Pulse Sequence Generator (PSG-2)

Operation Manual

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For questions or comments, please contact ISSI
Innovative Scientific Solutions, Incorporated
7610 McEwen Road
Dayton, OH 45459
Ph: (937) 630-3012
Fax: (937) 630-3015
www.psp-tsp.com

Features

- Two dual-channel independently programmable pulse generators (each PSG-2 has 4 total channels)
    - The PSG-2 can produce two separate frequency outputs either synchronously or asynchronously.
- Four high-current TTL level outputs
    - Extends the utility of this generator by allowing it to drive low impedance loads (50 Ohms) such as solenoids and drive logic over long cable runs
- Remotely programmable through Ethernet
- Multiple timing bases
- Multiple PSG-2s can be cascaded to increase the number of channels
- BNC inhibit input (TTL high level) to allow the PSG-2 to be gated by an external source
- User application controlled or external signal triggering:
    - «Start» command from user application
    - Positive or negative transition on the trigger input
    - Level on the trigger input
    - «Start» signal from Master PSG-2 in cascaded configuration
- Firmware upgradeability through USB

Figure 1: PSG-2 Front Panel

Figure 2: PSG-2 Back Panel

Description and Specifications

- Interface   Ethernet, USB 2.0
- Master clock   50 MHz +/-30 ppm
- Timing clocks (programmable)   20, 40, 80, 160 ns
- Pulse width   20ns to 10s
- Frequency Range   0.1 Hz to 25 MHz
- Pulse sequence period   timing base $* (2 - 2^{26})$
- Pulse start position (ref. to trigger) and duration   timing base $* (2 - 2^{26})$
- Number of pulses in sequence $1 - 2^{17}$
- Output impedance   50 Om
- Output voltage
  - @ 50 Ω load   2.5V
  - @ 1 K Ω load   4.0 V
- External trigger input:
  - Input impedance   >1 M Ω
  - Max. voltage range   -0.5V — 7V
  - Maximum input trigger frequency   5 MHz
- Power supply   85-264 VAC, 50-60 Hz

Functional Description

PSG-2 has two dual-channel pulse generators. First generator outputs pulses on BNC connectors marked as 1 and 2 and a second on BNC connectors marked as 3 and 4 on the front panel. There are also LED indicators showing the presence of pulses on the outputs (please note that LED brightness depends on the duty cycle of the generated sequence).
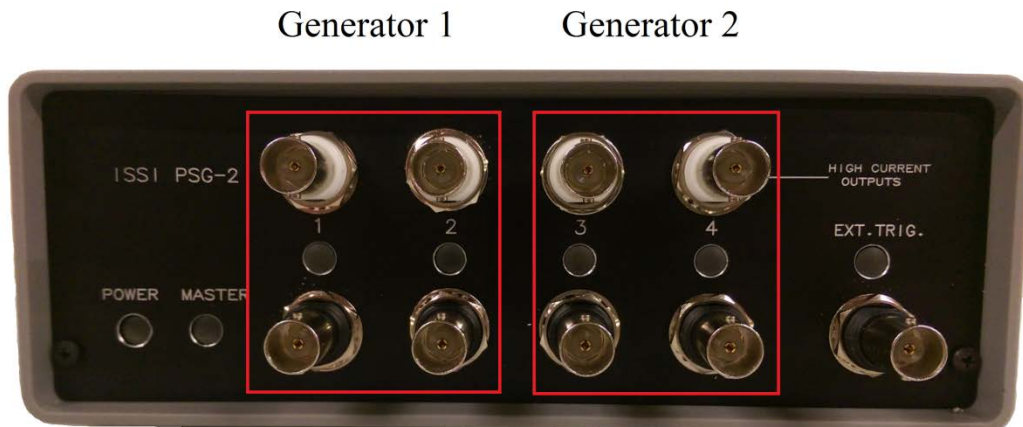
Each generator's period and number of pulses are programmable. The period and number of pulses can be different between the two generators. In the generators, the start and duration of pulses in the channels are programmable independently but the period and number of pulses is the same for both channels (these values cannot exceed the period of the pulse sequence and the smallest pulse duration is equal to the timing base). Pulse start position is referenced to the trigger moment (τ_0) which is either initiated by user application or by the external trigger signal.

Connections Description

Front Panel

Power	Device is powered on
Master	Device is acting as 'Master' PSG-2
I, II, III, IV	Each channel of the PSG-2. Two channels per generator.
High Current Outputs	Mirrors the output of I, II, III, and IV. Used for long cable lengths or other low impedance loads.
Ext Trig	External trigger input from external device.

Back Panel

Trig Inhibit + 5VDC	Inhibits the front panel when 5 VDC is applied
Test	Enters the PSG-2 into firmware upgrade mode
USB	Firmware upgrade / Communication with PC
Ethernet	Communication with PC
Ext. In	Synchronization input with additional PSG-2
Sync Out	Synchronization input with additional PSG-2
85-264 VAC (47-440 Hz)	Device power connection

ISSI

NIC Network Setup

The network on the PC NIC (network interface card) needs to be properly configured for communication over the network. To do this, navigate to the 'Network Connections' page on the control panel where the local networks of the computer are displayed. Right-click on the network where the PSG-2 is connected and select 'Properties.'
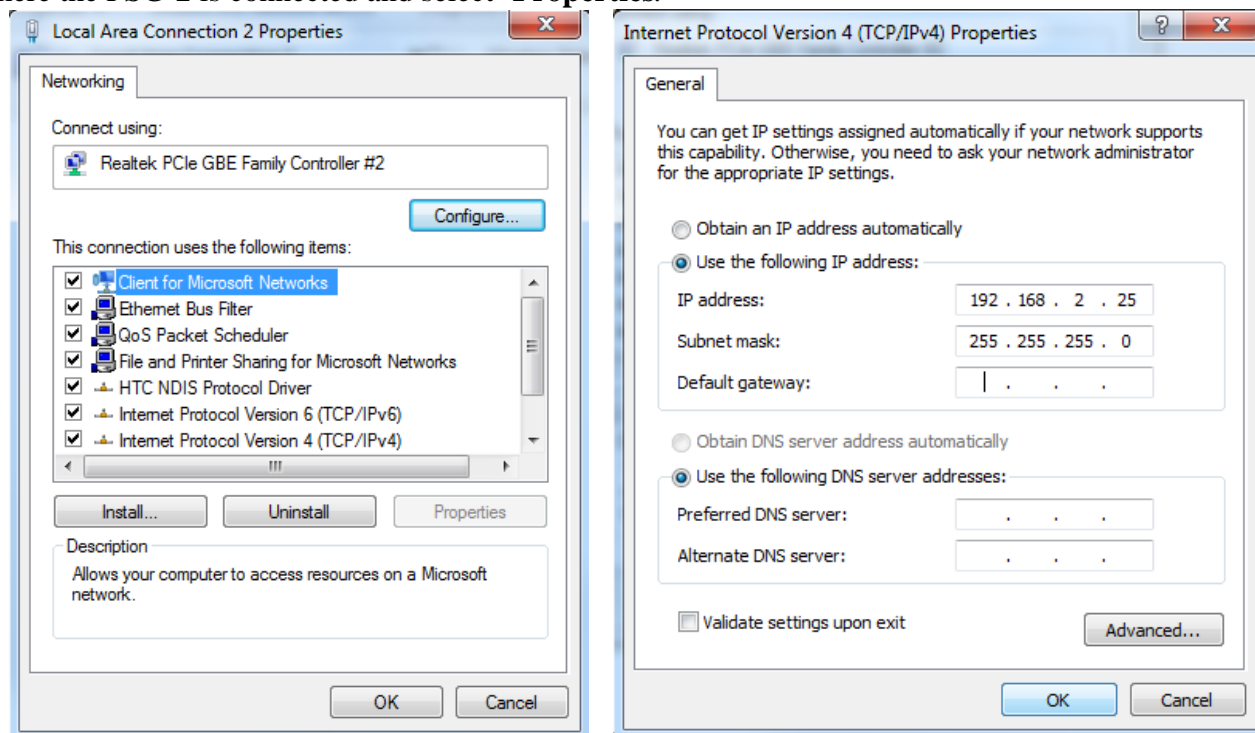
From the 'Local Area Connection X Properties' window (above, left), click on 'Internet Protocol Version 4 (TCP/IPv4)' and then press the 'Properties' button, now useable. This will open the 'Internet Protocol Version 4 (TCP/IPv4) Properties' window. This is where the IP addresses are entered so that the PSG-2 can be reached over the network. The settings needed for communication are **IP Address** and **Subnet mask**. The IP address of the NIC should use the following conventions

IP Format: *Network.Network.Subnet.Host*

- PSG-2 IP: 192.168.2.30
- NIC IP: 192.168.2.XXX

The NIC IP address should have the same network and subnet addresses but a unique host, the last line of the IP address. The host can be any value 1-254 but different from the host address of the PSG-2. The subnet mask should be set to match that of the PSG-2 which, by default is 255.255.255.0. The **Default Gateway** and all other fields can be left blank.

Communication over USB is plug-and-play using the *ISSI PSG-2 Interface* program.

Software Operation

There are two options for software operation of the PSG-2. The PSG-2 can be operated over a web browser simply by entering the IP address of the PSG-2 in the address bar and also be operated over software, *ISSI PSG-2 Interface*. The PSG-2 will only operate over USB via the software interface. This software installation will automatically install USB drivers to communicate with the PSG-2.

Web Interface

PSG-2 web interface

Open any web browser and enter the exact IP address of the PSG-2(s) and press 'Enter.' This will navigate to the web browser interface. Select '**Pulse Delay and Width Setup**' and the control screen will appear.

(Under the heading '_Pulse Delay and Width Setup_' in the web interface)

Trigger Source

- **Ext. Trig. Raising Edge:** The PSG will send out a pulse or pulse train on the rising edge of a trigger pulse.
- **Ext. Trig. Lowering Edge:** The PSG will send out a pulse or pulse train on the falling edge of a trigger pulse.
- **Ext. Trig. High Level:** The PSG will generate pulses as long as the external trigger remains high.
- **Ext. Sync.:** This is an external trigger control that is used to set one PSG as master and subsequent PSG as slaves to the master PSG. It can be used to extend the PSG on the same clock. See section on *External Synchronization* for more detail.
- **Software:** All control of the PSG is done through the web interface. The PSG will start sending out pulses when prompted by the user on the GUI.

Period: Inverse of frequency. If the period is set to 0, that generator will remain high and lock on.

Number of Pulses ('Pulses' in GUI): Number of pulses the PSG will send out once triggered or started in the software. Set to 0 for continuous pulses.

Channel Delay and Width: Channel Delay is the time to delay pulses from trigger (either internal or external). Width is the pulse width output of the selected channel. Note that all are in milliseconds in the web interface and GUI by default.

Time Units: Also called the time base, *base frequency or clock settings. Adjustable from: 20-ns, 40-ns, 80-ns, and 160-ns.

The base frequency is determined by the duration over which measurements of the waveform are collected. It represents the interval between the spectral bands which can be computed from the waveforms.
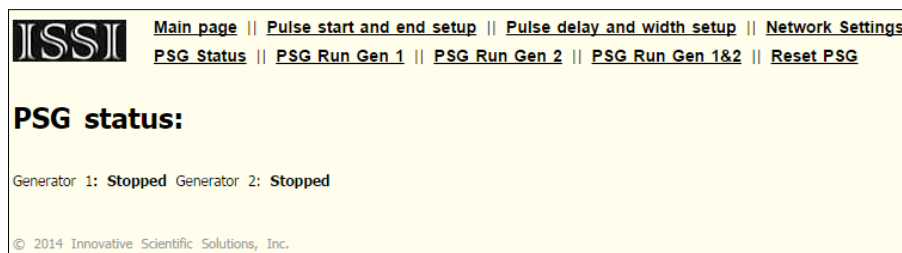
To check the status of the connected pulse generator, the '**Status**' heading will show whether the generators are running or stopped. This is useful for applications where there is no visual access to the PSG-2 connected.

PSG-2 Windows GUI

ISSI PSG-2 Interface for Windows is installed as an executable file, '*Setup_PSG2_interface.exe'*. This will automatically install the PSG-2 drivers on the host computer for USB connection with the PSG-2. The GUI will also be installed from the executable file. The GUI gives the option to connect over USB or Ethernet to communicate with the PSG-2.
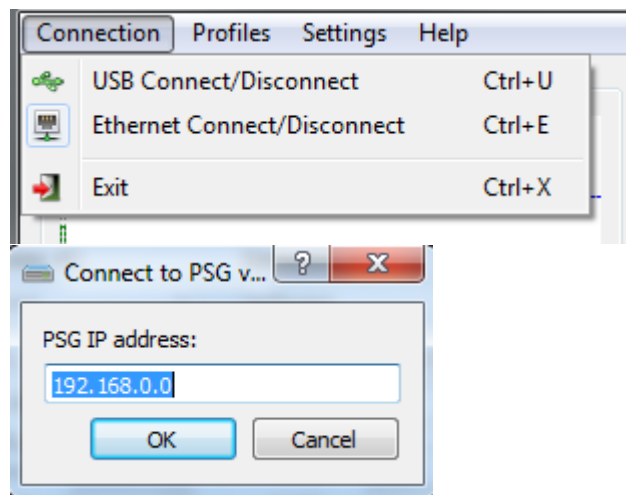
Navigate to the appropriate connection by selecting USB or Ethernet. For USB, it will connect as long as the USB cable is connected. For the Ethernet connection, it will prompt the user to enter the IP address of the attached PSG-2.

Once connected, the IP address of the connected PSG-2 will be displayed on the front panel in the '**Connection Status**' block.

The PSG-2 GUI has all of the same functionality found in the web browser plus several additional features. This GUI also displays the oscilloscope view of the output of each generator based on the settings input by the user. When connected, the GUI will display all of the buttons and input boxes. When disconnected, all will be grayed out. By default, all values are displayed in milliseconds for Period, Delay and Width.
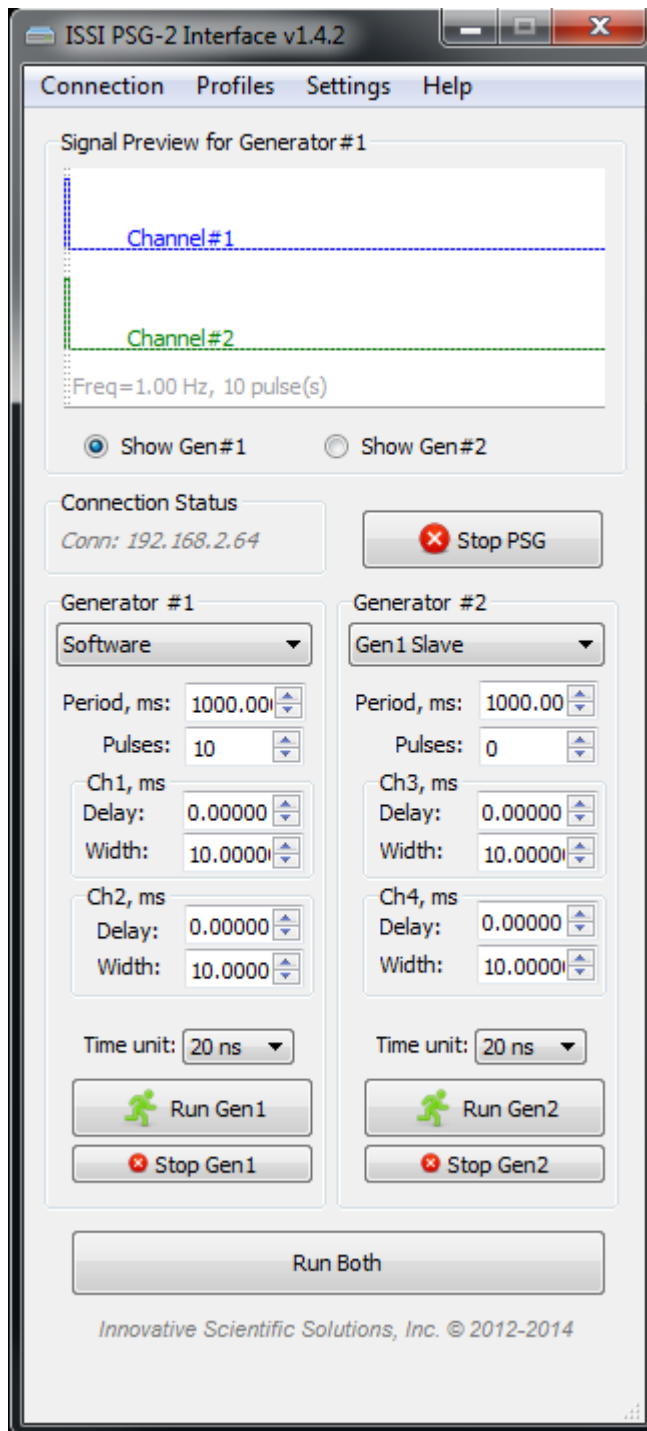
The PSG-2 can be operated either via software or one of the many triggering types, selected from the pull-down menu under Generator #1. Generator #2 can either be used in software mode or

slaved to the operation of Generator #1. When the generator mode is changed, it will immediately stop the PSG-2 and change to this mode on the PSG-2. The triggering options for each generator in the GUI are functionally the same as described for the web interface on page 6.
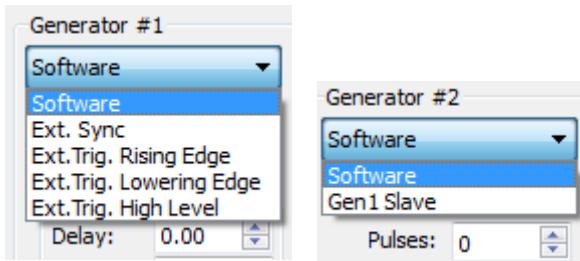

The clock settings can be changed for different repetition rates of the PSG-2. The same limits on the clock settings apply as they are shown on the web browser page. Time units are adjustable between milliseconds and microseconds. This is done in the '**Settings**' tab and selecting '**Time Units**.' This applies the time units update to the entire front panel of the GUI.
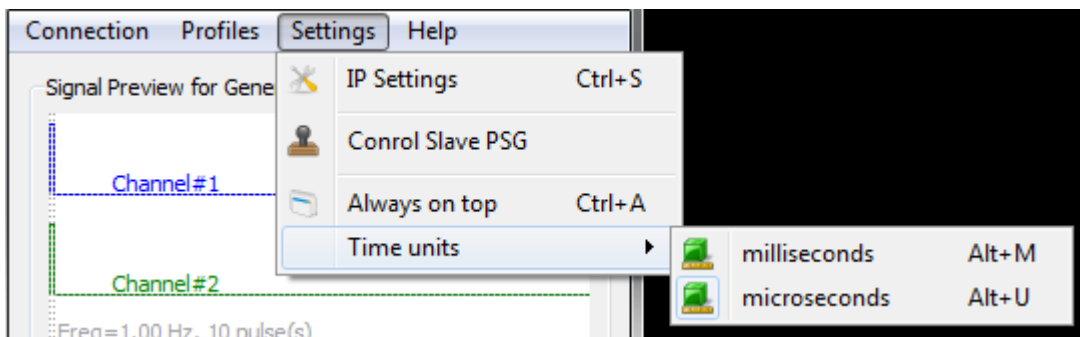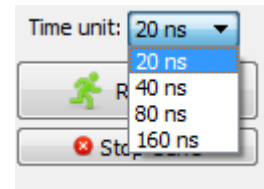
'**Always on Top**' will bring the GUI to the front of all other windows open on the desktop.

Profiles

A time-saving feature of the PSG-2 Windows interface is the ability to save user profiles on each computer. From the '**Profiles**' tab, user profiles can be added or removed for different experiments or users. The profile saves everything on the front panel of the PSG Windows interface from trigger method, period, number of pulses, pulse width and delay. These can be recalled from the '**Profiles**' tab by selecting the profile from the drop-down menu.
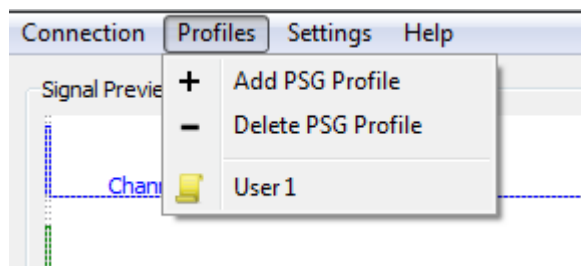

Profiles with the same name will overwrite older profiles.

Slave PSG Control

The '**Control Slave PSG**' in the '**Settings**' tab allows users to set the parameters of any PSG-2 connected to the network. For systems with multiple subsystems, each controlled by an individual PSG-2, this can be advantageous in changing settings for the group all at once. Open the slave PSG control from the '**Settings**' tab:
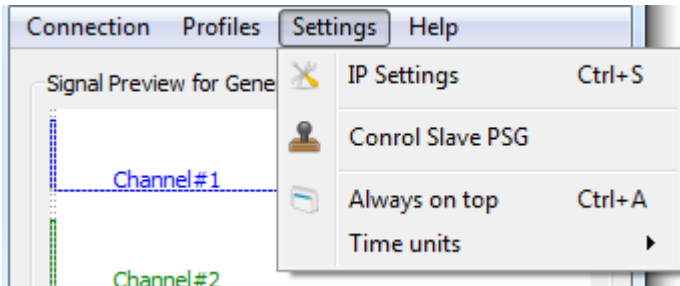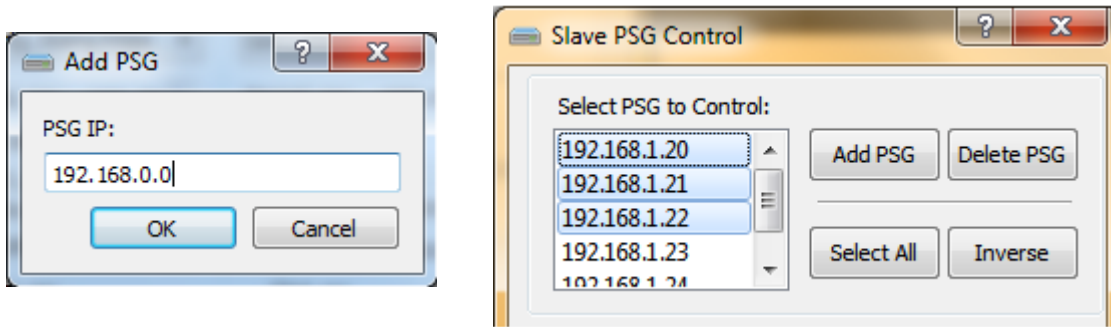

This will open the '**Control Slave PSG**' window.
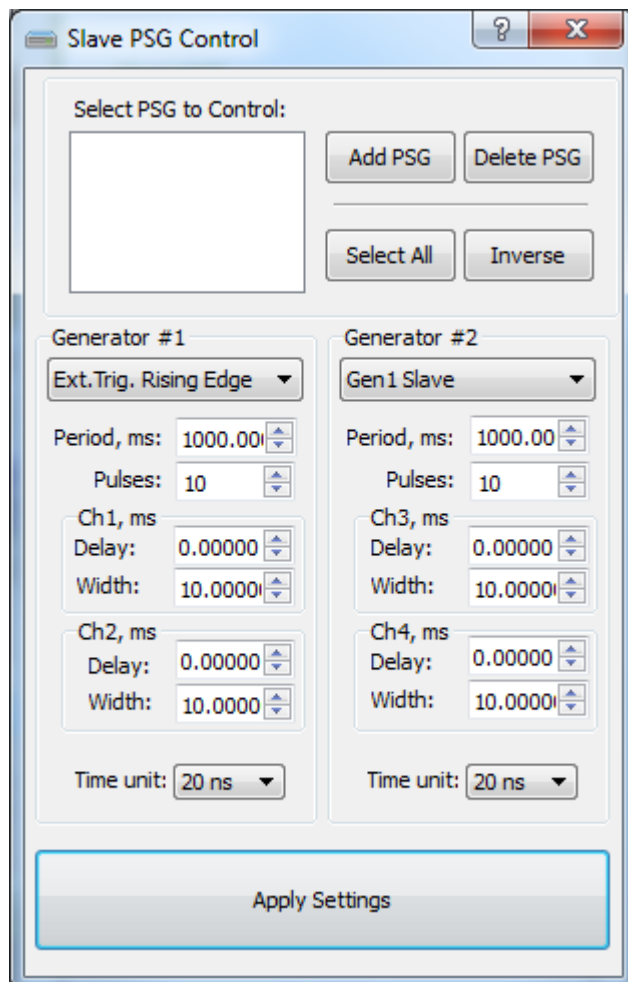
The window opens with no PSGs selected. Add them and remove them as needed. Adding a new PSG will open up the '**Add PSG**' window. The identification of each PSG is based on the unique IP

address of each PSG. Type the IP address to add each new PSG to the list.

Once added, settings entered in the '**Control Slave PSG**' window will be applied to all selected PSGs once '**Apply Settings**' is clicked.

Note: This will not start the generators on each PSG, it will only set those PSGs to those settings. The generators must be started from the main menu or web browser. Each time new settings are applied, the PSGs will stop to apply settings. To select/deselect multiple PSGs, hold down Ctrl and select desired PSGs.

Networking

The PSG-2's network parameters should be set to accommodate the particular needs of the network used to connect the PSG-2(s) to the local network. The default network parameters are as follows:
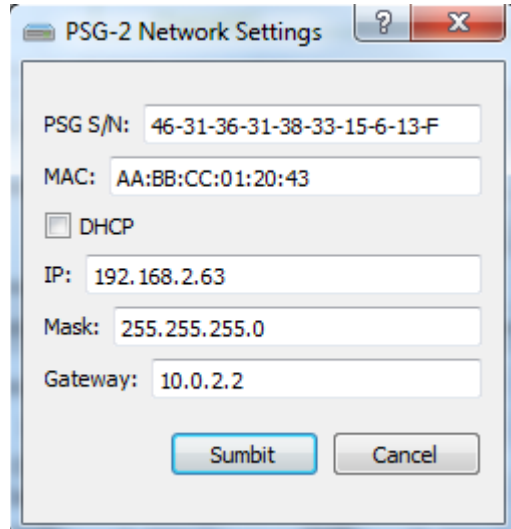
- Ethernet MAC address: (this is unique to each PSG-2)
- DHCP: disabled
- IP address: 192.168.2.30
- Subnet mask: 255.255.255.0
- Gateway: 10.0.2.2

If this is not suitable or more than one PSG-2 is going to be used on the same network, these parameters should be changed. There are two possibilities to change these parameters:

Note: Each PSG-2 is assigned a unique IP address before it is put into stock. This address is printed on the back panel of each PSG-2 and should only be changed by the user if necessary to communicate over the local network.   If the device is reset, it will revert back to the factory default IP of 192.168.2.30 as described in the initial configuration and firmware upgrade section of this manual.

Network Settings – ISSI PSG-2 Interface

The PSG-2 network settings (shown below) can be changed under the 'Settings' tab on the *ISSI PSG-2 Interface.* This can be done via USB or Ethernet connection. If the IP address of the PSG-2 was changed and is not currently known, connecting over USB will display the current IP so it can be recorded or changed. *'Submit'* to affect the changes.

Network Settings ISSI PSG-2 Interface

Network Settings – Web browser

- If the network *is* operational, use any internet browser to navigate to the URL corresponding to the PSG-2's network address (i.e http://192.168.2.30 for the default configuration).
  - o On the PSG-2's main page, navigate to the '*Network Settings*' link. (i.e http://192.168.2.30/network.shtml address in default settings) - see Figure 5.
  - o On the '*Network Settings'* page, enter the desired configuration and click the *'Submit'* button.
    Important: Make sure that the Ethernet MAC and the IP addresses are unique on the network**

Figure 5: PSG-2 Network Settings page

To activate new configuration(s), cycle the power of PSG-2.

External Synchronization

The PSG-2 can be set to one of two modes: Master or Slave (Master mode is indicated by red LED on the front panel). In Master/Slave configuration PSG-2s are connected using **SYNC OUT** (master PSG-2) and **SYNC IN** (slave PSG-2) connectors on the rear panel.

Master mode trigger configurations:

- Both generators in the PSG-2 are triggered independently with individual "Start" commands from user's application.
- Both generators in the PSG-2 are triggered at the same time with the "Start" command sent to the first generator. In this case the first generator propagates the trigger to the second generator.
- First generator is triggered from the external signal ('**EXT TRIG**' BNC connector), second generator is triggered with "Start" command from user's application.
- Both generators in the PSG-2 are triggered at the same time from the external signal. The external trigger input connected to first generator only but it gets propagated to the second generator.

*Note: External trigger options are described below.*

Slave mode trigger configuration:

In slave mode the PSG-2 receives the synchronization signal and master clock from the master PSG-2. In this case both generators in the PSG-2 are triggered from master's PSG-2 first generator. The nominal propagation delay for clock and trigger is ~20 ns, thus the slave's PSG-2 pulse sequences will be delayed by this amount of time. It is still possible to set the second generator in the slave PSG-2 to be triggered from user's application "Start" command.

Note: The slave PSG-2 can use different time base settings from master PSG-2.

A special RJ14 connector is used to connect two or more pulse generators using the '**EXT IN**' and '**SYNC OUT'** connections on the back panel. This allows one PSG-2 to operate as the master and subsequent PSG-2s connected to be slaves, starting from τ_0. This expands the amount of individual channels (individually set pulse width and delay) for the PSG-2.
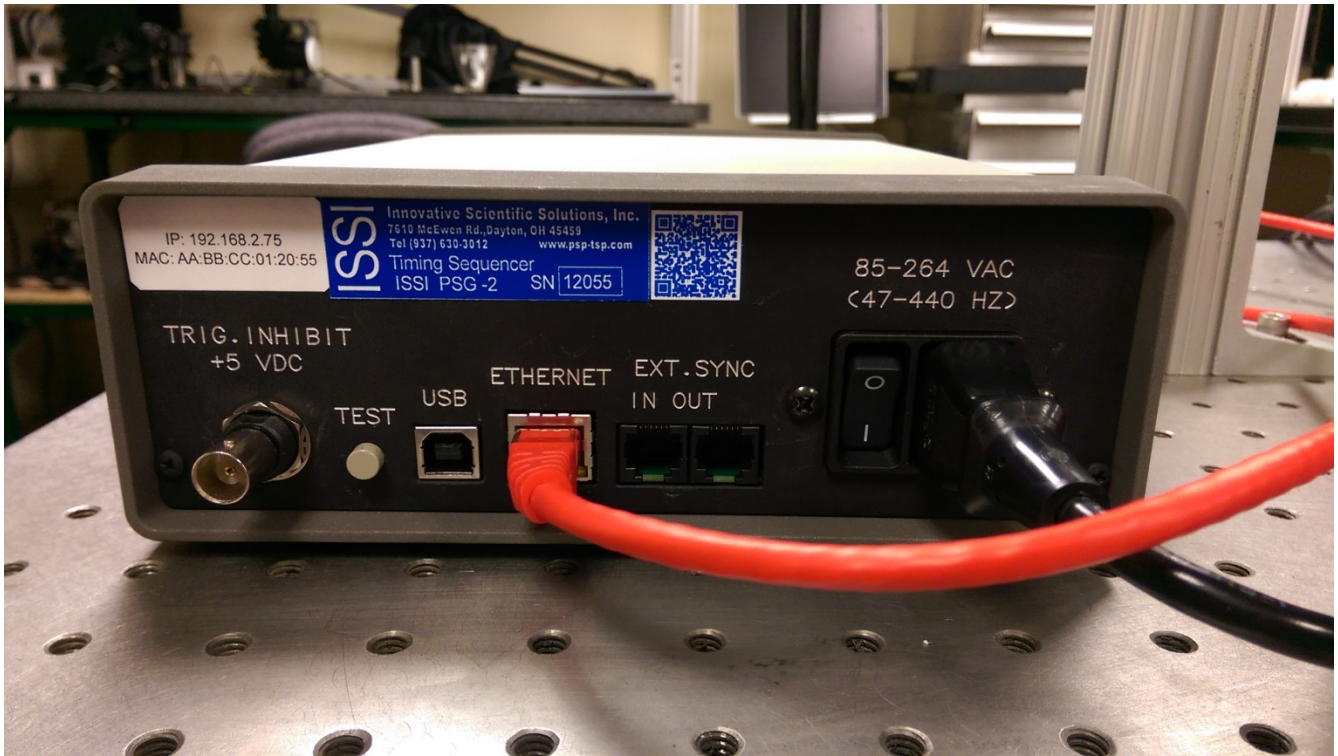
Once the RJ14 cable is connected, one PSG-2 will be shown as master and the other without the master light will be the slave. The slave PSG-2 will start from the start command of the master PSG-2. To configure each as master and slave, the connection with the RJ14 needs to be as shown below.
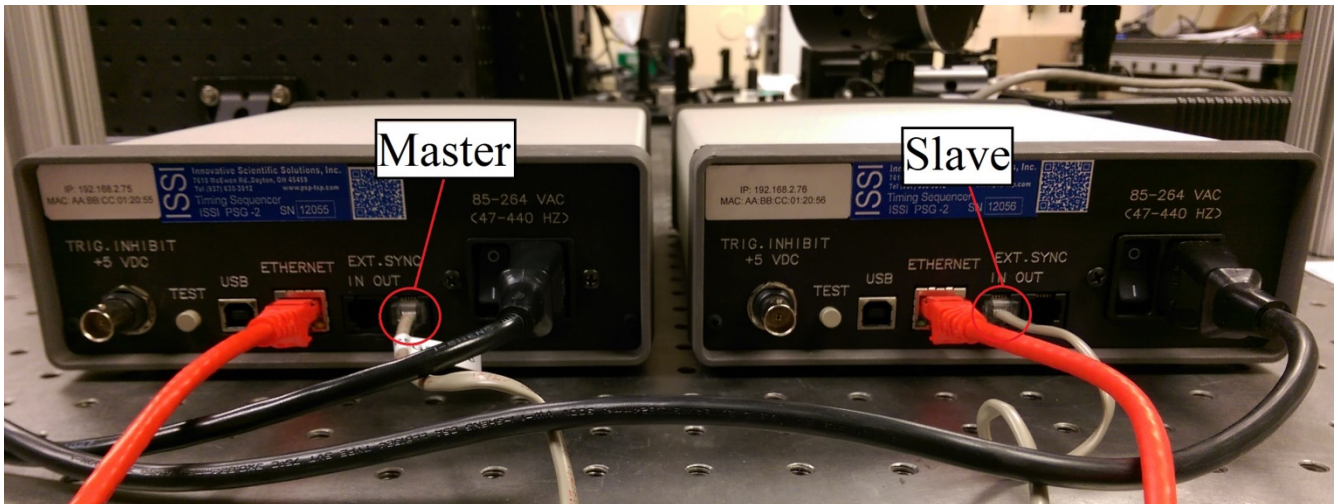
The master PSG-2 sends its synchronization pulse out of '*SYNC OUT*' to the '*EXT IN*' of the slave PSG-2 via the RJ14 cable. The insertion delay between the two is at minimum 20-ns but will increase as the telephone line length increases. The master/slave assignment then needs to be made in the software.
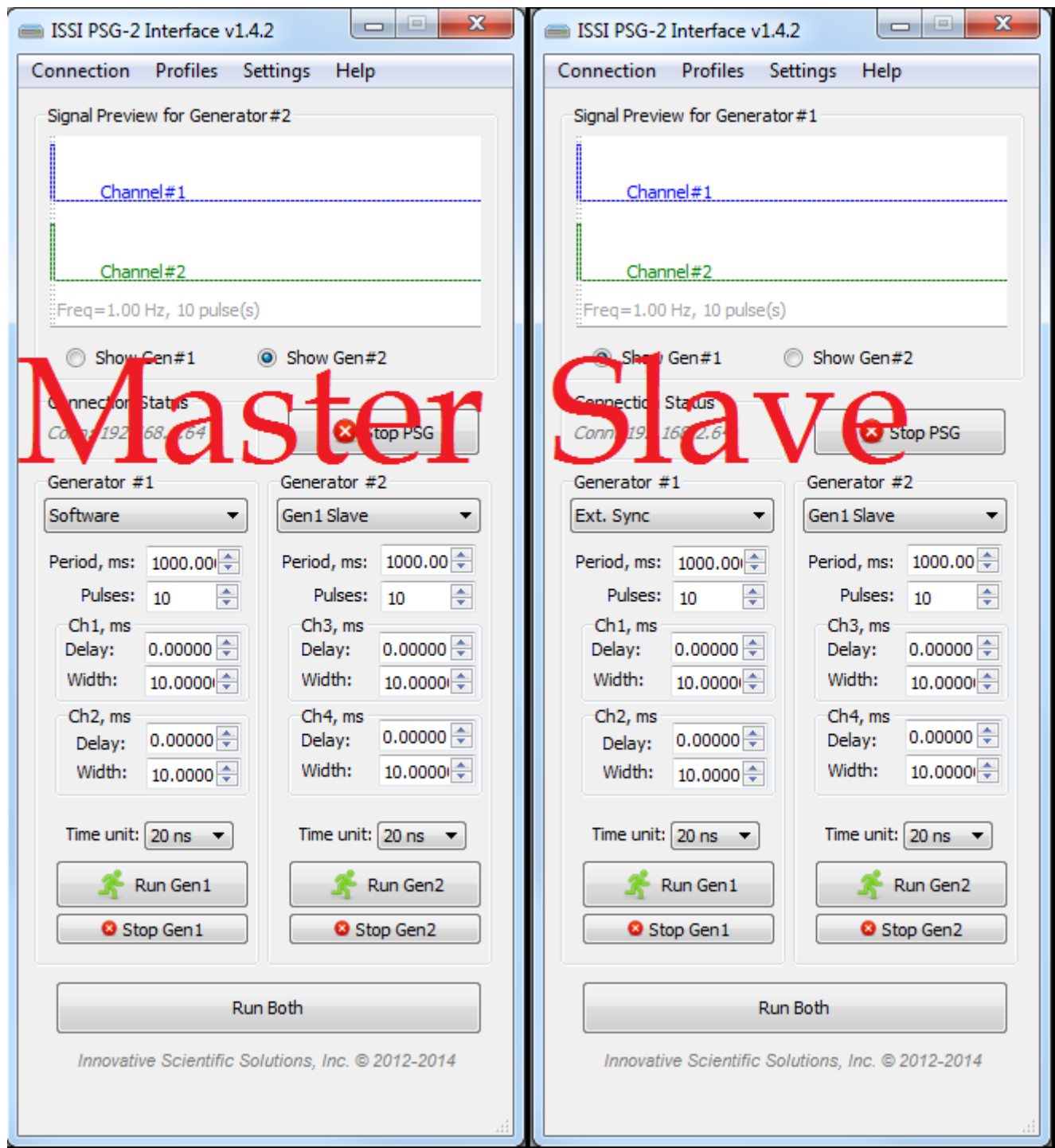
Connect to each PSG-2 via its IP address over Ethernet (by networking both PSG-2s). The master PSG-2 should be set up in '**Software**' mode for Generator #1 and Generator #2. The slave PSG-2 should be set up in '**Ext. Sync**' for Generator #1 and '**Gen 1 Slave**' for Generator #2. This means the

slave PSG-2 will take its start command from the '***EXT IN***' on the rear panel which is coming from the master PSG-2.

The delay between the output of two synchronized PSG-2s is shown on an oscilloscope with nominal delay ~20-ns between the two.

Firmware Upgrade

All that is needed is a USB Type-B cable, and PSG USB-drivers.

The procedure is simple:
1) Turn off PSG.
2) Push and hold *Test* button PSG and turn on PSG;
3) Wait 5 second, and release *Test* button;

Once the driver is installed ^^,
4) Run *flash_firmware_XXXX.cmd* file wait until it is finished (the name may change with version number);

5) Restart (by power) PSG;

If the firmware does not automatically run when the *flash_firmware_XXXX.cmd* file is run, open the command prompt and navigate to the folder where the file is saved. Then enter *flash_firmware_XXXX.cmd* into the command prompt window.

Important! This firmware will only upgrade the PSG logic, and will not change PSG time settings and network settings.

Dimensions

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