Gowin Virtual Input Output
User Guide

SUG1189-1.2E, 12/31/2024

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Revision History

Date	Version	Description
07/05/2024	1.0E	Initial version published.
08/09/2024	1.1E	When jointly debugging with GVIO and GAO, the "save" and "save as" function buttons removed from the toolbar of runtime interface.
12/31/2024	1.2E	Remote programming and debugging supported.

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1 About This Guide

1.1 Purpose

This manual primarily introduces Gowin Virtual Input Output (GVIO). It describes the GVIO configuration files and the usage of the GVIO tool, aiming to help users quickly become familiar with GVIO and improve design analysis efficiency. The software screenshots and the supported products listed in this manual are based on Gowin Software 1.9.11. 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. Refer to the related documents at www.gowinsemi.com:

- SUG100, Gowin Software User Guide
- SUG918, Gowin Software Quick Start Guide
- SUG114, Gowin Analyzer Oscilloscope 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
AO Core	Analysis Oscilloscope Core
FPGA	Field Programmable Gate Array
GAO	Gowin Analyzer Oscilloscope
GVIO	Gowin Virtual Input Output
JTAG	Joint Test Action Group

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 using the information provided below.

Website: www.gowinsemi.com

E-mail:support@gowinsemi.com

2 Introduction

GVIO is a digital signal dynamic debugging tool designed in-house by Gowin. It can monitor and drive the internal signals of FPGA in real-time. When used in conjunction with Gowin Analyzer Oscilloscope (GAO), GVIO provides a more powerful debugging environment. This environment can generate internal signal stimulus and obtain logical responses through the GAO, aiming to help users quickly conduct system analysis and fault localization, thereby improving design efficiency.

The working principle of GVIO involves two main components: the control core and Analysis Oscilloscope Core (AO Core). The control core acts as a communication controller between all AO cores and the JTAG scan circuit, while the AO cores are responsible for generating stimulus signals and sampling signals. The control core connects the master computer to the AO core, receiving instructions from the master computer during configuration and transmitting them to the AO core. During data reading, it transmits the data collected by the AO core back to the master computer and displays it in Gowin Software interface. The AO core communicates directly with the control core, receiving instructions transmitted by the control core, performing data acquisition, and TX stimulus signals according to the instructions.

GVIO includes stimulus ports and sampling ports. The stimulus ports are used to drive signals within the design, and the sampling ports are used to sample signals within the design. GVIO supports providing stimulus and sampling data for RTL-level signals and can be used for jointly debugging with GAO of the "For RTL Design" type, but not with GAO of the "For Post-Synthesis Netlist" type. GVIO can set the initial value of stimulus signals, making it convenient for users to analyze the status at the power-on instant.

GVIO has the following features:

- Provides stimulus to drive signals within the design
- Samples signals within the design
- Supports up to 16 AOs
- Each AO core supports up to 64 stimulus signal and sampling signal ports respectively

- Each stimulus and sampling signal port supports a maximum width of 256 bits
- Allows customization of stimulus signal port initialization
- Provides activity detector to monitor levels changes during sampling

3 GVIO Config File

GVIO configuration window is primarily used to configure and modify parameters of the control core and AO cores. It aims to help users efficiently analyze data signals post synthesis and PnR, thereby enhancing analysis efficiency effectively.

3.1 GVIO Config File

3.1.1 Start GVIO Configuration Window

GVIO configuration window can be started by either creating or loading a configuration file (.gvio). Below are the steps for each method:

Create GVIO Config File

The steps are as follows.

1. In the "Design" view, right-click and select "New File...". The "New" dialog box will pop up, as shown in Figure 3-1.
2. Select the "GVIO Config File" and click "OK". The "New GVIO Config File" dialog box will pop up, as shown in Figure 3-2.
3. Enter the config file name in "Name" editing box, then click "OK" button to create the .gvio configuration file.

Figure 3-1 Create GVIO Config File

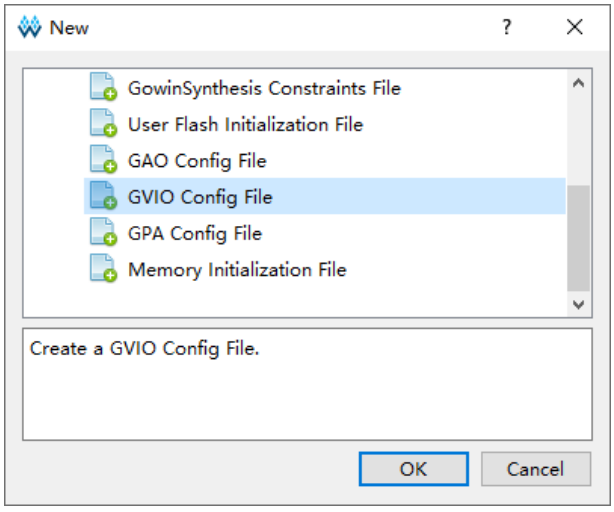
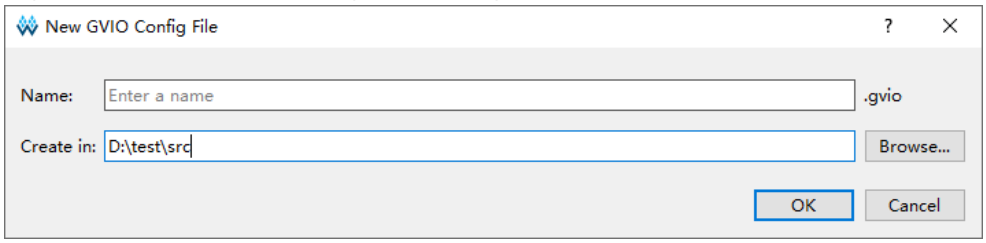


Figure 3-2 New GVIO Config File Dialog Box



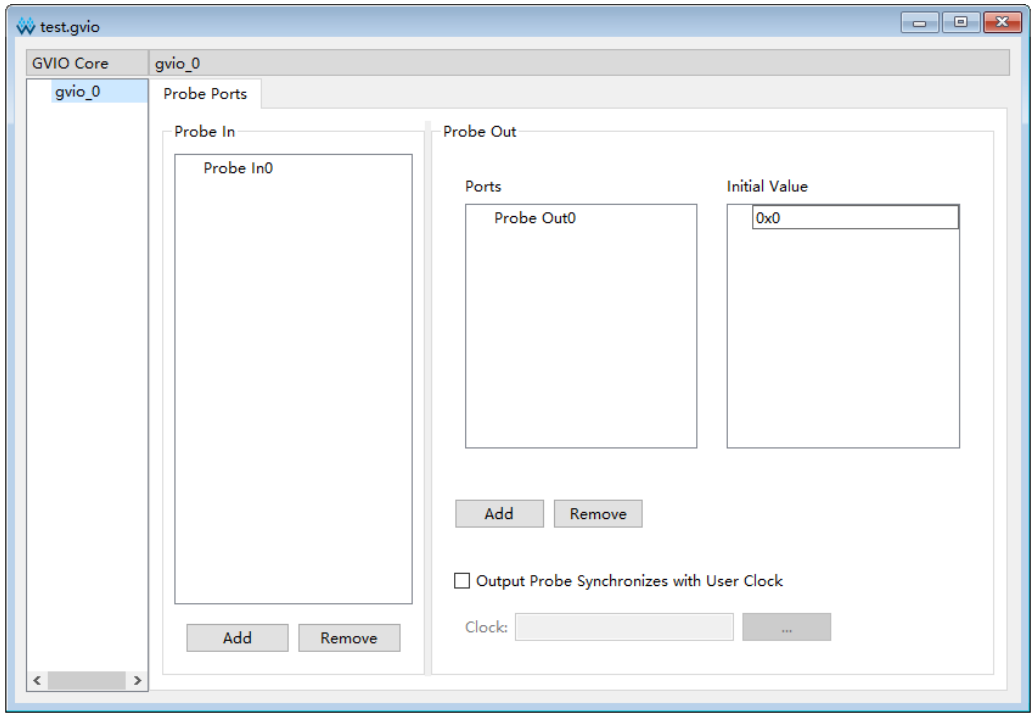
Add GVIO Config File

The steps are as follows.

1. In the "Design" view, right-click to select "Add Files...". The "Select Files" window will pop up.
2. Select an existing GVIO configuration file (.gvio) and load it into the "Design" window of the project.

Double-click the configuration file (.gvio) in the "Design" view. The GVIO Config window will pop up, as shown in Figure 3-3. The GVIO configuration window includes the GVIO Core view for configuring the number of AO cores and their corresponding signal configuration view. The core signal configuration view consists of "Probe In" view for configuring sampling signals and "Probe Out" view for configuring stimulus signals.

Figure 3-3 GVIO Configuration Window



3.1.2 Configure GVIO File

The GVIO configuration window is used to configure the number of AO cores, sampling signals, and stimulus signals.

AO Core Configuration

The GVIO Core is used to display and configure the number of AOs used by current project, as shown in Figure 3-4. GVIO Core view initially includes only gvio_0, supporting up to 16 cores arranged sequentially as gvio_0 to gvio_15, and you can perform the following operations:

1. Right-click anywhere in the "GVIO Core" view and select "Add" to add a new GVIO Core.
2. Select and right-click a core in "GVIO Core" view and select "Remove" to remove a core.
3. When a core is deleted, the subsequent core number decreases successively, and the core number increases continuously.
4. If you select a core, the signal configuration view on the right will display the configuration view corresponding to that Core, as shown in Figure 3-5. For example, if you select "gvio_3" in the GVIO Core view, the right side will show the configuration view for "gvio_3."

Note!

- When there is only one core in the GVIO Core view, it is not allowed to delete it. If the core is selected and right-click "Remove", the prompt will pop up, as shown in Figure 3-6.
- 16 cores are supported at most. When more than 16 cores are added, a prompt box will pop up, as shown in Figure 3-7.

Figure 3-4 GVIO Core View

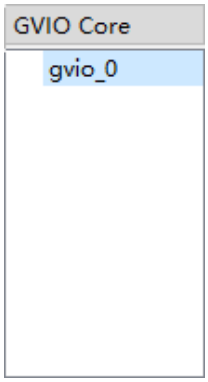


Figure 3-5 Configuration View of Selected Core

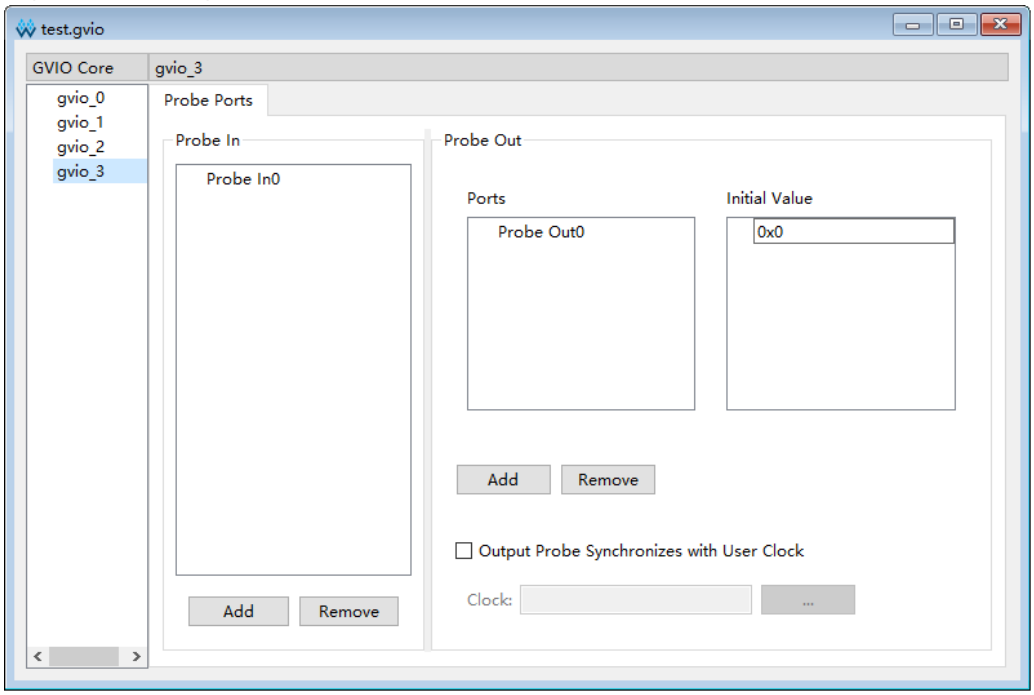


Figure 3-6 Prohibit Deletion of the Only GVIO Core

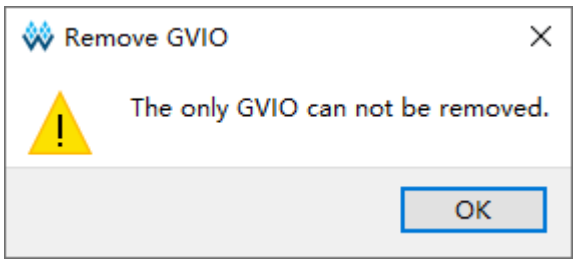
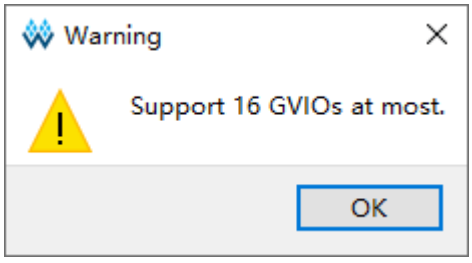


Figure 3-7 Warning for GVIO Core Quantity Limit



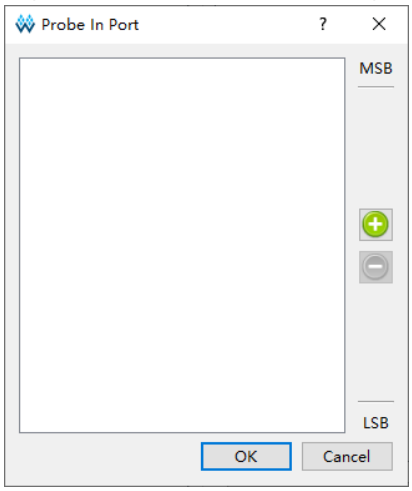
Sampling Signal Configuration

The Probe In view is used to configure the sampling signal ports of AO core, as shown in Figure 3-3. Probe In supports up to 64 sampling signal ports, including Probe In0 ~ Probe In63. Each port has a bit-width range of 1 to 256. The specific operations for the Probe In view are as follows:

1. Click the "Add" button to add a Probe In port.
2. Click "Remove" button to delete a Probe In port.

3. Double-click on one of the Probe In ports to open the "Probe In Port" dialog box, as shown in Figure 3-8.
4. Click "  " and the "Search Nets" dialog box pops up. Click "Search" complete the signal matching, as shown in Figure 3-9. The signals grayed out are not available.
5. Select the sampling signal and click "OK" to complete the selection of the sampling signal.

Figure 3-8 Probe In Port Dialog Box



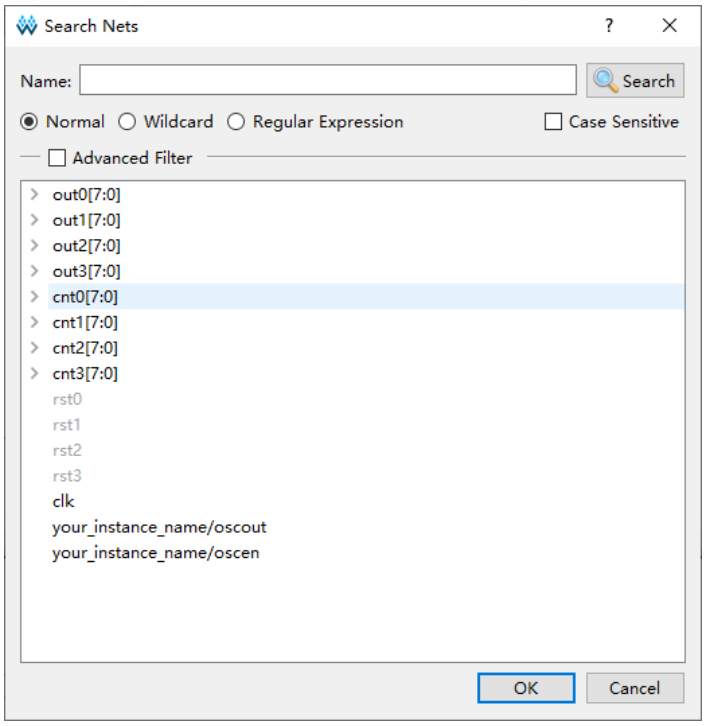
Note!

MSB and LSB in Figure 3-8 represent the most significant bit and least significant bit of the sampling signal port respectively.

The signals in the Probe In Port dialog box can be operated as follows:

- Deletion of sampling signals is supported. Left-click to select a single port, or use Shift+left-click or Ctrl+left-click to select multiple signals, then click "  " to complete deletion.
- Signal sorting are supported. Left-click to select a single port, or use Shift+left-click or Ctrl+left-click to select multiple signals, then left-click and drag to complete signal sorting.
- The same signal cannot be added repeatedly in a single Probe In Port. The rules are as follows.
  - If a single signal is added again, the addition will fail.
  - If a sub-signal of a bus signal is already added, when the bus signal is added again, the previously added sub-signal will be removed, retaining the entire bus signal.
  - If a bus signal is already added, adding its sub-signal will fail.

Figure 3-9 Probe In Port Search Nets Dialog Box



Normal, Wildcard, and Regular Expression are mutually exclusive in Search Nets dialog box.

- Normal means searching in a normal way. Click "Search" to match the string in "Name" text box, as shown in Figure 3-10.
- Wildcard means searching with wildcard. Click "Search" to match the string in "Name" text box. The string contains wildcards (*,?) , as shown in Figure 3-11.
- Regular expression means searching with a regular expression. Click "Search" to match the string in "Name" text box, as shown in Figure 3-12.
- If "Case Sensitive" is checked, the case-sensitive rule will be applied during signal matching. The Signal area below the Search Nets dialog box supports functions such as single selection with the left click, multi-selection with Shift+left-click and Ctrl+left-click.

Figure 3-10 Normal Mode

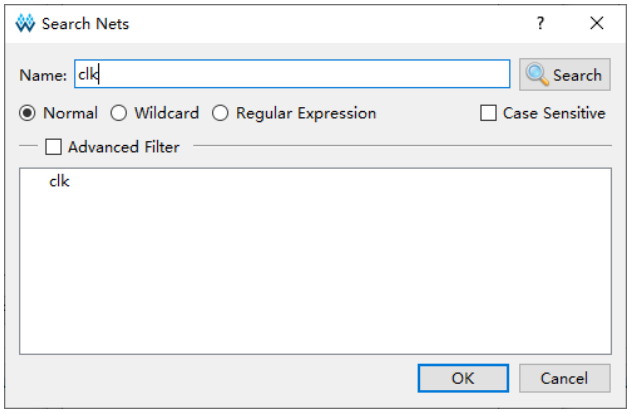


Figure 3-11 Wildcard Mode

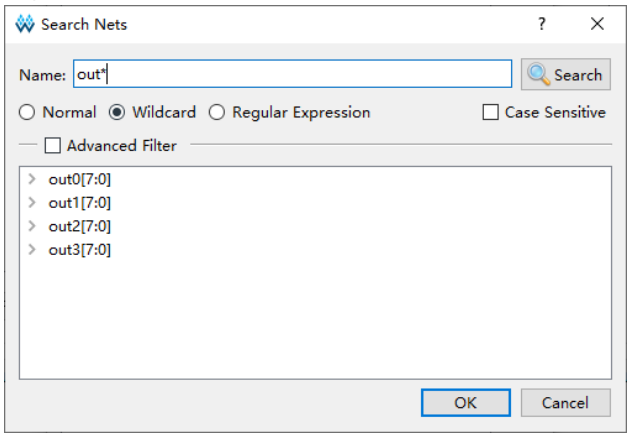
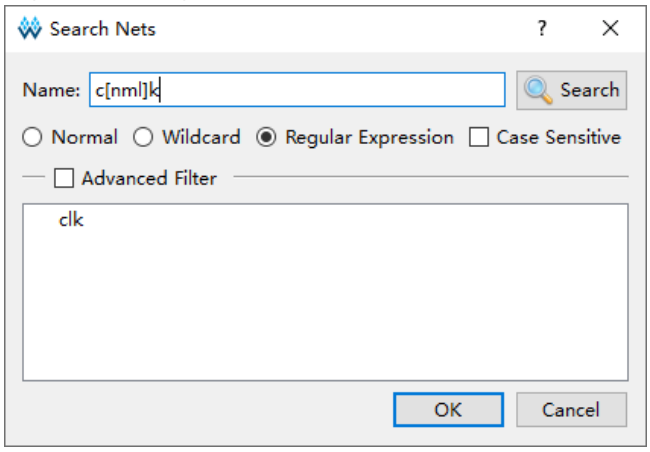


Figure 3-12 Regular Expression Mode

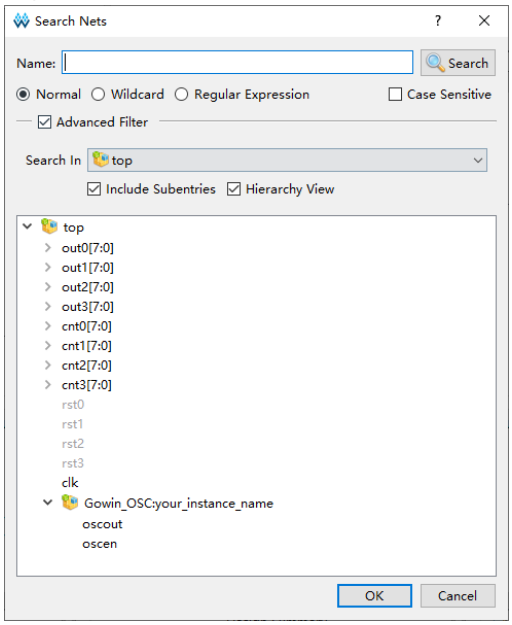


Select the "Advanced Filter" to further define filter conditions to search the required signals more specifically. Among them:

- 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.
- The "Hierarchy View" is used to display signals through the hierarchical structure designed by the user.

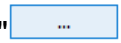
For example, as shown in Figure 3-13, selecting "top" under "Search In", along with checking "Include Subentries" and "Hierarchy View", then clicking the "Search" button, all relevant signals will be displayed from the top module and its submodules in a hierarchical structure.

Figure 3-13 Advanced Filter



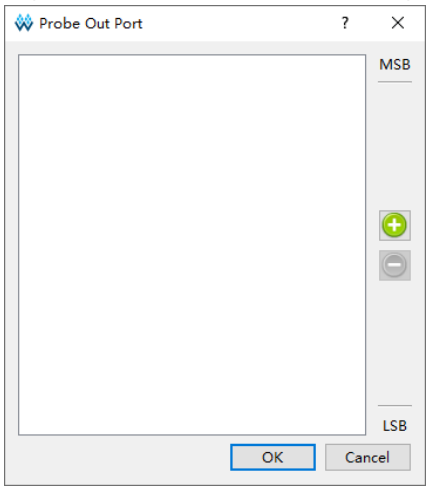
Configure Stimulus Signals

The Probe Out view is used to configure stimulus signal ports of the AO core, consisting of "Ports", "Initial Value", and "Output Probe Synchronizes with User Clock", as shown in Figure 3-3. Up to 64 stimulus signal ports are supported, including Probe Out0 ~ Probe Out63. Each port has a bit-width range of 1 to 256. Initial Value is used to set the initial value for each corresponding stimulus signal. Output Probe Synchronizes with User Clock is used to determine whether the stimulus signals should synchronize with the user-defined clock signal. Specific operations in the Probe Out view include:

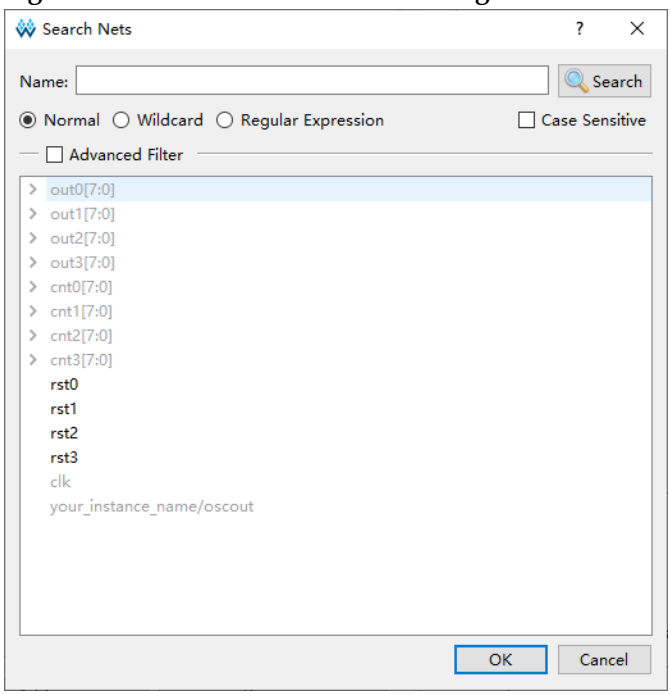
- Click the "Add" button to add a Probe Out port.
- Click the "Remove" button to delete a Probe Out port.
- Double-click on a Probe Out port to open the Probe Out Port dialog box, as shown in Figure 3-14.
- Click "  " to open the "Search Nets" dialog box, then click the "Search" button to complete signal matching, as shown in Figrue 3-15. The signals grayed out are not available. Signals without a source can be used as stimulus signals.
- Select the stimulus signal and click "OK" to complete the selection.
- Set the corresponding Initial Value for the stimulus signal on the right side, with the default value 0 displayed in hexadecimal.
- Check "Output Probe Synchronizes with User Clock" to synchronize the stimulus signals with the user-defined clock. Click " 

" button next to "Clock" to open the "Search Nets" dialog box for adding the clock signal.

Figure 3-14 Probe Out Port Dialog Box



Figrue 3-15 Out Port Search Nets Dialog Box



Note!

- When saving the configuration file (.gvio), if a configured synchronous clock signal does not exist, a prompt message will pop up, indicating the absence of the synchronous clock signal, as shown in Figure 3-16.
- If "Output Probe Synchronizes with User Clock" is enabled but no synchronous clock is configured, a prompt message will pop up, indicating no synchronous clock is specified, as shown in Figure 3-17.
- Probe In and Probe Out ports can be left without signal configurations individually, but both cannot be left without signals simultaneously; otherwise, an error will occur, as shown in Figure 3-18.

Figure 3-16 Absence of the Synchronous Clock Signal

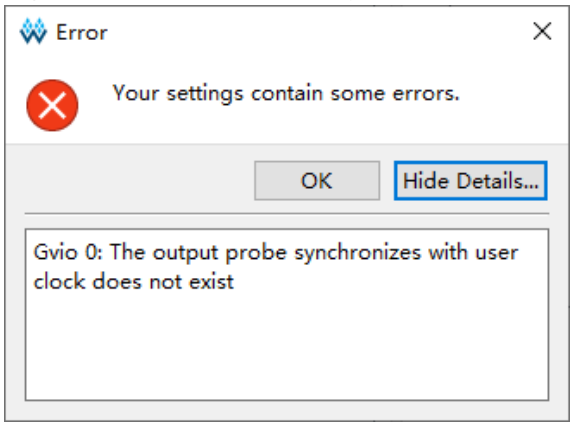


Figure 3-17 No Synchronous Clock Specified

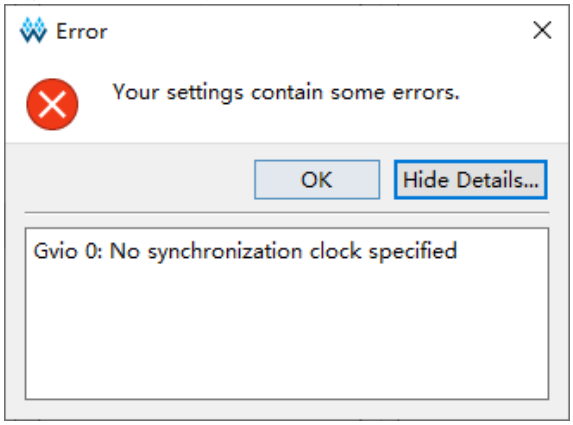
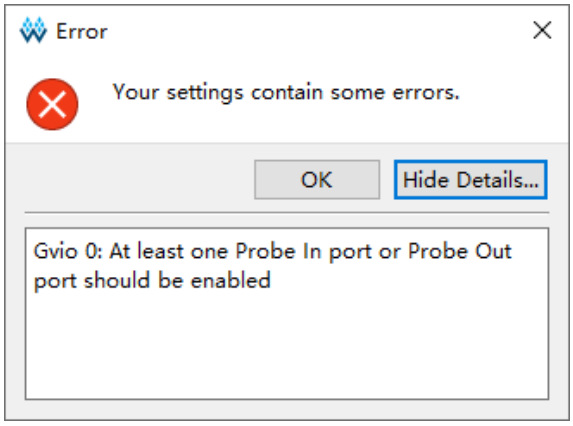


Figure 3-18 Probe In and Probe Out Disabled Simultaneously



3.1.3 Generate Bitstream File

After completing GVIO files configuration, double-click "Place & Route" in the "Process" to run PnR. This process generates a bitstream file containing user designs and GVIO configuration. By default, the file name is the project's name and is placed in the "/impl/pnr/" directory under the project path.

4 GVIO Usage

GVIO is primarily used to reconfigure the values of stimulus port signals through the JTAG interface, and it can also sample and display signal data, which aims to make it easier for users to debug and observe data signals.

For RTL Design GAO (.rao), jointly debugging with the GVIO is possible. However, for Post-Synthesis Netlist GAO (.gao), jointly debugging is not supported. The following sections introduce debugging with GVIO standalone and jointly debugging with GVIO and GAO.

4.1 Debugging with GVIO Standalone

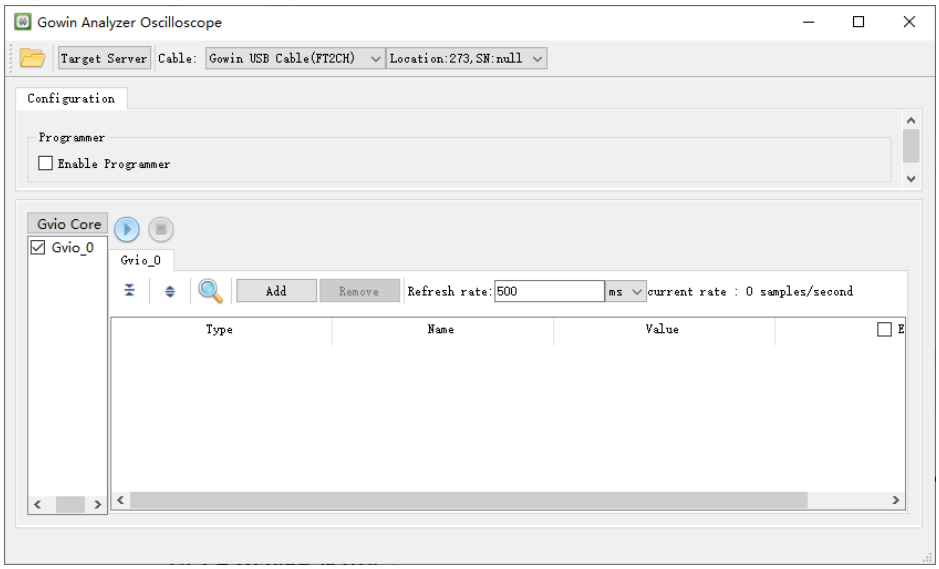
4.1.1 Start GVIO

Since GVIO is similar to GAO as a logic analysis tool, both GVIO and GAO use Gowin Analyzer Oscilloscope tool for operation. The steps to load a .gvio configuration file are as follows:

1. Select "Tools" from the menu bar.
2. Select "Gowin Analyzer Oscilloscope" from the pull-down list to start GVIO. By default, it will load the active .gvio configuration file in the project, as shown in Figure 4-1. Alternatively, you can click the "Open" button and select the .gvio configuration file you need to load.

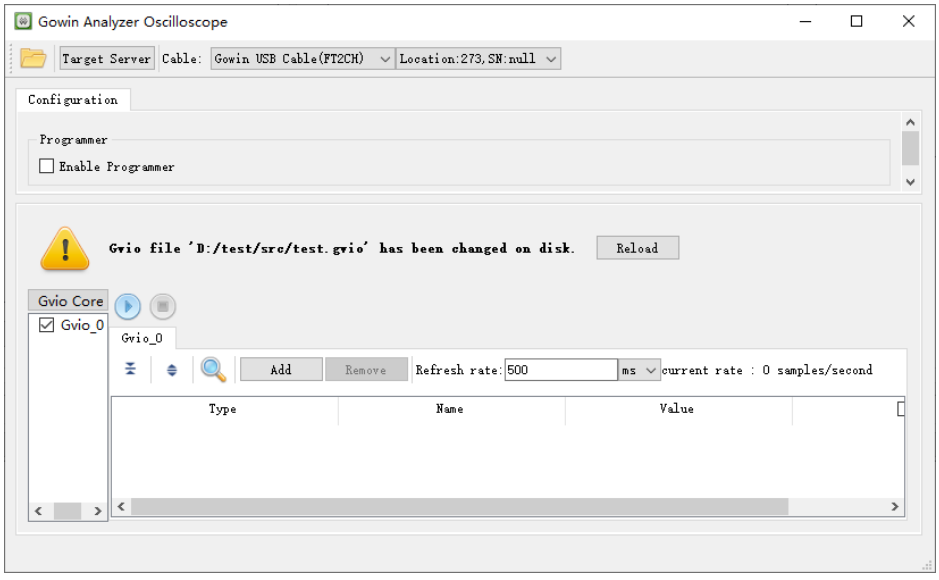
Additionally, clicking "  " on the IDE toolbar icon will also start the GVIO. For the configuration process of the .gvio file, please see section 3.1.2 Configure GVIO File.

Figure 4-1 GVIO Configuration Window



After the .gvio configuration file is updated, GVIO will display a Reload prompt box, as shown in Figure 4-2. Click the "Reload" button to reload the updated .gvio file.

Figure 4-2 Reload Prompt



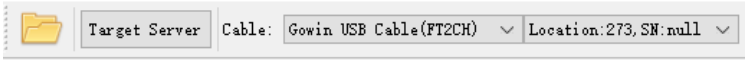
4.1.2 Run GVIO

As shown in Figure 4-1, GVIO window include toolbar and Configuration View. The toolbar allows for loading configuration files (.gvio), setting the Target Server, and configuring the Cable type. The Configuration view includes Programmer and AO core configuration, and AO core configuration comprises GVIO Core enable configuration, stimulus signal configuration, and the display of sampling signal data.

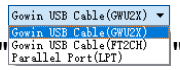
Toolbar

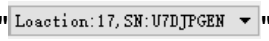
The toolbar of the GAO includes "  ", "Target Server", and "Cable", as shown in Figure 4-3.

Figure 4-3 Toolbar



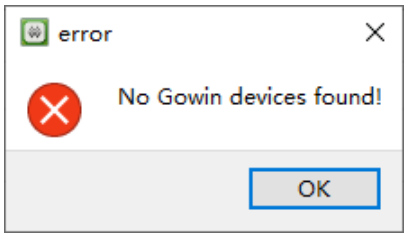
The detailed descriptions are as follows:

- "  ": Used to load configuration file (.gvio).
- Target Server: Used to connect GVIO to a Local server or Remote server. For the details, see the Target Server descriptions in Section 4.1.2 in *SUG114, Gowin Analyzer Oscilloscope User Guide*.
- " 

": The capture window supports serial download via Gowin USB Cable (GWU2X) and Gowin USB Cable (FT2CH) as well as parallel download via Parallel Port (LPT). When the GVIO interface is opened, the tool automatically scans the Cable type. When using GVIO Programmer to download Bitstream or to send stimulus and sampling data, the Cable type must be selected correctly, otherwise an error will occur, as shown in Figure 4-4.
- " 

": Used to automatically scans the connected cables and displays the corresponding Location and SN code parameters. When connected to dual-channel cables or multiple cables, you can manually select the corresponding cable based on these parameters for operation.

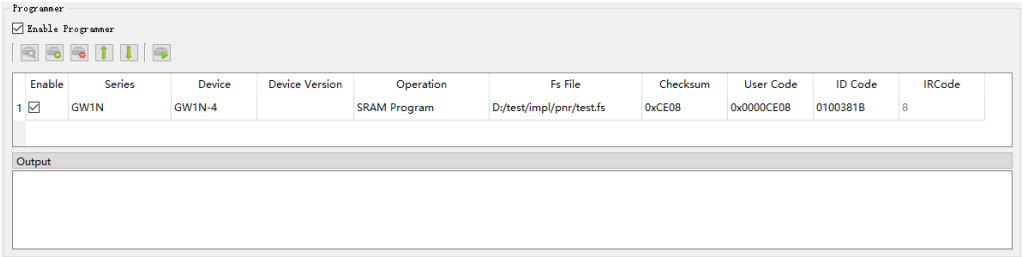
Figure 4-4 Incorrect Cable Prompt



Programmer

GVIO interface integrates the Programmer, similar to GAO Programmer, as shown in Figure 4-5. For details, see section 4.1.2 of *SUG114, Gowin Analyzer Oscilloscope User Guide*.

Figure 4-5 GVIO Programmer



GVIO Core Enable

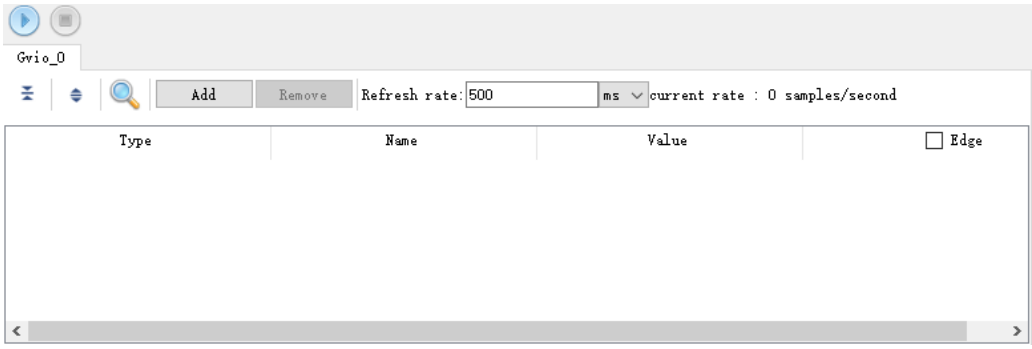
GVIO supports up to 16 cores. In the GVIO interface, you can enable each core by checking the checkbox before Gvio_0~Gvio_15. Only enabled GVIO cores can provide operations for stimulus signals and sampling signals, as shown in Figure 4-6.

Figure 4-6 GVIO Core Configuration

Stimulus and Sampling Signal Configuration

The stimulus and sampling signal configuration view is shown in Figure 4-7. During GVIO runtime, you can dynamically configure the values of stimulus signals and periodically read back sampling signal data. This view includes toolbar andsignal display list areas.

Figure 4-7 Stimulus and Sampling Signal Configuration



The toolbar includes the following functions.

- "  ": Start button; click this button to start GVIO to send stimulus signal and periodically read back sampling data.
- "  ": Stop button; click this button to stop the operations of stimulus signal transmission and reading back sampling data.
- "  ": Collapse button; click this button to collapse all bus signals in the signal list area.
- "  ": Expand button; click this button to expand all bus signals in the signal list area.

- "  ": Search button; click this button to search signals in the signal list area.
- "Add": Click this button to open the Search Nets dialog box for adding stimulus and sampling signals. Signals already added to the list will not appear in the Search Nets dialog box.
- "Remove": Click this button to delete selected signals from the list.
- "Refresh rate": Used to set the period for reading back sampling signals, with units in milliseconds (ms) and seconds (s). You can choose one from the drop-down menu, and the default is 500 ms, the minimum is 1 ms. After clicking "Start", GVIO will read sampling signal according to the Refresh rate. It will drive stimulus signals through the JTAG ports into the design after the user updates the stimulus signal values.
- "Current rate": Used to display the actual frequency of reading back sampling signal, defaulting to 0 Samples/second.

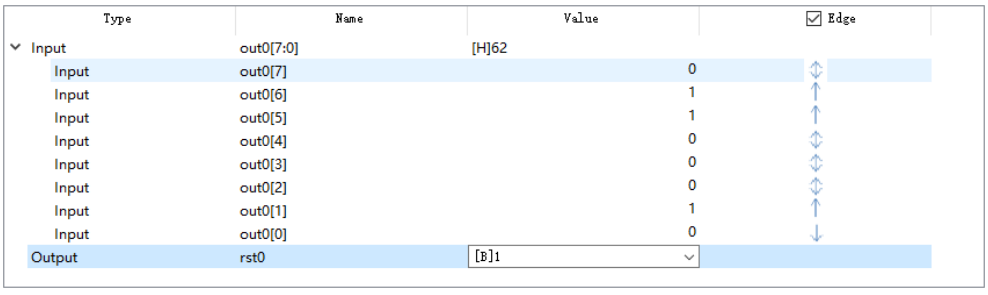
The signal list includes 4 columns:

- Type: Indicates the direction of the signals; input for sampling signals, and output for stimulus signals.
- Name: Displays the name of the signal.
- Value: Shows the value of sampling signal and stimulus signal.
- Edge: When Edge is enabled, this column displays the direction change for sampling signals over a certain period, including rising edge, falling edge, and both rising and falling edges simultaneously, as shown in Figure 4-8.

Note!

Signals in the list can be reordered by dragging them up or down.

Figure 4-8 Signal Direction Change in Edge Column



When selecting a sampling signal in the signal list and right-clicking, the pop-up menu includes the followings, as shown in Figure 4-9.

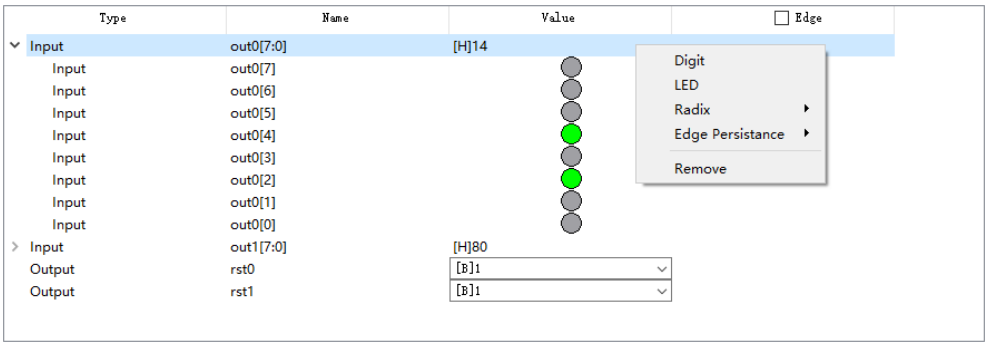
- Digit: Displays the value of the sampling signal in number.
- LED: Displays the value of the sampling signal using LED. Green represents a high level, while gray represents a low level. For example, out0[0] is displayed as a gray LED, indicating a low level, and out0[2] is displayed as a green LED, indicating a high level, as shown in Figure 4-9.

- Radix: Modifies the radix of bus signals. There are 5 options available: Binary, Octal, Signed Decimal, Unsigned Decimal, and Hexadecimal. The default radix is Hexadecimal.
- Edge Persistence: Indicates the arrow display time of the level change in the Edge column, the drop-down list of this option includes 8 Samples, 40 Samples, 80 Samples and Infinite, which represent the four time ranges of Refresh Rate *8, Refresh Rate *40, Refresh Rate *80 and Infinite four time ranges, respectively.
- Remove: Deletes the selected sampling signal.

Note!

- When setting the right-click menu for a bus signal to Digit or LED, all sub-signals will display data uniformly according to the chosen display method, while the bus signal itself will always display data in Digit form.
- When setting the right-click menu for a sub-signal to Digit or LED, only the selected sub-signal will display data according to the chosen display method, while the bus signal itself will always display data in Digit form.

Figure 4-9 Right-click Menu for Sampling Signal



When a stimulus signal is selected in the signal list and the right-click menu is opened, the pop-up menu includes the followings, as shown in Figure 4-10.

- Digit: Displays the value of the sampling signal in number.
- Active-High Button: Represents the stimulus signal value as a button. The initial value is 0. When the button is pressed, the value changes to 1, and the button color turns white. When the button is released, the value returns to 0, and the button color turns gray, such as the rst0 Value column in the Figure 4-10.
- Active-Low Button: Represents the stimulus signal value as a button. The initial value is 1. When the button is pressed, the value changes to 0, and the button color turns gray. When the button is released, the value returns to 1, and the button color turns white, such as the rst1 Value column in the Figure 4-10.
- Toggle Button: Represents the stimulus signal value as a toggle button. Each click toggles the signal value between high and low, such as the rst2 Value column in the Figure 4-10.
- Radix: Modifies the radix of bus signals. There are 5 options: Binary, Octal, Signed Decimal, Unsigned Decimal, and Hexadecimal. The

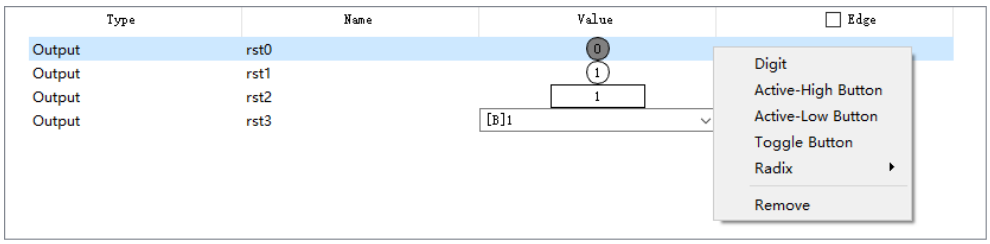
default radix is Hexadecimal.

- Remove: Deletes the selected stimulus signal.

Note!

- The Active-High Button, Active-Low Button, and Toggle Button options are not available to bus signal; bus signals will always be displayed in Digit form.
- When a bus signal is selected with Active-High Button, Active-Low Button, or Toggle Button, these settings apply to all sub-signals.

Figure 4-10 Right-click for Stimulus Signal



4.2 Jointly Debugging with GVIO and GAO

Combining GVIO and GAO provides a more powerful debugging environment. GVIO enables real-time updates of control signals, forces the trigger conditions set in GAO, simulates external sensor data, and other operations. By sampling with GAO, users can obtain the corresponding logical responses, making it easier to debug their designs.

4.2.1 GAO Config File

GVIO can be used together with GAO of the For RTL Design (.rao) for debugging. For information on creating a .rao configuration file, see Chapter 3 of *SUG114, Gowin Analyzer Oscilloscope User Guide*.

4.2.2 GVIO Config File

For information on creating a GVIO configuration file, see the 3.1.2 Configure GVIO File.

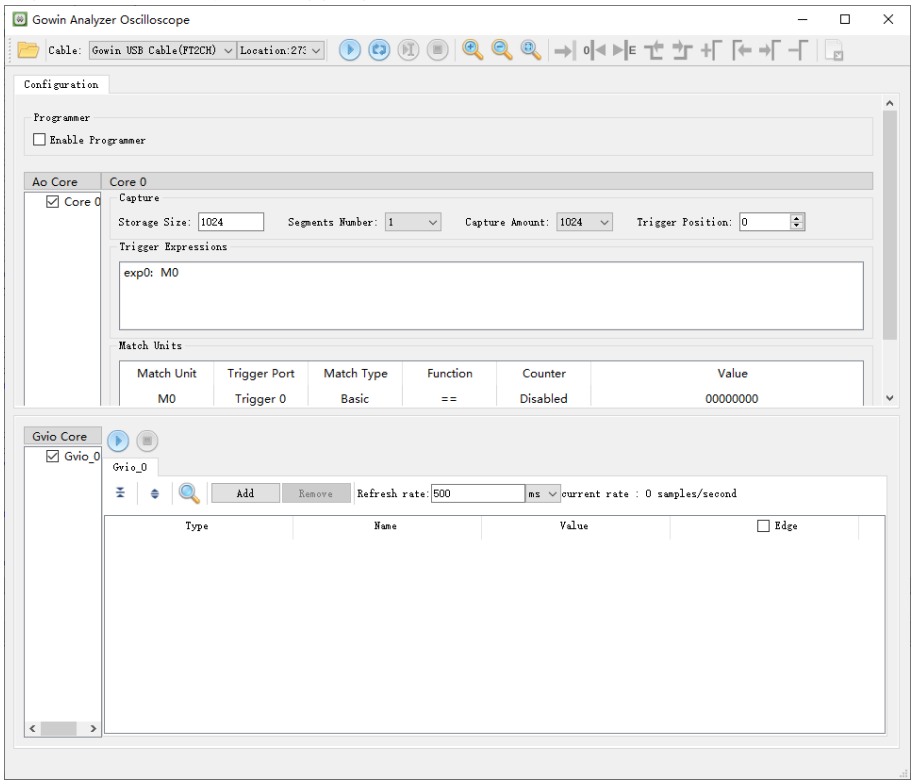
4.2.3 Run GAO and GVIO

When jointly debugging with GVIO and GAO, Gowin Analyzer Oscilloscope tool need to be used. The steps to load the .gvio and .rao configuration files are as follows:

1. Select "Tools" from the menu bar.
2. In the drop-down menu, select "Gowin Analyzer Oscilloscope". This tool will automatically load the active.gvio and .rao configuration files from the project, as shown in Figure 4-11.

Additionally, you can also start Gowin Analyzer Oscilloscope tool by clicking the icon "" on the IDE toolbar .

Figure 4-11 Jointly Debugging with GVIO and GAO



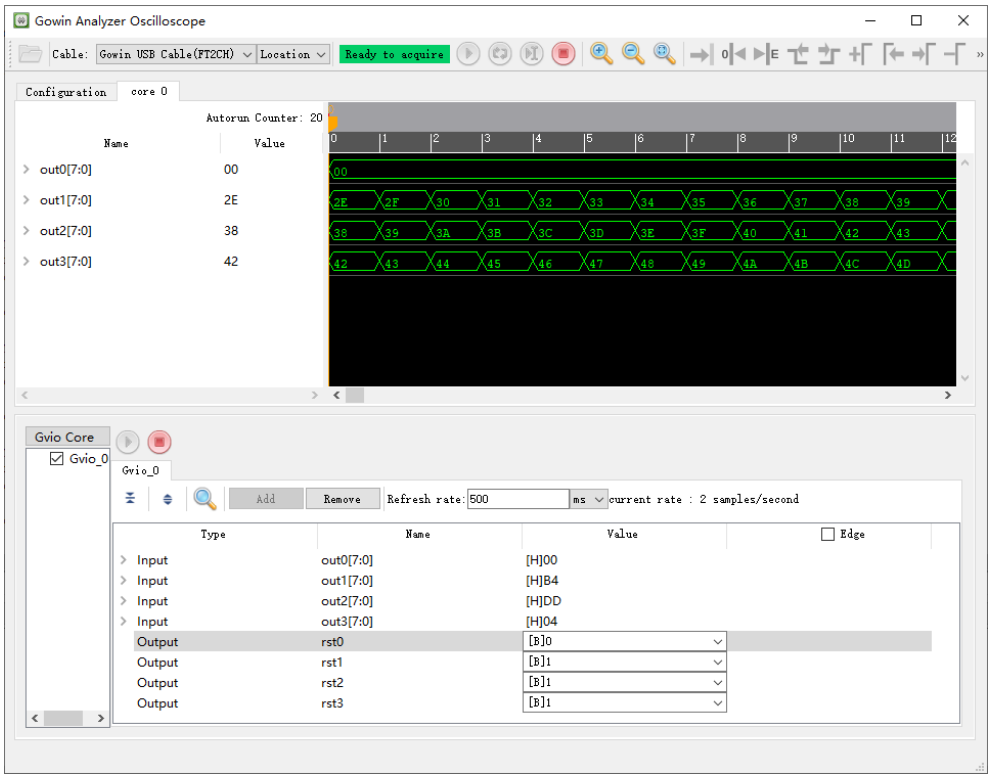
For operations related to the GAO toolbar, Programmer, and AO Core configuration in the interface, see Section 4.1.2 of *SUG114, Gowin Analyzer Oscilloscope User Guide*.

For operations related to the GVIO toolbar and GVIO Core configuration, see 4.1.2 Run GVIO.

As shown in Figure 4-12, there are two "Start" buttons. The upper "Start" button controls GAO operation, while the lower "Start" button controls GVIO operation. GAO and GVIO can run simultaneously or individually. Taking simultaneously running GAO and GVIO as an example in the followings.

As shown in Figure 4-12, rst0, rst1, rst2, and rst3 are respective reset signals for out0, out1, out2, and out3. These signals are active-low. When the signals are provided with stimulus by GVIO (rst0=0, rst1=1, rst2=1, rst3=1), the sampling results from GAO indicate that the out0 signal has been reset.

Figure 4-12 Sampling Results from Jointly Debugging with GVIO and GAO

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