



Gowin Video Warping IP

User Guide

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1 About This Guide

1.1 Purpose

Gowin Video Warping IP User Guide includes functional description, signal definition, usage description, and interface configuration. It can help you quickly learn the features and usage of Gowin Video Warping IP. The software screenshots and the supported products listed in this manual are based on Gowin Software V1.9.11.02. As the software is subject to change without notice, some information may not remain relevant and may need to be adjusted according to the software that is in use.

1.2 Related Documents

You can find the related documents at www.gowinsemi.com:

- [DS1103, GW5A series of FPGA Products Data Sheet](#)
- [DS981, GW5AT series of FPGA Products Data Sheet](#)
- [SUG100, Gowin Software User Guide](#)
- [SUG283, Gowin Primitive User Guide](#)
- [UG290, Gowin FPGA Products Programming and Configuration Guide](#)

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
FPGA	Field Programmable Gate Array
IP	Intellectual Property

1.4 Support and Feedback

Gowin Semiconductor provides customers with comprehensive technical support. If you have any questions, comments, or suggestions, please feel free to contact us directly using the information provided below.

Website: www.gowinsemi.com

E-mail: support@gowinsemi.com

2 Function Introduction

2.1 Introduction to Gowin Video Warping IP

Image Distortion Correction is an image processing technique that repairs geometric deformations caused by lenses, commonly used to correct barrel distortion and pincushion distortion. By leveraging lens models or calibration parameters, this technology restores the true proportions and shapes of objects in images, enhancing geometric accuracy and visual quality. It is widely applied in photography, autonomous driving, 3D reconstruction, AR/VR, and other fields.

Gowin Video Warping IP delivers efficient image distortion correction. The IP integrates dynamic address mapping and bilinear interpolation modules, enabling precise correction of barrel, pincushion, and other common distortions while supporting multiple resolutions and image parameters. Featuring a parallel processing architecture and low-latency design, the IP also allows users to flexibly load correction parameters via a configuration interface.

Table 2-1 Gowin Video Warping IP Overview

Gowin Video Warping IP	
Logic Resource	Please refer to Table 2-2.
Delivered Doc.	
Design Files	Verilog (encrypted)
Reference Design	Verilog
TestBench	Verilog
Test and Design Flow	
Synthesis Software	GowinSynthesis
Application Software	Gowin Software (V1.9.11.02 and above)

Note!

For the devices supported, you can click [here](#) to get the information.

2.2 IP Features

The features of Gowin Video Warping IP include:

- Supports resolutions from 80×80 to 1600×1440 pixels
- Supports 4th-order polynomials

2.3 Resource Utilization

Taking Gowin GW5AT-138 device as an instance, the resource utilization of Gowin Video Warping IP is as shown in Table 2-2.

Table 2-2 Resource Utilization

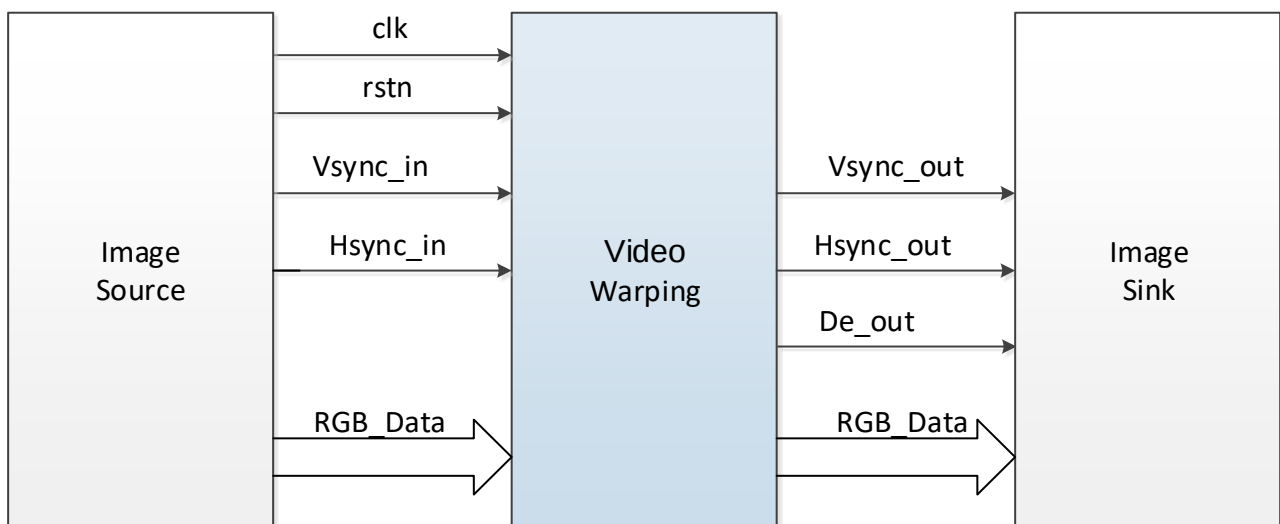
Device	Programming Language	LUT	REG	DSP	BSRAM
GW5AT-138	Verilog	2948	3545	40	240

3 Functional Description

3.1 Gowin Video Warping IP Structure Block Diagram

The input data for Gowin Video Warping IP comes from RGB image data generated by an image source. After processing based on a given set of matrix coefficients, the IP outputs the data. The implementation block diagram is shown in Figure 3-1. The control and use of the module can be adjusted based on actual functional requirements.

Figure 3-1 Structure Block Diagram



3.2 Algorithm Introduction

Video Warping is a fundamental and essential image geometric transformation technique, widely used in image registration, visual effects, augmented reality, and other applications. Essentially, it involves remapping image coordinates at the pixel level to alter the image's shape and structure.

The algorithm mainly involves the following three steps:

1. Transformation Model Definition: Defines a transformation model between the source image and the target image, which can be either linear or nonlinear.
2. Inverse Mapping: For each pixel in the target image, use the transformation function to compute its corresponding location in the source image.
3. Interpolation: Since the mapped coordinates are typically non-integer values, bilinear interpolation is applied to calculate pixel values and reconstruct the target image.

Figure 3-2 Original Image

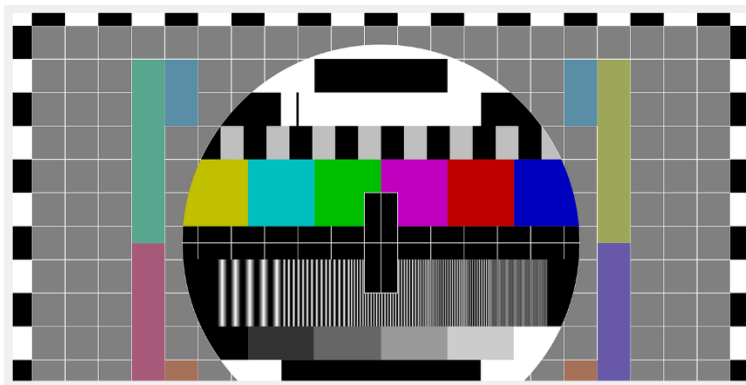
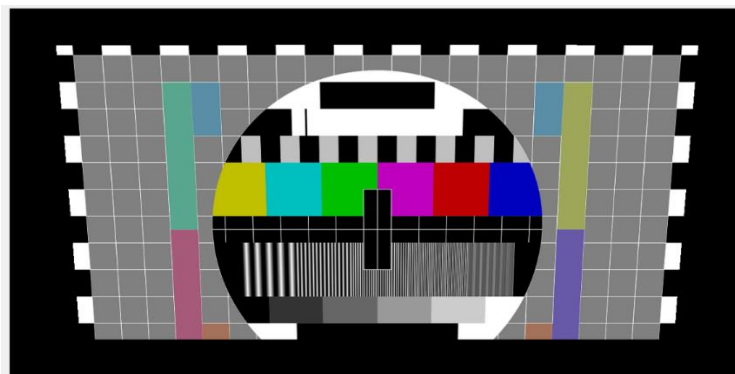


Figure 3-3 Distorted Image



Gowin Video Warping IP utilizes a two-dimensional 4th-order polynomial transformation for address inverse mapping. It employs 15 polynomial coefficients to fit the nonlinear mapping relationships of x' and y' relative to the original coordinates x and y , enabling high-precision image spatial registration and geometric correction. The transformations follow the equations below:

$$x' = a_0 + a_1x + a_2y + a_3x^2 + a_4xy + a_5y^2 + a_6x^3 + a_7x^2y + a_8xy^2 + a_9y^3 +$$

$$a_{10}x^4 + a_{11}x^3y + a_{12}x^2y^2 + a_{13}xy^3 + a_{14}y^4$$

$$y' = b_0 + b_1x + b_2y + b_3x^2 + b_4xy + b_5y^2 + b_6x^3 + b_7x^2y + b_8xy^2 + b_9y^3 + b_{10}x^4 + b_{11}x^3y + b_{12}x^2y^2 + b_{13}xy^3 + b_{14}y^4$$

The a and b are the distortion coefficients defined by the user. x and y represent the iterated pixel addresses, and x' and y' are the corresponding mapped source addresses.

3.3 Gowin Video Warping IP Control Commands

The commands supported by Gowin Video Warping IP are as shown in Table 3-1.

Table 3-1 Command Definition

Name	Address	Type	Default	Description
WARP_A0	16'h0100	W	0x00000000	Polynomial coefficient A ₀ (constant term for x')
WARP_A1	16'h0101	W	0x00000000	Polynomial coefficient A ₁ (x)
WARP_A2	16'h0102	W	0x00000000	Polynomial coefficient A ₂ (y)
WARP_A3	16'h0103	W	0x00000000	Polynomial coefficient A ₃ (x ²)
WARP_A4	16'h0104	W	0x00000000	Polynomial coefficient A ₄ (xy)
WARP_A5	16'h0105	W	0x00000000	Polynomial coefficient A ₅ (y ²)
WARP_A6	16'h0106	W	0x00000000	Polynomial coefficient A ₆ (x ³)
WARP_A7	16'h0107	W	0x00000000	Polynomial coefficient A ₇ (x ² y)
WARP_A8	16'h0108	W	0x00000000	Polynomial coefficient A ₈ (xy ²)
WARP_A9	16'h0109	W	0x00000000	Polynomial coefficient A ₉ (y ³)
WARP_A10	16'h010A	W	0x00000000	Polynomial coefficient A ₁₀ (x ⁴)
WARP_A11	16'h010B	W	0x00000000	Polynomial coefficient A ₁₁ (x ³ y)
WARP_A12	16'h010C	W	0x00000000	Polynomial coefficient A ₁₂ (x ² y ²)
WARP_A13	16'h010D	W	0x00000000	Polynomial coefficient A ₁₃ (xy ³)
WARP_A14	16'h010E	W	0x00000000	Polynomial coefficient A ₁₄ (y ⁴)
WARP_B0	16'h0200	W	0x00000000	Polynomial coefficient B ₀ (constant term for y')
WARP_B1	16'h0201	W	0x00000000	Polynomial coefficient B ₁ (x)
WARP_B2	16'h0202	W	0x00000000	Polynomial coefficient B ₂ (y)
WARP_B3	16'h0203	W	0x00000000	Polynomial coefficient B ₃ (x ²)
WARP_B4	16'h0204	W	0x00000000	Polynomial coefficient B ₄ (xy)

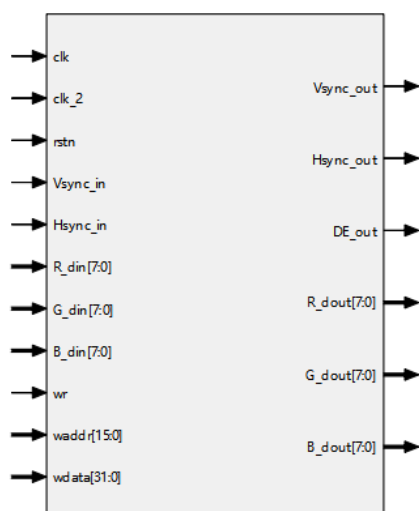
Name	Address	Type	Default	Description
WARP_B5	16'h0205	W	0x00000000	Polynomial coefficient $B_5(y^2)$
WARP_B6	16'h0206	W	0x00000000	Polynomial coefficient $B_6(x^3)$
WARP_B7	16'h0207	W	0x00000000	Polynomial coefficient $B_7(x^2y)$
WARP_B8	16'h0208	W	0x00000000	Polynomial coefficient $B_8(xy^2)$
WARP_B9	16'h0209	W	0x00000000	Polynomial coefficient $B_9(y^3)$
WARP_B10	16'h020A	W	0x00000000	Polynomial coefficient $B_{10}(x^4)$
WARP_B11	16'h020B	W	0x00000000	Polynomial coefficient $B_{11}(x^3y)$
WARP_B12	16'h020C	W	0x00000000	Polynomial coefficient $B_{12}(x^2y^2)$
WARP_B13	16'h020D	W	0x00000000	Polynomial coefficient $B_{13}(xy^3)$
WARP_B14	16'h020E	W	0x00000000	Polynomial coefficient $B_{14}(y^4)$

4 Signal Definition

4.1 Signal Definition

The IO ports of Gowin Video Warping IP are shown in Figure 4-1.

Figure 4-1 Gowin Video Warping IP I/O Port Diagram



The IO definitions of Gowin Video Warping IP are shown in Table 4-1.

Table 4-1 Gowin Video Warping IP IO Definition

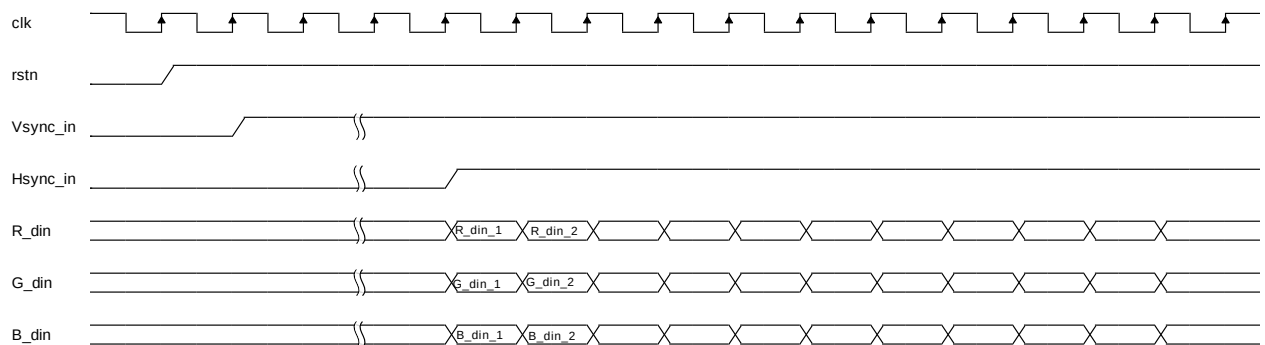
Signal	I/O	Data Width	Description
clk	I	1	Input clock signal, serving as the pixel clock.
clk_2	I	1	Input clock signal, used as the computation clock, which is twice the frequency of the pixel clock.
rstn	I	1	Reset signal, active-low.

Signal	I/O	Data Width	Description
Vsync_in	I	1	Input vertical synchronization signal
Hsync_in	I	1	Input horizontal sync signal (indicates valid image data)
R_din	I	8	Input image data signal
G_din	I	8	Input image data signal
B_din	I	8	Input image data signal
wr	I	1	Write signal
waddr	I	16	Write address signal
wdata	I	32	Write data signal
Vsync_out	O	1	Output vertical sync signal
Hsync_out	O	1	Output horizontal sync signal
DE_out	O	1	Output valid signal, active-high.
R_dout	O	Variable	Output image data signal
G_dout	O	Variable	Output image data signal
B_dout	O	Variable	Output image data signal

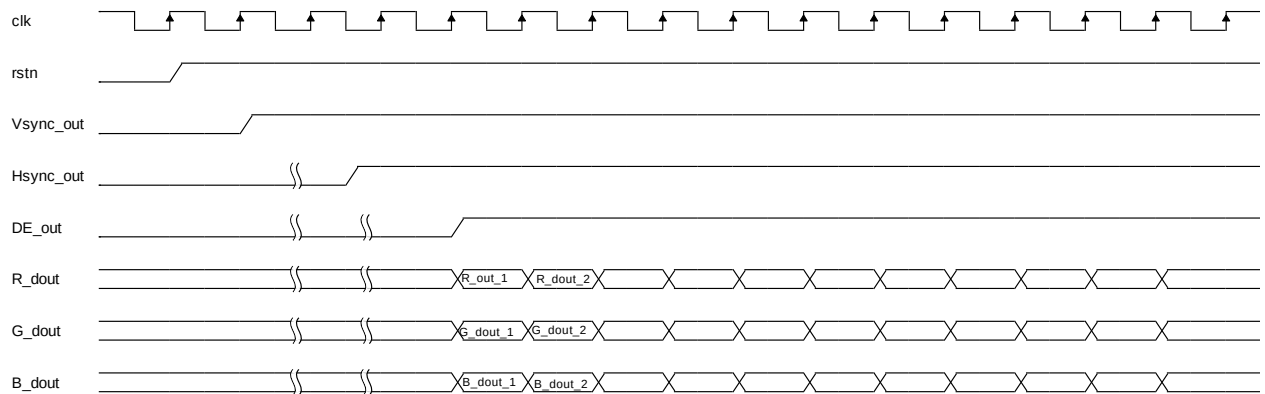
4.2 Signal Timing

The input signal timing is as shown in Figure 4-2.

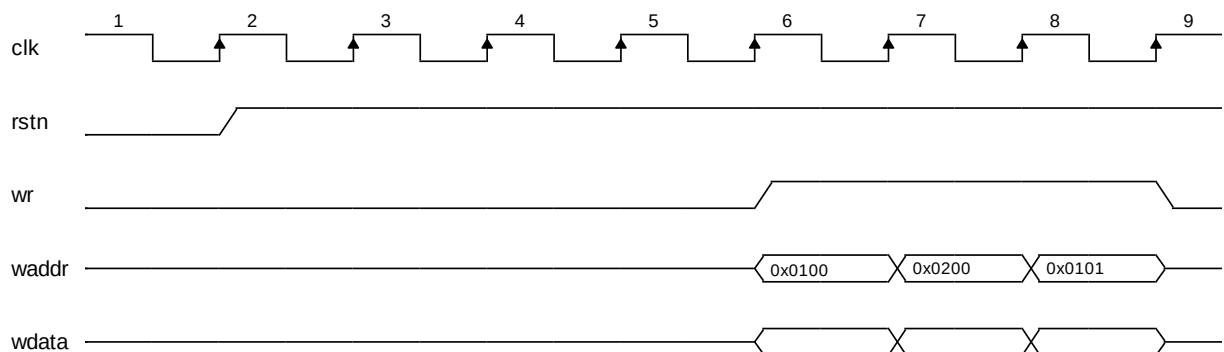
Figure 4-2 Input Signal Timing



The output signal timing is as shown in Figure 4-3.

Figure 4-3 Output Signal Timing

The timing for writing distortion coefficients is shown in Figure 4-4. The update of the distortion coefficients is uniformly performed at the beginning of each frame's vertical sync signal. The distortion effect for the current frame is entirely based on the coefficient values that were submitted previously. Newly input distortion parameters will take effect in the next frame.

Figure 4-4 Timing Diagram of Writing Distortion Coefficient

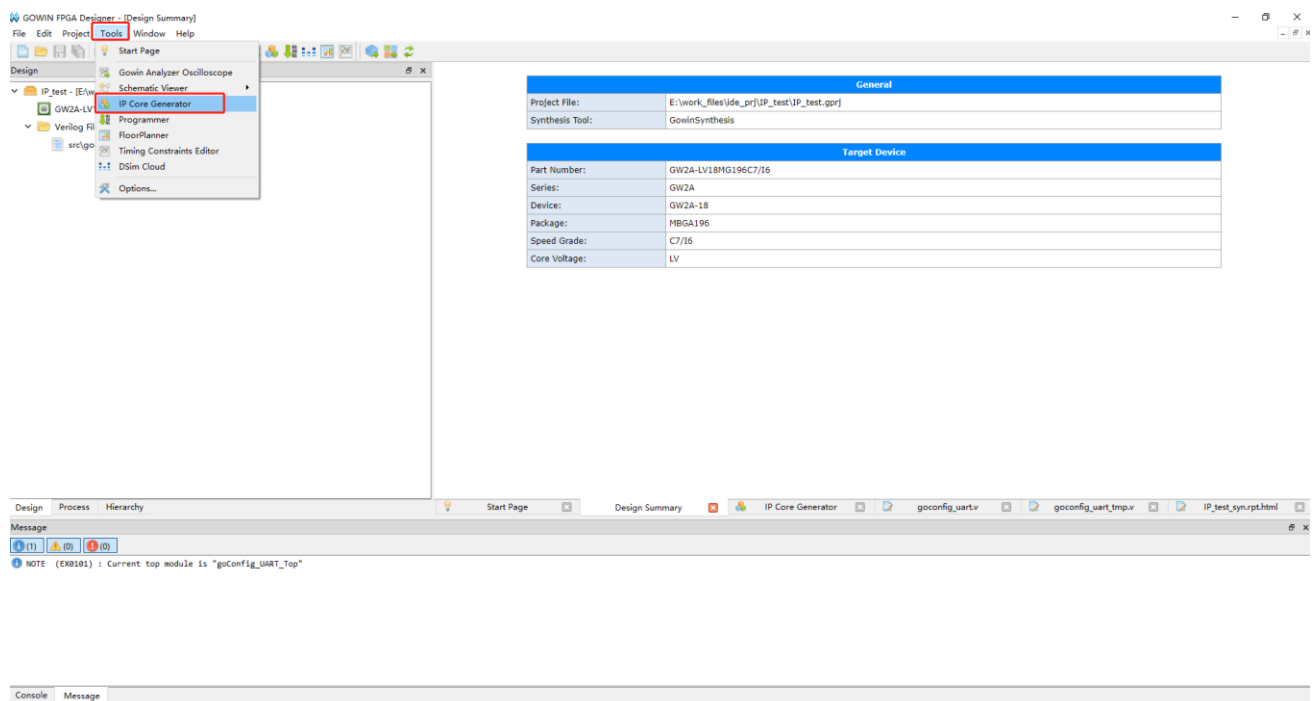
5 Interface Configuration

You can select “Tools” in Gowin Software to start the IP Core Generator to invoke and configure Gowin Video Warping IP.

1. Open IP Core Generator.

After creating the project, you can click the “Tools” tab in the upper-left corner, then click the “IP Core Generator” via the drop-down list, as shown in Figure 5-1.

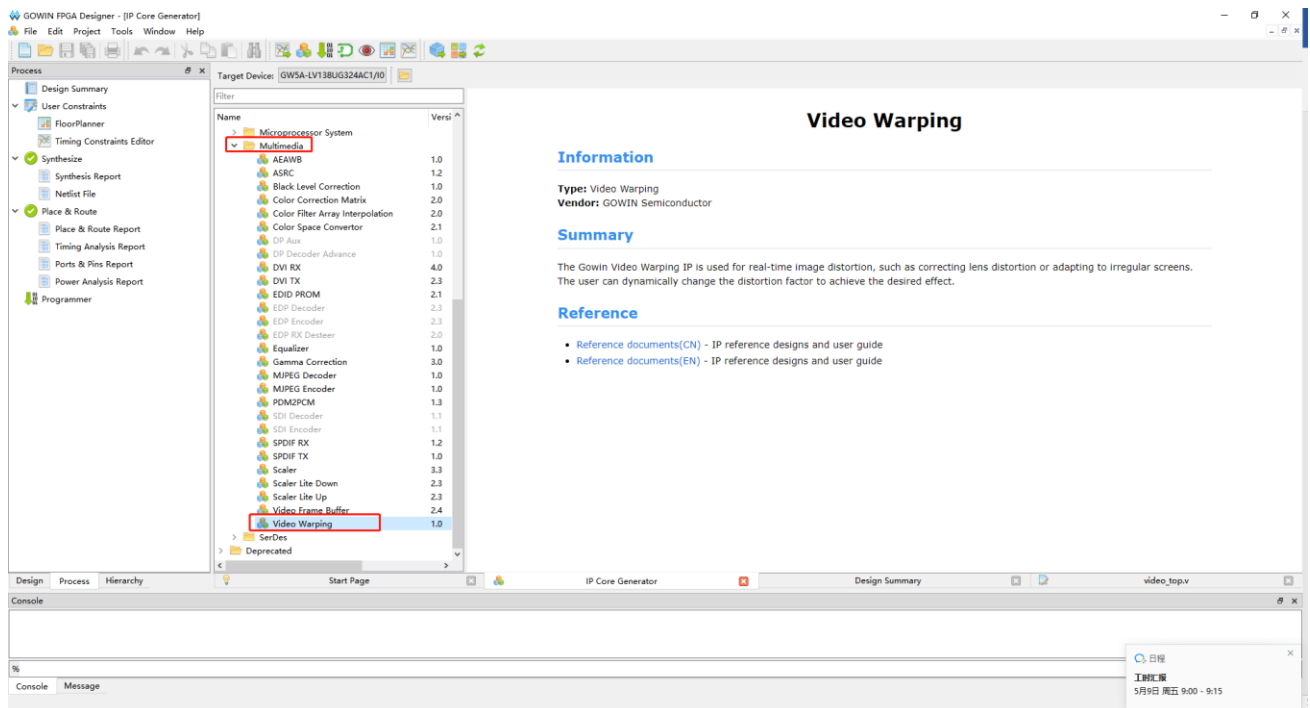
Figure 5-1 IP Core Generator



2. Open Gowin Video Warping IP

Select “Soft IP Core > Multimedia > Video Warping”, as shown in Figure 5-2. Double click to open the configuration interface.

Figure 5-2 Open Video Warping IP Core



3. The configuration interface of Gowin Video Warping IP is as shown in Figure 5-3. The port diagram is on the left, and options are on the right.
 - You can configure the generated file name by modifying “File Name” text box.
 - You can configure the generated top module name by modifying “Module Name” text box.
 - You can configure the image dimensions by modifying “Frame Dimension”.
 - You can configure the distortion parameters by modifying “Warping Matrix”.

Figure 5-3 Video Warping Configuration Interface

Video Warping

General

Device: GW5A-138 Device Version: C

Part Number: GW5A-LV138UG324AC1/I0 Language: Verilog

File Name: video_warping Module Name: Video_Warping_Top

Create In: File\ISP_V3\video_warp\Sowin_Warping_RefDesign\project\src\video_warping

Options

Frame Dimension

Maximum Columns: 1280 (80-1600)

Maximum Rows: 640 (80-1440)

Data Width: 8

Warping Matrix

	Zoom Length	Warping Matrix A	Warping Matrix B
[1]	4	2b3	3fe92
[2]	15	3f7a4	7cf8
[3]	15	77d4	9d7
[4]	25	3fc6b	b36
[5]	25	3ffc1	169d
[6]	25	3fd	3f25e
[7]	36	3f997	3cf27
[8]	36	3fd45	9ed
[9]	36	31d2	33dfd
[10]	36	cd5	b98
[11]	46	2e45	f43
[12]	46	3ec14	2902
[13]	46	1d6	3f7a6
[14]	46	3bf37	d3a4
[15]	46	3fc66	3f82b

OK Cancel

Table 5-1 Parameter Configuration

Option	Description	Note
Maximum Columns	Maximum image width	—
Maximum Rows	Maximum image height	—
Data Width	Pixel bit width (per color channel)	—
Warping Matrix	Distortion parameter	18-bit signed values; Zoom Length indicates the zoom factor.

6 Reference Design

Please refer to the related test cases in [RefDesign](#).

7 Appendix

Distortion Coefficient Generation

The distortion coefficient generation is primarily based on the displacement of control points. Refer to the following figures for details.

Figure 7-1 Floating-Point Coefficient Generation

```

1 % Project : Video Warp IP
2 % File : warp_coeff_est.m
3 % Description : Estimation of warping coefficients
4 % Version : 1.0
5 % Date : 15 May, 2025
6 % Author : Thomas Cheng
7
8 clear all
9 name = ['grid_data'];
10 load([name, '.mat'])
11
12 % Control points, each row is a point: [x y]
13 src_points = [reshape(originalPos(:, :, 1), [], 1) 721-reshape(originalPos(:, :, 2), [], 1)];
14 % Example: [x1, y1;
15 %          x2, y2;
16 %          ...
17 %          xn, yn]
18
19 dst_points = [reshape(newPos(:, :, 1), [], 1) 721-reshape(newPos(:, :, 2), [], 1)];
20 % Example: [x1', y1';
21 %          x2', y2';
22 %          ...
23 %          xn', yn']
24
25 % Check if the number of points is correct
26 assert(size(src_points, 1) >= 15, 'At least 15 control points are required');
27 assert(size(src_points, 1) == size(dst_points, 1), 'The number of control points');
28
29 N = size(src_points, 1); % Number of points
30
31 % Construct matrix A, each row corresponds to polynomial
32 % features of a control point
33 A = zeros(N, 15);
34 for i = 1:N
35     x = src_points(i, 1);
36     y = src_points(i, 2);
37
38     A(i, :) = [...
39         1, y, x, ...
40         x*y, y^2, x^2, ...
41         x^2*y, x^2*y^2, y^3, x^3, ...
42         x^3*y, x^2*y^2, x^3*y, y^4, x^4];
43 end
44
45 % Coordinate vectors of the target image
46 x_prime = dst_points(:, 1); % All x'
47 y_prime = dst_points(:, 2); % All y'
48
49 % Solve the least squares solution to obtain the coefficient vectors
50 a = A \ x_prime; % Coefficients for x-direction mapping (a0 ~ a14)
51 b = A \ y_prime; % Coefficients for y-direction mapping (b0 ~ b14)
52
53 % Display the results
54 disp('Polynomial coefficients for x'' mapping (a):');
55 disp(a);
56
57 disp('Polynomial coefficients for y'' mapping (b):');
58 disp(b);
59

```

After generating the floating-point coefficients a and b, they must be converted into fixed-point numbers for loading into the IP. The zoom factor (magnification) depends on the Zoom Length option in the interface configuration.

Figure 7-2 Fixed-Point Coefficient Generation

```
1  coe =load('main_coef.mat').m2;
2
3
4  for i=1:15
5      if(i==1)
6          coe_s(i,1:2)=coe(i,1:2)*2^4;
7      elseif(1<i)&&(i<=3)
8          coe_s(i,1:2)=coe(i,1:2)*2^15;
9      elseif(3<i)&&(i<=6)
10         coe_s(i,1:2)=coe(i,1:2)*2^25;
11     elseif(6<i)&&(i<=10)
12         coe_s(i,1:2)=coe(i,1:2)*2^36;
13     elseif(10<i)&&(i<=15)
14         coe_s(i,1:2)=coe(i,1:2)*2^46;
15     end
16 end
17 coe_f=round(coe_s);
18 coeA=coe_f(:,1);
19 coeB=coe_f(:,2);
20 for i=1:15
21     if(coeA(i)>=0)
22         coeA(i)=coeA(i);
23     else
24         coeA(i)=2^(18)+coeA(i);
25     end
26     if(coeB(i)>=0)
27         coeB(i)=coeB(i);
28     else
29         coeB(i)=2^(18)+coeB(i);
30     end
31 end
32 |
```

