ONFi Analysis Window

User Guide

KEYSIGHT TECHNOLOGIES

Notices

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Warranty

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CAUTION

A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Contents

1 Analyzing ONFi Data using the ONFi Analysis Window

Overview

To analyze the captured NAND Flash memory data, you can use various tabs available in the **ONFi Analysis** window.

NOTE You need the software license option B4661A-4FP Performance Analysis to get the full feature set and capabilities of the ONFi Analysis window. Without this license, it is possible to compute only limited number of NAND Flash memory transactions from the captured data.

ONFi Analysis Window - An Overview

Using the ONFi Analysis window, you can perform post processing on the captured NAND Flash memory data to evaluate and troubleshoot your NAND Flash memory devices.

In the different tabs and panes of the ONFi Analysis window, you can:

- compute and view decoded ONFi transactions from the captured data.
- analyze the captured NAND Flash memory traffic statistics categorized on the basis of ONFi commands.
- visualize an ONFi operation as a set of logically grouped ONFi commands in a sequence.
- view the payload for an ONFi command.

Supported NAND Flash Interfaces and ONFi Specifications

The ONFi Analysis window supports the ONFi 4.0 and 4.1 specifications.

You can analyze the data captured for the following NAND Flash data interfaces.

- NV-DDR2
- NV DDR3
- SDR

Broad Steps for Analyzing ONFi Data

1. Capture the NAND Flash memory data. Ensure that the captured data meets the requirements for ONFi analysis so that ONFi transactions are computed accurately.
2. Add an ONFi Analysis window instance to the logic analyzer setup with captured data in the Logic and Protocol Analyzer GUI.

   You can add an ONFi Analysis window instance to a logic analyzer module such as U4154A/B or U4164A or a data import module. You should NOT attach it to a Filter tool. Filtering can impair some of the memory analysis features if some data such as clock speeds is filtered.
3. Configure ONFi properties in the ONFi Analysis window.
4. Customize ONFi decode (if needed) using an XML file.
5. Compute the decoded NAND Flash memory transactions and traffic analysis chart from the captured data in the ONFi Analysis window.
6. Analyze the data presented in the ONFi Analysis window.
7. Customize the chart settings and redraw chart, if required in the ONFi Analysis window.

Data Capture Requirements for ONFi Analysis

When capturing ONFi data for analysis in the ONFi Analysis window, ensure that the following control and data signals are present in this captured data. These signals are needed for the accurate computation of ONFi data in the ONFi Analysis window.

Control Signals	Data signals
CLE ALE RE_n WE_n CE_n (For systems with multiple targets, the CE_n bus/signal contains multiple assigned channels – one per target.)	DQ DQS

Configuring ONFi Properties

A NAND Flash memory device may have one or more "Chip Enables" enabled. At times, you may be interested in viewing the decoded ONFi transactions for a particular Chip Enable only. Or some of the Chip Enables of the DUT may not be in use.

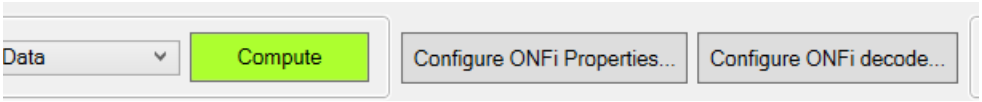
In such situations, you can configure ONFi properties to ensure that the ONFi transactions are decoded only for the chip enable(s) of your choice. You need to configure ONFi properties before you start computing ONFi transactions from the captured data.

You use the **Configure ONFi Properties** dialog box in the ONFi Analysis window to set up/modify/verify the chip enables for which analysis data is to be computed.

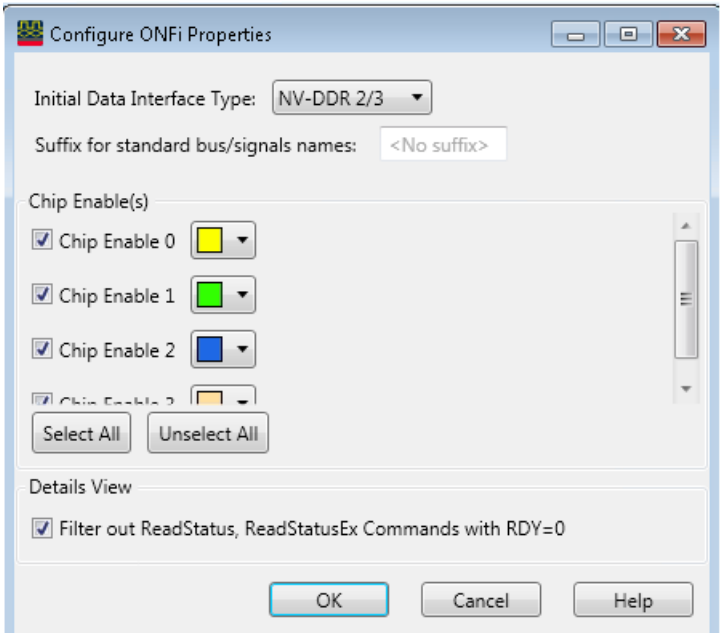
NOTE The Chip Enables of the DUT are automatically discovered from the captured data and updated into the Configure ONFi Properties dialog.

To configure ONFi properties

1 Click the **Configure ONFi Properties...** button displayed in the ONFi Analysis window's toolbar.

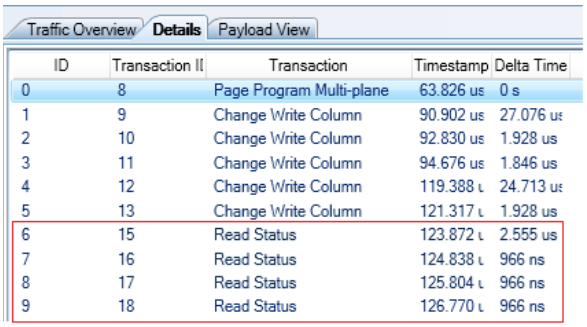


The **Configure ONFi Properties** dialog box is displayed.

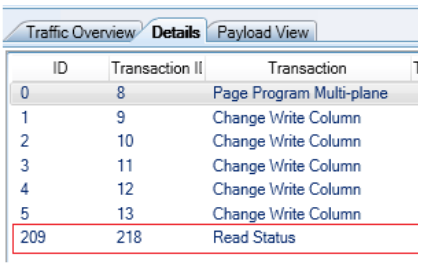


2 Set the following fields in the dialog box:

Field	Description
Initial Data Interface Type	In the ONFi Analysis window, you can analyze the data captured for the following NAND Flash data interfaces. - NV-DDR2 - NV DDR3 - SDR This listbox allows you to set the NAND Flash data interface type to be analyzed so that the decoder can use the appropriate decode mode based on this data interface type. This decode mode is the default decode mode set for the decoder. However, if the decoder encounters an ONFi sequence that requires the decode mode other than the default decode mode, the decoder automatically uses the appropriate non-default decode mode. If needed, you can also override the default decode mode for specific OpCode(s) by customizing the ONFi decode. Refer to the <OpCodeModeOverrides> element in the topic "ONFi Decode Customization XML File Structure and Elements" on page 14 to know more.
Suffix for standard bus/signals names	Allows you to specify the suffix that you have used with the standard signal names (labels). Providing the suffix ensures that the decoder looks for this suffix with the signal names and handles only those signals with which this suffix is attached. The suffix usage is optional. However, its usage is needed in situations when you want to capture and analyze data from multiple ONFi buses using a single logic analyzer module. With multiple ONFi buses involved, there is a need to differentiate the signals of an ONFi bus from signals of other ONFi buses using suffixes. To know more about the usage of this suffix, refer to the topic "Capturing and Analyzing Data from Multiple ONFi Buses" on page 10.
Chip Enable	From this section, select the checkboxes for the chip enables for which you want the ONFi transactions and analysis data to be computed. For the transaction decoding to be correct, make sure that the chip enables that are being used in the system must be enabled and unused chip enables must not be enabled. Choose a color for an enabled Chip Enable. The color coding selected for a chip enable is mapped to the color coding used for the corresponding target. This color coding is used in: ▪ the Target # field of transactions displayed in the upper pane of the ONFi Analysis window. ▪ the ONFi command counts plotted for targets in the traffic overview chart. Changing the color coding in the Configure ONFi Properties dialog box reflects these changes in the Traffic Overview chart color picker legend and vice versa.
Filter Out Read Status and Read Status Enhanced Commands with RDY =0	This checkbox is selected by default. Selecting this checkbox ensures that the software filters out the Read Status and Read Status Enhanced ONFi commands that have the RDY bit set to 0 in their Status Register. The RDY bit set to 0 indicates that the last command issued is still in progress and that another command cannot be accepted. There may be several such commands resulting in clogging your data display. Filtering out such commands can help you focus on the commands that are of significance to you for analysis and debug. These commands are filtered out only from the logically grouped sequential list of commands in the Details tab of the ONFi Analysis window. Filtering out does not filter out these commands from the captured data or from the list of transactions in the upper pane. You can deselect this checkbox to bring these commands back into the Details tab data. This filtering does not filter out the Read Status and Read Status Enhanced ONFi commands that have the RDY bit set to 1 in their Status Register (indicating that another command can be accepted).



With Filtering Off



With Filtering On

Capturing and Analyzing Data from Multiple ONFi Buses

To capture and analyze data from a single ONFi bus

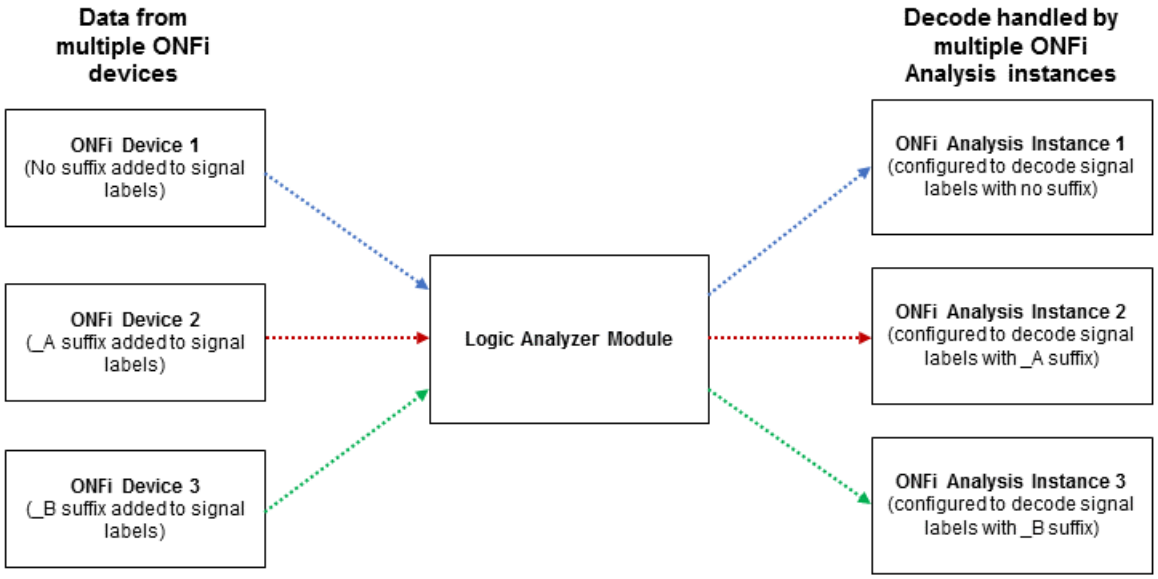
In the Logic and Protocol Analyzer GUI, add a single instance of the ONFi Analysis window to your logic analyzer module.

To capture and analyze data from multiple ONFi buses using a single logic analyzer module

In the Logic and Protocol Analyzer GUI:

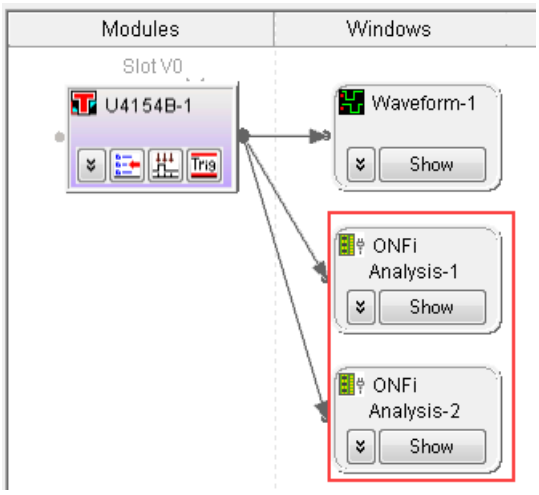
- Add multiple instances of the ONFi Analysis window to your logic analyzer module. Each of these instances will be independently used for decoding data from an ONFi bus.
- As a single logic analyzer module is being used to capture and analyze data from multiple ONFi buses, you need to differentiate the signals of an ONFi bus from signals of other ONFi buses. To do this, you need to add a unique suffix to the signal labels of each of these ONFi buses.
- Then you need to configure each of the added ONFi Analysis instances to use the appropriate suffixes. This ensures that an ONFi Analysis instance is mapped to a single ONFi bus and decodes the data relevant to that ONFi bus only.

  The following picture illustrates the decoding of three ONFi buses using a single logic analyzer module.

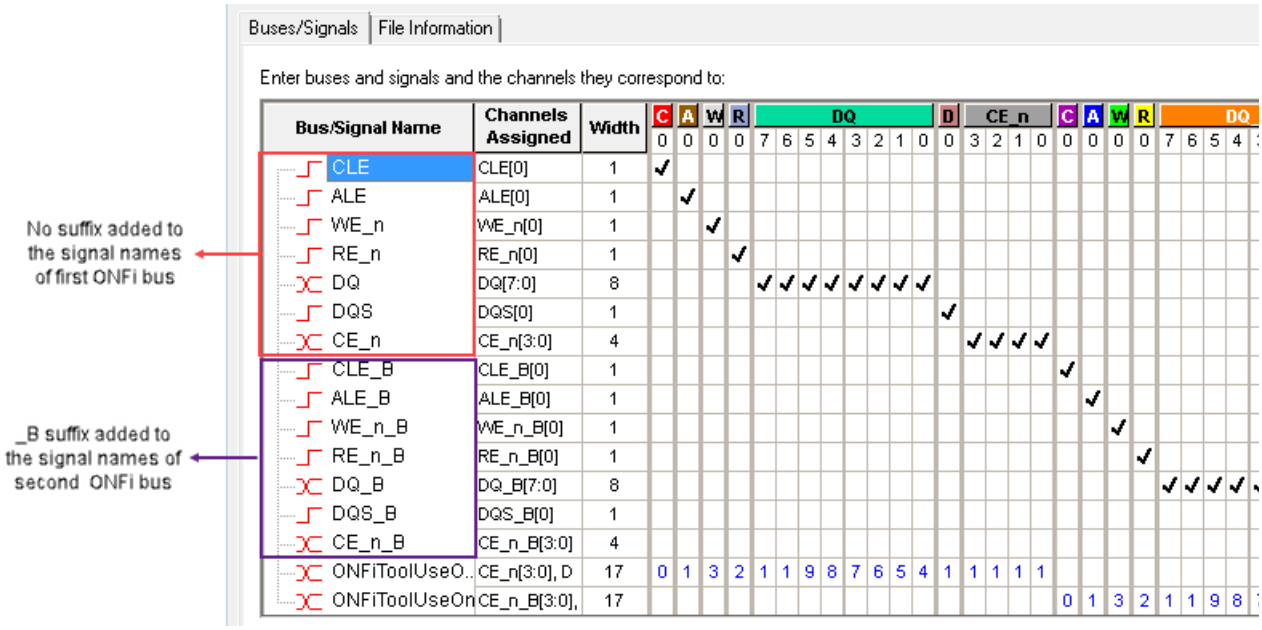


Example

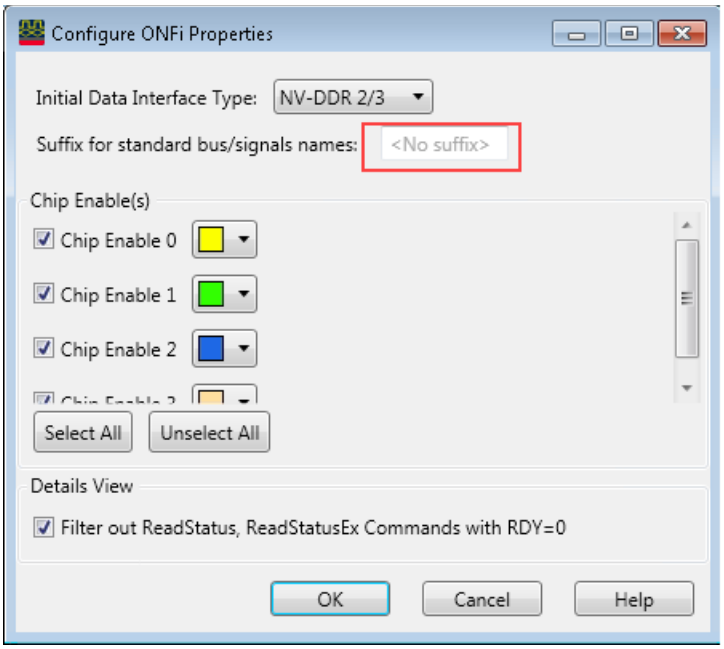
In the following example, two ONFi Analysis instances have been added to decode two ONFi buses using a logic analyzer module.

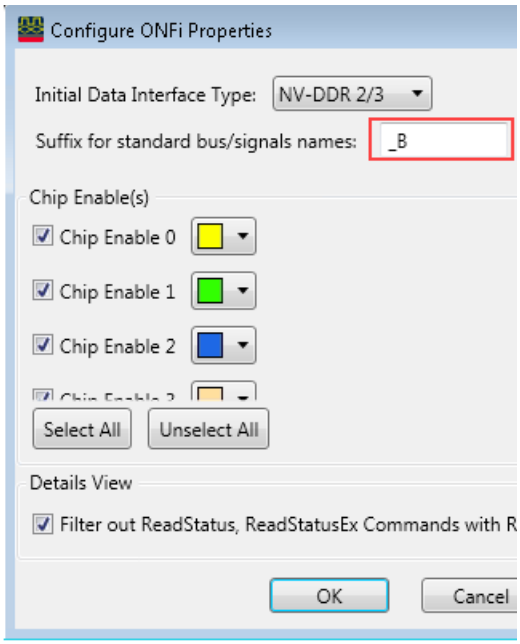


The signal names of the two ONFi buses have been differentiated by adding no suffix to the signal names of first ONFi bus and adding _B suffix to the signal names of the second ONFi bus.



The properties of the two ONFi Analysis instances have been configured to use the appropriate suffix to allow the decode of signals of a specific ONFi bus only.


Configure ONFi Properties
Initial Data Interface Type:
NV-DDR 2/3
Suffix for standard bus/signals names:
<No suffix>
Chip Enable(s)
Chip Enable 0
Chip Enable 1
Chip Enable 2
Select All
Unselect All
Details View
Filter out ReadStatus, ReadStatusEx Commands with RDY=0
OK
Cancel
Help


Configure ONFi Properties
Initial Data Interface Type:
NV-DDR 2/3
Suffix for standard bus/signals names:
_B
Chip Enable(s)
Chip Enable 0
Chip Enable 1
Chip Enable 2
Select All
Unselect All
Details View
Filter out ReadStatus, ReadStatusEx Commands with R
OK
Cancel

Customizing ONFi Decode

You can customize how the ONFi data is decoded for display in the ONFi Analysis window by specifying the available customization options in an xml data file.

The format for this file should be as per the format provided in the topic "ONFi Decode Customization XML File Structure and Elements" on page 14. You may also refer to an example of this xml file included in the topic "ONFi Decode Customization XML File - Example" on page 23.

The ONFi decode customizations that you specify in the XML file allow you to instruct how the decoder should interpret the sequences of commands and addresses and the address space definition as per your specific requirements. The customization options available for ONFi decode are as follows:

Customization	Description
Commands customization	Allows you to include your customizations to commands and sequences so that the decoder can recognize these custom sequences and can accurately interpret and present these in the Viewer. These can be: ▪ Variations to existing Read and Page Program ONFI commands ▪ Completely new command sequences (vendor-defined or reserved OpCodes.) ▪ Overriding the default decode mode for specific OpCodes ▪ Modifications to the Change Read Column command
Address Space customization	Allows you to include your own unique address mapping information for specific memory parts that may define address space differently from the standard address mapping. By doing so, you can display the address information in the format that your device specifies.
LUN Indexing Customization	Allows you to index ONFi commands in the Traffic Overview tab by targets and Logical Units (LUNs) combination. By default, the commands are indexed by targets only in the Traffic Overview tab. Once you enable LUN indexing, targets are used as primary indexing criterion and within these targets, LUNs are used as secondary indexing criterion.

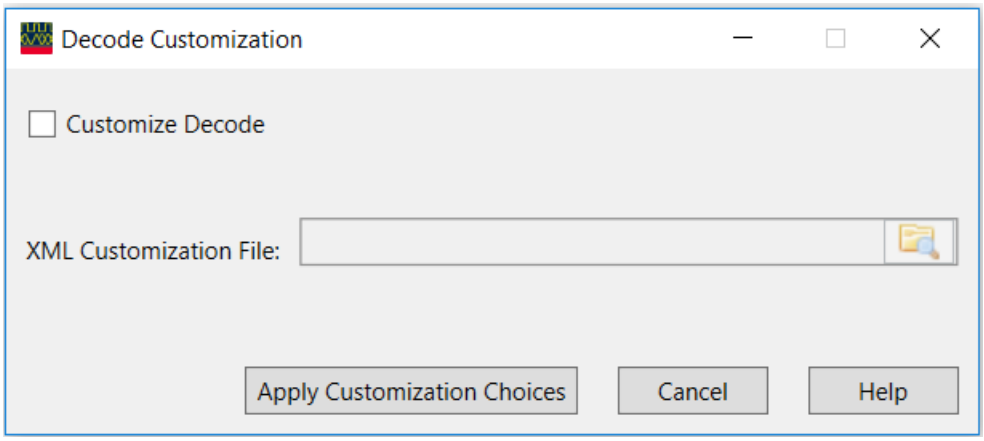
The XML elements used for these customizations are described in detail in the XML file topic that follows this topic.

NOTE You need to apply the customization options for the ONFi decode before you start computing ONFi transactions from the captured data.

To customize ONFi decode

1 Click the **Configure ONFi Decode...** button displayed in the ONFi Analysis window's toolbar.

The **Decode Customization** dialog box is displayed.



2 Select the **Customize Decode** check box.

3 Click the **Browse** button displayed with the XML Customization File field and browse to the location where you have stored the XML file that you want to use for ONFi decode customization.

4 Select the XML file and click **Open**.

5 Click the **Apply Customization Choices** button.

6 Recompute the ONFi decode for the customizations to be applied to the decode.

To remove customization from the ONFi decode

1 In the Decode Customization dialog box, deselect the **Customize Decode** check box and then click the **Apply Customization Choices** button.

2 Recompute the ONFi decode to remove customizations from the decode.

ONFi Decode Customization XML File Structure and Elements

You can create/edit the XML file for customizing ONFi decode using any text editor. This topic describes the format and hierarchy of the XML elements to be followed for this XML file.

(Refer to "ONFi Decode Customization XML File - Example" on page 23 to get an example of an XML file in the required format.)

XML Elements Hierarchy

```
<ONFiOptions>
        <AddressDefinitions>
            <AddressDefinition>
                <Segment>
                    <Bits/>
                    <FixedBits/>
        <DecoderOptions>
            <CustomSequences>
                <Sequence>
                    <MatchCmdValue/>
                    <MatchAddrLen/>
                    <MatchDataInLen/>
```

```
                    <MatchDataOutLen/>
               <CommandSpecificOptions>
                    <PageProgramCmdOptions>
                         <OpCodesToIgnore>
                              <OpCode/>
                    <ReadCmdOptions>
                         <OpCodesToIgnore>
                              <OpCode/>
               <CommandModifications>
                    <ChangeReadColumn>
               <OpCodeModeOverrides>
                    <SDROpCodes>
                         <OpCode/>
                    <DDROpCodes>
                         <OpCode/>
          <LUNOptions>
               <LUNAlias/>
               <LUNIndexing/>
               <LUNAddressCommands>
                    <LUNAddressCommand/>
```

These XML elements are described in detail in the table below.

XML Elements Description

XML Element	Description	Children	Parent	Attributes
<ONFiOptions>	The ONFi decode customization XML file begins with the <ONFiOptions> element.	<AddressDefinitions> <DecoderOptions> <LUNOptions>	-	-
<AddressDefinitions>	Allows you to define a set of one or more customized formats for the address information.	<AddressDefinition>	<ONFiOptions>	-
<AddressDefinition>	Allows you to define customized format of the address segment(s) for commands with the specified length of address bytes.		<AddressDefinitions>	**AppliesToAddrLen** - Indicates the length of address, in bytes. The decoder applies the customized address segments format to the commands that have the specified address bytes length. Valid values: 1, 2, 3, 5 Example <AddressDefinition AppliesToAddrLen="5">

XML Element	Description	Children	Parent	Attributes
	Allows you to define the customized format for an address segment such as a block address, page address, LUN address, or an offset. This customized address format can be based on the: ▪ specified start and end bits from the packet data (using the <Bits/> element) ▪ specified fixed value bits of a specified length (using the <FixedBits/> element)	<Bits/> <FixedBts/>	<AddressDefinition>	**DecodeText** - The customized name with which you want the address segment to be displayed in the ONFi decode. Valid value: String Example
<Bits/>	Allows you to define the start and end bits from a specific address byte that the decoder should use for the specific address segment. You can also use multiple <Bits/> elements to define the start and end bits that comprise an address segment.	-		**ByteIndex** - Indicates the index of address bytes. The byte index values start with Zero. So, 0 is considered the first address byte and so on. **StartBit** - The bit in the specific address byte that should be used as the starting point for an address segment. The value for this attribute starts with Zero. Therefore, 0 is considered the first bit in the address byte. **EndBit** - The bit in the specific address byte that should be used as the ending point for an address segment. The value for this attribute starts with Zero. The value is inclusive which means that the end bit is also included in the address segment format. Examples <Bits ByteIndex="4" StartBit="0" EndBit="4"/> (The bits 0-4 of the address byte at the 4th index value are shown as address in the decoded results.) <Bits ByteIndex="0" StartBit="0" EndBit="7" /> (The bits 0-7 of the first address byte are shown as address in the decoded results. In this example, if the address contains just one byte, then the decoder will show this entire byte in the decoded results.)
<FixedBits/>	Allows you to define a fixed value with which you want the decoder to replace the bits marked as "Fixed" in the address bytes. You also need to specify the number of these bits that should be replaced in the address bytes. You can also use a <FixedBits/> element along with <Bits/> elements to define the address format for an address segment. This combination allows you to define the address format based on actual address bits as well as a specified fixed value.	-		**Value** - A 1 bit value with which you want the decoder to replace the bits marked as "Fixed" in the address bytes. Valid values: 0 or 1 **Length** - The number of fixed value bits that you want the decoder to replace in the address bytes. Example <FixedBits Value="0" Length="2"/>

XML Element	Description	Children	Parent	Attributes
<DecoderOptions>	Use this element to define a set of one or more customized command and address sequences. These customizations can be: ▪ Variations to Read and Page Program ONFI commands using the <CommandSpecificOptions> child element ▪ Completely new (vendor-defined or reserved OpCodes) command sequences using the <CustomSequences> child element. On encountering a defined custom sequence in the ONFi data, the decoder decodes and presents it as a single packet entry with the customized name and color. ▪ Modifications to the number of address bytes expected for the Change Read Column command using the <CommandModifications> child element) ▪ Overriding the default decode mode setting for specified OpCode(s) using the <OpCodeModeOverrides> child element	<CustomSequences> <CommandSpecificOptions> <CommandModifications> <OpCodeModeOverrides>	<ONFiOptions>	-
<CustomSequences>	Use this element to define new custom sequence(s) for the decoder. This is for vendor-specific or reserved OpCodes.	<Sequence>	<DecoderOptions>	-

XML Element	Description	Children	Parent	Attributes
<Sequence>	Defines a custom sequence for the decoder. For a custom sequence, you specify a value in the StartOpCode attribute of this element. When the decoder encounters a command matching this value, it starts the matching process for this custom sequence based on the matching condition that you specified using a child element for this sequence. This matching condition can be: ▪ A command ▪ An address type ▪ Length for a Data-In or Data-Out type If a match for this condition is found in the ONFi data, the decoder applies the customizations (name and color) that you specified in this custom sequence and presents the sequence as a single packet. You can control whether or not the custom sequence should completely replace the standard definition of the OpCode in the decode. You do this using the MergeMatchingStartOpcode attribute.	<MatchCmdValue> <MatchAddrLen> <MatchDataInLen> <MatchDataOutLen>	<CustomSequences>	**DecodeText**: The customized name with which you want the custom sequence packet to be displayed in the ONFi decode. Valid value: String **MergeMatchingStartOpcode**: Indicates whether or not you want the custom definition to completely replace the standard definition of the OpCode. If you specify True for this attribute, the standard and custom definitions of the OpCode can co-exist and both are appropriately decoded by the decoder. Valid values: True / False **StartOpCode**: The start OpCode of a command on encountering which the decoder starts the matching for the sequence. **Color**: The color that you want to use for displaying the custom sequence packet in the ONFi decode. **IsLUNLevel**: By default, a custom sequence is assumed to be a target-level command. You can use the optional IsLUNLevel attribute to Indicate that the custom sequence should be considered as an LUN-level command sequence. As a result, the decoder indexes this custom command according to the currently selected LUN. Valid values: True / False **Examples** <Sequence DecodeText="Short1" MergeMatchingStartOpcode="False" StartOpCode="DA" Color="0000FF"/> *A custom sequence to completely replace the standard definition of the 0XDA OpCode with this customized definition.* <Sequence DecodeText="ShortAddr" MergeMatchingStartOpcode="True" StartOpcode="00" Color="0000FF"/> <MatchAddrLen Length="1"/> *A custom sequence to allow the co-existence of the standard definition of the 0X00 OpCode as well as this customized definition for the 0X00 OpCode in the decode. Both standard and custom command will then appear in the decode.*

XML Element	Description	Children	Parent	Attributes
<MatchCmdValue/>	Used for defining a command with a specific value. The decoder uses this value as the matching condition for a custom sequence.	-	<Sequence>	**Value**: Indicates a command that you want the decoder to use as the matching condition for a custom sequence. Example <MatchCmdValue Value="62"/>
<MatchAddrLen/>	Used for defining an address type with a specific length. The decoder uses this length as the matching condition for a custom sequence.	-	<Sequence>	**Length**: Indicates the length of an address type that you want the decoder to use as the matching condition for a custom sequence.
<MatchDataInLen/>	Matches Data-In type with the length that you specified in the 'Length' attribute.	-	<Sequence>	**Length**: Indicates the length of a Data-In type that you want the decoder to use as the matching condition for a custom sequence. A value of -1 indicates, matching any length.
<MatchDataOutLen/>	Matches Data-Out type with the length that you specified in the 'Length' attribute.	-	<Sequence>	**Length**: Indicates the length of a Data-Out type that you want the decoder to use as the matching condition for a custom sequence. A value of -1 indicates, matching any length.
<CommandSpecificOptions>	Use this element to define one or more custom sequences that are variations on the existing Read and Page Program ONFi commands. To define a variation, you can instruct the decoder to replace the start OpCode or the end OpCode or both start and end OpCodes of the relevant command with the specified OpCode(s). The decoder then applies the customizations (name, color, and OpCode(s)) that you specified in this custom sequence and presents the sequence as a single packet.	<PageProgramCmdOptions> <ReadCmdOptions>	<DecoderOptions-	-

XML Element	Description	Children	Parent	Attributes
<PageProgramCmdOptions>	Use this element to define a vendor-specific variation of the Page Program ONFi command.	<OpsCodesToIgnore>	<CommandSpecificOptions>	**DecodeText**: The customized name with which you want the custom sequence packet to be displayed in the ONFi decode. Valid value: String **Color**: The color that you want to use for displaying the custom sequence packet in the ONFi decode. **ReplaceStartOpCode** - Indicates whether or not you want the decoder to replace the start OpCode of the custom Page Program command. Valid values: True, False **StartOpCode**: The OpCode with which you want the decode to replace the start OpCode of the custom Page Program command. This is done only if the ReplaceStartOpCode is set to True. If ReplaceStartOpCode is set to False, then set the StartOpCode to the default value "00" so that an XML error is not generated for leaving it blank. **ReplaceEndOpCode** - - Indicates whether or not you want the decoder to replace the end OpCode of the custom Page Program command. Valid values: True, False **EndOpCode**: The OpCode with which you want the decode to replace the end OpCode of the custom Page Program command. This is done only if the ReplaceEndOpCode is set to True. If ReplaceEndOpCode is set to False, then set the EndOpCode to the default value "00" so that an XML error is not generated for leaving it blank. Example <PageProgramCmdOptions DecodeText="Fast Write" Color="7FFF8E" ReplaceStartOpCode="False" StartOpCode="00" ReplaceEndOpCode="True" EndOpCode="C0">

XML Element	Description	Children	Parent	Attributes
<ReadCmdOptions>	Use this element to define a vendor-specific variation of the Read ONFi command.	<OpsCodesToIgnore>	<CommandSpecificOptions>	**DecodeText**: The customized name with which you want the custom sequence packet to be displayed in the ONFi decode. Valid value: String **Color**: The color that you want to use for displaying the custom sequence packet in the ONFi decode. **ReplaceStartOpCode** - Indicates whether or not you want the decoder to replace the start OpCode of the custom Read command. Valid values: True, False **StartOpCode**: The OpCode with which you want the decode to replace the start OpCode of the custom Read command. This is done only if the ReplaceStartOpCode is set to True. If ReplaceStartOpCode is set to False, then set the StartOpCode to the default value "00" so that an XML error is not generated for leaving it blank. **ReplaceEndOpCode** - - Indicates whether or not you want the decoder to replace the end opcode of the custom Read command. Valid values: True, False **EndOpCode**: The opcode with which you want the decode to replace the end opcode of the custom Read command. This is done only if the ReplaceEndOpCode is set to True. If ReplaceEndOpCode is set to False, then set the EndOpCode to the default value "00" so that an XML error is not generated for leaving it blank. Example <ReadCmdOptions DecodeText="Fast Read" Color="FFD800" ReplaceStartOpCode="False" StartOpCode="00" ReplaceEndOpCode="True" EndOpCode="50">
<OpCodesToIgnore>	Use this element to create a list of OpCodes that you want the decoder to ignore for a custom sequence. This list ensures that on encountering any of the opcodes from this list, the decoder interprets the sequence to be still in continuation and does not consider the sequence as complete.	<OpCode>	<PageProgramCmdOptions> <ReadCmdOptions>	-
<OpCode>	A specific OpCode that you want the decoder to ignore for a custom sequence.	-	<OpCodesToIgnore>	-

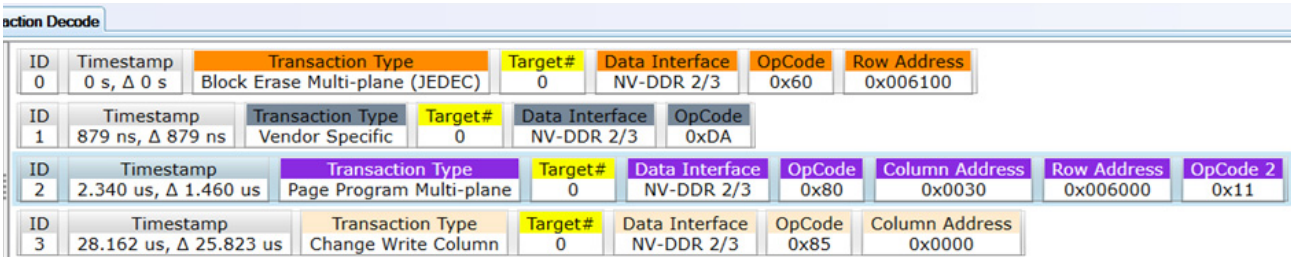
XML Element	Description	Children	Parent	Attributes
<CommandModifications>	Use this element to specify modifications to the specific ONFi commands such as the *Change Read Column* command.	<ChangeReadColumn>	<DecoderOptions>	-
<ChangeReadColumn/>	Use this element to override the number of address bytes expected for the Change Read Column command. As per the ONFi specifications, three address bytes are expected for the Change Read Column command. If the decoder encounters any number of address bytes other than three, it reports this as an error. However, if needed, you can override this default behavior and specify the number of address bytes that you want the decoder to expect for the Change Read Column command.	-	<CommandModifications>	AddressLength - The number of address bytes that the decoder should expect for the Change Read Column command. Example <ChangeReadColumn AddressLength="5" />
<OpCodeModeOverrides>	Use this element to specify OpCode(s) for which you want the decoder to use the specified decode mode overriding the currently set default decode mode. On encountering any of the specified OpCodes in a command sequence, the decoder decodes that entire command sequence in the specified decode mode regardless of the default decode mode that you set for decoder. Note that the entire command sequence in which one of the specified OpCodes is found and any data associated with that sequence is decoded in the specified mode.	<SDROpCodes> <DDROpCodes>	<DecoderOptions>	-
<SDROpCodes>	Use this element to create a list of OpCodes for which you want the decoder to use the SDR decode mode regardless of the default decode mode that you set for decoder.	<OpCode>	<OpCodeModeOverrides>	-
<DDROpCodes>	Use this element to create a list of OpCodes for which you want the decoder to use the DDR2/3 decode mode regardless of the default decode mode that you set for decoder.	<OpCode>	<OpCodeModeOverrides>	-
<OpCode>	Use this element to specify an OpCode for which you want the decoder to override the default decode mode and instead use the specified (SDR or DDR2/3) decode mode. If this element is used as a sub-element of the <DDROpCodes> element, then DDR2/3 is used as the decode mode for that OpCode. If this element is used as a sub-element of the <SDROpCodes> element, then SDR is used as the decode mode for that OpCode.	-	<SDROpCodes> <DDROpCodes>	Example <SDROpCodes> <OpCode>07</OpCode> <OpCode>0C</OpCode> </SDROpCodes> (On detecting the OpCodes 0x07 or 0x0C, the decoder switches to the SDR mode to decode the entire command sequence in which these OpCodes are present.)

XML Element	Description	Children	Parent	Attributes
<LUNOptions>	Allows you to define the customization options available for indexing the ONFI commands by targets and logical units (LUNs) in the Traffic Overview tab. By default, the commands are indexed by targets only in the Traffic Overview tab.	<LUNAlias> <LUNIndexing> <LUNAddressCommands>	<ONFiOptions>	-
	NOTE: For the LUN indexing related customizations to work, you must define the format of the LUN address segment for commands with the length of address bytes as 3 and 5. The decoder uses this information to correctly decode the LUN address for these commands. Example: <AddressDefinition AppliesToAddrLen="5"> <Bits ByteIndex="4" StartBit="5" EndBit="7"/> 			
<LUNAlias>	An optional element to specify a string that you want the decoder to use instead of “LUN” in the ONFi decode.	-	<LUNOptions>	Example: <LUNAlias>Chip</LUNAlias>
<LUNIndexing>	Allows you to enable/disable the LUN level indexing of ONFi commands in the Traffic Overview tab of the ONFi Analysis window. By default, the indexing is according to targets only. Once you enable LUN indexing, targets are used as primary indexing criterion and within these targets, LUNs are used as secondary indexing criterion.	-	<LUNOptions>	-
<LUNAddressCommands>	Allows you to define one or more vendor-specific commands that select an LUN.	<LUNAddressCommand>	<LUNOptions>	-
<LUNAddressCommand>	Allows you to specify the Opcode and selected LUN for a vendor-specific command.	-	<LUNAddressCommands>	AddressValue - The LUN that the vendor-specific command selects. OpCode - The OpCode of the vendor-specific command that selects an LUN. Example <LUNAddressCommand AddressValue="0" OpCode="41"/>

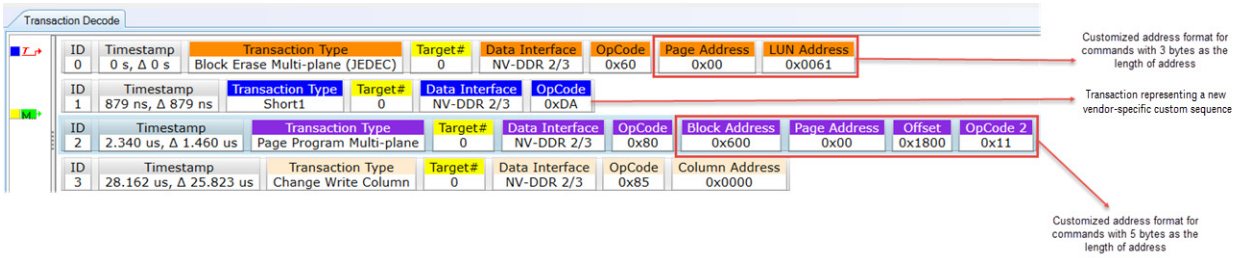
ONFi Decode Customization XML File - Example

This topic includes an example of the XML file created in the required format to customize the ONFi decode. To get a description of each XML element used in this example file, refer to the topic “ONFi Decode Customization XML File Structure and Elements" on page 14.

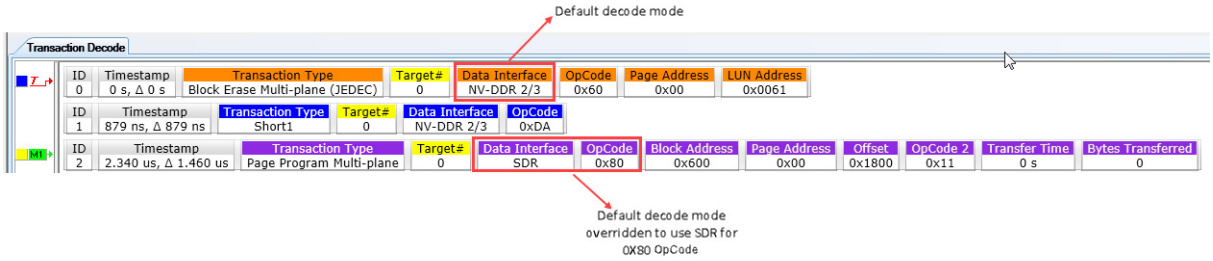
Sample screens of the ONFi decode computed with and without applying the customization choices included in the XML file are displayed below.



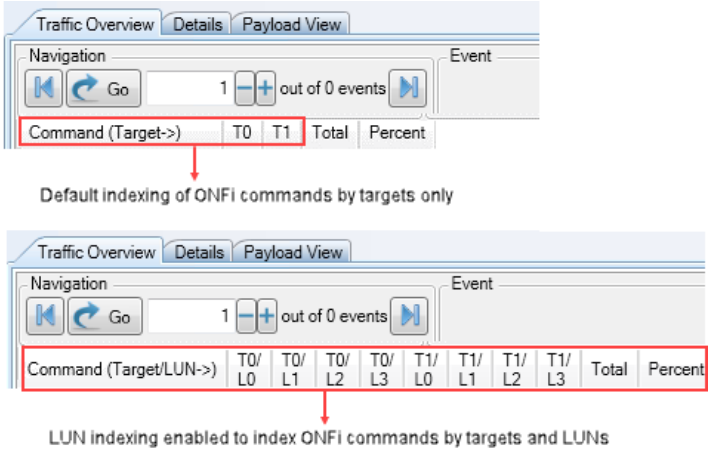
<Sample screen 1 - ONFi decode computed without customization choices applied>



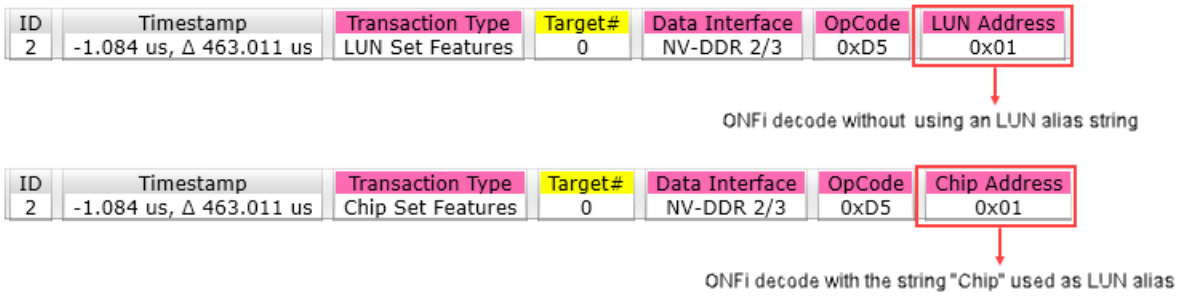
<Sample screen 2 - ONFi decode computed with customization choices applied>



<Sample screen 3 - ONFi decode computed with customization to override the default decode mode for a specific OpCode>



<Sample screen 4 - ONFi decode computed with customization to index ONFi commands by targets and LUNs instead of the default target only indexing>



<Sample screen 5 - ONFi decode computed with customization to include an alias for LUN in the decode results>

ONFi Decode Customization Example XML File

```
<ONFiOptions Version="6.50">
<!-- Address decoding options -->
<AddressDefinitions>
   <AddressDefinition AppliesToAddrLen="5">
     <Segment DecodeText="Block Address">
         <Bits ByteIndex="4" StartBit="0" EndBit="4"/>
         <Bits ByteIndex="3" StartBit="1" EndBit="7"/>
     </Segment>
     <Segment DecodeText="Page Address">
         <Bits ByteIndex="2" StartBit="0" EndBit="7"/>
     </Segment>
     <Segment DecodeText="Offset">
         <Bits ByteIndex="1" StartBit="0" EndBit="6"/>
         <Bits ByteIndex="0" StartBit="0" EndBit="7"/>
     </Segment>
   </AddressDefinition>
   <AddressDefinition AppliesToAddrLen="3">
     <Segment DecodeText="Page Address">
         <Bits ByteIndex="2" StartBit="0" EndBit="7"/>
     </Segment>
     <Segment DecodeText="LUN Address">
         <Bits ByteIndex="1" StartBit="0" EndBit="6"/>
         <Bits ByteIndex="0" StartBit="3" EndBit="7"/>
         <FixedBits Value="0" Length="2"/>
     </Segment>
   </AddressDefinition>
```

```
</AddressDefinitions>
<!-- Decoder customization -->
<DecoderOptions>
   <CustomSequences>
     <Sequence DecodeText="Short1" Color="0000FF" StartOpCode="DA"/>
     <Sequence DecodeText="Short2" Color="553333" StartOpCode="DF"/>
     <Sequence DecodeText="Long2" Color="550000" StartOpCode="91">
         <MatchCmdValue Value="62"/>
         <MatchCmdValue Value="A4"/>
         <MatchCmdValue Value="58"/>
         <MatchCmdValue Value="01"/>
     </Sequence>
   </CustomSequences>
   <CommandSpecificOptions>
     <PageProgramCmdOptions DecodeText="Fast Write" Color="7FFF8E"
     ReplaceStartOpCode="False" StartOpCode="81" ReplaceEndOpCode="True"
     EndOpCode="C0">
         <OpCodesToIgnore>
         <OpCode>51</OpCode>
         <OpCode>99</OpCode>
         </OpCodesToIgnore>
     </PageProgramCmdOptions>
     <ReadCmdOptions DecodeText="Fast Read" Color="FFD800"
     ReplaceStartOpCode="False" StartOpCode="00" ReplaceEndOpCode="True"
     EndOpCode="50">
         <OpCodesToIgnore>
         <OpCode>37</OpCode>
         <OpCode>38</OpCode>
         </OpCodesToIgnore>
     </ReadCmdOptions>
   </CommandSpecificOptions>
   <CommandModifications>
     <ChangeReadColumn AddressLength="5" />
   </CommandModifications>
   <OpCodeModeOverrides>
          <SDROpCodes>
               <OpCode>07</OpCode>
               <OpCode>0C</OpCode>
          </SDROpCodes>
```

```
            <DDROpCodes>
                  <OpCode>07</OpCode>
                  <OpCode>0C</OpCode>
            </DDROpCodes>
   </OpCodeModeOverrides>
</DecoderOptions>
</ONFiOptions>
```

Computing Decoded ONFi Transactions and Chart

NOTE

Before you start computing the decoded transactions and chart, ensure that you have:

- correctly configured ONFi properties. Failing to do so can result in an inaccurate decoding of transactions.

- applied the decode customization choices (if needed) using an XML file. Failing to do so will result in the transactions being decoded and displayed without your specific customizations.

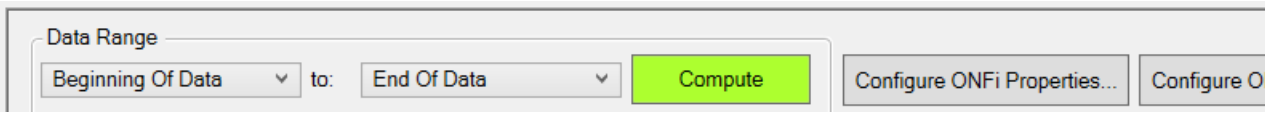
To compute ONFi transactions

1 Click the **Show** button on the ONFi Analysis instance in the **Overview** window to access the ONFi Analysis window.

The **ONFi Analysis** window is displayed.

2 In the **Data Range** groupbox, specify the start and end points of the captured ONFi data for which you want to compute decoded transactions and chart. Only the specified range of data is analyzed to compute data. Following options are available for setting this data range.

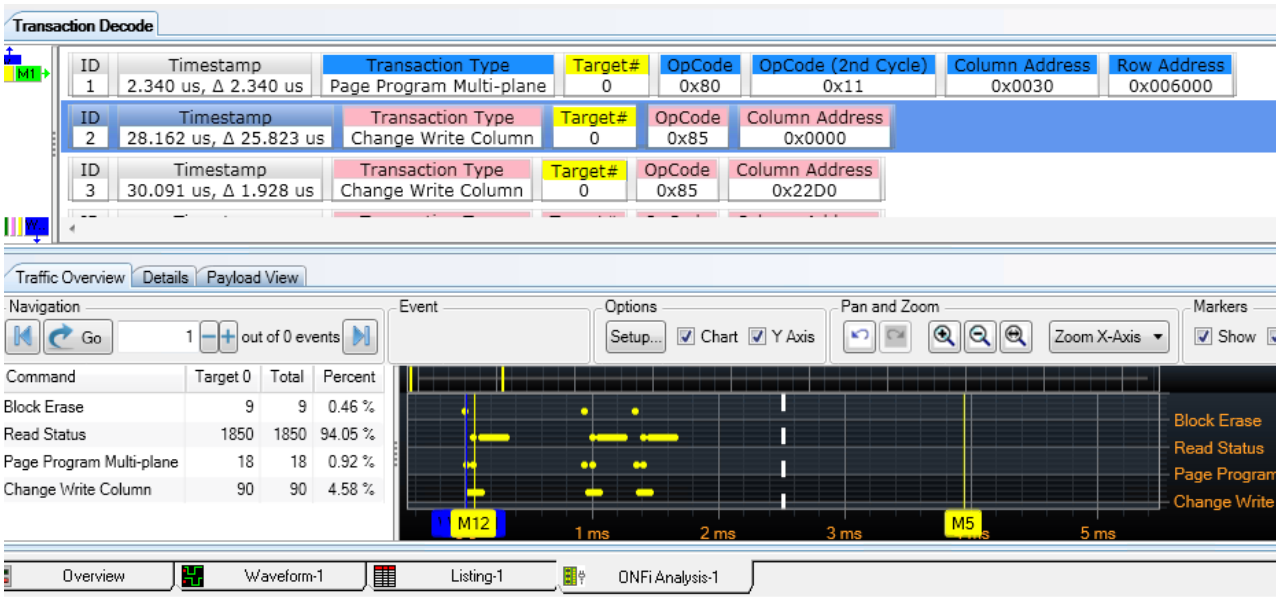
- **Beginning and End of data** - This data range selection ensures that the entire trace is used for the computation of ONFi transactions and chart.
- **Trigger** - Selecting Trigger in the data range ensures that ONFi transactions are computed from the point in the captured data where the trigger condition was met.
- **Markers** - Selecting markers in the data range ensures that ONFi transactions are computed for the specific portion of captured data defined by markers.



3 Click the **Compute** button displayed with the Data Range fields.

On clicking Compute, the transactions are decoded from the specified data range of ONFi trace. Then, statistics and chart are computed from these decoded transactions and results are displayed.

The following screen displays the computed transactions for a single-target NAND Flash memory device.



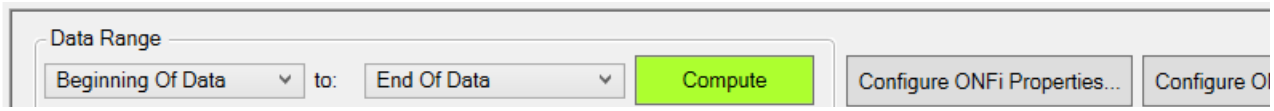
NOTE

You can show or hide a specific tab / pane in the ONFi Analysis window using the Show/Hide Tabs drop-down listbox at the top of the ONFi Analysis window.

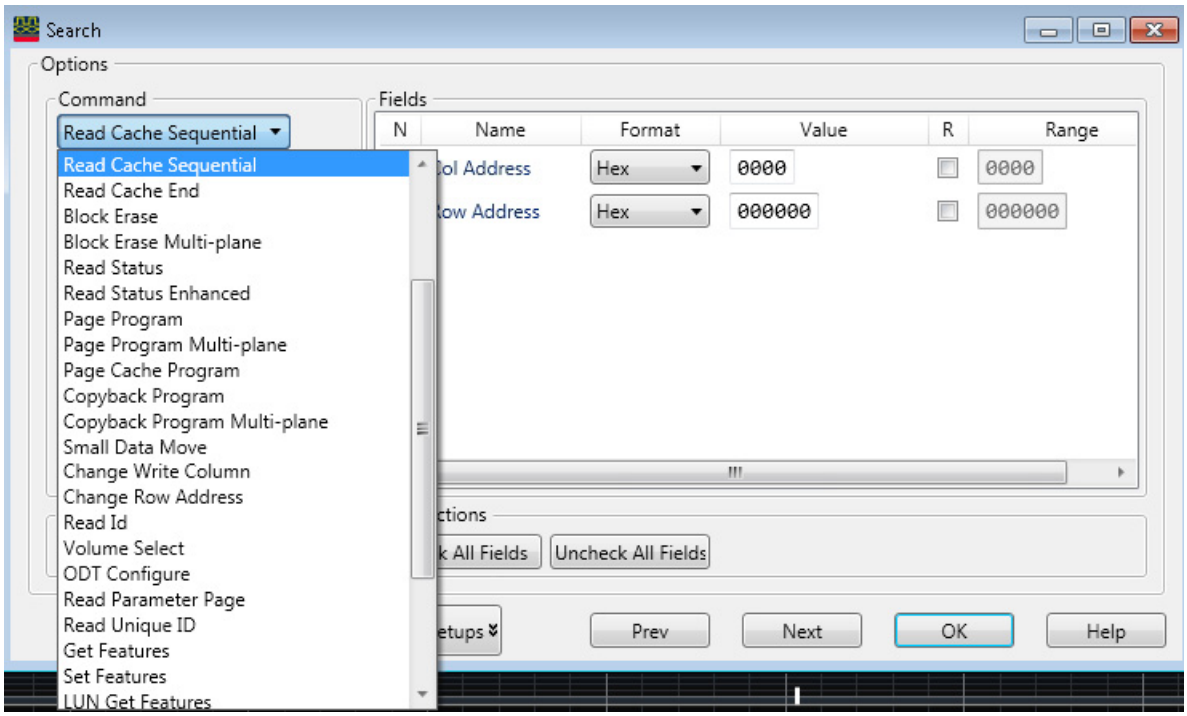
Hiding a tab using this drop-down listbox does not exclude the hidden tab from the Compute operation. The tab is only hidden from display but its data is still computed when you click Compute.

Searching for Specific ONFi Commands

You can quickly search for a particular ONFi command of interest from the list of decoded ONFi transactions displayed in the upper pane of the ONFi Analysis window. You can use the **Search** section in the ONFi Analysis toolbar to accomplish this.



To define your search criteria, you can choose the required ONFi command from the list of available ONFi commands in the Search dialog and further refine this criteria by specifying field values for the selected command.

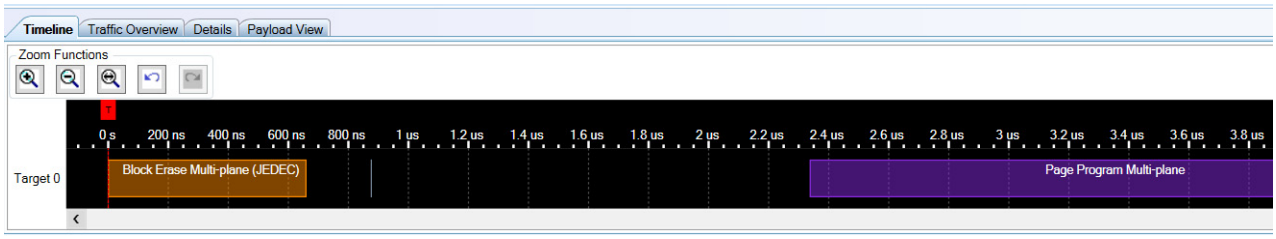


To know how to use the search feature and then view search results, refer to the Search dialog.

Viewing ONFi Data in a Timeline View

You can use the **Timeline** tab in the ONFi Analysis window to view ONFi transactions on a timeline (in the order in which these have occurred over a period of time). This allows you to get a visual depiction of the activities related to a NAND target on a timeline.

Each ONFi transaction is displayed as a linear bar on the timeline. The time axis used to depict this timeline is shown at the top of the tab.

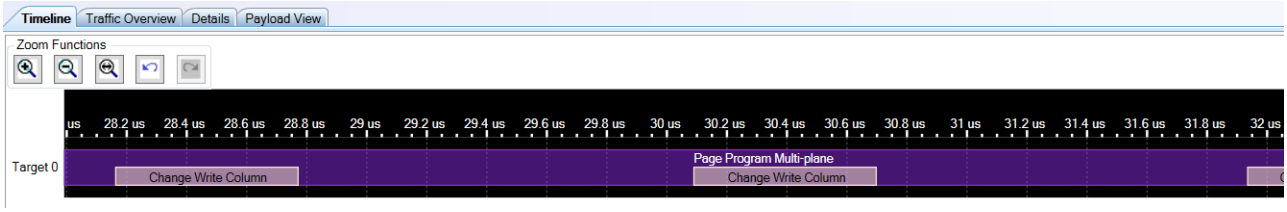


Timeline View for a Multi-target NAND Device

In the Timeline tab, a separate timeline is used to depict ONFi transactions separately for each NAND target.

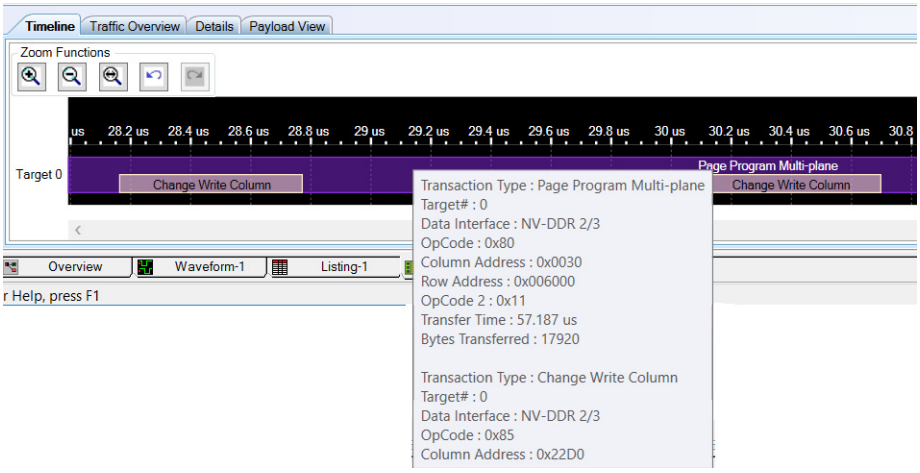
Depicting Concurrent Transactions on a Timeline

There may be situations when multiple transactions are concurrently occurring for a NAND target. One such example can be a Page Program command with the Change Write commands occurring in between. Such concurrent transactions are depicted on a timeline as displayed in the screen below.



Viewing Transaction Details on the Timeline

You can hover the mouse on a transaction bar in the Timeline view to display details for that particular transaction. For concurrent transactions, the details of the relevant transactions is shown together.



NOTE

You can zoom in or zoom out the entire data depicted on the timeline(s) using the buttons displayed in the Zoom Functions section of the Timeline tab.

- Zoom In magnifies the center 50% of the timeline to the full width of the timeline.
- Zoom Out doubles the time displayed in the full width of the timeline.
- Zoom Out Full displays the entire range of Computed data across the full width of the timeline.

You can also zoom a defined area in the timeline by drawing a zoom box using the left mouse button. To draw a zoom box, move the mouse pointer to the timeline location from which you want to begin zooming. Then left-click at this location and while keeping the left mouse button pressed, drag the mouse to the timeline location till which you want to zoom the display. When you release the left mouse button, the defined area is zoomed.

You can undo and redo zooms by clicking the and buttons in the Zoom Functions section.

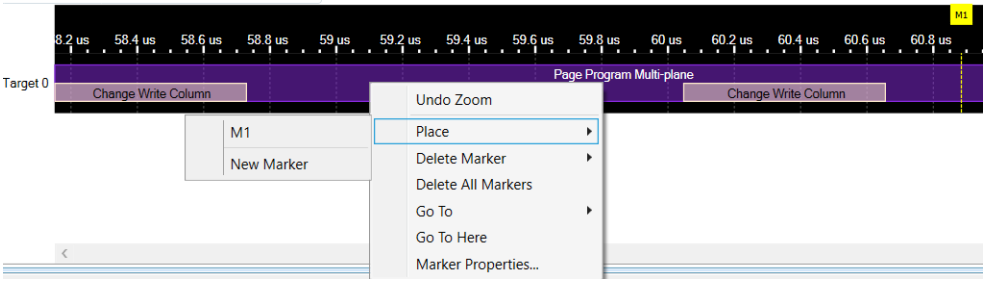
Placing Markers in a Timeline

You can place markers in a timeline and then use these markers to navigate to the exact trace position that corresponds to that marker location in the timeline.

Markers placed in the timeline are correlated to markers displayed in the trace data in the upper pane of the ONFi Analysis window.

To place a marker in a timeline

1 Right-click the timeline location where you want to place a marker. Then select **Place** > **New Marker** or select an existing marker to place that marker at the current location.



To navigate to a particular marker placed in the timeline

In situations when you have placed multiple markers in the timeline, you may want to navigate to a particular marker and its associated trace position in the upper pane. To do so, right-click anywhere in the timeline, select **Go To** and then select the marker to which you want to navigate.

On doing so, the timeline display moves to the point at which the selected marker is located. Also, the trace position corresponding to the selected marker is highlighted in the upper pane.

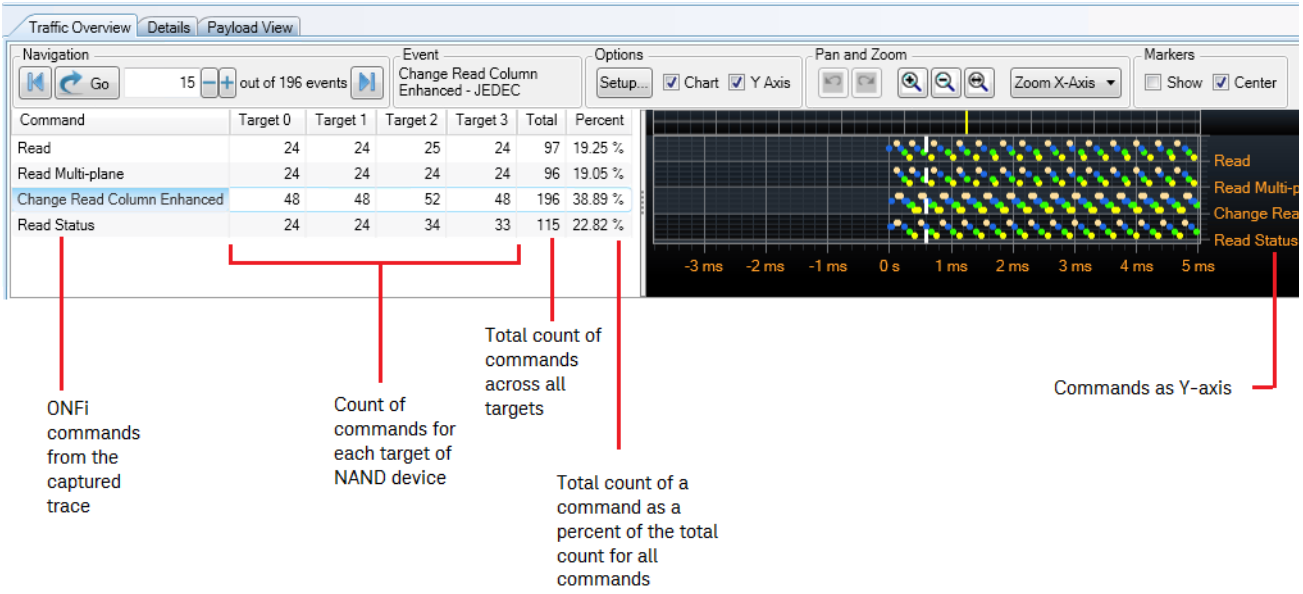
Analyzing ONFi Traffic Statistics

You can use the **Traffic Overview** tab in the ONFi Analysis window to view and analyze the traffic statistics for the ONFi data captured and displayed in the upper pane of the window.

On clicking the Compute button, the following data is computed in the Traffic Overview tab's left and right panes.

Left Pane	Right Pane
For each type of ONFi command found in the captured trace, the left pane displays a count of the number of times that ONFi command was found in the trace. For a multi-target NAND device, the count of each command is further categorized on the basis of these targets. (If required, you can categorize these commands by Logical Units (LUNs). To do this, you need to enable LUN indexing. Refer to the topic "ONFi Decode Customization XML File Structure and Elements" on page 14 to know more about LUN indexing.)	The right pane displays a traffic overview chart in which a count of ONFi commands found in the captured trace is plotted over the period of time as X-axis and the command types as Y-axis.

The following screen displays a sample ONFi traffic statistics for a NAND device with multiple targets.



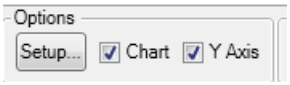
The following subsequent topics in this chapter describe the usage of the Traffic Overview tab in detail.

- Selecting the ONFi Commands to be Included in Traffic Overview
- Viewing and Customizing an ONFi Traffic Overview Chart
- Navigating Between ONFi Traffic Overview and Decoded ONFi Transactions

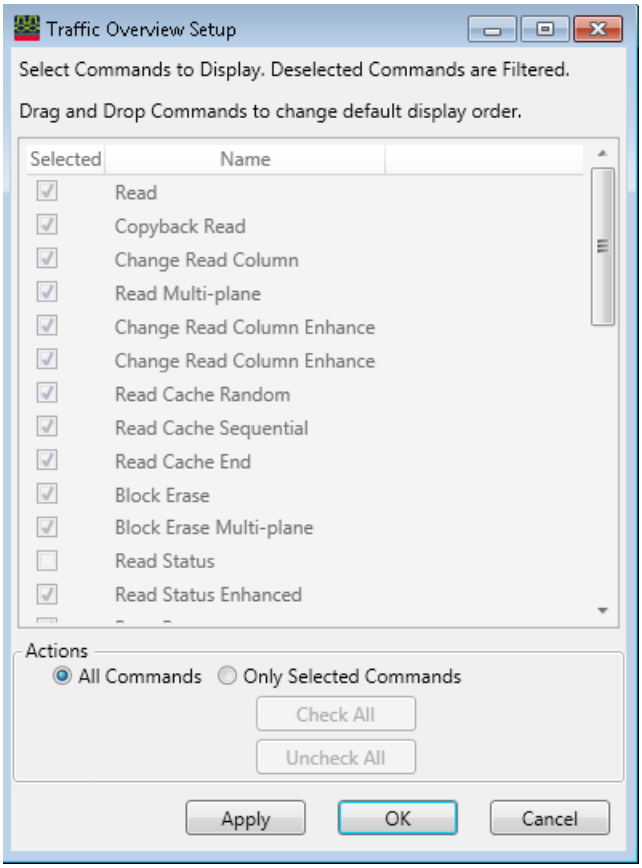
Selecting the ONFi Commands to be Included in Traffic Overview

You can choose the ONFi commands for which you want the traffic statistics and traffic overview chart to be displayed in the Traffic Overview tab. By default, all ONFi commands are selected for data display.

1 Click the **Setup...** button under the **Options** groupbox in the Traffic Overview tab of ONFi Analysis window.



The **Traffic Overview Setup** dialog box is displayed with the list of all the available ONFi commands. The **All Commands** radio button is selected by default which means all ONFi commands are selected for display in the Traffic Overview tab.



2 To filter out commands from the display in the Traffic Overview tab, click the **Only Selected Commands** radio button in the **Actions** groupbox.

3 Deselect the checkbox for each ONFi command that you do not want to include in the traffic statistics.

NOTE

You can also change the order in which an ONFi command is displayed in the traffic overview chart's Y-axis. To do so, drag and drop that command in the required sequence in the list of commands shown in the Traffic Overview Setup dialog. On clicking OK, this change gets reflected in the Y-axis of the chart.

4 Click **Apply** to confirm the changes or click **OK** to confirm the changes and close the dialog box. Click **Cancel** to close the dialog box without applying changes.

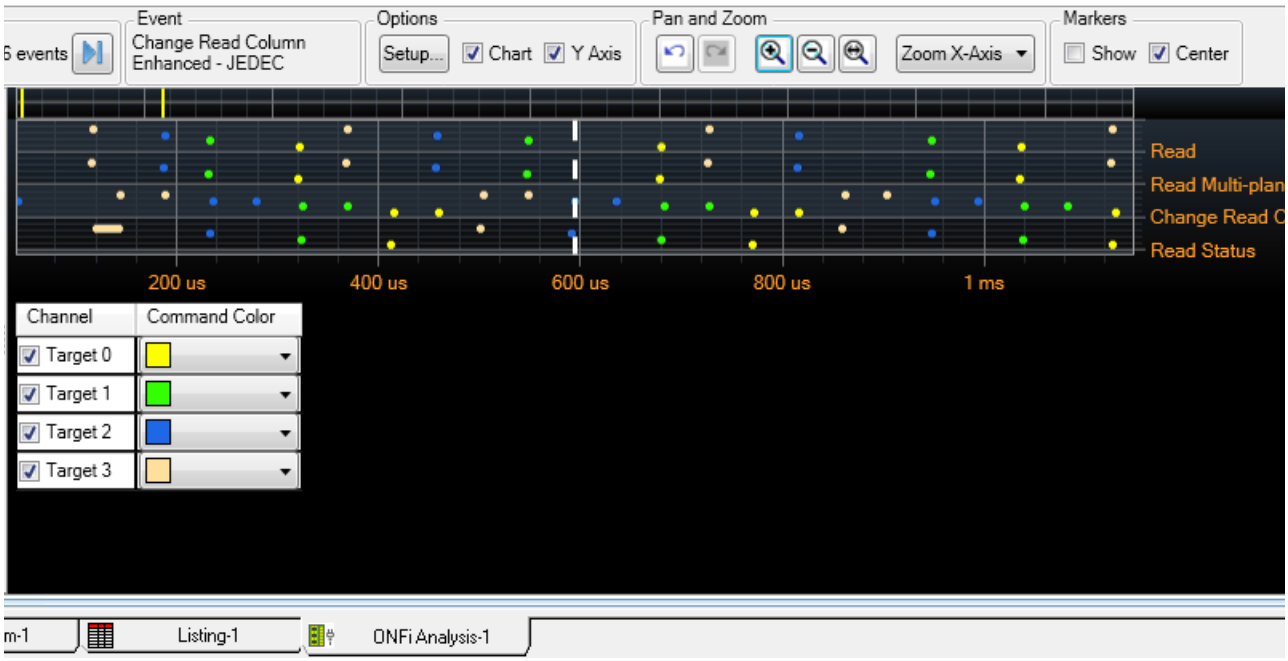
The changed selection of commands is reflected in the traffic statistics and chart.

Viewing and Customizing an ONFi Traffic Overview Chart

The computed ONFi traffic statistics displayed in the left pane of the **Traffic Overview** tab is also plotted on a chart in the tab's right pane.

For each ONFi command type found in the trace, there is a row in the chart. This row is used to plot the number of commands of that type sent over a period of time to individual NAND targets.

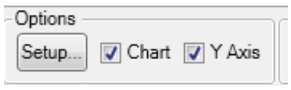
Color coding is used to differentiate ONFi command counts based on targets. For instance, in the below screen, yellow and blue colors are used to represent command counts for Target 0 and 2 respectively.



Some of the ways of customizing an ONFi traffic overview chart are described in this topic.

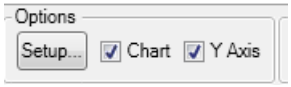
To display an ONFi traffic overview chart

By default, the traffic overview chart is displayed. To show/hide this chart, select/deselect the **Chart** checkbox from the **Options** groupbox in the Traffic Overview tab.



To hide the Y-axis (ONFi command types) in the traffic overview chart

1 Deselect the **Y Axis** checkbox from the **Options** groupbox in the Traffic Overview tab.

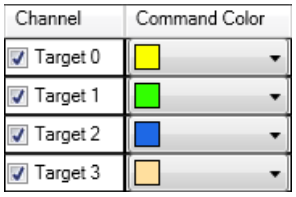


To view or change the color coding used in the traffic overview chart

The Color Picker Legend displays the currently applied color coding for the chart.

1 To display the Color Picker Legend, right-click anywhere in the plotted chart area and select **Show Color Picker Legend**.

The currently used color coding for the data plotted for each target is displayed in the Color Picker Legend.



2 To change the color coding for the data plotted for a particular target, click the **Command Color** drop-down and select the new color.

The commands count for that target is plotted using the new color in the chart.

The color coding that you set using the Color Picker Legend is automatically reflected in the Chip Enables color coding in the Configure ONFi Properties dialog box and vice versa.

To show/hide data for a target from the traffic overview chart

By default, the command counts for all the applicable NAND targets are displayed in the chart. You may want to hide the command counts for some of the targets to focus only on specific target(s) of interest.

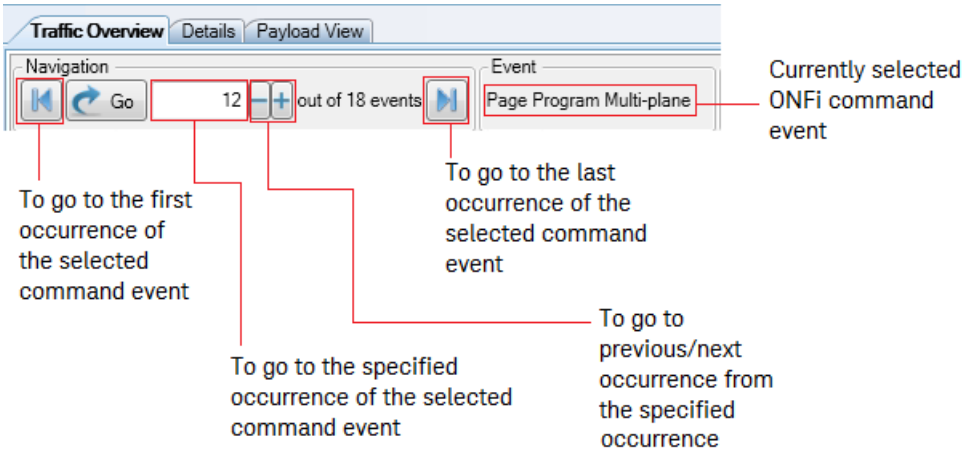
1 Right-click anywhere in the plotted chart area and select **Show Color Picker Legend**.

2 Select/deselect the checkbox for a target to show/hide the command counts for that target in the chart.

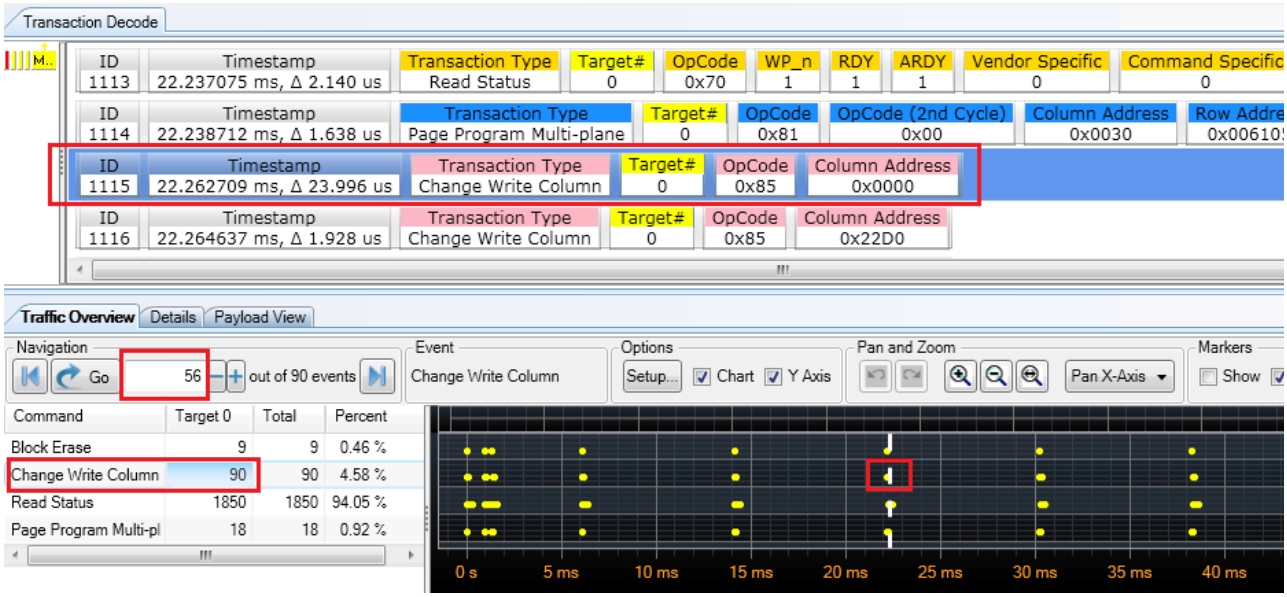
The chart is updated to reflect your selections of targets.

Navigating Between Traffic Overview and Decoded ONFi Transactions

You use the Navigation toolbar in the Traffic Overview tab to navigate from a specific occurrence of an ONFi command event to its applicable ONFi transaction in the upper pane. Simultaneously, the traffic overview chart display also moves to the point at which the specific ONFi command event is plotted in the chart.



For instance, in the following screen, there are total 90 occurrences of the Change Write Column commands and you want to navigate directly to the 56th Change Write Column command in the trace To do so, you can select the Change Write Column command type in the Traffic Overview left pane and then type 56 in the Navigation text box and click Go. This takes you directly to the 56th Change Write Column transaction in the upper pane of the ONFi Analysis window. The chart display is also simultaneously moved to bring the 56th occurrence of this command to the canter position in the chart.



Placing Markers in an ONFi Analysis Chart

You can place markers in the Traffic overview chart displayed in the ONFi analysis window and use these markers to navigate to the ONFi transaction associated with the chart location at which you placed a marker. This helps you navigate to the exact trace position that corresponds to that chart location.

Markers placed in the chart are correlated to markers displayed in the trace data in the upper pane of the ONFi Analysis window.

To place a marker in an ONFi analysis chart

1 Double-click the location in the chart at which you want to place a marker. A new marker is added to that chart location as a yellow vertical line and at the corresponding trace location in the upper pane.

Alternatively, right-click the chart location where you want to place a marker. Then select **Place** > **New Marker** or select an existing marker to place that marker at the current location.

To change the position of a marker

You can change the position of a marker by dragging/dropping markers.

1 Hover the mouse over the marker vertical line.

A double arrow will appear indicating that the marker is selected.

2 Left-click to drag and release to drop.

To navigate to a particular marker placed in the chart

In situations when you have placed multiple markers in the chart, you may want to navigate to a particular marker and its associated trace position in the upper pane. To do so, right-click anywhere in the chart, select Go To and then select the marker to which you want to navigate.

On doing so, the chart display moves to the point at which the selected marker is located. Also, the trace position corresponding to the selected marker is highlighted in the upper pane.

Using the Center marker

When you use the list in the left pane of a tab to navigate to a particular occurrence of an event in the chart on the right, the chart display moves to the point of the occurrence's location. The location is centered in the chart. To clearly identify the location, you can use the **Center** marker by selecting the **Center** checkbox from the top of the Chart pane. This marker is always displayed at the center of the charts display.

NOTE If the markers are not displayed in a chart, click the Show checkbox in the Markers section at the top of the chart pane.

Panning / Zooming an ONFi Analysis Chart

Using the Pan Option to Navigate Through an ONFi Analysis Chart

To navigate through a chart horizontally, that is X-axis, select the **Pan X-axis** option from the Pan and Zoom section.

Zooming an ONFi Analysis Chart

You can zoom in or zoom out a defined area in the chart or the complete chart.

To zoom X-Axis for a defined area in the chart

1 Click the **Zoom X-Axis** option from the combo box displayed in the **Pan and Zoom** section of the charts pane to make it active.
2 Move the mouse pointer to the chart location from which you want to begin zooming.
3 Left-click at this location and while keeping the left mouse button pressed, drag the mouse to the chart location till which you want to zoom the display. As you move the mouse, the zooming extent is defined in chart and highlighted with gray.

When you release the left mouse button, the defined X-axis area is zoomed.

You can also zoom in or zoom out complete charts. To do this, use the following buttons in the Pan and Zoom section of the charts pane.

-  - Zoom In magnifies the center 50% of the chart to the full width of the chart.
-  - Zoom Out doubles the time displayed in the full width of the chart.
-  - Zoom Out Full displays the entire range of Computed data across the full width of the chart.

NOTE You can undo and redo zooms by clicking the  and  buttons in the Pan and Zoom section of the charts pane.

Viewing ONFi Transactions as a Logically Grouped Sequential Set

An ONFi operation comprises of a number of commands issued in a specific sequence. In the upper pane of the ONFi Analysis window, ONFi transactions (commands) are decoded and listed in a time-wise order of their occurrence. At times, you may want a segregated view of the complete sequential set of transactions (commands) that comprise a specific ONFi operation. You can use the **Details** tab in the ONFi Analysis window to view this logically grouped sequential set of commands issued for a specific ONFi operation.

On selecting a decoded transaction row in the **Transaction Decode** tab of the ONFi Analysis window, the **Details** tab lists all the ONFi commands applicable for that transaction in a sequential flow.

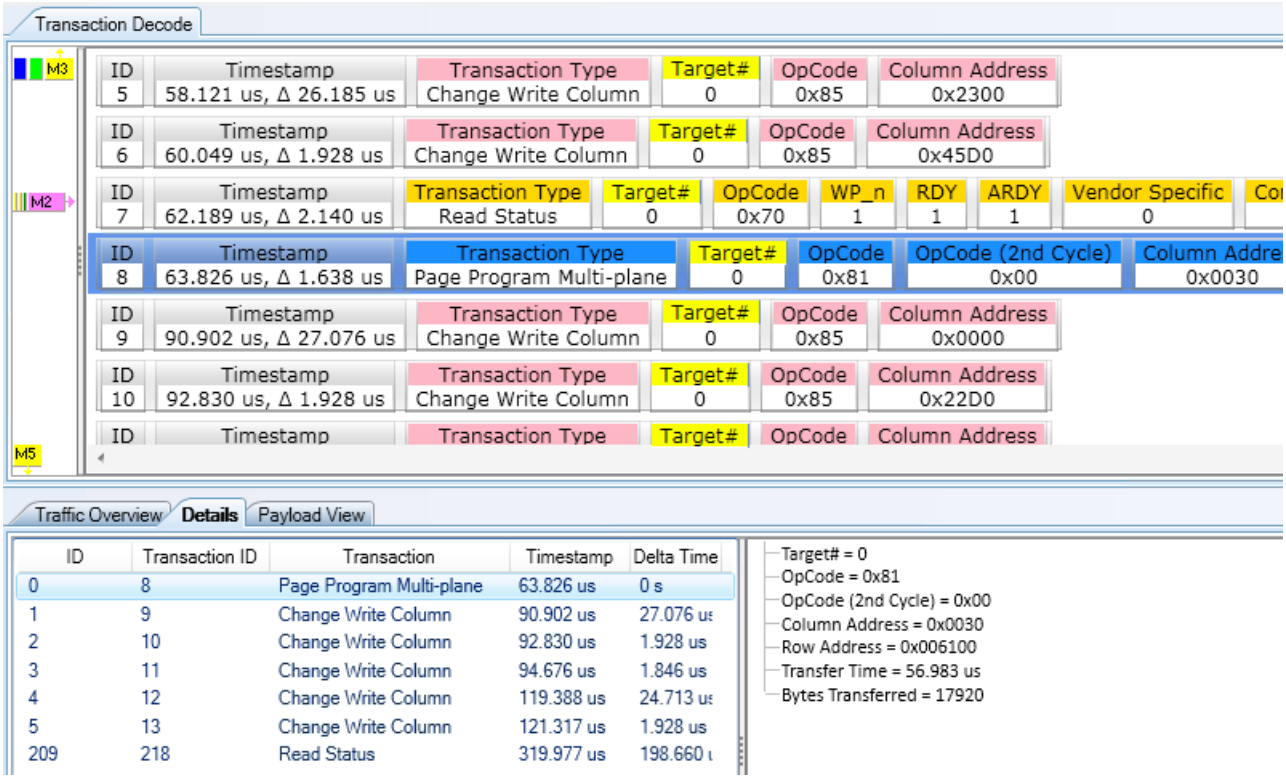
Example - A complete set of transactions for a Multi-plane Program operation

The following screen displays the complete sequence of commands applicable for the Page Program Multi-plane transaction highlighted in the upper pane.

In this sequence:

- The Page Program command transfers a page of data identified by a column address to the page register. The contents of the page register are then programmed into the Flash array at the row address indicated.
- The Change Write Column commands change the column addresses being written to in the page register.
- After several Read Status commands (with RDY bit set to 0), the ONFi sequence ends with the Read Status commands (with RDY bit set to 1) indicating that another command can be accepted.

(In this sequence, all the Read Status commands with the RDY bit set to 0 have been filtered out using the Configure ONFi properties dialog.)



The following table describes the fields displayed in the Details tab.

Field	Description
ID	Identifier assigned to an ONFi transaction in the logically grouped sequential set to indicate the transaction's order in the sequential flow.
Transaction ID	The identifier used for the ONFi transaction in the upper pane.
Transaction	The ONFi transaction name in the sequential flow.
Timestamp	Displays the timestamp for the transaction relative to the timestamp of the first transaction in the sequential set displayed in the Details tab.
Delta Time	Displays the difference between the timestamp of the transaction and the previous transaction in the sequential set shown in the Details tab.

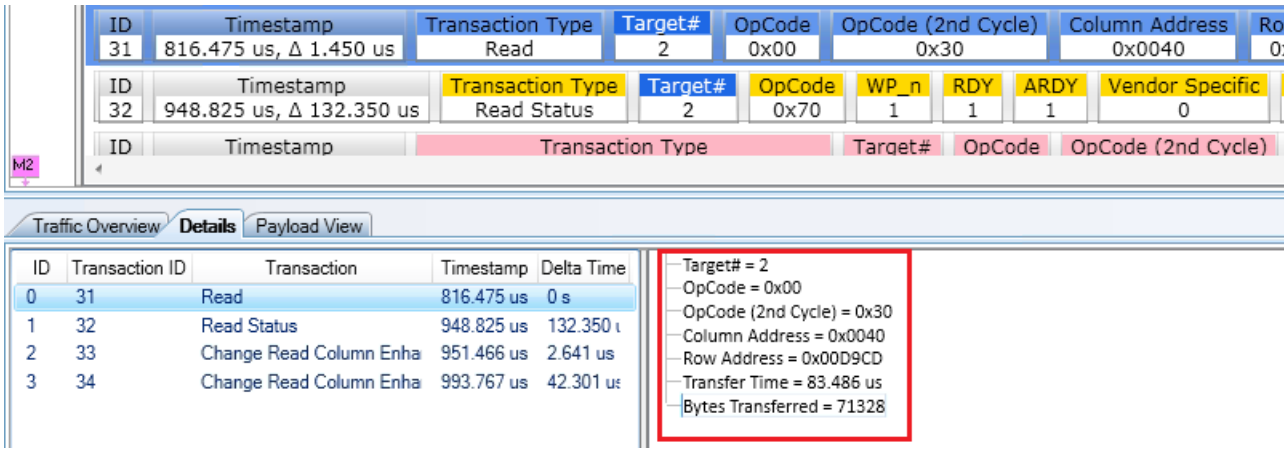
Viewing Details of an ONFi Transaction

Besides displaying a logically grouped sequential set of transactions in the left pane, the **Details** tab of the ONFi Analysis window also displays the details of the currently selected transaction in its right pane.

The details of a transaction shown in the right pane also includes additional information about the transaction such as:

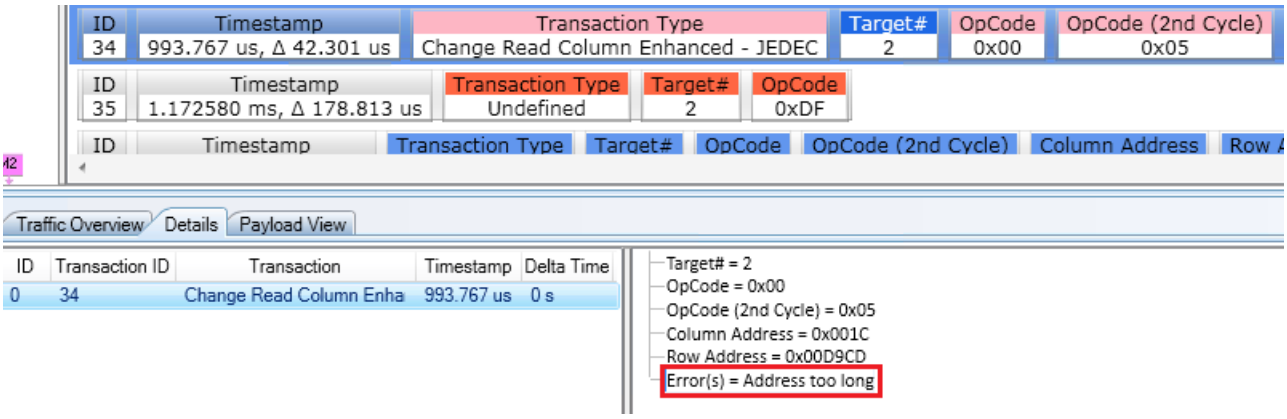
- Error information
- Transfer Time
- Bytes Transferred

The sample screen below displays the details of the currently selected ONFi transaction - Read.



Error information in the Details tab

In the Details tab, you can also view the error information (if any) pertaining to a particular transaction.



Viewing the Payload of an ONFi Transaction

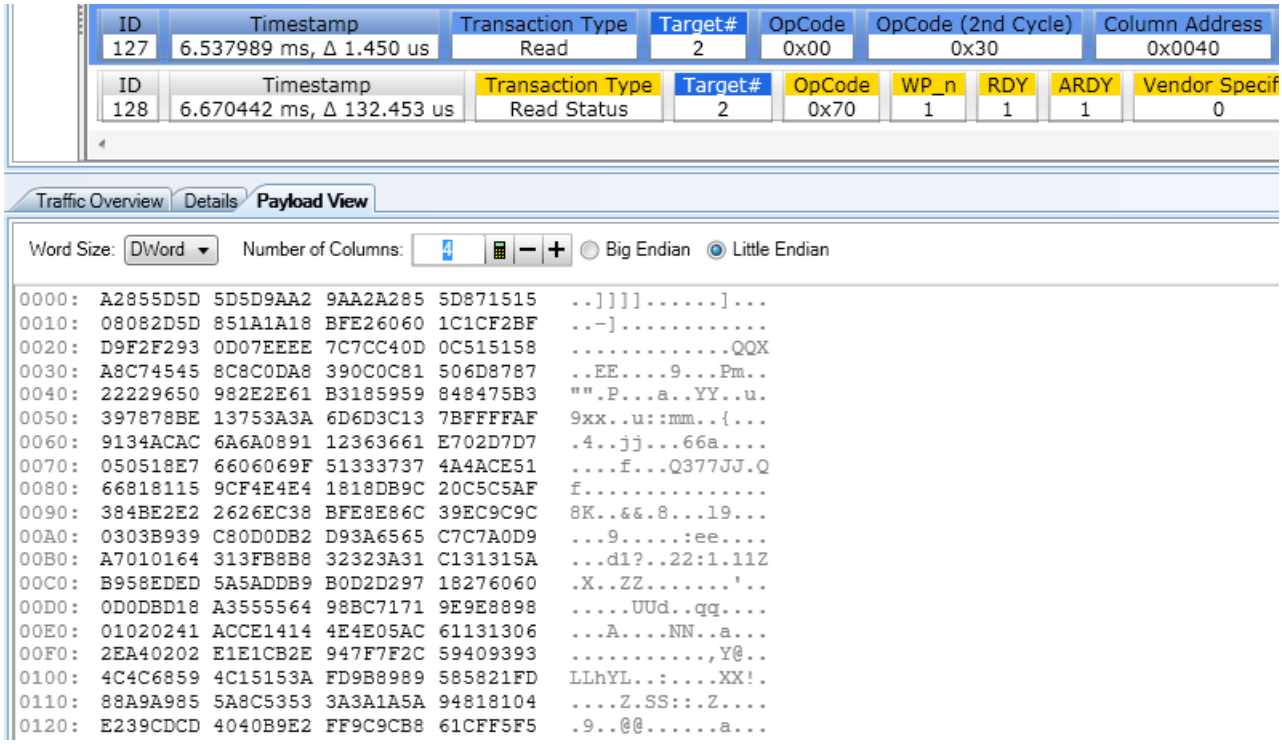
You can use the **Payload View** tab in the ONFi Analysis window to view the payload data comprising an ONFi transaction such as a Read or a Write transaction.

On selecting an ONFi transaction in the upper pane of the ONFi Analysis window, its payload data (if applicable) is displayed in the Payload View tab.

You can select:

- The unit that you want to use for the Word size in the payload.
- The number of columns to be used for displaying the payload.
- The format (Big Endian or Little Endian) in which you want the Words to be represented in the payload.

The sample screen below displays the payload data for a Read ONFi transaction.

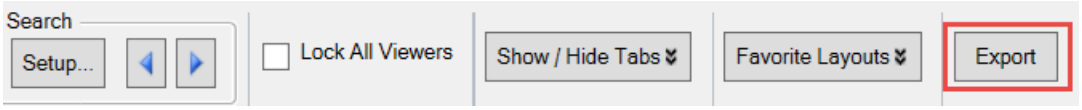


Exporting ONFi Data to a CSV File

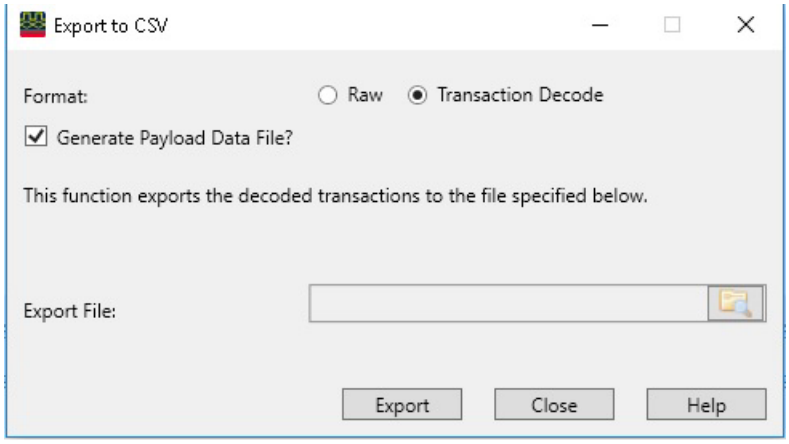
You can export the ONFi data displayed in the ONFi Analysis window to a specified .csv file and use it later in other analysis tools.

To export ONFi data

1 Click the **Export** button displayed in the ONFi Analysis window's toolbar.



The **Export to CSV** dialog box is displayed.



2 From the following two options, select the Format in which you want to export ONFi data.

- **Raw** - Exports the raw (uninterpreted) command, address, and data information from the computed ONFi data. This export format does not include the decoded transactions.
- **Transaction Decode** - Exports the decoded ONFi transactions data from the computed ONFi data. This export format includes the transactions data displayed in the Transaction Decode tab of the ONFi Analysis window.

3 Click the **Browse** button displayed with the Export File field and browse to the location where you want to save the main export (.CSV) file.

4 If you select the **Transaction Decode** export format, the **Generate Payload Data File** checkbox is enabled. Selecting this checkbox allows you to export the payload data for all the transactions included in the trace to a separate binary file (in addition to the main export .csv file). This binary file is saved at the location that you specify for the main export file. The following naming convention is used for this binary file:

<name of the main export file>_payload.bin

The payload data is exported to the binary file in the order of its occurrence in the trace. Therefore, to correctly interpret and analyze the payload data in the binary file, examine this data along with the transactions in the main export file. For analyzing the payload data of a specific transaction, you can ascertain the number of bytes of the payload data from that transaction and then use this information to assess the start and end of the payload data for that specific transaction in the binary file.

5 Click **Save**.

6 Click **Export**.

A sample of the raw ONFi data exported to a .csv file is displayed.

```
S#, Timestamp, Target#, Type, Hex/Length, Timestamp End
1, 0 s, 0, Command, 60,
2, 272 ns, 0, Address, 00,
3, 472 ns, 0, Address, 61,
4, 660 ns, 0, Address, 00,
5, 879 ns, 0, Command, DA,
6, 2.340 us, 0, Command, 80,
7, 2.619 us, 0, Address, 30,
8, 2.834 us, 0, Address, 00,
9, 3.192 us, 0, Address, 00,
10, 3.392 us, 0, Address, 60,
11, 3.581 us, 0, Address, 00,
12, 3.900 us, 0, DataInLong, 22A0, 27.313 us
13, 28.162 us, 0, Command, 85,
14, 28.555 us, 0, Address, 00,
15, 28.770 us, 0, Address, 00,
16, 29.089 us, 0, DataInLong, 30, 29.200 us
17, 30.091 us, 0, Command, 85,
18, 30.483 us, 0, Address, D0,
19, 30.698 us, 0, Address, 22,
20, 31.017 us, 0, DataInLong, 30, 31.128 us
```

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