Pulse Streamer 8/2 Documentation

Release 2.0

Swabian Instruments

Oct 15, 2024

CONTENTS

CHAPTER

ONE

GETTING STARTED

1.1 Software installation

The *Pulse Streamer 8/2* does not require any driver installation. It uses a standard Ethernet interface for communication, so all drivers are already provided with your operating system. The only requirement is that the *Pulse Streamer 8/2* must be added to your network, see the *Network Connection* section for further information. Additionally, a direct connection to the network card of your PC is supported as well.

1.1.1 Client software

Please visit the Software Downloads section of our website and download the client and example files for any of the supported programming languages. Alternatively, the packages for Python, MATLAB and LabVIEW are available via the PyPI, MATLAB Add-on Explorer and VI Package Manager, respectively.

The MATLAB toolbox can be installed with MATLAB Add-on Explorer or by downloading and double-clicking the toolbox package file (Windows). The toolbox is compatible with MATLAB versions starting from 2014b.

The LabVIEW package installation requires free JKI VI Package Manager, which is often installed alongside LabVIEW. You can find the "Pulse Streamer" package in the community repository if you search for it in the VI Package Manager.

The Python module for Pulse Streamer can be installed either from the www.pypi.org with the following command

```
pip install pulsestreamer

# or if you want to use gRPC client then
# install the pulsestreamer with optional "grpc" support
pip install pulsestreamer[grpc]
```

or from a local package file using the command

```
pip install path/to/packagefile.whl
```

Replace `path/to/packagefile.whl` with the actual path of the package file.

1.1.2 Graphical User Interface

The Pulse Streamer Application provides basic configuration functionality and allows for the generation of simple signals.

1. Download and install the most recent Pulse Streamer Windows App from our downloads site.
2. Start the `Pulse Streamer` Application from the Windows start menu.
3. The GUI window should show up on your screen.

> **Note**
>
> If you have already installed Pulse Streamer App v1.0.2, you have to uninstall the old version before installing version >=v1.5.0.

1.2 Generate simple pulse pattern

This section shows a simple example of how to generate a simple signal on digital output channel "0" of the *Pulse Streamer 8/2*. The signal will consist of a single pulse, which is repeated an infinite number of times. While this example is extremely simple, it shows a very typical way of defining and generating various signals.

1.2.1 Client software

Python

MATLAB

LabVIEW

```python
# import API classes into the current namespace
from pulsestreamer import PulseStreamer, Sequence

# A pulse with 10µs HIGH and 30µs LOW levels
pattern = [(10000, 1), (30000, 0)]

# Connect to Pulse Streamer
ip = 'pulsestreamer'
ps = PulseStreamer(ip)

# Create a sequence object
sequence = ps.createSequence()

# Create sequence and assign pattern to digital channel 0
sequence.setDigital(0, pattern)

# Stream the sequence and repeat it indefinitely
n_runs = PulseStreamer.REPEAT_INFINITELY
ps.stream(sequence, n_runs)
```

```
% import API classes into the current namespace
import PulseStreamer.*
```

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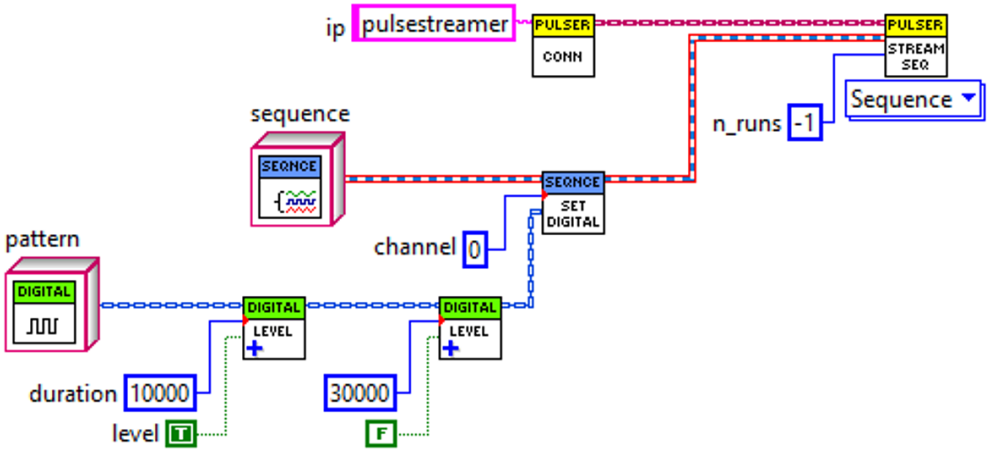
```
% A pulse with 10µs HIGH and 30µs LOW levels
pattern = {10000, 1; 30000, 0};

% Connect to Pulse Streamer
ip = 'pulsestreamer';
ps = PulseStreamer(ip);

% Create a sequence object
sequence = ps.createSequence();

% Assign pulse pattern to digital channel 0
sequence.setDigital(0, pattern);

% Stream the sequence and repeat it indefinitely
n_runs = PulseStreamer.REPEAT_INFINITELY; % endless streaming
ps.stream(sequence, n_runs);
```



Detailed information about the programming interface of the *Pulse Streamer 8/2* and the API can be found in the *Programming interface* section.

1.2.2 Graphical User Interface

After startup, the Pulse Streamer Application scans the network for connected Pulse Streamers and shows detailed information about all discovered devices.

If your device is not shown, make sure it is correctly connected to the network and press the `Auto Discover` button. Devices with firmware version v1.0.x can only be discovered with `Network Scan`.

1. Choose your device and click `Connect`.
2. On the right side, change the drop-down field `DIGITAL 0` from `Constant` to `Pulse`.
3. Set `Period` to 40,000 ns and `Duration` to 10,000 ns.
4. Click the `Play` button.

Note

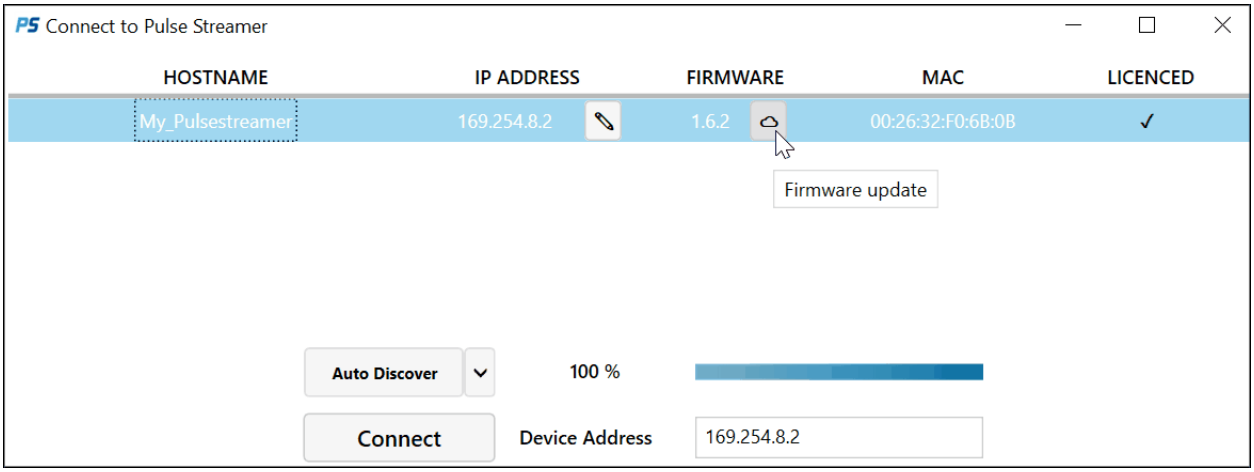


Fig. 1: Pulse Streamer Application: Start screen

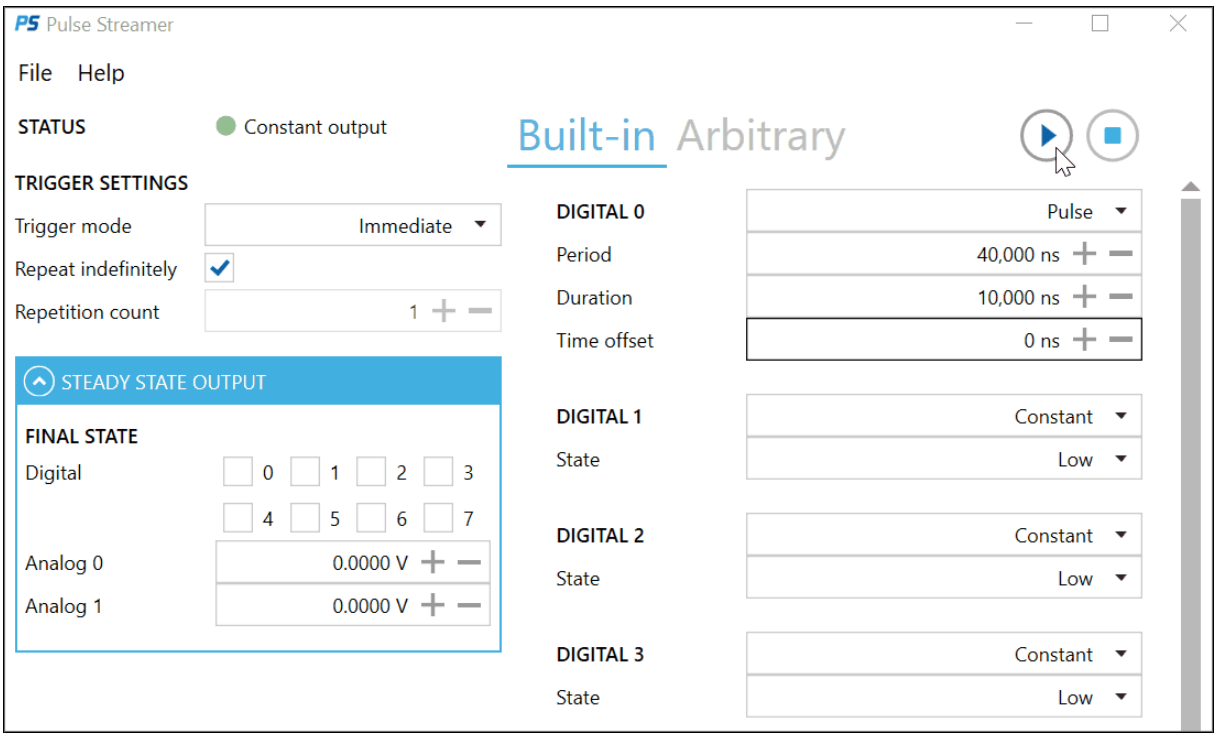


Fig. 2: Pulse Streamer Application: Sequence configuration

The Pulse Streamer Application provides easy-to-use device setup functionality, such as network configuration and firmware update. However, it currently offers only basic functionality concerning sequence generation and streaming. Essentially, it allows setting simple pulse repetitions or square waves for demonstration purposes. Particularly its capabilities of merging different channel patterns are limited. As a result, placing individual pulse patterns on different digital channels with only one or a few repetition counts will always preserve the desired frequencies (set via `Period`, `Time offset` and `Duration`) but might lead to deviation of the `Repetition count` set in the GUI window. We recommend using our API to benefit from the full functionality of the *Pulse Streamer 8/2*.

1.3 Firmware update

We recommend continuously updating all devices to our latest *Pulse Streamer 8/2* firmware. The Pulse Streamer GUI will inform you about available updates and guide you through the firmware update process. On the startup-screen with the listed devices, press the `Update firmware` button behind the field with the firmware version to open the firmware-updater-window and follow the further instructions.

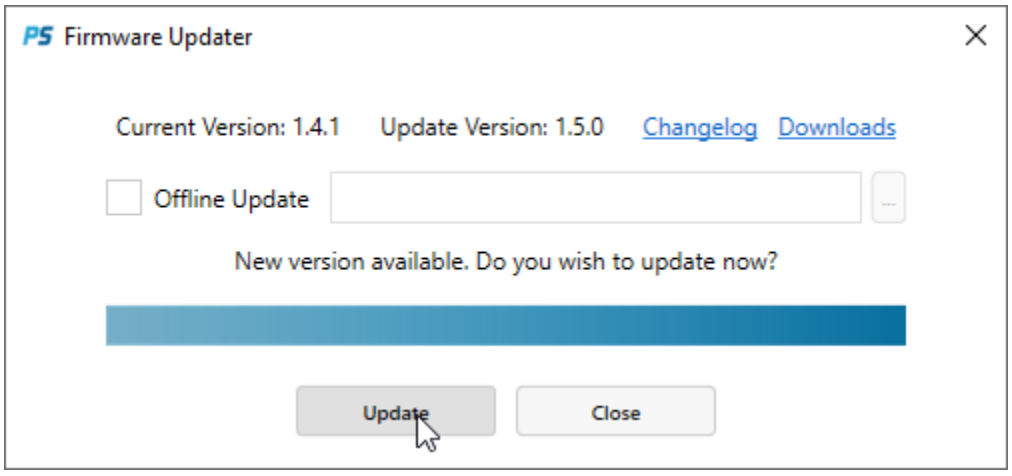


Fig. 3: Pulse Streamer Application: Firmware Updater

In case you need to update a device located in a network without internet access, you can manually download the updater file from our downloads site. After that, you can perform the firmware update process independently by using the offline mode and specifying the path to the updater.

If you face any problems or if your device is not equipped with firmware v1.0.1 or later, please contact support@swabianinstruments.com. We will provide a customized firmware update for you.

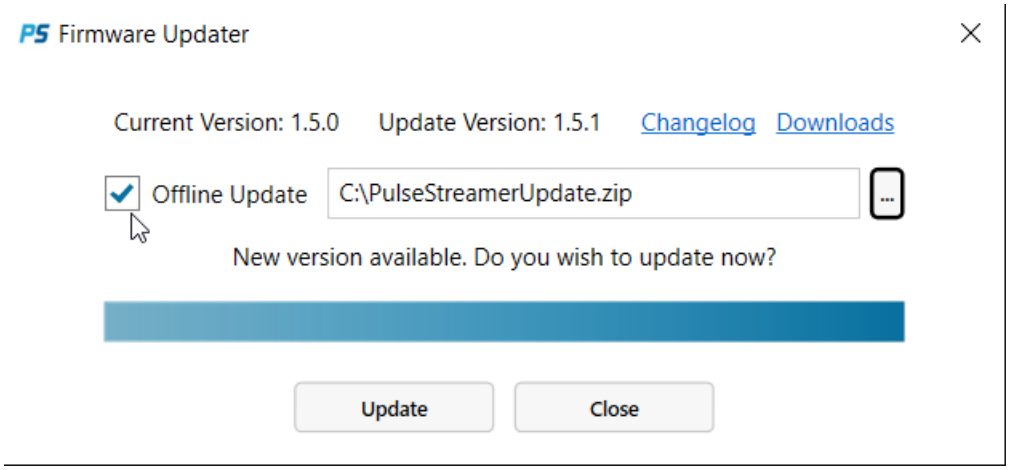


Fig. 4: Pulse Streamer Application: Firmware Updater offline mode

CHAPTER

TWO

HARDWARE

2.1 Output Channels

The *Pulse Streamer 8/2* has 8 digital and 2 analog output channels. The electrical characteristics are tabulated below.

2.1.1 Digital Output

Hardware Version 3.x

Hardware Version <= 2.x

Property	Value
Output into 50 Ohm	0 and 2.6 V
Output impedance[1]	~ 13 Ohm
Sampling rate	1 GHz
Rise/fall time (20%-80%)	< 300 ps
Minimum pulse width	2 ns
RMS jitter	< 50 ps

Property	Value
Output into 50 Ohm	0 and 3 V
Output impedance[1]	~ 5 Ohm
Sampling rate	1 GHz
Rise/fall time (20%-80%)	< 1.1 ns
Minimum pulse width	3 ns
RMS jitter	< 50 ps

[1] The *Pulse Streamer 8/2* expects a 50 Ohm termination to avoid reflections. All output voltages assume the 50 Ohm load termination. Without a termination, you will get a slightly higher output voltages due to the output impedance being greater than 0 Ohm.

2.1.2 Analog Output

Hardware Version 3.x

Hardware Version 3.1/3.0

Hardware Version <= 2.x

Property	Value
Sampling rate	125 MHz
Output into 50 Ohm	-1.0 to 1.0 V
Output impedance[Page 7, 1]	~ 2 Ohm
Bandwidth (-3db)	50 MHz
Resolution	14 bit
Offset error (into 50 Ohm load)	< 2 mV
Gain error (into 50 Ohm load)	< 1 %
Rise/fall time (20%-80%)	< 7 ns
Step response overshoot (typ.)	25 %
Output settling time (1%)	< 100 ns
Crosstalk (analog)	< -45 dB
Crosstalk (digital)	< -55 dB

Property	Value
Sampling rate	125 MHz
Output into 50 Ohm	-1.0 to 1.0 V
Output impedance[Page 7, 1]	~ 2 Ohm
Bandwidth (-3db)	50 MHz
Resolution	14 bit
Offset error (into 50 Ohm load)	< 2 mV
Gain error (into 50 Ohm load)	< 1 %
Rise/fall time (20%-80%)	< 7 ns
Step response overshoot (typ.)	25 %
Output settling time (1%)	< 100 ns
Crosstalk (analog)	< -45 dB
Crosstalk (digital)	< -55 dB

Warning

Around 20 s after power-cycling, the analog outputs have a short pulse (duration ~30 ns) with a voltage level of -0.5 V.

Property	Value
Sampling rate	125 MHz
Output into 50 Ohm[2]	-1.0 to 1.0 V
Output impedance[Page 7, 1]	~ 2 Ohm
Bandwidth (-3db)	50 MHz
Resolution	14 bit
Accuracy[3]	±5 mV
Rise/fall time (20%-80%)	< 7 ns
Crosstalk (analog)	< -45 dB
Crosstalk (digital)	< -55 dB

Note

Warning

During power-up, the analog outputs have an undefined output voltage value in the range of -1V to 1V.

Note

2.2 Trigger Input

The *Pulse Streamer 8/2* has one external trigger input, which can be enabled by software. By default, the Pulse Streamer is automatically rearmed after a sequence with a finite number of *n_runs* has finished. The sequence can be retriggered after the sequence has finished and the retrigger dead-time has passed. Triggers that arrive too early are discarded. Information about how to configure the trigger functionality of the *Pulse Streamer 8/2* can be found in the *Running pulse sequences* section

Electrical characteristics:

Hardware Version 3.4

Hardware Version <= 3.3

Hardware Version 2.x

[2] Some devices may have a reduced actual full range, smaller by up to 30 mV.

[3] Accuracy is specified with a 50 Ohm load. *Pulse Streamer 8/2* devices shipped with firmware version v1.3.0 or later include calibration data for the analog outputs. Devices with earlier firmware versions require calibration to achieve the specified accuracy. You can perform the calibration yourself. Please follow the instructions in the *Calibrating the analog outputs* section.

Property	Value
Termination	50 Ohm
Max. voltage range (no damage)	-0.3 to 5.3 V
Input voltage range	0 to 5 V
Trigger level	0.5 V
Minimum pulse width (rising/falling)[4]	4 ns
TriggerToData (rising/falling, typ.)[4]	65/66 ns
TriggerToData jitter	±4 ns
Retrigger dead-time[6]	< 50 ns

Note

Property	Value
Termination	50 Ohm
Max. voltage range (no damage)	-0.3 to 5.3 V
Input voltage range	0 to 5 V
Trigger level	0.5 V
Minimum pulse width (rising/falling)[5]	4/8 ns
TriggerToData (rising/falling, typ.)[5]	65/68 ns
TriggerToData jitter	±4 ns
Retrigger dead-time[6]	< 50 ns

Note

Property	Value
Termination	50 Ohm
Max. voltage range (no damage)	0 to 3.3 V
Input voltage range	0 to 3.3 V
Low-level range	0 to 0.8 V
High-level range	2.0 to 3.3 V
Minimum pulse width	< 2 ns
TriggerToData (typ.)	60 ns
TriggerToData jitter	±4 ns
Retrigger dead-time[6]	< 50 ns

Note

[4] Measured with a trigger signal amplitude of 0 to 2.6 V
[6] The minimum time gap required between the end of the streamed sequence to trigger the next sequence.
[5] Measured with a trigger signal amplitude of 0 to 2.6 V

2.2.1 TriggerToData

The trigger to data delay depends on the phase of the incoming trigger event relative to the clock of the *Pulse Streamer 8/2* (125 MHz). The trigger to data signal path exhibits, in the default case (internal clock signal) a delay that is equally distributed between 61 and 69 ns as shown in the following figure.

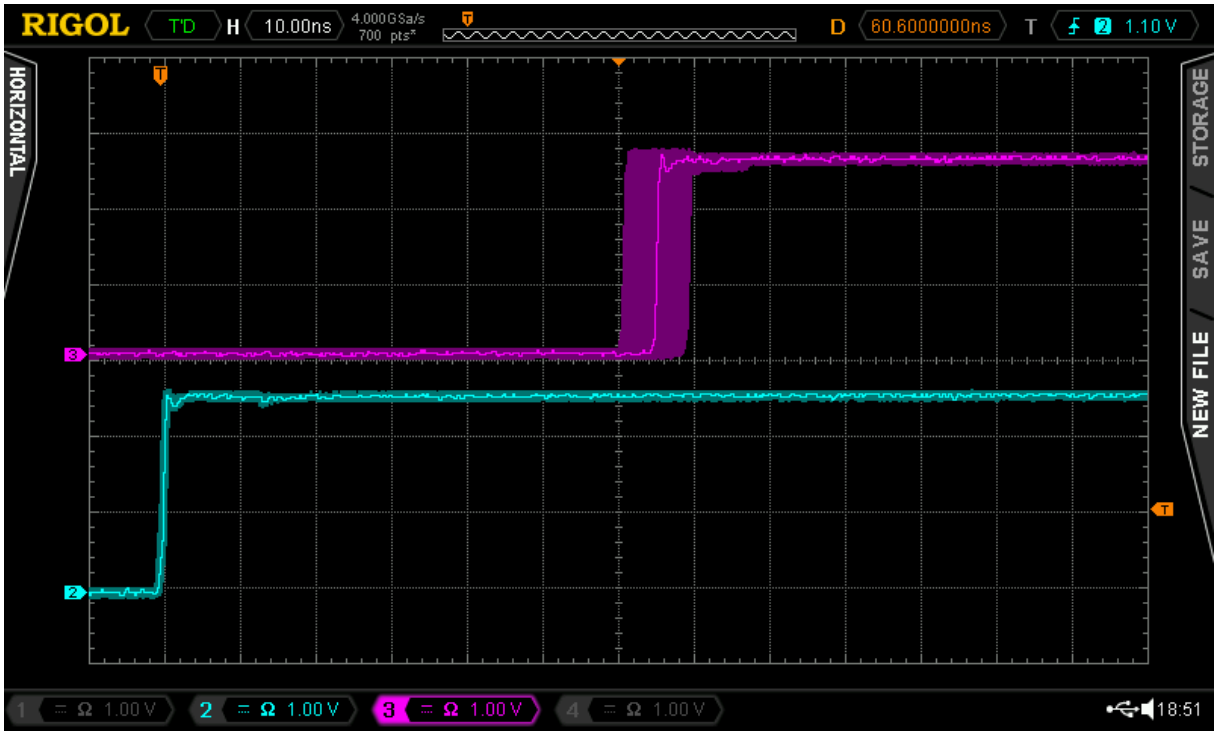


Fig. 1: TriggerToData: Trigger signal (bottom) and the data-out signal range (top)

The reason for this distribution is that all output clocks are derived from the *Pulse Streamer 8/2* clock signal (125 MHz). The positive clock edge samples the trigger events, resulting in an accuracy of 8 ns. This situation is visualized in the following figure.

How to avoid the TriggerToData jitter

One way to circumvent the TriggerToData jitter is to use the *Pulse Streamer 8/2* as a master device. When the other devices have a lower TriggerToData jitter, this can solve the issue.

Another possibility is to phase-align the the *Pulse Streamer 8/2* clock and the trigger signals.

2.2.2 Synchronization of Trigger and Pulse Streamer 8/2 clock

The jitter of the TriggerToData can be avoided by phase aligning the trigger signal with the *Pulse Streamer 8/2* clock. You can achieve synchronization by using the external 125 MHz clock input capability of the *Pulse Streamer 8/2* (see *Using an external clock*). All internal clocks related to the *Pulse Streamer 8/2* output stages will be derived from the signal fed to the clock input.

If the external trigger and the clock of the *Pulse Streamer 8/2* are phase-aligned, it will lead to a fixed TriggerToData value between 61-69 ns. The exact value depends on the trigger's phase position relative to the positive edge of the clock signal, as shown in the following figure:

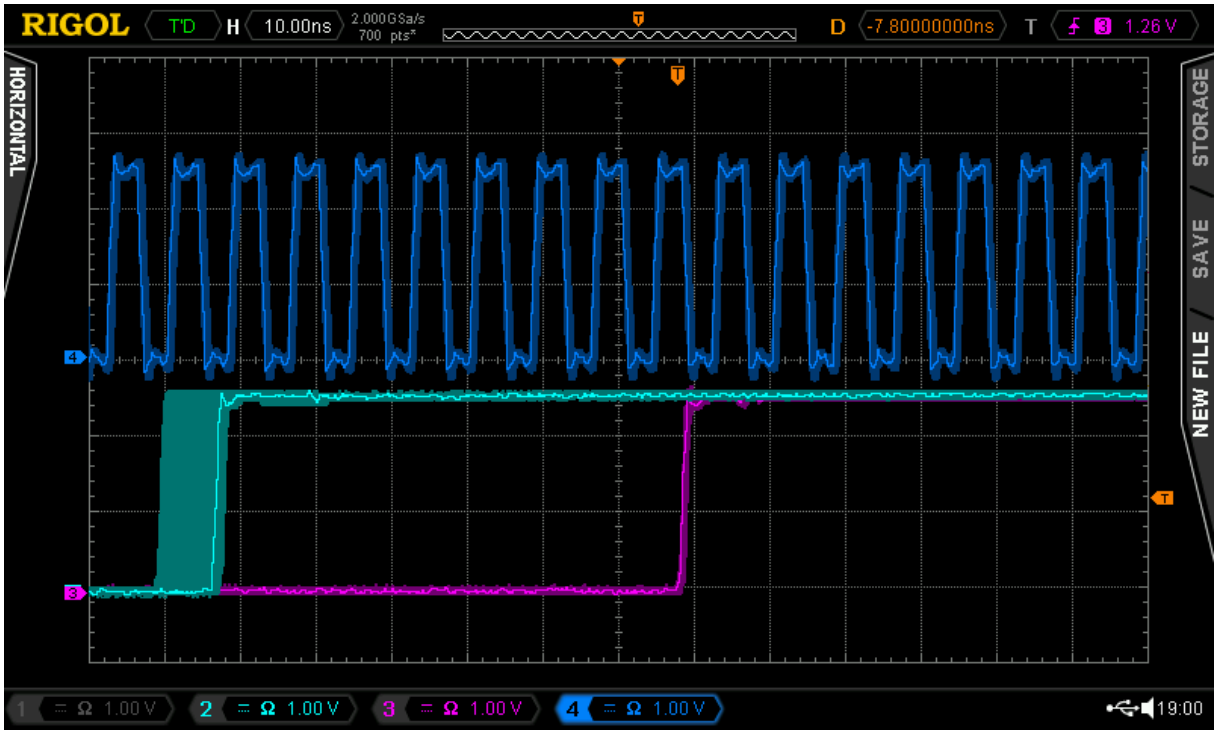


Fig. 2: *Pulse Streamer 8/2* clock signal (top, 125MHz), trigger signal (bottom left) and the data-out signal range (bottom right)

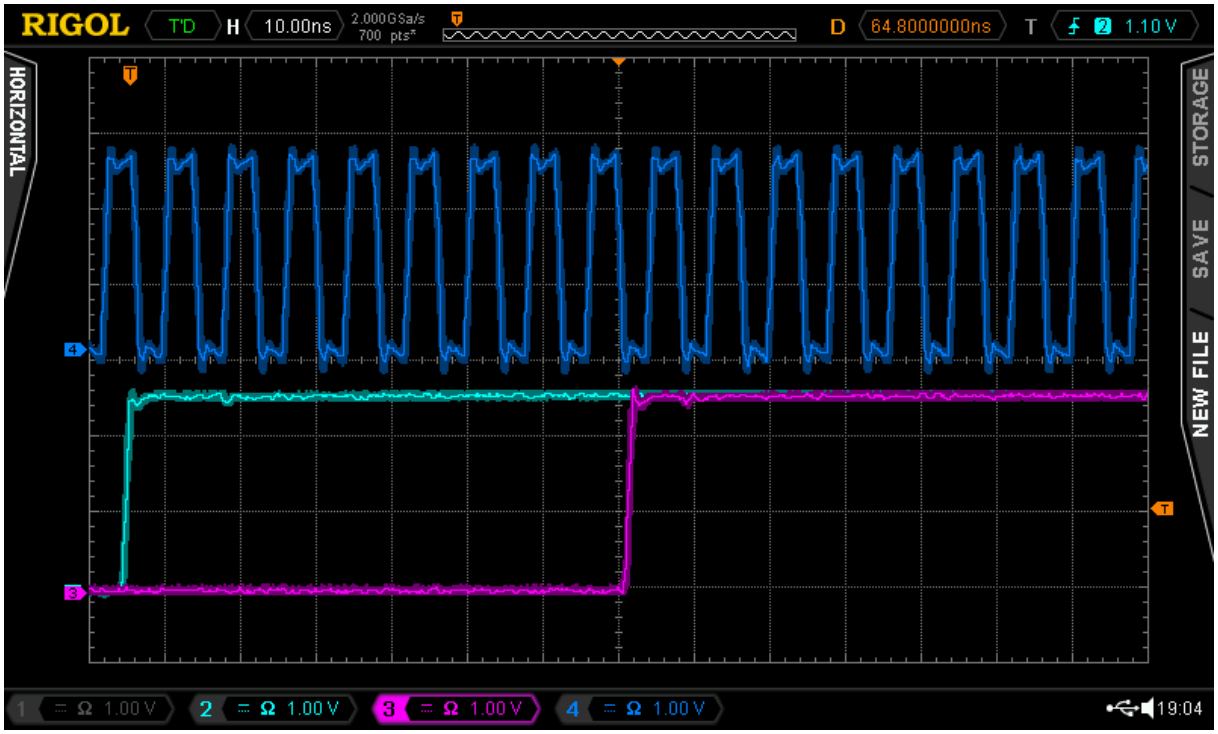


Fig. 3: *Pulse Streamer 8/2* clock (top, 125MHz), trigger signal (bottom left) and the data-out signal range (bottom center)

Note

When the trigger is exactly at the position of the sampling clock, the TriggerToData of each trigger will be randomly either +0 ns or +8 ns, as illustrated in the figure below:

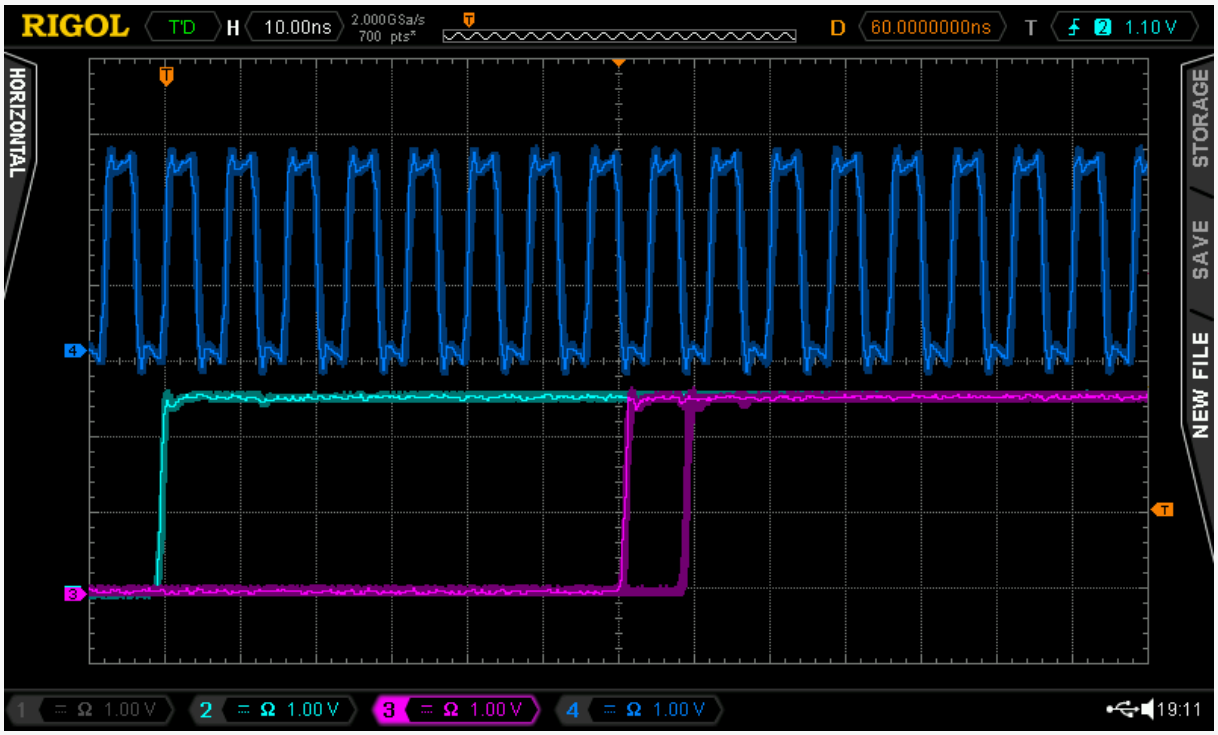


Fig. 4: Clock signal (top), trigger signal (bottom left) at the critical position with dt=0 showing the discrete 8 ns output jitter (bottom right)

When this situation occurs, please shift your signal ideally by half the clock period (4 ns), for example, by using a longer or shorter cable on the clock or trigger signal line.

Note

In case you are using a 10 MHz external reference clock for the *Pulse Streamer 8/2*, phase alignment with the 125 MHz clock is not possible.

2.3 External Clock Input

The *Pulse Streamer 8/2* has one input that can receive an external 125 MHz or 10 MHz reference clock. Further information about how to set the clock source of the Pulse Streamer can be found in the *Using an external clock* section.

Electrical characteristics:

Hardware Version 3.x

Hardware Version 2.x

Hardware Version <= 2.1

Property	Value
Termination	50 Ohm
Coupling	AC coupled
Amplitude range	0.2 - 5 Vpp
Accepted frequencies	10 or 125 MHz

Property	Value
Termination	50 Ohm
Input voltage range	0 to 3.3 V
Low-level range	0 to 0.8 V
High-level range	2.0 to 3.3 V
Accepted frequencies	10 or 125 MHz

Warning

Due to hardware limitations, there is a 100 mV ripple on the digital outputs if an external clock source is connected to the *Pulse Streamer 8/2*. The analog channels are not affected.

Property	Value
Termination	50 Ohm
Input voltage range	0 to 3.3 V
Low-level range	0 to 0.8 V
High-level range	2.0 to 3.3 V
Accepted frequencies	10 or 125 MHz

Warning

Due to hardware limitations, there is a 100 mV ripple on the digital outputs if an external clock source is connected to the *Pulse Streamer 8/2*. The analog channels are not affected.

Note

These hardware revisions of the *Pulse Streamer 8/2* have ambiguous labeling on the input ports. The correct input port for the external clock is the second one on the left side labeled either ***GP In*** or ***SlowDigital 1***.

2.4 Status LEDs

The *Pulse Streamer 8/2* has two LEDs that provide information about the status of the device and the network connection.

Device status LED:

green	Pulse Streamer successfully booted
blinking green-orange	sequence is streaming
orange	waiting for trigger/retrigger
blue	sequence finished - retrigger disabled
blinking yellow/white (slow)	wait in idle state
blinking green-white	wait while repeating
blinking red/white	expected data did not arrive in time
blinking blue	no valid license
continuous red	general error

Network LED:

red	no configuration/connection
blinking green-red	setting DHCP - no connection
green	setting DHCP - connection found
blinking blue-red	setting static IP - no connection
blue	setting static IP - connection found

CHAPTER

THREE

NETWORK CONNECTION

To communicate with the *Pulse Streamer 8/2*, you need to know its IP address. By default, the device will attempt to acquire an IP address via DHCP. There is also a preconfigured second permanent IP address that allows direct connection to the PC, see *Permanent Static IP*.

```
# Example:
#  using default hostname
ps = PulseStreamer('pulsestreamer')

#  using fallback IP
ps = PulseStreamer('169.254.8.2')
```

Starting from the Pulse Streamer firmware v1.2, you can discover all accessible Pulse Streamers in the network and their IP addresses using *findPulseStreamers()*.

```
# Example
# query the network for all connected Pulse Streamers
devices = findPulseStreamers()

# query the network for a Pulse Streamer with specific serial number
devices = findPulseStreamers("00:26:32:F0:3B:1B")
```

3.1 Assign a static IP with the MAC address and DHCP

You can configure your DHCP server or router to assign a static DHCP IP to the MAC address of the *Pulse Streamer 8/2*. This ensures that you know the IP that the *Pulse Streamer 8/2* will receive by DHCP. You find the MAC address of your *Pulse Streamer 8/2* on the bottom label of the device. It is the same as the serial number.

To verify your network configuration, open a terminal and enter:

```
[user@host~] arp

Address                  HWtype  HWaddress           Flags Mask            Iface
192.168.1.108            ether   00:26:32:f0:09:30   C                     wlp1s0
router                   ether   18:83:bf:c1:1f:67   C                     wlp1s0
```

In this example, the first line corresponds to the *Pulse Streamer 8/2*, and the second line corresponds to the router.

3.2 Permanent static IP: 169.254.8.2

The *Pulse Streamer 8/2* is always reachable via a permanent second static IP-address 169.254.8.2 (netmask 255.255.0.0). This address allows you to establish a connection when the *Pulse Streamer 8/2* is connected directly to your computer with an Ethernet cable. This should work out-of-the-box on both Windows and Linux (Linux requires Avahi/zeroconf). In some cases, however, you may need to reboot your computer to detect the *Pulse Streamer 8/2*, if there has been a DHCP-connection before.

3.3 Modify the network settings

By default, the *Pulse Streamer 8/2* will attempt to acquire an IP address via DHCP. If you want to assign a specific IP address to your device, you can disable DHCP and configure a static IP instead. We recommend using our Pulse Streamer Application (Windows only) to modify the *Pulse Streamer 8/2* network configuration. The graphical user interface will guide you through the network configuration. You can enable/disable DHCP and set a specific IP address, netmask, and default gateway for a static IP configuration. You can test the new network settings before deciding to apply the configuration permanently in a second step.

Requirements:

- network access to your *Pulse Streamer 8/2* (at least via permanent static fallback 169.254.8.2)
- Pulse Streamer firmware version 1.5.0 or later
- Pulse Streamer Application Software Downloads

Configuring the network settings:

1. On the startup-screen with the listed devices, click the button `Edit network configuration` behind the IP-address field.
2. Choose your settings in the pop-up window.
3. Click `Test Settings` to check if the device is reachable via the new settings (power-cycling resets the changes).
4. Click `Apply` to set the configuration permanent.

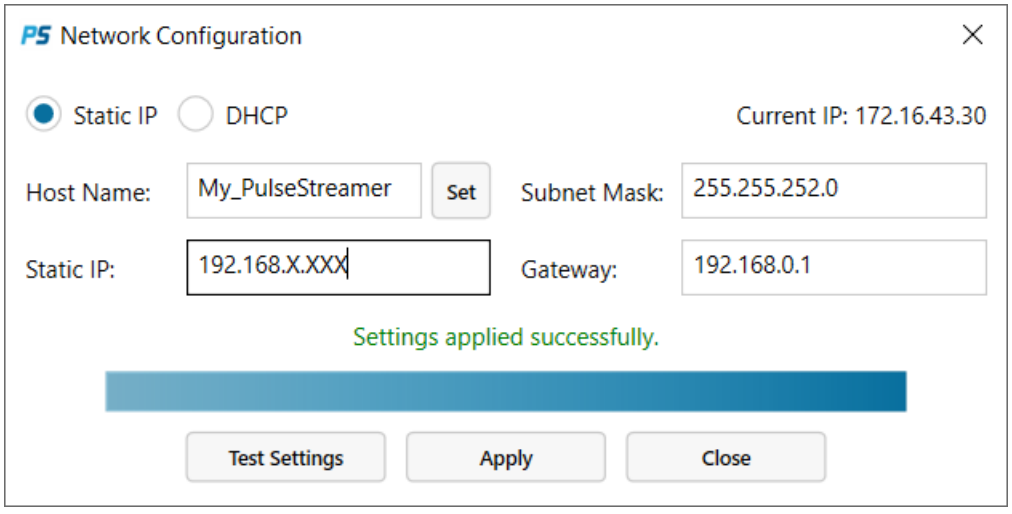


Fig. 1: Pulse Streamer Application: Network Configuration

Alternatively, you can configure the device's network settings via our client software interfaces. For more information, see the *Modify the network configuration* section.

3.3.1 Troubleshooting

If there are issues with the network connection of your Pulse Streamer, you can use the debug mode of the Pulse Streamer Application.

1. Start `Pulse Streamer (Debug mode)` from the Windows start menu. In debug mode, the Pulse Streamer Application will create a log file on your desktop containing information about your network settings and debug information for the Pulse Streamer GUI.

This information can help to determine incompatible network settings. If you want to alter the path of the log file, you can also start the Pulse Streamer Application from the command line. Please type

```
path/to/PulseStreamerApplication.exe /log path/to/logfile
```

Replace `path/to/PulseStreamerApplication.exe` with the actual path of the Pulse Streamer Application executable (e.g. "C:Program Files (x86)Swabian InstrumentsPulse StreamerPulseStreamer.exe") and `path/to/logfile` with your favoured destination for the log file.

For assistance with the network configuration, please contact support@swabianinstruments.com.

CHAPTER

FOUR

PROGRAMMING INTERFACE

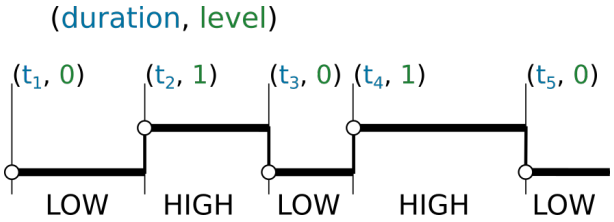
4.1 Overview

This section defines terminology used in this documentation and provides an overview of how signals can be generated with the Pulse Streamer API.

4.1.1 Pulse pattern

The pulse pattern is a sequence of levels, defining the signal to generate. It is defined as an array of *(duration, level)* tuples, in other words, using Run-Length Encoding (RLE). In contrast to defining pulse patterns as an array of values with equal time durations, the RLE encoded pattern is more memory efficient, especially for patterns that consist of levels of both short and long durations.

The *duration* is always specified in nanoseconds. The *level* is either 0 or 1 for digital output or a real number between -1 V and +1 V for analog outputs. See the *Hardware* section for more details on the electrical properties of the generated signals.



The following code shows how to define a pulse pattern similar to the one shown in the figure above. In addition, it shows an example of an analog pattern definition.

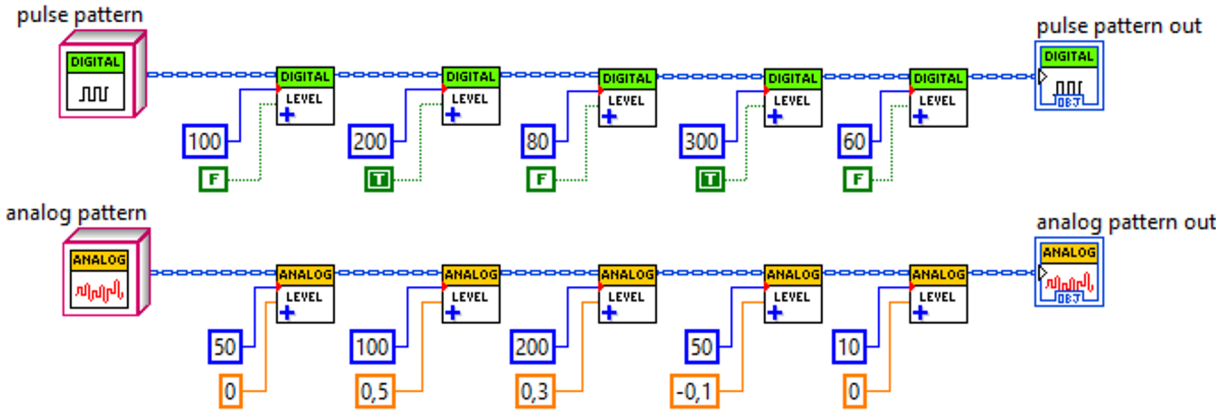
Python

Matlab

LabVIEW

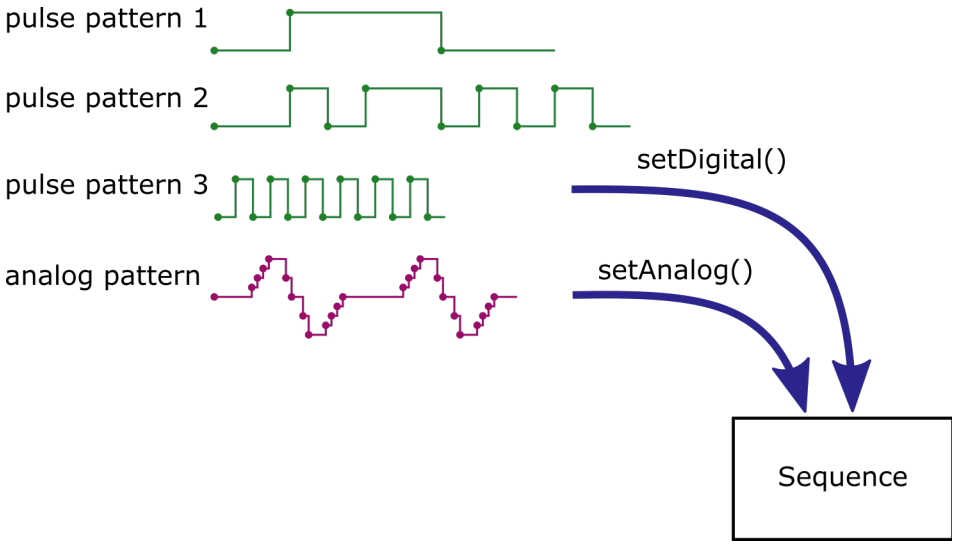
```
pulse_patt = [(100, 0), (200, 1), (80, 0), (300, 1), (60, 0)]
analog_patt = [( 50, 0), (100, 0.5), (200, 0.3), (50, -0.1), (10, 0)]
```

```
pulse_patt = {100, 0; 200, 1; 80, 0; 300, 1; 60, 0};
analog_patt = {50, 0; 100, 0.5; 200, 0.3; 50, -0.1; 10, 0};
```



4.1.2 Creating sequences

Before a pattern can be sent for streaming to the Pulse Streamer outputs, they have to be mapped to the output channels. All these steps are performed with the *Sequence* object, which is created with *PulseStreamer.createSequence()*. The digital and analog channel assignment is done with the *setDigital()* and *setAnalog()* methods, respectively.



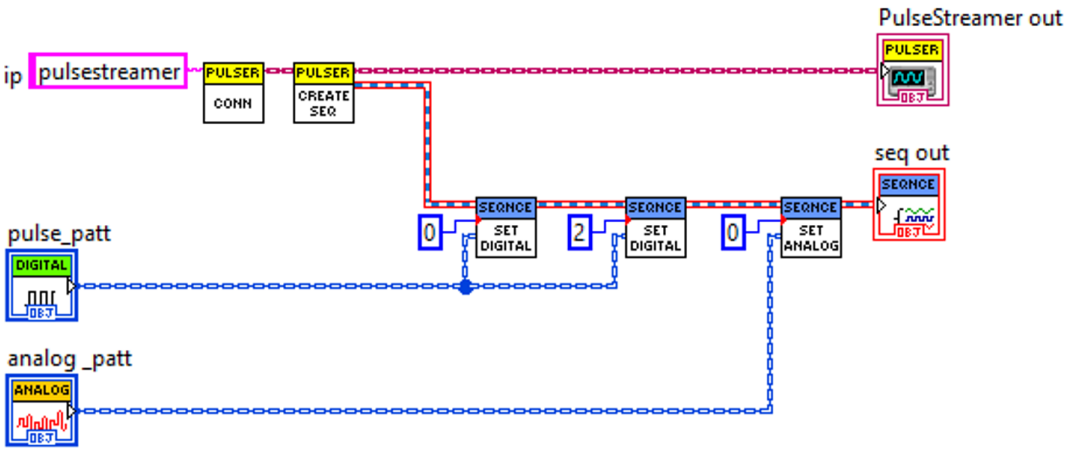
Python

Matlab

LabVIEW

```
from pulsestreamer import PulseStreamer

ps = PulseStreamer('pulsestreamer')

seq = ps.createSequence()
seq.setDigital(0, pulse_patt)
seq.setDigital(2, pulse_patt)
seq.setAnalog(0, analog_patt)
```

```
import PulseStreamer.PulseStreamer;

ps = PulseStreamer('pulsestreamer');

seq = ps.createSequence();
seq.setDigital(0, pulse_patt);
seq.setDigital(2, pulse_patt);
seq.setAnalog(0, analog_patt);
```



4.1.3 Sequence transformation

Sequence transformation methods enable the creation of complex sequences from simpler sub-sequences. The sequence data can be repeated or combined with another sequence. These operations, while inherently simple, have a few edge cases that are important to know. Concatenation and repetition operations are non-destructive, meaning that they preserve original sequence objects (immutability). The result is stored in a newly created sequence object. Internally, the sequence stores a map of the channel number and the pattern data with the pattern data left unmodified. In general, this results in a sequence that consists of patterns having different durations. On concatenation or repetitions, however, it is intuitively expected that a sequence is treated as a solid unit with every pattern of the same duration. Therefore, before concatenating the sequence data, the pattern durations are padded to the common duration.

When two sub-sequences being concatenated have a different set of mapped channels, the resulting sequence will include them all. This is explained in the following example. Let's assume we have two sequences, *seq1* and *seq2*, which we want to concatenate. The *seq1* has patterns mapped to channels *(0,2)*, and *seq2* has channels *(0,1)*, as shown in the code below.

Python

Matlab

LabVIEW

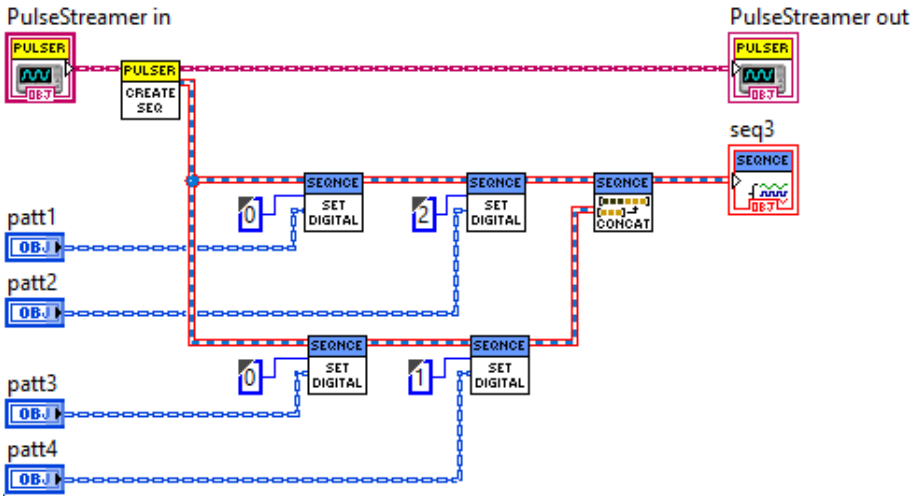
```
seq1 = ps.createSequence()
seq1.setDigital(0, patt1)
seq1.setDigital(2, patt2)

seq2 = ps.createSequence()
seq2.setDigital(0, patt3)
seq2.setDigital(1, patt4)
```

(continues on next page)

(continued from previous page)

```
seq3 = seq1 + seq2    # concatenation
```

```
seq1 = ps.createSequence();
seq1.setDigital(0, patt1);
seq1.setDigital(2, patt2);

seq2 = ps.createSequence();
seq2.setDigital(0, patt3);
seq2.setDigital(1, patt4);

seq3 = [seq1, seq2];   % concatenation
```



During the concatenation, the channel lists of the two sequences are compared and the output sequence *seq3* will include them all *(0,1,2)*. As a first step, a new sequence object *seq3* will be created as a copy of *seq1*, and an empty pattern will be assigned to the channel *1*. Next, all patterns in *seq3* will be padded to the duration of the longest one, which is essentially the sequence duration. Finally, the pattern data from *seq2* will be appended to the corresponding patterns of the *seq3*.

The duration padding is always performed with the value of the last element in the pattern. When there is no previous element, the default value is used. The repetition process behaves similarly and can be qualitatively understood as multiple concatenations of the object with itself.

4.1.4 Streaming

Now, any of the sequence objects created above can be sent for streaming by calling the *PulseStreamer.stream()* method, as shown in the following example for the sequence *seq*.

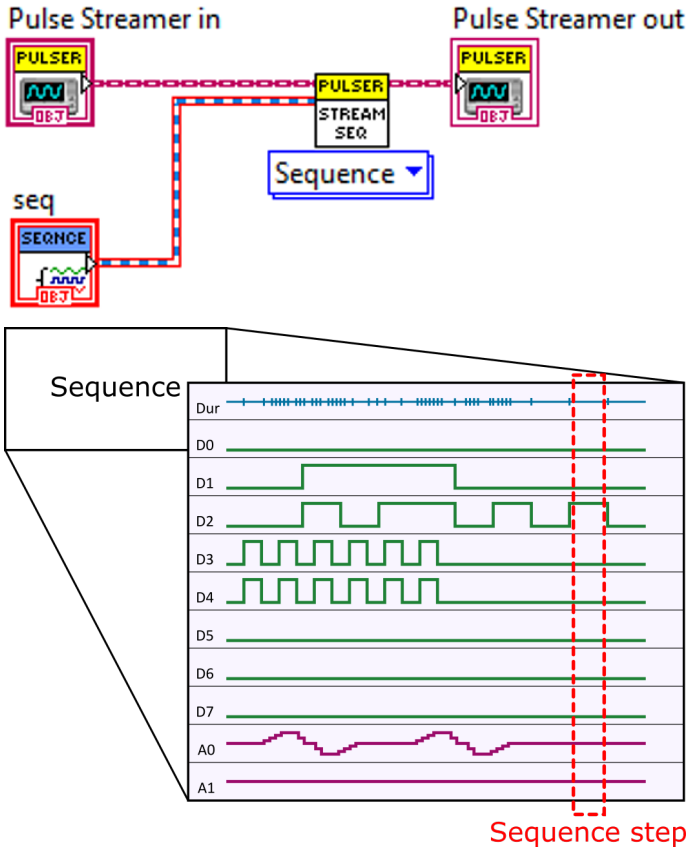
Python

Matlab

LabVIEW

```
ps.stream(seq)
```

```
ps.stream(seq);
```



On streaming, the sequence object is converted to a hardware-specific run-length encoded data block, which can be understood as an array of *Sequence steps*. Every step defines the state of all channels and the duration to hold the state. Sequences support a number of useful methods, like repetition, concatenation, preview plotting, etc. With this basic set of methods, complex sequences can be built from smaller and simpler sub-sequences.

Note

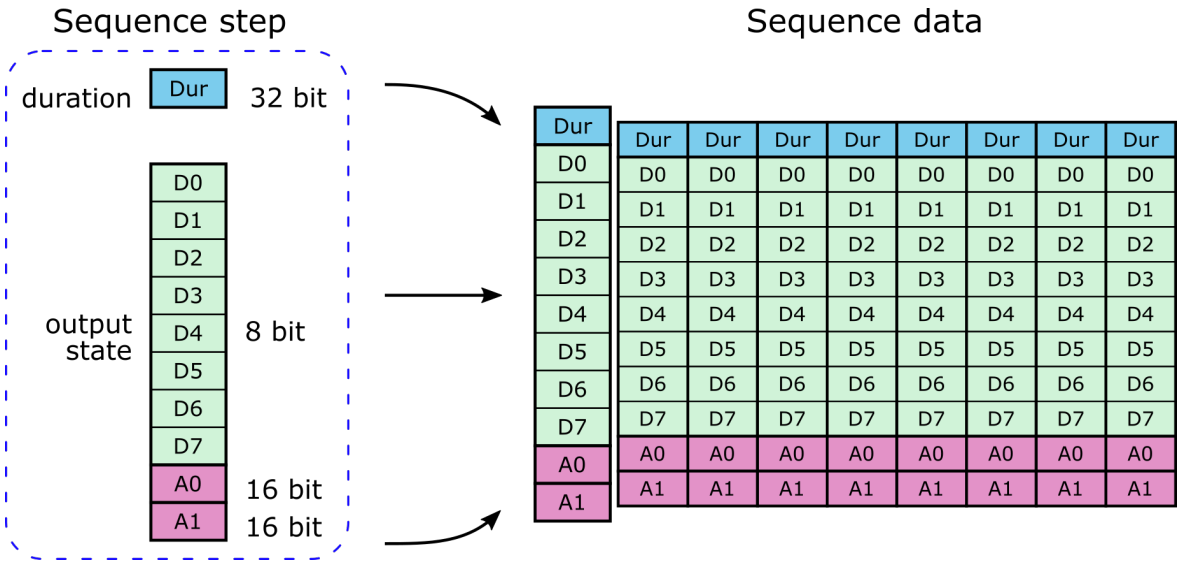
Internally, the Pulse Streamer hardware always splits the sequence data into 8 nanosecond long chunks. When a sequence is shorter than 8 ns or its length is not an exact multiple of 8 ns the extra time will be padded to complete the last chunk. You can observe the effects of such padding if you try to stream a short pulse repetitively.

Example 1. Your sequence consists of a 3 ns high-level and a 2 ns low-level and you stream it with infinite repetitions, the resulting signal will have 3 ns high-level but 5 ns low-level. Therefore, the actual pulse frequency will be 125 MHz instead of 200 MHz. For continuous periodic signals, you can solve this problem by creating a sequence of repetitive pulses that has a duration which is multiple of 8 ns. One easy way to guarantee that sequence duration is a multiple of 8 ns is to repeat it 8 times using `Sequence.repeat()` method, which will repeat the sequence data in PC memory before sending it to the Pulse Streamer hardware.

Example 2. You want to stream a sequence that is 12345 ns long and you want to repeat it infinitely by setting *n_runs=-1*. Since this sequence duration is not a multiple of 8 ns (12345 ns / 8 ns = 1543.125) the Pulse Streamer will allocate 1544 chunks, and the actual sequence duration will be 1544 * 8 ns = 12352 ns, or 7 ns longer.

4.1.5 Sequence step

The sequence step is the smallest element of a sequence that contains information on the state of every output of the *Pulse Streamer 8/2* and the *duration* for holding this state. The image below explains the relation between *Sequence step*, `Sequence`, and `OutputState` objects.



Warning

In a typical use of the client API, the user does not have to worry about how to create or operate on the sequence data directly. All necessary functionality is enclosed within the API presented in this article. The description of the *Sequence data* corresponds to the RAW data as it is required by the hardware. The internal API data structures are implemented slightly differently for each programming language, aiming at the optimization of the client performance. Furthermore, the RAW sequence data format is hardware-dependent and future Pulse Streamer models are likely to use a different format. See also: interface.

4.2 Module level functions

findPulseStreamers(*search_serial=''*)

Parameters
search_serial (*str*) – Pulse Streamer serial number as a string.

Returns
List of `DeviceInfo` objects.

This function searches and returns basic information about discovered Pulse Streamers. If non-empty *search_serial* string is provided, then information is returned only for a specific *Pulse Streamer 8/2* unit.

The returned value is a list of `DeviceInfo` objects containing the IP address and basic information.

class DeviceInfo

This class contains read-only information about the discovered *Pulse Streamer 8/2*.

Property name	Example data	Description
ip	“192.168.0.2”	Device IP address
serial	“00:26:32:f0:3b:1b”	Device serial number
hostname	“pulsestreamer”	Pulse Streamer hostname
model	“Pulse Streamer 8/2”	Pulse Streamer model name
fpgaid	“123456789ABCD”	FPGA ID number
firmware	“1.2.0”	Firmware version
hardware	“1.3”	Hardware version

The discovery algorithm sends Pulse Streamer specific query packets over all available and active network interfaces and listens for responses from the connected Pulse Streamers.

Note

The *findPulseStreamers()* is capable of finding the devices and reporting their IP addresses even in the networks without dynamic IP assignment by a DHCP server or an improper IP address configuration. Therefore, it might happen that the reported *Pulse Streamer 8/2* IP is not accessible from your network. For example, when the reported IP is *169.254.8.2* (static fallback) and your PC is configured as *192.168.1.2*, you will not be able to connect to the *Pulse Streamer 8/2*. This is due to the way IP networks operate. However, you will still be able to discover this *Pulse Streamer 8/2* and learn its IP, which is very helpful for identifying network connection problems.

4.3 PulseStreamer

The *PulseStreamer* class is a wrapper for the RPC interface provided by the Pulse Streamer hardware. It handles the connection to the hardware and exposes all available methods. This class is implemented in various supported programming languages with consistently named methods. However, in some languages, additional functionality common to that language is also implemented, such as callback functions in MATLAB.

class PulseStreamer

PulseStreamer(*ip*)

The class constructor accepts a single string argument, which can be either the IP address or a hostname through which the *Pulse Streamer 8/2* can be reached on the network. The constructor fails if the *ip* has an incorrect value or the device is not reachable. The Pulse Streamer hardware has a static fallback address “169.254.8.2”, which allows operation when the *Pulse Streamer 8/2* is directly connected to a PC network card without requiring any additional configuration.

Parameters
ip (*str*) – IP address or hostname of the *Pulse Streamer 8/2*.

reset()

Resets the *Pulse Streamer 8/2* device to the default state. All outputs are set to 0 V, and all functional configurations are set to default. The automatic rearm functionality is enabled, and the clock source is the internal clock of the device. No specific trigger functionality is enabled, which means that each sequence is streamed immediately when its upload is completed.

reboot()

Performs a soft reboot of the device without power cycling.

createSequence()

Creates a new hardware-specific *Sequence* object. A hardware-specific sequence object has the same functionality as *Sequence* and implements early checks for hardware limits. For example, an attempt to assign a pattern to a non-existing channel or to set analog voltage outside the DAC range will result in an error. The generic *Sequence* object's normal behavior is to check hardware limits only when calling the *PulseStreamer.stream()* method.

Returns

Hardware-specific *Sequence* object.

4.3.1 Setting constant output state

PulseStreamer.**constant**(*state=OutputState.ZERO*)

Sets the outputs to a constant state. Calling the method without a parameter will result in the default output state with all outputs set to 0 V. If you set the device to a constant output, any currently running streamed sequence is stopped. It is not possible to retrigger the last streamed sequence after setting the Pulse Streamer constant. *OutputState.ZERO* is a constant equal to `OutputState([],0,0)`.

Alternatively, the *state* parameter can be specified as a tuple consisting of three elements `([],0,0)`.

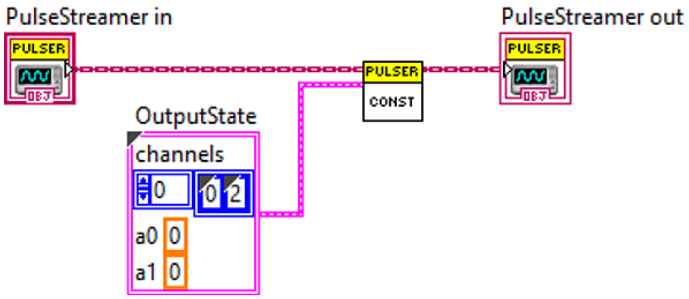
Python

Matlab

LabVIEW

```
ps.constant(OutputState([1, 2, 5], 0, 0))
# or
ps.constant(([1, 2, 5], 0, 0))
```

```
ps.constant(OutputState([1, 2, 5], 0, 0));
% or
ps.constant({[1, 2, 5], 0, 0});
```



Parameters

state (OutputState) – *OutputState* object that defines the state of outputs or a tuple.

4.3.2 Running pulse sequences

The *Pulse Streamer 8/2* provides two modes for running pulse patterns.

1. The first option allows you to stream a complete pulse sequence, which can be repeated either infinitely or for a specific number of times. The sequence is transferred to the *Pulse Streamer 8/2* with the *stream()* method, which starts it immediately by default. Alternatively, you can use *setTrigger()* to control when the output of the sequence starts, either with software-based trigger initiated with *startNow()* or with an external hardware trigger.
2. The second option is to use the continuous streaming functionality. To continuously stream sequence data, the *Pulse Streamer 8/2* is equipped with two independent memory slots. While running sequences from one slot, new sequences can be uploaded in the other slot by using the *upload()* method, without interrupting the current streaming. Several parameters can be used to control the exact transition process between the data slots. For instance, you can either continuously run the newly uploaded sequences or configure the device to repeat the previously uploaded sequences in succession without uploading new data. Furthermore, you can specify whether the device should wait in an idle state or repeat the sequences in the current memory slot while waiting for new data to arrive in the other slot. You can start running the uploaded sequences with the *start()* method, which allows you to specify how many memory slots (either a fixed number or infinite) will be played.

If you want to stop a running sequence and force it to the *final* state specified in the function call, you can do this by calling the method *forceFinal()*.

PulseStreamer.**stream**(*sequence*[, *n_runs=PulseStreamer.REPEAT_INFINITELY*[, *final=OutputState.ZERO*]])

Streams a complete pulse sequence to the *Pulse Streamer 8/2*. After the sequence has been repeated for the given *n_runs*, the constant state *final* will be reached. All parameters except *sequence* have default values and are optional. By default, the sequence is started immediately. Otherwise, it can be triggered using a configured software or hardware trigger. Please see the *setTrigger()* and *startNow()* methods.

If the sequence is empty, the *final* state will be set immediately.

The *sequence* parameter of the *stream()* method also accepts an RLE sequence defined as a list of 4 element tuples of the following format: *(duration_ns, [channels_to_set_HIGH], analogV_0, analogV_1)*

Python

Matlab

```
ps.stream([(100, [1, 2], 0, 0), (10, [2], 0, 0), (5, [], 0, 0)])
```

```
ps.stream([{100, [1, 2], 0, 0}, {10, [2], 0, 0}, {5, [], 0, 0}]);
```

Parameters

- **sequence** (Sequence) – Sequence object or a list of tuples.
- **n_runs** (*int*) – Number of times to repeat the sequence. Infinite repetitions if *n_runs<0*. There is also a symbolic constant *REPEAT_INFINITELY=-1*
- **final** (OutputState) – OutputState object, which defines the constant output after the sequence has finished.

PulseStreamer.**startNow**()

Starts streaming the sequence present in the memory of the *Pulse Streamer 8/2*. The behavior of this method depends on the trigger configuration performed with the *setTrigger()* method.

If the *start* is *TriggerStart.IMMEDIATE* and the sequence has finished, then *startNow()* will trigger the sequence again.

If the *start* is *TriggerStart.SOFTWARE*, then the sequence starts every time the *startNow()* is called. In the case of the *rearm*=*TriggerRearm.MANUAL*, the method *startNow()* will trigger the sequence only once. Call *rearm()* to manually rearm the trigger.

If the *start* is set to one of the hardware sources, then this method does nothing.

PulseStreamer.**upload**(*slot_nr*, *sequence*[, *n_runs=PulseStreamer.REPEAT_INFINITELY*[, *idle_state=OutputState.ZERO*[, *next_action=NextAction.SWITCH_SLOT_EXPECT_NEW_DATA*[, *when=When.IMMEDIATE*[, *on_nodata=OnNoData.ERROR*]]]]])

Uploads the sequence data to the *Pulse Streamer 8/2*. The data is written into the memory slot defined by the corresponding parameter *slot_nr*. All other parameters, except *sequence*, have default values and are optional. Before you start running the sequences with the method *start()*, you can upload new sequences to one or both memory slots, overwriting the previously uploaded data.

If the memory slot is not writable because it is being accessed by the *Pulse Streamer 8/2* to read the data, the method blocks and waits until the memory slot is writable again. This blocking timeout is set to 7 seconds. To avoid a timeout, you can check if a slot is ready to accept new data using the method *isReadyForData()*.

By default, new sequences are expected to be ready in the other slot to switch immediately to that data without disruption. If *next_action* is set to *NextAction.SWITCH_SLOT*, sequences in the other slot will be run regardless they are pre-existing or new. If *next_action* is set to *NextAction.REPEAT_SLOT*, the current memory slot's sequences will be repeated for the remaining *slots_to_run* defined in the *start()* method. Each of these repetions contains *n_runs* times the pulse sequence. If all *slots_to_run* have been played, the device enters the *idle_state*. If the *next_action* is *NextAction.STOP*, the device enters the *idle_state* when the current memory slot is completely played. After the continuous streaming ends, you can retrigger the sequence in the last active memory slot with an event of the currently active trigger start condition.

If the transition between two sequences is performed without disruption (parameters *when* and *on_nodata* set to *When.IMMEDIATE* and *OnNoData.ERROR*, respectively), the new data in the other memory slot must arrive in time. Therefore, the streamed sequence must be long enough to allow the next sequence to be uploaded on time. The upload time of a sequence is at least 30 ms and increases with the number of sequence steps up to about one second for the maximum number of allowed sequence steps (one million). Furthermore, if the data rate of the currently read sequence is high, the upload is throttled (approximately by a factor of two) to prioritize error-free reading from RAM. To ensure optimal upload performance, whenever possible, call the *Sequence.getData()* method of the sequence object in advance. At that point, all channel data is already merged and optimized, so it does not need to be processed during the *upload()* call.

If the new data does not arrive in time, an error will occur by default. You can configure the device to wait in the *idle_state* until the new data is ready by using *OnNoData.WAIT_IDLING*, or have the current data repeat until the new data becomes available by setting *OnNoData.WAIT_REPEATING*.

The Pulse Streamer clients support an *AUTO* mode for uploading sequence data. Instead

of explicitly setting *slot_nr* to 0 or 1, you can use *AUTO* mode by setting *slot_nr* to -1 or using the symbolic constant *AUTO*. In this case, the client will choose the correct sequence slot. Uploading starts with slot 0 and continues with the correct slot based on the *next_action* setting. The method *start()* starts with slot 0 if *AUTO* mode is selected. The method *isReadyForData()* with *AUTO* as an argument returns True or False based on the availability of the net slot that *AUTO* mode would select.

Python

Matlab

```
ps.upload(slot_nr=ps.AUTO, data=seq0, n_runs=ps.REPEAT_INFINITELY,␣
↪idle_state=OutputState.ZERO(), next_action=NextAction.SWITCH_SLOT_
↪EXPECT_NEW_DATA)

ps.start(slot_nr=ps.AUTO, slots_to_run=ps.REPEAT_INFINITELY)

ps.upload(slot_nr=ps.AUTO, data=seq1, n_runs=ps.REPEAT_INFINITELY,␣
↪idle_state=OutputState.ZERO(), next_action=NextAction.SWITCH_SLOT_
↪EXPECT_NEW_DATA)

ps.upload(slot_nr=ps.AUTO, data=seq2, n_runs=ps.REPEAT_INFINITELY,␣
↪idle_state=OutputState.ZERO(), next_action=NextAction.REPEAT_SLOT)
```

```
ps.upload(ps.AUTO, seq0, 'n_runs', ps.REPEAT_INFINITELY, ...
    'idle_state', PulseStreamer.OutputState.ZERO, ...
    'next_action', PulseStreamer.NextAction.SWITCH_SLOT_EXPECT_NEW_
↪DATA);

ps.start(ps.AUTO, ps.REPEAT_INFINITELY);

ps.upload(ps.AUTO, seq1, 'n_runs', ps.REPEAT_INFINITELY, ...
    'idle_state', PulseStreamer.OutputState.ZERO, ...
    'next_action', PulseStreamer.NextAction.SWITCH_SLOT_EXPECT_NEW_
↪DATA);

ps.upload(ps.AUTO, seq2, 'n_runs', ps.REPEAT_INFINITELY, ...
    'idle_state', PulseStreamer.OutputState.ZERO, ...
    'next_action', PulseStreamer.NextAction.REPEAT_SLOT);
```

Parameters

- **slot_nr** (*int*) – Memory slot (0 or 1) to store the sequence data. The client supports auto mode if -1 is set for *slt_nr*. There is also a symbolic constant *AUTO=-1*.
- **sequence** (Sequence) – Sequence object or a list of tuples.
- **n_runs** (*int*) – Number of times to repeat the sequence slot. Infinite repetitions if *n_runs `<0. There is also a symbolic constant `REPEAT_INFINITELY=-1*
- **idle_state** (OutputState) – OutputState object, which defines the constant output after the streaming has finished or no new data is present.
- **next_action** (NextAction) – Defines what happens if the slot data is completely streamed.
- **when** (When) – If the *when* is *When.IMMEDIATE*, the next slot is streamed without

disruption. If the *when* is `When.TRIGGER`, the next slot is started with the next trigger event of the currently active trigger start condition.

- **on_nodata** (`OnNoData`) – Defines what happens if the new sequence data is not ready on time. The behavior is defined by the enumeration `OnNoData`.

Returns
0 in case of a successful upload, -1 in case of an error/timeout.

> **Note**
>
> As the section *Streaming* describes, the Pulse Streamer hardware splits the sequence data into eight nanosecond-long chunks. Therefore, if the duration of the sequence data uploaded to the Pulse Streamer is not an exact multiple of 8 ns, the extra time will be padded to complete the last chunk.

`PulseStreamer.`**`start`**`([`*slot_nr=0*, *slots_to_run=REPEAT_INFINITELY* `])`

Starts the streaming of the uploaded sequence data in memory slot *slot_nr*. If the slot data is completely streamed, the streaming process is continued as defined by the parameters of `upload()`. By default, the overall repetition parameter *slots_to_run* is indefinite.

Parameters

- **slot_nr** (*int*) – Memory slot (0 or 1), which contains the data to start with. In auto mode, the streaming always starts with memory slot 0.
- **slots_to_run** (*int*) – The number of memory slots to be streamed. Streaming data completely from one memory slot includes its repetition parameter n_runs.

Returns
0 in case the streaming has been started successfully, -1 in case the streaming could not be started.

> **Note**
>
> If you upload data to both memory slots in advance, the internal buffers of the *Pulse Streamer 8/2* are filled before the actual streaming starts. But if you stream several slots of sequences of short duration as nested loops with *next_action* set to `NextAction.SWITCH_SLOT`, the time to access the data and refill the buffers (several µs) could exceed the sequence duration. In that case, you should use the options of `OnNoData.WAIT_IDLING` and `OnNoData.WAIT_REPEATING` to avoid an error condition.

`PulseStreamer.`**`isReadyForData`**`([`*slot_nr=AUTO* `])`

Parameters
slot_nr (*int*) – Memory slot (0 or 1) to store the sequence data. The client supports auto mode if -1 is set for *slot_nr*. There is also a symbolic constant *AUTO=-1*.

Returns
True if the dedicated slot can receive data. As long as the memory area is read or could be reread, the write to the slot is blocked and `isReadyForData()` returns False.

`PulseStreamer.`**`forceFinal`**`()`

Interrupts the sequence and sets the final state. This method does not modify the output state if the sequence has already finished and the Pulse Streamer is in the final state.

If no final state was declared in the current sequence, the output of the *Pulse Streamer 8/2* will change to (or stay in) the last known constant state.

The recommended way to stop the *Pulse Streamer 8/2* streaming is to set its output to a constant value via the method *constant()*, described above.

`PulseStreamer.`**`setCallbackFinished`**(*callback_func) (MATLAB only*)

Allows to set up a callback function, which will be called after the sequence streaming has finished. The callback function will be called with the following signature *callbackFunction(pulseStreamer_obj)*. An example of such a function is shown below.

Matlab

```
function callbackFunction(pulseStreamer)
    % this is an example of a callback function

    disp('hasFinishedCallback - Pulse Streamer finished.');

end
```

4.3.3 Configuring trigger settings

This section describes methods that allow to configure trigger properties.

`PulseStreamer.`**`setTrigger`**(*start*[, *rearm=TriggerRearm.AUTO*])

Defines how the uploaded sequence is triggered.

If you want to trigger the Pulse Streamer by using the external trigger input of the device, you have to set the *start* parameter to one of the following values: *start=TriggerStart.HARDWARE_RISING* (rising edge on the trigger input), *start=TriggerStart.HARDWARE_FALLING* (falling edge on the trigger input) or *start=TriggerStart.HARDWARE_RISING_AND_FALLING* (both edges are active).

If the automatic rearm functionality is enabled (*rearm=TriggerRearm.AUTO*), which is the default power-on state, you can re-trigger a sequence that is finished, by providing an appropriate trigger signal, depending on *start* argument. You can disable the automatic rearm by passing *rearm=TriggerRearm.MANUAL*.

If the automatic rearm functionality is disabled, you can manually rearm the Pulse Streamer by calling the method *rearm()*

Parameters

- **start** (TriggerStart) – Defines the source of the trigger signal
- **rearm** (TriggerRearm) – Enables or disables trigger automatic rearm.

`PulseStreamer.`**`getTriggerStart`**()

Queries the hardware for the currently active trigger start condition.

Returns
Returns *TriggerStart* value.

`PulseStreamer.`**`getTriggerRearm`**()

Queries the hardware for the currently active rearming method.

Returns
Returns *TriggerRearm* value.

`PulseStreamer.`**`rearm`**()

Rearms the trigger in case the *Pulse Streamer 8/2* has reached the final state of the current sequence and the trigger rearm method was set to *TriggerRearm.MANUAL*. Returns True on success.

Returns
True or False

4.3.4 Requesting the streaming state

The following methods allow you to request whether the Pulse Streamer has a sequence in memory, whether a sequence is currently being streamed or if it has already finished.

`PulseStreamer.`**`hasSequence`**`()`

Returns *True* if the *Pulse Streamer 8/2* memory contains a sequence.

Returns
True or False.

`PulseStreamer.`**`isStreaming`**`()`

Returns *True* if the *Pulse Streamer 8/2* is currently streaming a sequence. When the sequence has finished and the device remains in the final state, this method returns *False* again.

Returns
True or False.

`PulseStreamer.`**`hasFinished`**`()`

Returns *True* if the *Pulse Streamer 8/2* remains in the final state after having finished a sequence.

Returns
True or False.

4.3.5 Using an external clock

The *Pulse Streamer 8/2* can be clocked from three different clock sources. By default, the internal clock of the device is used. It is also possible to use an external clock of 125MHz (sampling clock) or an external 10MHz reference signal. You can choose the clock source via *selectClock()*. For more information on the required electrical parameters of an external clock signal, please see the section *Hardware*.

`PulseStreamer.`**`selectClock`**`(`*`source`*`)`

Sets the hardware clock source.

Parameters
source (ClockSource) – Specifies the clock source for the Pulse Streamer hardware.

`PulseStreamer.`**`getClock`**`()`

Returns a *ClockSource* element with the clock source currently used by the *Pulse Streamer 8/2*.

Returns
ClockSource Current clock source

Also, you can apply a continuous square wave of 125 MHz to the dedicated Pulse Streamer output channels as an external clock signal for other devices to be synchronized with the *Pulse Streamer 8/2*.

`PulseStreamer.`**`setSquareWave125MHz`**`(`*`channels=[]`*`)`

Sets a persistent square wave with a frequency of 125 MHz to the selected digital outputs. The 125 MHz will remain and will not be affected by any other settings applied to this channel unless the corresponding channel is deselected via *setSquareWave125MHz()* or the method *reset()* is called. A call to this method without a parameter will disable the 125 MHz signal on all channels it was enabled before.

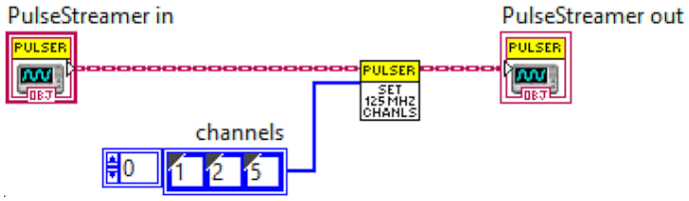
Python

Matlab

LabVIEW

```
ps.setSquareWave125MHz(channels=[1, 2, 5])
```

```
ps.setSquareWave125MHz([1, 2, 5])
```



Parameters

channels (*list*) – defines to which channels the 125 MHz square wave should be applied.

4.3.6 Hardware identification

`PulseStreamer.`**`getSerial`**`()`

Returns

String containing the serial number which is the same as MAC address of the Ethernet interface.

`PulseStreamer.`**`getFPGAID`**`()`

Returns

String containing FPGA ID number.

`PulseStreamer.`**`getFirmwareVersion`**`()`

Returns

String containing the firmware version number of the connected *Pulse Streamer 8/2*.

`PulseStreamer.`**`getHardwareVersion`**`()`

Returns

String containing the hardware revision number of the connected *Pulse Streamer 8/2*.

`PulseStreamer.`**`setHostname`**`(`*`hostname`*`)`

Parameters

hostname (*str*) – Hostname string to set for the connected *Pulse Streamer 8/2*.

Sets hostname of the connected *Pulse Streamer 8/2*.

> **Note**
>
> Depending on your network environment, this setting may not affect how your *Pulse Streamer 8/2* is identified in the network. However, the stored hostname will be returned when you call *getHostname()*.

PulseStreamer.**getHostname**()

Returns
String containing the hostname of the connected Pulse Streamer.

4.3.7 Calibrating the analog outputs

Pulse Streamer 8/2 devices shipped with firmware version v1.3.0 or later (published in July 2020) already include calibration data for analog outputs, and no further user action is required. Devices shipped with older firmware require analog output calibration in order to achieve specified accuracy, see *Hardware*. You can perform this calibration yourself by following the steps described below. The calibration requires a sufficiently accurate multimeter (not an oscilloscope) connected to the analog outputs (can be done one channel at a time).

Calibration procedure

1. Connect the multimeter to the analog output of the *Pulse Streamer 8/2*. The measurement has to be performed at 50 Ohm load, so you will need to attach 50 Ohm termination.
2. Using the Pulse Streamer API, set the analog output to several values and record multimeter readings. This has to be done at least for -0.9 V and +0.9 V output values.
3. Calculate the slope

   $$slope = \frac{voltage_{+0.9V} - voltage_{-0.9V}}{1.8}$$
4. Calculate the offset

   $$offset = voltage_{+0.9V} - slope * 0.9$$
5. Perform the steps 1 to 4 for each analog output.
6. Call the `setAnalogCalibration()` and specify both offsets and slopes.
7. Reboot the *Pulse Streamer 8/2* to apply the new calibration data (from firmware v1.5.0 on, the device is rebooted automatically).

> **Warning**
>
> If you perform repeated calibration, you have to reset the slope and offset to values 1 and 0, respectively. Failing to do so will lead to invalid calibration data.

PulseStreamer.**setAnalogCalibration**(*dc_offset_a0=0*, *dc_offset_a1=0*, *slope_a0=1*, *slope_a1=1*)

Sends the DC-offset and slope of each analog channel to the *Pulse Streamer 8/2* and stores it to internal memory. These values will be applied after reboot. With firmware version v1.5.0 or later, this is done automatically. If you use a former firmware of the *Pulse Streamer 8/2*, you will have to power cycle your device.

Parameters

- **dc_offset_a0** – The DC offset of analog channel 0
- **dc_offset_a1** – The DC offset of analog channel 1
- **slope_a0** – The gradient of the transfer function of analog channel 0
- **slope_a1** – The gradient of the transfer function of analog channel 1

If you need help during the calibration procedure, please contact support@swabianinstruments.com.

`PulseStreamer.getAnalogCalibration()`

Returns the stored calibration values of your Pulse Streamer. These values will be rounded according to the DAC resolution. If you call this method immediately after *setAnalogCalibration()*, the returned data will not reflect the actual calibration state.

Returns
structure of the four calibration values rounded to the DAC resolution.

4.3.8 Modify the network configuration

By default, the *Pulse Streamer 8/2* will attempt to acquire an IP address via DHCP. If you want to assign a specific IP address to your Pulse Streamer, you can disable DHCP and configure a static IP instead. We recommend using our graphical user interface (Windows only) to modify the *Pulse Streamer 8/2* network configuration. For more information, please have a look at *Network Connection*. Alternatively, the following methods allow you to configure the device's network settings via our client software interfaces.

`PulseStreamer.setNetworkConfiguration(`*dhcp*, *ip=''*, *netmask=''*, *gateway=''*, *testmode=True*`)`

Enables DHCP or sets static IP address, Netmask and Standard Gateway. If testmode=True, the configuration is applied temporarily. Power-cycling will restore the former configuration. If testmode=False, the configuration will be applied permanently and the device is rebooted.

Parameters

- **dhcp** (*bool*) – DHCP enable/disable True/False
- **ip** (*str*) – static IP address (If dhcp=True, this value is ignored)
- **netmask** (*str*) – Netmask for static IP address configuration (If dhcp=True, this value is ignored)
- **gateway** (*str*) – Standard gateway for static IP address configuration (If dhcp=True, this value is ignored)
- **testmode** (*bool*) – If True, the configuration is applied temporarily. Power-cycling will restore the former configuration. If False, the configuration will be applied permanently and the device is rebooted.

`PulseStreamer.getNetworkConfiguration(`*permanent=False*`)`

Parameters
permanent (*bool*) – If True, the method returns network settings stored in the device's configuration file. If False, the method returns the current network settings of the device.

Returns
structure of the current or stored network settings

`PulseStreamer.applyNetworkConfiguration()`

Applies current (and successfully tested) network configuration permanently and the device is rebooted.

4.3.9 Enumerations

class ClockSource(*enumeration*)

This enumeration describes the selectable clock sources of the *Pulse Streamer 8/2*

INTERNAL

Use internal clock generator (default)

EXT_125MHZ

Use external 125 MHz clock signal

EXT_10MHZ

Derive clock from external 10 MHz reference signal

class TriggerStart(*enumeration*)

This enumeration describes the selectable start modes of the *Pulse Streamer 8/2*

IMMEDIATE

Trigger immediately after a sequence is uploaded. (default)

SOFTWARE

Trigger by calling *startNow()* method.

HARDWARE_RISING

External trigger on the rising edge.

HARDWARE_FALLING

External trigger on the falling edge.

HARDWARE_RISING_AND_FALLING

External trigger on rising and falling edges.

class TriggerRearm(*enumeration*)

This enumeration describes the rearm functionality of the *Pulse Streamer 8/2*

AUTO

Trigger immediately after a sequence is uploaded. (default)

MANUAL

Trigger once only and do not rearm automatically. Rearm manually via the *rearm()* method.

class NextAction(*enumeration*)

This enumeration defines the transition behaviour during continuous streaming of the *Pulse Streamer 8/2*

STOP

Streaming will stop after finishing the current sequence slot

SWITCH_SLOT

After the data in the current memory slot is finished, the data in the other slot is run. If this slot has already been run once, the existing sequences will be run again.

SWITCH_SLOT_EXPECT_NEW_DATA

After the data in the current memory slot is finished, the data in the other slot is run. New data must be available in that slot.

REPEAT_SLOT

Current sequence slot is repeated after it has been completely streamed. The overall repetition parameter *slots_to_run* defines the number of remaining repetitions.

class When(*enumeration*)

IMMEDIATE

Action defined by *next_action* is performed immediately after the previous data slot has finished.

TRIGGER

Action defined by *next_action* is performed with the next trigger event of the currently active trigger start condition.

class OnNoData(*enumeration*)

ERROR

Device enters an error state if new data does not arrive in time.

WAIT_IDLING

Device waits in *idle_state* till the data of the following slot is present in the device buffers.

WAIT_REPEATING

Device repeats the current data slot till the data of the following slot is present in the device buffers.

4.4 Sequence

The Sequence contains information about the patterns and channel assignments. It also handles the mapping of patterns (see *Pulse pattern*) to output channels and has a number of built-in methods that operate on the whole sequence, like concatenation, repetitions, visualization, etc.

Warning

While the same pattern can be mapped to one or more channels, successive mappings to the same channel will overwrite the previous mapping.

class Sequence

Sequence()

Class constructor. The *Sequence* is a generic class without early hardware limit checks. Since this class is not aware of hardware-specific limitations, like available channels or analog range, the validation will be performed only during an attempt to stream this Sequence object.

Note

If you want to have early limit checks, channel number validation, please create a hardware-specific Sequence object with *PulseStreamer.createSequence()* method. This, however, requires an active connection to the hardware.

setDigital(*channels*, *pattern*)

Assigns a pattern to a digital output. The same pattern can be assigned to one or more channels simultaneously.

```
sequence.setDigital(0, patt1)
sequence.setDigital([1,2,6], patt2)
```

Parameters

- **channels** (*list[int]*) – Digital channel number(s) as labeled on the *Pulse Streamer 8/2* connectors panel.
- **pattern** (*list*) – A pattern to be assigned to the *channel*.

invertDigital(*channels*)

Inverts level values in the stored pattern for the specified *channel*.

```
sequence.setDigital(1, [(10, 0), (20, 1), (80, 0)])
sequence.invertDigital(1)
# is equivalent to
sequence.setDigital(1, [(10, 1), (20, 0), (80, 1)])
```

Parameters

channel (*int*) – Digital channel number.

setAnalog(*channels*, *pattern*)

Assigns a pattern to an analog output. The same pattern can be assigned to one or more channels simultaneously.

```
sequence.setAnalog([0,1], patt2)
```

Parameters

- **channels** (*list[int]*) – Analog channel number(s) as labeled on the *Pulse Streamer 8/2* connectors panel.
- **pattern** (*list*) – A pattern to be assigned to the *channel*.

invertAnalog(*channel*)

Inverts level values in the pattern for the specified *channel*.

```
sequence.setAnalog(0, [(100, -0.1), (200, 0), (800,  0.5)])
sequence.invertAnalog(0)
# is equivalent to
sequence.setAnalog(0, [(100,  0.1), (200, 0), (800, -0.5)])
```

Parameters

channel (*int*) – Analog channel number.

4.4.1 Properties

Sequence.**isEmpty**()

Sequence.**isempty**() *(in MATLAB)*

Returns True if the sequence is empty.

Sequence.**getDuration**()

Returns sequence duration in nanoseconds.

Sequence.**getLastState**()

Returns the last state in the sequence as an *OutputState* object.

Returns
OutputState Last state of the sequence.

Sequence.**getData**()

Returns the run-length encoded (RLE) sequence data. This method is called automatically by the *PulseStreamer.stream()* method.

Returns
Run-length encoded data.

4.4.2 Transformation

static Sequence.**repeat**(*sequence*, *n_times*)

Returns the sequence data duplicated *n_times*. The sequence data in the original object remains unmodified. In case the *Sequence* object consists of patterns with different durations, they will be padded to the longest one, which defines sequence duration as returned by *Sequence.getDuration()* method. In this context, a Sequence shall be understood as a set of patterns all of the same duration.

In Python, you can repeat sequences similarly to lists by multiplying them by a number.

Python

Matlab

```
# The following three lines are fully equivalent
seq1 = Sequence.repeat(seq, 5)
seq1 = seq * 5
seq1 = 5 * seq
```

```
seq1 = repeat(seq, 5)
```

Parameters

- **sequence** (Sequence) – Sequence object to be repeated.
- **n_times** (*int*) – Number of times the sequence is repeated.

Returns
Returns a new *Sequence* object with data duplicated *n_times*.

static Sequence.**concatenate**(*sequence1*, *sequence2*)

Creates a new *Sequence* object with a sequence of *sequence2* object appended at the end of this sequence. Both object, *sequence1* and *sequence2*, remain unmodified. In case the *sequence1* sequence consists of patterns with different durations, they will be padded to the longest one, which defines sequence duration as returned by *Sequence.getDuration()* method. In this context, a Sequence shall be understood as a set of patterns all of the same duration.

This method is exposed directly in LabVIEW. However, in MATLAB and Python, it is exposed only as the override of the concatenation operator. This allows for transparent use of any function of these languages that implicitly use concatenation. See the example code for each language.

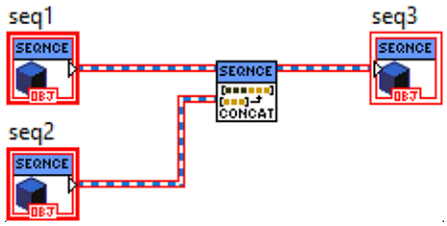
Python

Matlab

LabVIEW

```
seq3 = seq1 + seq2
```

```
seq3 = [seq1, seq2];
```



Returns

Returns a new *Sequence* object with concatenated data.

`static` Sequence.**split**(*sequence*, *at_times*)

Returns a list of sequences, which are the split partitions of the original sequence defined by the split points in *at_times*. The sequence data in the original object remains unmodified.

Python

Matlab

```
array_of_seq = Sequence.split(seq, [400, 900])
```

```
array_of_seq = seq.split([400, 900]);
```

Parameters

- **sequence** (Sequence) – Sequence object to be split.
- **at_times** (*list[int]*) – List with timestamps in nanoseconds where the sequence is split.

Returns

Returns a list with new *Sequence* objects, which are the split partitions of the original sequence.

4.4.3 Visualization

Sequence.**plotDigital**()

Plots the sequence data for digital outputs. Plotting is done into the current axes. (Only in MATLAB and LabView)

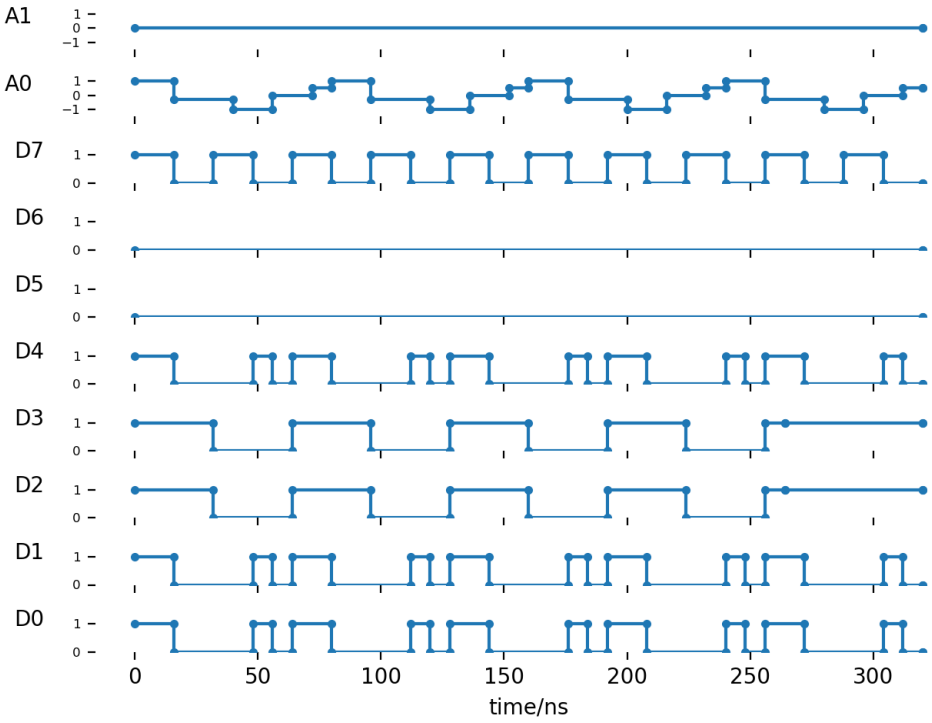
Sequence.**plotAnalog**()

Plots sequence data for analog outputs. Plotting is done into the current axes. (Only in MATLAB and LabView)

Sequence.**plot**()

Calls *plotDigital()* and *plotAnalog()* and shows the results as subplots in a single figure. Plotting is done in the current figure.

An example of the *plot()* output is shown in the image below.



Note

(Python only)

Since the Python Client release v1.6.1, importing the module matplotlib for *plot()* is optional. If you want to use visualization with Python, please ensure you have the package matplotlib installed.

4.5 OutputState

The *OutputState* is a simple value class that contains information on the state of every output of the *Pulse Streamer 8/2*.

class OutputState

OutputState(*channels*, *A0*, *A1*)

Class constructor. Input parameters specify the state of each output of the *Pulse Streamer 8/2*. Digital and analog output values are specified differently. In order to set a HIGH level at the digital channel, add the channel number to the *channels* list, for example `channels=[0,2,3]` will set HIGH level on the channels *0*, *2* and *3*. All other digital channels will be set to LOW. Output values at each of two analog outputs are specified with corresponding parameters *A0* and *A1*.

Parameters

- **channels** (*list*) – List of digital channels to be set HIGH.

- **A0** (*float*) – Analog output 0 voltage in volts.
- **A1** (*float*) – Analog output 1 voltage in volts.

ZERO

This is a helper constant equal to `OutputState([], 0, 0)`.

4.6 Advanced (Beta) features

4.6.1 Synchronized *Pulse Streamer 8/2* (Python only)

With our programming examples in Python, we provide the class *SyncPulseStreamer* as a wrapper class for the client interface of the *Pulse Streamer 8/2*. It combines two *Pulse Streamer 8/2* (requires firmware version v1.4.0 or later) and is currently only available for the Python client.

Synchronization concept and setup

One *Pulse Streamer 8/2* master generates the clock signal and trigger for one *Pulse Streamer 8/2* slave. The only necessary preparation is that digital channel 6 of the master must be connected to the external clock input of the slave as well as digital channel 7 of the master must be connected to the trigger input of the slave. To avoid race conditions between the trigger and trigger-sampling clock-edge, we recommend using cables of equal length.

The features of the resulting SyncPulseStreamer object can be described as follows:

- 14 digital channels (6 of the master, 8 of the slave)
- 4 analog channels (2 in each case master/slave)
- The slave is delayed by a constant time offset of ~70 ns (internal + cable)
- Increased $(\sim x * \sqrt{2})$ RMS jitter of the 8 digital channels of the slave (< 75 ps)
- In this configuration, devices with hardware Version 2.x (devices before 2021) have a 100 mV ripple on the digital channels of the slave due to the external clock signal. The analog outputs are not affected.

Usage and sequence generation

The Pulse Streamer synchronization wrapper offers the same API-structure as the original Pulse Streamer client if possible. For a detailed description of the Pulse Streamer API, please have a look at the *Programming interface* section and the provided Python example.

When it comes to sequence generation, unlike the original method `createSequence()`, the equivalent method of the sync-wrapper returns two sequence objects, one for the *Pulse Streamer 8/2* master and one for the *Pulse Streamer 8/2* slave. You can set the digital and analog channels of both sequences independently. Setting Channel 6 (clock signal) of the master will be ignored, and channel 7 (trigger) of the master will be overwritten by the stream method).

If you want to use a parameter *n_runs*>1 with the `stream()` function, you should ensure that the two sequences are of equal duration. Therefore the `stream()` prints a warning message if the duration of the two sequences differs.

To compensate for the delay of the *Pulse Streamer 8/2* slave, you can add an empty pulse as a first pulse to each channel of the master sequence, as it is shown in the Python code example. In that case, you have to take into account that if you want to use *n_runs*>1, you have to subtract the delay from the last pulses of the master-sequence, or you can accordingly pad the slave-sequence. The drawback is that this either requires the same state at the beginning and the end of the channel pattern, or you have to deal with the padding. Furthermore, you have to take into account that when a sequence is given to the method `stream()` of the *Pulse Streamer 8/2* or to the transformation-methods (see

Transformation) of the `Sequence` class, all channels are padded with the last value to the longest channel duration. For further information, please have a look at the sections *Creating sequences* and *Sequence*.

Just to give you the complete information of the padding issue: Due to the internal design of the *Pulse Streamer 8/2*, the device itself will pad the last sequence step to a duration that the sequence duration as a whole is a multiple of 8ns (which means a prolongation between 0 and 7 ns). This step is executed before the parameter n_runs is applied (see *Streaming*).

Further Limitations

1. If you use the synchronized *Pulse Streamer 8/2* with a fast external trigger, it is possible that the *Pulse Streamer 8/2*master is ready for retriggering and the slave is not and vice versa. Therefore, you should always poll the method :meth: `~PulseStreamer.hasFinished` before retriggering the *Pulse Streamer 8/2* with the external trigger.
2. If you stream a second pulse pattern into an already running sequence, you previously should set the *Pulse Streamer 8/2* to a constant state by using the methods `constant()` or `reset()`. Otherwise, the new sequence of the *Pulse Streamer 8/2* slave might already be triggered by the still running stream of the *Pulse Streamer 8/2* master.

CHAPTER

FIVE

CHANGELOG

5.1 2024-10-16

5.1.1 Firmware update v2.0.0 Beta2

With the release 2.0 of the Pulse Streamer 8/2 firmware, we will introduce the feature of continuous streaming. With the preliminary release 2.0.0 Beta2, you can use the new feature while the complete firmware release is finished. The API will not change for the official release, and the feature is fully backwards compatible with the former firmware versions.

- API has been supplemented by the methods: *upload()*, *start()*, *isReadyForData()*

5.1.2 Python v2.0.0 dev7 & Matlab v2.0.0.2

- Support firmware v2.0.0 Beta2
- New `split` method is added to `Sequence` class.
- Drop support for obsolete Python versions 2.7

5.2 2024-04-30

5.2.1 User interface v1.7.2

- Additional information in a Tooltip for the current Pulse Streamer in MainWindow
- Avoid duplicated devices with fallback IP detected via network scan
- Debug mode for User Interface selectable in the start menu to enable logging
- Fixed thread-safe logging
- Fixed correct handling and reporting issues that arise while establishing a connection with the Pulse Streamer device

5.2.2 Matlab client v1.7.1

- Fixed inconsistency between ClockSource enumeration naming and documentation. The change is backward-compatible

5.3 2023-06-01

5.3.1 Firmware update v1.7.2

This firmware brings updates of third-party components such as Linux kernel etc.

- Increased upload performance

5.3.2 User interface v1.7.0

- Fixed a rare bug that made Pulse Streamer Application fail when discovering devices
- Fixed a rare bug that made Pulse Streamer Application fail when establishing a connection

5.3.3 Python v1.7.0 & Matlab v1.7.0 & LabView v1.7.0

- Support firmware v1.7.x

5.4 2023-04-03

5.4.1 User interface v1.6.4

- Added optional logging support
- In case of failure, Pulse Streamer Application sends an error message to Swabian Instruments
- Fixed bug in loading arbitrary data from CSV-file

5.5 2023-03-08

5.5.1 Python Client update v1.6.2

- Fixed a bug that connection fails due to the post-release segment of Python package v1.6.1.post1

5.6 2023-02-27

5.6.1 User interface v1.6.3

- Fixed a bug that Pulse Streamer Application fails to connect without an internet connection.

5.7 2023-02-16

5.7.1 User interface v1.6.2

- Pulse Streamer Application shows proper messages in the case of an error and will controllably shut down.
- Package and .NET Framework update

5.7.2 Python Client v1.6.1

- Fixed a bug in the sequence creation process that, under some conditions, resulted in missing pulses of a sequence with pulses with a maximum duration value of a 32 Bit word.
- Updated package dependency of package protobuf
- Changed import of module matplotlib to optional

5.8 2022-10-05

5.8.1 Matlab Client update v1.6.2

- Fixed a bug that, under some conditions, resulted in fixed pulse duration of ~4.2 s when the requested pulse duration was longer than ~2.1 s.

5.9 2022-05-02

5.9.1 Firmware update v1.6.3

- Support hardware revision v3.3

5.10 2022-02-28

5.10.1 User interface v1.6.1

- Pulse Streamer Application handles an incorrect setting of sequence parameters with warning

5.11 2021-12-20

5.11.1 Firmware update v1.6.2

This update overcomes the recommended maximum limit of the retrigger frequency and brings automatic check and repair of sd-card partitions during bootup.

- No limitation of the trigger frequency except a fix retrigger dead-time (<50 ns)
- solved: Very rare boot failure due to sd-card partition damages automatically handled by fsck-tools during bootup
- solved: A sporadic case of missing firmware/hardware version information in Pulse Streamer discovery server information
- solved: Incorrect handling of empty sequences and n_runs=0 in v1.6.0 (internal release only)

5.11.2 Clients

Python v1.6.0

- Increased performance of sequence generation
- solved: zoom-in/panning within the sequence plot window

Matlab v1.6.1 & LabView v1.6.1

- Support firmware v1.6.2

5.12 2021-08-31

5.12.1 Firmware update v1.5.2

- solved: Server-side JSON-RPC request-id handling

This release resolves the packet dependency (tinyrpc<=1.1.0) of the Python client

5.13 2021-08-23

5.13.1 Client update v1.5.2

Python

- Fix packet version dependency: tinyrpc <=1.1.0 for Pulse Streamer 8/2 firmware <=1.5.1

5.14 2021-07-28

5.14.1 User interface v1.5.3

- solved: Correct firmware v1.0.x identification via Pulse Streamer Application

5.15 2021-05-20

5.15.1 User interface v1.5.2

- solved: Firmware v0.9 detection via Pulse Streamer Application
- solved: Detection of non-licensed devices via Pulse Streamer Application

5.16 2021-03-12

5.16.1 Firmware update v1.5.1

- solved: extraordinarily long pulse on analog channels of few devices during bootup with hardware version 3.1 and firmware version v1.5.0

User interface v1.5.1

- solved: Pulse Streamer Application crashes when trying to update the firmware without an internet connection available
- Firmware update can also be performed on a manually downloaded local updater file
- Pulse Streamer Application brings the opportunity to reconnect to different devices without restarting the application.

5.17 2021-02-12

5.17.1 Firmware/Client update v1.5.0

This update brings an improved Pulse Streamer Application (GUI).

- API has been supplemented by the methods: *reboot()*, *setNetworkConfiguration()*, *getNetworkConfiguration()*, *applyNetworkConfiguration()*
- solved: rare error in case of a sequence with one sequence step, RLE-value <= 8ns and n_runs=INFINITE
- Matlab and LabVIEW clients are now available from online repositories via *Matlab Addon Explorer* and *JKI VI Package Manager*, respectively.

User interface

- Pulse Streamer Application makes use of the full API extensions since version v1.0.2
- Pulse Streamer Application makes use of the device discovery functionality
- Pulse Streamer Application provides functionality for network configuration
- Pulse Streamer Application performs firmware update process

5.18 2020-11-12

5.18.1 Firmware/Client update v1.4.0

This update brings some functionality as output port enabling after power-cycling or automatic hardware version detection for the new hardware version v3.1 of the Pulse Streamer 8/2.

- API has been supplemented by the methods: *getHardwareVersion()*, *setSquareWave125MHz()*
- New trigger input stage leads to a typical TriggerToData of 65 ns (hardware version 3.1) respectively 60 ns (hardware version <= 2.3)

5.19 2020-08-17

5.19.1 Bug-fix in LabView client

- Internal sequence data for binary protocol uses little-endian encoding compared to big-endian of the JSON-RPC. This resulted in incorrect signal generation with binary protocol enabled firmware versions.

In order to fix the problem, you have to update the LabView client to the latest version.

5.20 2020-07-27

5.20.1 Firmware/Client update v1.3.0

This update brings the opportunity to calibrate the analog outputs to increase its accuracy. Devices shipped with firmware version v1.3.0 or later come with calibrated outputs. Devices which has been shipped with a previous firmware version can manually be calibrated by the user with a dedicated method.

- API has been supplemented by the methods: *setAnalogCalibration()*, *getAnalogCalibration()*
- solved: sequences with sequence steps longer than ~0.5 µs and a number of sequence steps near to the maximum limit could raise std::bad_alloc()

5.21 2020-01-20

5.21.1 Firmware/Client update v1.2.0

This update brings new device discovery functionality that greatly simplifies finding and connecting to the Pulse Streamer. Moreover, new getter methods are added to form a more complete set of functions that allows you to set and query the device state. Existing functionality has also received an upgrade in performance. Now sequence upload happens 2x faster thanks to a new binary communication protocol that works along the JSON-RPC.

- new network device discovery functionality, *findPulseStreamers()*
- sequence upload performance increased by factor two (requires both firmware and client interface update)
- API has been supplemented by the methods: *setHostname()*, *getHostname()*, *getTriggerStart()*, *getTriggerRearm()*, *getClock()*
- recommended maximum external retrigger frequency increased to 1 kHz
- minimum trigger pulse width reduced to < 2ns
- TriggerToData increased to 64.5/65.5 ns (mean value, rms jitter 2.3 ns)
- unified version numbers for the Pulse Streamer 8/2 firmware and the client interfaces that now share the first two numerals

5.22 2019-08-07

5.22.1 Firmware update v1.0.3

- solved: at rare intervals occurring server crashes
- solved: channel analog0 shows increased jitter (observed only on very few devices)
- solved: extremely rarely missed internal trigger (sequence-dependent)

5.23 2019-05-10

5.23.1 Client update v1.1.2

Matlab

- Bug-fix in the `PulseStreamer.debug.PulseStreamer_RPCLogger` class.
- `PulseStreamer_RPCLogger` class now stores log-file snapshots on RPC errors.

5.24 2019-04-23

5.24.1 Clients update v1.1.1

- Python: corrected overflow error for sequence durations above 4 seconds on some systems.
- Python client is now available at www.pypi.org. You can now install it with `pip install pulsestreamer`.
- Matlab: minor code cleanup.

5.25 2019-03-01

5.25.1 Client API update v1.1.0

This update brings homogenized API for PulseStreamer clients in all supported languages. From now on, the signatures of all currently present functions and methods are frozen and will remain stable over the future minor updates and releases. In the future, we plan to add any new functionality in a backward-compatible way with no user code modifications required.

- The API was slightly redesigned and homogenized in all supported languages.
- The use of high-level clients is now a recommended way of programming and streaming the pulse sequences with the Pulse Streamer.
- New methods `PulseStreamer.createSequence` and `PulseStreamer.createOutputState` that create hardware specific `Sequence` and `OutputState` objects.
- New method `PulseStreamer.getFPGAID`.
- New `OutputState` class for defining the state of Pulse Streamer outputs in some methods.
- New `OutputState.ZERO` constant.
- New named constant `PulseStreamer.REPEAT_INFINITELY = -1` for infinite sequence repetition.
- `Sequence` object now applies padding to the pattern data and previous levels on concatenation.
- Renamed enum `TriggerMode` to `TriggerRearm`, also renamed enumeration values.
- Renamed enumeration values in enums `TriggerStart`.
- Modified signature of the `PulseStreamer.getSerial()` method, which now has no input parameter and always returns hardware serial number.

Matlab

- The client code is now distributed as a packaged Matlab Toolbox.
- The PulseStreamer client is placed into its own namespace `PulseStreamer` in order to prevent possible collisions in function names. You can use `import PulseStreamer.*` to shorten the class names.
- Moved compatibility functions for FW v0.9 to `PulseStreamer.compat` sub-package.
- `Sequence.setDigital` and `Sequence.setAnalog` allows for overwriting mapped pulse patterns even after concatenation or repetition.
- `PulseStreamer.stream()` method now supports `Sequence` object and `[{duration,chan_list,a0,a1}; {...}]` cell array as input.

- Functionality of `PSSequenceBuilder` and `PSSequence` classes is now combined and moved to `Sequence` class.
- Renamed `PSTriggerMode` to `TriggerRearm`.
- Renamed `PSTriggerStart` to `TriggerStart`.
- Renamed `PSSequence` to `Sequence`.
- Removed `PSSerial` enum.
- `Sequence.plot` method plots the sequence data exactly as defined by the user without resampling to common time.
- `Sequence` is completely decoupled from `PulseStreamer` class. Use `PulseStreamer.createSequence()` method to create a `Sequence` object that does early channel number validation.
- Helper classes like `PulseStreamer_Dummy` and `PulseStreamer_RPCLogger` located in a sub-package `PulseStreamer.debug`.
- Solved problem with multiple timers created on repeated script runs with long sequences. Only one timer can exist for a given device.

LabView

- Pulse Streamer client code for LabView is now distributed as a VIPM package.
- Functionality of `SequenceBuilder` and `Sequence` classes is now combined into `Sequence` class.
- Added `Sequence:plot.vi`, which plots the pulse patterns according to user input with no resampling to common time.
- `PulseStreamer:stream.vi` method is a polymorphic VI with wrappers to handle implementation VIs with dynamic inputs.
- `PulseStreamer:stream.vi` supports `Sequence` object, old `Pulse` array, and `RLEdata` cluster as inputs.
- Renamed `Digital Pattern.lvclass` to `PulsePattern.lvclass`.
- Renamed `Analog Pattern.lvclass` to `AnalogPattern.lvclass`.

Python

- PulseStreamer client is distributed as wheel package `pulsestreamer`.
- PulseStreamer now uses standard `tinyrpc` package instead of previously used customized version `tinyrpc3.py`. Use `pip install tinyrpc` to install the package, if missing.
- Some changes in parameter names. Please see *Programming interface*.
- New `concatenate`, `repeat` and `` `plot `` methods are added to `Sequence` class.
- PulseStreamer client is organized into a python module with a cleaner layout.
- `PulseStreamer.stream` method accepts `Sequence` object as input parameter directly.

5.26 2018-12-17

5.26.1 Firmware update v1.0.2

- solved: occasionally missed external trigger

5.27 2018-11-09

5.27.1 Firmware update v1.0.1

- API has been supplemented by method rearm() and forceFinal()
- second permanent IP 169.254.8.2 added
- network configuration file on user partition -> static IP can be configured via RPCs
- login password changed

5.27.2 Clients

Python

- adapted to new API
- class Sequence added as handy sequence-builder
- channel_map {'ch0':0, 'ch1':1...} no longer supported - use channel_list e.g. [0,1,3,7]

Matlab

- adapted to new API
- large changes in the way sequences are created and manipulated
- new classes for sequence creation: `PSSequenceBuilder` and `PSSequence`
- classes `P` and `PH` are modified and labeled as deprecated
- added compatibility function `convert_PPH_to_PSSequence` that converts sequences created with `P` or `PH` objects into `PSSequence`
- added examples that show how to migrate old code to version 1.0
- code examples completely reworked to reflect the new way of building sequences

LabView

- adapted to new API
- large changes in the way sequences are created and manipulated
- new classes for sequence creation: `SequenceBuilder` and `Sequence`
- client code is now contained in a LabView library.
- slightly modified and renamed classes for signal pattern creation
- code examples completely reworked to reflect the new way of building sequences

5.28 2018-10-10

firmware update v1.0

- underflows do not occur any more -> getUnderflow() returns 0 always
- API changes (see API-migration-doc for details)
- substantial changes in the embedded Linux-operation system
- no network configuration file - only DHCP and fallback IP available

Clients

- Python, Matlab and LabVIEW adapted to new API

5.29 2018-01-05

user interface

- added a GUI to determine the IP address of the Pulse Streamer and to create simple pulses (beta release)

clients

- improved Python client

5.30 2017-05-07

clients

- added LabVIEW client
- improved Matlab client
- improved Python client

documentation

- added 'Getting Started' section

5.31 2016-04-08

Matlab client

- added links to the Matlab client examples

5.32 2016-03-17

static sequence beta 0.9

- enums in RPCs
- API name changes
- rising and falling edges on external trigger

5.33 2016-03-07

provide network configuration

- added section on network configuration

5.34 2016-03-03

static sequence alpha

- initial, final, underflow states
- software start
- external trigger
- rerun sequence
- separate underflow flags for digital and analog
- optional values in jRPC

5.35 2016-02-02

static sequence alpha

CHAPTER

SIX

PREVIOUS VERSIONS

Here you can find an archive of documentation for previous versions of PulseStreamer clients.

Generally, the versions of client software and firmware versions are not the same.

6.1 Version 1.x

- client: v1.7.x - firmware: v1.7.x
- client: v1.6.x - firmware: v1.6.x
- client: v1.5.x - firmware: v1.5.x
- client: v1.4.x - firmware: v1.4.x
- client: v1.3.x - firmware: v1.3.x
- client: v1.2.x - firmware: v1.2.x
- client: v1.1.x - firmware: v1.0.x
- client: v1.0.x - firmware: v1.0.x

6.2 Version 0.x

- client: v0.9 - firmware: v0.9

CHAPTER

SEVEN

INDICES AND TABLES

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