

Pulse Train Master for Rohde and Schwarz Signal Generators

Application Note

Products:

R&S SMB100A	R&S SMBV100A
R&S SMA100A	R&S SMJ100A
R&S SMF100A	R&S SMU200A

This Application Note describes a software program that provides easy creation and transfer of Pulse Trains between a PC and the R&S SMB100A, R&S SMA100A and R&S SMF100A analog signal generators with the Pulse Train option; or between a PC and the ARB of R&S SMBV100A, R&S SMJ100A or R&S SMU200A vector signal generators.

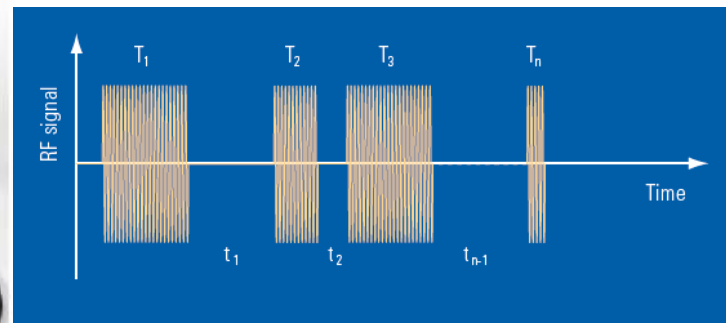


Table of Contents

1 Introduction	4
2 Installation of the Software	6
3 Connecting the PC to the Instrument.....	7
3.1 GPIB	7
3.2 Configuring a GPIB connection	7
3.3 LAN / Ethernet using an Intranet or Internet.....	8
3.4 LAN / Ethernet using a crossover connection	9
3.5 Configuring a LAN Connection.....	9
4 Basic Operation of the Software.....	10
4.1 Registration	10
4.2 Establish a connection with the instrument.....	11
4.3 Main Features of the Software	13
4.4 Creating a Pulse Train on the PC.....	14
4.5 Save the Pulse Train to a text file on the PC	16
4.6 Read the Pulse Train from a text file on the PC	18
4.7 Edit the pulse train.	18
4.8 Invert the Polarity of the Pulse Train.....	20
4.9 Swap the On and Off Times of the Pulse Train.....	21
4.10 Reverse the Direction of the Pulse Train	21
4.11 Transfer a Pulse Train from the PC to the SMF, and activate it.	22
4.12 Select a Pulse Train, activate it, and copy it back to the PC.....	23
4.13 Graphical Views of the Pulse Train.....	24
4.14 Control the frequency and amplitude parameters on the SMx.....	29
5 Other useful Application Notes.....	30
5.1 1MA 74, RS Commander	30
5.2 1MA 124, Tackling the Challenges of Pulsed Signal Measurements	30
5.3 1MA 141, RF Transient Analysis Software	30

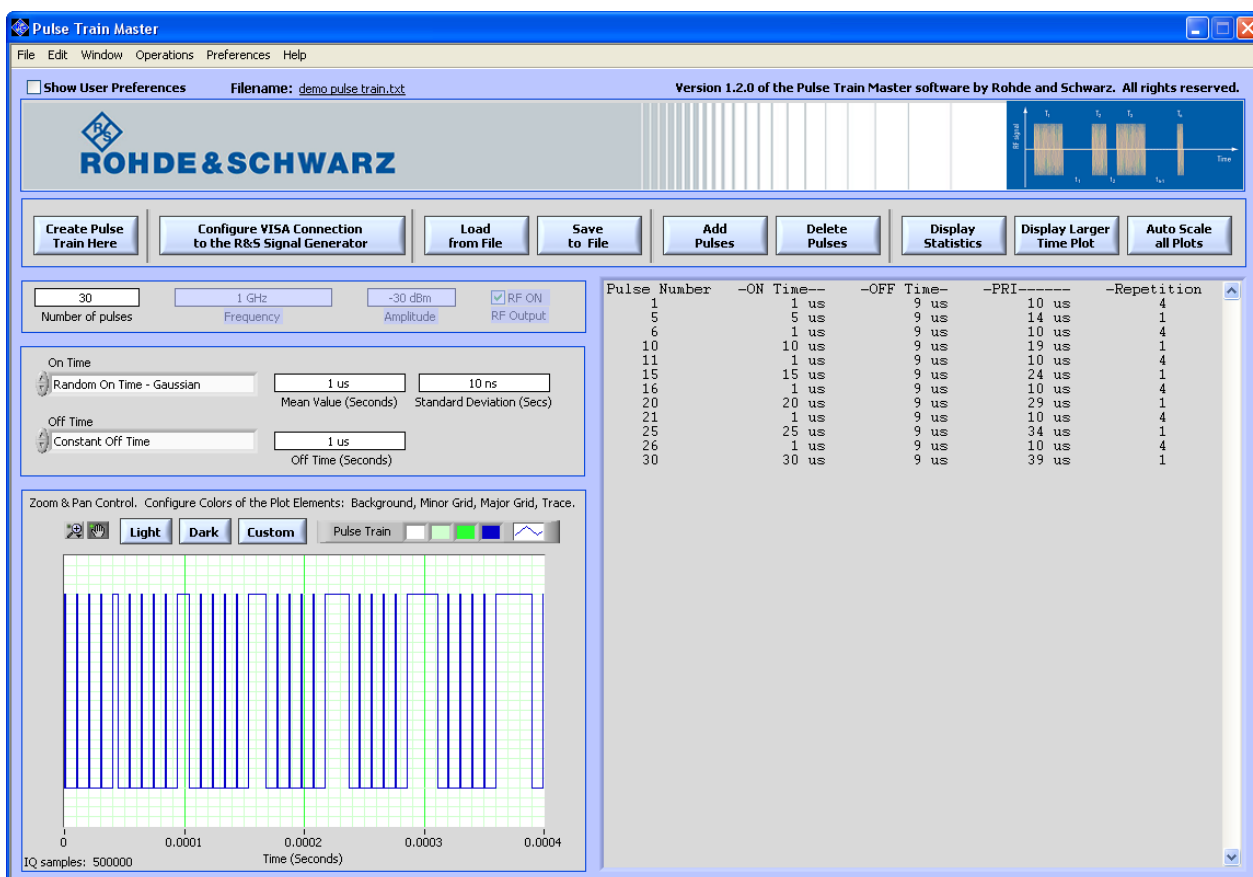
1 Introduction

This Application Note describes a software program that provides easy creation and transfer of Pulse Trains between a PC and the R&S SMB100A, R&S SMA100A or SMF100A analog signal generators with the Pulse Train option; or between a PC and the ARB of R&S SMBV200A, R&S SMJ100A or R&S SMU200A vector signal generators.

Note for Analog Signal Generators: *This software works in conjunction with the Pulse Train option on the analog signal generators. Pulse trains can be created and manipulated at any time with this software. But playback of the pulse trains on an SMB100A, SMA 100A or SMF100A requires that options SMB-K27, SMA-K27 or SMF-K27 respectively be installed on the signal generator.*

Note for Vector Signal Generators: *Playback of a pulse train on a vector signal generator uses the arbitrary waveform generator of the SMBVa00A, SMJ100A or SMU200A signal generators. No other options are required on these vector signal generators. The length of the pulse train is limited by the amount of arbitrary waveform memory that is installed on the signal generator.*

The pulse trains can be created on the PC, and then transferred to the signal generators. Alternatively, existing pulse trains on the signal generators can be transferred to the PC for viewing on the screen and for creating archives on the PC.



Pulse trains are commonly used in Radar Systems. They can be utilized in a radar receiver to help identify the intended target and to reduce noise and other interference. For example, pulse doublets are commonly used in weather radar, target tracking radar, and astronomical Doppler-radar. More complex pulse trains can be used to uniquely identify a radar transmitter or to lower the probability of intercept.

Pulse Trains are also used to simulate variation in a radar transmitter. For example, the pulse width can be jittered with a pulse train as a way of testing the robustness of a radar receiver. Similarly the pulse repetition interval can be jittered.

2 Installation of the Software

This application note is distributed with a software program named, "Pulse Train Master." This software can be installed by double clicking the Setup.exe file.

The installation will place the Executable into the directory, "C:\Program Files\Rohde-Schwarz\Pulse Master." A copy of this application note will be placed in the same directory, along with a few example pulse trains in text file format.

In addition to the executable, a copy of the National Instruments LabVIEW run time engine and the National Instruments run time VISA will also be installed on the PC.

Once installed, the program can be launched by selecting it from the Programs -> R&S Pulse Train Master -> Pulse Train Master Shortcut.

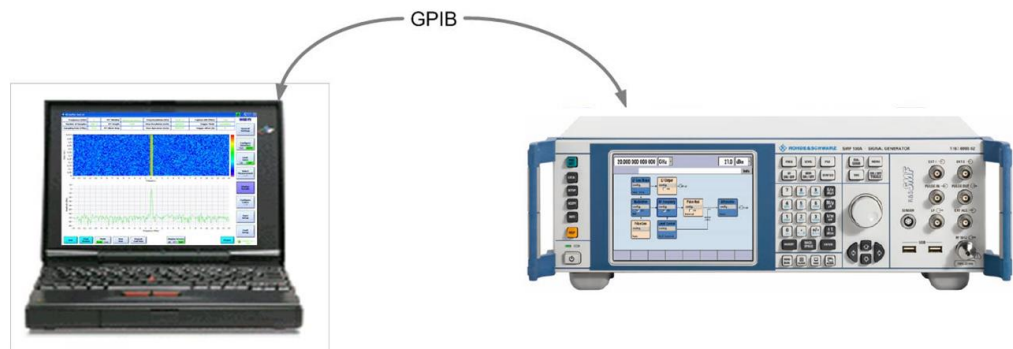
Name	Size	Type	Date Modified
bin		File Folder	4/24/2009 1:55 PM
license		File Folder	4/24/2009 11:51 AM
supportfiles		File Folder	4/24/2009 1:56 PM
setup.exe	3,944 KB	Application	11/18/2008 5:11 PM
setup.ini	15 KB	Configuration Settings	4/24/2009 1:56 PM
nidist.id	1 KB	ID File	4/24/2009 1:56 PM

3 Connecting the PC to the Instrument

A VISA connection needs to be established in order to transfer pulse trains between the PC and instrument. VISA interfaces can be a GPIB connection or a TCPIP connection over a LAN. Each of these options is described in more detail below.

3.1 GPIB

Some common examples of a GPIB connection may consist of a USB to GPIB adaptor, a PCMCIA GPIB interface card, or a PCI slot GPIB interface card. In these cases the instrument's GPIB address is used to identify the signal generator on the GPIB bus. The physical GPIB interface will also be assigned a number. The first GPIB interface is usually numbered "0", resulting in an interface name of "GPIB0." If only one GPIB interface is present on the PC, the 0 can often be omitted. This leaves the interface with the designated name "GPIB."



3.2 Configuring a GPIB connection

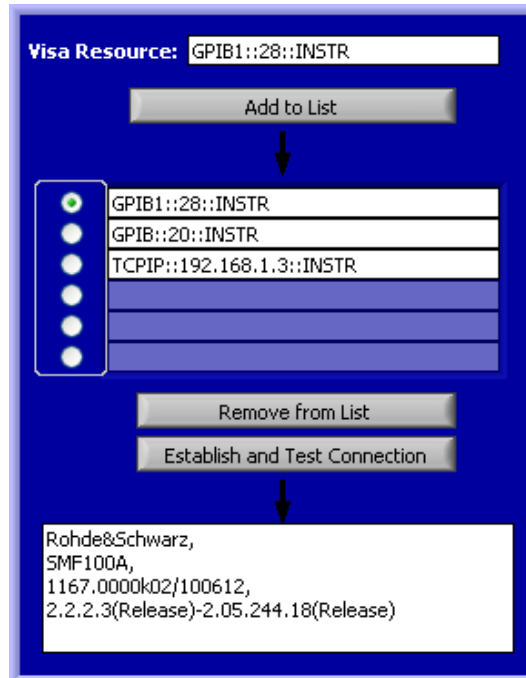
If the PC is connected to the instrument over GPIB, the user needs to enter the GPIB VISA address string for the instrument. For example, if GPIB bus 1 is utilized, and the signal generator's GPIB address is 28, then the VISA address string is the following:

```
GPIB1::28::instr
```

Alternately, if GPIB bus 0 were being utilized (most commonly used), and the instrument was at GPIB address 20, then the address string would be:

```
GPIB0::20::instr
```

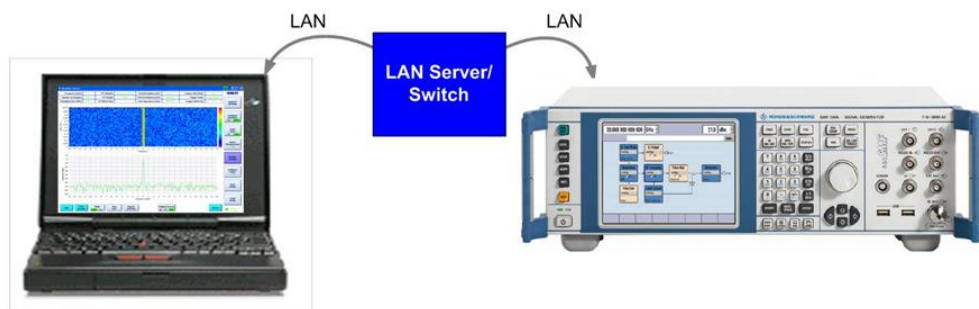
These two entries (along with some other options) are shown in the figure below. This window is accessed by pressing the “Configure” softkey near the top of the main window



3.3 LAN / Ethernet using an Intranet or Internet

The PC can control the signal generator over a LAN connection. In this case the instrument's IP address is used to identify the signal generator. Connect both the signal generator and the PC to the intranet or internet, and make sure both have valid IP addresses.

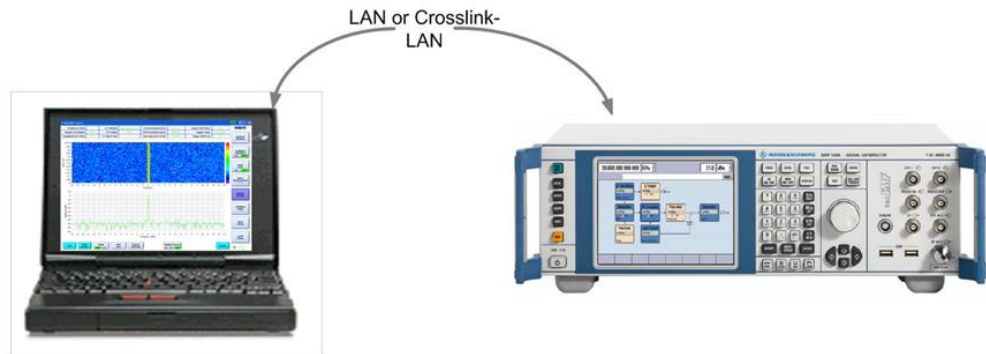
When connecting over a LAN / Ethernet connection, the name of the interface bus is TCPIP.



3.4 LAN / Ethernet using a crossover connection

A direct connection between the PC and the signal generator is also possible. Use a crossover cable unless the PC has an autosense Ethernet port. In this case both the PC and the signal generator need to be on the same subnet. Make sure that both have valid IP addresses, and that the PC can “PING” the signal generator.

The interface name in this case is still “TCPIP.”



3.5 Configuring a LAN Connection

To configure a LAN connection we need to know either the instrument's computer name or the IP address of the instrument

The instrument's IP address can be found by pressing SETUP and scrolling down to the Ethernet entry option.

Once the Signal Generator's IP address is known, enter it in the VISA string between the “::” marks. For example,

```
TCPIP::192.168.0.10::INSTR
```

As an alternative to using the IP address of the signal generator, you can enter the instrument's network name. For example,

```
TCPIP::SMF100A-100193::INSTR
```

4 Basic Operation of the Software

4.1 Registration

A registration window will appear when the program is first launched. Registration is optional, and does not enable any additional features. But if the program is registered, the user will not have to wait 5 seconds for the registration screen to go away each time the program is launched.

The registration window is displayed below. To register, follow the instructions in the window.

To bypass the registration, press the start key, and the window will close in ~ 5 seconds. The program is then available to the user.

Welcome to Pulse Train Master

You are using an unregistered version of Pulse Train Master. This version has full functionality and no expiration date. As we are continuously improving the program, we depend on your comments and experience with Pulse Train Master. Therefore, we kindly ask you to register Pulse Train Master. Registration is free of charge and doesn't obligate you or your company.

To register

1. Fill out the registration form below.
2. Click 'Copy Registration Form to Clipboard.'
3. Open your mail client and paste the clipboard into the email message field with 'Ctrl-V.'

Then send the registration form to TM-Applications@rohde-schwarz.com.
You will receive an email from Rohde & Schwarz with your registration key.

Name: *

* The registration key is derived from your name. The Email and Country information is also obligatory, all other information is optional. Please help us by also providing these details.

Company: Dept:

Street: City:

Telephone: Country: *

Email: *

Comments:

Copy Registration Form to Clipboard

Once you receive your registration key

1. Enter your User Name and Registration Key.
2. Click 'Start'.

Pulse Train Master will start immediately. This registration form will no longer appear at program start.

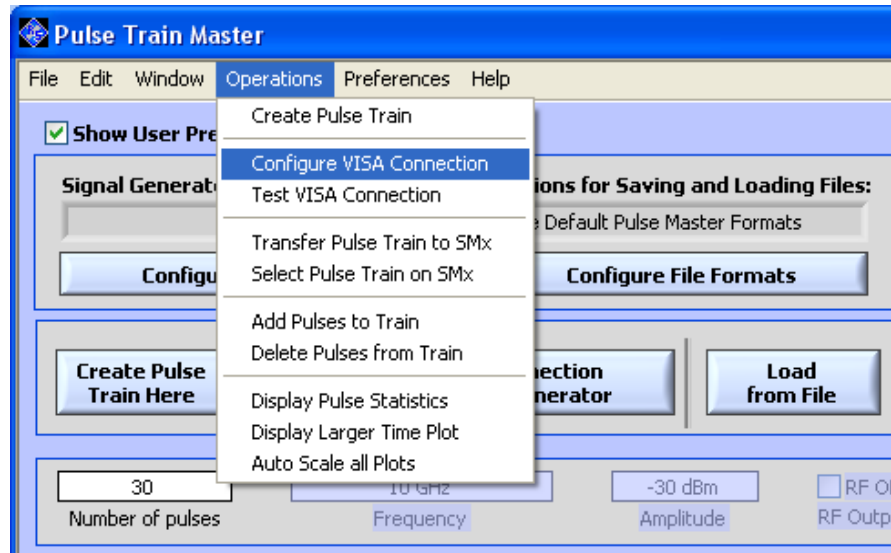
User Name:

Key Code:

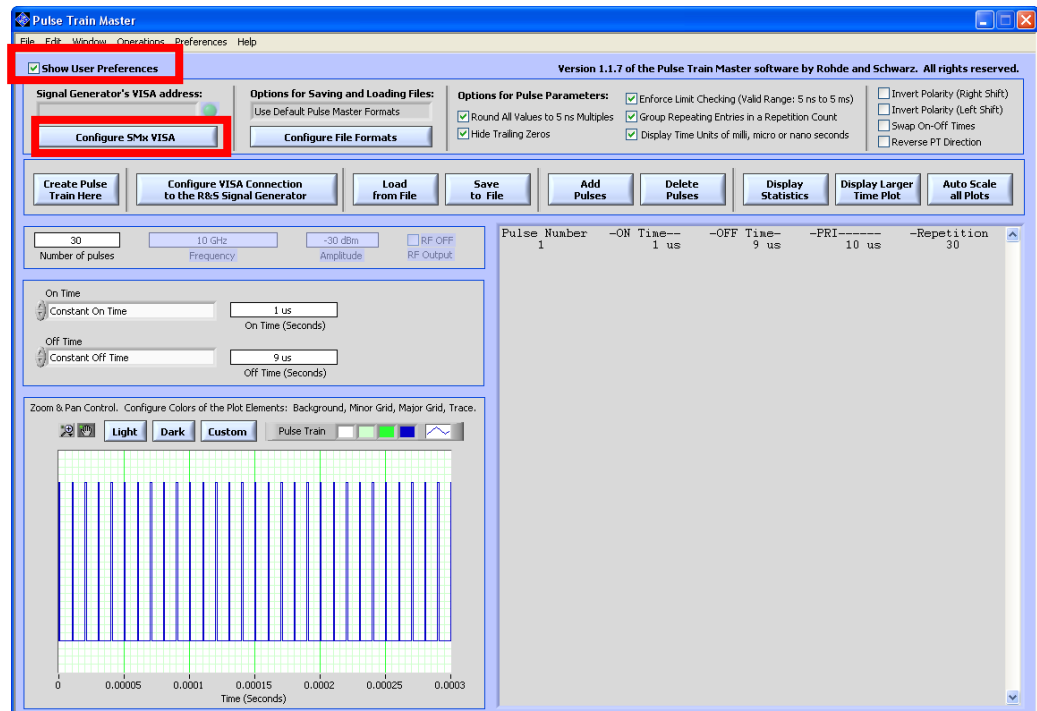
Start

4.2 Establish a connection with the instrument

The first step is to configure a connection between the PC and the instrument. Do this by selecting the “Configure VISA connection” item under the Operations menu.



Alternatively you can click on the “Configure SMx VISA” button near the top left corner of the screen. You can make this button visible by checking the “Show User Preferences” checkbox also near the top left corner of the screen.



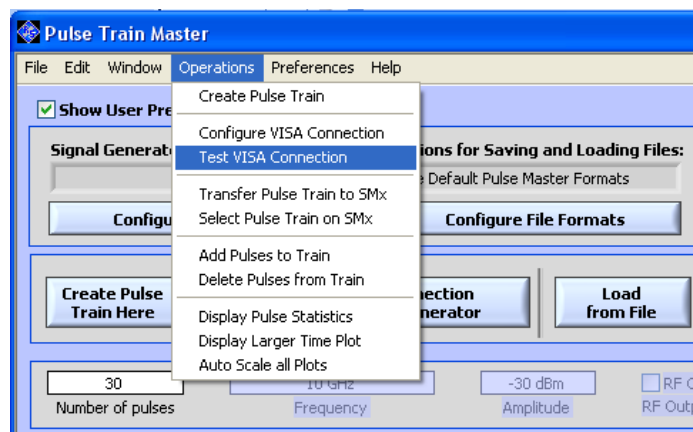
This will open a window where the VISA interface (either GPIB or TCPIP) is configured, along with the instrument's address. For more details on how to configure a VISA connection to the instrument, refer back to section 3.

Enter the instrument's address in the top box using the format that was described in section 3. Press the "Add to List" button to place the address in the table.

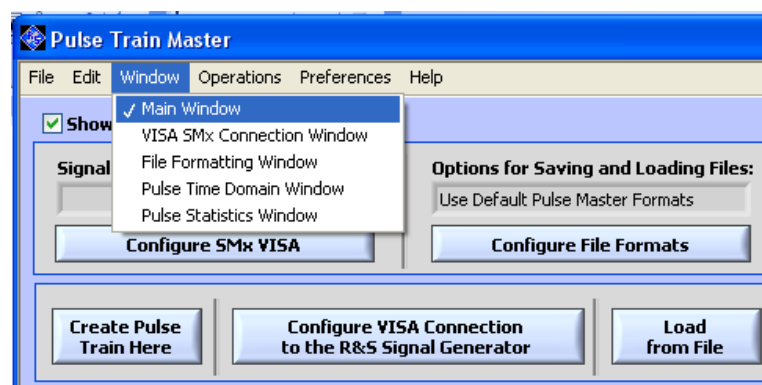
To remove entries from the table, select them with the radio button and press the "Remove from List" button.

The entries in the table will be preserved each time you run the program, making it easy to select between a few instruments that are used often with the program.

Select any address in the table by selecting the radio button next to it. Test the connection to the instrument by pressing the "Establish and Test Connection" button or by selecting "Test VISA Connection" under the preferences menu. If communication is successful, the instrument's name, model number and firmware revision will be displayed in the box at the bottom of the screen. If there is a problem with the communication, then a failure to connect message will be displayed instead.



Once communication is established with the instrument, press the "Return to Main Window" button or Select the Main Window from the File pull down menu in order to return to the program's main interface.



Below is an example of a successful test between the PC and an R&S SMF100A signal generator:



4.3 Main Features of the Software

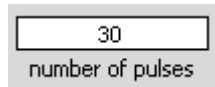
The Pulse Train Master has a few basic functions. These are listed below, and described in greater detail in the following sections.

- Create a variety of different pulse trains on the PC.
- Save a pulse train to a text file on the PC.
- Load a pulse train from a text file on the PC.
- Edit a pulse train on the PC by adding or deleting pulses.
- Edit a pulse train by inverting its polarity.
- Edit a pulse train by interchanging the on and off times.
- Edit a pulse train by reversing the direction of the pulse train.
- Transfer a pulse train from the PC to the signal generator and activate it.
- Select a pulse train on the signal generator, activate it, and copy it back to the PC
- Control the Frequency and Amplitude settings of the signal generator from the PC.

4.4 Creating a Pulse Train on the PC

This is the main use of the software program. It can be used to create a pulse train with a variety of characteristics.

The first parameter that needs to be entered is the number of pulses in the pulse train.



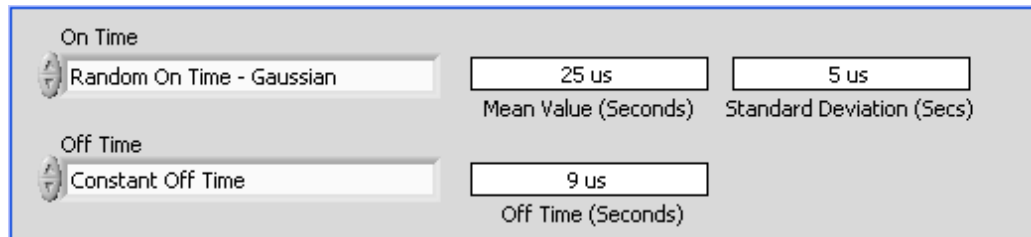
A screenshot of a software interface showing a text input field containing the number '30'. Below the input field is the label 'number of pulses'.

Each pulse can have an independent ON time, followed by an independent OFF time. So every pulse in the pulse train can be unique, if desired.

To modify the characteristics of the pulse train, select the criteria for the ON times from the drop down menu. The choices include:

- Constant ON Time.
- Constant PRI Time.
- Variable ON Time, incremented by a fixed amount from pulse to pulse
- Variable ON Time, decremented by a fixed amount from pulse to pulse
- A Random ON Time, with the variation described by a Uniform Distribution.
- A Random ON Time, with the variation described by a Gaussian distribution.

Once the desired criterion for the ON time of the pulses is selected, the controlling parameters will be available for entry into the new fields that will appear. An example showing a Gaussian Distributed ON Time is shown in the Figure Below:



A screenshot of a software interface showing settings for pulse train characteristics. The 'On Time' section has a dropdown menu set to 'Random On Time - Gaussian', with two input fields: 'Mean Value (Seconds)' set to '25 us' and 'Standard Deviation (Secs)' set to '5 us'. The 'Off Time' section has a dropdown menu set to 'Constant Off Time', with one input field: 'Off Time (Seconds)' set to '9 us'.

In this example, the ON Times of the pulses will be selected from a statistical pool of values which contain a mean value of 25 μs , and a standard deviation of 5 μs .

Similar options are available for setting the OFF times of the pulses. See the list of options below:

- Constant OFF Time.
- Constant PRI Time.
- Variable OFF Time, incremented by a fixed amount from pulse to pulse
- Variable OFF Time, decremented by a fixed amount from pulse to pulse
- A Random OFF Time, with the variation described by a Uniform Distribution.
- A Random OFF Time, with the variation described by a Gaussian distribution.

An example is shown below, to create 30 pulses, with a random ON time for each pulse. The ON times are Gaussian Distributed with a mean value of 25 μ s, and a standard deviation of 5 μ s. The OFF times are adjusted to maintain a constant PRI value of 50 μ s.

Number of pulses

On Time

Random On Time - Gaussian

Off Time

Constant PRI Time

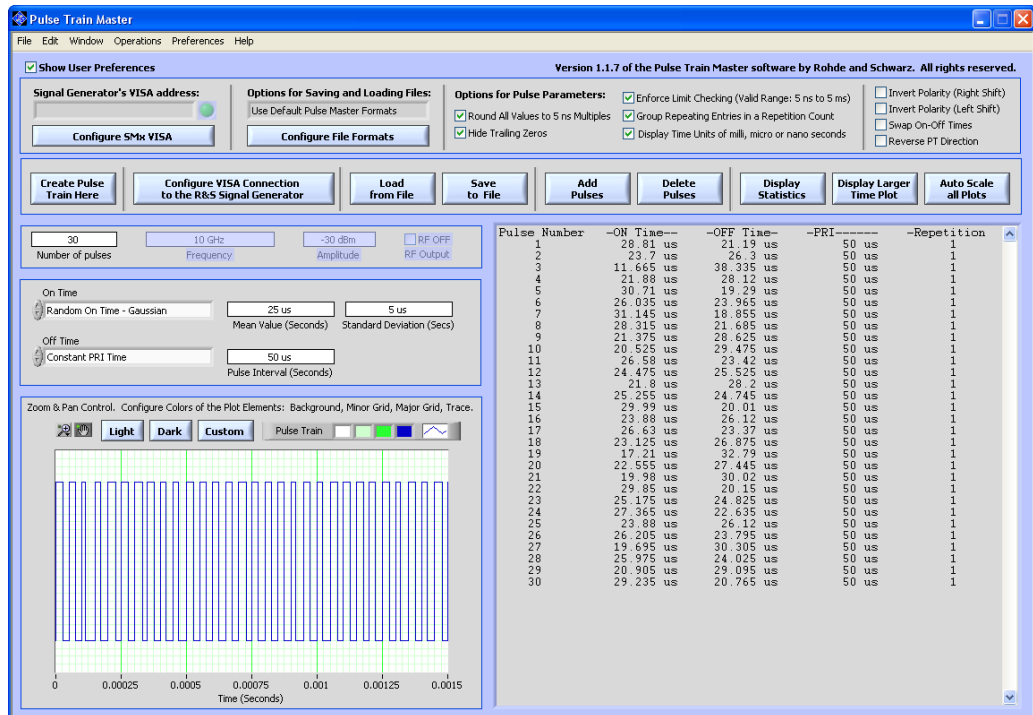
Mean Value (Seconds) Standard Deviation (Secs)

Pulse Interval (Seconds)

After selecting the pulse parameters, a press of the “Create Pulse Train Here” button will generate a pulse train list that meets the selected criteria. At this point the Pulse Train has only been created on the PC.

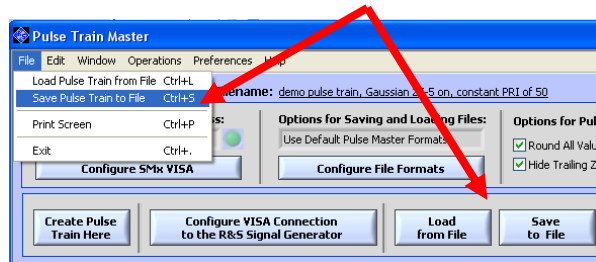
The output is a text based list of the pulse train, and also a graphical plot of the pulse train. The text list can be viewed using the scroll bar in the window. The graphical view supports zooming in and out, as well as panning operations.

The following screen shot shows the results of completing the example that has been described so far.

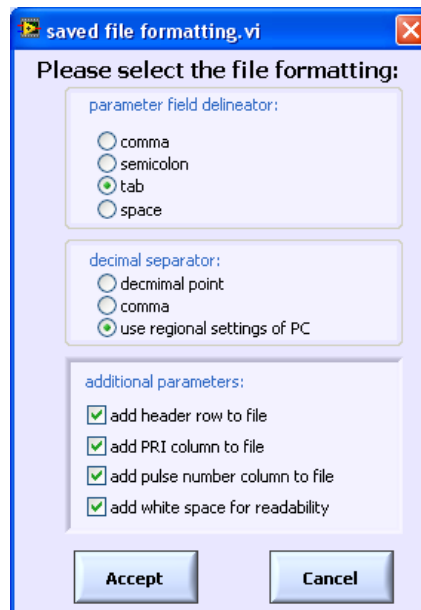


4.5 Save the Pulse Train to a text file on the PC

Now that a specific pulse train has been created, it might be useful to save it on the PC. Above the text window that contains the description of the pulse train there is a button named, “Save to File.” Selecting this button will open a dialog box allowing the user to create a new file or replace an existing file with ASCII text that contains the details of this pulse train. Or select “Save Pulse Train to File” under the pull down menu labeled “File.”



The data will be saved into an ASCII text file. The data fields can be delineated by a comma, semicolon, a tab or by a space. The decimal separator can be either a period or a comma. The first row contains an optional header that labels the columns in the file.



The first column contains the number of the pulse in the pulse train. This column is optional, and can be deleted by unchecking the “add pulse number column to file” box. The second column contains the ON time the pulses. The third column contains the OFF times of the pulses. A fourth column contains the pulse repetition interval (the on time plus the off time) for the pulse. This column is also optional and can be removed by unchecking the “add PRI column” box. The final column is a repetition count indicating how many times this particular pulse will be repeated before moving on to the next pulse.

By default, the user will be queried for these settings each time a pulse train file is saved or loaded into the software.

Alternatively, the user can configure the desired file format and then disable the automatic query function. This is done by selecting “Configure File Formats” from the Preferences pull down menu, or by clicking on the Configure File Formats button.

The resulting window lists all the options, and provides an example of the text of a pulse train using the selected settings. Uncheck the query box and these settings will be used for all future save and load operations.

Options for Saving and Loading Files:

Use Default Pulse Master Formats

The default Pulse Master file format uses a semicolon as the field delineator, and the region setting of either a "period" or a "comma" for the decimal separator. It also contains a header row along with 5 columns of information: Pulse Number, Pulse On Time, Pulse Off Time, Pulse Repetition Interval, and the number of Pulse Repetitions for that particular pulse. The default format also adds white space to the file to make it more readable.

The SMx GUI compatible file format is a minimal format that can be imported and exported by using the graphical user interface of the SMF and SMA signal generators. It uses the semicolon as a field delineator, and a period as a decimal separator. It does NOT contain a header row. It contains three columns: Pulse On Time, Pulse Off Time and the number of Pulse Repetitions for each particular pulse. This format does not add any extraneous white space to the file.

You can customize these values by checking the appropriate boxes.

You can also configure the software to query for the appropriate settings each time a file is loaded or saved.

Here is an example using the current file settings. (Note: a "tab" delineator is represented by "<tab>" in the example below.)

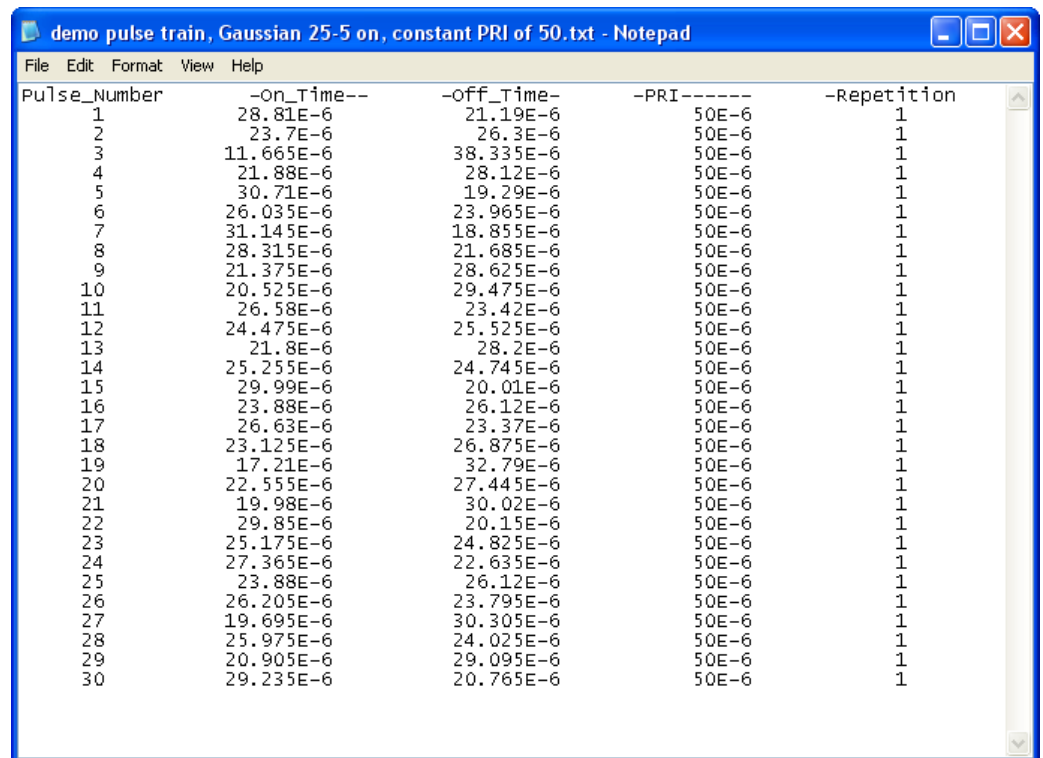
Pulse_Number <tab>	-On_Time- <tab>	-Off_Time- <tab>	-PRI- <tab>	-Repetition
1 <tab>	1E-6 <tab>	9.5E-6 <tab>	10.5E-6 <tab>	4
5 <tab>	5E-6 <tab>	9.5E-6 <tab>	14.5E-6 <tab>	1
6 <tab>	1E-6 <tab>	9.5E-6 <tab>	10.5E-6 <tab>	4
10 <tab>	10E-6 <tab>	9.5E-6 <tab>	19.5E-6 <tab>	1
11 <tab>	1E-6 <tab>	9.5E-6 <tab>	10.5E-6 <tab>	4
15 <tab>	15E-6 <tab>	9.5E-6 <tab>	24.5E-6 <tab>	1
16 <tab>	1E-6 <tab>	9.5E-6 <tab>	10.5E-6 <tab>	4
20 <tab>	20E-6 <tab>	9.5E-6 <tab>	29.5E-6 <tab>	1
21 <tab>	1E-6 <tab>	9.5E-6 <tab>	10.5E-6 <tab>	4
25 <tab>	25E-6 <tab>	9.5E-6 <tab>	34.5E-6 <tab>	1
26 <tab>	1E-6 <tab>	9.5E-6 <tab>	10.5E-6 <tab>	4
30 <tab>	30E-6 <tab>	9.5E-6 <tab>	39.5E-6 <tab>	1

There are two very common formats, and they can be selected with the “Use default file formats” and the “Use SMx GUI formats” buttons.

The “default file formats” use a configuration that is easy to import into, for example, Microsoft Excel. It uses a tab delineator, a period for the decimal separator, includes a header row and columns for the pulse count, on time, off time, PRI, and the repetition count.

The second format is labeled “Use SMx GUI formats.” This format matches the default format that the SMF and SMA signal generators use during the manual import and export of pulse trains. This is the format to use if a pulse train will be transferred to the instrument utilizing a USB memory stick, for example.

Here is the result of saving a similar example to a text file, and then opening it with Notepad.



Pulse_Number	-On_Time--	-Off_Time-	-PRI-----	-Repetition
1	28.81E-6	21.19E-6	50E-6	1
2	23.7E-6	26.3E-6	50E-6	1
3	11.665E-6	38.335E-6	50E-6	1
4	21.88E-6	28.12E-6	50E-6	1
5	30.71E-6	19.29E-6	50E-6	1
6	26.035E-6	23.965E-6	50E-6	1
7	31.145E-6	18.855E-6	50E-6	1
8	28.315E-6	21.685E-6	50E-6	1
9	21.375E-6	28.625E-6	50E-6	1
10	20.525E-6	29.475E-6	50E-6	1
11	26.58E-6	23.42E-6	50E-6	1
12	24.475E-6	25.525E-6	50E-6	1
13	21.8E-6	28.2E-6	50E-6	1
14	25.255E-6	24.745E-6	50E-6	1
15	29.99E-6	20.01E-6	50E-6	1
16	23.88E-6	26.12E-6	50E-6	1
17	26.63E-6	23.37E-6	50E-6	1
18	23.125E-6	26.875E-6	50E-6	1
19	17.21E-6	32.79E-6	50E-6	1
20	22.555E-6	27.445E-6	50E-6	1
21	19.98E-6	30.02E-6	50E-6	1
22	29.85E-6	20.15E-6	50E-6	1
23	25.175E-6	24.825E-6	50E-6	1
24	27.365E-6	22.635E-6	50E-6	1
25	23.88E-6	26.12E-6	50E-6	1
26	26.205E-6	23.795E-6	50E-6	1
27	19.695E-6	30.305E-6	50E-6	1
28	25.975E-6	24.025E-6	50E-6	1
29	20.905E-6	29.095E-6	50E-6	1
30	29.235E-6	20.765E-6	50E-6	1

4.6 Read the Pulse Train from a text file on the PC

Naturally the software can also read a pulse train from a text file if it follows one of the formats described in the last section. These files would be easy to create using MS Excel, for example, or any other program that can manipulate text files.

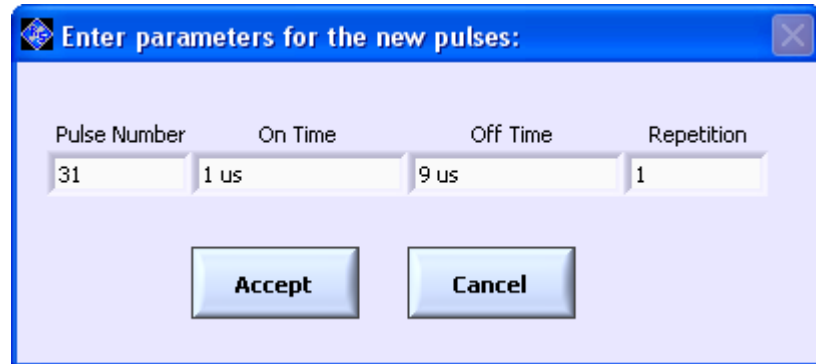
Press the “Load from File” button to open up a dialog box where the user can select the desired file format. After this, a dialog box is displayed so the user can select the desired file.

4.7 Edit the pulse train.

The user has the option of editing the pulse train directly in the summary window. Select any pulse parameter, change its value, and press enter to accept the change. Only one parameter may be modified at a time.

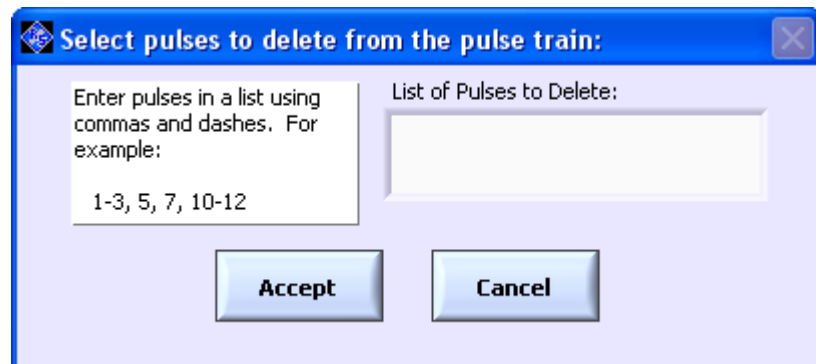
By changing the “pulse number”, the user can reposition any existing pulse to a new location within the pulse train.

In addition to changing any existing pulse, the user has the option of adding or deleting pulses. The Add Pulses button opens a dialog box that allows the user to enter the parameters for a new pulse. The example below inserts the new pulse in the 31st position of the pulse train.



To delete pulses from the pulse train, select the Delete Pulses button. In the dialog box, you may create a list of pulses that should be deleted. The list can be comma separated, and may also include a range of pulses separated by a dash "-".

The list of 1-5, 26-31 will delete the first five pulses and the last six pulses in the existing pulse train.



4.8 Invert the Polarity of the Pulse Train

This option will convert the on times of each pulse to an off time, and the off times of each pulse to an on time. Consider a pulse train that has an on-off pattern of:

```

on      off      on      off      on      off      on      off      (repeat)
1 us    2 us    3 us    4 us    5 us    6 us    7 us    8 us

```

To invert the pulse train, we change the on times to off times, and vice-versa. This leaves us with:

```

off     on      off     on      off     on      off     on      (repeat)
1 us    2 us    3 us    4 us    5 us    6 us    7 us    8 us

```

Since our convention is to list the pulse pairs by their on time followed by their off time, we have to rotate the pulse train to the right or left by one position (simply for display purposes). This results in the following:

Rotate Right:

```

on      off      on      off      on      off      on      off      (repeat)
8 us    1 us    2 us    3 us    4 us    5 us    6 us    7 us

```

Rotate Left

```

on      off      on      off      on      off      on      off      (repeat)
2 us    3 us    4 us    5 us    6 us    7 us    8 us    1 us

```

Which are equivalent. When inverting the pulse train, you can choose to rotate the pulse train to the right or to the left.

<input type="checkbox"/> Invert Polarity (Right Shift) <input type="checkbox"/> Invert Polarity (Left Shift) <input type="checkbox"/> Swap On-Off Times <input type="checkbox"/> Reverse PT Direction	<table border="1"> <thead> <tr> <th>Pulse Number</th> <th>-ON Time--</th> <th>-OFF Time-</th> <th>-PRI-----</th> <th>-Repetition</th> </tr> </thead> <tbody> <tr><td>1</td><td>1 us</td><td>2 us</td><td>3 us</td><td>1</td></tr> <tr><td>2</td><td>3 us</td><td>4 us</td><td>7 us</td><td>1</td></tr> <tr><td>3</td><td>5 us</td><td>6 us</td><td>11 us</td><td>1</td></tr> <tr><td>4</td><td>7 us</td><td>8 us</td><td>15 us</td><td>1</td></tr> </tbody> </table>	Pulse Number	-ON Time--	-OFF Time-	-PRI-----	-Repetition	1	1 us	2 us	3 us	1	2	3 us	4 us	7 us	1	3	5 us	6 us	11 us	1	4	7 us	8 us	15 us	1
Pulse Number	-ON Time--	-OFF Time-	-PRI-----	-Repetition																						
1	1 us	2 us	3 us	1																						
2	3 us	4 us	7 us	1																						
3	5 us	6 us	11 us	1																						
4	7 us	8 us	15 us	1																						
<input checked="" type="checkbox"/> Invert Polarity (Right Shift) <input type="checkbox"/> Invert Polarity (Left Shift) <input type="checkbox"/> Swap On-Off Times <input type="checkbox"/> Reverse PT Direction	<table border="1"> <thead> <tr> <th>Pulse Number</th> <th>-ON Time--</th> <th>-OFF Time-</th> <th>-PRI-----</th> <th>-Repetition</th> </tr> </thead> <tbody> <tr><td>1</td><td>8 us</td><td>1 us</td><td>9 us</td><td>1</td></tr> <tr><td>2</td><td>2 us</td><td>3 us</td><td>5 us</td><td>1</td></tr> <tr><td>3</td><td>4 us</td><td>5 us</td><td>9 us</td><td>1</td></tr> <tr><td>4</td><td>6 us</td><td>7 us</td><td>13 us</td><td>1</td></tr> </tbody> </table>	Pulse Number	-ON Time--	-OFF Time-	-PRI-----	-Repetition	1	8 us	1 us	9 us	1	2	2 us	3 us	5 us	1	3	4 us	5 us	9 us	1	4	6 us	7 us	13 us	1
Pulse Number	-ON Time--	-OFF Time-	-PRI-----	-Repetition																						
1	8 us	1 us	9 us	1																						
2	2 us	3 us	5 us	1																						
3	4 us	5 us	9 us	1																						
4	6 us	7 us	13 us	1																						
<input type="checkbox"/> Invert Polarity (Right Shift) <input checked="" type="checkbox"/> Invert Polarity (Left Shift) <input type="checkbox"/> Swap On-Off Times <input type="checkbox"/> Reverse PT Direction	<table border="1"> <thead> <tr> <th>Pulse Number</th> <th>-ON Time--</th> <th>-OFF Time-</th> <th>-PRI-----</th> <th>-Repetition</th> </tr> </thead> <tbody> <tr><td>1</td><td>2 us</td><td>3 us</td><td>5 us</td><td>1</td></tr> <tr><td>2</td><td>4 us</td><td>5 us</td><td>9 us</td><td>1</td></tr> <tr><td>3</td><td>6 us</td><td>7 us</td><td>13 us</td><td>1</td></tr> <tr><td>4</td><td>8 us</td><td>1 us</td><td>9 us</td><td>1</td></tr> </tbody> </table>	Pulse Number	-ON Time--	-OFF Time-	-PRI-----	-Repetition	1	2 us	3 us	5 us	1	2	4 us	5 us	9 us	1	3	6 us	7 us	13 us	1	4	8 us	1 us	9 us	1
Pulse Number	-ON Time--	-OFF Time-	-PRI-----	-Repetition																						
1	2 us	3 us	5 us	1																						
2	4 us	5 us	9 us	1																						
3	6 us	7 us	13 us	1																						
4	8 us	1 us	9 us	1																						

4.9 Swap the On and Off Times of the Pulse Train

This option will switch the on and off times of each individual pulse. It is not the same as inverting the polarity, although with some pulse trains the effect is identical.

Assume this starting pulse train

```

on      off      on      off      on      off      on      off      (repeat)
1 us    2 us    3 us    4 us    5 us    6 us    7 us    8 us

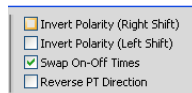
```

Swapping the on and off times results in the following pulse train

```

on      off      on      off      on      off      on      off      (repeat)
2 us    1 us    4 us    3 us    6 us    5 us    8 us    7 us

```



Pulse Number	-ON Time--	-OFF Time--	-PRI-----	-Repetition
1	2 us	1 us	3 us	1
2	4 us	3 us	7 us	1
3	6 us	5 us	11 us	1
4	8 us	7 us	15 us	1

4.10 Reverse the Direction of the Pulse Train

This option will play the pulse train out in the opposite direction.

Assume this starting pulse train

```

on      off      on      off      on      off      on      off      (repeat)
1 us    2 us    3 us    4 us    5 us    6 us    7 us    8 us

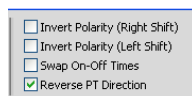
```

Reversing the direction of the pulse train results in the following:

```

on      off      on      off      on      off      on      off      (repeat)
7 us    8 us    5 us    6 us    3 us    4 us    1 us    2 us

```



Pulse Number	-ON Time--	-OFF Time--	-PRI-----	-Repetition
1	7 us	8 us	15 us	1
2	5 us	6 us	11 us	1
3	3 us	4 us	7 us	1
4	1 us	2 us	3 us	1

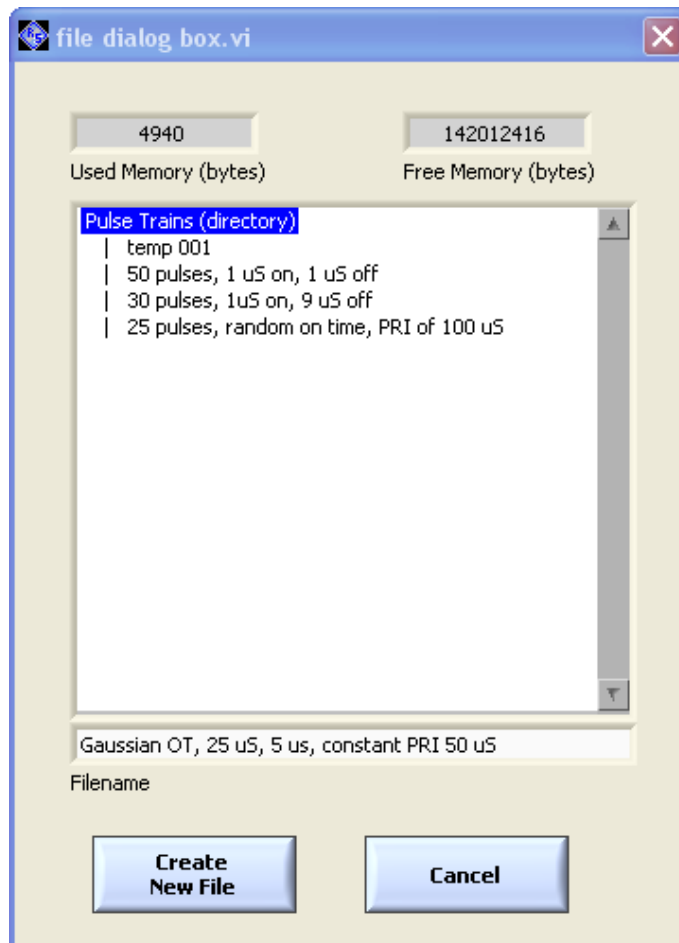
4.11 Transfer a Pulse Train from the PC to the SMF, and activate it.

This is one of the main functions of the software. As long as the user has configured a connection between the software and the instrument, the “Transfer PT to SMx” button will be enabled.

Pressing this button brings up a dialog box where the user is presented with the contents of the “Pulse Trains” directory on the instrument. The user has the option of replacing an existing pulse train, or creating a new file that contains this pulse train.

To continue the existing example, a new file is created with the name, “Gaussian OT, 25 μ s, 5 μ s, constant PRI 50 μ s.”

A press of the “Create New File” button transfers the pulse train, loads it, and activates the pulse train modulation in the SMx.

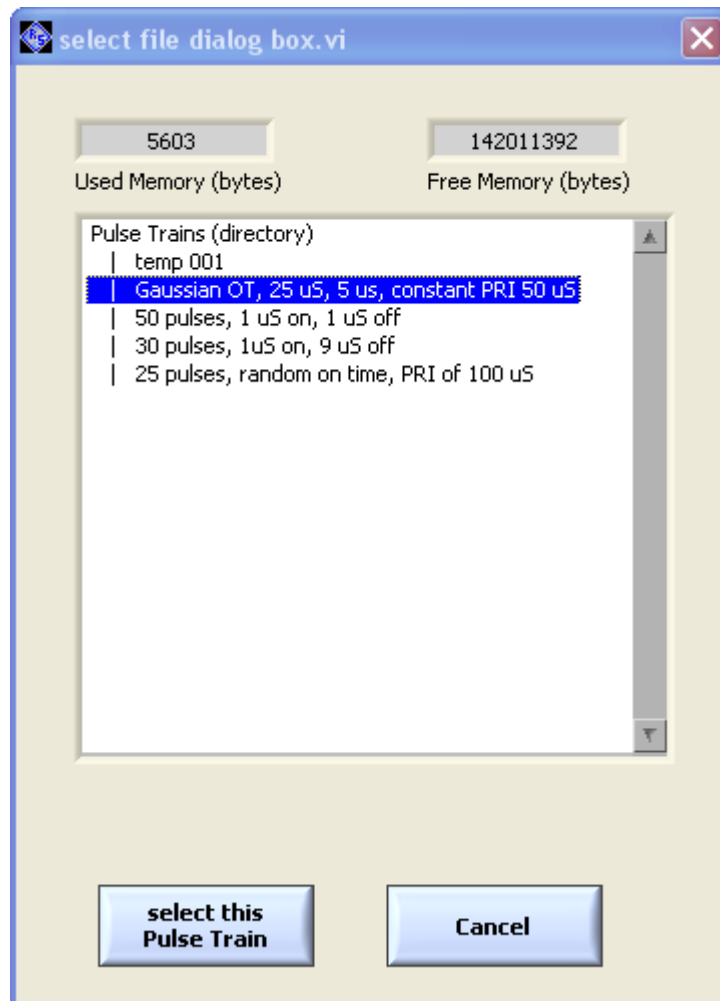


Select a Pulse Train, activate it, and copy it back to the PC.

4.12 Select a Pulse Train, activate it, and copy it back to the PC.

Once a pulse train has been loaded onto the SMx, it can be activated and then copied back to the PC at any time.

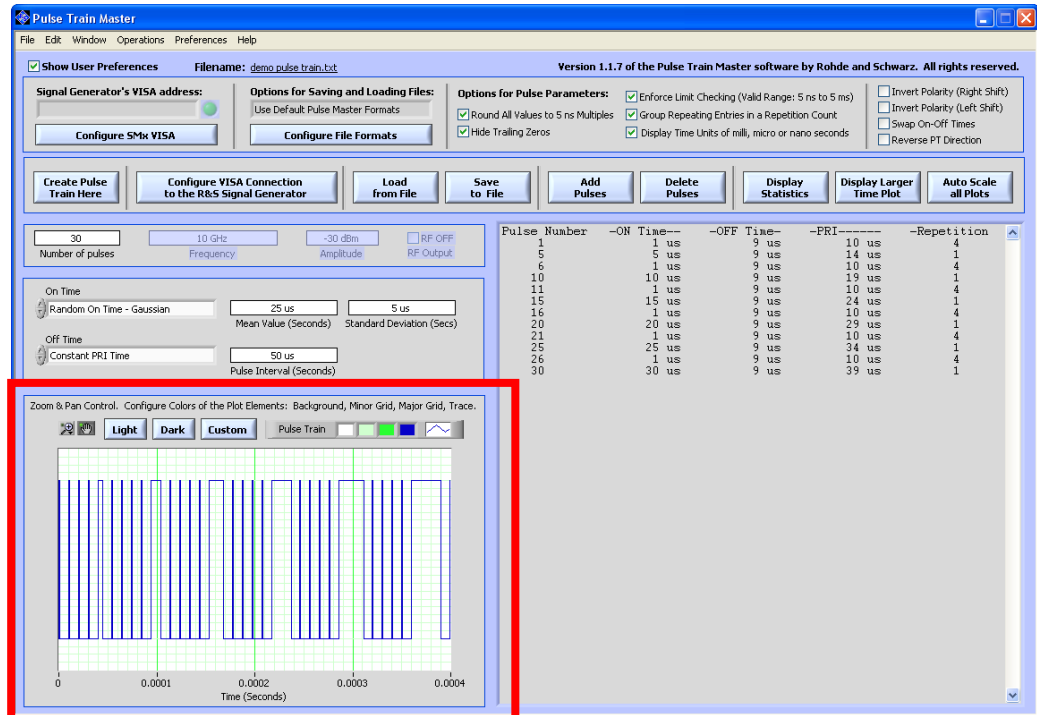
To do this, press the “Select Pulse Train on SMx” button. Another dialog box will appear, containing a list of all the pulse trains in the Pulse Trains directory. To continue the example, the pulse train that was just transferred to the SMF has been selected in the dialog box, as shown below:



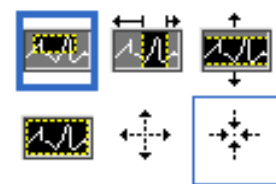
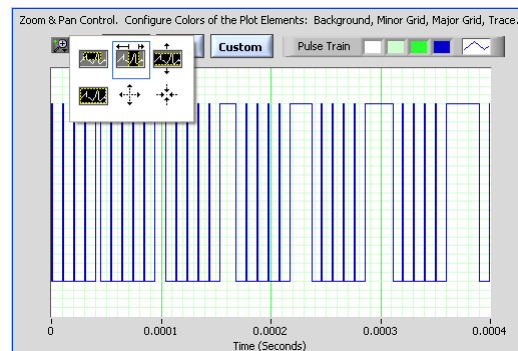
Note that selecting a pulse train with this method both activates the pulse train on the SMx, and copies it back to the PC so the user can observe the specifics of the activated pulse train.

4.13 Graphical Views of the Pulse Train.

There are several ways to view the pulse train graphically. The first is in the window located in the lower left hand corner of the application. This window shows the pulse train amplitudes (high and low) vs. time.



In this window you can pan or zoom the graph by using the graphical selection box.

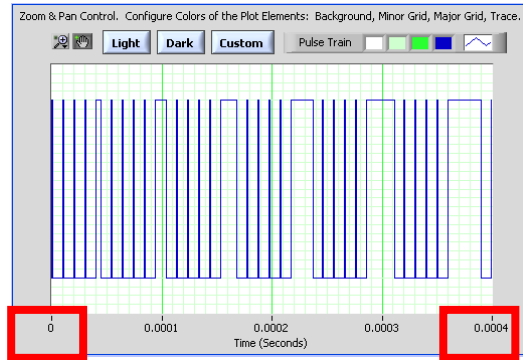


The first tool, in the upper left hand corner of the selection box, allows you to click and drag an area on the plot to zoom into that area. The tool to the right also zooms in on an area of the plot, but only zooms in on the X-axis. The last tool on the top row zooms in on an area of the plot, but only zooms in on the Y-axis.

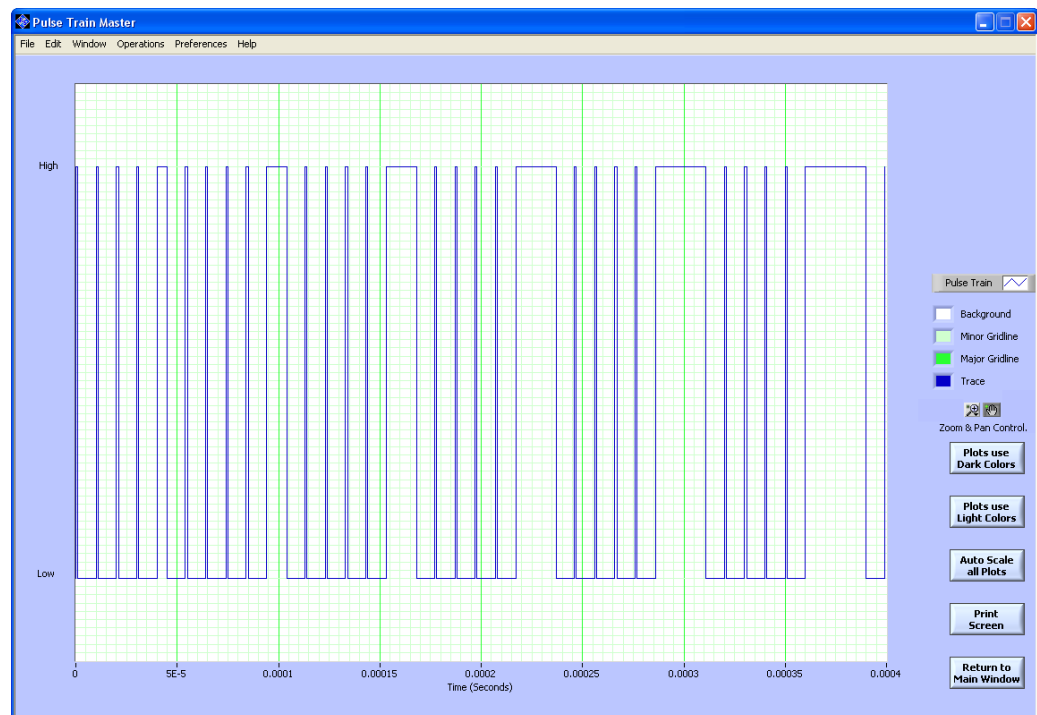
The leftmost selection in the bottom row returns to an "auto zoom" setting. The middle selection in the bottom row will zoom in on a point that is clicked on in a plot. The rightmost selection in the bottom row will zoom out on a point that is clicked on in a plot.

You can also change the scales of the charts by double clicking on the maximum and minimum values. This allows fine control over the level of zooming.

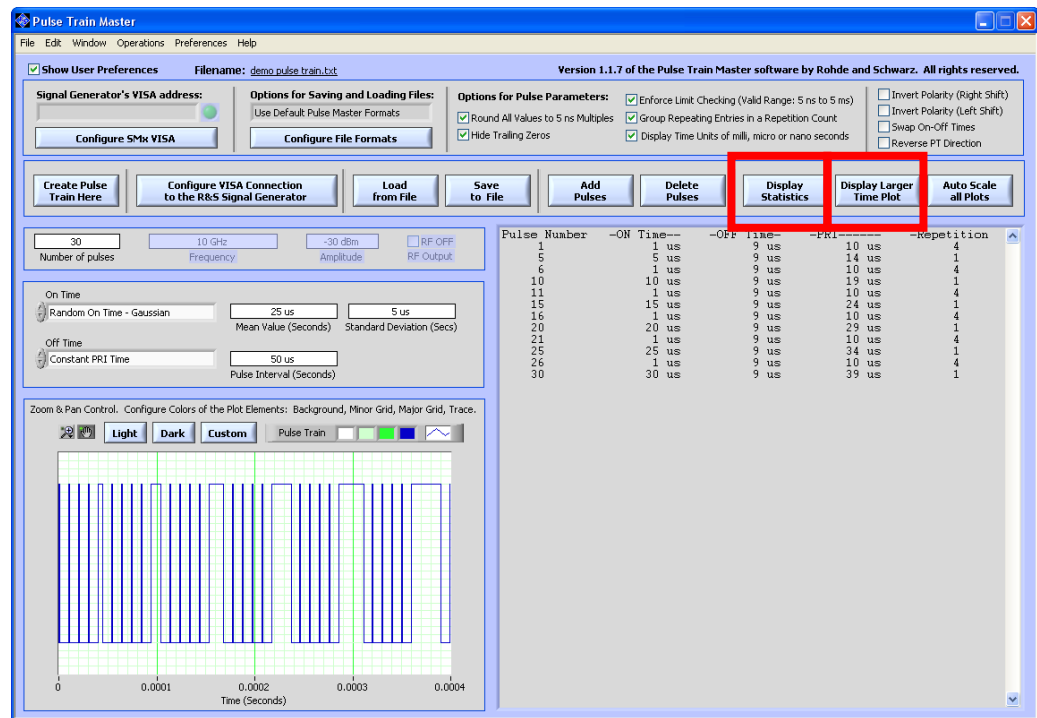
Panning is selecting by choosing the Hand Tool from the selection pallet. It is the rightmost selection in the pallet. Once the hand has been selecting, you can click and drag on a plot to change the area that is displayed.



Another option is to work with a larger size plot. This is accessed by clicking on the "Display Larger Time Plot" button, which opens a new window.

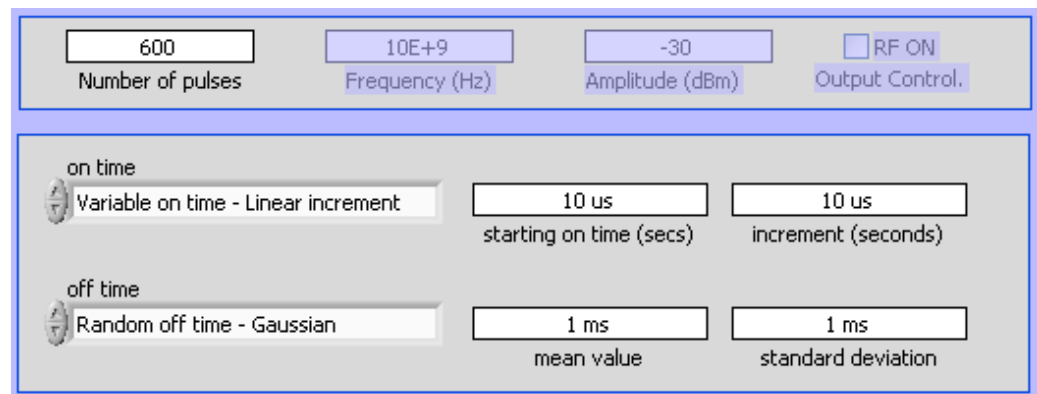


In addition to this time plot, there is also a statistical view of the pulse train. This is selected by clicking on the Display Statistics button.



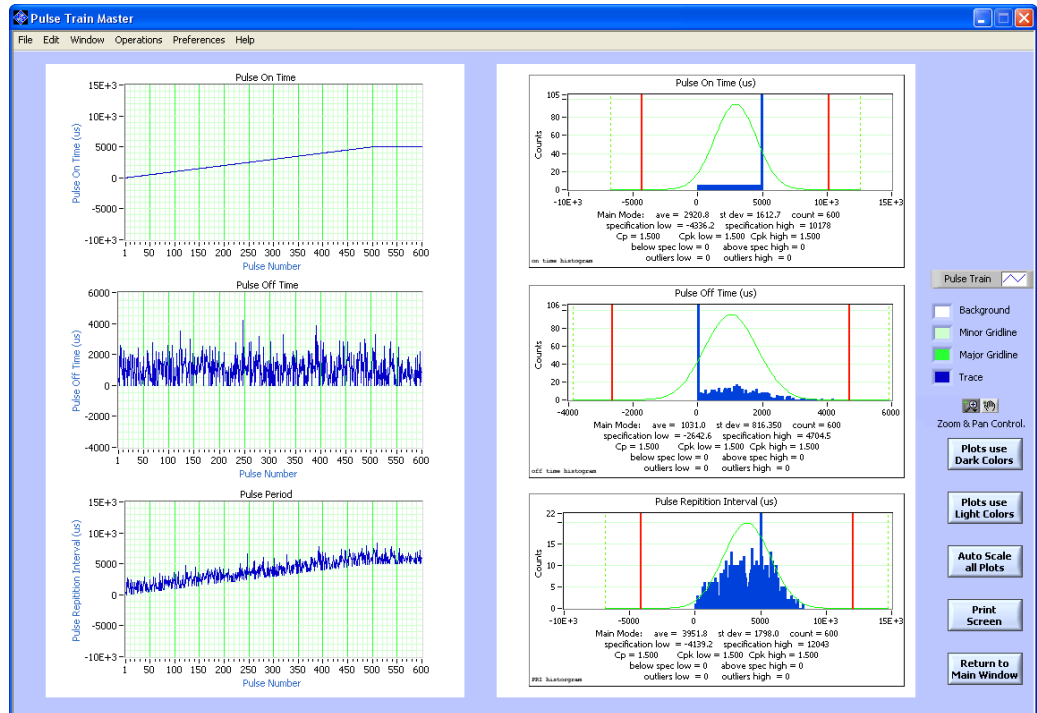
In this view a plot of the variation of the pulse on time, the pulse off time, and the PRI vs. time is created. Additionally, a histogram showing the distribution of these three parameters is also plotted.

To demonstrate this capability, create a new pulse train that is 600 pulses long. Set the "on time" increment from 10 us with a step size of 10 us. Set the off time be a Gaussian variable with a mean and standard deviation of 1 ms.



Create the pulse train. Then enter the statistical view.

Several things can be noticed quickly. First, the on time linearly ramps up but is clipped once it reaches a value of 5 ms. Second, the off time is Gaussian, but also clips at a lower value of 5 ns. The net result on the overall PRI is a Gaussian distribution with a larger than expected number of values at 5 ms...



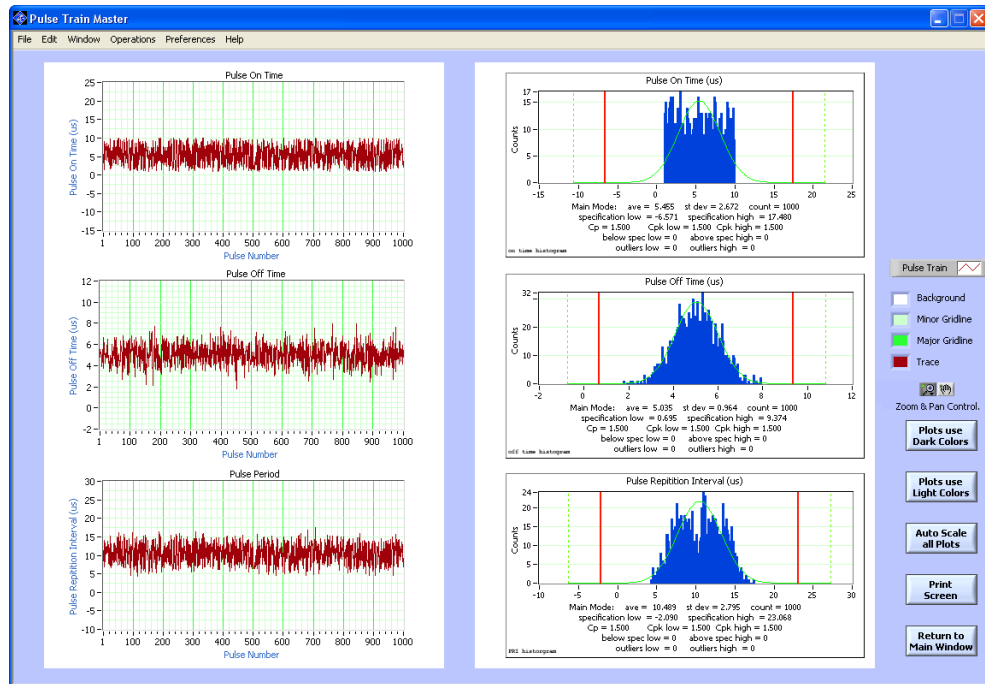
In a second example create a pulse train with 1000 entries. Select a uniform distribution for the on time that covers a range of 1 to 10 us. Select a Gaussian distribution for the off time with a mean value of 5 us, and a standard deviation of 1 us.

The configuration panel shows the following settings:

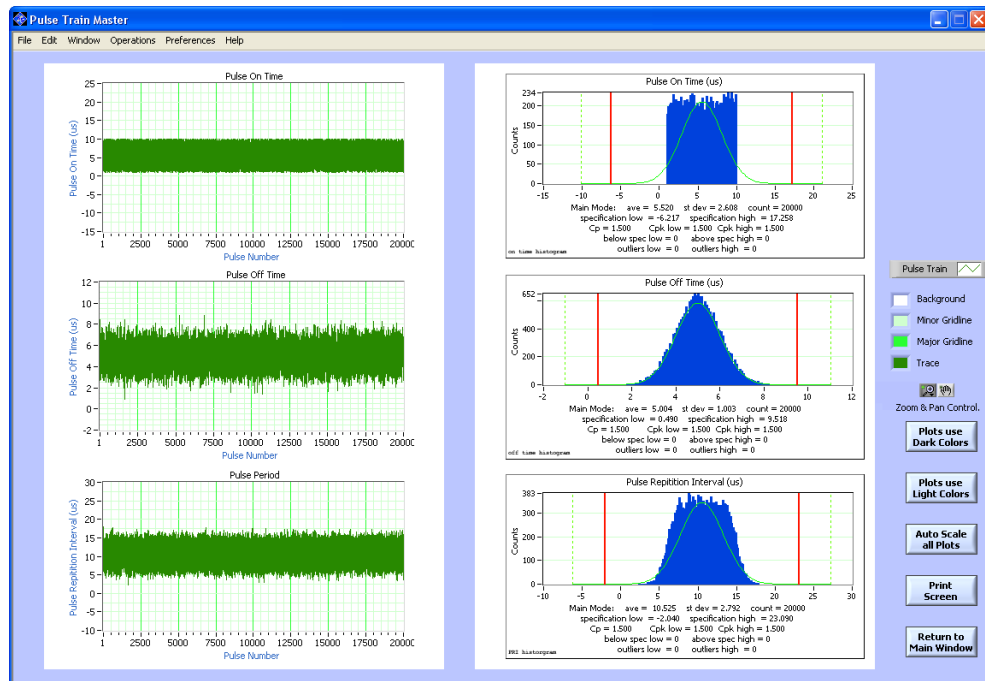
- Number of pulses: 1000
- Frequency (Hz): 10E+9
- Amplitude (dBm): -30
- Output Control: RF ON
- on time: Random on time - Uniform
 - minimum value (seconds): 1 us
 - max value (seconds): 10 us
- off time: Random off time - Gaussian
 - mean value: 5 us
 - standard deviation: 1 us

Create the pulse train, and select the statistical view.

Now we can verify the uniform distribution by observing the somewhat rectangular histogram. We can also see the mean value is approximately 5.55 us, which deviates by < 1% from the expected value.



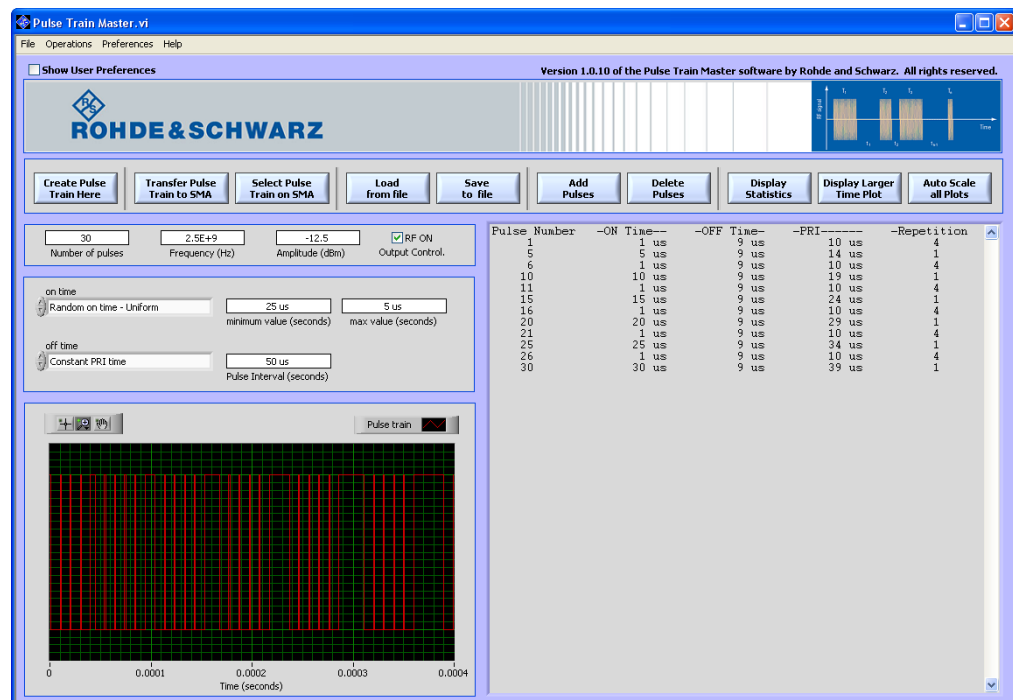
The off time also has an approximate Gaussian shape in the histogram window. The mean and standard deviations are reported as 5.035 us and 0.964 us respectively, which are < 1 % and < 3% away from the expected values. This variation from the expected values can be improved by increasing the number of pulses in the pulse train. See the next page for analysis of a pulse train with 20,000 entries.



4.14 Control the frequency and amplitude parameters on the SMx

Once a pulse train has been selected and loaded into the SMx, it is reasonable to want to set the Frequency and Amplitude of the signal. These can be entered directly into the PC software. As soon as the values are changed, they are downloaded to the instrument.

Additionally there is a check box that is used to turn the RF output on and off. We will complete the example that we developed in this section by setting the frequency to 2.5 GHz, the amplitude to -12.5 dBm, and the RF will then be turned on. Here is the final screen shot:



5 Other useful Application Notes

The following application notes offer more specific information that will be useful to anyone working with pulse trains, the R&S signal generators, and/or this software.

5.1 1MA 74, RS Commander

RS Commander has many useful applications. But the one that compliments this program is the ability to manipulate files contained on the instrument. With RS Commander the user can browse the hard drive directory of the Signal Generator using the same GPIB or LAN communication link as the Pulse Train Master software. RS Commander allows the user to delete files, create directories, and do other file manipulations.

5.2 1MA 124, Tackling the Challenges of Pulsed Signal Measurements

This application note describes a variety of measurement techniques that are useful to the engineer that needs to make pulsed RF / Microwave measurements.

5.3 1MA 141, RF Transient Analysis Software

The RF Transient Analysis software described in this application note is a good way to capture and analyze a pulse train that is being sourced by the SMF. This can be used to validate the jitter settings of a pulse train, or to test the performance of pulse transmitter.

About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

Regional contact

Europe, Africa, Middle East

+49 89 4129 12345

CustomerSupport@rohde-schwarz.com

North America

1-888-TEST-RSA (1-888-837-8772)

customer.support@rsa.rohde-schwarz.com

Latin America

+1-410-910-7988

customersupport.la@rohde-schwarz.com

Asia/Pacific

+65 65 13 04 88

customersupport.asia@rohde-schwarz.com

Certified Quality System
ISO 9001
DQS REG. NO 1954 QM

This application note and the supplied programs may only be used subject to the conditions of use set forth in the download area of the Rohde & Schwarz website.

ROHDE & SCHWARZ GmbH & Co. KG

Mühlhofstraße 15 | D - 81671 München

Phone + 49 89 4129 - 0 | Fax + 49 89 4129 - 13777

www.rohde-schwarz.com