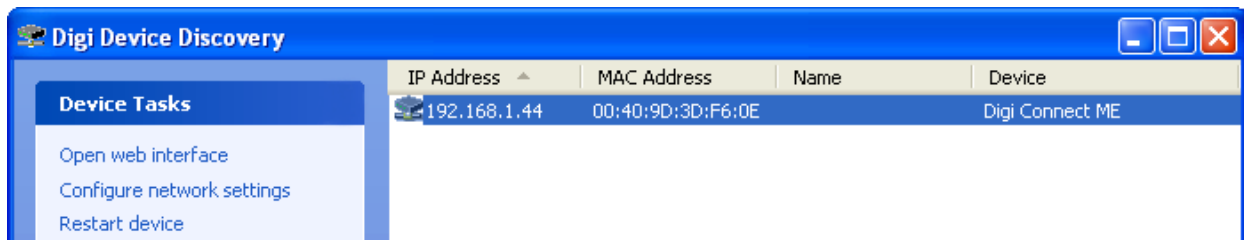
Figure 10 (Digi Device Discovery utility displaying Digi module discovered on the LAN)

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 a username and password. Units built after January 2021 will have a unique password for each unit. The password can be found on the paperwork shipped with the device and there will also be a label on the device indicating the password.

- Username: "root"
- Password: <unit specific>

The Digi Connect ME Configuration and Management home page will be displayed (**Figure 11** (Configuration Home page)).
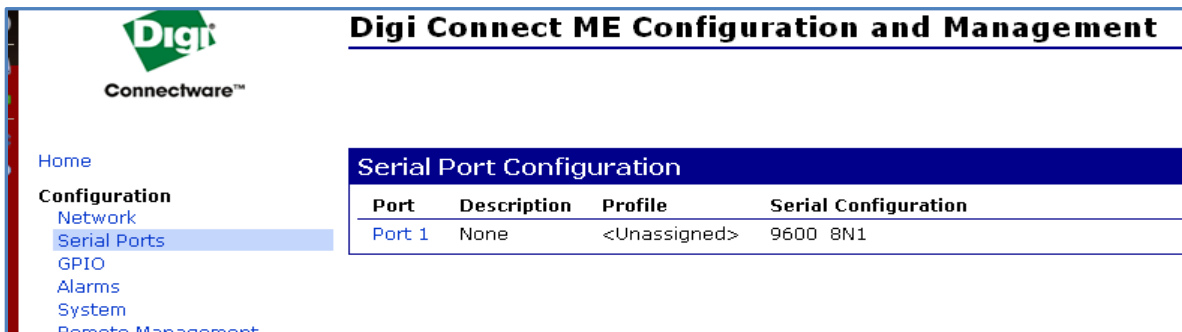
Figure 11 (Configuration Home page)
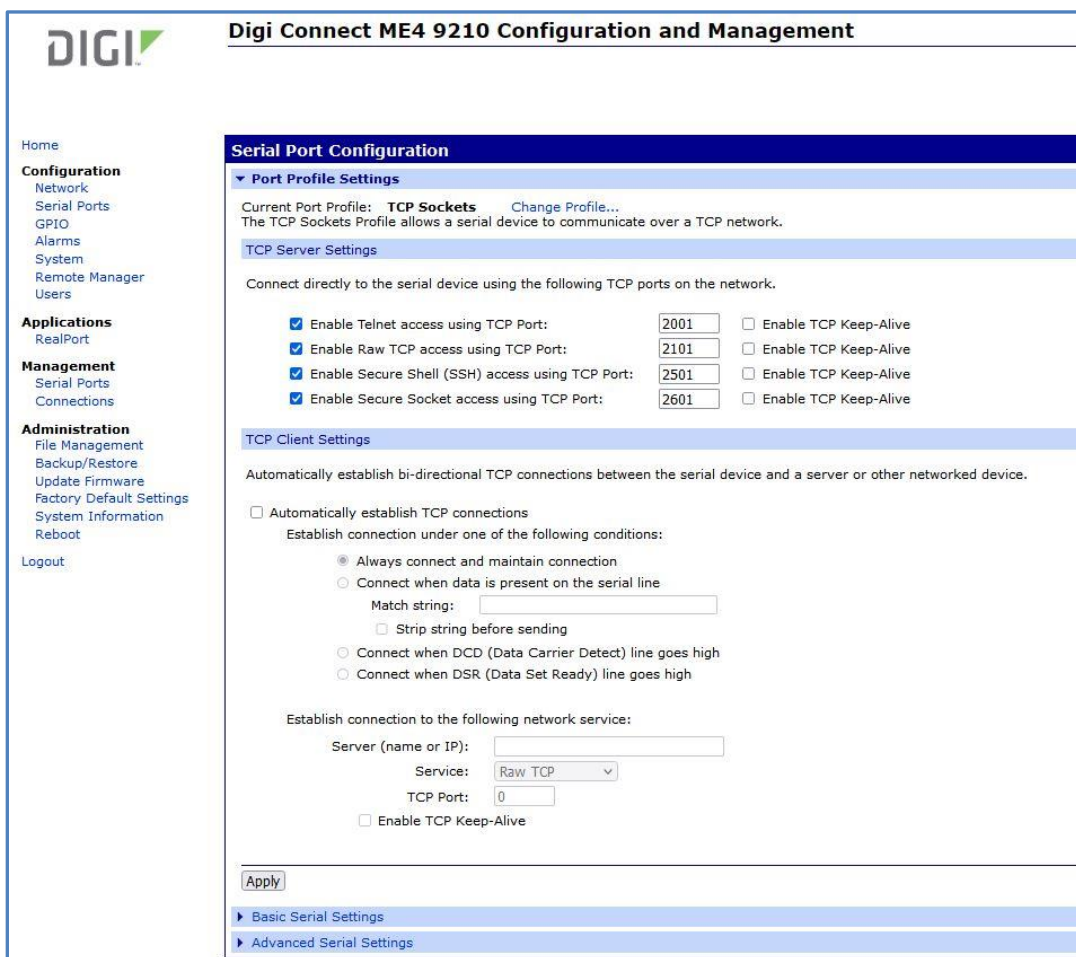
From the home page select "Serial Ports" on the left hand side. The serial port configuration page will be displayed (**Figure 12** (Serial Ports Page)).

Figure 12 (Serial Ports Page)

Select Port 1 from the list of ports. The Port 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. Then change the current port profile by selecting the "Change Profile…" link (**Figure 13** (Change Serial Port Profile)).

Figure 13 (Change Serial Port Profile)

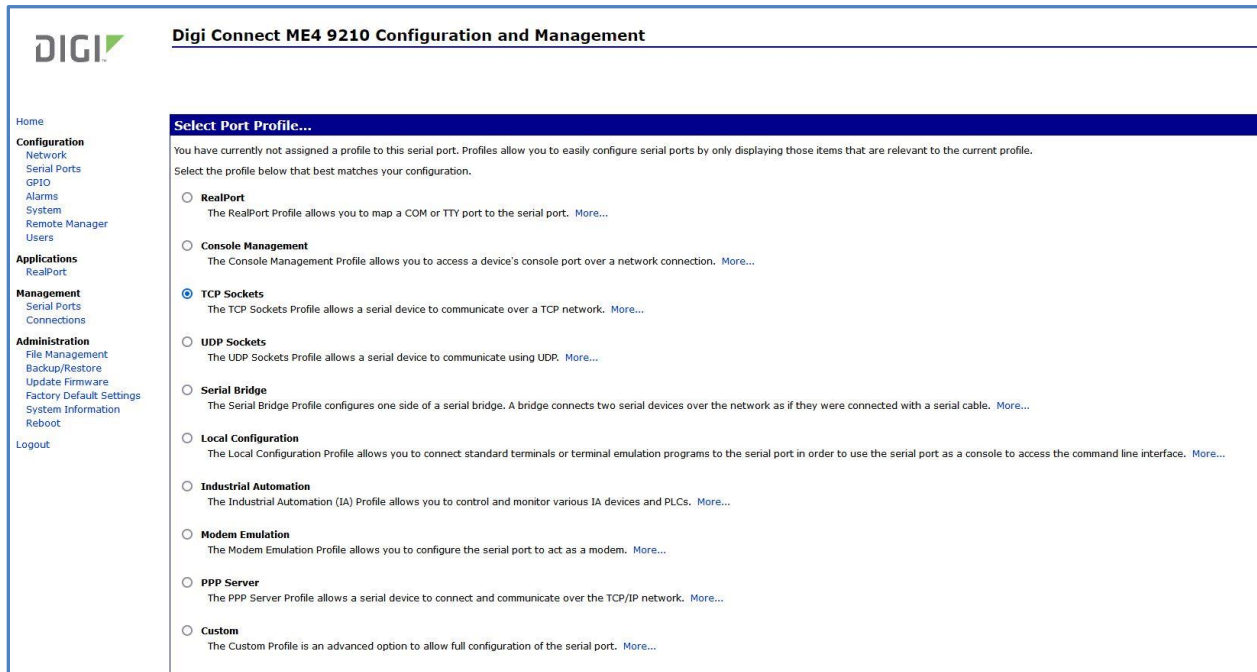Select TCP Sockets from the list of available profiles and click on apply at the bottom of the page (**Figure 14**).

Figure 14 (Selecting TCP Sockets)

Next, select the "Basic Serial Settings" section located below the "Port Profile Settings" section. Set the baud rate to 115200 (**Figure 15**).
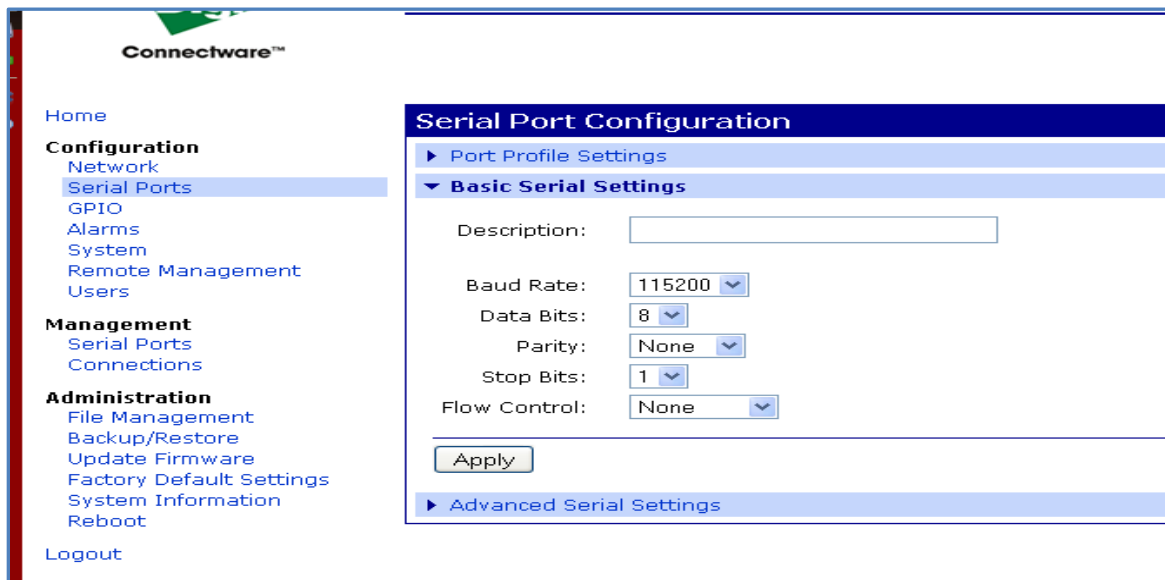

Figure 15 (Basic Serial Settings)

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 any terminal utility that supports TCPIP. Two options are the "VISA Interactive Control" that is installed with National Instruments VISA libraries and another is Putty.

VISA Interactive Control Example

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. The VISA Interactive Control can be found installed in the National Instruments program group. 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 16**). The resource string for Digi Connect Ethernet Modules in Quantum Composer pulse generators needs to be formatted as follows:

TCPIP0::<IP address>::2101::SOCKET
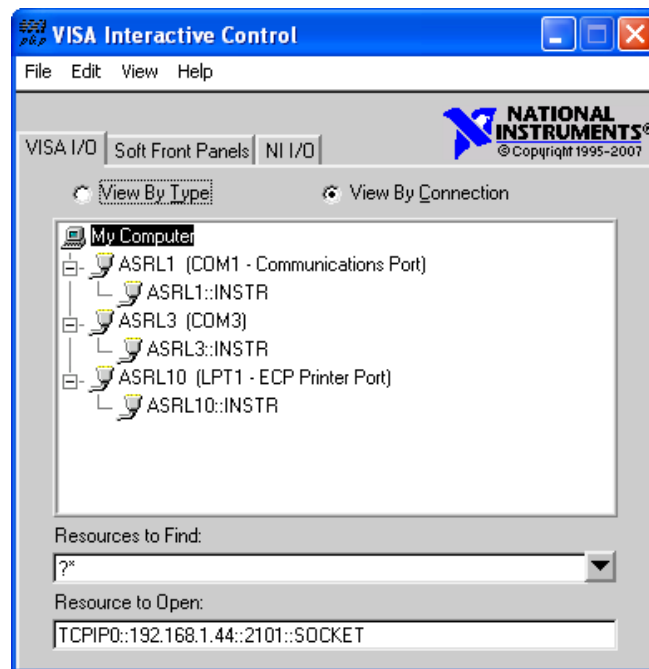
Or, for example:

TCPIP0::192.168.1.44::2101::SOCKET

Figure 16 (VISA Interactive Control)

A session window will open allowing access to communication parameters and read and write buffer access and control. Quantum Composer units 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". In hexadecimal, 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.
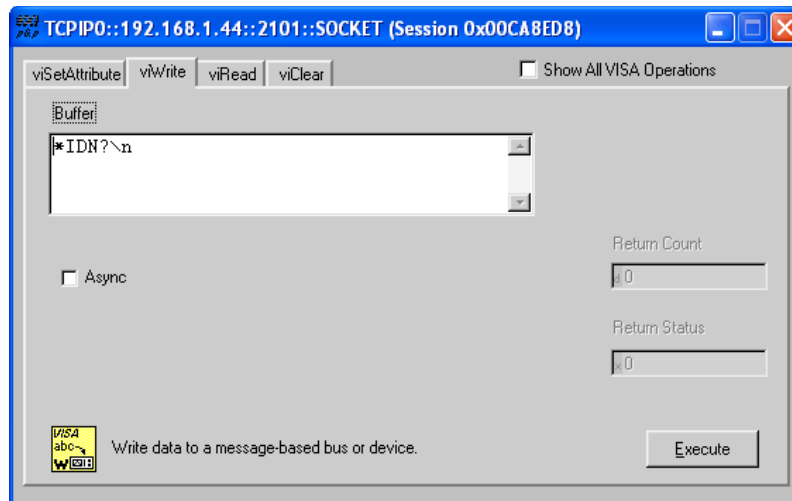
Select the "Write" tab (**Figure 17**).

Figure 17 (Write Tab)

The "Buffer" field can be edited to send any valid command to the pulse generator. Hit "Execute" to send the "*IDN?" command. Now select to the "Read" tab (**Figure 18**).
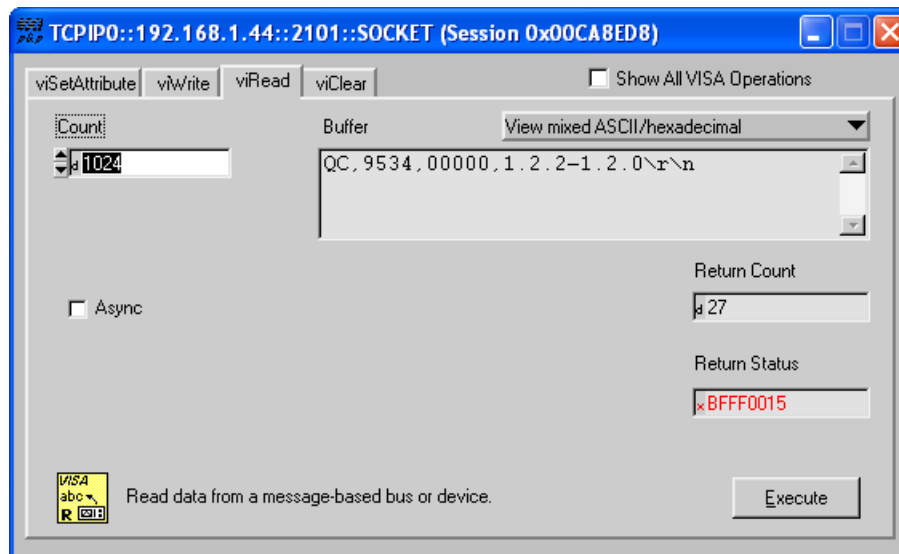

Figure 18 (Read Tab)

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.

Putty Example

Putty is an open source terminal emulator that can be used for various methods of communications. Once Putty is installed and run for the first time, a few parameters need to be entered before communications with the unit can be established (Figure 19).

- Host Name (or IP Address): Enter the IP address of the unit determined by using the Digi Device Discovery utility as described previously.
- Port: Enter the port number of the device as set during the device configuration. Default is 2101.
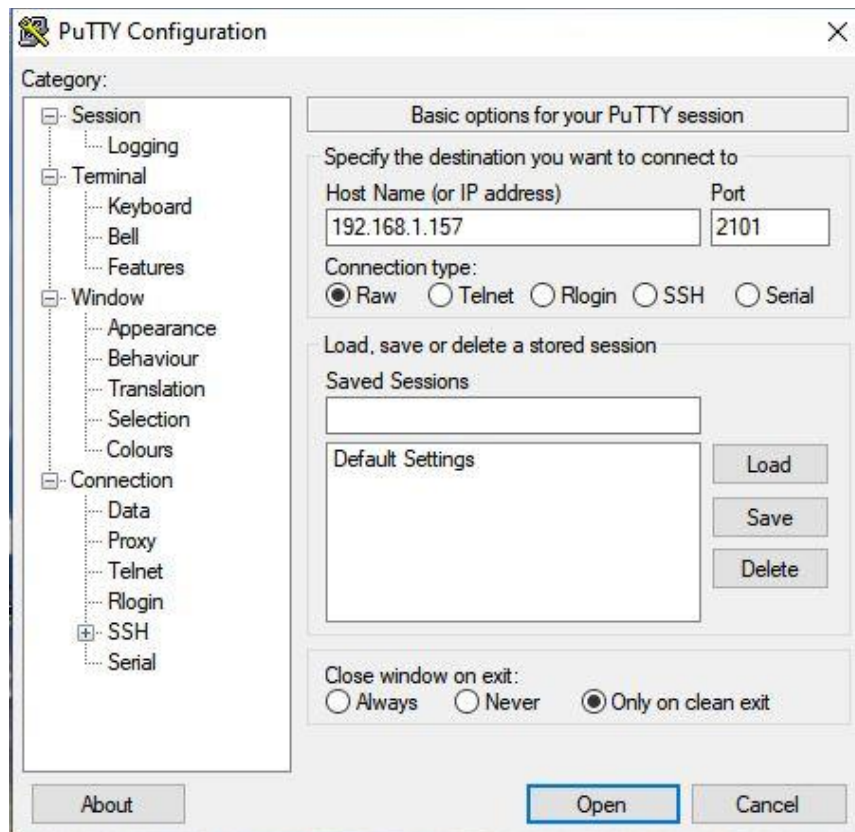- Connection type: Select Raw.

Figure 19 (Putty Settings)

Select Open and a new window will appear (Figure 20). In this window, commands or queries can be sent to the unit. In the example, an *IDN? query is sent. Once enter is pressed, a response should be received.
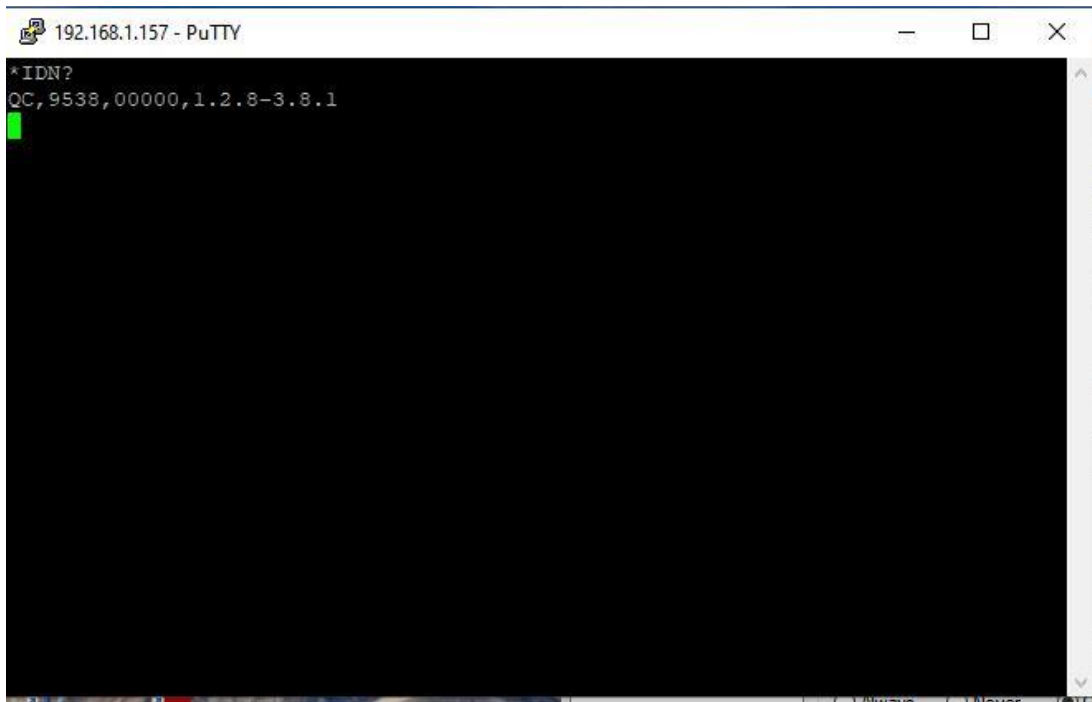
Figure 20 (Putty Terminal Window)

Many applications may need a communication mechanism no more sophisticated than what can be achieved with these simple utilities. At the very least, these tools 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 Quantum Composers 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.

10. 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

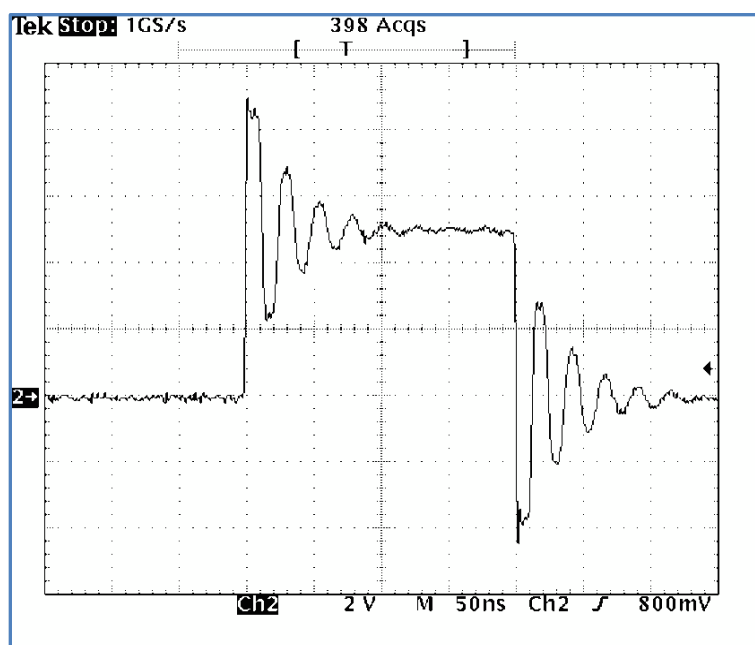*Note: The TZ50 module has significant overshoot and ringing through high impedance (see figure).*

Figure 9: Overshoot on the Output of TZ50 Module

11. Appendix H - External Clock

9550/8550 External Clock Operation

The 9550 pulse generator can utilize an external clock input to synchronize instrument timing. The following specifications must be met in order for proper external clock operation

Parameter:	Minimum	Maximum
Pulse Width	5 ns	-
Pulse Amplitude	3.3 V_{rms}	5 V_{rms}
Input Impedance	>10 KΩ	
Frequency	10 MHz	100 MHz
Jitter, Cycle to Cycle		± 300 ps
Jitter, Period		± 1 ns
Pulse Width Duty Cycle	45%	55%

Note: These specifications are preliminary and subject to change.

12.   Appendix I – 8550 Board Level Option

8550 Board Level Connection Information

8550 Board Level Overview

The 8550 is a board level option based on the 9550 series pulse generator. The specifications, communications, and overall functionality of the 8550 are the same as described for the 9550 series. The 8550 is available with 6, 12, 24 or 36 independent outputs that can be used for synchronizing multiple events. With the 8550 all communications will take place through USB, Ethernet, or RS-232 as there is no display or keypad for interactions. The guide for standard SCIP communications with the 8550 unit can be found above in the 9550 standard manual. As with the 9550, the 8550 is capable of generating multiple pulses for all applications; but additional setup is required before even basic pulsing may begin.

Digital Control Board Connection Information

Note: The Power Input and Power Switch Connector are required connections for the 8550 module to function.

Power Input Connector (J2 - DC In)

- The recommended connector is Molex 4 pin female C-grid (Molex #50-57-9404) or equivalent.
- The recommended contacts are Molex female terminals with **gold contacts** (Molex #16-02-0087) or equivalent.

Pin Number:	Connection:	Specification:
1 (denoted by arrow on connector)	+5 Volts DC	5 V±2%, 1.2 Amp nominal capability
2	Ground	
3	Ground	
4	+24 Volts DC	24 V±6%, 0.8 Amp nominal capability

Note: For an additional cost a recommended power supply and cable can be supplied.

Power Switch Connector (J3 – Pwr_Enab)

- The recommended connector is Molex 2 pin female C-grid (Molex #50-57-9402) or equivalent.
- The recommended contacts are Molex female terminals with **gold contacts** (Molex #16-02-0087) or equivalent.

Note: This is the power enable switch; Short the contacts to turn the unit on and open them to power down. (This connector will come shorted)

External Clock Input (J11)

- The recommended connector is a male SMA

Pin Number:	Connection:
1	Signal out (+5VDC)
2	Ground

Internal Clock Output (J8)

- The recommended connector for J8 is a male SMA

Pin Number:	Connection:
1	Signal input (+5VDC Max)
2	Ground

USB Communications Connector (J4 – USB)

- The recommended connector is a male USB Type B

Pin Number:	Connection:
1	Vbus + (+5 Volts DC)
2	Data -
3	Data +
4	Ground

RS-232 Communications Connector (J6 – RS-232)

- The recommended connector is a male standard density D-Sub 9 pin connector

Pin Number:	Connection:
1	N/C
2	Tx - Transmit
3	Rx - Receive
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	N/C

Ethernet Communications Connector (Ethernet Module - Optional)

- The recommended connector is a male RJ-45 Jack
- The pin out should be 568B or AT&T 258A

Pin Number:	Connection:	Wire Color:
1	Tx + (Transmit Data +)	Orange/White
2	Tx - (Transmit Data -)	Orange
3	Rx + (Receive Data +)	Green/White
4	N/C	Blue
5	N/C	Blue/White
6	Rx - (Receive Data -)	Green
7	N/C	Brown/White

8	N/C	Brown

External Gate Rear (J23)

- The recommended connector is a male BNC

Pin Number:	Connection:
1	Signal Input (0.5 to 30V)
2	Ground

External Trigger Rear (J22)

- The recommended connector is a male BNC

Pin Number:	Connection:
1	Signal Input (0.5 to 30V)
2	Ground

External Trigger/Gate Front (J21)

- The recommended connector is Molex 2 pin female C-grid (Molex #50-57-9402) or equivalent.

Pin Number:	Connection:
1	Signal Input (0.5 to 30V)
2	Ground

Sync Output (J26)

- The recommended connector is Molex 2 pin female C-grid (Molex #50-57-9402) or equivalent.

Pin Number:	Connection:
1	Signal Output (+5VDC)
2	Ground

Channel Outputs (J17A/B-J20A/B)

- The recommended connector is a male BNC

Pin Number:	Connection:
1	Signal Output (+5VDC TTL/0.2-20VDC Adj)
2	Ground

Mounting Information

- There are up to 9x 6 & 12 channel #4 (Ø.125) clearance holes that can be used to mount the Control Board depending on the channel options.

  Note: Each of these mounting holes are connected to Ground

  Note: 6 or 9 of the 9 mounting holes on the board are used to mount the optional channel expansion boards and will come with M-F standoffs if the 8550-24 or 8550-36 is ordered.

6 Channel Board Level

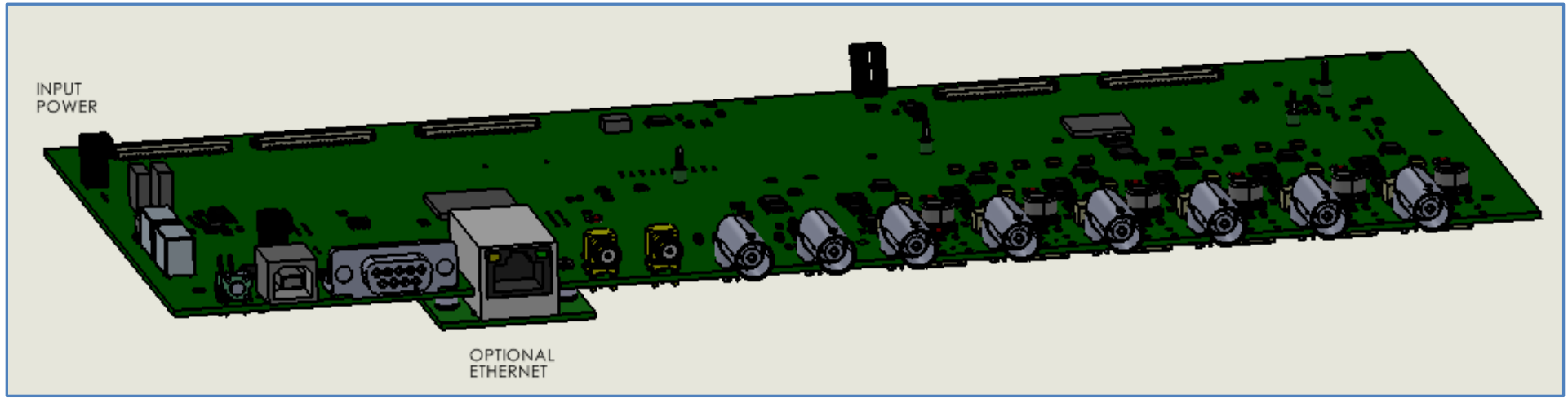NOTE: See Figure 6 for Channel and Communication Connections.

INPUT
POWER

OPTIONAL
ETHERNET

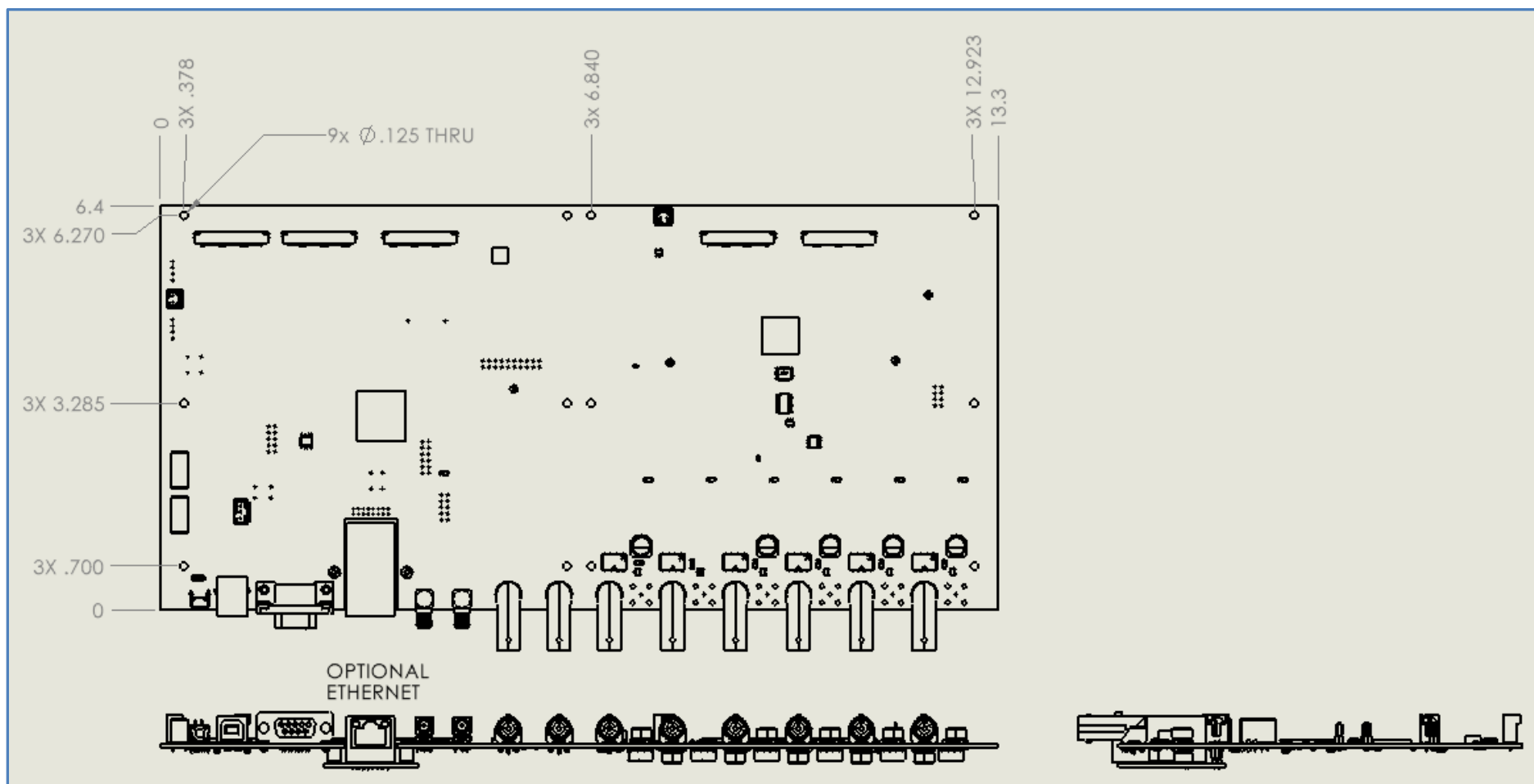**Figure 21   6 Channel Board Level**

Figure 22 6 Channel Board Level Size

12 Channel Board Level

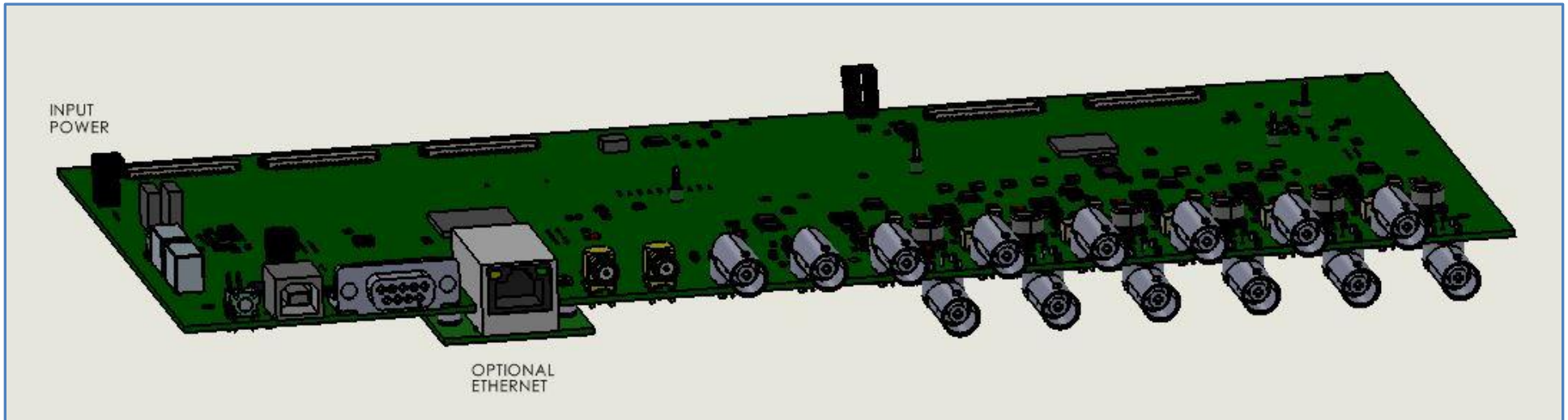NOTE: See Figure 7 for Channel and Communication Connections.
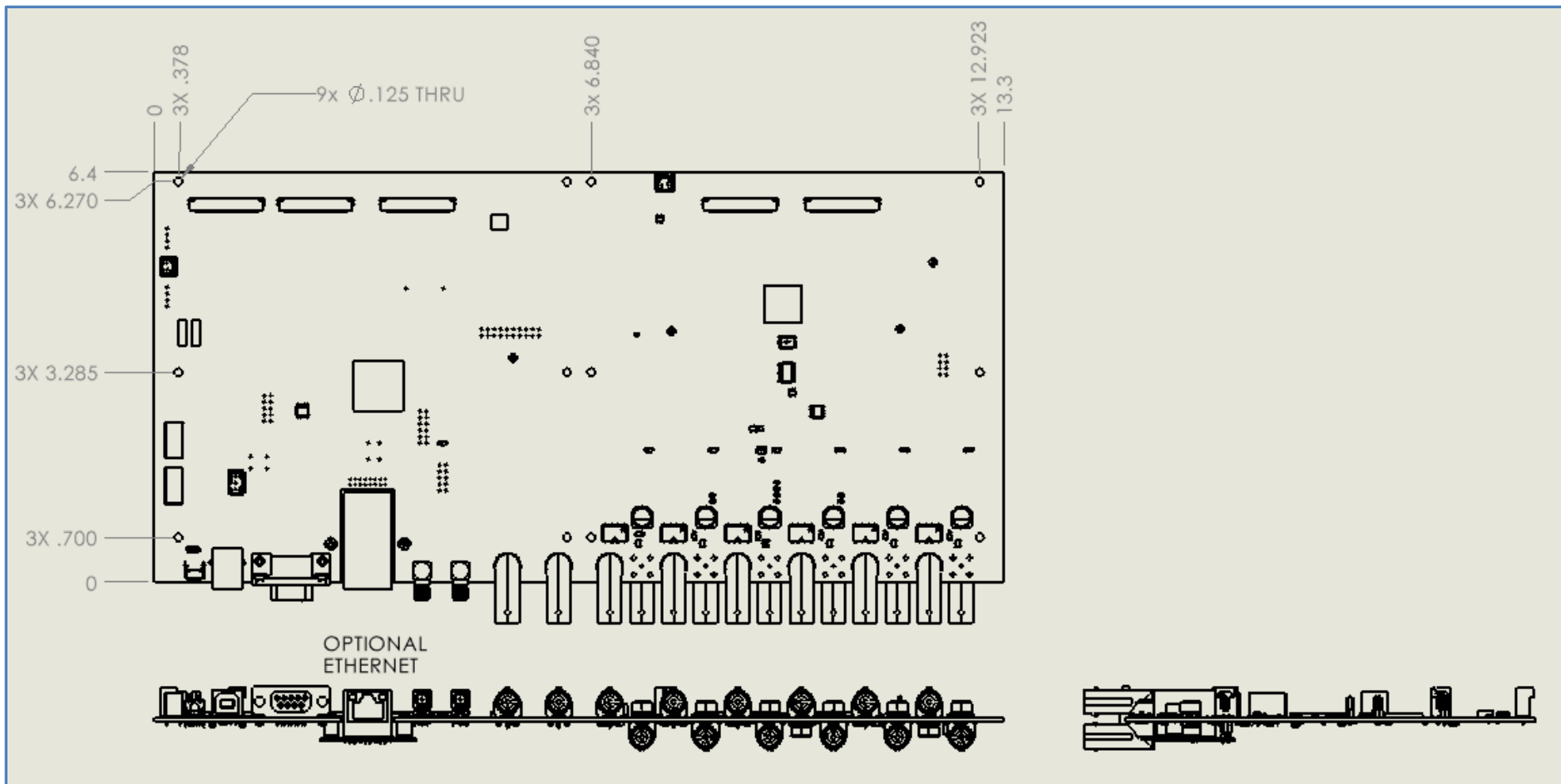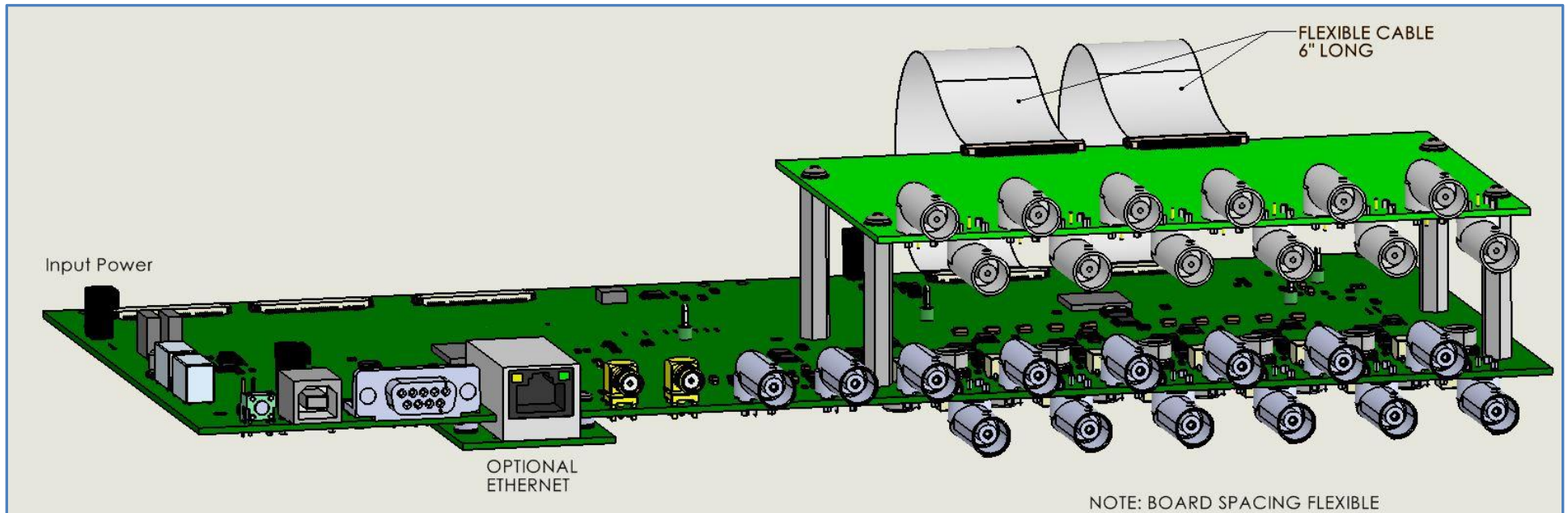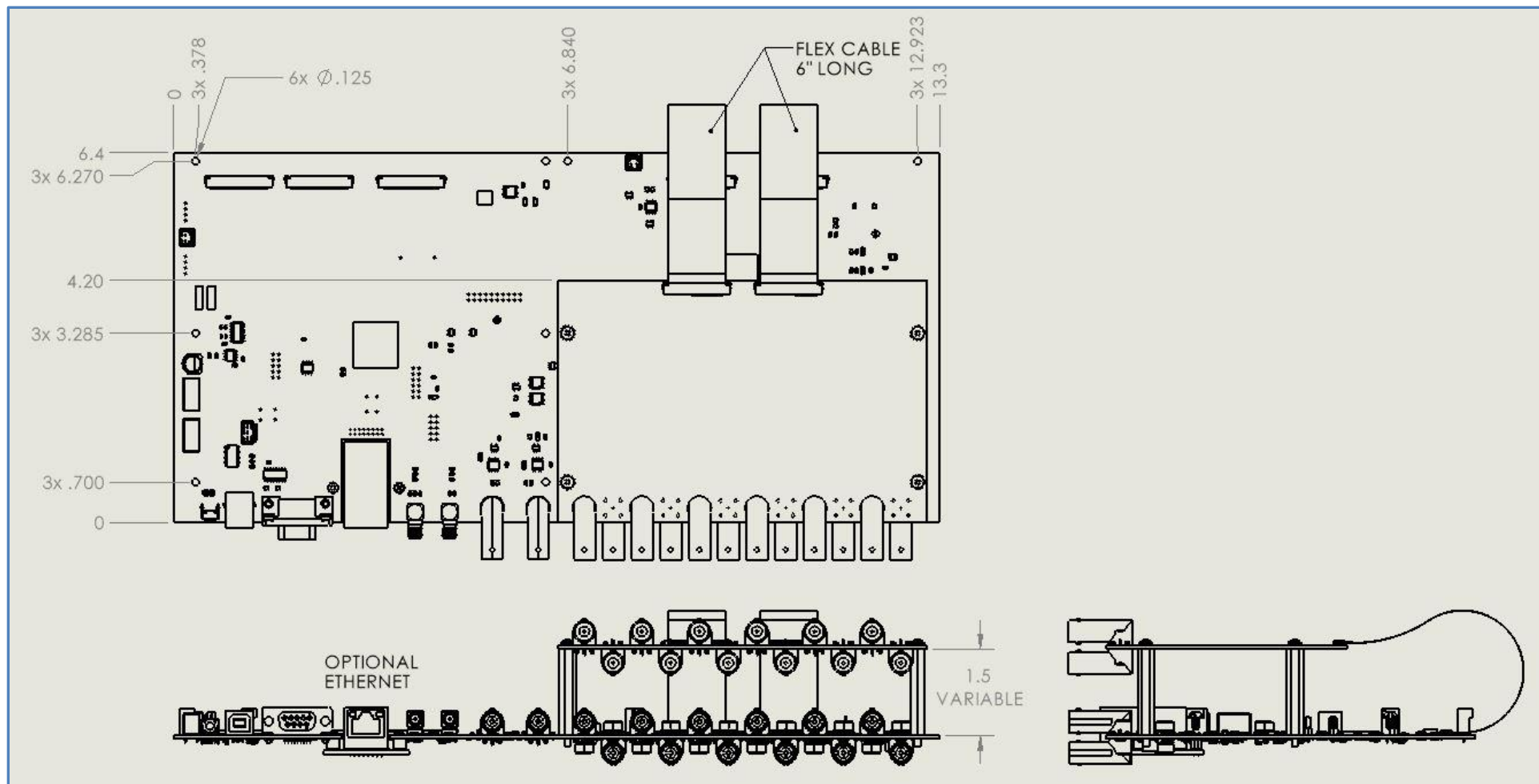

Figure 23 12 Channel Board Level

Figure 24 12 Channel Board Level Size

24 Channel Board Level

NOTE: See Figure 8 for Channel and Communication Connections

FLEXIBLE CABLE 6" LONG

Input Power

OPTIONAL ETHERNET

NOTE: BOARD SPACING FLEXIBLE

Figure 25 24 Channel Board Level

Figure 26 24 Channel Board Level Size

36 Channel Board Level

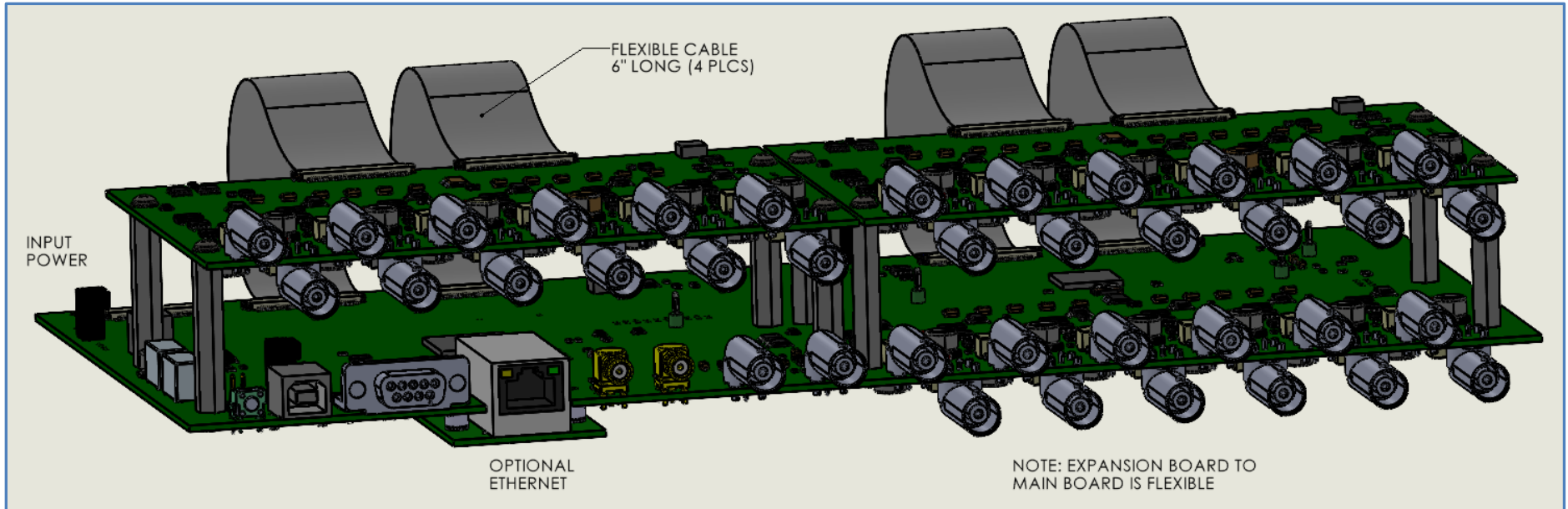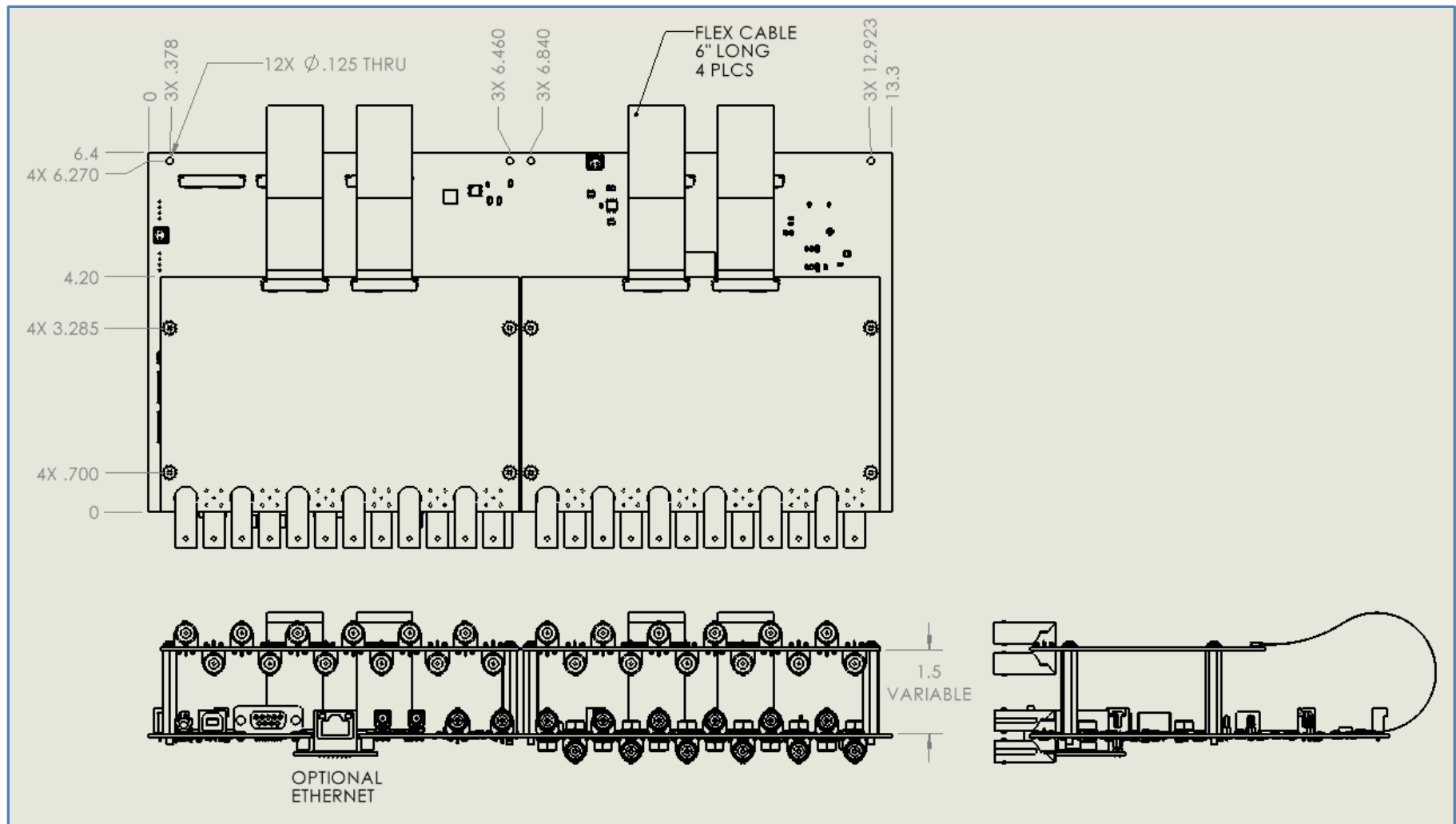NOTE: See Figure 9 for Channel and Communication Connections

Figure 27 36 Channel Board Level

Figure 28 36 Channel Board Level Size