




Gowin Analyzer Oscilloscope **User Guide**

SUG114-2.5E,11/02/2021

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Revision History

| Date | Version | Description |
|------------|---------|---|
| 11/28/2019 | 2.0E | <ul style="list-style-type: none"> ● GW1NRF-4B, GW1NSER-4C supported and GW1N-4S removed. ● Capture Signal supporting Bus signal Rename and Restore. ● Programmer and Device options merged ● You can adjust the column width of the Name and Value by dragging and retain the column width set by the user before trigger again. |
| 03/09/2020 | 2.1E | <ul style="list-style-type: none"> ● GW1NS-4C, GW2A-18C, GW2AR-18C and GW2A-55C supported. ● After you click "Start" or "Auto" in GAO capture window, GAO Programmer is grayed. |
| 05/20/2020 | 2.2E | <ul style="list-style-type: none"> ● GW1N-2, GW1N-2B and GW1N-6 removed. ● GW1N-9C, GW1NR-9C and GW2ANR-18C supported. ● Supports GAO to capture signals before RTL synthesis. ● Standard GAO supports dynamic trigger expressions. ● The signals unsupported are grayed when filtering. ● The file exported with extension prn supported. ● The description of importing.csv and .prn to Matlab added. |
| 09/07/2020 | 2.3E | <ul style="list-style-type: none"> ● Output view in GAO Programmer added. ● File monitoring function added. ● Reverse function in GAO Bus signals added. ● "Hierarchy View" in "Search Net" dialog box added. |
| 06/17/2021 | 2.4E | <p>Dynamic BSRAM Usage and Capture Utilization in the Standard/Lite GAO window can display the maximum amount of BSRAM supported by the device.</p> |
| 11/02/2021 | 2.5E | <ul style="list-style-type: none"> ● The shortcuts for Start, Auto Run, Force Trigger, and Stop added in waveform capture window, and they are F1, F2, F3, and F4 in order. ● The shortcuts for Zoom In, Zoom Out, and Zoom Fit modified to F8, F7, and F6 in order in waveform capture window. ● Trigger signals and capture signals that do not exist in the netlist are highlighted in red in the configuration window. ● Waveform color can be modified. ● The description of importing vcd to ModelSim added. |

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1 About This Guide

1.1 Purpose

This manual describes Gowin Analyzer Oscilloscope (GAO). It introduces GAO configuration file (.gao) and GAO usage so as to improve the efficiency of design analysis. The software screenshots in this manual are based on V1.9.8.01. As the software is subject to change without notice, some information may not remain relevant and may need to be adjusted according to the software that is in use.

1.2 Related Documents

The latest user guides are available on our Website www.gowinsemi.com. You can refer to [SUG100](#), Gowin Software User Guide.

1.3 Terminology and Abbreviations

Table 1-1 shows the abbreviations and terminology that are used in this manual.

Table 1-1 Terminology and Abbreviations

| Terminology and Abbreviations | Meaning |
|-------------------------------|------------------------------------|
| FPGA | Field Programmable Gate Array |
| JTAG | Joint Test Action Group |
| GAO | Gowin Analyzer Oscilloscope |
| AO Core | Analysis Oscilloscope Core |
| BSRAM | Block Static Random Access Memory |
| SSRAM | Shadow Static Random Access Memory |

1.4 Support and Feedback

Gowin Semiconductor provides customers with comprehensive technical support. If you have any questions, comments, or suggestions, please feel free to contact us directly by the following ways.

Website: www.gowinsemi.com

E-mail: support@gowinsemi.com

2 Introduction

GAO is a digital signal analyzer that is designed in-house by Gowin. It helps you more easily analyze the signal timing, quickly perform system analysis and fault location so as to improve design efficiency.

The GAO operates on the following basic principle: When operating, FPGA saves the signal in real time to memory according to the trigger conditions set by you. It reads the signal and displays it on the software GUI via JTAG. GAO includes the signal configuration window and waveform display window. The signal configuration window is mainly used to configure location in the design, and the location is based on the sampling clock, trigger unit, and trigger expression. The waveform display window connects to Gowin Software and target hardware via JTAG.

GAO supports RTL-level and post-synthesis netlist signal capture, and provides Standard and Lite versions. Standard GAO can support up to 16 AOs, each of which can be configured with one or more trigger ports, supporting multi-level static or dynamic trigger expressions. Lite GAO is easy to configure, and you do not need to set trigger conditions. Lite GAO can also capture the initial value of the signal, which is convenient for you to analyze the state of power on.

The GAO has the following features:

- Supports up to 16 AOs.
- Each AO supports one or more port trigger.
- Each AO supports one or more trigger levels.
- Each trigger port supports one or more match units.
- Each match unit supports six types of trigger match.
- Supports static or dynamic trigger expressions setting.
- Can capture signals before or after RTL synthesis.
- AO uses window capture, which supports one or more windows capture.
- Supports three kinds of waveform file: csv, vcd and prn.
- Uses data ports to save resources.

3 GAO Config File

The GAO consists of two parts: Control Core and AO Core. The Control Core is the communication controller of all AOs and JTAG scanning circuits. AO Core is used for configuring trigger signals, capturing and storing data. The Control Core connects the master and the AO Core. It receives instructions and sends them to the AO Core during configuration. It also transmits the data captured by the AO Core to the master. The AO Core directly communicates with Control Core, receives instructions from Control Core, captures and transmits data according to the instructions.

GAO Config window is used to configure AO Core and the Control Core. It helps you quickly and easily analyze data signals after synthesis, placement and routing. For a simple GAO example, see [SUG918](#), Gowin Software Quick Start Guide.

3.1 GAO Config File in Standard Mode

3.1.1 Start Standard Mode GAO

You first need to create or load the config file (.gao/.rao) before start Standard Mode GAO, including "For RTL Design" and "For Post-Synthesis Netlist". The "For RTL Design" is used to capture RTL signal before synthesis with extension .rao. The "For Post-Synthesis Netlist" is used to capture the netlist signal after synthesis with extension .gao. For the two types of Standard GAO configuration are similar, the following will take "For Post-Synthesis Netlist" in standard mode as an example.

Create GAO Config File in Standard Mode

The steps are as follows:

1. In the "Design" view, right-click and select "New File...". The "New" dialog box will open, as show in Figure 3-1.
2. Select "GAO Config File" and click "OK". The "New GAO Wizard" dialog box opens, as shown in Figure 3-2. select "Standard", and then click "Next".
3. Type the config file name in "New", then click "Next", as shown in Figure 3-3,.
4. Check the GAO config. file mode and path, as shown in Figure 3-4.

Click "Finish". You can see the config file in "GAO Config Files" view.

Figure 3-1 Create a GAO Config File in Standard Mode

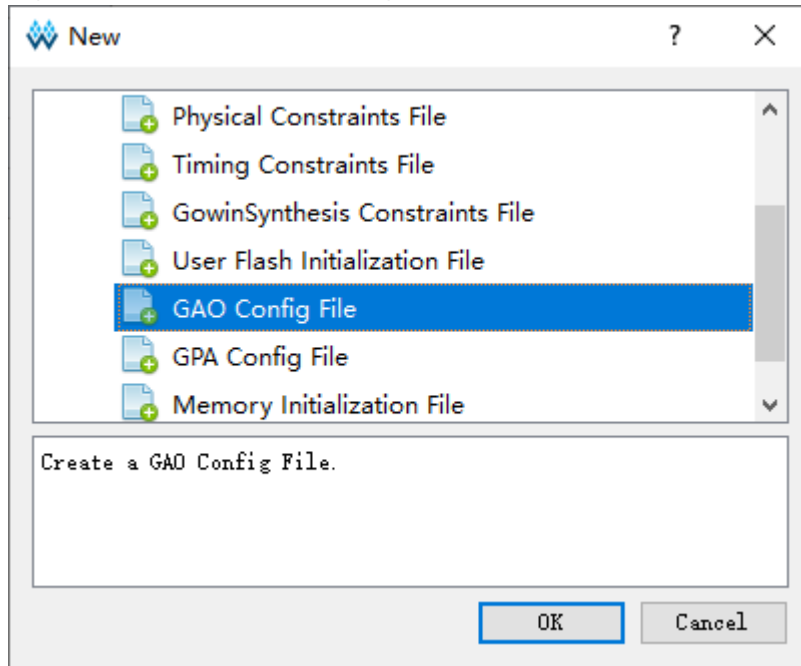


Figure 3-2 New GAO Wizard (Standard Mode)

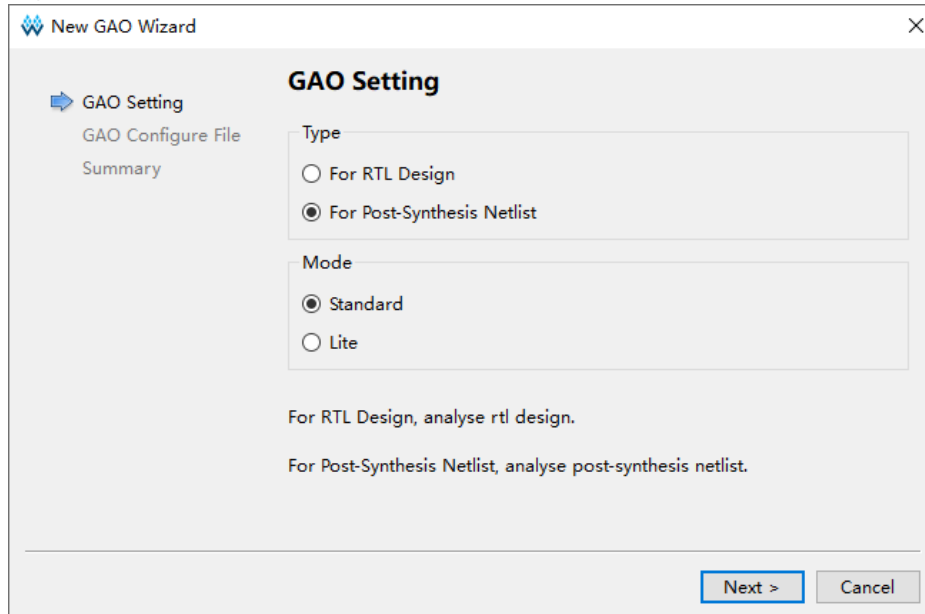
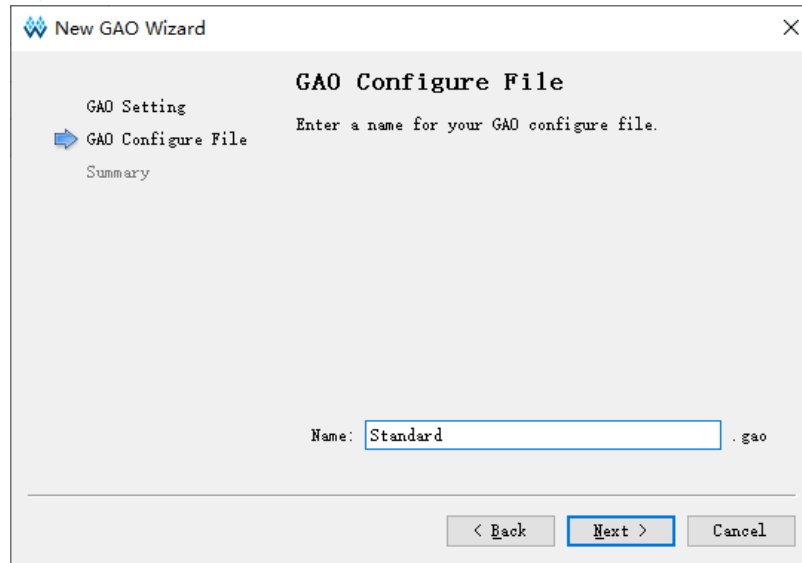
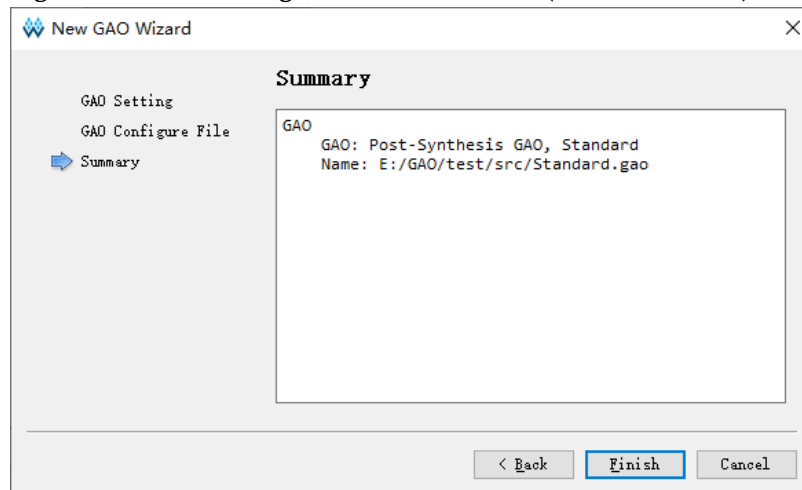


Figure 3-3 File Name**Figure 3-4 GAO Config File Mode and Path (Standard Mode)**

Load Standard Mode GAO File

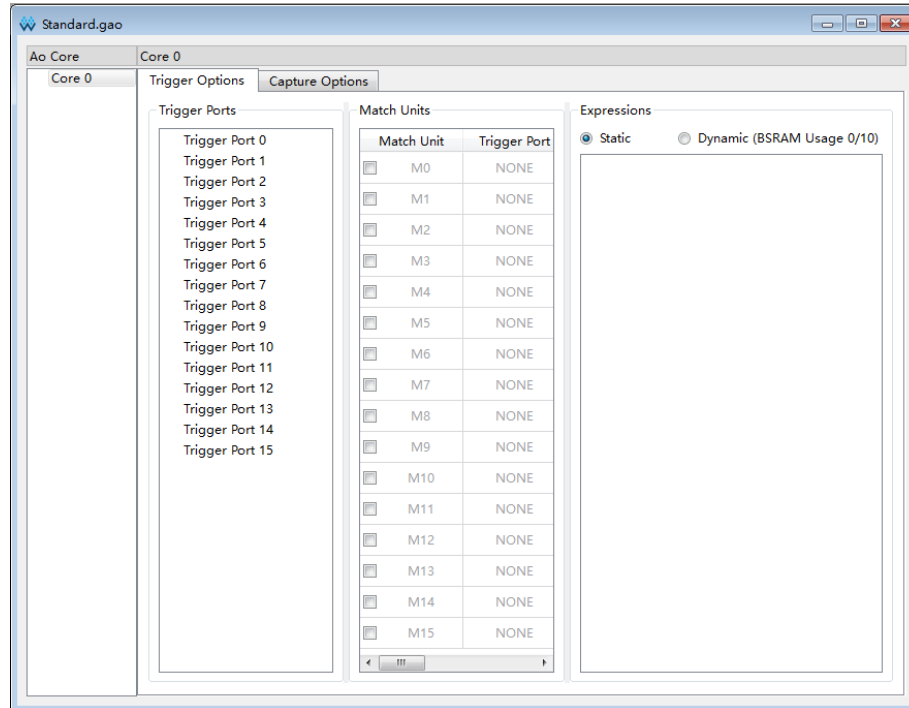
The steps are as follows:

1. In the "Design" view, right-click and select "Add Files...", the "Select Files" dialog box opens.
2. Select the config file (.gao) and load it to the project.

Start Standard Mode GAO

Double-click the configuration file (.gao) in the "Design" view. The "GAO Config View" will open, as shown in Figure 3-5. GAO configuration window includes AO Core, Trigger Options, and Capture Options.

Figure 3-5 Gowin GAO Window (Standard Mode)

**Note!**

If the project is without synthesis, when user double-clicks the config file (.gao), the "Warning" prompt will pop up.

3.1.2 Standard Mode GAO Configuration

GAO includes AO Core, Trigger Options, and Capture Options.

AO Core Configuration

The AO Core is used to display and configure the number of AO used by current project, as shown in Figure 3-6. The AO Core only includes Core0 by default, and it can support up to 16 cores. The following operations can be performed:

1. Right click anywhere in the AO Core view and click "Add" to add new AO Core.
2. Select and right click a core in AO Core view and click "Remove" to remove core.
3. When a core is deleted, the subsequent core number decreases successively, and the core number increases continuously.
4. Select a core, and the core configuration view will be displayed on the right, as shown in Figure 3-7. For example, when Core2 is selected in AO Core, on the right is the Core2 configuration.

Note!

- When there is only one core in the AO Core, it is not allowed to delete it. If you select the core and click "Remove", the prompt will pop up.
- 16 cores are supported at most. When there are more than 16 cores, an error prompt will pop up.

Figure 3-6 AO Core View

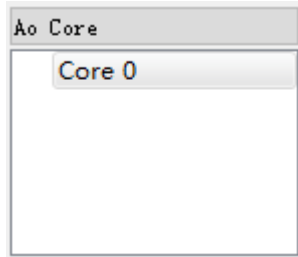
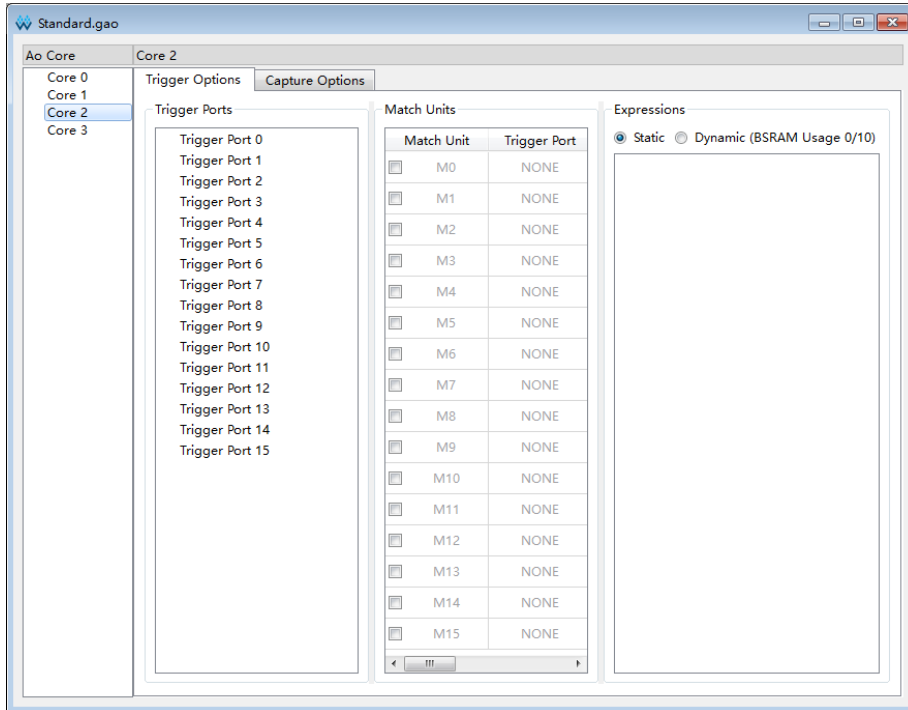
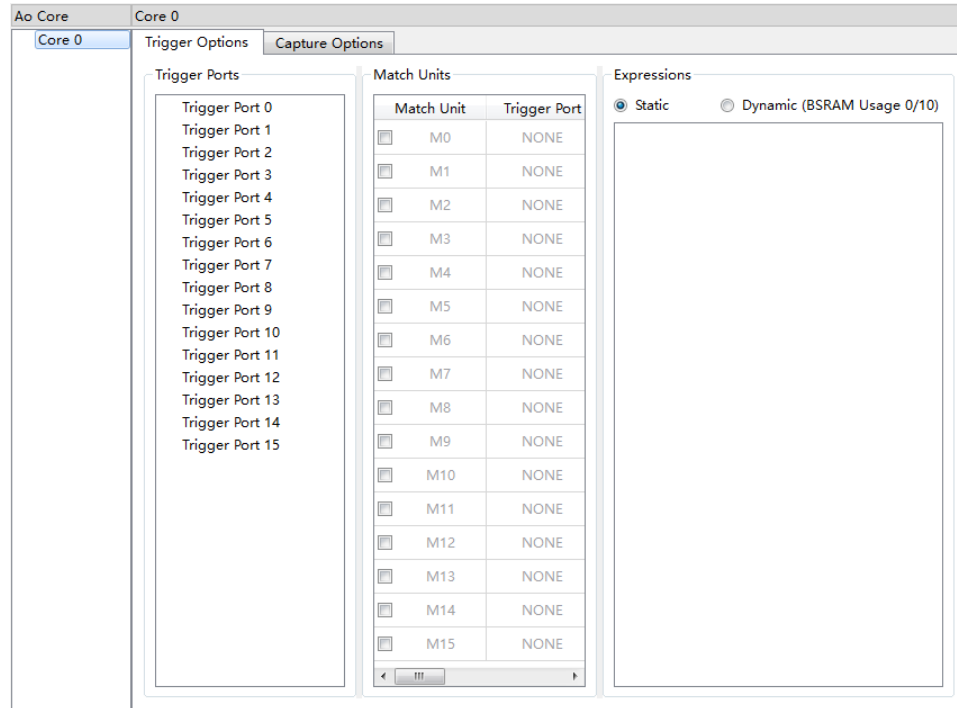


Figure 3-7 Select a Core




Trigger Options

Trigger options are used to configure signal trigger conditions, as shown in Figure 3-8. The Trigger Options view includes Trigger Ports, Match Units and Expressions.

Figure 3-8 Trigger Options View

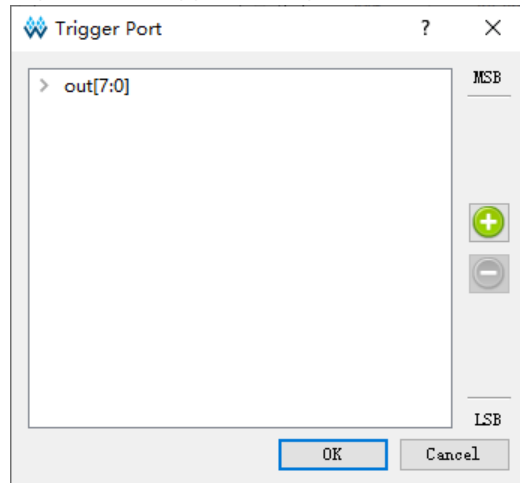
Trigger Ports Configuration

The Trigger Ports is used to configure the AO trigger ports and the steps are as follows:

1. Double-click on trigger port. The dialog box will open, as shown in Figure 3-9.
2. Click " " and the "Search Nets" dialog box opens. Click "Search", as shown in Figure 3-10. The signals grayed out are not available.
3. Select trigger signal and click "OK".

Note!

- There are 16 trigger Ports (Trigger Port 0 ~ Trigger Port 15), and each trigger port width range is from 1 to 64.
- After the netlist is updated, if the signal that has been selected in the Trigger window does not exist in the netlist, the trigger signal is highlighted in red.

Figure 3-9 Trigger Dialog Box**Note!**

MSB and LSB in Figure 3-9 indicate the most and least bit of the trigger port.

You can perform the following operations:


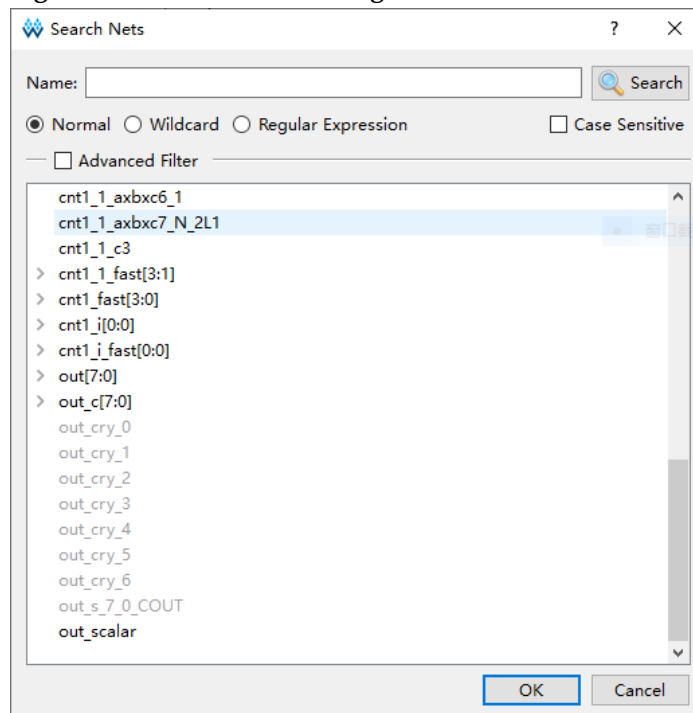
- You can select signals by left-click, shift+left click, Ctrl+left to delete them by clicking "".
- You can select signals by left-click, shift+left click, Ctrl+left to sort by dragging.

Figure 3-10 Search Nets Dialog Box

Normal, Wildcard, and Regular Expression are mutually exclusive.

- Normal means searching in a normal way. Click "Search" to match the string in "Name" text box, as shown in Figure 3-11.

- Wildcard means searching with wildcard. Click "Search" to match the string in "Name" text box. The string contains wildcards (*,?) , as shown in Figure 3-12.
- Regular expression means searching with a regular expression. Click "Search" to match the string in "Name" text box. The string contains regular expression.
- If "Case Sensitive" is checked, the case-sensitive rule will be applied during signal matching. The signals area in the Search Nets dialog box supports left-click, Shift + left and Ctrl + left.

Figure 3-11 Normal Mode

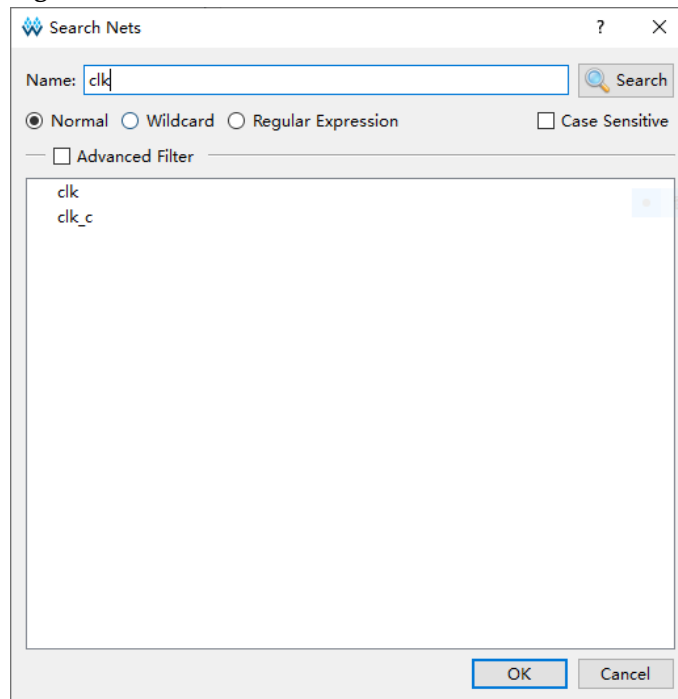
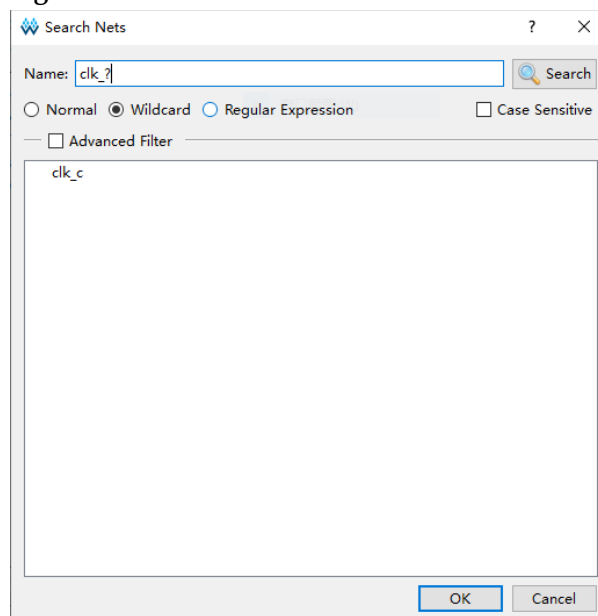


Figure 3-12 Wildcard Mode

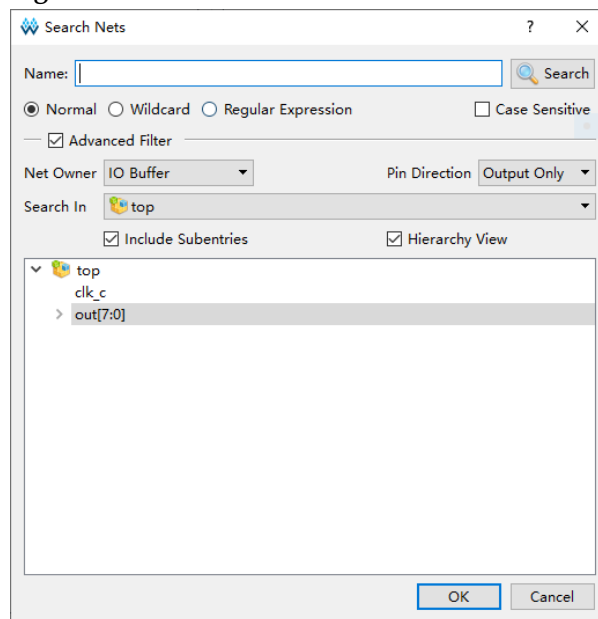


Select the "Advanced Filter" to further define filter conditions to search the required signals more specifically. Among them:

- The Net Owner is used to set the type of module where the signal belongs to. You can select a module or all.
- The Pin Directions is used to set whether the signal is Output only, Input only or All Directions.
- The Search In is used to set which module to filter signals from.
- The "Include Subentries" is used to set whether to filter the signal from the submodule.
- Hierarchy View is used to display signals in hierarchical structure.

As shown in Figure 3-13, the "Net Owner" selects IO_Buffer, "Pin Directions" selects "Output Only", "Search In" selects "top", and selects "Include Subentries" and "Hierarchy View". Click "Search" to display all output signals associated with IO_Buffer in top modules and their sub-modules in hierarchical structure.

Figure 3-13 Advanced Filter



Match Units Configuration

The match units option is used to configure the match unit of trigger ports. There are up to 16 trigger match units, which range from M0-M15. Match unit is the minimum unit required by GAO to achieve trigger conditions. AO processes the trigger port signals designed by the user by the match unit and realizes the trigger if the trigger signal port signals meet the requirements.

Note!

- A trigger port can use one or more trigger match units, but a trigger match units can only belong to one trigger port.
- Select "Static" in "Expressions", and all trigger ports can only use up to 16 trigger match units.

- Select "Dynamic" in "Expressions", all trigger ports can only use up to 10 trigger match units.
1. In Match Units view, check the "Match Units" to the select trigger match unit, as shown in Figure 3-14.

Figure 3-14 Match Units View

| Match Unit | Trigger Port | Match Type | Function | Counter |
|--|--------------|------------|----------|----------|
| <input checked="" type="checkbox"/> M0 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M1 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M2 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M3 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M4 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M5 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M6 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M7 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M8 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M9 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M10 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M11 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M12 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M13 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M14 | NONE | Basic | == | Disabled |
| <input type="checkbox"/> M15 | NONE | Basic | == | Disabled |

2. Double-click one match unit to open "Match Unit Config" dialog box and configure the trigger conditions, as shown in Figure 3-15.

Figure 3-15 Match Unit Config Dialog Box

Match Unit 0

On Trigger Port: Trigger Port 0

Match Type: Basic

Function: =

Value: BIN (selected), OCT, DEC, HEX

Value: 00000000

Counter: Counter

Width: 6 Count: 2

Continuous

OK Cancel

3. Click "On Trigger Port" drop-down list and select the trigger port.

4. Select the match type and function from the "Match Type" and "Function" drop-down lists respectively. The details are as follows:
 - Basic: Execute "=" and "!=" operations, which are used for general signal comparison, and it save resource.
 - Basic w/edges: Execute "=" and "!=" and the jump test operations for control signal jump.
 - Extended: Execute "==", "!=", ">", ">=", "<", and "<=" operations for the value of address or data signal.
 - Extended w/edges: Execute "==", "!=", ">", ">=", "<", "<=" and jump test operations for the value of address or data signal or signal jump.
 - Range: Execute "==", "!=", ">", ">=", "<", "<=", in/out of the range detection operations for the value of specific address or data signal.
 - Range: Execute "==", "!=", ">", ">=", "<", "<=", in/out of the range detection and jump test operations for the value of specific address, data signal and signal jump.

Value is used to set the bit value that correlates with the match type, as shown in Table 3-1. The bit value currently supports binary, hexadecimal, and octal forms.

Table 3-1 Match Type Supported By Trigger Match Unit

| Type | Bit Values | Matching Function | Description |
|------------------|---------------------|---|--|
| Basic | 0, 1, X | ==,! = | Used for general signal comparison, and it can save resource. |
| Basic w/edges | 0, 1, X, R, F, B, N | = =,! =, jump detection | Used to control signal jump. |
| Extended | 0, 1, X | ==,! =,>,>=,<,<= | Used for the value of address or data signal. |
| Extended w/edges | 0, 1, X, R, F, B, N | ==,! =,>,>=,<,<=, jump detection | Used for the value of address or data signal and jump signal. |
| Range | 0, 1, X | ==,! =,>,>=,<,<=, in/out of the range detection. | Used for the value of address or data signal in specific range. |
| Range w/edges | 0, 1, X, R, F, B, N | ==,! =,>,>=,<,<=, in/out of the range detection, jump detection | Used for the value of address or data signal in specific range and jump detection. |

Note!

In Bit Values:

- "0" means low level.
- "1" means high level.
- "X" means either of them.
- "R" indicates rising edge 0->1.
- "F" indicates falling edge 1->0.
- "B" indicates rising or falling edge transition.
- "N" means no logical level transition.

- If selecting "Range" or "Range w/edges" in "Match Type", and selecting in range or not in range in "Function", the value in the "Minimum" is the lower limit value, and the value in "Maximum" is the upper limit value, as shown in Figure 3-16.

Figure 3-16 Minimum/Maximum in/not in Range

The screenshot shows the 'Match Unit Config' dialog box. It is titled 'Match Unit 0'. On the left, there is a text area containing '> out[7:0]'. On the right, there are several configuration fields: 'On Trigger Port' is a dropdown menu set to 'Trigger Port 0'; 'Match Type' is a dropdown menu set to 'Range'; 'Function' is a dropdown menu set to 'in range'; 'Value' section has radio buttons for 'BIN', 'OCT', 'DEC', and 'HEX', with 'BIN' selected; 'Minimum' is a text box containing '00000000'; 'Maximum' is a text box containing '00000111'; 'Counter' checkbox is checked, with a text box containing '00000000~11111111'; 'Width' is a spinner box set to '6'; 'Count' is a spinner box set to '2'; 'Continuous' checkbox is unchecked. At the bottom, there are 'OK' and 'Cancel' buttons.

Each trigger match unit has a counter for sampling data after the trigger conditions are met N times, where N is the counter value.

- Check "Counter" to set and use the counter. If the counter is unused, capture data after matching 1 time by default.
- Check "Counter" and enter value in "Width", and modify or add/remove data in the box by clicking the up and down buttons on the right or using the mouse wheel.
- The range of the counter width is [1, 16], which determines the maximum value of the counter.
- If the counter width is set to 3, the maximum value is 2^3 .
- Enter n in "Count". This triggers after matching n times. If the check "Continuous" is checked, enter value n in the "Count". This triggers after matching n times.

Note!

- If the error prompt pops up, click the "Hide Details" to show the details.
- When config file (.gao) is saved, if the number of signal trigger unit changes, but the match unit is not modified accordingly, the error prompt box will open, as shown in Figure 3-17.
- If the trigger port belonging to the match unit is not configured, the error prompt box will open when the .gao is saved, as shown in Figure 3-18.
- When in range or not in range in "Function" selected, if the minimum is greater than the maximum, the "Value Invalid" prompt will pop up.
- When the cursor is hovered over the Value box,, the configurable range displays, as

shown in Figure 3-16.

Figure 3-17 Error Prompt

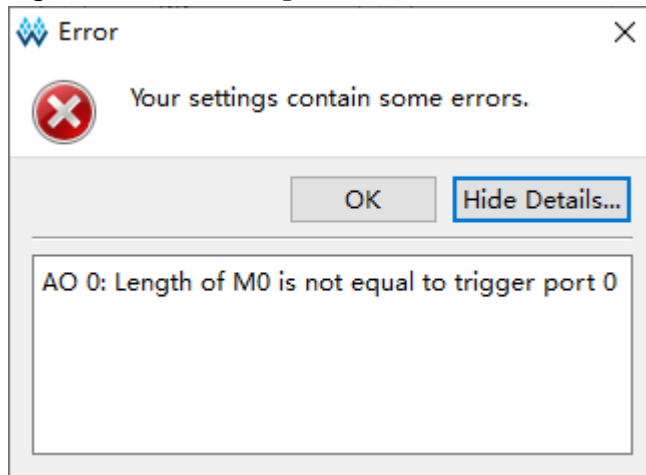
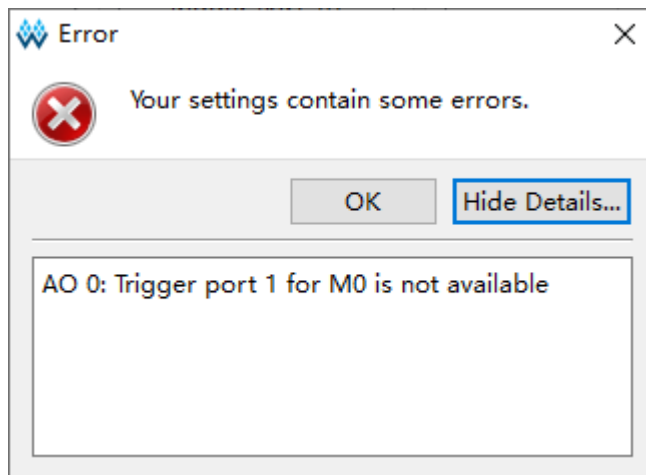


Figure 3-18 Prompt



Trigger Expressions Configuration

Expressions are used to set the trigger expressions. An AO has 16 trigger expressions at most.

In the "Expressions" view, the trigger expressions is sorted in Expression:0~Expression:15

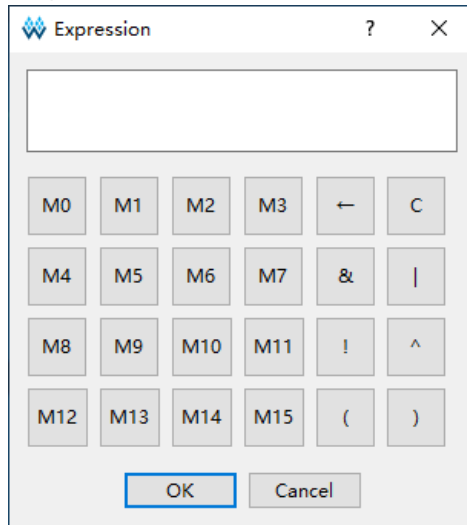
The related operations are as follows:

- Select "Static", and the number of Match Unit used is 16, but it cannot dynamically modify the trigger expression.
- Select "Dynamic", and the number of Match Unit used is 10. It can dynamically modify the trigger expression without re-synthesis and PnR.
- Double-click any trigger expression to edit.
- Right-click anywhere in Expressions, and select "Add" to add expression.
- The Expression dialog box will open, as shown in Figure 3-19. You can

configure the trigger expressions in the dialog box.

- Select the expression that you need to delete, right-click and select "Remove" to remove the trigger expression.

Figure 3-19 Expression View



Note!

When "Static" is selected, the number of match unit that can be edited is 16, that is, M0~M15. When "Dynamic" is selected, the number of match unit that can be edited is 10, that is, M0~M9, and the M10~M15 are grayed out, as shown in Figure 3-19.

Expression 0 ~ Expression 15 correspond to Level 0 ~ Level 15. When setting the AO trigger conditions, the minimum trigger Level is one (Level 0), and the maximum is 16 (Level 0 to Level15). The trigger level corresponds to the number of trigger expressions. If the trigger level is N and the first level trigger condition is met, the second level trigger condition will be estimated, and so on, until the Level. The final trigger signal is generated, and AO begins to capture data.

Trigger expressions can logically combine one or more trigger match units, which follow these rules:

- Supports &, | and !. Supports logical operators, and "()".
- Trigger expression can only logically combine the selected trigger match units.
- The same trigger match unit can be used one or more times in a trigger expression.
- The logic combination that triggers match unit between different trigger expressions is not affected, and the same trigger match unit and operator can be used.
- Different expressions can call the same trigger match unit, or the same number or a different number of trigger match units.

For example, if you set eight match units M0-M7, for each level of trigger expressions, any number of the match units from these eight can be logically combined. For example:

M0&M1

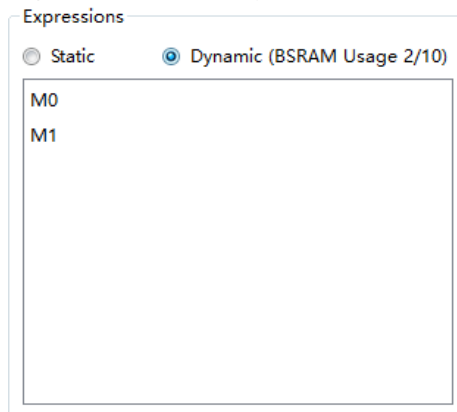
!M4&(M3|M6)

.....

Configure an expression by double-clicking the text box in the expression dialog. Click "OK" to finish.

If "Dynamic" is checked, the BSRAM resource of the device will be utilized. When Trigger Level is N, N BSRAM will be used. As shown in Figure 3-20, if Trigger Level is 2, then Dynamic Expression utilizes two BSRAMs.

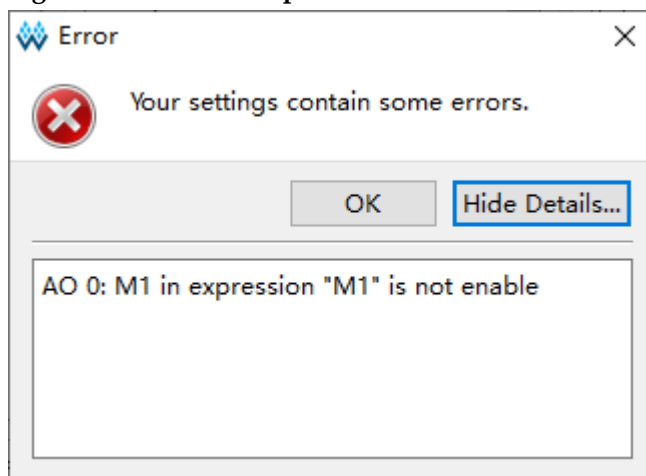
Figure 3-20 Check Dynamic



Note!

- If the wrong syntax exists in the expression, the error will pop up when you click "OK" to save:
- When the configuration file (.gao) is saved, the prompt will pop up if the unselected match units are used in expressions, as shown in Figure 3-21.
- An AO can add up to 16 expressions. If more than 16 expressions are added, an error prompt will pop up.

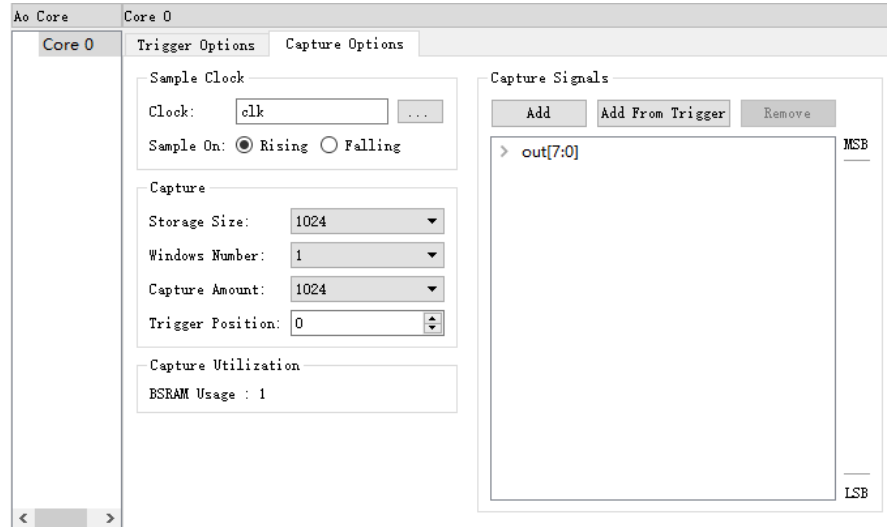
Figure 3-21 Error Prompt



Capture Signals Configuration

As shown in Figure 3-22, the "Capture Options" includes the "Sample Clock", "Capture Signals", "Cpture" and "Capture Utilization".

Figure 3-22 Capture Options

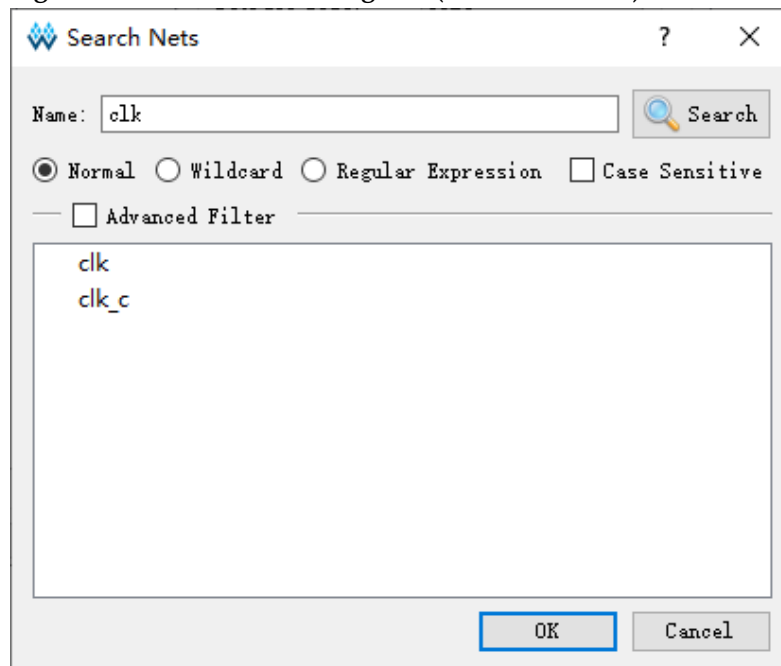


You can select the clock in the user design or other clocks as the sample. The sample clock supports sampling on rising edge and falling edge.

You can employ the following two methods to add sample clock signals:

- Enter the sample clock name in the "Sample Clock" text box.
- Click the "..." and the "Select Nets" dialog box will open to select the sample clock signal, as shown in Figure 3-23. Click "OK" to add the signal.

Figure 3-23 Select Nets Dialog Box (Standard Mode)



Note!

- After the netlist is updated, if the signal selected in the Capture Signals view does not exist in the updated netlist, the captured signal is highlighted in red

- The sample clock frequency should be double or above the frequency of the configured expression and the sample data signal. It is recommended that the configured expression and sample data signal belong to the same clock domain.
- If the configured sample clock does not exist when the configuration file (.gao) is saved, the error prompt box will appear, as shown in Figure 3-24.
- If there is no sample clock, the error dialog box, an error prompt will appear, as shown in Figure 3-25.

Figure 3-24 Error Prompt

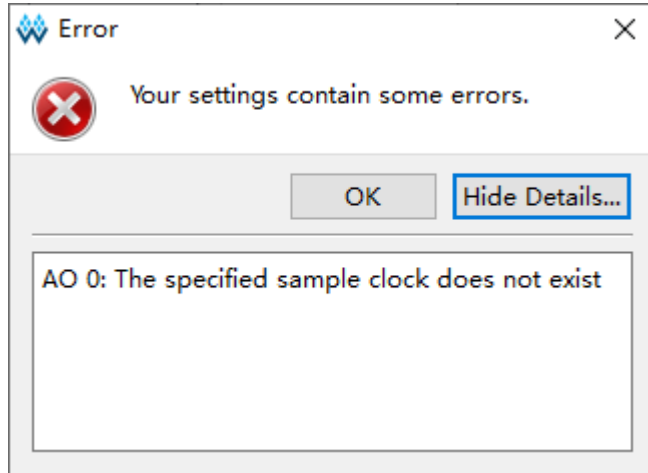
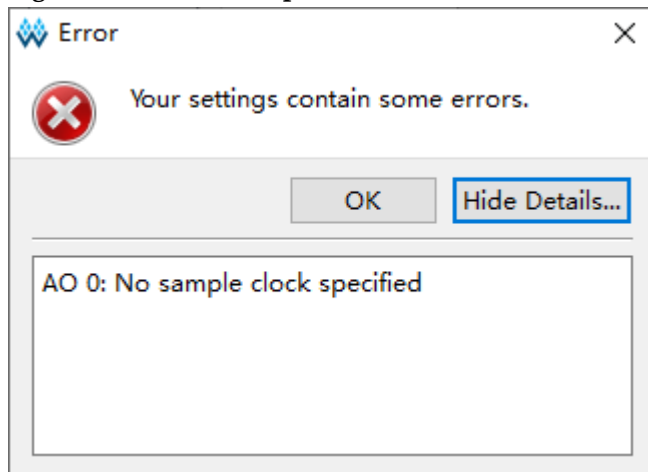


Figure 3-25 Error Prompt



Capture Configuration

As shown in Figure 3-26, the storage info includes storage size, windows number, capture amount, and trigger position.

Figure 3-26 Capture Configuration

The image shows a configuration panel titled 'Capture'. It contains four settings, each with a dropdown menu or a spin box:

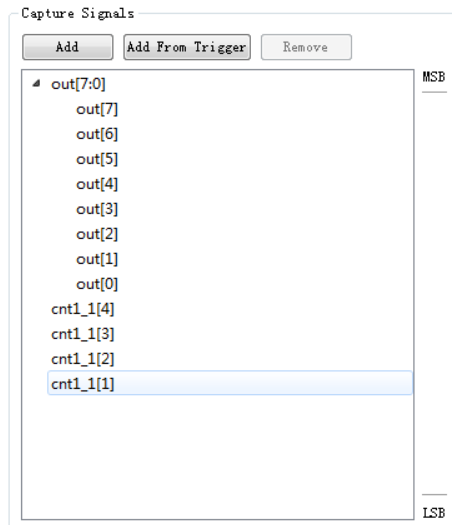
- Storage Size: 1024
- Windows Number: 1
- Capture Amount: 1024
- Trigger Position: 0

- "Storage Size" is the memory address depth for data capture. Click the "Storage Size" drop-down list and select the required size: 256, 512, 1024, 2048, 4096, 8192, 16384, 32768, or 65536.
- "Windows Number" is the number of capture windows. AO uses the window capture mode. The capture buffer is divided into one or more pages that have the same or multiple sizes. Each AO supports 8 windows at most, and 1 window at least. Select the number of windows number from the drop-down list.
- Capture Amount: The address depth of the memory being used on each capture buffer page. Each capture window has the same capture amount, and the total capture amount can not be more than the configured storage size. Select the capture amount from the drop-down list.
- "Trigger Position" is the capture data position in memory when triggering. Enter or select the required value in the "Trigger Position" text box. The address starts from 0.

Capture Signals Configuration

The "Capture Signals" in Figure 3-27 can be used to configure capture signals. The data port signal is the input signal of the data port specified in the user design.

Figure 3-27 Capture Signal



- "Add" is used to select the signal. click "Add", and "Search Nets" dialog box pops up, then select your required data port signal, click "OK" to finish. Bus signals can also be added, such as ". [7:0]", as shown in Figure 3-27.
- You can use trigger signal as the capture signal if selecting "Add From Trigger". One or more trigger ports can be selected in the "Add From Trigger" list, as shown in Figure 3-28.
- You can delete signal by clicking "Remove".
- You can select signals by left-click, shift+left click, Ctrl+left to sort by

dragging.

- Select and right-click to set Group, Ungroup, Rename, Restore Original Name and Reverse, as shown in Figure 3-29.

Figure 3-28 Add From Trigger

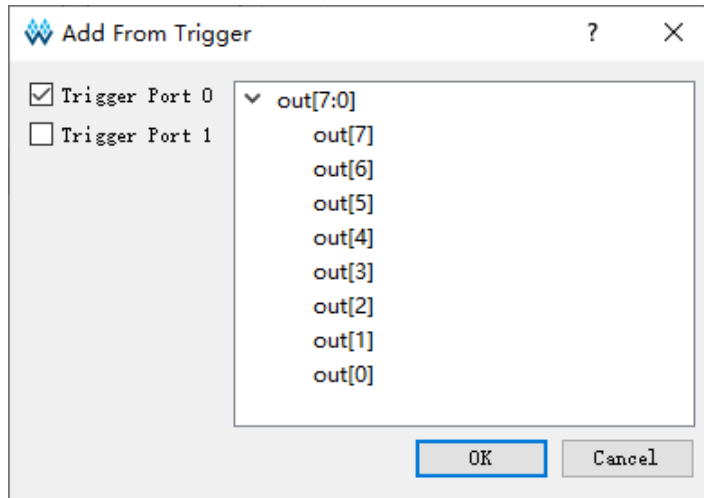
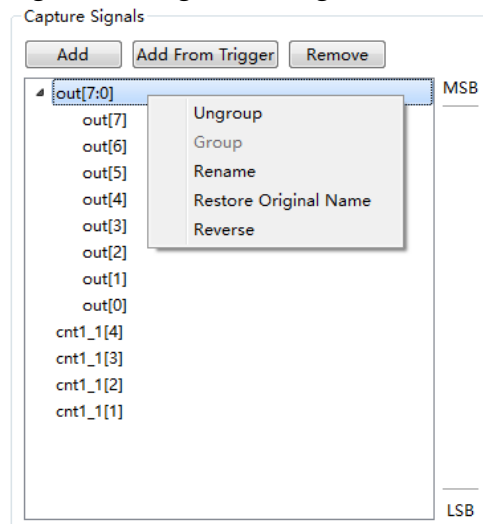


Figure 3-29 Right-click Signal



Capture Signals BSRAM Utilization

As shown in Figure 3-30, it displays the BSRAM utilization.

Figure 3-30 BSRAM Used by AO Core Capture Signals



3.1.3 Generate Bitstream File

After GAO files configuration, double-click "Place&Route" in the "Process" to run PnR. Generate a bitstream file containing user designs and GAO configuration. The files are named after the AO name by default, such as "ao_0.fs", and they are stored in the project path "/impl/pnr/" by

default.

3.2 GAO Config File in Lite Mode

3.2.1 Start Lite Mode GAO

You first need to create or load the configuration file (.gao/.rao) before start, including "For RTL Design" and "For Post-Synthesis Netlist". The "For RTL Design" is used to capture RTL signal before synthesis with extension .rao. The 'For Post-Synthesis Netlist' is used to capture the netlist signal after synthesis with extension .gao. For the two types of Lite GAO configuration are similar, the following will take "For Post-Synthesis Netlist" in Lite GAO as an example.

Create GAO Config File in Lite Mode

The steps are as follows:

1. In the "Design" view, right-click and select "New File...".The "New" dialog box will open, as show in Figure 3-31.
2. Select the "GAO Config File" and click "OK". The "New GAO Wizard" dialog box will open, as shown in Figure 3-32. Select "Lite", and then click "Next".
3. Enter the config file name in "Name", as shown in Figure 3-33, and then click "Next".
4. Check the GAO config. file mode and path, as shown in Figure 3-34 . Click "Finish". You can see the config file in "GAO Config Files" view.

Figure 3-31 Create GAO Config File (Lite Mode)

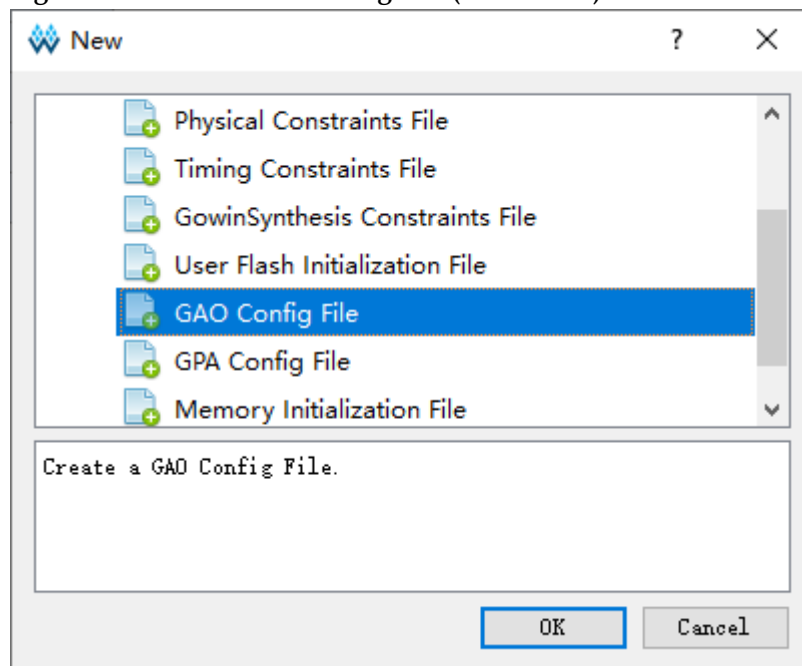


Figure 3-32 New GAO Wizard (Lite Mode)

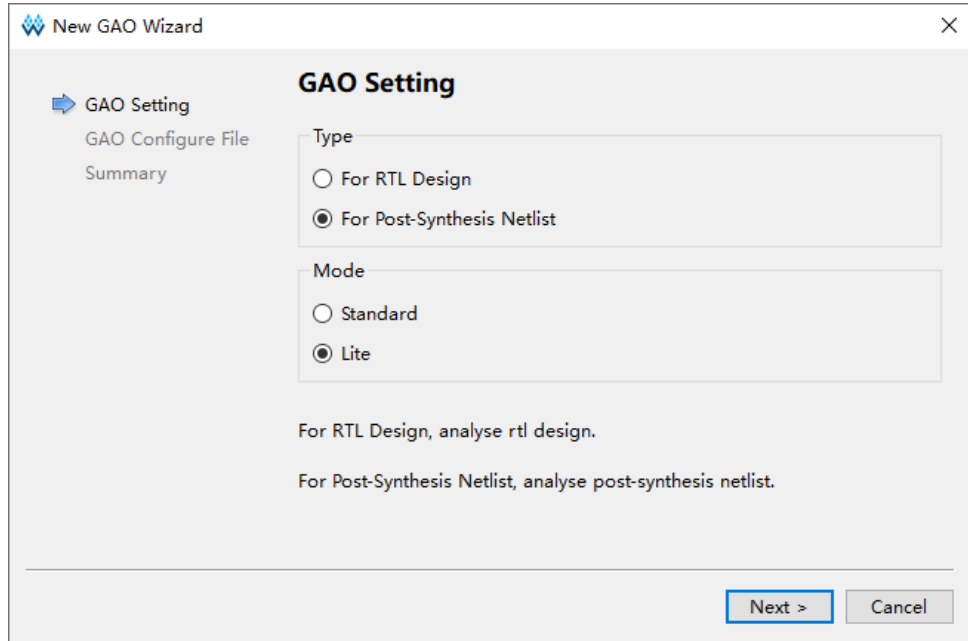


Figure 3-33 GAO Config File Name (Lite Mode)

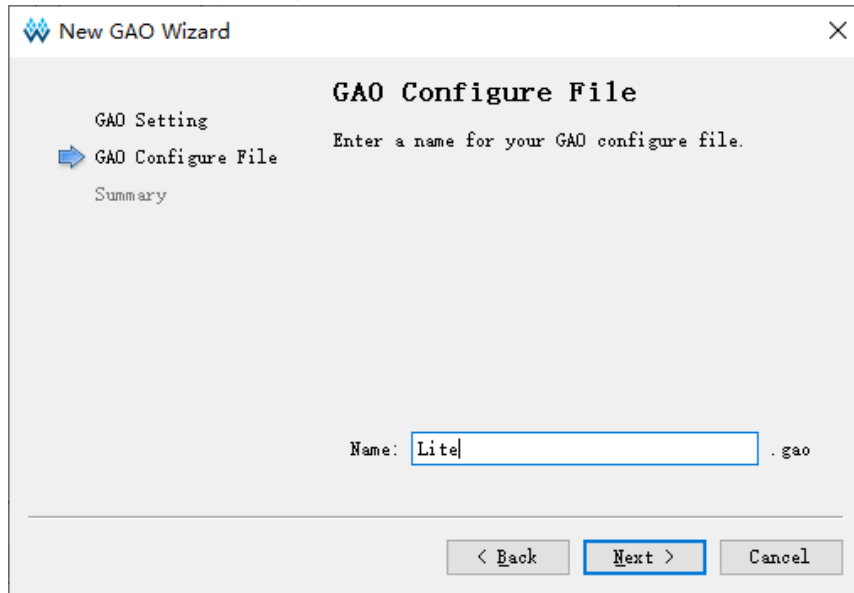
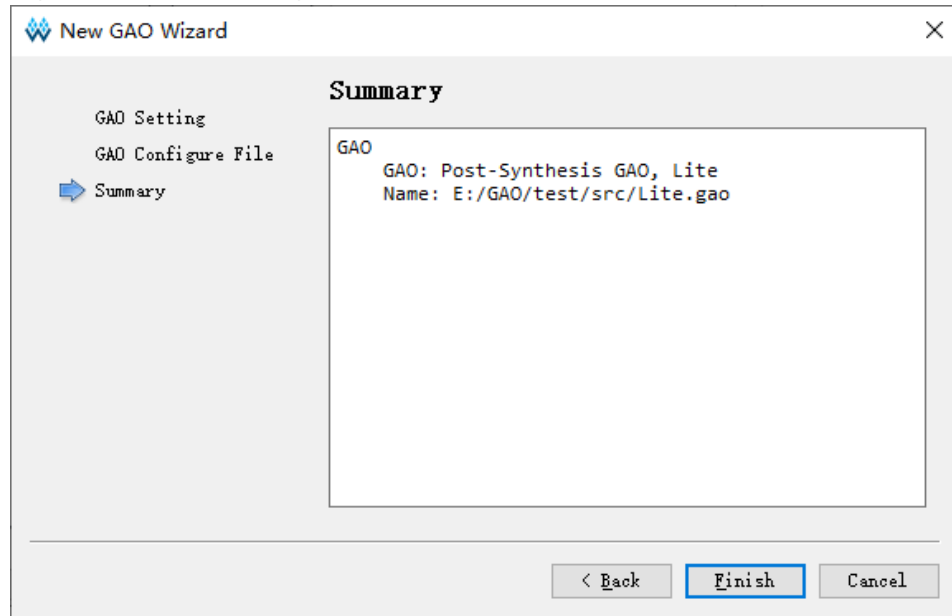


Figure 3-34 GAO Config File Mode and Path (Lite Mode)

Load GAO Config File

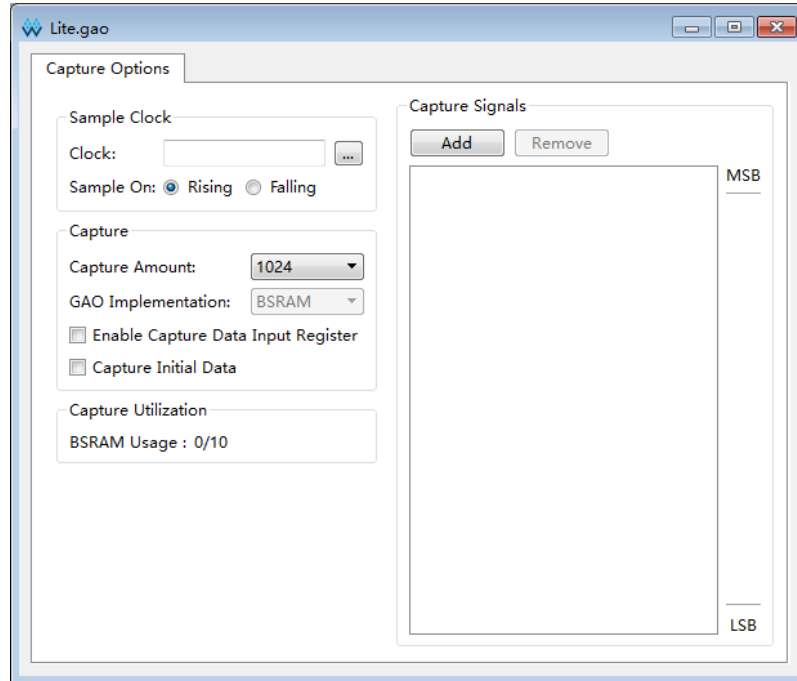
The steps are as follows:

1. In the "Design" view, right-click and select "Add Files..."; the "Select Files" dialog box opens.
2. Select the config file (.gao) and load it to the project.

Start Lite Mode GAO

Double-click the configuration file (.gao) in the "Design" window. The "GAO Config" will open, as shown in Figure 3-35.

The GAO configuration window displays the capture options.

Figure 3-35 Gowin GAO (Lite Mode)**Note!**

If the project is without synthesis, when user double-clicks the config file (.gao), the "Warning" prompt will pop up.

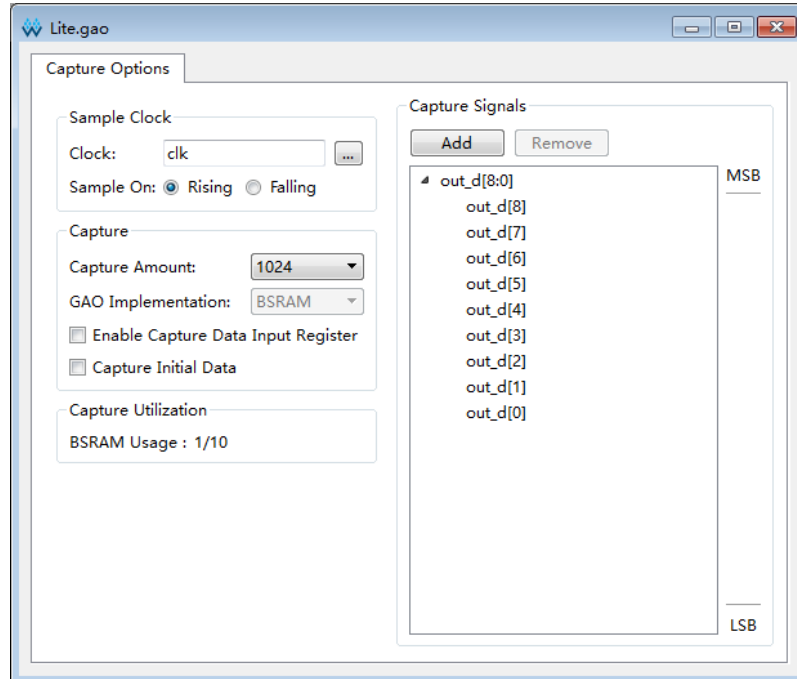
3.2.2 Lite Mode GAO Configuration

The "Lite Mode GAO" is used to configure the signal capture conditions.

Capture Signals Configuration

As shown in Figure 3 -36, the "Capture Options" includes the "Sample Clock", "Capture Signals", "Cpture" and "Capture Utilization".

Figure 3 -36 Capture Options (Lite Mode)

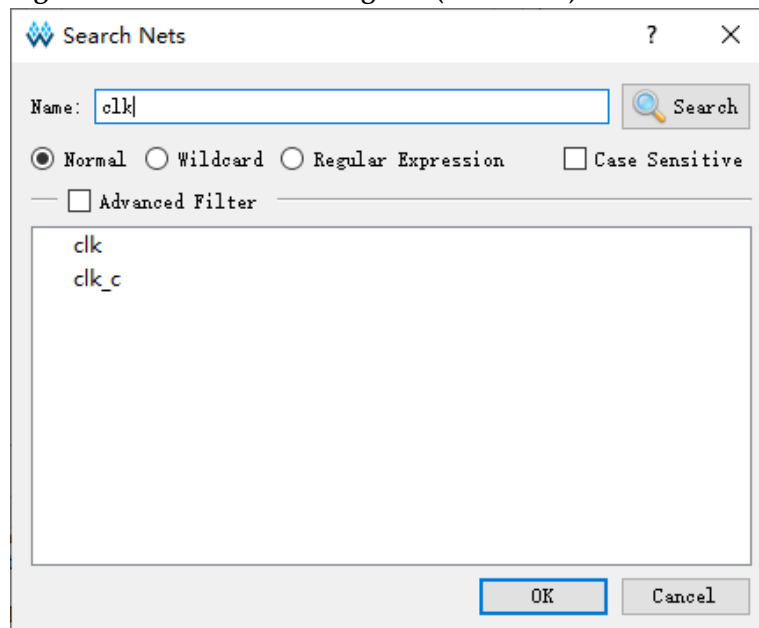


You can select the clock in the user design or other clocks as the sample. The sample clock supports sampling on rising edge and falling edge.

You can employ the following two methods to add sample clock signals:

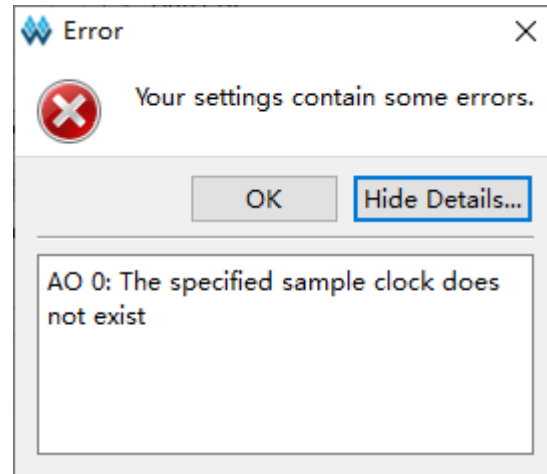
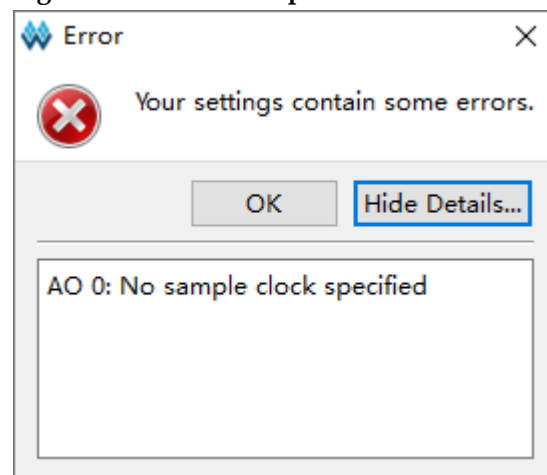
- Enter the sample clock name in the "Sample Clock" text box.
- Click the "..." and the "Select Nets" dialog box will open to select the sample clock signal, as shown in Figure 3-37. Click "OK" to add the signal.

Figure 3-37 Select Nets Dialog Box (Lite Mode)



Note!

- If the configured sample clock does not exist when the config file (.gao) is saved, the error prompt box will pop up, as shown in Figure 3-38.
- If there is no sample clock, the error dialog box, "No sample clock specified", will pop up, as shown in Figure 3-39.

Figure 3-38 Error Prompt**Figure 3-39 Error Prompt****Capture Configuration**

As shown in Figure 3-40, it displays Capture Amount, GAO Implementation, Enable Capture Data Input Register and Capture Initial Data.

Figure 3-40 Capture Configuration (Lite Mode)

Capture

Capture Amount:

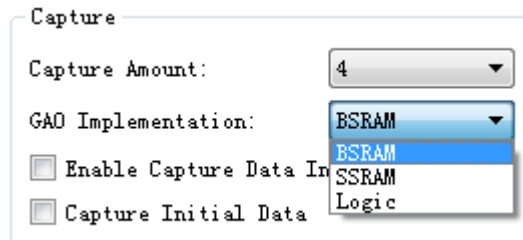
GAO Implementation:

Enable Capture Data Input Register

Capture Initial Data

- Capture Amount: The address depth of the memory being used on each capture buffer page.
- GAO Implementation: Storage mode. Captured data signals can use the BSRAM resource or logic resource. You can select the storage resource from the "GAO Implementation" drop-down list.
- Enable Capture Data Input Register: Adjust timing. If there is a delay from the clk to BSRAM, you can select this option to adjust the timing to add a layer of reg for capture data.
- Capture Initial Data: Capture the data of power-on. Select this option to capture the data of power-on.
- For GW1NZ-1-ZV device, GAO Implementation supports SSRAM implementation in addition to BSRAM and Logic, as shown in Figure 3-41.

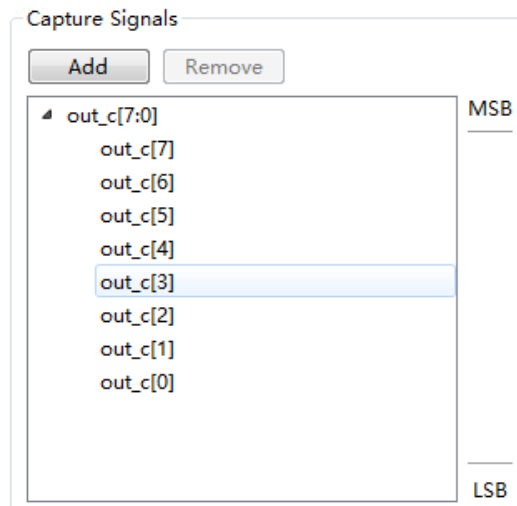
Figure 3-41 SSRAM Implementation for GW1NZ-1-ZV (Lite Mode)



Capture Signals Configuration

The "Capture Signals" in Figure 3-42 can be used to configure capture signals. The data port signal is the input signal of the data port specified in the user design.

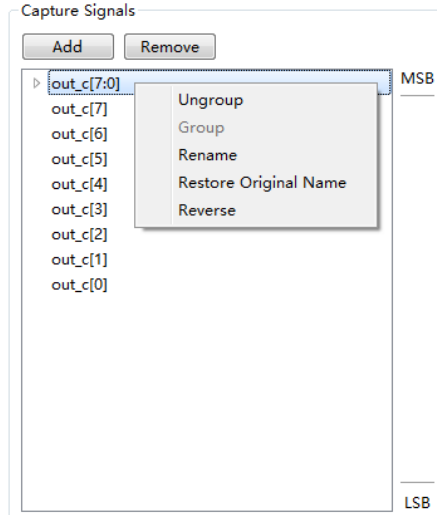
Figure 3-42 Capture Signals



- "Add" is used to select the signal. Click "Add", and "Search Nets" dialog box pops up, then select your required data port signal, click "OK" to finish. Bus signals can also be added, such as out[7:0] as shown in Figure 3-42.

- You can delete signal by clicking "Remove".
- You can select signals by left-click, shift+left click, Ctrl+left to sort by dragging.
- Select and right-click to set Group, Ungroup, Rename, Restore Original Name and Reverse, as shown in Figure 3-43.

Figure 3-43 Right-click Menu



Note!

After the netlist is updated, if the signal that has been selected in the Trigger view does not exist in the updated netlist, the trigger signal is highlighted in red.

Capture Signals BSRAM Utilization

As shown in Figure 3-44, it displays the BSRAM utilization.

Figure 3-44 BSRAM Used by GAO



3.2.3 Generate Bitstream File

After GAO files configuration, double-click "Place & Route" in the "Process" to run PnR. Generate a bitstream file containing user designs and GAO configuration. The files are named after the AO name by default, such as "ao_0.fs", and they are stored in the project path "/impl/pnr" by default.

4 GAO Usage

GAO is used to display the capture signal waveform. It can also be used to configure the AO capture window number, capture amount, and match conditions for match units via the JTAG. It helps you to observe data signals much more directly and visually. For a simple GAO example, see [SUG918](#), Gowin Software Quick Start Guide.

4.1 GAO Usage in Standard Mode

4.1.1 Start GAO in Standard Mode

Gowin Software can create either "For RTL Design" Standard Mode GAO config file with extension `.rao` or the "For Post-Synthesis Netlist" Standard Mode GAO config file with extension `.gao`, which has the same capture window. Therefore, the capture interface for loading the `.gao` configuration file is described here.

The steps are as follows:

1. Select "Tools" from the menu bar.
2. Select "Gowin Analyzer Oscilloscope" from the pull-down list to start GAO and the `.gao` file can be loaded automatically. Or click "Open" to select Standard Mode config file (`.gao`) or Project file (`.analyzer_prj`) that you require.
3. According to "Static" and "Dynamic" in [3.1.2 Standard Mode GAO Configuration > Trigger Expressions Configuration](#), the capture windows after loading the `.gao` config file are different. When "Static" is configured, the capture interface is as shown in Figure 4-1. When "Dynamic" is configured, the capture window is shown in Figure 4-2. The difference is whether the trigger expression of the capture window can be dynamically edited, so only the capture window when the trigger expression is configured as "Dynamic" is described.

Note!


- You can also click "" to start GAO.
- In addition to the GAO config file with the extension `.gao`, the GAO config file with the extension `.rao` can also be loaded. For the configuration of the `.gao/.rao` config file, see [3.1.1 Start Standard Mode GAO](#).

Figure 4-1 Gowin Analyzer Oscilloscope (Static Standard Mode)

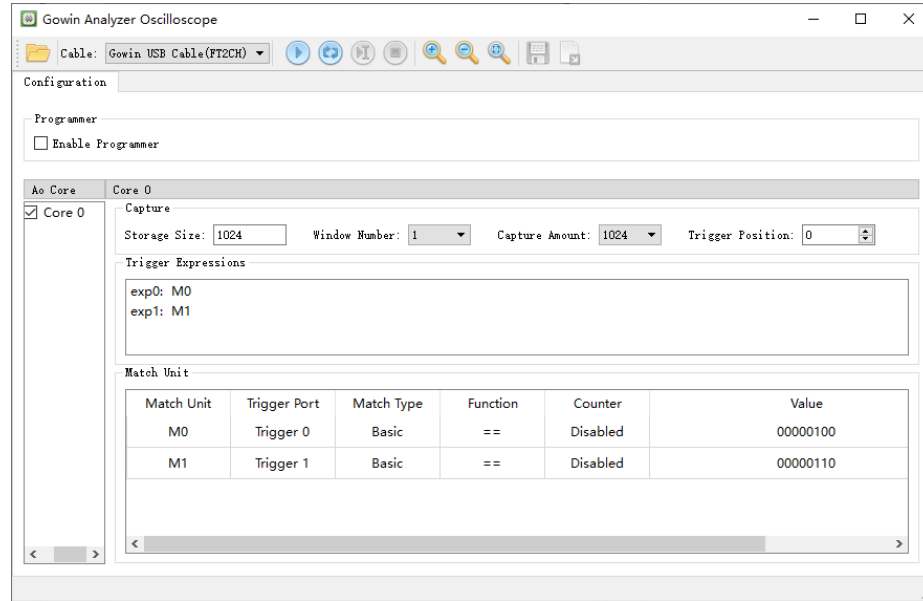
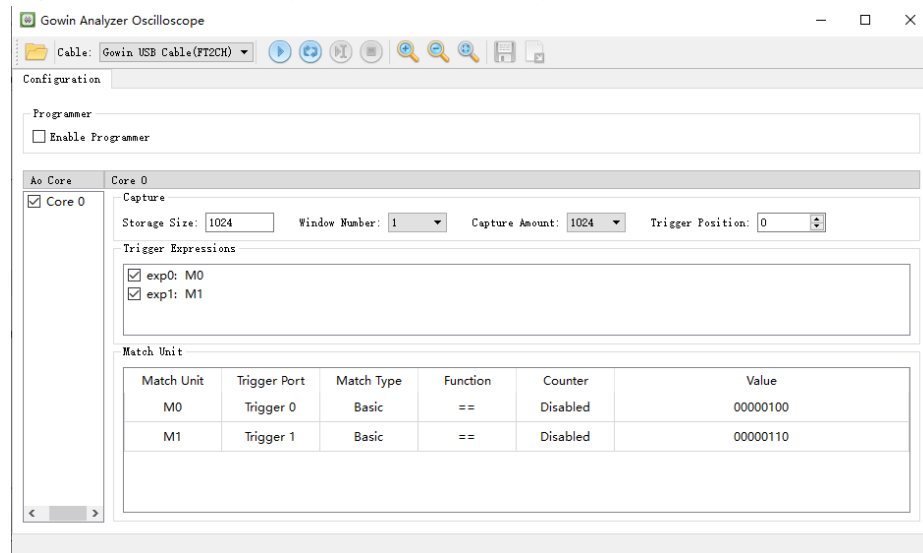


Figure 4-2 Gowin Analyzer Oscilloscope (Dynamic Standard Mode)



4.1.2 Run GAO

As shown in Figure 4-2, GAO window includes toolbar, Configuration view and Window view. The tool bar can be used for loading config files (.gao), project file (.analyzer_prj) or, etc. Configuration view is used for configuring dynamic parameters of AO. Window view is used for waveform display.


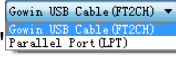









Toolbar

GAO toolbar includes open..., cable, start/stop control, auto run, force trigger, zoom in/out, etc., as shown in Figure 4-3.

Figure 4-3 Toolbar (Standard Mode)



The detailed description is as follows:

- : Open and load config files (.gao).
- : Gowin USB Cable and Parallel Port, which can be selected from pull-down list.
- , , , : Start, Auto Run, Force Trigger, and Stop. The shortcut keys are "F1", "F2", "F3" and "F4" in order.
- , , : Zoom in/out and fullscreen. The shortcut keys are "F8", "F7" and "F6" in order.
- : Output waveform.
- : Save the waveform and project file *.analyzer_prj. The steps are as follows:
 - The user is allowed to save .gao/.rao file to the project file *.analyzer_prj. It includes the group, rename, etc.
 - When GAO window opens, the user can manually load the *.analyzer_prj.
 - After the *.analyzer_prj file is loaded, the Window displays the waveform and configuration saved by the user.

Note!

At present, Auto Run is only supported when the number of Window is 1. Analyzer will loop and display the signal of match in the window in real time until the user clicks stop.

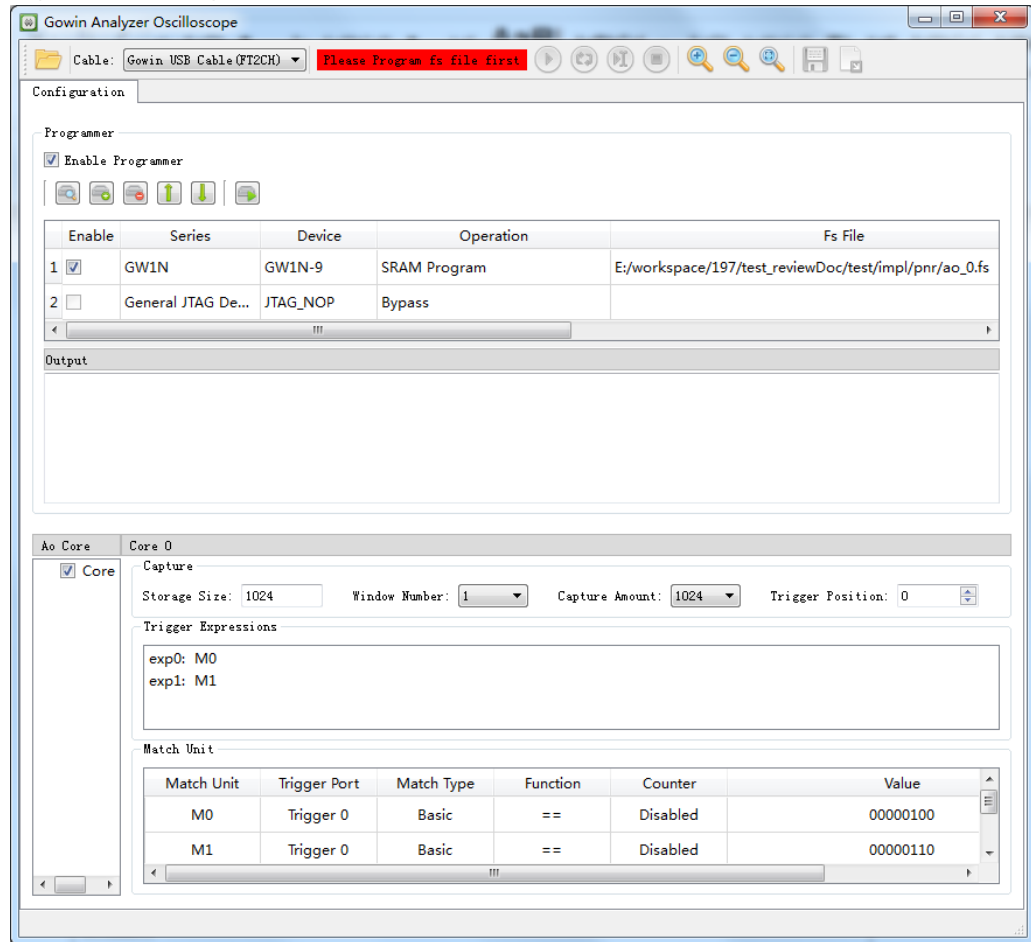
AO Configuration

AO Configuration has the following functions:




- Whether to use Programmer.
- Whether to use the device chain, you can select General JTAG device or Gowin device.
- Display AO sampling data, Expressions, and Match Unit.
- Modify configuration parameters.

Configuration view includes Programmer and AO Core (Capture, Trigger Expressions and Match Unit), as shown in Figure 4-4.

Figure 4-4 Configuration



Programmer has the following functions:

- After Enable Programmer is checked, Programmer is supported. According to GAO Programmer requirements, only Access Mode and Operation are supported. For the usage, see [SUG502](#), Programmer User Guide.
- Click "" to scan device and display details, such as, Series, Device, Operation, ID Code and IRCode. If the ID code of the scanning device is the same as the one of other devices, the popover displays all the devices with the same ID code for you to select.
- Device chain function can be implemented. Click "" can add device. The default series is General JTAG Device (Non Gowin device). The default device is JTAG_NOP. Double-click Series and Device column of Device to pop up the drop-down list, you can select series and device as required. In addition, IRCode of General JTAG Device can be configured from 1 to 16. The IRCode of Gowin Device is 8 by default and can not be modified.
- Click "" to delete the selected device.

- Click "↑" to move up the selected device.
- Click "↓" to move down the selected device.
- Click "📄" to download bitstream file.
- GAO can only capture the signal data of Gowin Device, but cannot capture the signal data of General JTAG Device, so you can only check Gowin Device in Enable.
- Output can display downloading information.
AO Core view includes Capture, Trigger Expressions, and Match Unit.
Capture has the following functions:
 - Configure storage size, windows number, capture amount, and trigger position.
 - Modify the above parameters.

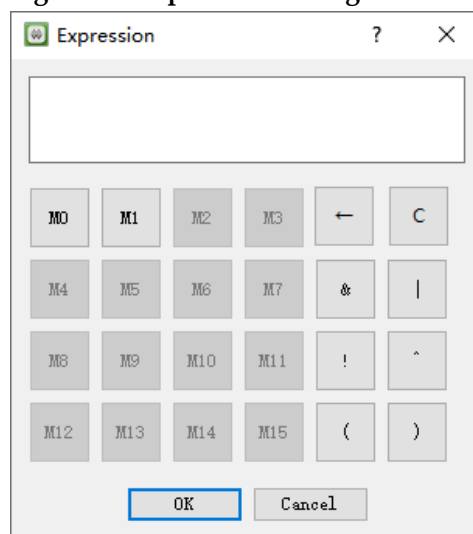
Note!

For the details, please refer to Capture Configuration.

Trigger Expressions has the following functions:

- After .gao file is loaded, all trigger expressions are checked by default on the capture window.
- Double-click any trigger expression to pop up the Expression dialog box, which can be edited. The Match Unit not checked will be grayed out, as shown in Figure 4-5.
- Trigger Expression can not be added.
- Any trigger is implemented when none of the trigger expressions is checked.

Figure 4-5 Expression Dialogue Box



Match Unit includes the following functions:

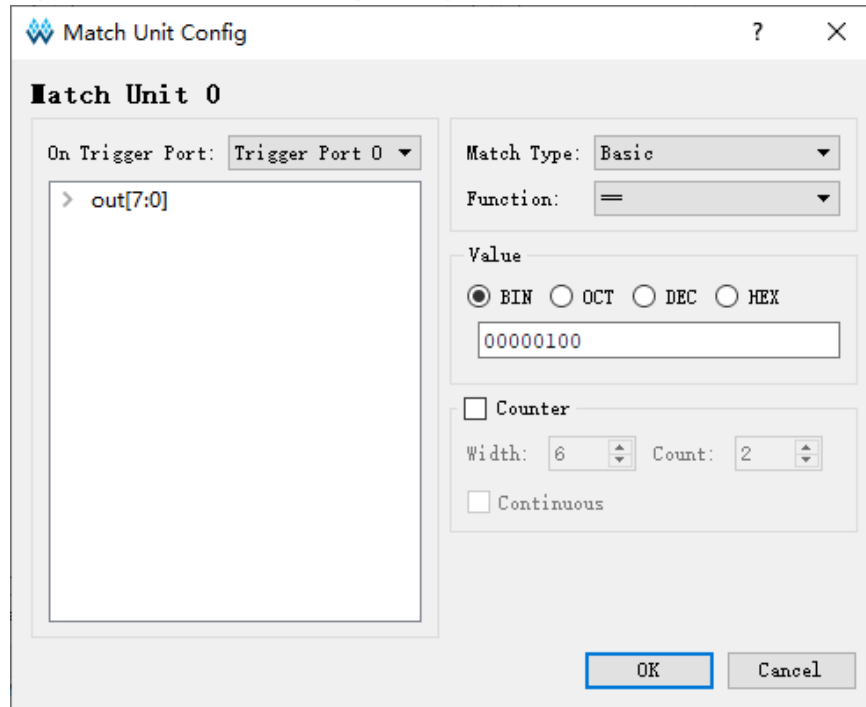
- Display the name, trigger port, and match type, etc.

- Double click the match unit, modify the match functions and Bit Value in "Match Unit Config" dialog box, such as, AO Counter, and match times, as shown in Figure 4-6.

Note!

For the details, see [3.1.2 Standard Mode GAO Configuration](#).


Figure 4-6 Match Unit Config Dialog Box







Display Waveform

Window is used to display signal waveform and supports the following functions:

- Mark the position with nonius.
- Zoom in/out and fullscreen.
- Change the order of signals.
- Configure Group, Ungroup, Rename, Restore Original Name, Reverse and Format.

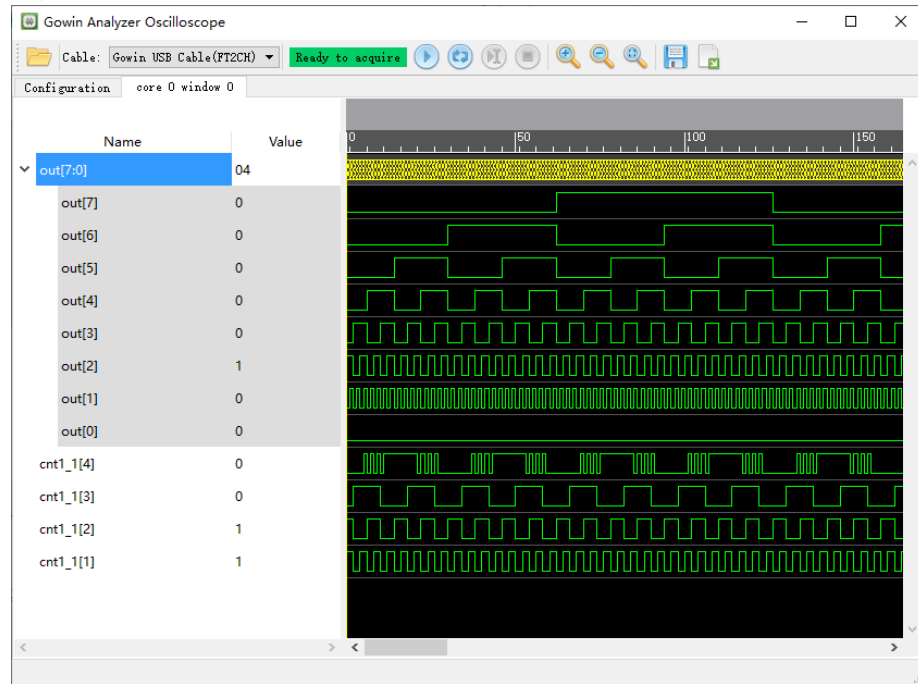
Click " " or use shortcut "F1" to run GAO. When the trigger conditions are met, GAO displays Windows number, and the windows number equals to the configured number of capture windows. Figure 4-7 shows capture signal name, Value, and waveforms. Click one waveform, and it will be highlighted with yellow.

If you click the " " and the trigger condition does not meet, you can click the " " or use "F3" to force the trigger; or click the " " or use shortcut "F4" to stop running.

In addition, click the " " or use shortcut "F2" to start the GAO Auto

Run. At present, Auto Run is only supported when the number of Windows and AO Core is both 1. Analyzer will loop and display the signal of match in the window in real time until you click stop.

Figure 4-7 GAO Waveform Display (Standard Mode)

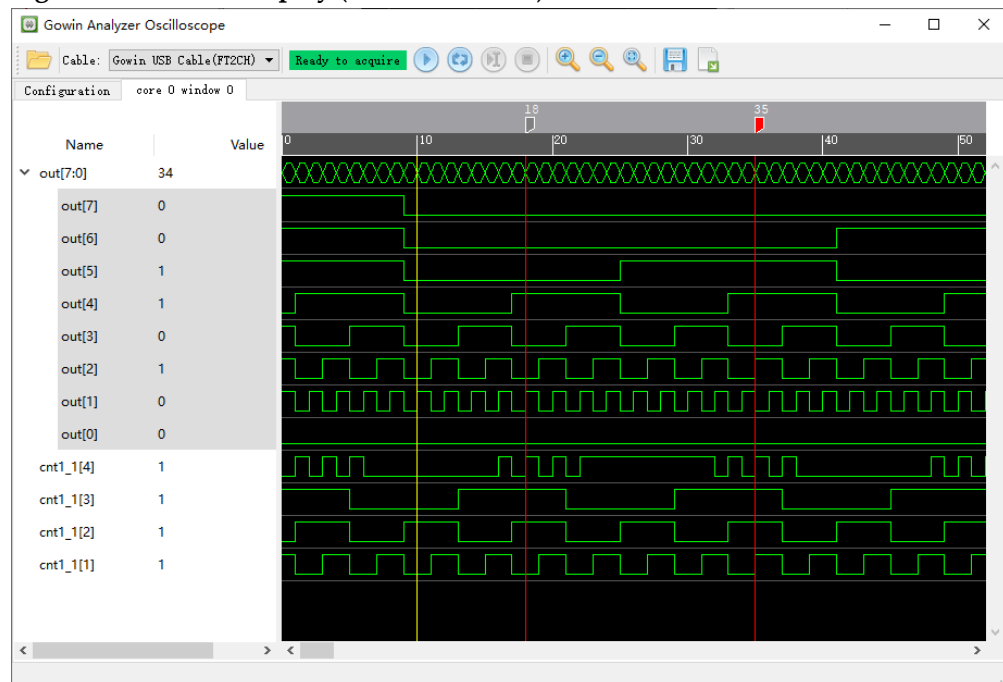


Note!

Click "▶" or "⏸", GAO Programmer is grayed out.

As shown in Figure 4-8, initial position of nonius is the trigger position by default. The trigger point is marked with yellow line. Right-click the blank above the nonius to add a new nonius, and you can drag by left-clicking; right-click nonius and select "Remove Marker" to delete the nonius.

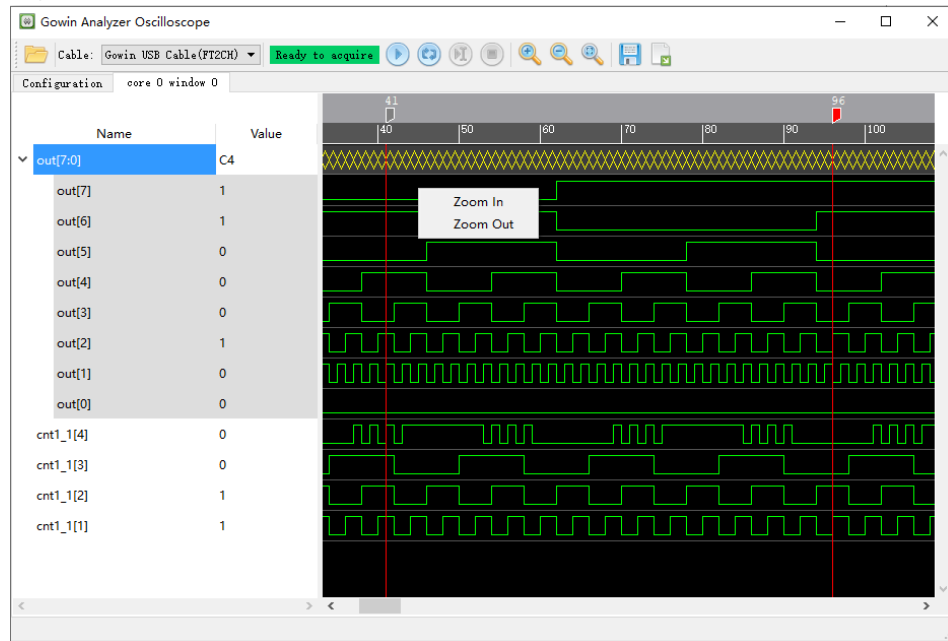
Figure 4-8 Nonius Display (Standard Mode)



Right-click in the waveform display area to pop up the menu, as shown in Figure 4-9.

Click "Zoom In", "Zoom Out", or "🔍", or "🔍", or use the shortcut keys "F8", "F7", or Ctrl+ mouse wheel to zoom in/out the waveform. Click the "🔍", or use the shortcut key "F6" to display the waveform fullscreen.

Figure 4-9 Zoom In/Out (Standard Mode)

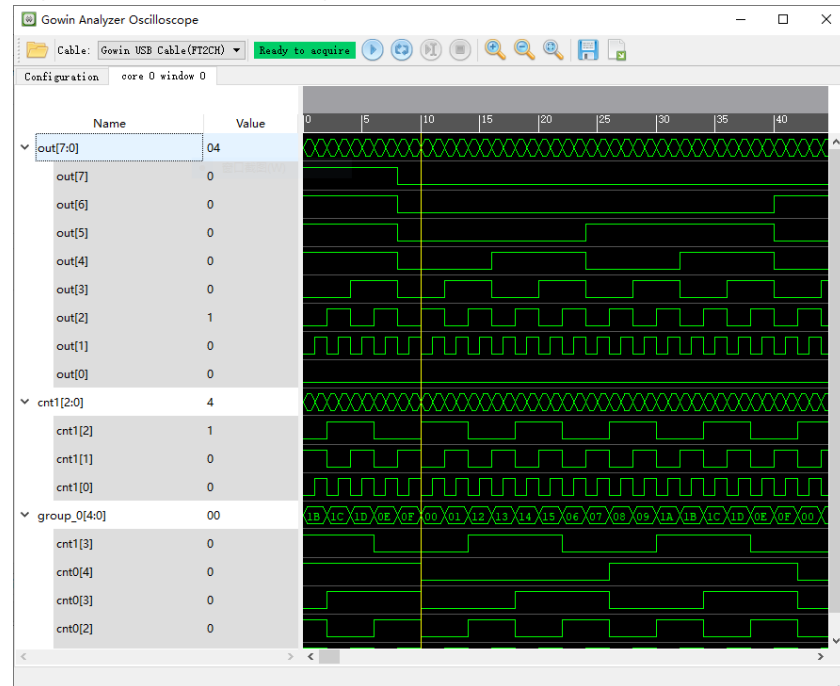


Change signals order by clicking signals in Name column.

The Name column and Value column width can be adjusted, and the adjustment made by you before the trigger is retained when triggered again.

In Name Column, you can select multiple signals. Right click and select Group in the pop-up menu to group Bus signals. For signals with the same name and continuous subscript, such as cnt[1], cnt[0], the grouped Bus signal name is cnt[1:0]. For signals with different names or same names but discontinuous subscriptions, the grouped Bus signal name defaults to group_index[n:0], index and n are integers greater than or equal to 0, as shown in Figure 4-10.

Figure 4-10 Group Bus Signal (Standard Mode)



The Window includes the following functions:

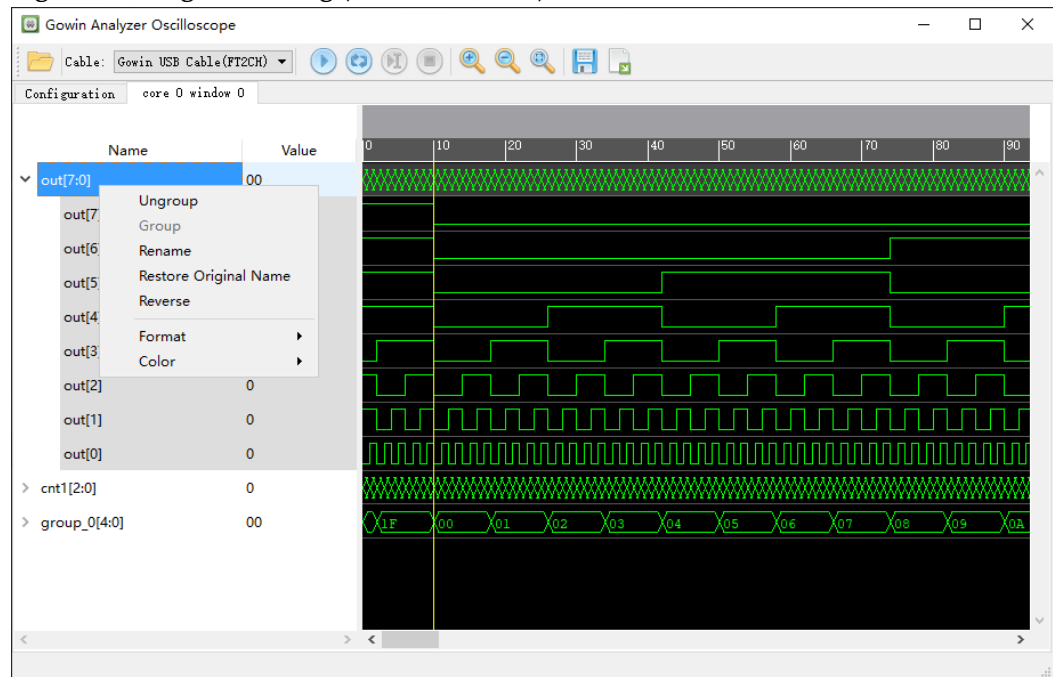
- Click "▶" again to capture sampling signals waveform. The Bus signal generated by "Group" still exists.
- Do not close the GAO capture window to trigger again, and the waveform display view size remains the same as last time.
- Right-click the Bus signal\ in "Name" column and select "Ungroup" in the pop-up menu to ungroup Bus signal.
- The Bus signal generated by "Group" is not saved as a .analyzer_prj file. When GAO opens it again, it is necessary to regroup it, save it as an .analyzer_prj file and load it with GAO.
- Bus Signals can be added in the Capture Signals of GAO configuration view. When they are added together, the waveform view will directly display as Bus Signals out [7:0], as shown in Figure 4-10.
- It is not allowed to select some of the Bus signals to group a new Bus.

In Value area, select one signal and right-click to pop up the menu, as shown in Figure 4-11.

- You can rename the selected signal by clicking Rename.
- You can restore signals to netlist names by clicking Restore Original Name.
- You can reverse the selected signals by clicking Reverse.
- Select "Binary/Octal/Signed Decimal/Unsigned Decimal/Hexadecimal" as the sampling signals value, and it's Hexadecimal by default.
- You can modify the color of the selected signal by clicking color,

including Green, Light Green, Dark Red, Red, Orange, Yellow, Blue, Light Blue, Dark Blue, Purple, and the waveform color is Green by default.

Figure 4-11 Right-Clicking (Standard Mode)



Monitor File

GAO monitors whether the loaded .gao/.rao or .fs files are updated. If they have been updated, you will be prompted.

1. GAO Config files Updated

After GAO config file is updated, if GAO does not capture data at this time, the prompt will pop up immediately. Otherwise, the prompt will pop up after the data is captured, as shown in Figure 4-12. Click "Reload" to load the updated GAO config file. At the same time, GAO Programmer is updated to "Disable", and waveform view is closed, as shown in Figure 4-13.

Figure 4-12 Prompt

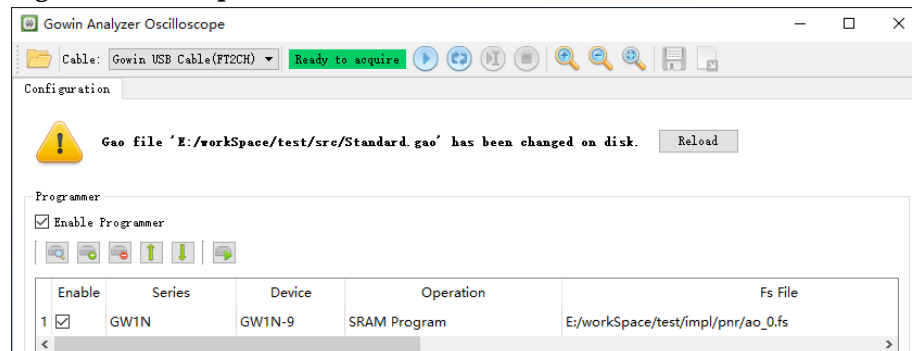
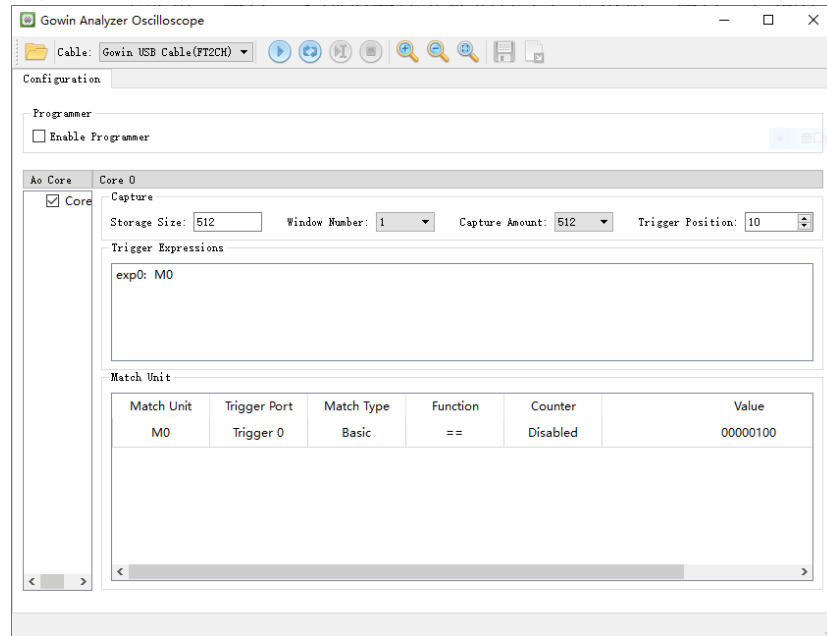


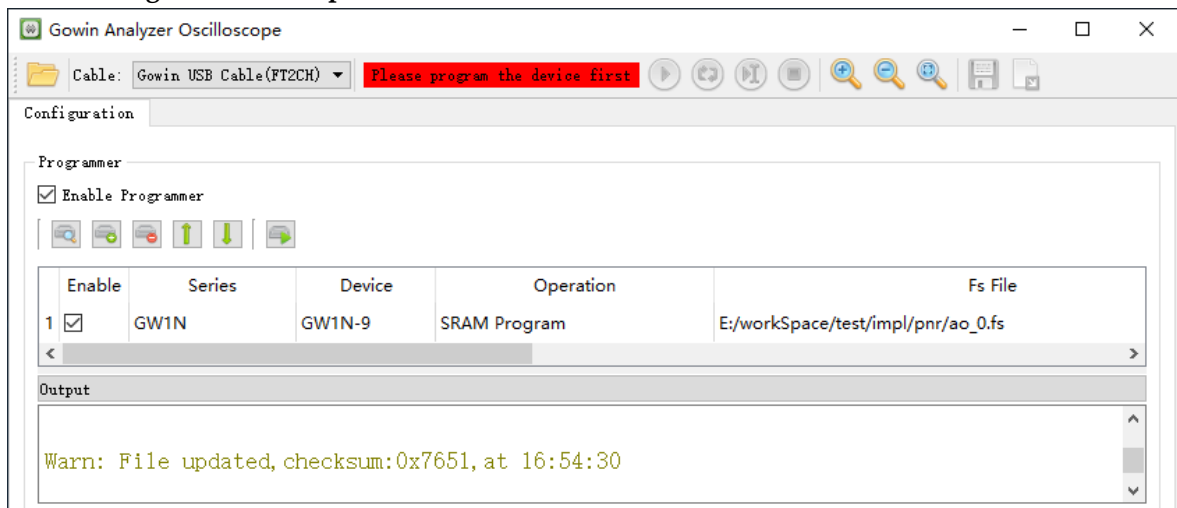
Figure 4-13 Reload Config File



2. Bitstream File Updated

- If GAO prompts "Please program the device first", it will no longer prompt you to update the bitstream file.
- If GAO prompts "Ready to acquire", it will prompt you to update the bitstream file. If GAO does not capture data at this time, prompt will pop up immediately in GAO Programmer Output; otherwise, prompt will pop up after the data is captured, and the prompt updates to "Please program the device first", as shown in Figure 4-14.

Figure 4-14 Prompt



4.1.3 Output Waveform

The steps are as follows:

1. Click the " " in the toolbar.

2. The Export dialog box pops up, specifying the wave file information, where the clock signal (Clock Signal) is the sampled clock signal specified in GAO and cannot be changed, as shown in Figure 4-15.

The GAO export file supports the following settings:

- AO core (Export Core) that specifies the waveform data to be exported is supported.
- The specified file export path (Export to) is supported.
- The specified file export format, including *.csv, *.vcd and *.prn is supported.
- The output waveform data file supports binary, octal, decimal and hexadecimal.
- Tab_delimited Text- (*.prn) consists of three forms, "All Signals/Buses", "Waveform Signals/Buses" and Only Buses, as shown in Figure 4-16.
 - All Signals/Buses: The prn file will display all signals and buses signal, including the signals grouping the Buses.
 - Waveform Signals/Buses: The prn file will display all signals and buses signal data, but does not include the signals grouping the Buses.
 - Only Buses: The prn file will display only the Bus signal checked by the user, as shown in Figure 4-17.
- Clock period supports us, ns and ps.

Figure 4-15 Export Dialog Box

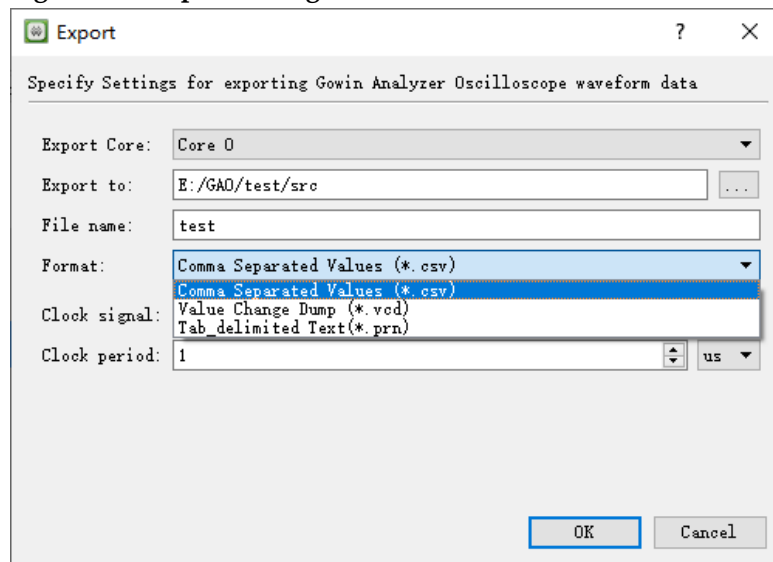


Figure 4-16 Export Tab_delimited Text (*.prn)

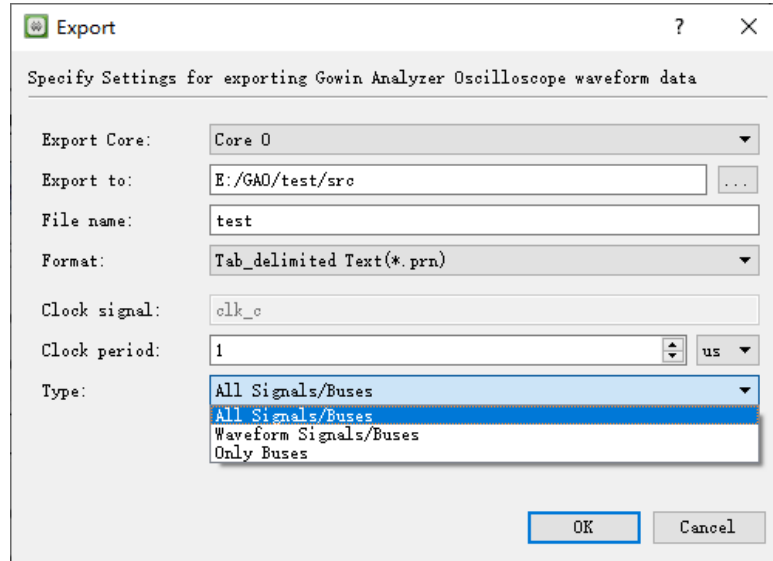
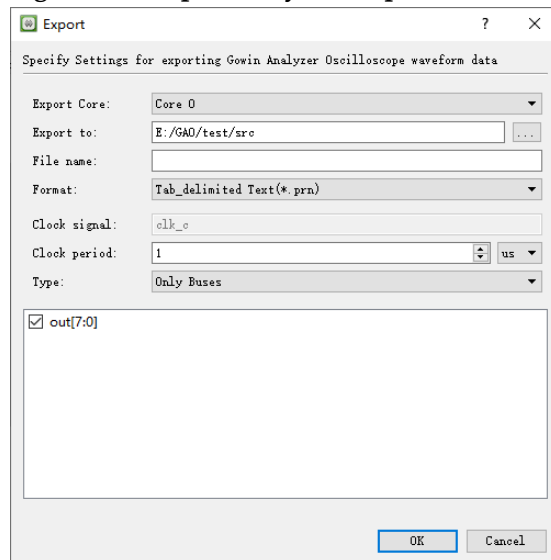


Figure 4-17 Export Only Buses prn



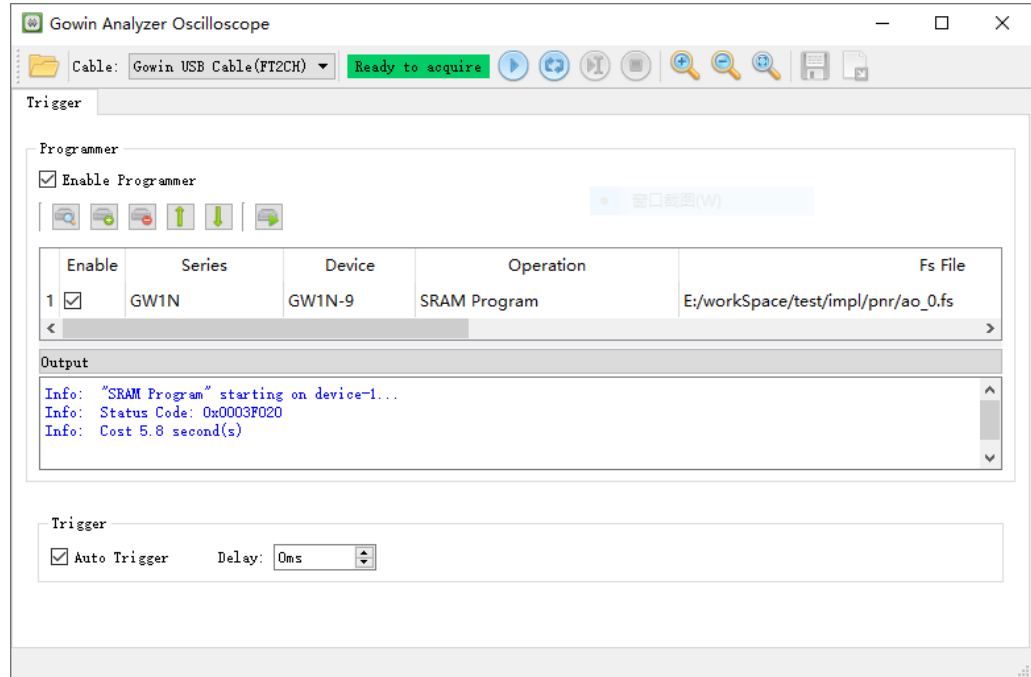
4.2 GAO Usage in Standard Mode

4.2.1 Start Lite Mode GAO

The steps are as follows:

1. Select "Tools" from the menu bar.
2. Select "Gowin Analyzer Oscilloscope" from the pull-down list to start GAO, click "Open" to select Lite Mode gao config file (.gao) or .analyzer_prj you require, as shown in Figure 4-18.

Figure 4-18 Gowin Analyzer Oscilloscope Window (Lite Mode)



4.2.2 Run GAO

Toolbar

Please see [4.1.2 Run GAO > Toolbar](#) for details.

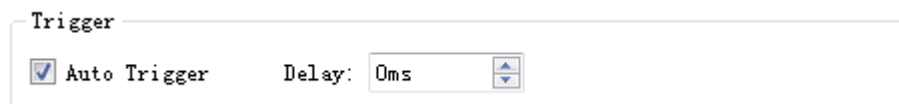
Trigger

This section is a bit different from [4.1.2 Run Gao > AO Configuration](#). Only the differences are described here.

The differences are as follows: Lite GAO Trigger view is as shown in Figure 4-19. Its main functions are as follows:

- Auto Trigger: click "Start" to trigger automatically when you select this option.
- Delay: configure the trigger delay.

Figure 4-19 Trigger View



Display Waveform

Please see [4.1.2 Run GAO > Display Waveform](#) for details.

Monitor File

Please see [4.1.2 Run GAO > Monitor File](#) for details.

4.2.3 Output Waveform

Please see [4.1.3 Output Waveform](#) for details.

5 Import Waveform File

GAO supports csv, vcd and prn. csv and prn can be imported to Matlab; vcd can be imported to ModelSim.

Note!

You need a third-party license to use Matlab and ModelSim.

5.1 Import csv to Matlab

To analyze the data easily, the data is imported to csv file in the form of Bus. The following is an example of importing the csv in decimal to Matlab.

The steps are as follows:

1. As shown in Figure 5-1, click "Import Data" to select the file to be imported.
2. Set the delimiter by clicking "Delimited". The content is separated by commas. Therefore, when importing csv file to Matlab, you need to set the delimiter as a comma. As shown in Figure 5-2, select "Comma" in "Delimited" drop-down list.
3. Save only the variable name and waveform data in csv, delete the header annotation. Or import the data to Matlab, select the data range to be imported by "Range". As shown in Figure 5-2, the range is A6:N1023, that is, import 14 columns and 1024 rows of data.
4. "Variable Names Row" can specify the row in which the variable name is in order to import the variable name. As shown in Figure 5-2, the row of the variable name is specified as the fourth.
5. Click "Import Selection" to import the selected variable name and data in matrix, as shown in Figure 5-3.

Figure 5-1 Matlab Import Data

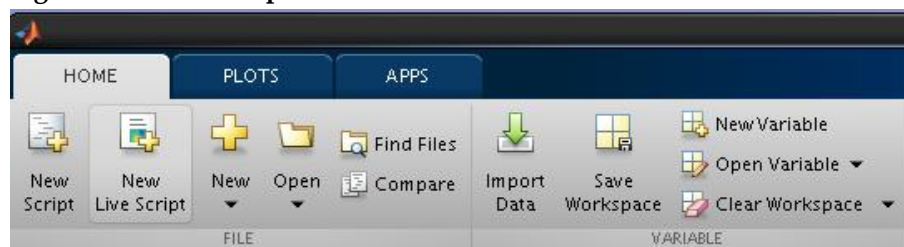


Figure 5-2 Import csv to Matlab

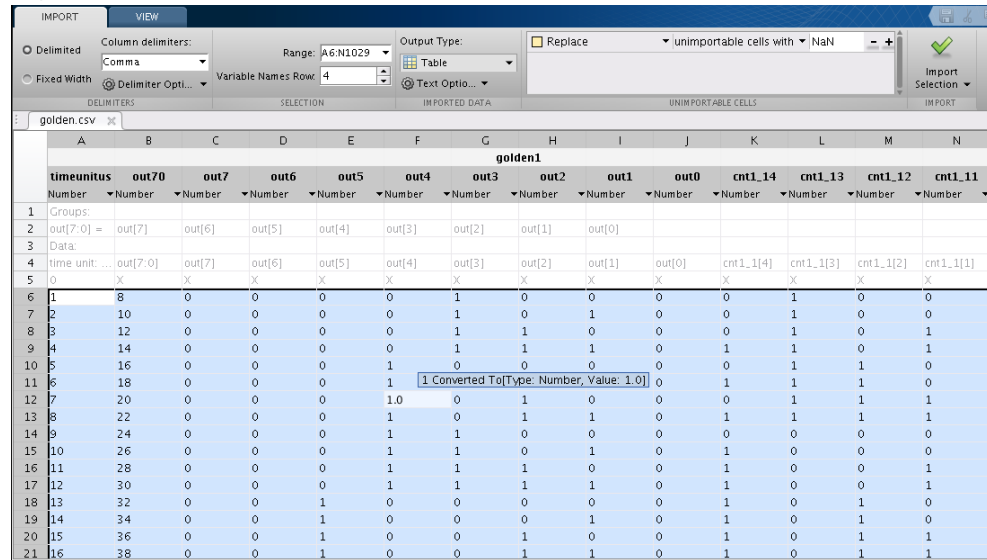
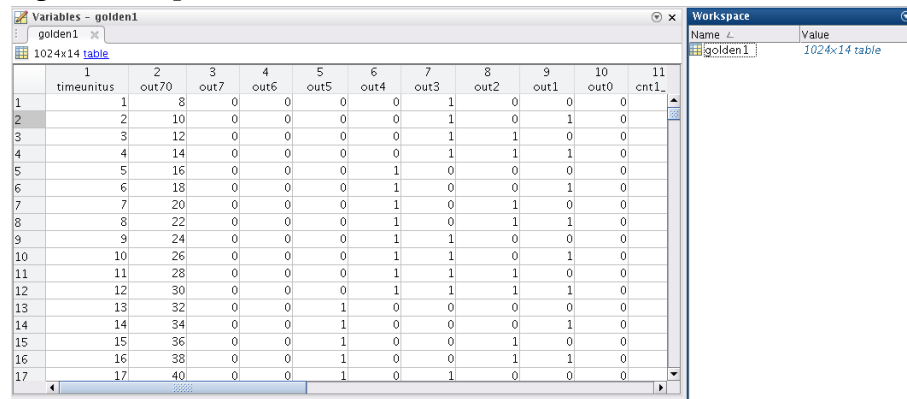


Figure 5-3 Import csv to Matlab in Matrix



5.2 Import prn to Matlab

To analyze the data easily, the data is usually exported to the prn file in Bus. Here the decimal prn file exported in "Only Buses" is used to import to the Matlab. The prn file only contains the Bus.

Similar to the step of importing the csv file to Matlab, since the prn file does not have the header annotation and the variable name defaults to the first row, you do not need to manually select the range and specify the row of the variable name. In addition, the prn file is a file with tab as a delimiter, so when you import the prn file, you do not need to select a delimiter, as shown in Figure 5-4.

The imported data displays in matrix, as shown in Figure 5-5.

Figure 5-4 Import prn to Matlab

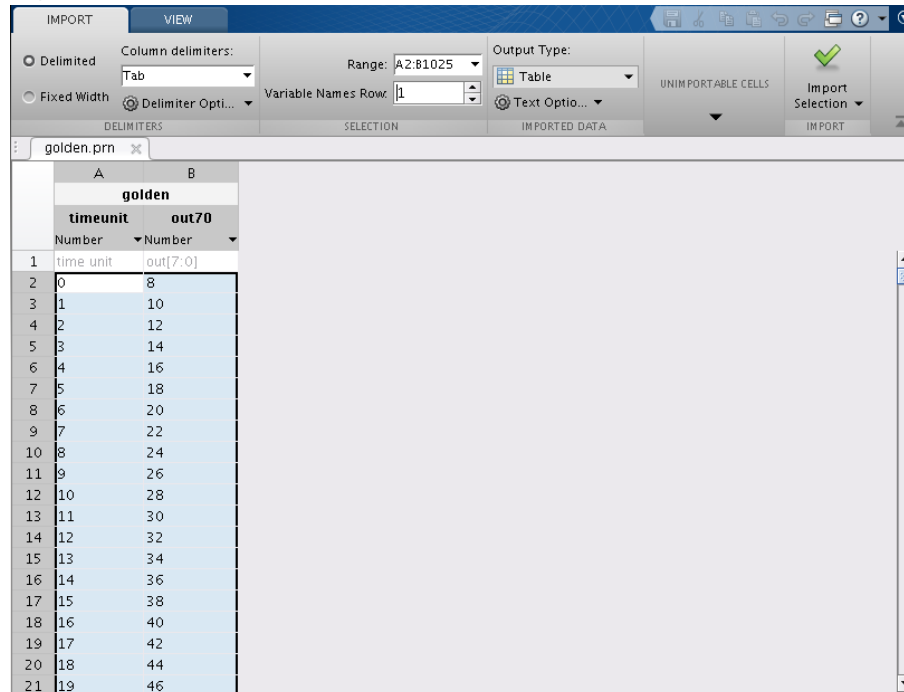
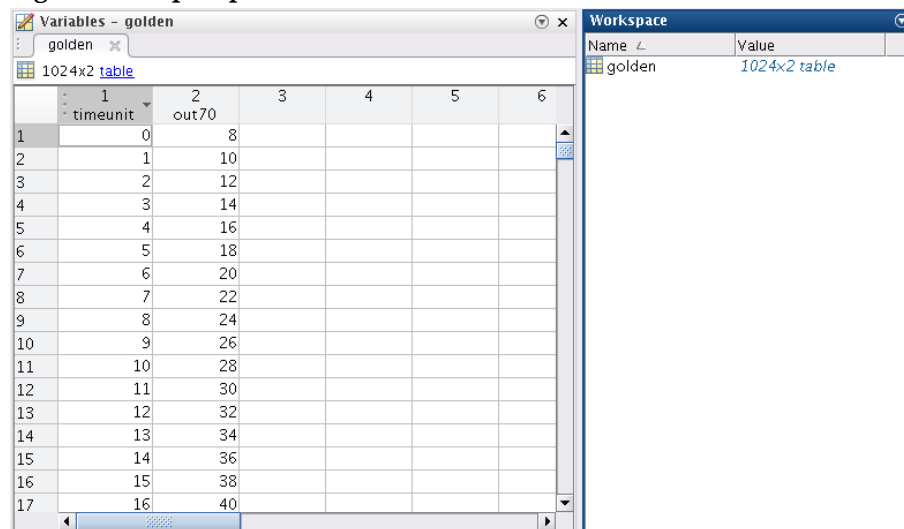


Figure 5-5 Import prn to Matlab in Matrix



5.3 Import vcd to ModelSim

The steps to open vcd waveform files with ModelSim are as follows.

1. In ModelSim, use the command "vcd2wlf test.vcd test.wlf" to convert vcd to wlf, as shown in Figure 5 6.
2. Use the command vsim -view test.wlf or click File > Open in the menu bar to open the wlf file; display the waveform in ModelSim through the right-click menu "Add Wave", as shown in Figure 5 7.

Figure 5-6 vcd to wlf

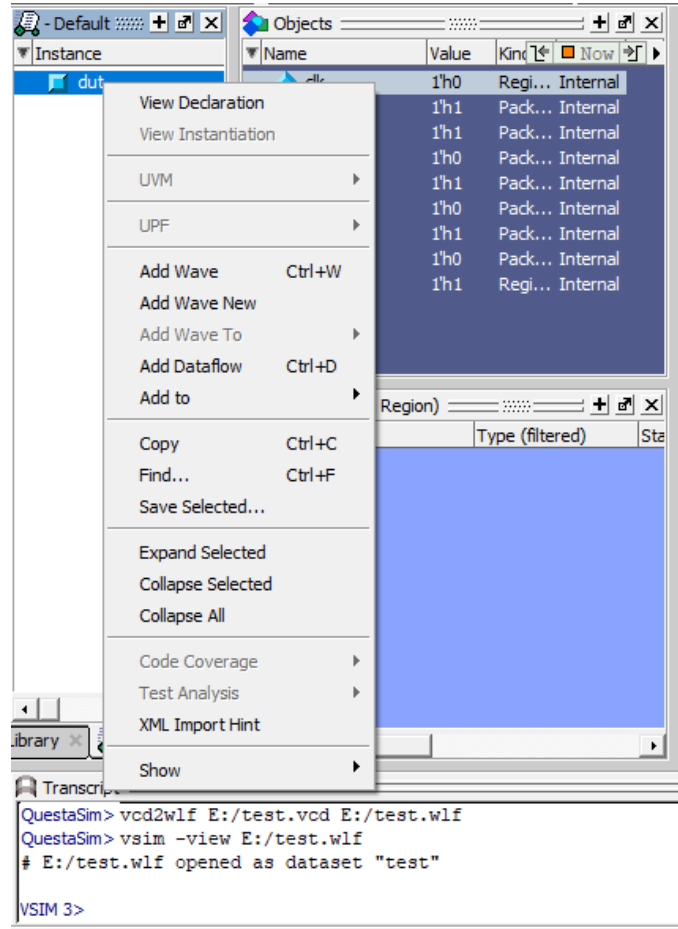


Figure 5-7 Open vcd Waveform with ModelSim

