



Gowin Clock User Guide

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Revision History

Date	Version	Description
05/18/2016	1.05E	Initial version published.
07/15/2016	1.06E	The graphics standardized.
08/31/2016	1.07E	GW2A series of FPGA products supported.
10/27/2016	1.08E	GW2A series of FPGA products supported.
09/22/2017	1.09E	Modified according to the latest software source library.
10/16/2017	1.10E	The description of GW1N and related diagrams added.
01/05/2018	1.2E	The description of HCLK updated.
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01/14/2021	1.6E	PLLO, OSCO, CLKDIVG and DCCG modules added.
02/01/2021	1.7E	<ul style="list-style-type: none"> ● CLKOUTD3 timing of rPLL added. ● The description of PLLO updated. ● GW1NR-2, GW2AN-55C added.
04/13/2021	1.7.1E	GW1NZ-2 removed.
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08/10/2022	1.9.5E	Device supported of rPLL and OSC updated.
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09/12/2023	1.9.7E	<ul style="list-style-type: none"> ● The configuration box File modified to General and Device Version option added on the IP interface. ● The description of PLL duty cycle trim updated.

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1 About This Guide

1.1 Purpose

This manual provides descriptions of the function, primitive definition and usage of Gowin clock.

1.2 Related Documents

The latest user guides are available on GOWINSEMI® Website. Refer to the related documents at www.gowinsemi.com:

- [DS100, GW1N series of FPGA Products Data Sheet](#)
- [DS117, GW1NR series of FPGA Products Data Sheet](#)
- [DS821, GW1NS series of FPGA Products Data Sheet](#)
- [DS861, GW1NSR series of FPGA Products Data Sheet](#)
- [DS871, GW1NSE series of FPGA Products Data Sheet](#)
- [DS841, GW1NZ series of FPGA Products Data Sheet](#)
- [DS102, GW2A series of FPGA Products Data Sheet](#)
- [DS226, GW2AR series of FPGA Products Data Sheet](#)

1.3 Terminology and Abbreviations

The terminology and abbreviations used in this manual are as shown in Table 1-1.

Table 1-1 Terminology and Abbreviations

Terminology and Abbreviations	Meaning
CIU	Configurable Interface Unit
CLKDIV	Clock Divider
CRU	Configurable Routing Unit
DCC	HCLK Duty Cycle Correction
DCS	Dynamic Clock Selector
DHCEN	Dynamic HCLK Clock Enable with Inverted Gate
DLLDLY	DLL Delay

Terminology and Abbreviations	Meaning
DQCE	Dynamic Quadrant Clock Enable
DQS	Bidirectional Data Strobe Circuit for DDR Memory
GCLK	Global Clock
HCLK	High-speed Clock
LW	Long Wire
OSC	Oscillator
PCLK	Primary Clock
PLL	Phase-locked Loop

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 Overview

This chapter describes the clock resources of GOWINSEMI FPGA products, including the dedicated clock input, buffers, and routing resources. The basic clock resources include a series of low-capacity and low-offset interconnect wires that are suitable for high frequency signals and can help reduce clock jitter and improve the performance, which can be applied to all clock signals.

The clock resources and routing are critical for high-performance applications of FPGA. GOWINSEMI FPGA products provide the global clock (GCLK) including primary clock (PCLK) and long wire (LW), which connects directly to all the resources. Besides the global clock network, clock resources such as PLL, high-speed clock HCLK, and DQS in DDR memory interface are also provided.

2.1 Global Clock

GCLKs are distributed in quadrants in Gowin FPGA products, and GCLKs in LittleBee® (1K, 2K, 4K) family FPGA products are divided into two quadrants, L and R, as shown in Figure 2-1. The GCLKs in LittleBee® (9K) and Arora family FPGA products are divided into four quadrants, BL, BR, TL, and TR, as shown in Figure 2-2. Each quadrant provides eight GCLK networks, and the selectable clock sources for each GCLK include dedicated clock input pins and common routing resources. Dedicated clock input pins can provide better clock performance.

LW can be used as a control wire to provide clock enable (CE) and reset (SET/RESET) signals to the DFF on one hand, and as a logic wire for general data signals on the other hand.

Figure 2-1 Quadrant Distribution of GCLKs in the LittleBee® FPGA Family (1K, 2K, 4K)

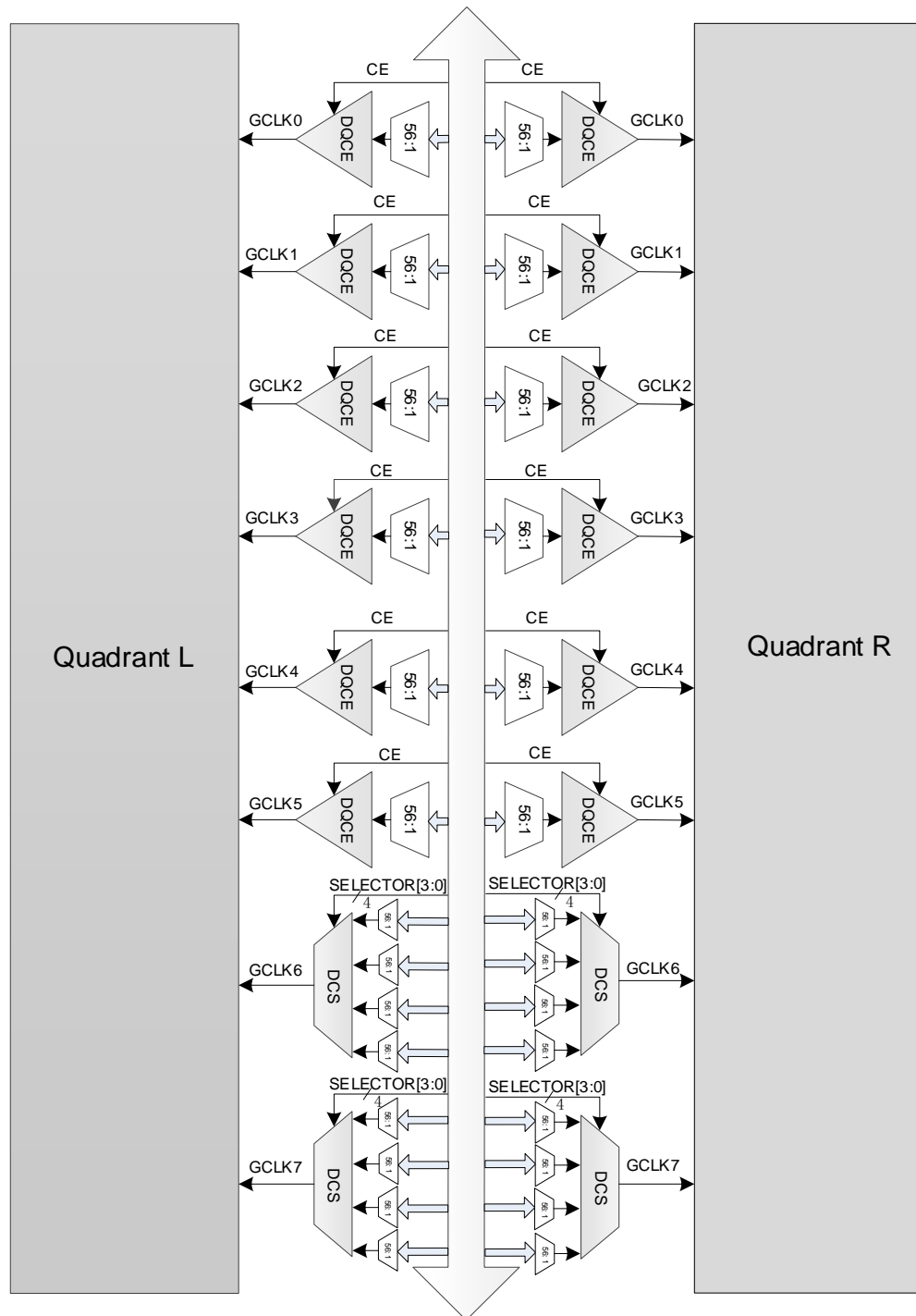
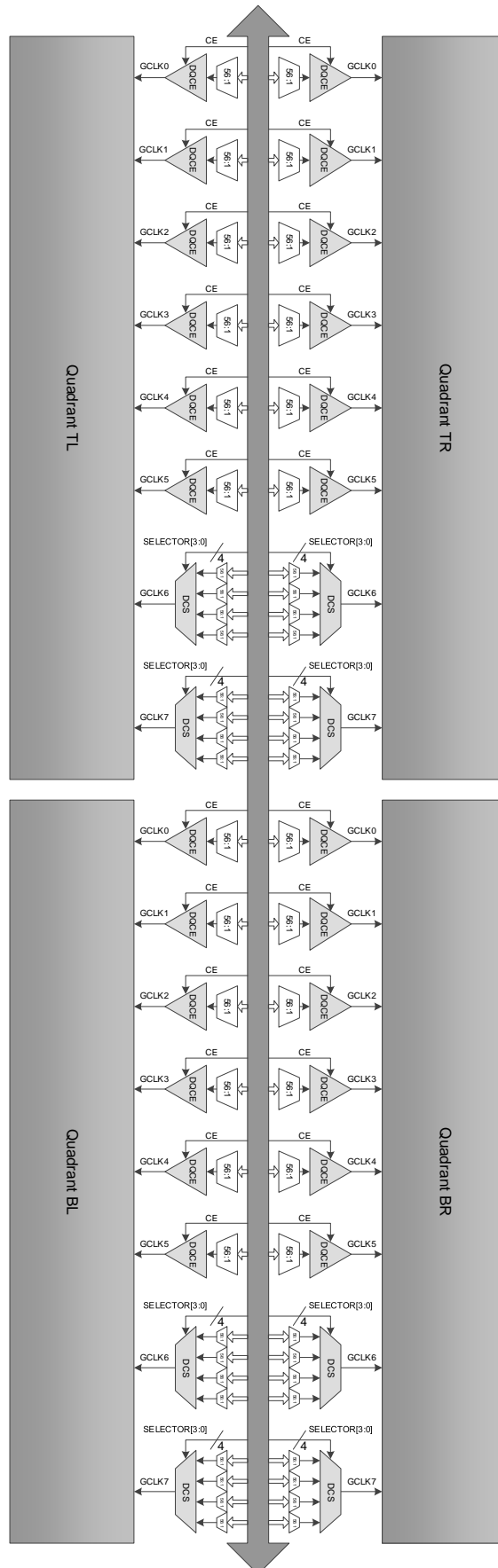


Figure 2-2 Quadrant Distribution of GCLKs in the LittleBee® (9K) and Arora FPGA Family



GCLK0~GCLK5 in each quadrant are dynamically controlled by DQCE to turn on/off. When GCLK0~GCLK5 in the quadrant are off, all the logic driven by them will not toggle; therefore, lower power consumption can be achieved.

GCLK6~GCLK7 in each quadrant are controlled by DCS. The internal logic can dynamically be selected within the four clock inputs through CRU and output a clock without glitches.

2.2 HCLK

HCLK is the high-speed clock in the GOWINSEMI FPGA products. It offers low jitter and low deviation, which can support high-speed data transfer. It is mainly suitable for source synchronous data transfer protocols. There is an HCLKMUX module in the middle of the high-speed clock HCLK. HCLKMUX can send the HCLK clock signal from bank to bank; as such, HCLK can be used flexibly.

For HCLK diagrams, please refer to the following related documents.

- [DS100, GW1N series of FPGA Products Data Sheet](#)
- [DS117, GW1NR series of FPGA Products Data Sheet](#)
- [DS821, GW1NS series of FPGA Products Data Sheet](#)
- [DS861, GW1NSR series of FPGA Products Data Sheet](#)
- [DS871, GW1NSE series of FPGA Products Data Sheet](#)
- [DS841, GW1NZ series of FPGA Products Data Sheet](#)
- [DS102, GW2A series of FPGA Products Data Sheet](#)
- [DS226, GW2AR series of FPGA Products Data Sheet](#)

2.3 PLL

Phase-locked Loop (PLL) is a feedback control circuit. The frequency and phase of the internal oscillator signal are controlled by the external input reference clock.

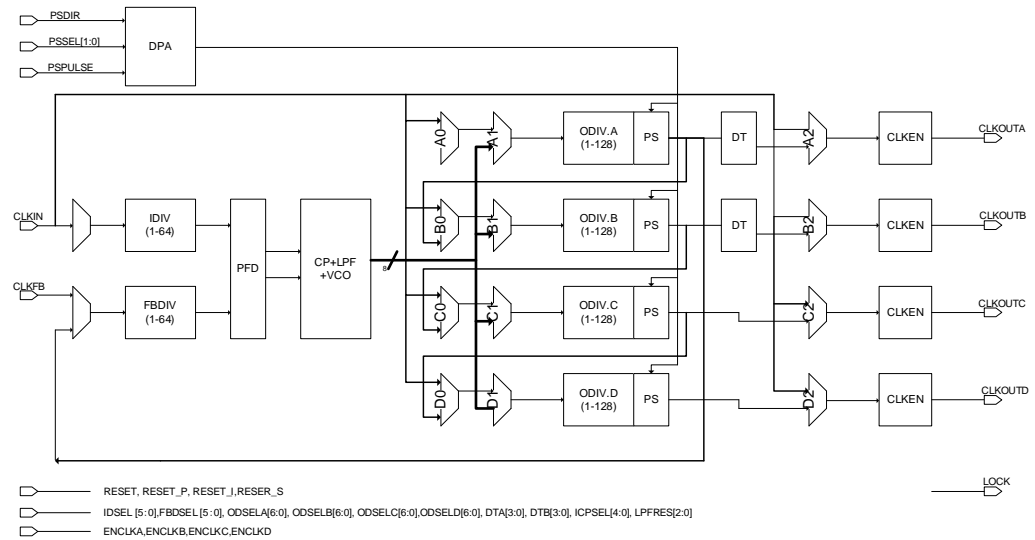
PLL blocks in the GOWINSEMI FPGA products provide the ability to synthesize clock frequencies. Frequency adjustment (multiplication and division), phase shift, and duty cycle adjustment can be realized by parameters configuration.

2.3.1 GW1N-1P5/GW1N-2/GW1NR-2/GW2AN-18X/GW2AN-9X

Note!

The description in this section only applies to the devices of GW1N-1P5, GW1N-2, GW1NR-2, GW2AN-18X, and GW2AN-9X.

See Figure 2-3 for the PLL structure of GW1N-1P5, GW1N-2, GW1NR-2, GW2AN-18X, and GW2AN-9X.

Figure 2-3 PLL Structure

See Table 2-1 for definitions of the PLL ports.

Table 2-1 PLL Ports Definition

Port Name	Signal	Description
CLKIN	I	Reference clock input
CLKFB	I	Feedback clock input
RESET	I	PLL reset
RESET_P	I	PLL Power Down
RESET_I	I	PLL with IDIV reset
RESET_S	I	Only Channel B/C/D reset
IDSEL [5:0]	I	Dynamic IDIV control: 1~64
FBDSEL [5:0]	I	Dynamic FBDIV control: 1~64
ODSELA[6:0]	I	Dynamic ODIVA control: 1~128
ODSELB[6:0]	I	Dynamic ODIVB control: 1~128
ODSELC[6:0]	I	Dynamic ODIVC control: 1~128
ODSELD[6:0]	I	Dynamic ODIVD control: 1~128
DTA[3:0]	I	Dynamic control of CLKOUTA dutycycle
DTB[3:0]	I	Dynamic control of CLKOUTB dutycycle
ICPSEL[4:0]	I	Dynamic control of ICP size
LPFRES[2:0]	I	Dynamic control LPFRES size
PSDIR	I	Dynamic control of phase shift direction
PSSEL[1:0]	I	Dynamic control of phase shift channel selection
PSPULSE	I	Dynamic control of phase shift clock
ENCLKA ENCLKB ENCLKC ENCLKD	O	Dynamic control of clock output enable
CLKOUTA	O	Clock output of Channel A (by default)

Port Name	Signal	Description
CLKOUTB	O	Clock output of Channel B (by default)
CLKOUTC	O	Clock output of Channel C (by default)
CLKOUTD	O	Clock output of Channel D (by default)
LOCK	O	PLL lock status: 1: locked, 0: unlocked

The PLL reference clock source can come from an external PLL pin or from internal routing GCLK, HCLK, or general data signal. PLL feedback signal can come from the external PLL feedback input or from internal routing GCLK, HCLK, or general data signal.

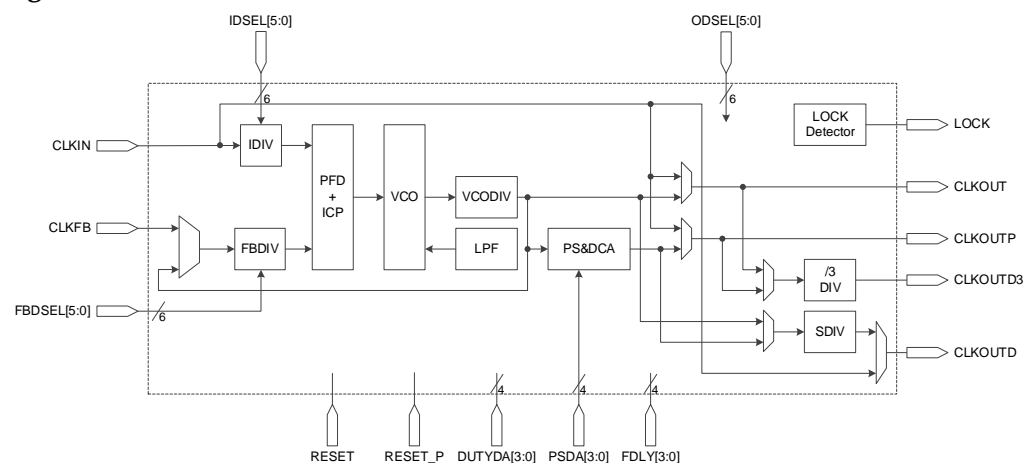
2.3.2 Other Devices in LittleBee® family and Arora family

Note!

The description in this section applies to all devices in LittleBee® family and Arora family except GW1N-1P5, GW1N-2, GW1NR-2, GW2AN-18X, and GW2AN-9X.

See Figure 2-4 for the PLL structure.

Figure 2-4 PLL Structure



See Table 2-2 for a definition of the PLL ports.

Table 2-2 PLL Ports Definition

Port Name	Signal	Description
CLKIN	I	Reference clock input
CLKFB	I	Feedback clock input
RESET	I	PLL reset
RESET_P	I	PLL Power Down
IDSEL [5:0]	I	Dynamic IDIV control: 1~64
FBDSEL [5:0]	I	Dynamic FBDIV control:1~64
PSDA [3:0]	I	Dynamic phase control (rising edge effective)
DUTYDA [3:0]	I	Dynamic duty cycle control (falling edge effective)
FDLY[3:0]	I	CLKOUTP dynamic delay control

Port Name	Signal	Description
CLKOUT	O	Clock output with no phase and duty cycle adjustment
CLKOUTP	O	Clock output with phase and duty cycle adjustment
CLKOUTD	O	Clock divider from CLKOUT and CLKOUTP (controlled by SDIV)
CLKOUTD3	O	clock divider from CLKOUT and CLKOUTP (controlled by DIV3 with the constant division value 3)
LOCK	O	PLL lock status: 1: locked, 0: unlocked

The PLL reference clock source can come from an external PLL pin or from internal routing GCLK, HCLK, or general data signal. PLL feedback signal can come from the external PLL feedback input or from internal routing GCLK, HCLK, or general data signal.

3 Global Clock

3.1 DQCE

3.1.1 Primitive Introduction

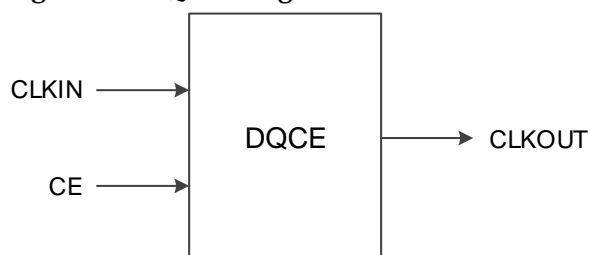
Gowin FPGA devices feature dynamic clock control that allows the internal logic to enable or disable the PCLK network in the quadrant. In addition, the DQCE dynamic clock control can be disabled to always enable the PCLK network. When the PCLK clock network is disabled, all logic driven by this clock is no longer toggled, thus reducing the total power of the device.

Functional Description

GCLK0~GCLK5 can be dynamically turned on/off through DQCE. When GCLK0~GCLK5 in the quadrant is off, all the internal logic driven by them will not toggle; therefore, lower power consumption can be achieved. Normal operation of the DQCE requires the CLKIN signal to have at least one falling edge change.

Port Diagram

Figure 3-1 DQCE Diagram



Port Description

Table 3-1 DQCE Port Description

Port	I/O	Description
CLKIN	Input	Clock input signal
CE	Input	Clock enable signal, active-high.
CLKOUT	Output	Clock output signal

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```
DQCE dqce_inst (  
    .CLKIN(clkin),  
    .CE(ce),  
    .CLKOUT(clkout)  
);
```

Vhdl Instantiation:

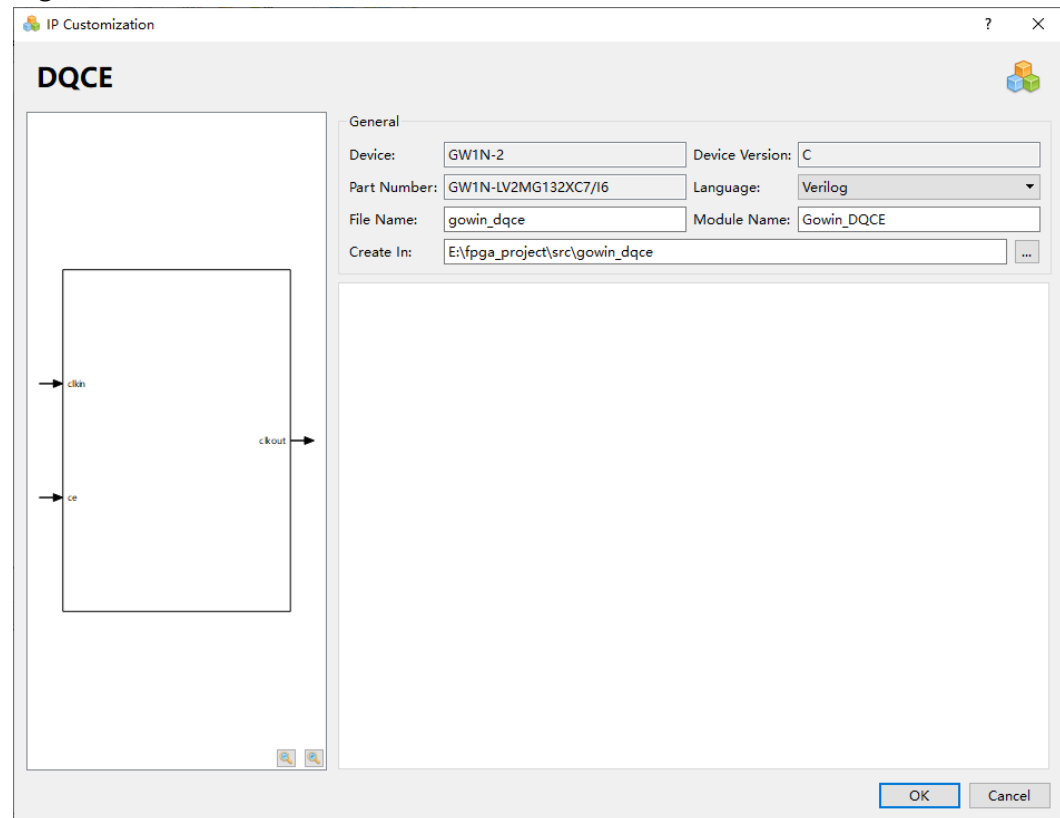
```
COMPONENT DQCE  
    PORT(  
        CLKOUT:OUT std_logic;  
        CE:IN std_logic;  
        CLKIN:IN std_logic  
    );  
END COMPONENT;  
uut:DQCE  
PORT MAP (  
    CLKIN=>clkin,  
    CLKOUT=>clkout,  
    CE=>ce  
);
```

3.1.2 IP Generation

Click "DQCE" on the IP Core Generator and an overview of DQCE will be displayed on the right side of the interface.

IP Configuration

Double-click on "DQCE", and the "IP Customization" window pops up. It includes the "General", and port diagram, as shown in Figure 3-2.

Figure 3-2 IP Customization of DQCE

1. General

The General configuration box is used to configure the generated IP design files.

- Device: Select a device.
- Device Version: Select a device version
- Part Number: Select a part number
- Language: Hardware description language used to generate the IP design files. Click the drop-down list to select the language, including Verilog and VHDL.
- Module Name: The module name of the generated IP design files. Enter the module name in the text box. Module name cannot be the same as the primitive name. If it is the same, an error will be reported.
- File Name: The name of the generated IP design files. Enter the file name in the text box.
- Create In: The path in which the generated IP files will be stored. Enter the target path in the box or select the target path by clicking the right textbox.

2. Port Diagram

The port diagram displays a sample diagram of IP Core configuration, as shown in Figure 3-2.

Generated Files

After configuration, three files that are named after the "File Name" will be generated.

- "gowin_dqce.v" file is a complete Verilog module to generate instantiated DQCE, and it is generated according to the IP configuration;
- "gowin_dqce_tmp.v" is the template file;
- "gowin_dqce.ipc" file is IP configuration file. You can load the file to configure the IP.

Note!

If VHDL is selected as the hardware description language, the first two files will be named with .vhd suffix.

3.2 DCS

3.2.1 Primitive Introduction

There are two DCSs in each quadrant, corresponding to GCLK6 and GCLK7. The output of DCS is connected to GCLK6 or GCLK7, i.e., among eight GCLKs in a quadrant, GCLK6 and GCLK7 have dynamic clock selection (DCS) function. DCS clock selection signal, CLKSEL, comes from CIU, and the internal logic allows CLKOUT to dynamically switch among the four clock inputs via the CRU.

Functional Description

GCLK6~GCLK7 of each quadrant is controlled by the dynamic clock selector (DCS); select one of the four clocks as the global clock. The internal logic can be switched dynamically within the four clocks by CRU, and output a glitch-free clock.

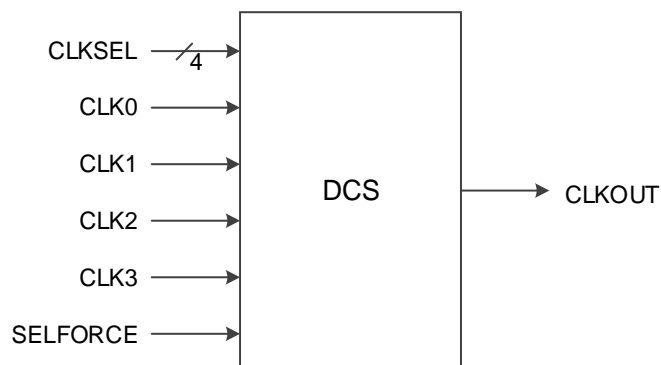
DCS has two clock switching modes, namely "Non-glitchless" and "Glitchless".

In Non-Glitchless mode, DCS acts like a multiplexer, switching clock signals only through CLKSEL signals, allowing glitch on the output, depending on the time of switching.

In Glitchless mode, it is possible to avoid glitch on the output clock that you can configure the CLKSEL signal to dynamically switch the clock signal by DCS_MODE.

Port Diagram

Figure 3-3 DCS Port Diagram



Port Description

Table 3-2 DCS Port Description

Port	I/O	Description
CLK0	Input	Clock input signal 0
CLK1	Input	Clock input signal 1
CLK2	Input	Clock input signal 2
CLK3	Input	Clock input signal 3
CLKSEL[3:0]	Input	Clock selection signal
SELFCE	Input	Mandatory mode selection 0: Glitchless mode 1; Non-glitchless mode
CLKOUT	Output	Clock output signal

Parameter Description

Table 3-3 DCS Parameter Description

Name	Value	Default	Description
DCS_MODE	"CLK0", "CLK1", "CLK2", "CLK3", "GND", "VCC", "RISING", "FALLING", "CLK0_GND", "CLK1_GND", "CLK2_GND", "CLK3_GND", "CLK0_VCC", "CLK1_VCC", "CLK2_VCC", "CLK3_VCC"	"RISING"	Sets DCS mode

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```
DCS dcs_inst (
```

```

        .CLK0(clk0),
        .CLK1(clk1),
        .CLK2(clk2),
        .CLK3(clk3),
        .CLKSEL(clksel[3:0]),
        .SELFORCE(selfforce),
        .CLKOUT(clkout)
    );
    defparam dcs_inst.DCS_MODE="RISING";

```

Vhdl Instantiation:

```

COMPONENT DCS
    GENERIC(DCS_MODE:string:="RISING");
    PORT(
        CLK0 : IN std_logic;
        CLK1:IN std_logic;
        CLK2:IN std_logic;
        CLK3:IN std_logic;
        CLKSEL:IN std_logic_vector(3 downto 0);
        SELFORCE:IN std_logic;
        CLKOUT:OUT std_logic
    );
END COMPONENT;

uut:DCS
    GENERIC MAP(DCS_MODE=>"RISING")
    PORT MAP(
        CLK0=>clk0,
        CLK1=>clk1,
        CLK2=>clk2,
        CLK3=>clk3,
        CLKSEL=>clksel,
        SELFORCE=>selfforce,
        CLKOUT=>clkout
    );

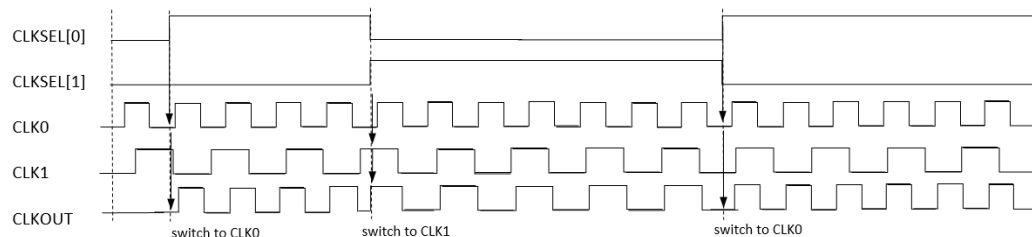
```

Timing Diagrams

The timing of Non-Glitchless mode is shown in Figure 3-4. CLKSEL

[3]~CLKSEL [0] are corresponding to CLK3~CLK0 with the same converting timing, active-high.

Figure 3-4 Timing Diagram of Non-Glitchless



The timing of Glitchless mode is shown in Figure 3-5~Figure 3-8 CLKSEL [3]~CLKSEL [0] are corresponding to CLK3~CLK0 with the same converting timing.

Figure 3-5 RISING Timing Diagram in DCS Mode

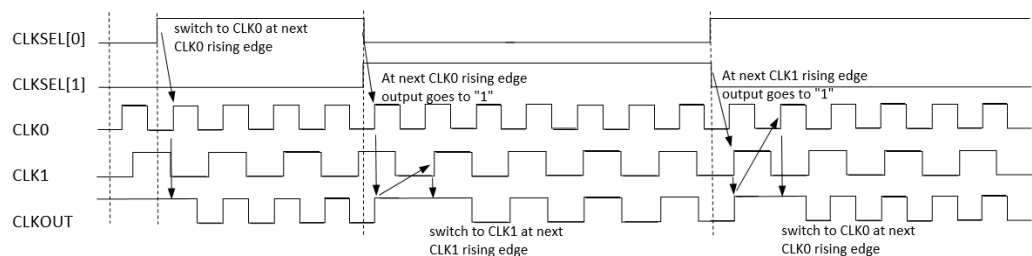


Figure 3-6 FALLING Timing Diagram in DCS Mode

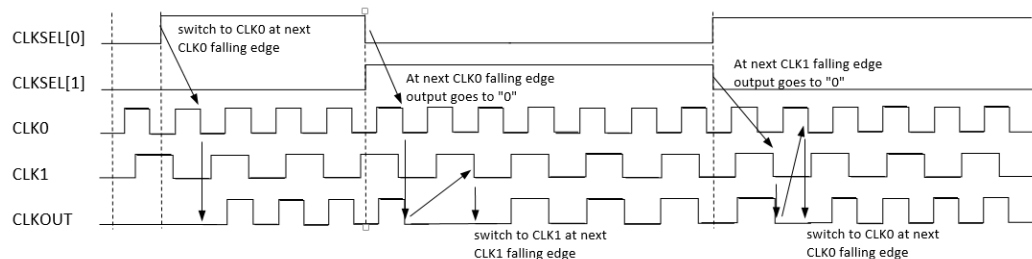


Figure 3-7 CLK0_GND Timing Diagram in DCS Mode

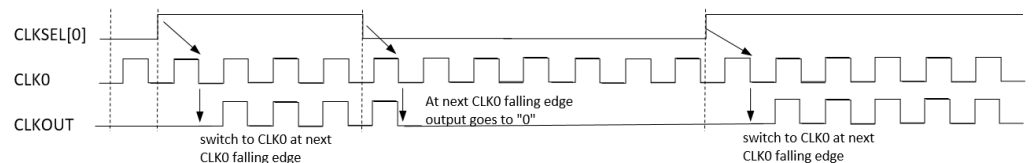
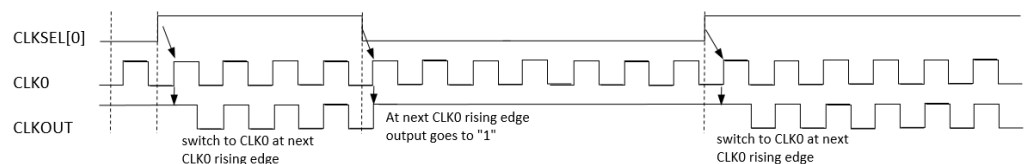


Figure 3-8 CLK0_VCC Timing Diagram in DCS Mode



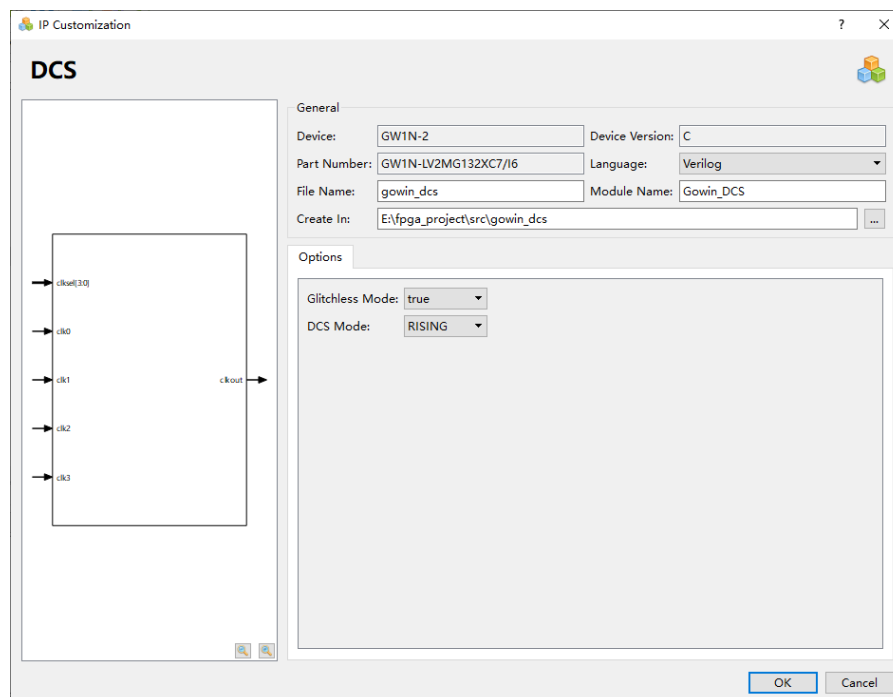
3.2.2 IP Generation

Click "DCS" on the "IP Core Generator" and an overview of DCS will be displayed on the right side of the interface.

IP Configuration

Double-click on "DCS", and the "IP Customization" window pops up. It includes the "General", "Options", and port diagram, as shown in Figure 3-9.

Figure 3-9 IP Customization of DCS



1. General

The General configuration box is used to configure the generated IP design file. The DCS General configuration box is similar to that of DQCE. For the details, please refer to the General description in [3.1.2 IP Generation](#).

2. Options

The Options Configuration box is used to configure IP, as shown in Figure 3-9.

- Glitchless Mode: Enables/ disables Glitchless
- DCS Mode: Sets DCS mode

3. Port Diagram

The port diagram displays a sample diagram of IP Core configuration, as shown in Figure 3-9.

Generated Files

After configuration, three files that are named after the "File Name" will be generated.

- "gowin_dcs.v" file is a complete Verilog module to generate instantiated DCS, and it is generated according to the IP configuration;
- "gowin_dcs_tmp.v" is the template file;
- "gowin_dcs.ipc" file is IP configuration file. You can load the file to configure the IP.

Note!

If VHDL is selected as the hardware description language, the first two files will be named with .vhd suffix.

4 HCLK

4.1 DHCEN

4.1.1 Primitive Introduction

You can use DHCEN to dynamically turn on/off HCLK, and DHCEN is conductive when CE is low.

Port Diagram

Figure 4-1 DHCEN Port Diagram



Port Description

Table 4-1 DHCEN Port Description

Port Name	I/O	Description
CLKIN	input	Clock input signal
CE	input	Clock enable input signal, active-low.
CLKOUT	output	Clock output signal

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```
DHCEN dhcen_inst (  
    .CLKIN(clkin),  
    .CE(ce),  
    .CLKOUT(clkout)  
);
```

Vhdl Instantiation:

```
COMPONENT DHCEN
  PORT(
    CLKOUT:OUT std_logic;
    CE:IN std_logic;
    CLKIN:IN std_logic
  );
END COMPONENT;

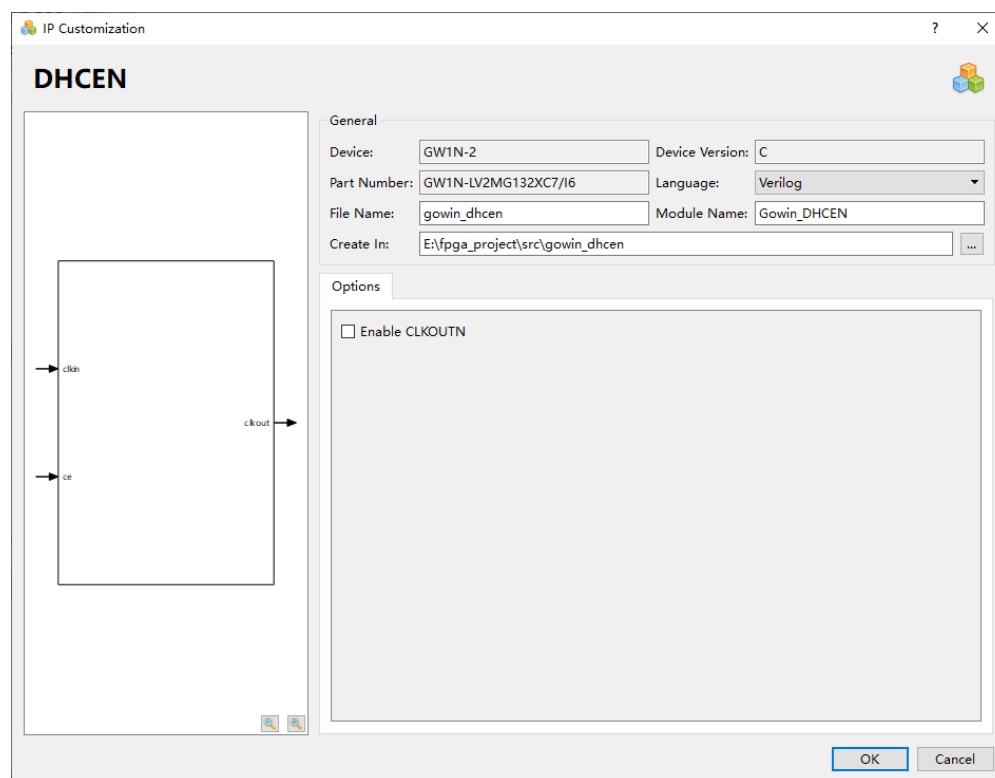
uut:DHCEN
PORT MAP (
  CLKIN=>clkin,
  CLKOUT=>clkout,
  CE=>ce
);
```

4.1.2 IP Generation

Click "DHCEN" on the "IP Core Generator" interface and an overview of related information about DHCEN will be displayed on the right side of the interface.

IP Configuration

Double-click on "DHCEN", and the "IP Customization" window pops up. It includes the "General", "Options", and port diagram, as shown in Figure 4-2.

Figure 4-2 IP Customization of DHCEN

1. General
The General configuration box is used to configure the generated IP design file. DHCEN General configuration is similar to that of DQCE. For the details, please refer to the General description in [3.1.2 IP Generation](#).
2. Options
The Options configuration box is used to configure IP, as shown in Figure 4-2. Enable CLKOUTN: Instantiates DHCENC when enabled, and instantiates DHCEN when disabled.
3. Port Diagram
The port diagram displays a sample diagram of IP Core configuration, as shown in Figure 4-2.

Generated Files

After configuration, three files that are named after the "File Name" will be generated.

- "gowin_dhcn.v" file is a complete Verilog module to generate instantiated DHCEN, and it is generated according to the IP configuration;
- "gowin_dhcn_tmp.v" is the template file;
- "gowin_dhcn.ipc" file is IP configuration file. You can load the file to configure the IP.

Note!

If VHDL is selected as the hardware description language, the first two files will be named with .vhd suffix.

4.2 DHCENC

4.2.1 Primitive Introduction

You can use DHCENC to dynamically turn on/off HCLK, and DHCENC is conductive when CE is low.

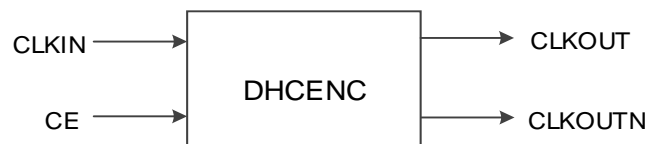
Device Supported

Table 4-2 DHCENC Device Supported

Product Family	Series	Device
LittleBee®	GW1N	GW1N-9C, GW1N-2, GW1N-1P5, GW1N-2B, GW1N-1P5B
	GW1NR	GW1NR-9C, GW1NR-2, GW1NR-2B

Port Diagram

Figure 4-3 DHCENC Port Diagram



Port Description

Table 4-3 DHCENC Port Description

Port Name	I/O	Description
CLKIN	input	Clock input signal
CE	input	Clock enable signal, active-low.
CLKOUT	output	Clock output signal
CLKOUTN	output	Clock output signal, CLKOUTN negated.

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```

DHCENC dhcenc_inst (
    .CLKIN(clkin),
    .CE(ce),
    .CLKOUT(clkout),
    .CLKOUTN(clkoutn)
);
  
```

Vhdl Instantiation:

```

COMPONENT DHCENC
  PORT(
    CLKOUT:OUT std_logic;
    CLKOUTN:OUT std_logic;
    CE:IN std_logic;
    CLKIN:IN std_logic
  );
END COMPONENT;
uut:DHCENC
PORT MAP (
  CLKIN=>clkin,
  CLKOUT=>clkout,
  CLKOUTN=>clkoutn,
  CE=>ce
);

```

4.2.2 IP Generation

The IP interface and calling method of DHCENC and DHCEN are the same, you can see [4.1.2 IP Generation](#).

4.3 DCC**4.3.1 Primitive Introduction**

HCLK duty cycle correction module (DCC)

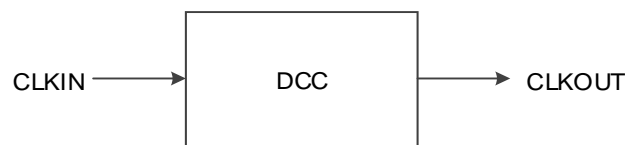
Device Supported

Table 4-4 DCC Device Supported

Product Family	Series	Device
LittleBee®	GW1N	GW1N-9C
	GW1NR	GW1NR-9C

Port Diagram

Figure 4-4 DCC Port Diagram



Port Description

Table 4-5 DCC Port Description

Port Name	I/O	Description
CLKIN	input	Clock input signal
CLKOUT	output	Clock output signal

Parameter Description

Table 4-6 DCC Parameter Description

Parameter	Value	Default	Description
DCC_EN	1'b1, 1'b0	1'b1	1'b1: Enables DCC 1'b0: Disables DCC
FCLKIN	–	50.0	Input clock frequency

Primitive Instantiation

Verilog Instantiation:

```
DCC dcc_inst (
    .CLKIN(clkin),
    .CLKOUT(clkout)
);
defparam dcc_inst.DCC_EN=1'b1;
defparam dcc_inst.FCLKIN=50.0;
```

VHDL Instantiation:

```
COMPONENT DCC
    GENERIC (
        DCC_EN : bit := '1';  --'1':enable dcc; '0': disable dcc
        FCLKIN : REAL := 50.0 --frequency of the clkin(M)
    );
    PORT(
        CLKOUT:OUT std_logic;
        CLKIN:IN std_logic
    );
END COMPONENT;

uut:DCC
GENERIC MAP(
    DCC_EN=>'1',
    FCLKIN=>50.0
```

```

    )
    PORT MAP(
        CLKIN=>clk_in,
        CLKOUT=>clk_out
    );

```

4.4 DCCG

4.4.1 Primitive Introduction

HCLK duty cycle correction module (DCCG)

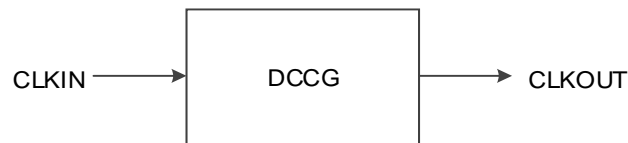
Device Supported

Table 4-7 DCCG Device Supported

Family	Series	Device
LittleBee®	GW1N	GW1N-2, GW1N-1P5, GW1N-2B, GW1N-1P5B
	GW1NR	GW1NR-2, GW1NR-2B

Port Diagram

Figure 4-5 DCCG Port Diagram



Port Description

Table 4-8 DCCG Port Description

Port	I/O	Description
CLKIN	input	Clock input signal
CLKOUT	output	Clock output signal

Parameter Description

Table 4-9 DCCG Parameter Description

Parameter	Value	Default	Description
DCC_MODE	2'b00, 2'b01, 2'b10, 2'b11	2'b00	2'b00/2'b01:Buffered 2'b10: +80ps 2'b11: -80ps
FCLKIN	–	50.0	Input clock frequency

Primitive Instantiation

Verilog Instantiation:

```
DCCG dccg_inst (  
    .CLKIN(clkin),  
    .CLKOUT(clkout)  
);  
defparam dccg_inst.DCC_MODE=2'b00;  
defparam dccg_inst.FCLKIN=50.0;
```

VHDL Instantiation:

```
COMPONENT DCCG  
    GENERIC (  
        DCC_MODE : bit_vector := "00";  
        FCLKIN : REAL := 50.0 --frequency of the clkin(M)  
    );  
    PORT(  
        CLKOUT:OUT std_logic;  
        CLKIN:IN std_logic  
    );  
END COMPONENT;  
uut:DCCG  
    GENERIC MAP(  
        DCC_MODE=>"00",  
        FCLKIN=>50.0  
    )  
    PORT MAP(  
        CLKIN=>clkin,  
        CLKOUT=>clkout  
    );
```

4.5 CLKDIV2

4.5.1 Primitive Introduction

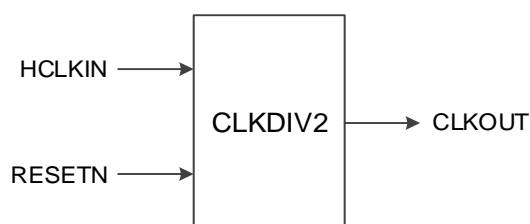
The CLKDIV2 is a clock divider. It realizes a divide-by-two clock. The output of CLKDIV2 can only drive CLKIN of DCC/DCCG, FCLK of IOLOGIC, CLKIN and CLKFB of PLL, FCLK of DQS, and HCLKIN of CLKDIV.

Functional Description

CLKDIV2 is a HCLK divider module that generates a divide-by-two clock with the same phase as the input clock.

Port Diagram

Figure 4-6 CLKDIV2 Port Diagram



Port Description

Table 4-10 CLKDIV2 Port Description

Port Name	I/O	Description
HCLKIN	Input	Clock input signal
RESETN	Input	Asynchronous reset signal, active-low.
CLKOUT	Output	Clock output signal

Parameter Description

Table 4-11 CLKDIV2 Parameter Description

Name	Value	Default	Description
GSREN	"false", "true"	"false"	Enable global reset

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```

CLKDIV2 clkdiv2_inst(
    .HCLKIN(hclkin),
    .RESETN(resetn),
    .CLKOUT(clkout)
  )
  
```

```
);
defparam clkdiv2_inst.GSREN="false";
```

Vhdl Instantiation:

```
COMPONENT CLKDIV2
    GENERIC(
        GSREN:STRING:="false"
    );
    PORT(
        HCLKIN:IN std_logic;
        RESETN:IN std_logic;
        CLKOUT:OUT std_logic
    );
END COMPONENT;

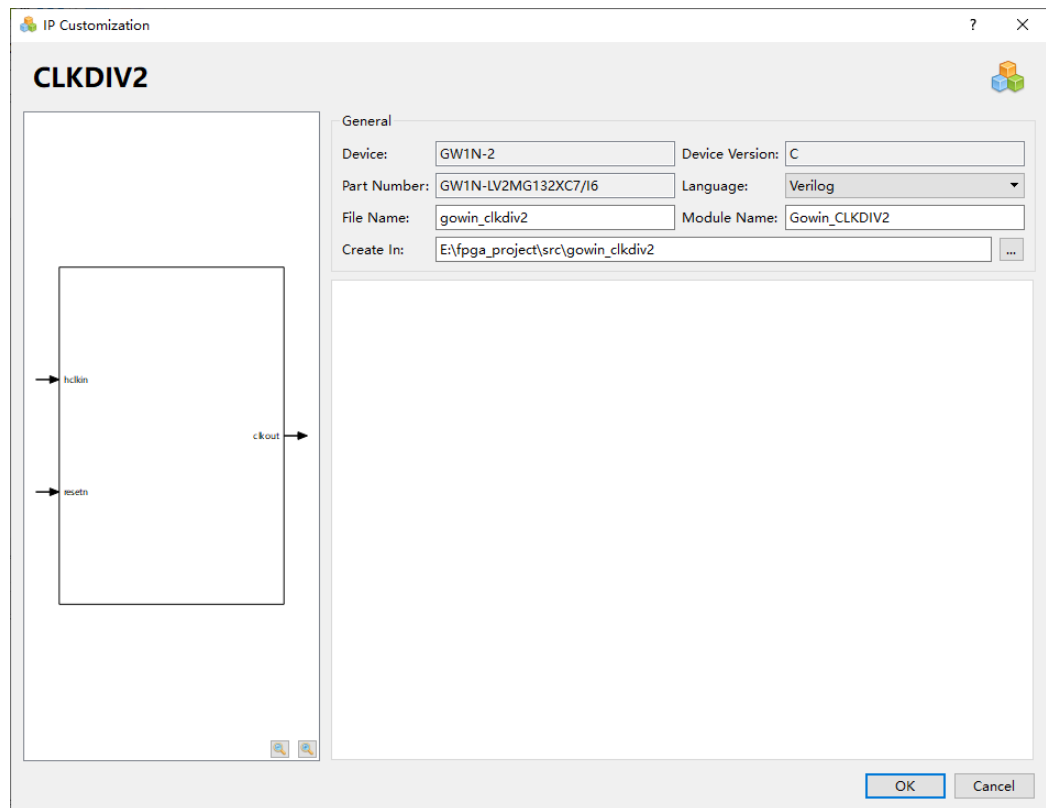
uut:CLKDIV2
    GENERIC MAP(
        GSREN=>"false"
    )
    PORT MAP (
        HCLKIN=>hclkin,
        RESETN=>resetn,
        CLKOUT=>clkout
    );
```

4.5.2 IP Generation

Click "CLKDIV2" on the "IP Core Generator" interface and an overview of CLKDIV2 will be displayed on the right side of the interface.

IP Configuration

Double-click on "CLKDIV2", and the "IP Customization" window pops up. It includes the "General", and port diagram, as shown in Figure 4-7.

Figure 4-7 IP Customization of CLKDIV2

1. General

The General configuration box is used to configure the generated IP design file. The CLKDIV2 General configuration is similar to that of DQCE. For the details, please refer to the General description in [3.1.2 IP Generation](#).

2. Port Diagram

The port diagram displays a sample diagram of IP Core configuration, as shown in Figure 4-7.

IP Generated Files

After configuration, three files that are named after the "File Name" will be generated.

- "gowin_clkdiv2.v" file is a complete Verilog module to generate instantiated CLKDIV2, and it is generated according to the IP configuration;
- "gowin_clkdiv2_tmp.v" is the template file;
- "gowin_clkdiv2.ipc" file is IP configuration file. You can load the file to configure the IP.

Note!

If VHDL is selected as the hardware description language, the first two files will be named with .vhd suffix.

5 System Clock

5.1 rPLL

5.1.1 Primitive Introduction

Gowin FPGA provides rPLLs to control the frequency and phase of the oscillation signals in the loop via external input reference clock signals.

Device Supported

Table 5-1 rPLL Device Supported

Product Family	Series	Device
Arora	GW2A	GW2A-18, GW2A-18C, GW2A-55, GW2A-55C
	GW2AN	GW2AN-55C
	GW2AR	GW2AR-18, GW2AR-18C
	GW2ANR	GW2ANR-18C
LittleBee®	GW1N	GW1N-1, GW1N-1S, GW1N-4, GW1N-4B, GW1N-4D, GW1N-9, GW1N-9C
	GW1NR	GW1NR-1, GW1NR-4, GW1NR-4B, GW1NR-4D, GW1NR-9, GW1NR-9C
	GW1NRF	GW1NRF-4B
	GW1NS	GW1NS-2, GW1NS-2C
	GW1NSE	GW1NSE-2C
	GW1NSR	GW1NSR-2, GW1NSR-2C
	GW1NZ	GW1NZ-1, GW1NZ-1C

Functional Description

Based on the given input clock, rPLL adjusts clock phase, duty cycle, frequency (multiplication and division) to generate output clocks with different phases and frequencies.

rPLL can adjust the frequency of the input clock CLKIN (multiplication and division). The formulas are as follows:

$$f_{CLKOUT} = (f_{CLKIN} * FB DIV) / IDIV$$

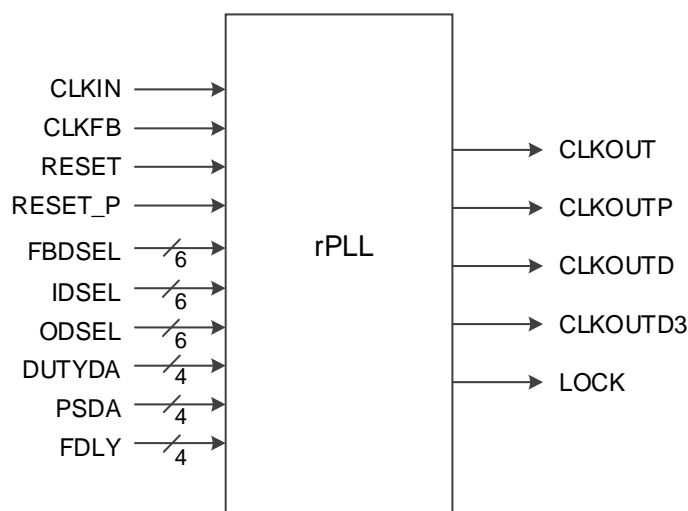
$$f_{VCO} = f_{CLKOUT} * ODIV$$

$$f_{CLKOUTD} = f_{CLKOUT}/SDIV$$

$$f_{PFD} = f_{CLKIN}/IDIV = f_{CLKOUT}/FBDIV$$

Note!

- f_{CLKIN} is the input clock CLKIN frequency; f_{CLKOUT} is the CLKOUT and CLKOUTP frequency; $f_{CLKOUTD}$ is the CLKOUTD frequency, and f_{PFD} is the PFD phase detection frequency.
- IDIV, FBDIV, ODIV and SDIV are the frequency division coefficients of different frequency dividers, which can be adjusted to get the clock signal with expected frequency.
- For the frequency range of the rPLL, please refer to the [FPGA Product Datasheet](#).

Port Diagram**Figure 5-1 rPLL Port Diagram****Port Description****Table 5-2 rPLL Port Description**

Port Name	I/O	Description
CLKIN	Input	Reference clock input signal
CLKFB	Input	Feedback clock input signal
RESET	Input	rPLL asynchronous reset input signal, active-high.
RESET_P	Input	rPLL power down input signal, active-high. The output of CLKOUT/CLKOUTP/CLKOUTD/CLKOUTD3 is 0 when PLL is not in bypass mode and RESET_P is in high level.
FBDSEL[5:0]	Input	Dynamically controls FBDIV value, ranging from 0 to 63, and the actual value is 64-FBDSEL.
IDSEL[5:0]	Input	Dynamically controls IDIV value, ranging from 0 to 63, and the actual value is 64-IDSEL.
ODSEL[5:0]	Input	Dynamically controls ODIV value: 2,4,8,16,32,48,64,80,96,112,128
DUTYDA[3:0]	Input	Duty cycle dynamic adjustment signal
PSDA[3:0]	Input	Phase dynamic adjustment signal
FDLY[3:0]	Input	Fine delay dynamic adjustment signal

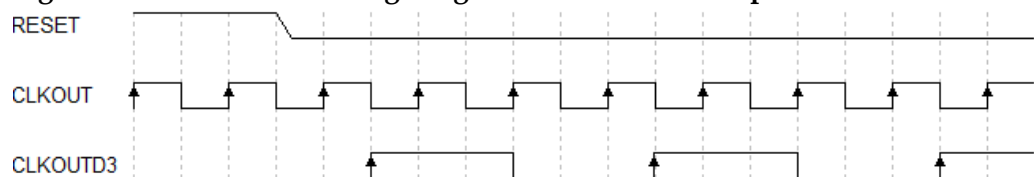
Port Name	I/O	Description
CLKOUT	Output	rPLL clock output signal
LOCK	Output	rPLL locked indicator. 1: locked, 0: unlocked.
CLKOUTP	Output	rPLL clock output signal with phase and duty cycle adjustment
CLKOUTD	Output	Clock output signal of rPLL through SDIV, output signal of CLKOUT or CLKOUTP through SDIV divider output signal.
CLKOUTD3	Output	Clock output signal of rPLL through DIV3, output signal of CLKOUT or CLKOUTP through DIV3.

CLKOUTD3 is a divide-by-three output clock signal with two input sources.

- If the input source is CLKOUT:

As shown in Figure 5-2, after the RESET is released, CLKOUTD3 goes high on the first falling edge of the CLKOUT and then goes low on the subsequent second rising edge.

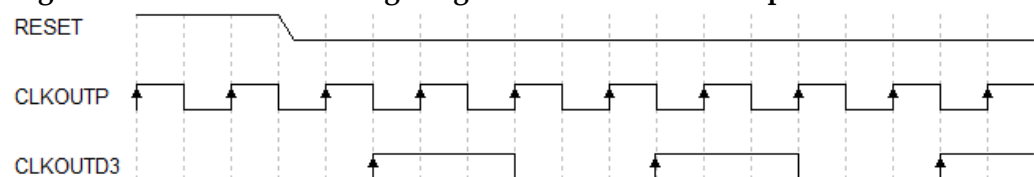
Figure 5-2 CLKOUTD3 Timing Diagram with CLKOUT Input Source



- If the input source is CLKOUTP:

As shown in Figure 5-3, after RESET reset is released, CLKOUTD3 goes high on the first falling edge of CLKOUTP and then goes low on the subsequent second rising edge.

Figure 5-3 CLKOUTD3 Timing Diagram with CLKOUTP Input Source



Parameter Description

Table 5-3 rPLL Parameter Description

Name	Value	Default	Description
FCLKIN	"3" ~ "500"	"100"	Reference clock frequency
IDIV_SEL	0~63	0	IDIV frequency division coefficient static setting
DYN_IDIV_SEL	"true", "false"	"false"	IDIV frequency division coefficient static control parameter or dynamic control signal selection. <ul style="list-style-type: none"> ● false: Static, that is, select the parameter IDIV_SEL. ● true: Dynamic, namely select signal IDSEL.
FBDIV_SEL	0~63	0	FBDIV frequency division coefficient static setting
DYN_FBDIV_SEL	"true", "false"	"false"	FBDIV frequency division coefficient static control parameter or dynamic control signal selection. <ul style="list-style-type: none"> ● false: Static, that is, select the parameter FBDIV_SEL. ● true: Dynamic, namely select signal FBDSEL.
ODIV_SEL	2,4,8,16,32,48,64,80,96,112,128	8	ODIV frequency division coefficient static setting
DYN_ODIV_SEL	"true", "false"	"false"	ODIV frequency division coefficient static control parameter or dynamic control signal selection. <ul style="list-style-type: none"> ● false: Static, that is, select the parameter ODIV_SEL. ● true: Dynamic, namely select signal ODSEL.
PSDA_SEL	"0000" ~ "1111"	"0000"	Phase static adjustment
DUTYDA_SEL	"0010" ~ "1110"	"1000"	Duty cycle static adjustment
DYN_DA_EN	"true", "false"	"false"	The dynamic signal is selected as the control of phase and duty cycle adjustment. <ul style="list-style-type: none"> ● false: Static control ● true: Dynamic control
CLKOUT_FT_DIR	1'b1	1'b1	CLKOUT trim direction setting 1'b1: Decrease
CLKOUT_DLY_STEP	0,1,2,4	0	CLKOUT trim coefficient

Name	Value	Default	Description
			setting CLKOUT_DLY_STEP*delay(delay=50ps)
CLKOUTP_FT_DIR	1'b1	1'b1	CLKOUTP trim direction setting 1'b1: Decrease
CLKOUTP_DLY_STEP	0,1,2	0	CLKOUTP trim coefficient setting CLKOUTP_DLY_STEP*delay(delay=50ps)
DYN_SDIV_SEL	2~128 (Even)	2	SDIV frequency division coefficient static setting
CLKFB_SEL	"internal", "external"	"internal"	CLKFB source selection <ul style="list-style-type: none"> ● internal: Feedback from internal CLKOUT. ● external: Feedback from external signal.
CLKOUTD_SRC	"CLKOUT", "CLKOUTP"	"CLKOUT"	CLKOUTD source selection
CLKOUTD3_SRC	"CLKOUT", "CLKOUTP"	"CLKOUT"	CLKOUTD3 source selection
CLKOUT_BYPASS	"True", "false"	"false"	Bypasses rPLL, and CLKOUT comes directly from CLKIN. <ul style="list-style-type: none"> ● true: CLKIN bypasses rPLL and acts directly on CLKOUT. ● false: Normal
CLKOUTP_BYPASS	"True", "false"	"false"	Bypasses rPLL, and CLKOUTP comes directly from CLKIN. <ul style="list-style-type: none"> ● true: CLKIN bypasses rPLL and acts directly on CLKOUTP ● false: Normal
CLKOUTD_BYPASS	"True", "false"	"false"	Bypasses rPLL, and CLKOUTD comes directly from CLKIN. <ul style="list-style-type: none"> ● true: CLKIN bypasses rPLL and acts directly on CLKOUTD. ● false: Normal
DEVICE	"GW1N-1", "GW1NR-1", "GW1N-1S", "GW1NZ-1", "GW1NZ-1C", "GW1N-4", "GW1N-4B", "GW1N-4D",	"GW1N-4"	Devices selected

Name	Value	Default	Description
	"GW1NR-4", "GW1NR-4B", "GW1NR-4D", "GW1NRF-4B", "GW1N-9", "GW1N-9C", "GW1NR-9", "GW1NR-9C", "GW2A-18", "GW2AR-18", "GW2A-55", "GW2A-55C"		

Table 5-4 IDSEL Port Parameter Comparison Table

IDSEL[5:0]	IDIV Static Parameter Value	IDIV Actual Value
111111	0	1
111110	1	2
111101	2	3
111100	3	4
111011	4	5
111010	5	6
111001	6	7
111000	7	8
110111	8	9
.....
000000	63	64

Table 5-5 FBDSEL Port Parameter Comparison Table

FBDSEL [5:0]	FBDIV Static Parameter Value	FBDIV Actual Value
111111	0	1
111110	1	2
111101	2	3
111100	3	4
111011	4	5
111010	5	6
111001	6	7
111000	7	8
110111	8	9
.....
000000	63	64

Table 5-6 ODSEL Port Parameter Comparison Table

ODSEL [5:0]	ODIV Parameter Value	ODIV Actual Value
111111	2	2
111110	4	4
111100	8	8
111000	16	16
110000	32	32
101000	48	48
100000	64	64
011000	80	80
010000	96	96
001000	112	112
000000	128	128

Table 5-7 rPLL Phase Parameter Adjustment

Parameter PSDA_SEL or Port PSDA Setting	Phase Shift
0000	0°
0001	22.5°
0010	45°
0011	67.5°
0100	90°
0101	112.5°
0110	135°
0111	157.5°
1000	180°
1001	202.5°
1010	225°
1011	247.5°
1100	270°
1101	292.5°
1110	315°
1111	337.5°

Table 5-8 rPLL Duty Cycle Parameter Adjustment

Parameters DUTYDA_SEL Setting	Duty Cycle Setting (/16)
0010	2
0011	3
0100	4
0101	5

Parameters DUTYDA_SEL Setting	Duty Cycle Setting (/16)
0110	6
0111	7
1000	8
1001	9
1010	10
1011	11
1100	12
1101	13
1110	14

You need to see phase shift setting for dynamic duty cycle adjustment. For example, when the phase shift setting is "0" (00000), the 50% duty cycle setting will be "8" (1000). If the phase shift setting is "180°", the 50% duty cycle setting is "0" (0000).

The calculation of dynamic duty cycle is as follows.

- If DUTYDA [3:0] > PSDA [3:0], DutyCycle = $1/16 \times (\text{DUTYDA [3:0]} - \text{PSDA [3:0]})$.
- If DUTYDA [3:0] < PSDA [3:0], DutyCycle = $1/16 \times (16 + \text{DUTYDA [3:0]} - \text{PSDA [3:0]})$.

Note!

The following three situations are not supported: DutyCycle = 0, 1, 15.

You can use FDLY [3: 0] to dynamically control CLKOUTP delay. Each step increases 0.125 ns, and you need to use the phase shift setting to achieve lagging^[1] and leading^[2].

Note!

- [1]CLKOUTP lags behind input signal.
- [2]CLKOUTP leads the input signal.

Table 5-9 rPLL Ports Configuration

Port FDLY [3:0 (GW1N-1/GW1N-1S)	Port FDLY [3:0] (other devices)	Delay Steps
0000	1111	0
0001	1110	1
0010	1101	2
0100	1011	4
1000	0111	8

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```

rPLL rppll_inst(
    .CLKOUT(clkout),
    .LOCK(lock),
    .CLKOUTP(clkoutp),
    .CLKOUTD(clkoutd),
    .CLKOUTD3(clkoutd3),
    .RESET(reset),
    .RESET_P(reset_p),
    .CLKIN(clkin),
    .CLKFB(clkfb),
    .FBDSEL(fbdsel),
    .IDSEL(idsel),
    .ODSEL(odsel),
    .PSDA(psda),
    .DUTYDA(dutyda),
    .FDLY(fdly)
);

defparam rppll_inst.FCLKIN = "50";
defparam rppll_inst.DYN_IDIV_SEL = "false";
defparam rppll_inst.IDIV_SEL = 0;
defparam rppll_inst.DYN_FBDIV_SEL = "false";
defparam rppll_inst.FBDIV_SEL = 1;
defparam rppll_inst.ODIV_SEL = 8;
defparam rppll_inst.PSDA_SEL = "0100";
defparam rppll_inst.DYN_DA_EN = "false";
defparam rppll_inst.DUTYDA_SEL = "1000";
defparam rppll_inst.CLKOUT_FT_DIR = 1'b1;
defparam rppll_inst.CLKOUTP_FT_DIR = 1'b1;
defparam rppll_inst.CLKOUT_DLY_STEP = 0;
defparam rppll_inst.CLKOUTP_DLY_STEP = 0;
defparam rppll_inst.CLKFB_SEL = "external";
defparam rppll_inst.CLKOUT_BYPASS = "false";
defparam rppll_inst.CLKOUTP_BYPASS = "false";
defparam rppll_inst.CLKOUTD_BYPASS = "false";

```

```

defparam rpll_inst.DYN_SDIV_SEL = 2;
defparam rpll_inst.CLKOUTD_SRC = "CLKOUT";
defparam rpll_inst.CLKOUTD3_SRC = "CLKOUT";
defparam rpll_inst.DEVICE = "GW1N-4";

```

Vhdl Instantiation:

```

COMPONENT rPLL

```

```

    GENERIC(

```

```

        FCLKIN:STRING:= "100.0";
        DEVICE:STRING:= "GW1N-4";
        DYN_IDIV_SEL:STRING:="false";
        IDIV_SEL:integer:=0;
        DYN_FBDIV_SEL:STRING:="false";
        FBDIV_SEL:integer:=0;
        DYN_ODIV_SEL:STRING:="false";
        ODIV_SEL:integer:=8;
        PSDA_SEL:STRING:="0000";
        DYN_DA_EN:STRING:="false";
        DUTYDA_SEL:STRING:="1000";
        CLKOUT_FT_DIR:bit:='1';
        CLKOUTP_FT_DIR:bit:='1';
        CLKOUT_DLY_STEP:integer:=0;
        CLKOUTP_DLY_STEP:integer:=0;
        CLKOUTD3_SRC:STRING:="CLKOUT";
        CLKFB_SEL : STRING:="internal";
        CLKOUT_BYPASS:STRING:="false";
        CLKOUTP_BYPASS:STRING:="false";
        CLKOUTD_BYPASS:STRING:="false";
        CLKOUTD_SRC:STRING:="CLKOUT";
        DYN_SDIV_SEL:integer:=2

```

```

    );

```

```

    PORT(

```

```

        CLKIN:IN std_logic;
        CLKFB:IN std_logic;
        IDSEL:IN std_logic_vector(5 downto 0);
        FBDSEL:IN std_logic_vector(5 downto 0);

```



```

        ODSEL:IN std_logic_vector(5 downto 0);
        RESET:IN std_logic;
        RESET_P:IN std_logic;
        PSDA,FDLY:IN std_logic_vector(3 downto 0);
        DUTYDA:IN std_logic_vector(3 downto 0);
        LOCK:OUT std_logic;
        CLKOUT:OUT std_logic;
        CLKOUTD:OUT std_logic;
        CLKOUTP:OUT std_logic;
        CLKOUTD3:OUT std_logic

    );
END COMPONENT;
uut:rPLL

```

```

    GENERIC MAP(
        FCLKIN =>"100.0",
        DEVICE =>"GW2A-18",
        DYN_IDIV_SEL=>"false",
        IDIV_SEL=>0,
        DYN_FBDIV_SEL=>"false",
        FBDIV_SEL=>0,
        DYN_ODIV_SEL=>"false",
        ODIV_SEL=>8,
        PSDA_SEL=>"0000",
        DYN_DA_EN=>"false",
        DUTYDA_SEL=>"1000",
        CLKOUT_FT_DIR=>'1',
        CLKOUTP_FT_DIR=>'1',
        CLKOUT_DLY_STEP=>0,
        CLKOUTP_DLY_STEP=>0,
        CLKOUTD3_SRC=>"CLKOUT",
        CLKFB_SEL=>"internal",
        CLKOUT_BYPASS=>"false",
        CLKOUTP_BYPASS=>"false",
        CLKOUTD_BYPASS=>"false",
        CLKOUTD_SRC=>"CLKOUT",

```

```

                                DYN_SDIV_SEL=>2
                                )
    PORT MAP (
        CLKIN=>clk_in,
        CLKFB=>clkfb,
        IDSEL=>idsel,
        FBDSEL=>fbdsel,
        ODSEL=>odsel,
        RESET=>reset,
        RESET_P=>reset_p,
        PSDA=>psda,
        FDLY=>fdly,
        DUTYDA=>dutyda,
        LOCK=>lock,
        CLKOUT=>clkout,
        CLKOUTD=>clkoutd,
        CLKOUTP=>clkoutp ,
        CLKOUTD3=>clkoutd3
    );

```

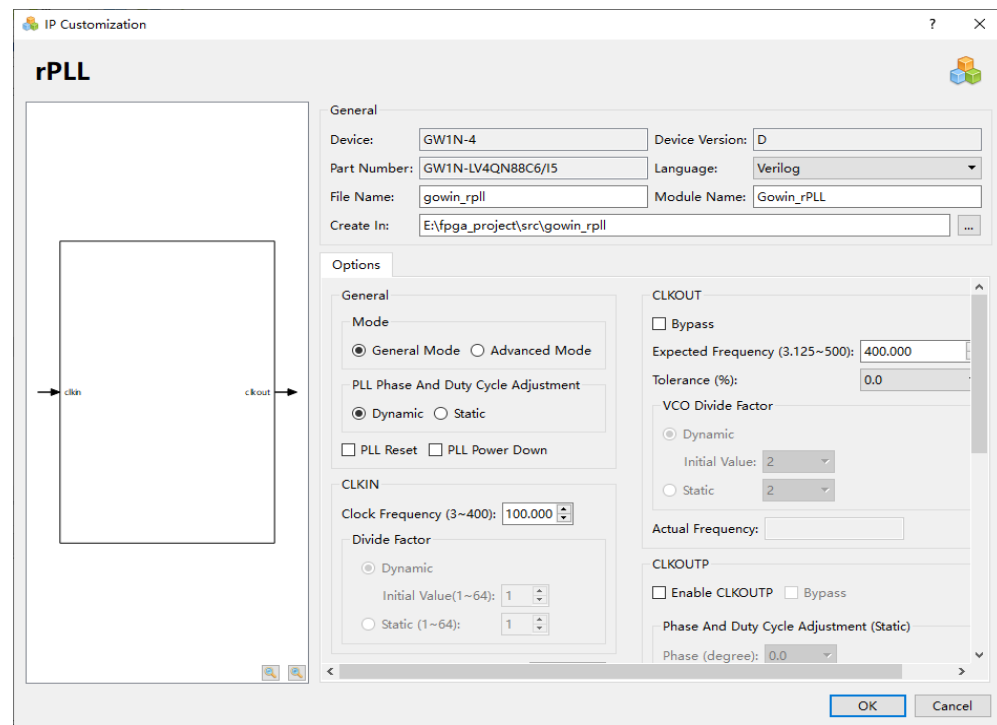
5.1.2 IP Generation

Click "rPLL" on the IP Core Generator interface and an overview of related information about rPLL will be displayed on the right side of the interface.

IP Configuration

Double-click on the "rPLL" on the IP Core Generator interface to open the "IP Customization" window. It includes the "General", "Options", and ports diagram, as shown in Figure 5-4.

Figure 5-4 IP Customization of rPLL



1. General

The General configuration box is used to configure the generated IP design file. rPLL General configuration is similar to that of DQCE. For the details, please refer to the General description in [3.1.2 IP Generation](#).

2. Options

The Options configuration box is used to configure IP by users, as shown in Figure 5-4.

- General: Configure "General Mode" or "Advanced Mode", select "Static Mode" or "Dynamic Mode" for PLL phase and duty cycle, and enable PLL Reset.
 - Mode: "General Mode" or "Advanced Mode". Input the input clock frequency and output clock frequency in general mode, the software will automatically calculate different division factors. Advanced mode is intended for advanced users and allows inputting the input frequency and different division factors to obtain the desired output frequency.
 - "PLL Phase And Duty Cycle Adjustment": "Static" Mode or "Dynamic" Mode.
 - "PLL Reset": Configures rPLL reset mode.
 - "PLL Power Down": Configures the reset_p port to put the rPLL in power saving mode.
- CLKIN: Configures input clock frequency, divide factor, and IDESEL Reset.

- "Clock Frequency": Configures the frequency of the input clock with the range determined by the device.
- Divide Factor: Sets the Divide Factor as "Dynamic" or "Static" in advanced mode. In Static mode, Divide Factor value can be set as a specific value, which ranges from 1 to 64. If the CLKOUT frequency is not in the range required by the device, an error prompt will pop up when you click "Calculate" or "OK" ; If the frequency of CLKIN/IDIV is not in the range required by the device, an error prompt will pop up when you click "Calculate" or "OK".
- CLKFB: Configures the source and divide factor of rPLL.
 - When configuring the source of the feedback clock, you can select Internal and External.
 - Divide Factor: Sets the Divide Factor as "Dynamic" or "Static" in advanced mode. In static mode, Divide Factor value can be set as a specific value, which ranges from 1 to 64. If the configuration is invalid, an error prompt will pop up when you click "Calculate" or "OK".
- Enable LOCK: Enables the LOCK port.
- CLKOUT: Configures the expected frequency, VCO, tolerance and actual frequency.
 - Bypass: Enables/ disables clkout bypass;
 - "Expected Frequency": Configures the expected frequency of the CLKOUT in general mode, with the range determined by the device.
 - Tolerance(%): Sets a tolerance for the CLKOUT between the expected frequency and actual frequency calculated.
 - VCO Divide Factor: Sets Divide Factor as "Dynamic" or "Static" in advanced mode. In static mode, the Divide Factor value can be set as a specific value, and the range is 2/4/8/16/32/48/64/80/96/112/128. If the configuration is invalid, an error prompt will pop up when you click "Calculate" or "OK".
 - Actual Frequency: The actual frequency that can be generated automatically.
- CLKOUTP: Configures the parameter of phase shift clock period trim, configures the adjustment parameter of phase and duty cycle, enables/disables reset of the phase shift clock.
 - Enable CLKOUTP: Configures phase shift clock output enable;
 - Bypass: Configures phase shift clock bypass enable;
 - Phase And Duty Cycle Adjustment (Static): Configures Phase (degree) and Duty Cycle (*1/16) in static mode;
- CLKOUTD: Configures the source, expected frequency, and divide

factor of the clock divider, and enables/disables CLKOUTD reset.

- Enable CLKOUTD: Configures frequency division clock output enable.
- Bypass: Configures frequency division clock bypass enable;
- Source: Configures the clock source for the frequency division clock output, CLKOUT and CLKOUTP.
- Expected Frequency: Sets the output clock frequency in General mode with the range determined by the device.
- Tolerance (%): Sets a tolerance for the CLKOUTD between the expected frequency and actual frequency calculated.
- Divide Factor (2~128): Selects the divide factor from the drop-down list in advanced mode. Only an even number between 2 and 128 can be selected. If an odd number is set, an error prompt will pop up when you click "OK".
- Actual Frequency: The actual frequency that can be generated automatically.
- CLKOUTD3: Select the source for divided-by-three clock output.
 - Enable CLKOUTD3: Enables/disables divided-by-three clock;
 - Source: Selects the clock source for the divided-by-three clock output, CLKOUT and CLKOUTP.
- Calculate: Calculates whether the current configuration is reasonable.
 - Calculate Divide Factor settings are based on the input/output frequency in general mode. If the actual frequency is different from the expected frequency, an Error prompt will pop up and the invalid value will be marked in red.
 - In "Advanced Mode", calculate the static division/multiplication frequency and VCO parameters. If the calculated results are invalid, click "Calculate", an Error prompt will pop up. If valid, click "Calculate", "succeed" prompt will pop up.

3. Port Diagram

The port diagram is based on the IP Core configuration. The input/output number is updated in real time based on the configuration, as shown in Figure 5-4.

IP Generated Files

After configuration, three files that are named after the "File Name" will be generated.

- "gowin_rpll.v" file is a complete Verilog module to generate instantiated rPLL, and it is generated according to the IP configuration;
- "gowin_rpll_tmp.v" is the template file;
- "gowin_rpll.ipc" file is IP configuration file. You can load the file to

configure the IP.

Note!

If VHDL is selected as the hardware description language, the first two files will be named with .vhd suffix.

5.2 PLLVR

5.2.1 Primitive Introduction

Gowin FPGA provides PLLVR (Phase_Locked Loop with regulator), which uses an external input reference clock signal to control the frequency and phase in the loop of internal oscillation signals.

Device Supported

Table 5-10 PLLVR Device Supported

Product Family	Series	Device
LittleBee®	GW1NS	GW1NS-4, GW1NS-4C, GW1NSR-4, GW1NSR-4C, GW1NSER-4C

Functional Description

PLLVR is a PLL with power regulation, and, based on the given input clock, it can adjust clock phase, duty cycle, frequency (multiplication and division) to output clocks with different phases and frequencies.

The performance of PLLVR is as follows:

PLLVR can adjust the frequency of the input clock CLKIN (multiply and division). The formulas are as follows:

$$f_{CLKOUT} = (f_{CLKIN} * FBDIV) / IDIV$$

$$f_{VCO} = f_{CLKOUT} * ODIV$$

$$f_{CLKOUTD} = f_{CLKOUT} / SDIV$$

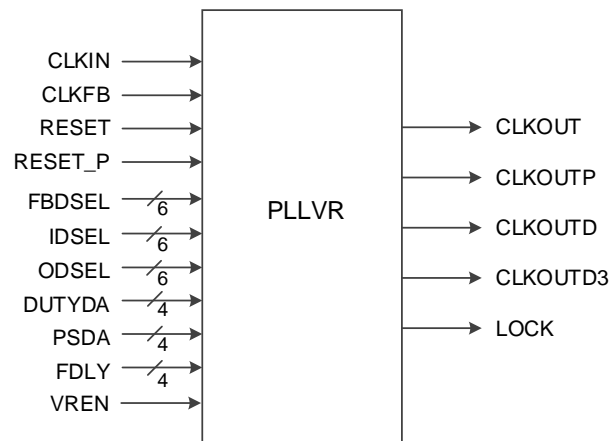
$$f_{PFD} = f_{CLKIN} / IDIV = f_{CLKOUT} / FBDIV$$

Note!

- f_{CLKIN} is the input CLKIN frequency; f_{CLKOUT} is the CLKOUT and CLKOUTP frequency; $f_{CLKOUTD}$ is the CLKOUTD frequency, and f_{PFD} is the PFD phase discrimination frequency.
- IDIV, FBDIV, ODIV and SDIV are the actual frequency division coefficients of different frequency dividers, which can be adjusted to get the clock signal with expected frequency.
- For the frequency range of the PLLVR, please refer to the [FPGA Product Datasheet](#).

Port Diagram

Figure 5-5 PLLVR Port Diagram



Port Description

Table 5-11 Port Description

Port Name	I/O	Description
CLKIN	Input	Reference clock input signal
CLKFB	Input	Feedback clock input signal
RESET	Input	PLLVR asynchronous reset input signal, active-high.
RESET_P	Input	PLLVR power down input signal, active-high. The output of CLKOUT/CLKOUTP/CLKOUTD/CLKOUTD3 is 0 when PLL is not in bypass mode and RESET_P is in high level.
FBDSEL[5:0]	Input	Dynamically controls FBDIV value, ranging from 0 to 63, and the actual value is 64-FBDSEL.
IDSEL[5:0]	Input	Dynamically controls IDIV value, ranging from 0 to 63, and the actual value is 64-IDSEL.
ODSEL[5:0]	Input	Dynamically controls ODIV value: 2,4,8,16,32,48,64,80,96,112,128
DUTYDA[3:0]	Input	Duty cycle dynamic adjustment signal
PSDA[3:0]	Input	Phase dynamic adjustment signal
FDLY[3:0]	Input	Fine delay dynamic adjustment signal
VREN	Input	PLLVR power supply enable signal, active high.
CLKOUT	Output	PLLVR clock output signal
LOCK	Output	PLLVR locked indicator, 1: locked, 0: unlocked.
CLKOUTP	Output	PLLVR clock output signal with phase and duty cycle adjustment
CLKOUTD	Output	Clock output signal of PLLVR through SDIV, output signal of CLKOUT or CLKOUTP through SDIV.
CLKOUTD3	Output	Clock output signal of PLLVR through DIV3, output signal of CLKOUT or CLKOUTP through DIV3.

Note!

CLKOUTD3 is the output clock signal of CLKOUT or CLKOUTP through DIV3. For its timing, you can refer to rPLL.

Parameter Description

Table 5-12 PLLO Parameter Description

Name	Value	Default	Description
FCLKIN	3~500	100	Reference clock frequency
IDIV_SEL	0~63	0	IDIV frequency division coefficient static setting
DYN_IDIV_SEL	"true", "false"	"false"	IDIV frequency division coefficient static control parameter or dynamic control signal selection. <ul style="list-style-type: none"> ● false: Static, that is, select the parameter IDIV_SEL. ● true: Dynamic, namely select signal IDSEL.
FBDIV_SEL	0~63	0	FBDIV frequency division coefficient static setting
DYN_FBDIV_SEL	"true", "false"	"false"	FBDIV frequency division coefficient static control parameter or dynamic control signal selection. <ul style="list-style-type: none"> ● false: Static, that is, select the parameter FBDIV_SEL. ● true: Dynamic, namely select signal FBDSEL.
ODIV_SEL	2,4,8,16,32,48,64,80,96,112,128	8	ODIV frequency division coefficient static setting
DYN_ODIV_SEL	"true", "false"	"false"	ODIV frequency division coefficient static control parameter or dynamic control signal selection. <ul style="list-style-type: none"> ● false: Static, that is, select the parameter ODIV_SEL. ● true: Dynamic,

Name	Value	Default	Description
			namely select signal ODSEL.
PSDA_SEL	"0000"~"1111"	"0000"	Phase static adjustment
DUTYDA_SEL	"0010"~"1110"	"1000"	Duty cycle static adjustment
DYN_DA_EN	"true", "false"	"false"	The dynamic signal is selected as the control of phase and duty cycle adjustment. <ul style="list-style-type: none"> ● false: Static control ● true: Dynamic control
CLKOUT_FT_DIR	1'b1	1'b1	CLKOUT trim direction setting 1'b1: Decrease
CLKOUT_DLY_STEP	0,1, 2,4	0	CLKOUT trim coefficient setting CLKOUT_DLY_STEP* delay(delay=50ps)
CLKOUTP_FT_DIR	1'b1	1'b1	CLKOUTP trim direction setting 1'b1: Decrease
CLKOUTP_DLY_STEP	0,1, 2	0	CLKOUTP trim coefficient setting CLKOUTP_DLY_STEP*delay(delay=50ps)
DYN_SDIV_SEL	2~128 (Even)	2	SDIV frequency division coefficient static setting
CLKFB_SEL	"internal", "external"	"internal"	CLKFB source selection <ul style="list-style-type: none"> ● internal: Feedback from internal CLKOUT. ● external: Feedback from external signals.
CLKOUTD_SRC	"CLKOUT", "CLKOUTP"	"CLKOUT"	CLKOUTD source selection
CLKOUTD3_SRC	"CLKOUT", "CLKOUTP"	"CLKOUT"	CLKOUTD3 source selection
CLKOUT_BYPASS	"true", "false"	"false"	Bypasses PLLVR, and CLKOUT comes directly from CLKIN. <ul style="list-style-type: none"> ● true: CLKIN bypasses PLLVR and acts directly on CLKOUT.

Name	Value	Default	Description
			<ul style="list-style-type: none"> ● false: Normal
CLKOUTP_BYPASS	"true", "false"	"false"	Bypasses PLLVR, and CLKOUT comes directly from CLKIN. <ul style="list-style-type: none"> ● true: CLKIN bypasses PLLVR and acts directly on CLKOUTP. ● false: Normal
CLKOUTD_BYPASS	"true", "false"	"false"	Bypasses PLLVR, and CLKOUT comes directly from CLKIN. <ul style="list-style-type: none"> ● true: CLKIN bypasses PLLVR and acts directly on CLKOUTD. ● false: Normal
DEVICE	"GW1NS-4", "GW1NS-4C", "GW1NSR-4", "GW1NSR-4C", "GW1NSER-4C"	"GW1NS-4"	Devices selected

Note!

For IDSEL, FBDESL and ODSELport and parameter tables, phase and duty cycle tables, you can see those of [rPLL](#).

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```

PLLVR pllvr_inst(
    .CLKOUT(clkout),
    .LOCK(lock),
    .CLKOUTP(clkoutp),
    .CLKOUTD(clkoutd),
    .CLKOUTD3(clkoutd3),
    .VREN(vren),
    .RESET(reset),
    .RESET_P(reset_p),
    .CLKIN(clkin),
    .CLKFB(clkfb),
    .FBDESEL(fbdsel),
    .IDSEL(idsel),

```

```

        .ODSEL(odsel),
        .PSDA(psda),
        .DUTYDA(dutyda),
        .FDLY(fdly)
    );
    defparam pllvr_inst.FCLKIN = "50";
    defparam pllvr_inst.DYN_IDIV_SEL = "false";
    defparam pllvr_inst.IDIV_SEL = 0;
    defparam pllvr_inst.DYN_FBDIV_SEL = "false";
    defparam pllvr_inst.FBDIV_SEL = 1;
    defparam pllvr_inst.ODIV_SEL = 8;
    defparam pllvr_inst.PSDA_SEL = "0100";
    defparam pllvr_inst.DYN_DA_EN = "false";
    defparam pllvr_inst.DUTYDA_SEL = "1000";
    defparam pllvr_inst.CLKOUT_FT_DIR = 1'b1;
    defparam pllvr_inst.CLKOUTP_FT_DIR = 1'b1;
    defparam pllvr_inst.CLKOUT_DLY_STEP = 0;
    defparam pllvr_inst.CLKOUTP_DLY_STEP = 0;
    defparam pllvr_inst.CLKFB_SEL = "external";
    defparam pllvr_inst.CLKOUT_BYPASS = "false";
    defparam pllvr_inst.CLKOUTP_BYPASS = "false";
    defparam pllvr_inst.CLKOUTD_BYPASS = "false";
    defparam pllvr_inst.DYN_SDIV_SEL = 2;
    defparam pllvr_inst.CLKOUTD_SRC = "CLKOUT";
    defparam pllvr_inst.CLKOUTD3_SRC = "CLKOUT";
    defparam pllvr_inst.DEVICE = "GW1NS-4";

```

Vhdl Instantiation:

```

COMPONENT PLLVR
    GENERIC(
        FCLKIN:STRING:= "100.0";
        DEVICE:STRING:= "GW1NS-4";
        DYN_IDIV_SEL:STRING:="false";
        IDIV_SEL:integer:=0;
        DYN_FBDIV_SEL:STRING:="false";
        FBDIV_SEL:integer:=0;

```

```

        DYN_ODIV_SEL:STRING:="false";
        ODIV_SEL:integer:=8;
        PSDA_SEL:STRING:="0000";
        DYN_DA_EN:STRING:="false";
        DUTYDA_SEL:STRING:="1000";
        CLKOUT_FT_DIR:bit:='1';
        CLKOUTP_FT_DIR:bit:='1';
        CLKOUT_DLY_STEP:integer:=0;
        CLKOUTP_DLY_STEP:integer:=0;
        CLKOUTD3_SRC:STRING:="CLKOUT";
        CLKFB_SEL : STRING:="internal";
        CLKOUT_BYPASS:STRING:="false";
        CLKOUTP_BYPASS:STRING:="false";
        CLKOUTD_BYPASS:STRING:="false";
        CLKOUTD_SRC:STRING:="CLKOUT";
        DYN_SDIV_SEL:integer:=2
    );
    PORT(
        CLKIN:IN std_logic;
        CLKFB:IN std_logic;
        IDSEL:IN std_logic_vector(5 downto 0);
        FBDSEL:IN std_logic_vector(5 downto 0);
        ODSEL:IN std_logic_vector(5 downto 0);
        VREN:IN std_logic;
        RESET:IN std_logic;
        RESET_P:IN std_logic;
        PSDA,FDLY:IN std_logic_vector(3 downto 0);
        DUTYDA:IN std_logic_vector(3 downto 0);
        LOCK:OUT std_logic;
        CLKOUT:OUT std_logic;
        CLKOUTD:OUT std_logic;
        CLKOUTP:OUT std_logic;
        CLKOUTD3:OUT std_logic
    );
END COMPONENT;
```

uut:PLLVR

GENERIC MAP(

```

    FCLKIN =>"100.0",
    DEVICE =>"GW1NS-4",
    DYN_IDIV_SEL=>"false",
    IDIV_SEL=>0,
    DYN_FBDIV_SEL=>"false",
    FBDIV_SEL=>0,
    DYN_ODIV_SEL=>"false",
    ODIV_SEL=>8,
    PSDA_SEL=>"0000",
    DYN_DA_EN=>"false",
    DUTYDA_SEL=>"1000",
    CLKOUT_FT_DIR=>'1',
    CLKOUTP_FT_DIR=>'1',
    CLKOUT_DLY_STEP=>0,
    CLKOUTP_DLY_STEP=>0,
    CLKOUTD3_SRC=>"CLKOUT",
    CLKFB_SEL=>"internal",
    CLKOUT_BYPASS=>"false",
    CLKOUTP_BYPASS=>"false",
    CLKOUTD_BYPASS=>"false",
    CLKOUTD_SRC=>"CLKOUT",
    DYN_SDIV_SEL=>2

```

)

PORT MAP (

```

    CLKIN=>clk_in,
    CLKFB=>clkfb,
    IDSEL=>idsel,
    FBDSEL=>fbdsel,
    ODSEL=>odsel,
    VREN=>vren,
    RESET=>reset,
    RESET_P=>reset_p,
    PSDA=>psda,

```

```

FDLY=>fdly,
DUTYDA=>dutyda,
LOCK=>lock,
CLKOUT=>clkout,
CLKOUTD=>clkoutd,
CLKOUTP=>clkoutp ,
CLKOUTD3=>clkoutd3
);

```

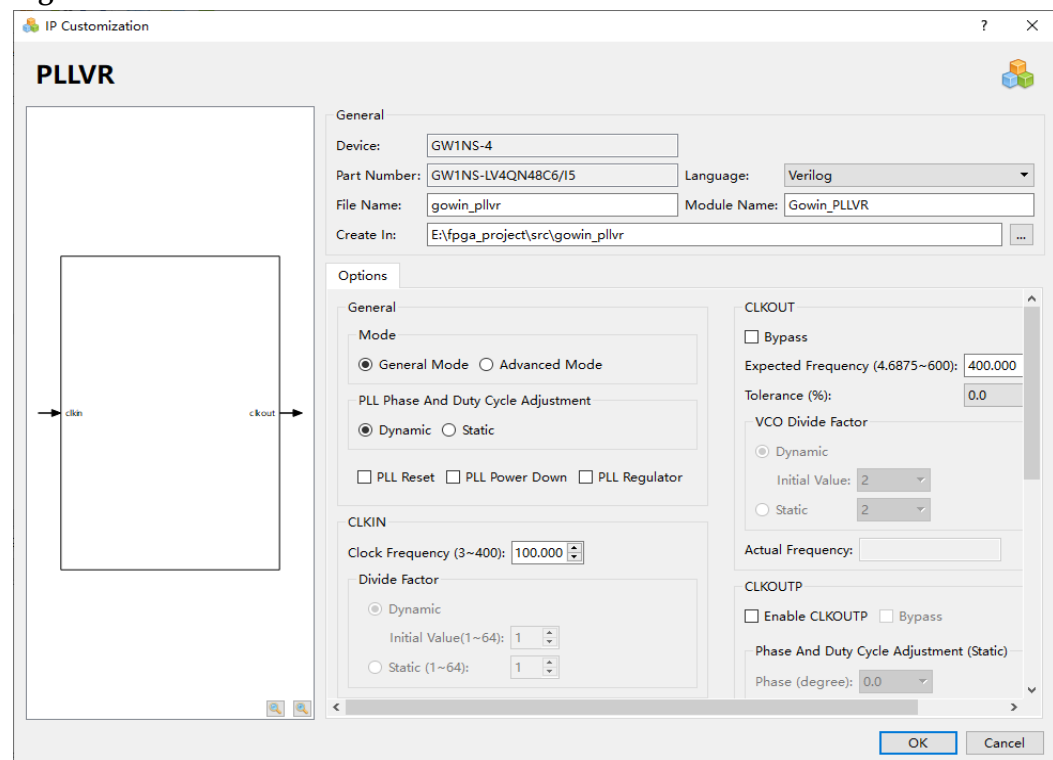
5.2.2 IP Generation

Click "PLLVR" on the IP Core Generator, and a brief introduction to the PLLVR will be displayed.

IP Configuration

Double-click on the "PLLVR" to open the "IP Customization" window. It includes the "General", "Options", port diagram, and the "Help", as shown in Figure 5-6.

Figure 5-6 IP Customization of PLLVR



1. General
The General configuration box is used to configure the generated IP design file. The PLLVR General configuration is similar to that of DQCE. For the details, please refer to the General description in [3.1.2 IP Generation](#).
2. Options

The Options configuration box is used to configure IP, as shown in Figure 5-6. PLLVR Options configuration box is similar to that of rPLL. For the details, please refer to rPLL, and PLL Regulator option is newly added.

3. Port Diagram

The port diagram displays a sample diagram of the IP Core configuration. The number of input and output ports is updated in real time according to the Options configuration, as shown in Figure 5-4.

IP Generated Files

After configuration, three files that are named after the "File Name" will be generated.

- "gowin_pllvr.v" file is a complete Verilog module to generate instantiated PLLVR, and it is generated according to the IP configuration;
- "gowin_pllvr_tmp.v" is the template file;
- "gowin_pllvr.ipc" file is IP configuration file. You can load the file to configure the IP.

Note!

If VHDL is selected as the hardware description language, the first two files will be named with .vhd suffix.

5.3 PLLO

5.3.1 Primitive Introduction

Gowin FPGA products provide PLLO that supports four clock outputs and adjusts frequency, phase, and duty cycle based on a given input clock.

Device Supported

Table 5-13 PLLO Device Supported

Product Family	Series	Device
LittleBee®	GW1N	GW1N-2, GW1N-1P5, GW1N-2B, GW1N-1P5B
	GW1NR	GW1NR-2, GW1NR-2B
Arora	GW2AN	GW2AN-18X, GW2AN-9X

Functional Description

PLLO supports four clock outputs and adjusts frequency (multiplication and division), phase, and duty cycle based on a given input clock to output clocks of different phases and frequencies. For the correct clock output, the input clock frequency must be set according to the frequency range described in the [FPGA Product Datasheet](#).

PLLO can adjust the frequency of the input clock CLKIN (multiplication and division). The formulas are as follows:

$$f_{CLKOUTA} = (f_{CLKIN} * FB DIV) / IDIV$$

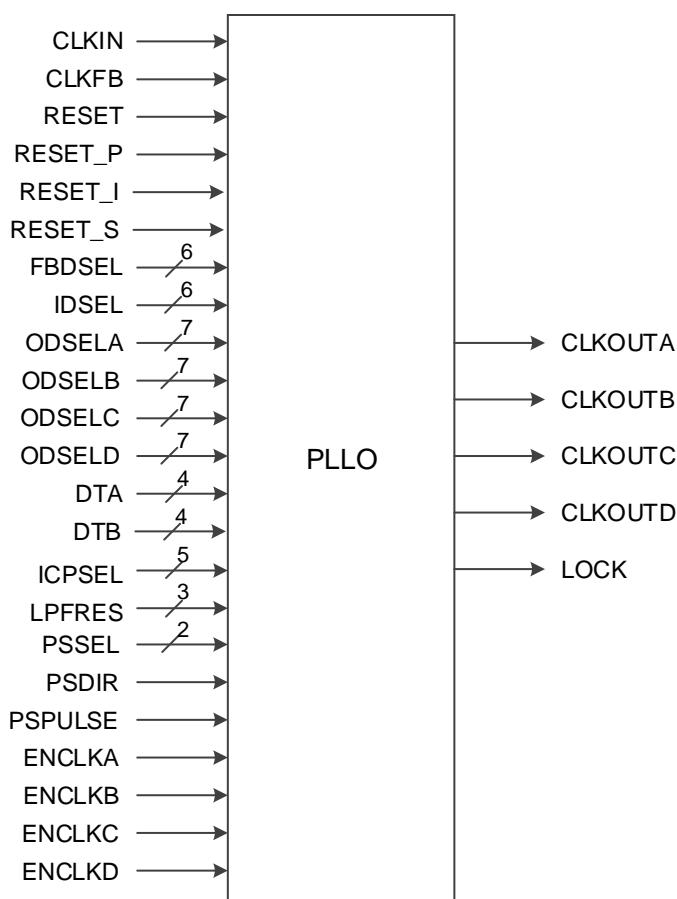
$$f_{VCO} = f_{CLKOUTA} * ODIVA$$

$$f_{CLKOUTX} = f_{IN_ODIVX} / ODIVX$$

$$f_{PFD} = f_{CLKIN} / IDIV = f_{CLKOUTA} / FBDIV$$

Note!

- f_{CLKIN} is the input CLKIN frequency;
- $f_{CLKOUTX}$: X=A/B/C/D is the output clock frequency of A/B/C/D channel, and ODIVX is the output division factor of A/B/C/D channel.
- f_{IN_ODIVX} : X=A/B/C/D is the input clock frequency of ODIVX, and the default is f_{VCO} . It is connected according to the actual circuit when cascaded or bypassed.
- f_{PFD} is the PFD phase discrimination frequency with a minimum value of not less than 3 MHz..
- IDIV, FBDIV, ODIV and SDIV are the actual frequency division coefficients of different dividers, which can be adjusted to get the clock signal with expected frequency.
- For the frequency range of the PLLO, please refer to the [FPGA Product Datasheet](#).

Port Diagram**Figure 5-7 PLLO Port Diagram****Port Description****Table 5-14 PLLO Port Description**

Port Name	I/O	Description
CLKIN	Input	Reference clock input signal

Port Name	I/O	Description
CLKFB	Input	Feedback clock input signal
RESET	Input	PLL reset signal, active-high.
RESET_P	Input	PLL power down signal, active-high.
RESET_I	Input	All with IDIV reset signal, including RESET and IDIV reset, active-high.
RESET_S	Input	Reset B/C/D channels, active-high.
FBDSEL[5:0]	Input	Dynamically controls FBDIV value, ranging from 0 to 63, and the actual value is 64-FBDSEL.
IDSEL[5:0]	Input	Dynamically controls IDIV value, ranging from 0 to 63, and the actual value is 64-IDSEL.
ODSELA[6:0]	Input	Dynamically controls ODIVA value, ranging from 0~127, and the actual value is 128-ODSELA.
ODSELB[6:0]	Input	Dynamically controls ODIVB value, ranging from 0~127, and the actual value is 128-ODSELA.
ODSELC[6:0]	Input	Dynamically controls ODIVC value, ranging from 0~127, and the actual value is 128-ODSELA.
ODSELD[6:0]	Input	Dynamically controls ODIVD value, ranging from 0~127, and the actual value is 128-ODSELA.
DTA[3:0]	Input	CLKOUTA duty cycle dynamic adjustment signal
DTB[3:0]	Input	CLKOUTB duty cycle dynamic adjustment signal
ICPSEL[4:0]	Input	Dynamically controls ICP current. The current increases with the increase of the value, and the current is the smallest when the value is 0.
LPFRES[2:0]	Input	Dynamically controls the size of LPFRES. The value range of LPFRES is from small to large, which is R0~R7. The bandwidth corresponding to R0 is the largest, and the bandwidth corresponding to R7 is the smallest.
PSSEL[1:0]	Input	Dynamically controls phase shift channel selection
PSDIR	Input	Dynamically controls phase shift direction
PSPULSE	Input	Dynamically controls phase shift clock pulses
ENCLKA	Input	Dynamically controls the A channel clock output enable, if you want to use the dynamic enable, you need the static parameter CLKOUTA_EN = "TRUE".
ENCLKB	Input	Dynamically controls the B channel clock output enable, if you want to use dynamic enable, you need the static parameter CLKOUTB_EN = "TRUE".
ENCLKC	Input	Dynamically controls the C channel clock output enable, if you want to use dynamic enable, you need the static parameter CLKOUTC_EN = "TRUE".
ENCLKD	Input	Dynamically controls the D channel clock output enable, if you want to use dynamic enable, you need the static parameter CLKOUTD_EN = "TRUE".
CLKOUTA	Output	A channel clock output
CLKOUTB	Output	B channel clock output
CLKOUTC	Output	C channel clock output

Port Name	I/O	Description
CLKOUTD	Output	D channel clock output
LOCK	Output	PLL lock indication signal. 1: locked, 0: unlocked.

Parameter Description

Table 5-15 PLLO Parameter Description

Name	Value	Default	Description
FCLKIN	"3"~"400"	"100.0"	Reference clock frequency
IDIV_SEL	0~63	0	IDIV frequency division coefficient static setting, ranging from 1~64.
DYN_IDIV_SEL	"TRUE", "FALSE"	"FALSE"	IDIV frequency division coefficient static control parameter or dynamic control signal selection. FLASE: Static, that is, select the parameter IDIV_SEL. TRUE: Dynamic, namely select signal IDSEL.
FBDIV_SEL	0~63	0	FBDIV frequency division coefficient static setting, ranging from 1-64.
DYN_FBDIV_SEL	"TRUE", "FALSE"	"FALSE"	FBDIV frequency division coefficient static control parameter or dynamic control signal selection. FLASE: Static, that is, select the parameter FBDIV_SEL. TRUE: Dynamic, namely select signal FBDSEL.
ODIV_SEL	1~128	4	ODIVA frequency division coefficient static setting
DYN_ODIVA_SEL	"TRUE", "FALSE"	"FALSE"	ODIVA frequency division coefficient static control parameter or dynamic control signal selection. FLASE: Static, that is, select the parameter ODIVA_SEL. TRUE: Dynamic, namely select signal ODSELA.
ODIVB_SEL	1~128	4	ODIVB frequency division coefficient static setting
DYN_ODIVC_SEL	"TRUE", "FALSE"	"FALSE"	ODIVB frequency division coefficient static control parameter or dynamic control signal selection. FLASE: Static, that is, select the parameter ODIVB_SEL. TRUE: Dynamic, namely select signal ODSELB.
ODIVC_SEL	1~128	4	ODIVC frequency division coefficient static setting
DYN_ODIVC_SEL	"TRUE", "FALSE"	"FALSE"	ODIVC frequency division coefficient static control parameter or dynamic

Name	Value	Default	Description
			control signal selection. FLASE: Static, that is, select the parameter ODIVC_SEL. TRUE: Dynamic, namely select signal ODSELC.
ODIVD_SEL	1~128	4	ODIVD frequency division coefficient static setting
DYN_ODIVD_SEL	"TRUE", "FALSE"	"FALSE"	ODIVD frequency division coefficient static control parameter or dynamic control signal selection. FLASE: Static, that is, select the parameter ODIVD_SEL. TRUE: Dynamic, namely select signal ODSELD.
CLKOUTA_EN	"TRUE", "FALSE"	"TRUE"	A channel clock output enable
CLKOUTB_EN	"TRUE", "FALSE"	"TRUE"	B channel clock output enable
CLKOUTC_EN	"TRUE", "FALSE"	"TRUE"	C channel clock output enable
CLKOUTD_EN	"TRUE", "FALSE"	"TRUE"	D channel clock output enable
DYN_DTA_SEL	"TRUE", "FALSE"	"FALSE"	A channel duty cycle trim static control parameter or dynamic control signal selection. FALSE: Static, that is, select ODIVC_SEL CLKOUTA_DT_DIR & CLKOUTA_DT_STEP TRUE: Dynamic, namely select signal DTA
DYN_DTB_SEL	"TRUE", "FALSE"	"FALSE"	B channel duty cycle trim static control parameter or dynamic control signal selection. FALSE: Static, that is, select CLKOUTB_DT_DIR & CLKOUTB_DT_STEP. TRUE: Dynamic, namely select signal DTB.
CLKOUTA_DT_DIR	1'b1, 1'b0	1'b1	A channel duty cycle static trim direction. 1'b1: + means duty cycle increases, and adjusts the falling edge based on rising edge alignment. 1'b0: - means duty cycle decreases, and adjusts the rising edge based on falling edge alignment.
CLKOUTB_DT_DIR	1'b1, 1'b0	1'b1	B channel duty cycle static trim direction. 1'b1: + means duty cycle increases, and adjusts the falling edge based on

Name	Value	Default	Description
			rising edge alignment. 1'b0: - means duty cycle decreases, and adjusts the rising edge based on falling edge alignment.
CLKOUTA_DT_STEP	0,1,2,4	0	A channel duty cycle static trim step, 50ps per step.
CLKOUTB_DT_STEP	0,1,2,4	0	B channel duty cycle static trim step, 50ps per step.
CLKA_IN_SEL	2'b00,2'b01,2'b11	2'b00	ODIVA input clock source selection 2'b00/2'b01: From VCO output 2'b11: Bypass comes from CLKIN.
CLKA_OUT_SEL	1'b0, 1'b1	1'b0	A channel output clock source selection 1'b0: Form ODIVA output 1'b1: The output clock bypass comes from CLKIN.
CLKB_IN_SEL	2'b00,2'b01,2'b10,2'b11	2'b00	ODIVB input clock source selection 2'b00/2'b01: Form VCO output 2'b10: Cascade comes from CLKCAS_A. 2'b11: Bypass comes from CLKIN.
CLKB_OUT_SEL	1'b0, 1'b1	1'b0	B channel output clock source selection 1'b0: From ODIVB output 1'b1: The output clock bypass comes from CLKIN.
CLKC_IN_SEL	2'b00,2'b01,2'b10,2'b11	2'b00	ODIVC input clock source selection 2'b00/2'b01: From VCO output 2'b10: Cascade comes from CLKCAS_B 2'b11: Bypass comes from CLKIN
CLKC_OUT_SEL	1'b0, 1'b1	1'b0	C channel output clock source selection 1'b0: From ODIVC output 1'b1: The output clock bypass comes from CLKIN.
CLKD_IN_SEL	2'b00,2'b01,2'b10,2'b11	2'b00	ODIVD input clock source selection 2'b00/2'b01: From VCO output 2'b10: Cascade comes from CLKCAS_C 2'b11: Bypass comes from CLKIN.
CLKD_OUT_SEL	1'b0, 1'b1	1'b0	D channel output clock source selection 1'b0: From ODIVD output 1'b1: The output clock bypass comes from CLKIN.
CLKFB_SEL	"INTERNAL",	"INTERNAL"	CLKFB source selection INTERNAL: From the feedback of

Name	Value	Default	Description
	"EXTERNAL"		internal CLKOUTA EXTERNAL: From the feedback of external signal
DYN_DPA_EN	"TRUE", "FALSE"	"FALSE"	Dynamic phase shift adjustment enable
DYN_PSB_SEL	"TRUE", "FALSE"	"FALSE"	B channel phase shift static control parameter or dynamic control signal selection FALSE: Static, that is, select PSB_COARSE & PSB_FINE TRUE. TRUE: Dynamic, that is, select DPA signals(PSEL& PSDIR& PSPULSE) to achieve, while DYN_DPA_EN="TRUE" is required.
DYN_PSC_SEL	"TRUE", "FALSE"	"FALSE"	C channel phase shift static control parameter or dynamic control signal selection FALSE: Static, that is, select PSC_COARSE & PSC_FINE TRUE TRUE: Dynamic, that is, select DPA signals (PSEL& PSDIR& PSPULSE) to achieve, while DYN_DPA_EN="TRUE" is required.
DYN_PSD_SEL	"TRUE", "FALSE"	"FALSE"	D channel phase shift static control parameter or dynamic control signal selection FALSE: Static, that is, select PSD_COARSE & PSD_FINE TRUE. TRUE: Dynamic, that is, select DPA signals (PSEL& PSDIR& PSPULSE) to achieve, while DYN_DPA_EN="TRUE" is required.
PSB_COARSE	1~128	1	B-channel phase coarse shift static setting
PSB_FINE	0~7	0	B-channel phase fine shift static setting
PSC_COARSE	1~128	1	C-channel phase coarse shift static setting
PSC_FINE	0~7	0	C-channel phase fine shift static setting
PSD_COARSE	1~128	1	D-channel phase coarse shift static setting
PSD_FINE	0~7	0	D-channel phase fine shift static setting
DTMS_ENB	"TRUE", "FALSE"	"FALSE"	B channel (ODIVB=2~128) duty cycle adjustment enable FALSE: 50% duty cycle TRUE: When DYN_PSB_SEL="TRUE", set PSB_COARSE & PSB_FINE as the falling edge and combine it with

Name	Value	Default	Description
			dynamic phase shift as the rising edge to achieve dynamic adjustment of duty cycle (falling edge - rising edge).
DTMS_ENC	"TRUE", "FALSE"	"FALSE"	C channel (ODIVC=2~128) duty cycle adjustment enable FALSE: 50% duty cycle TRUE: When DYN_PSC_SEL="TRUE", set PSC_COARSE & PSC_FINE as the falling edge and combine it with dynamic phase shift as the rising edge to achieve dynamic adjustment of duty cycle (falling edge - rising edge).
DTMS_END	"TRUE", "FALSE"	"FALSE"	D channel (ODIVD=2~128) duty cycle adjustment enable FALSE: 50% duty cycle TRUE: When DYN_PSD_SEL="TRUE", set PSD_COARSE & PSD_FINE as the falling edge and combine it with dynamic phase shift as the rising edge to achieve dynamic adjustment of duty cycle (falling edge - rising edge).
RESET_I_EN	"TRUE", "FALSE"	"FALSE"	Enable the dynamic signal RESET_I, if you need to use the RESET_I port, you need to set this parameter to TRUE.
RESET_S_EN	"TRUE", "FALSE"	"FALSE"	Enable the dynamic signal RESET_S, if you need to use the RESET_S port, you need to set this parameter to TRUE.
DYN_ICP_SEL	"TRUE", "FALSE"	"FALSE"	ICPSEL static control parameter or dynamic control signal selection FALSE: Static, i.e. the parameter ICP_SEL is selected. TRUE: Dynamic, i.e. the dynamic signal ICPSEL is selected.
ICP_SEL	5'bXXXX X, 5'b00000 ~5'b1111 1	5'bXXXX X	ICP current static setting 5'bXXXXX: Indicates that the software will automatically calculate and set this parameter. 5'b00000~5'b11111: If you need to set it by yourself, you can set it in the parameter range as needed.
DYN_RES_SEL	"TRUE", "FALSE"	"FALSE"	LPRREF static control parameter or dynamic control signal selection FALSE: Static, i.e. select the parameter LPR_REF. TRUE: Dynamic, i.e. select the dynamic signal LPFRES.
LPR_REF	7'bXXXX	7'bXXXX	LPRRES static setting

Name	Value	Default	Description
	XXX, 7'b000000 00(R0),7' b000000 1(R1),7'b 0000010(R2),7'b00 00100(R 3),7'b000 1000(R4) ,7'b00100 00(R5),7' b010000 0(R6),7'b 1000000(R7)	XXX	7'bXXXXXXX: Indicates that the software will automatically calculate and set the parameter. 7'b00000000~7'b10000000 (8 values): If you need to set it by yourself, you can choose to set it in the corresponding eight values as needed.

Table 5-16 IDSEL Port Parameter Comparison Table

IDSEL[5:0]	IDIV Static Value	IDIV Actual Value
111111	0	1
111110	1	2
111101	2	3
111100	3	4
111011	4	5
111010	5	6
111001	6	7
111000	7	8
110111	8	9
.....
000000	63	64

Table 5-17 FBDSEL Port Parameter Comparison Table

FBDSEL [5:0]	FBDIV Static Value	FBDIV Actual Value
111111	0	1
111110	1	2
111101	2	3
111100	3	4
111011	4	5
111010	5	6
111001	6	7
111000	7	8
110111	8	9
.....

FBDSEL [5:0]	FBDIV Static Value	FBDIV Actual Value
000000	63	64

Table 5-18 ODSELX (X=A/B/C/D) Port Parameter Comparison Table

ODSELX [6:0]	ODIVX Static Value	ODIVX Actual Value
1111111	1	1
1111110	2	2
1111101	3	3
1111100	4	4
1111011	5	5
1111010	6	6
1111001	7	7
1111000	8	8
1110111	9	9
.....
0000000	128	128

Phase Shift

PLLO supports phase shift, which includes static phase shift and dynamic phase shift, and the dynamic phase shift is only supported by B/C/D channels. Static phase shift is achieved by setting the parameters PSX_COARSE and PSX_FINE (X=A/B/C/D). Dynamic phase shift is achieved by signals PSSEL, PSDIR and PSPULSE. PSSEL is used to control channel selection, PSDIR is used to control plus or minus operation. For a PSPULSE pulse falling edge, DYN_FINE is plus/minus 1. DYN_COARSE is plus or minus 1 when DYN_FINE overflows or underflows, where DYN_COARSE value is less than or equal to ODIV.

The phase shift can be configured and calculated according to the following equation (using the B channel as an example)

- If COARSE_B < ODIVB, $ps = (FINE_B/8 + COARSE_B)/ODIVB \times 360$
- COARSE_B = ODIVB, $ps = (FINE_B/8)/ODIVB \times 360$

Note!

- DYN_FINE and DYN_COARSE are internal signals generated by the DPA through PSSEL, PSDIR, PSPULSE signals.
- FINE_B is the dynamic DYN_FINE_B or the static parameter PSB_FINE selected via DYN_PSB_SEL, and COARSE_B is the dynamic DYN_COARSE_B or the static parameter PSB_COARSE selected via DYN_PSB_SEL.
- When CLKX_IN_SEL(X=B/C/D), FINE_X (X=B/C/D) should be set to 0 when bypass or cascade is selected.

Duty Cycle Adjustment

PLLO dynamic duty cycle adjustment is only supported by B/C/D channels. Duty cycle is defined as follows:

$$\text{Duty cycle} = (\text{falling edge} - \text{rising edge}) / \text{cycle_period}$$

The position of the falling edge is determined by the static phase shift setting, defined as DUTY. The position of the rising edge is determined by the dynamic phase shift setting PHASE, DYN_FINE and DYN_COARSE are internal signals generated by the DPA, and you can see the relevant descriptions in the Duty Cycle Adjustment. The formula for calculating DUTY and PHASE is as follows (using channel B as an example).

$$\text{DUTY} = (\text{PSB_FINE}/8 + \text{PSB_COARSE})$$

$$\text{PHASE} = (\text{DYN_FINEB}/8 + \text{DYN_COARSEB})$$

The dynamic duty cycle calculation is as follows:

- If $\text{DUTY} > \text{PHASE}$, $\text{DutyCycle} = (\text{DUTY} - \text{PHASE}) / \text{ODIVB}$.
- If $\text{DUTY} < \text{PHASE}$, $\text{DutyCycle} = (\text{DUTY} - \text{PHASE}) / \text{ODIVB} + 1$.

Note!

- Dynamic duty cycle adjustment is not supported when $\text{ODIV}=1$, and the duty cycle is 50%.
- When $\text{ODIV} \geq 2$, $\text{DUTY} - \text{PHASE}$ does not support a value between $(-0.5, 0.5)$.
- When $\text{CLKX_IN_SEL}(X=B/C/D)$ selects bypass or cascade, if $\text{ODIV}(>2)$ is odd then duty cycle is not 50% (high < low, i.e. less than 50%).

Duty Cycle Trim

The A and B channels of PLLO supports duty cycle trim, which is achieved by setting the direction and step of duty cycle; static and dynamic modes are supported.

1. Static

- Trim direction, controlled by the parameters $\text{CLKOUTA_DT_DIR}/\text{CLKOUTB_DT_DIR}$.
- Trim step, controlled by the parameters $\text{CLKOUTA_DT_STEP}/\text{CLKOUTB_DT_STEP}$.

2. Dynamic.

- Trim direction, controlled by ports $\text{DTA}[3]/\text{DTB}[3]$.
- Trim step, controlled by ports $\text{DTA}[2:0]/\text{DTB}[2:0]$.

Table 5-19 PLLO Duty Trim Comparison Table

Direction	Step	Delay Value
1'b0	0	0
	1	-50ps
	2	-100ps
	4	-200ps
1'b1	0	0
	1	+50ps
	2	+100ps

Direction	Step	Delay Value
	4	+200ps

A and B channels output the same frequency clock, and the B channel clock duty cycle is finely adjusted taking A channel clock as a reference. The specific timing is as shown in Figure 5-6 and Figure 5-7.

Figure 5-8 B-channel Duty Cycle Trim Timing Diagram (Direction 1'b1, Step 1)

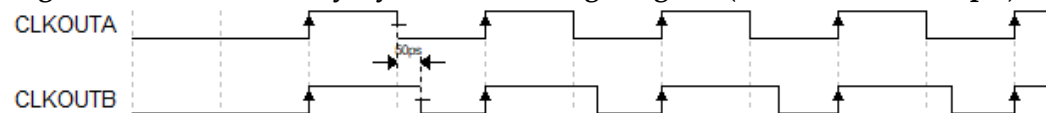
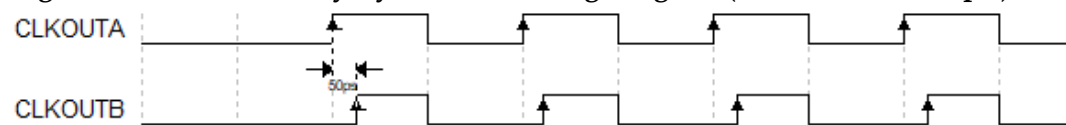


Figure 5-9 B-channel Duty Cycle Trim Timing Diagram (Direction 1'b0, Step 1)



ICPSEL/ LPFRES Setting

PLL0 supports ICPSEL and LPFRES setting, including static and dynamic. You can set the dynamic according to the actual needs, the static default is X. Gowin software will automatically calculate and configure if you need.

The value range of ICPSEL increases linearly from small to large, and can be divided into ICP1, ICP2,ICPN..... ICP31, ICP32, with a total of 32. ICP1 corresponds to the minimum current, and ICP32 corresponds to the maximum current. The value of ICP can be considered qualitatively as the larger N is, the larger ICP is, and the smaller N is, the smaller ICP is.

The range of LPFRES values from small to large is R0, R1, R2, R3, R4, R5, R6, R7. R0 corresponds to the largest bandwidth and R7 corresponds to the smallest bandwidth. Several typical values are given: R7->250KHz, R4->1.6MHz, R1->12MHz.

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```

PLL0 pll0_inst (
    .LOCK(lock),
    .CLKOUTA(clkouta),
    .CLKOUTB(clkoutb),
    .CLKOUTC(clkoutc),
    .CLKOUTD(clkoutd),

```

```

.CLKIN(clkin),
.CLKFB(clkfb),
.RESET(reset),
.RESET_P(reset_p),
.RESET_I(reset_i),
.RESET_S(reset_s),
.FBDSEL(fbdsel),
.IDSEL(idsel),
.ODSELA(odsel_a),
.ODSELB(odsel_b),
.ODSELC(odsel_c),
.ODSELD(odsel_d),
.DTA(dta),
.DTB(dtb),
.ICPSEL(icpsel),
.LPFRES(lpfres),
.PSSEL(pssel),
.PSDIR(psdir),
.PSPULSE(phpulse),
.ENCLKA(enclka),
.ENCLKB(enclkb),
.ENCLKC(enclkc),
.ENCLKD(enclkd)
);

defparam pllo_inst.FCLKIN = "100";
defparam pllo_inst.DYN_IDIV_SEL = "FALSE";
defparam pllo_inst.IDIV_SEL = 0;
defparam pllo_inst.DYN_FBDIV_SEL = "FALSE";
defparam pllo_inst.FBDIV_SEL = 0;
defparam pllo_inst.DYN_ODIVA_SEL = "FALSE";
defparam pllo_inst.ODIVA_SEL = 4;
defparam pllo_inst.DYN_ODIVB_SEL = "FALSE";
defparam pllo_inst.ODIVB_SEL = 4;
defparam pllo_inst.DYN_ODIVC_SEL = "FALSE";

```

```
defparam pllo_inst.ODIVC_SEL = 4;
defparam pllo_inst.DYN_ODIVD_SEL = "FALSE";
defparam pllo_inst.ODIVD_SEL = 4;
defparam pllo_inst.CLKOUTA_EN = "TRUE";
defparam pllo_inst.CLKOUTB_EN = "FALSE";
defparam pllo_inst.CLKOUTC_EN = "FALSE";
defparam pllo_inst.CLKOUTD_EN = "FALSE";
defparam pllo_inst.DYN_DTA_SEL = "FALSE";
defparam pllo_inst.DYN_DTB_SEL = "FALSE";
defparam pllo_inst.CLKOUTA_DT_DIR = 1'b1;
defparam pllo_inst.CLKOUTB_DT_DIR = 1'b1;
defparam pllo_inst.CLKOUTA_DT_STEP = 0;
defparam pllo_inst.CLKOUTB_DT_STEP = 0;
defparam pllo_inst.CLKA_IN_SEL = 2'b00;
defparam pllo_inst.CLKA_OUT_SEL = 1'b0;
defparam pllo_inst.CLKB_IN_SEL = 2'b00;
defparam pllo_inst.CLKB_OUT_SEL = 1'b0;
defparam pllo_inst.CLKC_IN_SEL = 2'b00;
defparam pllo_inst.CLKC_OUT_SEL = 1'b0;
defparam pllo_inst.CLKD_IN_SEL = 2'b00;
defparam pllo_inst.CLKD_OUT_SEL = 1'b0;
defparam pllo_inst.CLKFB_SEL = "INTERNAL";
defparam pllo_inst.DYN_DPA_EN = "FALSE";
defparam pllo_inst.DYN_PSB_SEL = "FALSE";
defparam pllo_inst.DYN_PSC_SEL = "FALSE";
defparam pllo_inst.DYN_PSD_SEL = "FALSE";
defparam pllo_inst.PSB_COARSE = 1;
defparam pllo_inst.PSB_FINE = 0;
defparam pllo_inst.PSC_COARSE = 1;
defparam pllo_inst.PSC_FINE = 0;
defparam pllo_inst.PSD_COARSE = 1;
defparam pllo_inst.PSD_FINE = 0;
defparam pllo_inst.DTMS_ENB = "FALSE";
defparam pllo_inst.DTMS_ENC = "FALSE";
defparam pllo_inst.DTMS_END = "FALSE";
```

```

defparam pllo_inst.RESET_I_EN = "FALSE";
defparam pllo_inst.RESET_S_EN = "FALSE";
defparam pllo_inst.DYN_ICP_SEL = "FALSE";
defparam pllo_inst.ICP_SEL = 5'bXXXXXX;
defparam pllo_inst.DYN_RES_SEL = "FALSE";
defparam pllo_inst.LPR_REF = 7'bXXXXXXXX

```

VHDL Instantiation:

COMPONENT PLLO

GENERIC (

```

    FCLKIN : STRING := "100.0";
    DYN_IDIV_SEL : STRING := "FALSE";
    IDIV_SEL : integer := 0;
    DYN_FBDIV_SEL : STRING := "FALSE";
    FBDIV_SEL : integer := 0;
    DYN_ODIVA_SEL : STRING := "FALSE";
    ODIVA_SEL : integer := 4;
    DYN_ODIVB_SEL : STRING := "FALSE";
    ODIVB_SEL : integer := 4;
    DYN_ODIVC_SEL : STRING := "FALSE";
    ODIVC_SEL : integer := 4;
    DYN_ODIVD_SEL : STRING := "FALSE";
    ODIVD_SEL : integer := 4;
    CLKOUTA_EN : STRING := "TRUE";
    CLKOUTB_EN : STRING := "TRUE";
    CLKOUTC_EN : STRING := "TRUE";
    CLKOUTD_EN : STRING := "TRUE";

    DYN_DTA_SEL : STRING := "FALSE";
    DYN_DTB_SEL : STRING := "FALSE";
    CLKOUTA_DT_DIR : bit := '1';
    CLKOUTB_DT_DIR : bit := '1';
    CLKOUTA_DT_STEP : integer := 0;
    CLKOUTB_DT_STEP : integer := 0;
    CLKA_IN_SEL : bit_vector := "00";
    CLKA_OUT_SEL : bit := '0';

```

```

        CLKB_IN_SEL  : bit_vector := "00";
        CLKB_OUT_SEL : bit := '0';
        CLKC_IN_SEL  : bit_vector := "00";
        CLKC_OUT_SEL : bit := '0';
        CLKD_IN_SEL  : bit_vector := "00";
        CLKD_OUT_SEL : bit := '0';
        CLKFB_SEL : STRING := "INTERNAL";
        DYN_DPA_EN : STRING := "FALSE";
        DYN_PSB_SEL : STRING := "FALSE";
        DYN_PSC_SEL : STRING := "FALSE";
        DYN_PSD_SEL : STRING := "FALSE";
        PSB_COARSE : integer := 1;
        PSB_FINE : integer := 0;
        PSC_COARSE : integer := 1;
        PSC_FINE : integer := 0;
        PSD_COARSE : integer := 1;
        PSD_FINE : integer := 0;
        DTMS_ENB : STRING := "FALSE";
        DTMS_ENC : STRING := "FALSE";
        DTMS_END : STRING := "FALSE";
        RESET_I_EN : STRING := "FALSE";
        RESET_S_EN : STRING := "FALSE";
        DYN_ICP_SEL : STRING := "FALSE";
        ICP_SEL : std_logic_vector(4 downto 0) := "XXXXX";
        DYN_RES_SEL : STRING := "FALSE";
        LPR_REF : std_logic_vector(6 downto 0) := "XXXXXXX"
    );
    PORT (
        CLKIN : IN std_logic;
        CLKFB : IN std_logic:= '0';
        RESET, RESET_P : IN std_logic:= '0';
        RESET_I, RESET_S : IN std_logic:= '0';
        IDSEL, FBDSSEL : IN std_logic_vector(5 downto 0);
        ODSELA,  ODSELB,  ODSELC,  ODSELD  :  IN
std_logic_vector(6 downto 0);

```

```

        DTA, DTB : IN std_logic_vector(3 downto 0);
        ICPSEL : IN std_logic_vector(4 downto 0);
        LPFRES : IN std_logic_vector(2 downto 0);
        PSSEL : IN std_logic_vector(1 downto 0);
        PSDIR,PSPULSE : IN std_logic;
        ENCLKA,ENCLKB,ENCLKC,ENCLKD : IN std_logic;
        LOCK : OUT std_logic;
        CLKOUTA : OUT std_logic;
        CLKOUTB : OUT std_logic;
        CLKOUTC : OUT std_logic;
        CLKOUTD : OUT std_logic
    );
END COMPONENT;
 uut:PLLO
    GENERIC MAP(
        FCLKIN : STRING => "100.0";
        DYN_IDIV_SEL =>"FALSE";
        IDIV_SEL => 0;
        DYN_FBDIV_SEL=> "FALSE";
        FBDIV_SEL => 0;
        DYN_ODIVA_SEL =>"FALSE";
        ODIVA_SEL => 4;
        DYN_ODIVB_SEL=> "FALSE";
        ODIVB_SEL => 4;
        DYN_ODIVC_SEL => "FALSE";
        ODIVC_SEL => 4;
        DYN_ODIVD_SEL=> "FALSE";
        ODIVD_SEL => 4;
        CLKOUTA_EN => "TRUE";
        CLKOUTB_EN => "TRUE";
        CLKOUTC_EN => "TRUE";
        CLKOUTD_EN =>"TRUE";
        DYN_DTA_SEL =>"FALSE";
        DYN_DTB_SEL =>"FALSE";
        CLKOUTA_DT_DIR => '1';
    
```

```
CLKOUTB_DT_DIR => '1';
CLKOUTA_DT_STEP => 0;
CLKOUTB_DT_STEP => 0;
CLKA_IN_SEL => "00";
CLKA_OUT_SEL => '0';
CLKB_IN_SEL => "00";
CLKB_OUT_SEL => '0';
CLKC_IN_SEL => "00";
CLKC_OUT_SEL => '0';
CLKD_IN_SEL => "00";
CLKD_OUT_SEL => '0';
CLKFB_SEL => "INTERNAL";
DYN_DPA_EN => "FALSE";
DYN_PSB_SEL => "FALSE";
DYN_PSC_SEL => "FALSE";
DYN_PSD_SEL => "FALSE";
PSA_COARSE => 0;
PSA_FINE => 0;
PSB_COARSE => 0;
PSB_FINE => 0;
PSC_COARSE => 0;
PSC_FINE => 0;
PSD_COARSE => 0;
PSD_FINE => 0;
DTMS_ENB => "FALSE";
DTMS_ENC => "FALSE";
DTMS_END => "FALSE";
RESET_I_EN => "FALSE";
RESET_S_EN => "FALSE";
DYN_ICP_SEL => "FALSE";
ICP_SEL => "XXXXX";
DYN_RES_SEL => "FALSE";
LPR_REF => "XXXXXXXX"
)
PORT MAP(
```



```

        LOCK=>lock,
        CLKOUTA=> clkouta,
        CLKOUTB=>clkoutb,
        CLKOUTC=>clkoutc,
        CLKOUTD=>clkoutd,
        CLKIN=>clkin,
        CLKFB=>clkfb,
        RESET=>reset,
        RESET_P=>reset_p,
        RESET_I=>reset_i,
        RESET_S=>reset_s,
        FBDSEL=>fbdsel,
        IDSEL=>idsel,
        ODSELA=>odsela,
        ODSELB=>odselb,
        ODSELC=>odselc,
        ODSELD=>odseld,
        DTA=>dta,
        DTB=>dtb,
        ICPSEL=>icpsel,
        LPFRES=>lpfres,
        PSSEL=>pssel,
        PSDIR=>psdir,
        PSPULSE=>pspulse,
        ENCLKA=>enclka,
        ENCLKB=>enclkb,
        ENCLKC=>enclkc,
        ENCLKD=>enclkd
    );

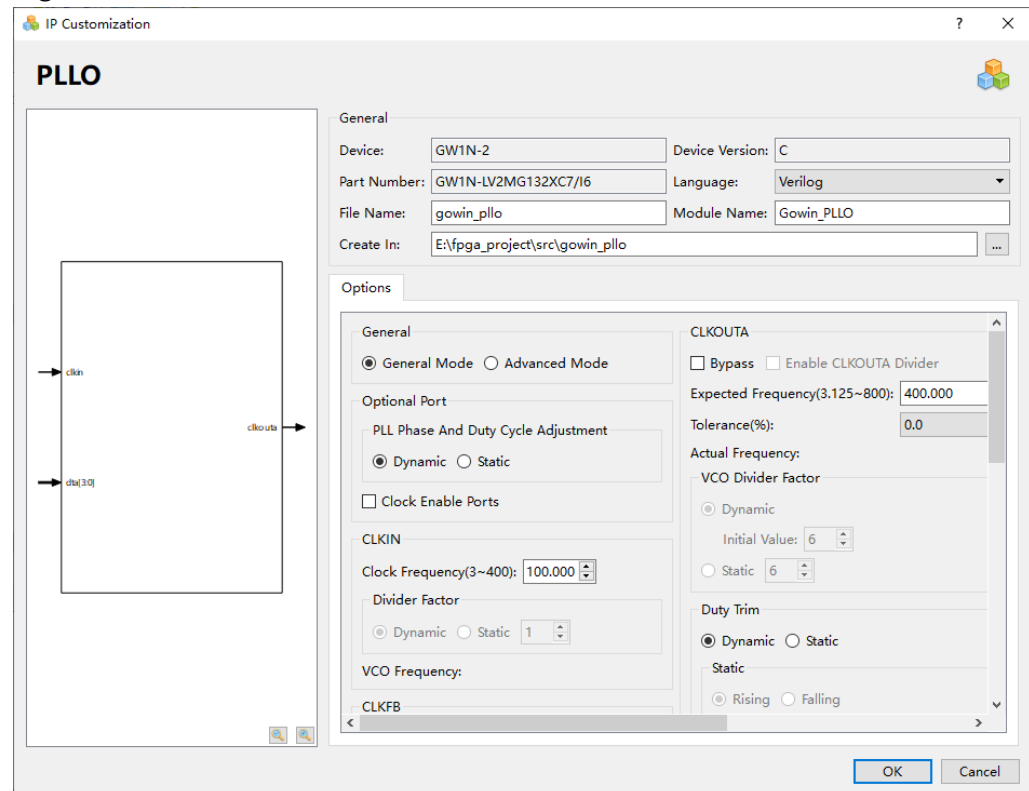
```

5.3.2 IP Generation

Click "PLLO" on the IP Core Generator, and a brief introduction to the PLLO will be displayed.

IP Configuration

Double-click on the "PLLO" to open the "IP Customization" window. It includes the "General", "Options", and ports diagram, as shown in Figure 5-10.

Figure 5-10 IP Customization of PLLO

1. General

The General configuration box is used to configure the generated IP design file. PLLO General configuration is similar to that of DQCE. For the details, please refer to the General description in [3.1.2 IP Generation](#).

2. Options

The Options configuration box is used to configure IP, as shown in Figure 5-10.

- **General:** Configures "General Mode" or "Advanced Mode". Input the input clock frequency and output clock frequency in general mode, the software will automatically calculate different division factors. Advanced mode is intended for advanced users and allows inputting the input frequency and different division factors to obtain the desired output frequency.
- **Optional Port:** Configures dynamic and static modes for output phase and duty cycle adjustment, and enables PLLO output clock
 - "PLL Phase And Duty Cycle Adjustment": "Static" Mode or "Dynamic" Mode. You can configure the duty cycle of the output and the mode of the phase shift.
 - "Clock Enable Ports": Enables the output clock port of PLLO.
- **CLKIN:** Configures input clock frequency and divide factor.
 - "Clock Frequency": Configures the frequency of the input clock with the range of 3~400MHz.

- Divide Factor: Sets the Divide Factor as "Dynamic" or "Static" in advanced mode. In Static mode, Divide Factor value can be set as a specific value, ranging from 1 to 64. If the CLKOUT frequency is not in the range required by the device, an error prompt will pop up when you click "Calculate" or "OK" ; If the frequency of CLKIN/IDIV is not in the range required by the device, an error prompt will pop up when you click "Calculate" or "OK".
- "VCO Frequency" is the calculated frequency of the VCO, read only.
- CLKFB: Configures the source and divide factor of PLL0.
 - When configuring the source of the feedback clock, you can select Internal and External.
 - Divide Factor: Sets the Divide Factor as "Dynamic" or "Static" in advanced mode. In static mode, Divide Factor value can be set as a specific value, ranging from 1 to 64. If the configuration is invalid, an error prompt will pop up when you click "Calculate" or "OK".
- ICP and LPF
 - ICPSEL: Configures ICP current, supports "Dynamic" and "Static". In static mode, you can configure ICP value, the range is ICP1 ~ ICP32, the default is X, meaning the software will automatically calculate and configure.
 - LPFRES: Configures low-pass filtering resistor, supports "Dynamic" and "Static". In static mode, you can configure the value of RES, and the range is R0~R7, the default is X, meaning the software will automatically calculate and configure.
- PLL Reset
 - "PLL Reset": Configures the RESET enable mode of PLL0.
 - "PLL Power Down": Configures the RESET_P port to put the PLL0 in power-down mode.
 - "CLKIN Divider Reset": Enables RESET_I.
 - "CLKOUTB/CLKOUTC/CLKOUTD Divider Reset": Enables RESET_S.
- Enable LOCK: Enables the LOCK port.
- CLKOUTA: Configures the expected frequency, VCO and duty trim of A channel.
 - Bypass: Enables/ disables bypass.
 - Enable CLKOUTA Divider: Configures VCO clock bypass.
 - "Expected Frequency": Configures the expected frequency of the output clock CLKOUTA in general mode, with the range of

3.125M~800M in non-bypass mode.

- Tolerance(%): Sets a tolerance for the CLKOUTA between expected frequency and actual frequency calculated.
- VCO Divide Factor: "Dynamic" or "Static" in advanced mode. In static mode, the Divide Factor value can be set as a specific value, and the range of 1~128. If the configuration is invalid, an error prompt will pop up when the user clicks "Calculate" or "OK".
- Actual Frequency: The actual frequency that can be generated automatically.
- Duty Trim: Trims duty cycle, and supports "Dynamic" and "Static". In static mode, it includes "Rising" and "Falling", and you can configure the specific value of "Step" as 0, 1, 2, 4.
- CLKOUTB: Configures the expected frequency, VCO, duty trim, etc. of B channel.
 - Bypass: Enables/disables bypass.
 - Enable CLKOUTB Divider: Configures VCO clock bypass.
 - "Expected Frequency": Configures the expected frequency of the output clock CLKOUTB in general mode, with the range of 3.125M~800M in non-bypass mode.
 - Tolerance(%): Sets a tolerance for the CLKOUTB between expected frequency and actual frequency calculated.
 - VCO Divide Factor: "Dynamic" or "Static" in advanced mode. In static mode, the Divide Factor value can be set as a specific value, and the range of 1~128. If the configuration is invalid, an error prompt will pop up when you click "Calculate" or "OK".
 - Actual Frequency: The actual frequency that can be generated automatically.
 - Duty Trim: Trims duty cycle, and supports "Dynamic" and "Static". In static mode, it includes "Rising" and "Falling", and you can configure the specific value of "Step" as 0, 1, 2, 4.
 - Phase (degree): Configures the adjusted phase degree, supports "Dynamic" and "Static". In the static mode, you can configure the phase degree.
 - Duty Cycle: Configures duty cycle, supports "Dynamic" and "Static". In static mode, it is 50%. In dynamic mode, you need to configure the phase and combine with dynamic DPA to achieve the duty cycle.
- CLKOUTC: Configures the expected frequency, VCO, duty trim, etc. of C channel.
 - Bypass: Enables/ disables bypass.
 - Enable CLKOUTC Divider: Configures VCO clock bypass.

- "Expected Frequency": Configures the expected frequency of the output clock CLKOUTC in general mode, with the range of 3.125M~800M in non-bypass mode.
- Tolerance(%): Sets a tolerance for the CLKOUTC between expected frequency and actual frequency calculated.
- VCO Divide Factor: "Dynamic" or "Static" in advanced mode. In static mode, the Divide Factor value can be set as a specific value, and the range of 1~128. If the configuration is invalid, an error prompt will pop up when you click "Calculate" or "OK".
- Actual Frequency: The actual frequency that can be generated automatically.
- Phase (degree): Configures the adjusted phase degree, supports "Dynamic" and "Static". In the static mode, you can configure the phase degree.
- Duty Cycle: Configures duty cycle, supports "Dynamic" and "Static". In static mode, it is 50%. In dynamic mode, you need to configure the phase and combine with dynamic DPA to achieve the duty cycle.
- CLKOUTD: Configures the expected frequency, VCO, duty trim, etc. of B channel.
 - Bypass: Enables/ disables bypass.
 - Enable CLKOUTD Divider: Configures VCO clock bypass.
 - "Expected Frequency": Configures the expected frequency of the output clock CLKOUTD in general mode, with the range of 3.125M~800M in non-bypass mode.
 - Tolerance(%): Sets a tolerance for the CLKOUTD between expected frequency and actual frequency calculated.
 - VCO Divide Factor: "Dynamic" or "Static" in advanced mode. In static mode, the Divide Factor value can be set as a specific value, and the range of 1~128. If the configuration is invalid, an error prompt will pop up when the user clicks "Calculate" or "OK".
 - Actual Frequency: The actual frequency that can be generated automatically.
 - Phase (degree): Configures the adjusted phase degree, supports "Dynamic" and "Static". In the static mode, you can configure the phase degree.
 - Duty Cycle: Configures duty cycle, supports "Dynamic" and "Static". In static mode, it is 50%. In dynamic mode, you need to configure the phase and combine with dynamic DPA to achieve the duty cycle.
- Calculate: Calculates whether the current configuration is reasonable.

- In "General Mode", calculate the division/multiplication frequency and VCO parameters. If the actual frequency is different from the expected frequency, an Error prompt will pop up.
- In "Advanced Mode", calculate the static division/multiplication frequency and VCO parameters. If the calculated results are invalid, click "Calculate", an Error prompt will pop up. If valid, click "Calculate", "succeed" prompt will pop up.

3. Port Diagram

The port diagram is based on the IP Core configuration. The input/output number is updated in real time based on the "Options" configuration, as shown in Figure 5-10.

IP Generated Files

After configuration, three files that are named after the "File Name" will be generated.

- "gowin_pllo.v" file is a complete Verilog module to generate instantiated PLLO, and it is generated according to the IP configuration;
- "gowin_pllo_tmp.v" is the template file;
- "gowin_pllo.ipc" file is IP configuration file. You can load the file to configure the IP.

Note!

If VHDL is selected as the hardware description language, the first two files will be named with .vhd suffix.

5.4 DLLDLY

5.4.1 Primitive Introduction

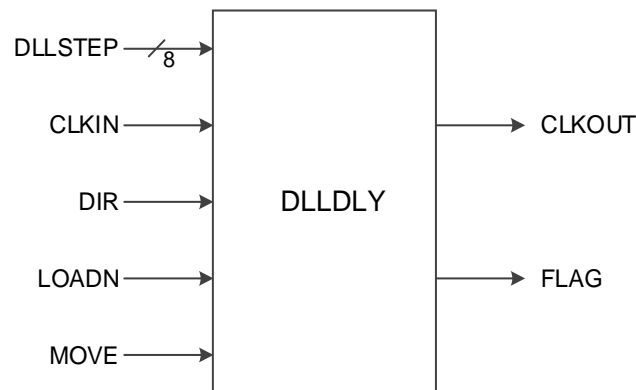
DLLDLY is the clock delay module that adjusts the input clock according to the DLLSTEP signal and gets delay adjustment output of the clock.

Functional Description

DLLDLY generates the corresponding phase delay based on DLLSTEP to get the delay output based on CLKIN.

Port Diagram

Figure 5-11 DLLDLY Port Diagram



Port Description

Table 5-20 DLLDLY Port Description

Port Name	I/O	Description
CLKOUT	Output	Clock output signal
FLAG	Output	An output flag that represents under-flow or over-flow in dynamical delay adjustment
DLLSTEP[7:0]	Input	Delay step input signal
CLKIN	Input	Clock input signal
DIR	Input	Sets the direction of dynamic delay adjustment 0: Increases delay 1: Decreases delay
LOADN	Input	Controls the loading of DLLSTEP 0: Loads DLLSTEP 1: adjusts the delay dynamically
MOVE	Input	When MOVE is dynamically adjusted on falling edge, each pulse moves one delay step.

Parameter Description

Table 5-21 DLLDLY Parameter Description

Name	Type	Value	Default	Description
DLL_INSEL	Integer	1'b1	1'b1	1'b1: Normal mode, using DLLDLY delay module
DLY_SIGN	String	1'b0, 1'b1	1'b0	Sets the sign of delay adjustment 1'b0: '+' 1'b1: '-'
DLY_ADJ	Integer	0~255	0	Delay adjustment setting dly_sign=0 DLY_ADJ; dly_sign=1

Name	Type	Value	Default	Description
				-256+ DLY_ADJ

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```

DLLDLY dlldly_0 (
    .CLKIN(clkin),
    .DLLSTEP(step[7:0]),
    .DIR(dir),
    .LOADN(loadn),
    .MOVE(move),
    .CLKOUT(clkout),
    .FLAG(flag)
);
defparam dlldly_0.DLL_INSEL=1'b1;
defparam dlldly_0.DLY_SIGN=1'b1;
defparam dlldly_0.DLY_ADJ=0;

```

Vhdl Instantiation:

```

COMPONENT DLLDLY
    GENERIC(
        DLL_INSEL:bit:=0';
        DLY_SIGN:bit:=0';
        LY_ADJ:integer:=0
    );
    PORT(
        DLLSTEP:IN std_logic_vector(7 downto 0);
        CLKIN:IN std_logic;
        DIR,LOADN,MOVE:IN std_logic;
        CLKOUT:OUT std_logic;
        FLAG:OUT std_logic
    );
END COMPONENT;
 uut:DLLDLY

```



```

GENERIC MAP(
    DLL_INSEL=>'1',
    DLY_SIGN=>'0',
    LY_ADJ=>0
)
PORT MAP (
    DLLSTEP=>step,
    CLKIN=>clkin,
    DIR=>dir,
    LOADN=>loadn,
    MOVE=>move,
    CLKOUT=>clkout,
    FLAG=>flag
);

```

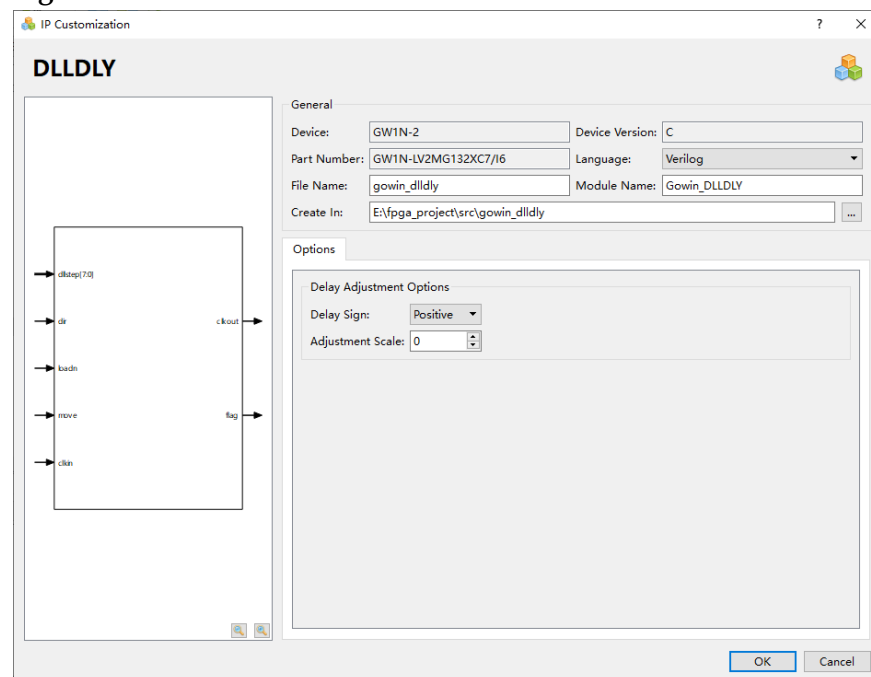
5.4.2 IP Generation

Click "DLLDLY" on the "IP Core Generator" interface and an overview of DLLDLY will be displayed on the right side of the interface.

IP Configuration

Double-click on "DLLDLY", and the "IP Customization" window pops up. It includes the "General", "Options", and port diagram, as shown in Figure 5-12.

Figure 5-12 IP Customization of DLLDLY



1. General
The General configuration box is used to configure the generated IP design file. The DLLDLY General configuration is similar to that of DQCE. For the details, please refer to the General description in [3.1.2 IP Generation](#).
2. Options
The Options configuration box is used to customize the IP, as shown in Figure 5-12.
 - Delay Sign: Sets the sign of delay.
 - Adjustment Scale: Delay adjustment.
3. Port Diagram
The port diagram displays a sample diagram of IP Core configuration, as shown in Figure 5-12.

IP Generated Files

After configuration, three files that are named after the "File Name" will be generated.

- "gowin_dllldly.v" file is a complete Verilog module to generate instantiated DLLDLY, and it is generated according to the IP configuration;
- "gowin_dllldly_tmp.v" is the template file;
- "gowin_dllldly.ipc" file is IP configuration file. You can load the file to configure the IP.

Note!

If VHDL is selected as the hardware description language, the first two files will be named with .vhd suffix.

5.5 CLKDIV

5.5.1 Primitive Introduction

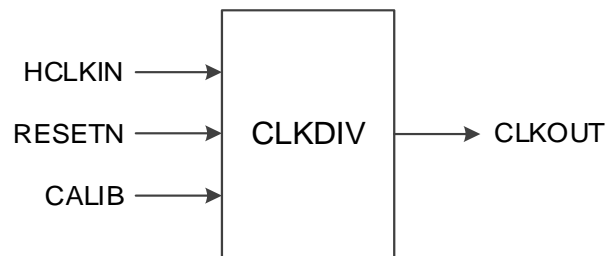
The CLKDIV is a clock frequency divider to adjust the clock frequency.

Functional Description

CLKDIV generates a divider clock that has the same phase with the input clock, which is used in the IO logic mode. GW1N-1S, GW1NS-4, GW1NS-4C, GW1NSR-4, GW1NSR-4C, GW1NSER-4C, GW1N-9, GW1N-9C, GW1NR-9, GW1NR-9C, GW1N-2, GW1N-1P5, GW1N-2B, GW1N-1P5B, GW1NR-2, and GW1NR-2B support 2/3.5/4/5/8 frequency division and other devices support 2/3.5/4/5 frequency division.

Port Diagram

Figure 5-13 CLKDIV Diagram



Port Description

Table 5-22 CLKDIV Port Description

Port Name	I/O	Description
HCLKIN	Input	Clock input signal
RESETN	Input	Asynchronous reset signal, active-low
CALIB	Input	CALIB input signal, adjusting output clock
CLKOUT	Output	Clock output signal

The above CALIB signal can be used in conjunction with CALIB in IOLOGIC, and the functions are as follows:

- For frequency divided by 2, the phase is adjusted every 2 falling edges with 180 degrees, and 2 adjustments are for one cycle.
- For frequency divided by 3.5, the phase is adjusted every 1 falling edge with about 102.8 degrees, and 7 adjustments are for one cycle.
- For frequency divided by 4.5, the phase is adjusted every 2 falling edges with 90 degrees, and 4 adjustments are for one cycle.
- For frequency divided by 5, the phase is adjusted every 2 falling edges with about 72 degrees, and 5 adjustments are for one cycle.
- For frequency divided by 8, the phase is adjusted every 2 falling edges, with about 45 degrees, and 8 adjustments are for one cycle.

Parameter Description

Table 5-23 CLKDIV Parameter Description

Name	Value	Default	Description
DIV_MODE	2, 3.5, 4, 5 (8)	2	Sets the clock frequency division coefficient
GSREN	"false", "true"	"false"	Enables global reset

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```

CLKDIV clkdiv_inst (
    .HCLKIN(hclkin),
    .RESETN(resetn),
    .CALIB(calib),
    .CLKOUT(clkout)
);
defparam clkdiv_inst.DIV_MODE="3.5";
defparam clkdiv_inst.GSREN="false";

```

Vhdl Instantiation:

```

COMPONENT CLKDIV
    GENERIC(
        DIV_MODE:STRING:="2";
        GSREN:STRING:="false"
    );
    PORT(
        HCLKIN:IN std_logic;
        RESETN:IN std_logic;
        CALIB:IN std_logic;
        CLKOUT:OUT std_logic
    );
END COMPONENT;

uut:CLKDIV
    GENERIC MAP(
        DIV_MODE=>"2",
        GSREN=>"false"
    )
    PORT MAP (
        HCLKIN=>hclkin,
        RESETN=>resetn,
        CALIB=>calib,
        CLKOUT=>clkout
    );

```

5.5.2 IP Generation

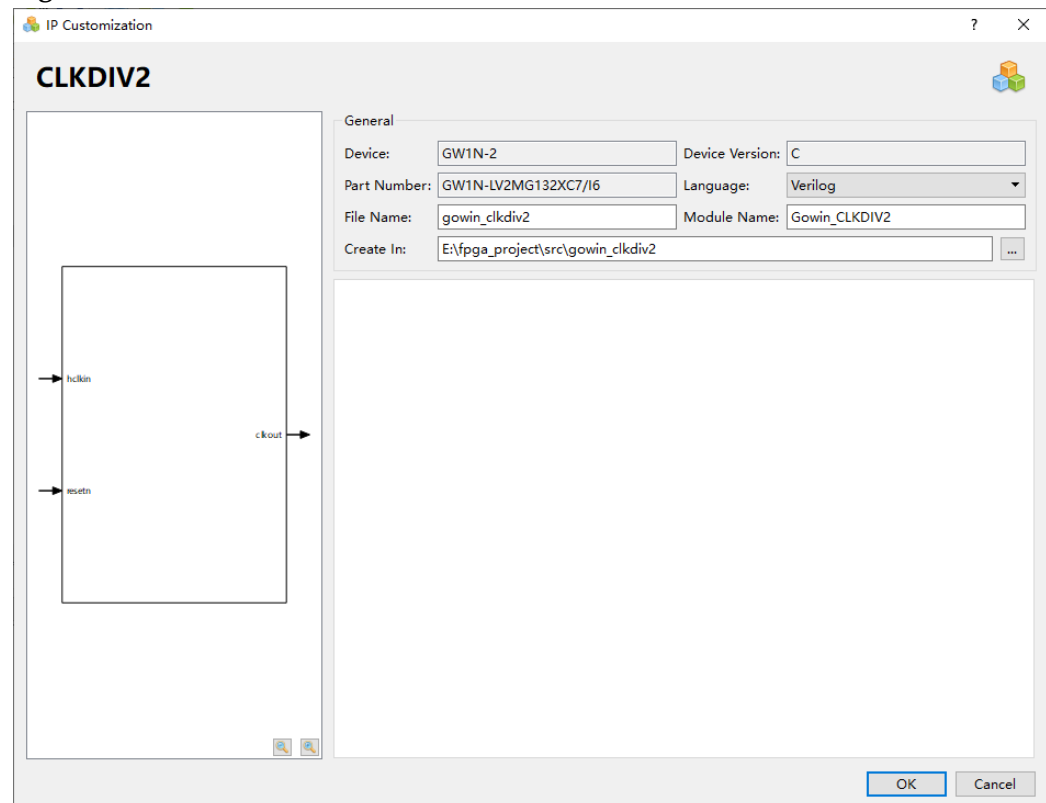
Click "CLKDIV" on the "IP Core Generator" interface and an overview

of CLKDIV will be displayed on the right side of the interface.

IP Configuration

Double-click on "CLKDIV", and the "IP Customization" window pops up. It includes the "General", "Options", and port diagram, as shown in Figure 5-14.

Figure 5-14 IP Customization of CLKDIV



1. General
The General configuration box is used to configure the generated IP design file. The CLKDIV General configuration box is similar to that of DQCE. For the details, please refer to the General description in [3.1.2 IP Generation](#).
2. Options
The Options configuration box is used to configure IP, as shown in Figure 5-14.
 - Division Factor: Division factor
 - Calibration: Enables/disables calibration
3. Port Diagram
The port diagram displays a sample diagram of IP Core configuration, as shown in Figure 5-14.

IP Generated Files

After configuration, three files that are named after the "File Name" will be generated.

- "gowin_clkdiv.v" file is a complete Verilog module to generate instantiated CLKDIV, and it is generated according to the IP configuration;
- "gowin_clkdiv_tmp.v" is the template file;
- "gowin_clkdiv.ipc" file is IP configuration file. You can load the file to configure the IP.

Note!

If VHDL is selected as the hardware description language, the first two files will be named with .vhd suffix.

5.6 CLKDIVG

5.6.1 Primitive Introduction

CLKDIVG is a clock divider to adjust the clock frequency

Devices Supported

Table 5-24 CLKDIVG Device Supported

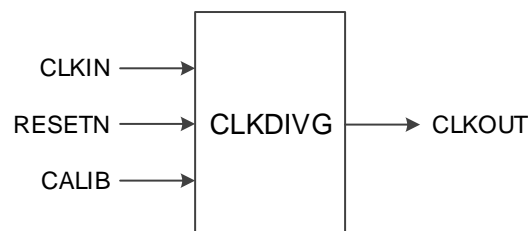
Family	Series	Device
LittleBee®	GW1N	GW1N-2, GW1N-1P5, GW1N-2B, GW1N-1P5B
	GW1NR	GW1NR-2, GW1NR-2B
Arora	GW2AN	GW2AN-18X, GW2AN-9X

Functional Description

The CLKDIVG is a clock divider module that generates a divider clock with the same phase as the input clock; there is only one CLKDIVG with a fixed position. Its input is from fixed IO and its functions are the same as those of CLKDIV.

Port Diagram

Figure 5-15 CLKDIVG Port Diagram



Port Description

Table 5-25 CLKDIVG Port Description

Port	I/O	Description
CLKIN	Input	Clock input signal
RESETN	Input	Asynchronous reset signal, active-low.
CALIB	Input	CALIB input signal, adjusting output clock.
CLKOUT	Output	Clock output signal

The above CALIB signal can be used in conjunction with CALIB in IOLOGIC; for the details, you can see the descriptions in [5.5 CLKDIV](#).

Parameter Description

Table 5-26 CLKDIVG Parameter Description

Parameter	Value	Default	Description
DIV_MODE	2, 3.5, 4, 5, 8	2	Sets the clock division factor
GSREN	"false", "true"	"false"	Enable global reset GSR

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```
CLKDIVG CLKDIVG_inst (
    .CLKIN(clkin),
    .RESETN(resetn),
    .CALIB(calib),
    .CLKOUT(clkout)
);
defparam CLKDIVG_inst.DIV_MODE="2";
defparam CLKDIVG_inst.GSREN="false";
```

VHDL Instantiation:

```
COMPONENT CLKDIVG
    GENERIC(
        DIV_MODE:STRING:="2";
        GSREN:STRING:="false"
    );
    PORT(
        CLKIN:IN std_logic;
```

```

        RESETN:IN std_logic;
        CALIB:IN std_logic;
        CLKOUT:OUT std_logic
    );
END COMPONENT;
uut:CLKDIVG
    GENERIC MAP(
        DIV_MODE=>"2",
        GSREN=>"false"
    )
    PORT MAP(
        CLKIN=>clk_in,
        RESETN=>resetn,
        CALIB=>calib,
        CLKOUT=>clkout
    );

```

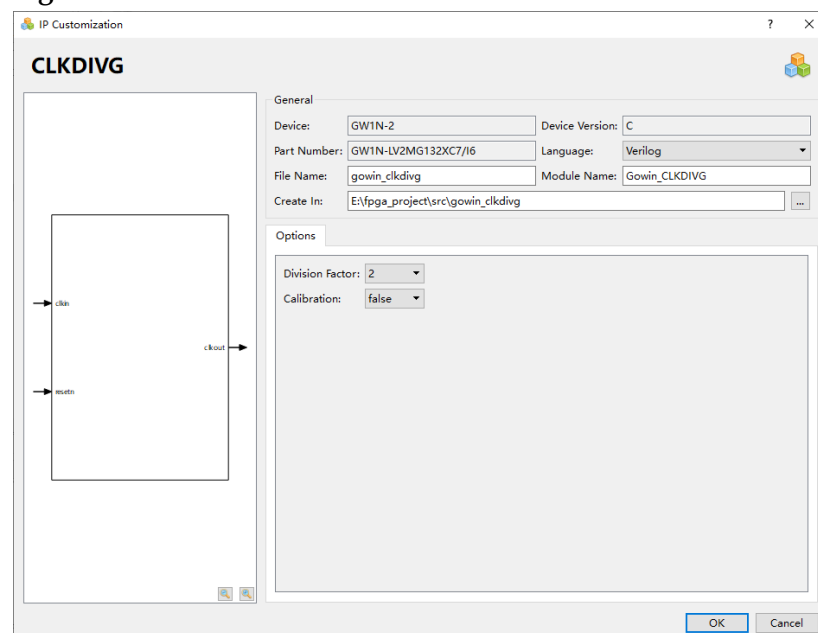
5.6.2 IP Generation

Click "CLKDIVG" on the "IP Core Generator" interface and an overview of CLKDIVG will be displayed on the right side of the interface.

IP Configuration

Double-click on "CLKDIVG", and the "IP Customization" window pops up. It includes the "General", "Options", and port diagram, as shown in Figure 5-16.

Figure 5-16 IP Customization of CLKDIVG



1. General

The General configuration box is used to configure the generated IP design file. The CLKDIV General configuration is similar to that of DQCE. For the details, please refer to the General description in [3.1.2 IP Generation](#).

2. Options

The Options configuration box is used to configure IP, as shown in Figure 5-16.

- Division Factor: Division factor
- Calibration: Enables/disables calibration

3. Port Diagram

The port diagram displays a sample diagram of IP Core configuration, as shown in Figure 5-16.

IP Generated Files

After configuration, three files that are named after the "File Name" will be generated.

- "gowin_clkdivg.v" file is a complete Verilog module to generate instantiated CLKDIVG, and it is generated according to the IP configuration;
- "gowin_clkdivg_tmp.v" is the template file;
- "gowin_clkdivg.ipc" file is IP configuration file. You can load the file to configure the IP.

Note!

If VHDL is selected as the hardware description language, the first two files will be named with .vhd suffix.

5.7 DQS

5.7.1 Primitive Introduction

DQS is a bi-directional data strobe circuit for DDR memory interface.

Device Supported

Table 5-27 DQS Device Supported

Product Family	Series	Device
Arora	GW2A	GW2A-18, GW2A-18C, GW2A-55, GW2A-55C
	GW2AN	GW2AN-55C, GW2AN-18X, GW2AN-9X
	GW2AR	GW2AR-18, GW2AR-18C
	GW2ANR	GW2ANR-18C

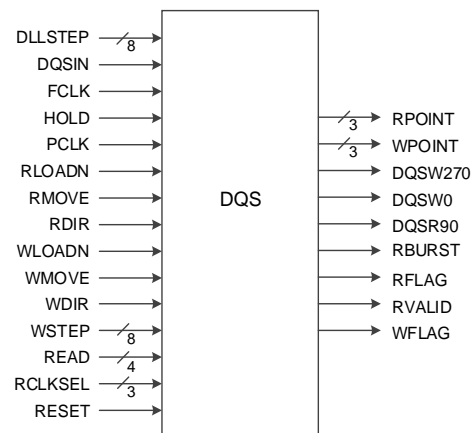
Functional Description

DQS is a key component of memory control IP, which is mainly used to adjust the phase relationship between DQSIN and DQSR90, DQSW0 and

DQSW270, and to complete write balance and read calibration.

Port Diagram

Figure 5-17 DQS Port Diagram



Port Description

Table 5-28 DQS Port Description

Port Name	I/O	Description
DLLSTEP[7:0]	input	DQS delay step control input
DQSIN	input	DQS input from IO PAD
FCLK	input	Fast clock comes from the output of two different FCLK clock trees.
HOLD	input	For DQS write, stop write signals to synchronize the output clock; For DQS read, reset FIFO counter
PCLK	input	Primary clock, from the PCLK clock tree
RDIR	input	Adjusts the delay direction of DDR read "0" increases the delay. "1" decreases the delay.
RLOADN	input	Resets the final delay step of DDR read, active-low.
RMOVE	input	Changes the delay step of DDR read on RMOVE falling edge, once per pulse.
WDIR	input	Adjusts the delay direction of DDR write "0" increases the delay. "1" decreases the delay.
WLOADN	input	Resets the final delay step of DDR write, active-low.
WMOVE	input	Changes the delay step of DDR write on WMOVE falling edge, once per pulse.
WSTEP[7:0]	input	DDR write equalization delay control.
READ[3:0]	input	READ signal for DDR read mode
RCLKSEL[2:0]	input	Selects read clock source and polarity control
RESET	input	DQS reset input, active-high.
RPOINT[2:0]	output	FIFO read pointer works on RADDR in IOLOGIC or on user logic via routing.

Port Name	I/O	Description
WPOINT[2:0]	output	FIFO write pointer works on WADDR in IOLOGIC or on user logic via routing.
DQSW0	output	PCLK/FCLK 0° phase shift output works on TCLK in IOLOGIC or on user logic via routing.
DQSW270	output	PCLK/FCLK 270° phase shift output works on TCLK in IOLOGIC or on user logic via routing.
DQSR90	output	DQSI 90° phase shift output works on TCLK in IOLOGIC or on user logic via routing.
RFLAG	output	An output flag that represents under-flow or over-flow in READ delay adjustment.
WFLAG	output	An output flag that represents under-flow or over-flow in WRITE delay adjustment.
RVALID	output	Data valid flag in READ mode
RBURST	output	READ burst detection output

Parameter Description

Table 5-29 DQS Parameter Description

Name	Value	Default	Description
FIFO_MODE_SEL	1'b0 , 1'b1	1'b0	FIFO mode selection 1'b0: DDR memory mode 1'b1: GDDR mode
RD_PNTR	"000", "001", "010", "011", "100", "101", "110", "111"	3'b000	FIFO read pointer setting
DQS_MODE	"X1", "X2_DDR2", "X2_DDR3", "X4", "X2_DDR3_EXT"	"X1"	DQS mode selection
HWL	"false", "true"	"false"	update0/1 timing relationship control "False ": update1 is one cycle ahead of update0. "True ": the timing of update1 and update0 are the same.
GSREN	"false", "true"	"false"	Enable global reset

Connection Rule

- The input DQSI of DQS comes from IO PAD.
- The output RPOINT of DQS can be connected to the RADDR of IOLOGIC and also can work on user logic.
- The output WPOINT of DQS can be connected to the WADDR of IOLOGIC and also can work on user logic.
- The output DQSR90 of DQS can be connected to the ICLK of IOLOGIC and also can work on user logic

- The output DQSW0/ DQSW270 of DQS can be connected to the TCLK of IOLOGIC and also can work on user logic.

Primitive Instantiation

Verilog Instantiation:

```

DQS uut (
    .DQSIN(dqs),
    .PCLK(pclk),
    .FCLK(fclk),
    .RESET(reset),
    .READ(read),
    .RCLKSEL(rsel),
    .DLLSTEP(step),
    .WSTEP(wstep),
    .RLOADN(1'b0),
    .RMOVE(1'b0),
    .RDIR(1'b0),
    .WLOADN(1'b0),
    .WMOVE(1'b0),
    .WDIR(1'b0),
    .HOLD(hold),
    .DQSR90(dqsr90),
    .DQSW0(dqsw0),
    .DQSW270(dqsw270),
    .RPOINT(rpoint),
    .WPOINT(wpoint),
    .RVALID(rvalid),
    .RBURST(rburst),
    .RFLAG(rflag),
    .WFLAG(wflag)
);

defparam uut.DQS_MODE = "X1";
defparam uut.FIFO_MODE_SEL = 1'b0;
defparam uut.RD_PNTR = 3'b001;

```

Vhdl Instantiation:

```

COMPONENT DQS

```

```

    GENERIC(
        FIFO_MODE_SEL:bit:='0';
        RD_PNTR : bit_vector:="000";
        DQS_MODE:string:="X1";
        HWL:string:="false";
        GSREN : string:="false"
    );
    PORT(
        DQSIN,PCLK,FCLK,RESET:IN std_logic;
        READ:IN std_logic_vector(3 downto 0);
        RCLKSEL:IN std_logic_vector(2 downto 0);
        DLLSTEP,WSTEP:IN std_logic_vector(7 downto 0);
        RLOADN,RMOVE,RDIR,HOLD:IN std_logic;
        WLOADN,WMOVE,WDIR:IN std_logic;
        DQSR90,DQSW0,DQSW270:OUT std_logic;
        RPOINT, WPOINT:OUT std_logic_vector(2 downto 0);
        RVALID,RBURST,RFLAG,WFLAG:OUT std_logic
    );
END COMPONENT;
uut:DQS
    GENERIC MAP(
        FIFO_MODE_SEL=>'0',
        RD_PNTR=>"000",
        DQS_MODE=>"X1",
        HWL=>"false",
        GSREN=>"false"
    )
    PORT MAP (
        DQSIN=>dqsin,
        PCLK=>pclk,
        FCLK=>fclk,
        RESET=>reset,
        READ=>read,
        RCLKSEL=>rclkssel,
        DLLSTEP=>step,

```

```
WSTEP=>wstep,  
RLOADN=>rloadn,  
RMOVE=>rmove,  
RDIR=>rdir,  
HOLD=>hold,  
WLOADN=>wloadn,  
WMOVE=>wmove,  
WDIR=>wdir,  
DQSR90=>dqsr90,  
DQSW0=>dqsw0,  
DQSW270=>dqsw270,  
RPOINT=>rpoint,  
WPOINT=>wpoint,  
RVALID=>rvalid,  
RBURST=>rburst,  
RFLAG=>rflag,  
WFLAG=>wflag  
);
```

6 Crystal Oscillator Clock

6.1 Primitive Introduction

6.1.1 OSC

OSC, on-chip crystal oscillator.

Device Supported

Table 6-1 OSC Device Supported

Product Family	Series	Device
Arora	GW2A	GW2A-18, GW2A-18C, GW2A-55, GW2A-55C
	GW2AN	GW2AN-55C
	GW2AR	GW2AR-18, GW2AR-18C
	GW2ANR	GW2ANR-18C
LittleBee®	GW1N	GW1N-4, GW1N-4B, GW1N-4D, GW1N-9, GW1N-9C
	GW1NR	GW1NR-4, GW1NR-4B, GW1NR-4D, GW1NR-9, GW1NR-9C
	GW1NRF	GW1NRF-4B

Functional Description

GOWIN FPGA is embedded with a programmable on-chip oscillator, which provides a clock source for MSPI programming mode. The on-chip oscillator also provides a clock resource for user designs. Up to 64 clock frequencies can be obtained by setting the parameters.

The output clock frequency of the device can be calculated by the following formula:

$$f_{CLKOUT} = f_{osc} / \text{FREQ_DIV};$$

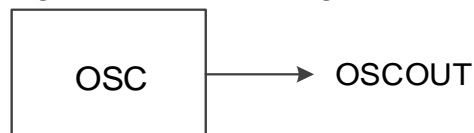
Among them, f_{osc} is the OSC oscillation frequency, the divisor FREQ_DIV is the configuration parameter, and the range is even numbers from 2 to 128.

Note!

f_osc takes different values according to different devices, 210MHz for GW1N-4, GW1NR-4, GW1N-4B, GW1NR-4B, GW1NRF-4B, GW1N-4D, GW1NR-4D devices, 250MHz for other supported devices.

Port Diagram

Figure 6-1 OSC Port Diagram



Port Description

Table 6-2 OSC Port Description

Port Name	I/O	Description
OSCOUT	output	OSC output clock signal

Parameter Description

Table 6-3 OSC Parameter Description

Name	Value	Default	Description
FREQ_DIV	2~128(even)	100	OSC frequency division coefficient setting
DEVICE	"GW1N-4", "GW1N-4B", "GW1N-4D", "GW1NR-4", "GW1NR-4B", "GW1NR-4D", "GW1NRF-4B", "GW1N-9", "GW1N-9C", "GW1NR-9", "GW1NR-9C", "GW2A-18", "GW2AR-18", "GW2A-55", "GW2A-55C", "GW2AN-55C"	GW1N-4 (GW1N series) GW2A-18 (GW2A series)	Devices selected

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```

OSC uut(
    .OSCOUT(oscout)
);
  
```



```

defparam uut.FREQ_DIV=100;
defparam uut.DEVICE="GW2A-18";
Vhdl Instantiation:
COMPONENT OSC
    GENERIC(
        FREQ_DIV:integer:=100;
        DEVICE:string:="GW2A-18"
    );
    PORT(OSCOUT:OUT STD_LOGIC);
END COMPONENT;
uut:OSC
    GENERIC MAP(
        FREQ_DIV=>100,
        DEVICE=>"GW2A-18"
    )
    PORT MAP(OSCOUT=>oscout);

```

6.1.2 OSCZ

OSCZ is an on-chip oscillator supporting dynamically shutting down OSC.

Device Supported

Table 6-4 OSCZ Device Supported

Product Family	Series	Device
LittleBee®	GW1NS	GW1NS-4, GW1NS-4C
	GW1NSR	GW1NSR-4, GW1NSR-4C
	GW1NSER	GW1NSER-4C
	GW1NZ	GW1NZ-1, GW1NZ-1C

Functional Description

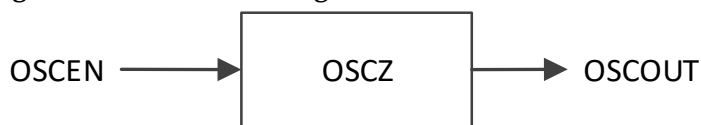
The GW1NZ series of FPGA products are embedded with a programmable on-chip oscillator, clock accuracy up to $\pm 5\%$, and support to dynamically turn on/off OSC. The on-chip oscillator provides a clock source for MSPI programming and user designs. Up to 64 clock frequencies can be obtained by setting the parameters. The following formula is employed to get the output clock frequency:

$$f_{CLKOUT} = f_{oscZ} / FREQ_DIV;$$

f_{oscZ} is the OSC oscillation frequency; FREQ_DIV is the division configuration parameter with a range of 2~128, and it supports even numbers only.

Note !

f_{osc} takes different values according to different devices, 260MHz for C7 speed grade of GW1NS-4/GW1NS-4C/GW1NSR-4/GW1NSR-4CGW1NSER-4C devices , 250MHz for other speed grades of other supported devices.

Port Diagram**Figure 6-2 OSCZ Port Diagram****Port Description****Table 6-5 OSCZ Port Description**

Port Name	I/O	Description
OSCEN	input	OSC enable signal
OSCOUT	output	OSC clock output signal

Parameter Description**Table 6-6 OSCZ Parameter Description**

Name	Value	Default	Description
FREQ_DIV	2~128(even)	100	OSC frequency division coefficient setting
S_RATE	"SLOW", "FAST"	"SLOW"	For C7 of GWINS-4 devices, it needs to be set to "FAST"; for others, it is set to "SLOW".

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```

OSCZ uut(
    .OSCOUT(oscout),
    .OSCEN(oscen)
);
defparam uut.FREQ_DIV=100;
defparam uut.S_RATE="SLOW";
  
```

Vhdl Instantiation:

```

COMPONENT OSCZ
  GENERIC(
    FREQ_DIV:integer:=100,
  
```

```

        S_RATE:string:="SLOW"
    );
    PORT(
        OSCOUT:OUT STD_LOGIC;
        OSCEN:IN std_logic
    );
END COMPONENT;
uut:OSCZ
    GENERIC MAP(
        FREQ_DIV=>100,
        S_RATE=>"SLOW"
    )
    PORT MAP (
        OSCOUT=>oscout,
        OSCEN(oscen)
    );

```

6.1.3 OSCH

OSCH, on-chip crystal

Device Supported

Table 6-7 OSCH Device Supported

Product Family	Series	Device
LittleBee®	GW1N	GW1N-1,GW1N-1S
	GW1NR	GW1NR-1

Functional Description

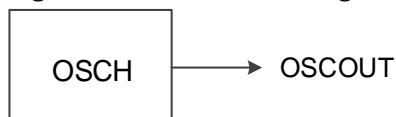
The on-chip oscillator provides a clock source for MSPI programming and user designs. Up to 64 clock frequencies can be obtained by setting the parameters. The following formula is employed to get the output clock frequency:

$$f_{CLKOUT} = 240MHz / FREQ_DIV;$$

"FREQ_DIV" is the configuration parameter and has a range of 2~128. It supports even numbers only.

Port Diagram

Figure 6-3 OSCH Port Diagram



Port Description

Table 6-8 OSCH Port Description

Port Name	I/O	Description
OSCOUT	output	OSC clock output signal

Parameter Description

Table 6-9 OSCH Parameter Description

Name	Value	Default	Description
FREQ_DIV	2~128(even)	100	OSC frequency division coefficient setting

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```
OSCH uut(
    .OSCOUT(oscout)
);
defparam uut.FREQ_DIV=100;
```

Vhdl Instantiation:

```
COMPONENT OSCH
    GENERIC(
        FREQ_DIV:integer:=100;
    );
    PORT(OSCOUT:OUT STD_LOGIC);
END COMPONENT;
uut:OSCH
    GENERIC MAP(
        FREQ_DIV=>100,
    )
    PORT MAP(OSCOUT=>oscout);
```

6.1.4 OSCO

OSCO is an on-chip crystal supporting dynamically shutdowning OSC and regulator power supply.

Device Supported

Table 6-10 OSCO Device Supported

Family	Series	Device
LittleBee®	GW1N	GW1N-2, GW1N-1P5, GW1N-2B, GW1N-1P5B
	GW1NR	GW1NR-2, GW1NR-2B

Functional Description

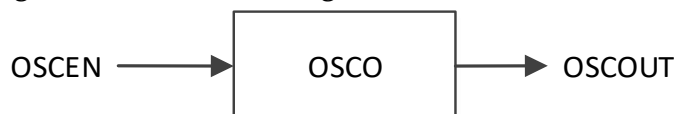
Gowin FPGA products are embedded with a programmable on-chip oscillator with the clock accuracy up to $\pm 5\%$, and support dynamic on/off OSC and regulator power supply. The on-chip oscillator provides a clock source for MSPI programming and user designs. Up to 64 kinds of clock frequencies can be obtained by setting the parameters. The following formula is employed to get the output clock frequency:

$$f_{CLKOUT} = 250MHz / \text{FREQ_DIV}$$

"FREQ_DIV" is the configuration parameter and has a range of 2~128, supporting even numbers only.

Port Diagram

Figure 6-4 OSCO Port Diagram



Port Description

Table 6-11 OSCO Port Description

Port	I/O	Description
OSCEN	input	OSC enable signal, active-high.
OSCOUT	output	OSC clock output signal

Parameter Description

Table 6-12 OSCO Parameter Description

Parameter	Value	Dedault	Description
FREQ_DIV	2~128(even)	100	OSC division factor setting
REGULATOR_EN	1'b0, 1'b1	1'b0	1'b0: OSCO is powered by VCC. 1'b1: OSCO is powered by Regulator.

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```

OSCO uut(
    .OSCOOUT(oscout),
    .OSCEN(oscen)
);
defparam uut.FREQ_DIV=100;
defparam uut.REGULATOR_EN =1'b0;

```

VHDL Instantiation:

```

COMPONENT OSCO
    GENERIC(
        FREQ_DIV:integer:=100;
        REGULATOR_EN : bit := '0'
    );
    PORT(
        OSCOUT:OUT STD_LOGIC;
        OSCEN:IN std_logic
    );
END COMPONENT;
uut:OSCO
    GENERIC MAP(
        FREQ_DIV=>100,
        REGULATOR_EN=> '0'
    )
    PORT MAP(
        OSCOUT=>oscout,
        OSCEN(oscen)
    );

```

6.1.5 OSCW

OSCW, on-chip crystal.

Device Supported**Table 6-13 OSCW Device Supported**

Family	Series	Device
Arora	GW2AN	GW2AN-18X, GW2AN-9X

Functional Description

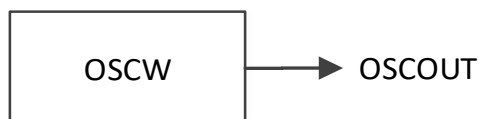
Gowin FPGA products are embedded with a programmable on-chip oscillator with the clock accuracy up to $\pm 5\%$. The on-chip oscillator provides a clock source for MSPI programming and user design. Up to 64 kinds of clock frequencies can be obtained by setting the parameters. The following formula is employed to get the output clock frequency:

$$f_{CLKOUT} = 200MHz / \text{FREQ_DIV}$$

"FREQ_DIV" is the configuration parameter and has a range of 2~128, supporting even numbers only.

Port Diagram

Figure 6-5 OSCW Port Diagram



Port Description

Table 6-14 OSCO Port Description

Port	I/O	Description
OSCOUT	output	OSC clock output signal

Parameter Description

Table 6-15 OSCW Parameter Description

Parameter	Value	Default	Description
FREQ_DIV	2~128(even)	80	OSC division factor setting

Primitive Instantiation

The primitive can be instantiated directly, or generated by the IP Core Generator tool.

Verilog Instantiation:

```

OSCW uut(
    .OSCOUT(oscout)
);
defparam uut.FREQ_DIV=80;
  
```

VHDL Instantiation:

```

COMPONENT OSCW
    GENERIC(
        FREQ_DIV:integer:=100
    );
    PORT(
  
```

```

        OSCOUT:OUT STD_LOGIC
    );
END COMPONENT;
 uut:OSCW
    GENERIC MAP(
        FREQ_DIV=>80
    )
    PORT MAP(
        OSCOUT=>oscout
    );

```

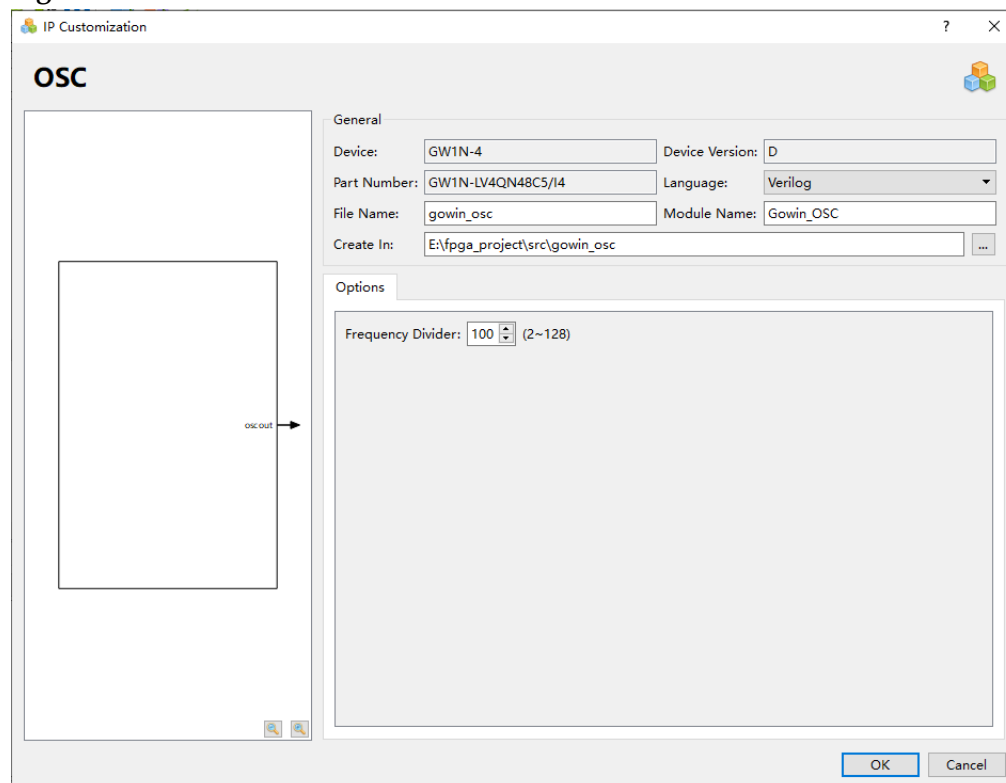
6.2 IP Generation

Click "OSC" on the "IP Core Generator" interface and an overview of related information about OSC will be displayed on the right side of the interface.

IP Configuration

Double-click on "OSC", and the "IP Customization" window pops up. It includes the "General", "Options", and port diagram, as shown in Figure 6-6.

Figure 6-6 IP Customization of OSC



1. General

The File configuration box is used to configure the generated IP design file. The OSC General configuration box is similar to that of DQCE. For the details, please refer to the General description in [3.1.2 IP Generation](#).

2. Options

The Options configuration box is used to configure IP, as shown Figure 6-6. Frequency Divider: Selects any even number from 2 to 128.

3. Port Diagram

The port diagram displays a sample diagram of IP Core configuration, as shown in Figure 6-6.

IP Generated Files

After configuration, three files that are named after the "File Name" will be generated.

- "gowin_osc.v" file is a complete Verilog module to generate instantiated OSC, and it is generated according to the IP configuration;
- "gowin_osc_tmp.v" is the template file;
- "gowin_osc.ipc" file is IP configuration file. You can load the file to configure the IP.

Note!

If VHDL is selected as the hardware description language, the first two files will be named with .vhd suffix.

