

# Keysight DOCSIS 3.1 Configuration Wizard

Version 1.3

Installation  
& User's Guide

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## DOCSIS 3.1 Configuration Wizard Installation & User's Guide

### Introduction

89600 VSA now supports DOCSIS 3.1 DS (Down Stream) & US (Up Stream) modulation analysis with 89601B/BN-BHF Custom OFDM option. Because of complexity of OFDM signals defined in DOCSIS 3.1 standard, this wizard tool helps to configure the OFDM signals for your test with 89600 VSA software.

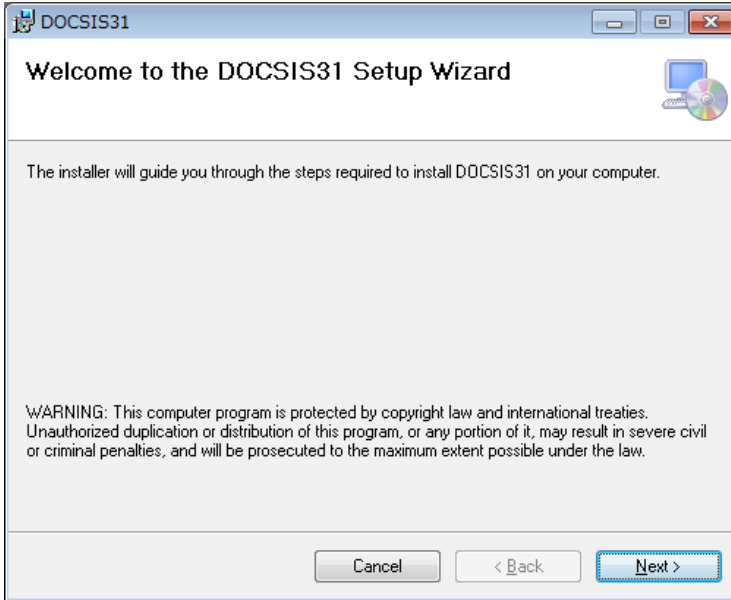
### Prerequisites:

- 89600 VSA version 18.5 or later to be installed on your PC or PC-based instruments
- Valid licenses of 89601B/BN-200 (Basic VSA), 300 (Connectivity), and BHF (Custom OFDM)

### How to get the DOCSIS wizard:

1. Uninstall the previous DOCSIS 3.1 configuration wizard with "Agilent" files in your PC.
2. Visit [www.keysight.com/find/89601B](http://www.keysight.com/find/89601B)
3. Move to Technical Support
4. Select "Driver, Firmware, & Software" tab
5. Click 89600 VSA Software DOCSIS 3.1 Configuration Wizard
6. Click on the Download button
7. Choose to save the zip file to your PC in default download folder or C:\Temp folder.
8. Click on Save
9. Unzip the file to find Setup-DOCSIS31-Wizard\_1.3.0.msi and run the installer to use with 89600 VSA software.
10. Follow the step-by-step installation by selecting the installation folder. The program and start icon will be created at C:\Program Files (x86)\Keysight Technologies\DOCSIS31 by default.

Figure 1 DOCSIS 3.1 Wizard Installer Menu

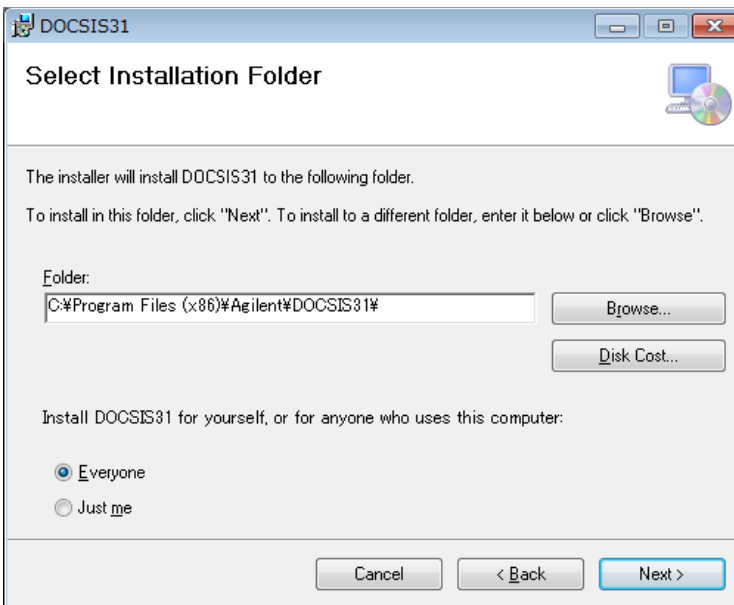


a. Select Installation Folder

If you want to change the installation folder, enter it below or click "Browse" button.

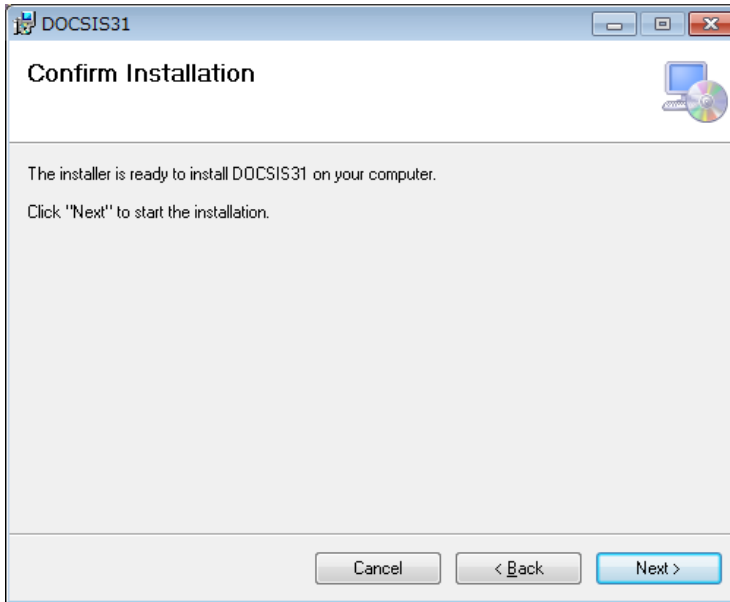
You can also specify the user of DOCSIS 3.1 wizard just you or everyone to access the PC or PC-based instruments.

Figure 2 Select Installation Folder



- b. Click "Next" to start the installation. You can get "Installation Complete" menu after finishing.

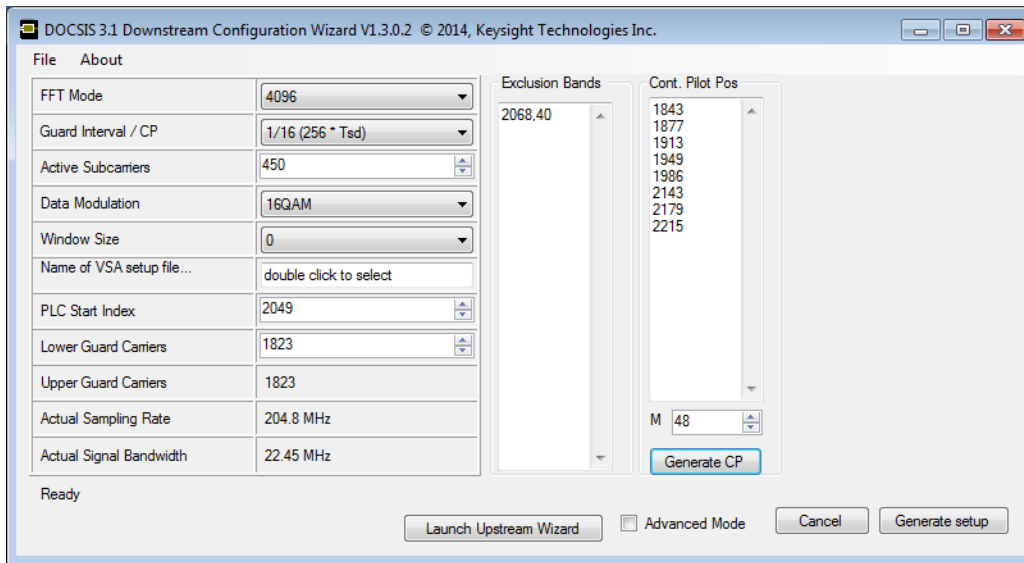
Figure 3 Confirm Installation



## How to start the DOCSIS wizard:

- I. Before opening DOCSIS wizard, start 89600 VSA (version 18.5 or later) on your PC or PC-based instrument.
- II. Double click the DOCSIS31ConfigWizard.exe to launch the configuration wizard. Or you can create a short-cut on your desktop with this wizard to find Docsis31ConfigWizard.exe.
- III. Follow the steps to this wizard.

Figure 4 DOCSIS 3.1 Configuration Wizard (DS, Downstream)



## How to create the DOCSIS Downstream setup files for 89600 VSA Custom OFDM (Option BHF):

### Step 1 Basic parameters

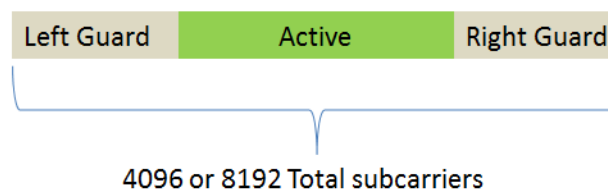
1. Select FFT mode (4096 or 8192).
2. Select guard interval (cyclic prefix) using the pull-down menu.
  - 1/16 (256 \* Tsd) [default]
  - 3/64 (192 \* Tsd)
  - 1/8 (512 \* Tsd)
  - 3/16 (768 \* Tsd)
  - 1/4 (1024 \* Tsd)
3. Select or type in a number for active subcarriers. Up/down arrow can also work to select active subcarriers. Table 1 below shows typical entries for a given nominal channel bandwidth. The actual bandwidth shown on the wizard menu means only the bandwidth of the used (assigned) subcarriers. So it will be a few MHz less than the nominal channel bandwidth as listed in the table 1 below. The channel bandwidth allows for some band-gap

between channels.

**Table 1 Recommended active subcarriers setting for channel bandwidth**

Channel Band width (MHz)	FFT Mode = 4096	FFT Mode = 8192
22.5	450	900
47.5	950	1900
95	1900	3600
190	3800	7600

**Figure 5 Active subcarrier and guard bands**



The active subcarriers are allocated to the center of the band, centered on the DC subcarrier which is the FFT size divided by 2. The total number of subcarriers is equal to the FFT size. Typically there are some unused subcarriers at the very left (lower frequency) and right (upper frequency) called guard carriers. They may be called as left-guard or lower guard, and right-guard or upper guard carriers (see in Figure 2)

The number of guard carriers is calculated by these equations:

$$N_{fft} = \text{NumberOfLeftGuard} + \text{NumberOfActive} + \text{NumberOfRightGuard}$$

4. Select data modulation. This is the modulation applied to all of the data subcarriers in the DOCSIS 3.1 downstream signal.
  - BPSK, QPSK, 8PSK
  - 16QAM [default], 32QAM, 64QAM, 128QAM, 256QAM, 512QAM, 1024QAM, 2048QAM, 4096QAM, 8192QAM, 16384QAM (8192QAM & 16384QAM are only available after VSA version 18.5)
5. Select window size –
  - 0
  - 1/64 (64 \* Tsd)
  - 1/32 (128 \* Tsd)
  - 3/64 (192 \* Tsd)
  - 1/16 (256 \* Tsd)
6. Select a name for the setup file to be created – do this by double clicking on the text box to the right of the label “Name of VSA setup file...” on the left side of wizard menu. File-save dialog box will open to allow naming the output file name. The file name will have “\*.setx” extension to be recognized as 89600 VSA setup file.

7. Select a number of the PLC Start Index. The PLC (PHY Link Channel) is a 400 kHz region with 8 (FFT = 2048) or 16 (FFT = 4096) subcarriers. Typically the PLC is in the center of the band, and the number to put in this box is exactly 1/2 of the FFT size. For FFT mode 4096, the default is 2048. For FFT mode 8192, the default is 4096. (You can select a different number here, but make sure that PLC is within the bandwidth of the active subcarriers. There is a concept of a "PLC region" which is 6 MHz with PLC in the center. You should not select a center position that is closer than 3 MHz from the edge of the band for active subcarriers. You should make sure that no exclusion band subcarriers or manually entered continuous pilot carriers are in the PLC.
8. Lower Guard Carriers is adjustable to be lower guard + upper guard + active subcarriers to be equal to FFT size. (If you adjust lower guard carries so high, upper guards goes to 0.) When you double-click the Lower Guard Carrier numeric box, it can center the carrier.
9. Now you can move to the center column to set exclusion bands.

## Step 2 Exclusion bands (EB) setup

Exclusion bands are bands of sequential subcarriers that are not to be used by the DOCSIS 3.1 signal. This may be due to interference reasons, or because some parts of cable spectrum are in use by some legacy service, such as a 6 MHz QAM or analog channel.

1. There is a text box to enter exclusion band information. In this text box, enter one exclusion band per line. On each line, you should put two numbers separated by a comma. Example "1024,1"
  - The first number is the index of the first subcarrier of the exclusion band.
  - The second number after a comma is the width or length of the exclusion band (how many subcarriers)

The EB expressed as a whole number of subcarriers. The width could be as low as one subcarrier.

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**NOTE**            The subcarrier spacing is 50 kHz for 4096 FFT and 25 kHz for 8192 FFT. This equates to 20 or 40 subcarriers per MHz of bandwidth. Typically an EB is a 6 MHz channel on the cable system, so for these cases an EB would normally be 120 or 240 subcarriers, with potentially a few additional ones for a band-gap as determined by the cable plant frequency plan.

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2. Copy and paste operation works with this text box for EB. You can use the mouse to select any text and copy it to some other window, or to copy from some other window into this text box.

Key things to remember with exclusion bands (EB)

- Make sure that any excluded subcarriers are within the band of active subcarriers – exclusion bands may not extend into the upper or lower guard regions.
- Subcarrier indexes start with subcarrier 0 as the first index in the left/lower guard region. The last subcarrier of the right/upper guard region is index  $N_{fft}-1$  (4095 or 8191).
- You should not have any exclusion band subcarriers within the 1 MHz of the PLC.
- There are some specific rules about exclusion bands in the DOCSIS specification.



- Whenever you make changes to the exclusion band information, you may want to check or regenerate the continuous pilot positions to make sure that no continuous pilots are located in an exclusion band (refer DOCSIS 3.1 specifications section 7.2.5 Channel Band Rules, this was changed from previously named as 7.2.5 Exclusion Band Rules.)

### Step 3 Continuous pilots

This is defined in section 7.5.15.2.2. of the 6/10/2014 DOCSIS 3.1 Physical Layer Specification.

1. Automatic generation – to automatically generate continuous pilot locations, select an “M” value using the numeric control box (values from 48 to 120 are available), then press the [Generate CP] button. Pilot positions are computed based on the parameters entered in step 1 and 2 and populated in the box of “Continuous Pilot Position(s)” on the dialog. If you want to change these, you can just click this box and edit them. The allowed values are determined by the FFT size (0 to 4095 for 4096 FFT, 0 to 8191 for 8192 FFT). They are further limited by the guard bands. Do not place continuous pilots outside of the region of active subcarriers. After you generate the continuous pilot positions and go back to step 1 or step 2 for making any changes, you may need to press [Generate CP] button again. Any changes like FFT size, PLC start position, or exclusion bands in step 1 and/or step 2 may affect calculations of continuous pilot positions. So you should always either check over the continuous pilot positions, or re-generate them using the [Generate CP] button.
2. Manual entry – you can manually enter the subcarrier indexes of continuous pilots by typing them one number per line in the provided box.

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**NOTE** Subcarrier indexes start with subcarrier 0 as the first index in the left/lower guard region. The last subcarrier of the right/upper guard region is index  $N_{fft}-1$  (4095 or 8191).

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3. This text box of Continuous Pilot Position(s) also works copy and paste. You can use the mouse to select the text and copy it to some other window, or to copy text from some other window to paste into the box.

### Advanced Mode

When you check this box, you will find a new entry field named as Symbol Modulation Pattern. You can specifically describe the modulation types changing symbol by symbol as 100@64QAM,200@256QAM,... as you like. In this example, the first 100 symbols are 64QAM modulation, and next 200 symbols are 256QAM, and next symbols could be different modulation types. If your signal just contains single modulation type in data subcarriers, this setup under Advanced Mode is not required.

### Step 4 Generate setup file

1. Press the [Generate setup] button on the lower right to generate the setup file. The wizard will create a “\*.setx” file to your selected folder to use with 89600 VSA with Custom OFDM (option BHF). To load the setup file from VSA later, use the file menu as File > Recall Setup and select the named file for DOCSIS 3.1 configuration.

Key things to know about how to use the OFDM setup file on 89600 VSA software:

The setup file is generated assuming you will be using a recording signal file with a center frequency at 1 GHz by default on 89600 VSA software. To measure the live signal not from a recording, use the Input menu and select Data From > Hardware instead of Recording. You will then need to set the center frequency, bandwidth, and amplitude as appropriate for your signal and hardware platform connected from 89600 VSA software.

Once you have setup these measurement conditions, again use the file menu on 89600 VSA as File > Save Setup to replace the generated setup file by the DOCSIS 3.1 wizard. Now you can save all other settings with center frequency, bandwidth, and amplitude to actual input signals for you to easily set up tests next time by recalling the setup file.

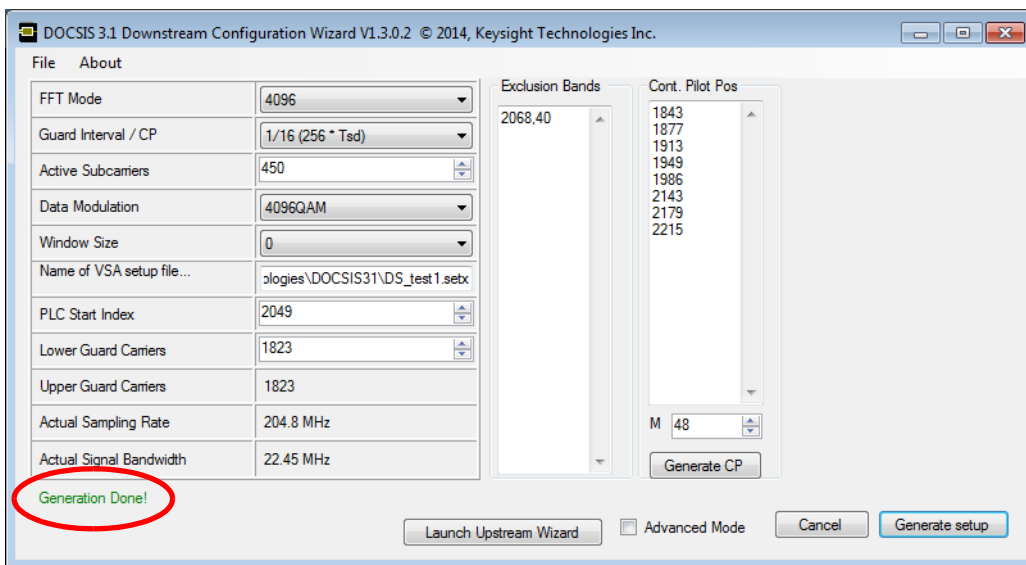
2. When generation is completed with no error, "Generation Done!" message in green will come out on lower left of the wizard.

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**NOTE** The latest wizard v1.3 adds the menu tool bar to allow the DOCSIS 3.1 wizard setup file (\*.ini) for easy open, save, or save as. You can load (open) or save setting files you created with the DOCSIS wizard.

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Figure 6 DOCSIS 3.1 Configuration Wizard (setup file generation succeeded)



3. You may get a pop-up viewer to show how your configured signal may look like in vertical (symbol, time domain) and horizontal (subcarrier, frequency domain) layout.

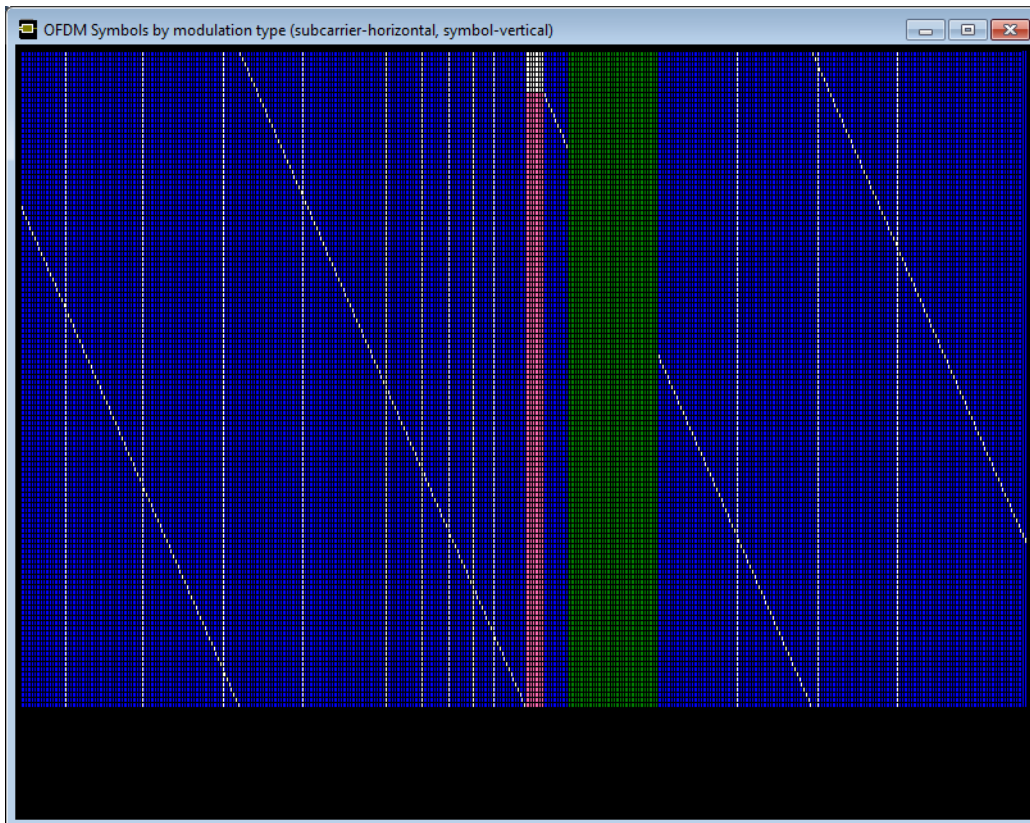
*Color:*

*White as found in BPSK (continuous pilots, PLC pilots and scatter pilots)*

*Blue (data subcarriers)*

*\*\* Up to 17 colored modulation types may be seen based on the modulation type in the OFDM signal; Green, Hot pink, Cyan, Yellow, Purple, Red, Light blue, Light green, Light salmon, Light golden yellow, Light pink, Orange, Turquoise, and Slate blue.*

Figure 7 DOCSIS 3.1 OFDM Layout Viewer

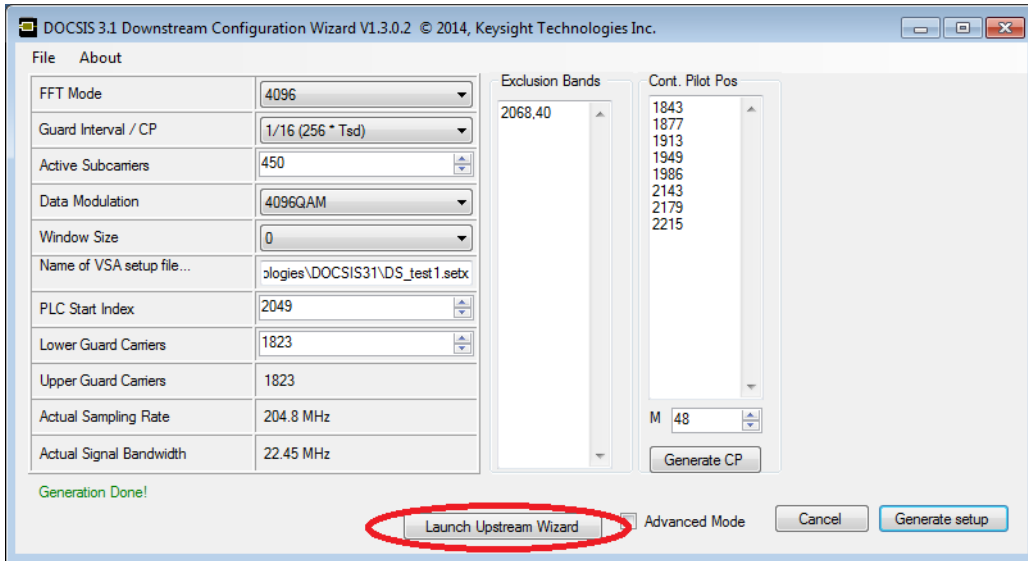


The top left of the viewer screen shows the lowest frequency active subcarrier of the first symbol of the 128 symbol DOCSIS frame. The bottom right of the viewer shows the highest frequency subcarrier of the last symbol of DOCSIS frame.

## How to create DOCSIS 3.1 Upstream (US) signals

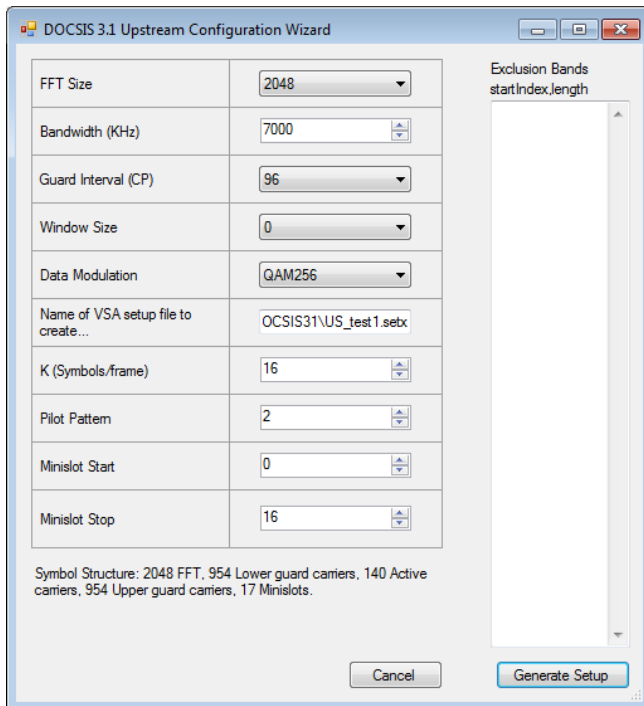
First, start the Upstream Wizard from the menu at the bottom of the Downstream menu.

Figure 8 DOCSIS 3.1 Configuration Wizard (Launch Upstream Wizard)



Configure Upstream signal in the configuration tool.

Figure 9 DOCSIS 3.1 Configuration Wizard (US, Upstream)



## How to create the DOCSIS 3.1 US setup files for 89600 VSA Custom OFDM (Option BHF):

### Step 1 Basic parameters

1. Select FFT mode (2048 or 4096).
2. Select Bandwidth in kHz unit.
  - Minimum 6400 for 4096 FFT (or 10000 kHz for 2048 FFT) to Maximum 96000
  - Typical bandwidths: Full 96000 kHz, 1/2 48000 kHz, or 1/4 24000 kHz
  - Step size is 25 kHz for 4096 FFT, 50 kHz for 2048 FFT
  - To be revised in future DOCSIS 3.1 specifications updates
3. Select Guard Interval (CP, cyclic prefix) using the pull-down menu.
  - 96, 128, 160, 192, 224, 255, 288, 320, 384, 512, 640
  - This is the size for the guard interval in samples as defined in Table 7-2 of the DOCSIS 3.1 specifications.
4. Select Window Size from 0 to 224 – Better to keep this size small compared to the guard interval; 1/2 or less of the guard interval is common.
5. Choose Data Modulation type from pull down menu.
  - BPSK, QPSK, 8PSK
  - QAM16, QAM32, QAM64, QAM128, QAM256 [default], QAM512, QAM1024, QAM2048, QAM4096, QAM8192, QAM16384
  - Modulation symbols are populated with a random number generator. There is no upper layer signaling or channel coding for the data symbols.
  - Remember that modulation for pilot subcarriers is always BPSK. Modulation order for complementary pilots will be 4 orders lower than modulation order for data, with a minimum of BPSK.
6. Select a name for the setup file to be created – do this by double clicking on the text box to the right of the label “Name of VSA setup file to create...” on the left side of wizard menu. File-save dialog box will open to allow naming the output file name. The file name will have “\*.setx” extension to be recognized as 89600 VSA setup file.
7. Specify K value (symbols per frame) from 6 to 36.
  - DOCSIS 3.1 Upstream consists of a burst OFDMA signal. The burst width is selectable according to this K value. The allowed number of symbols varies depending on FFT size and pilot pattern selection.
8. Set Pilot Pattern from 1 to 14.
  - The DOCSIS 3.1 Upstream specifications allow different arrangements or patterns of pilot subcarriers within a burst. Pattern 1 to 7 are used for 2048 FFT. Pattern 8 to 14 are for 4096 FFT. Please refer the section 7.4.17.1 and 7.4.17.2 of DOCSIS 3.1 specifications.

## 9. Choose Minislot Start.

- The minislot start parameter is the lowest numbered minislot to be transmitted. It can range from 0 to 239 depending on the bandwidth selected.
- DOCSIS 3.1 Upstream signals can be partitioned in time and in frequency. The burst width in time is specified by the K value above. The burst width in frequency is specified by the concept of minislots.
- A minislot is 8 adjacent subcarriers for 2048 FFT (50 kHz subcarrier spacing = 400 kHz per minislot). For 4096 FFT, a minislot is 16 adjacent subcarriers (25 kHz subcarrier spacing = 400 kHz per minislot).
- The entire band of active subcarriers is divided into groups of 8 or 16 subcarriers. These groups are called minislots, and they are numbered starting with 0 at the lower edge of the band and increasing indexes to up to 239 at the upper end of the band, The total number of available minislots is a function the bandwidth and any exclusion bands.

## 10. Set Minislot Stop

- This is the upper edge of the transmitted signal in frequency terms; the number of the highest transmitted minislot. It can range from 0 to 239 depending on the bandwidth selected.

Example 1: Very narrow frequency burst at lowest edge of frequency band  
Minislot start = 0, Minislot stop = 0

Example 2: Full bandwidth burst for 96000 kHz wide signal  
Minislot start = 0, Minislot stop = 239

## Step 2 Exclusion bands (EB) setup

This allows users to specify certain subcarriers as “unused” or excluded. Exclusion bands are commonly used to avoid interference or legacy services in the spectrum.

- Enter exclusion bands as two numbers separated by commas (Example: 1026,64)
- First number: the index of the first subcarrier of the exclusion band. Set from 0 to the FFT size -1. The start of exclusion band must be on a subcarrier that is the start of a minislot.
- Second number: the length in subcarriers of the exclusion band. Subcarrier spacing is 50 kHz for 2048 FFT or 25 kHz for 4096 FFT.

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**NOTE** Due to the specification rules exclusion bands to limit their placement and width, remember following facts to specify the exclusion bands.

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- Excluded subcarriers cannot be in the guard bands (lower or upper) – if your exclusion bands starts in the lower guard band of carriers, or extends into the upper guard band, an error message will be generated in the wizard tool.
- Exclusion bands may not have subcarriers inside of minislots. Minislots are 8 subcarriers each (for 2048 FFT) or 16 subcarriers for 4096 FFT. The start index of an exclusion band must be placed so that it starts inside of a minislot. This restriction mainly affects the start index. The length can be any number as long as the excluded subcarriers don't intrude into the upper guard band.

### Step 3 Generate setup file

1. Press the [Generate setup] button on the lower left to generate the setup file. The wizard will create a "\*.setx" file to your selected folder to use with 89600 VSA with Custom OFDM (option BHF). To load the setup file from VSA later, use the file menu as File > Recall Setup and select the named file for DOCSIS 3.1 configuration.

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Once you have setup these measurement conditions, again use the file menu on 89600 VSA as File > Save Setup to replace the generated setup file by the DOCSIS 3.1 wizard. Now you can save all other settings with center frequency, bandwidth, and amplitude to actual input signals for you to easily set up tests next time by recalling the setup file.

Figure 10 DOCSIS 3.1 Upstream

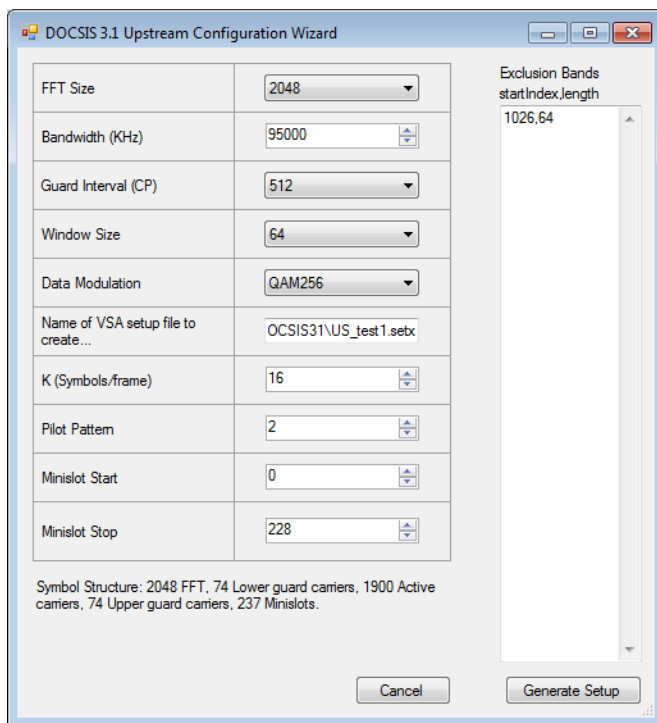
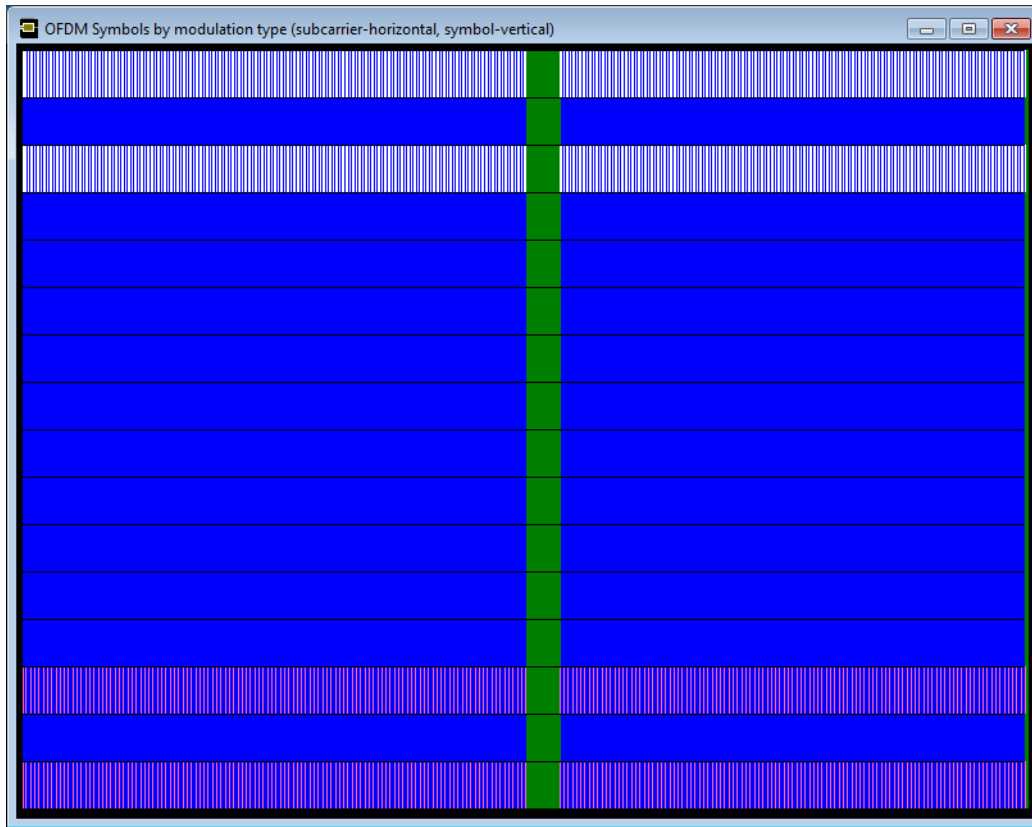


Figure 11 DOCSIS OFDM Layer View (Upstream)



In this example, you see 1900 active subcarriers with EB in green (horizontal), 16 symbols in vertical with pilot in white. (Colors can be changed by modulation types in your configuration.)

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