



Gowin Color Correction Matrix IP

User Guide

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Revision History

Date	Version	Description
03/02/2021	1.0E	Initial version published.

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1 About This Guide

1.1 Purpose

The purpose of Gowin Color Correction Matrix IP User Guide is to help you learn the features and usage of this product by providing the descriptions of functions, ports, timing, GUI and reference design.

1.2 Related Documents

The latest user guides are available on the GOWINSEMI Website. You can find the related documents at www.gowinsemi.com:

- [DS100](#), GW1N series of FPGA Products Data Sheet
- [DS117](#), GW1NR series of FPGA Products Data Sheet
- [DS102](#), GW2A series of FPGA Products Data Sheet
- [DS226](#), GW2AR series of FPGA Products Data Sheet
- [DS971](#), GW2AR series of FPGA Products Data Sheet
- [SUG100](#), Gowin Software User 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
DSP	Digital Signal Processing
SRAM	Static Random Access Memory
BSRAM	Block Static Random Access Memory
ISP	Image Signal Processing

Terminology and Abbreviations	Meaning
FPGA	Field Programmable Gate Array
CCM	Color Correction Matrix
RGB	R(Red) G(Green) B(Blue)

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

2.1 Introduction to Gowin Color Correction Matrix IP

Gowin Color Correction Matrix IP is a 3x3 matrix multiplication IP with configurable coefficient and offset compensation function. This IP can be used for color correction, such as color error and contrast.

Table 2-1 Gowin Color Correction Matrix IP Overview

Gowin Color Correction Matrix IP	
IP Core Application	
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	Synplify Pro
Application Software	Gowin Software

2.2 Features

- Supports input images with 8x8~4320x7680 pixels.
- Supports input images with 8, 10, 12, 16 bits data width.
- Supports output images with 8, 10, 12, 16 bits data width.
- Support 3x3 coefficient matrix and 1x3 offset matrix.

2.3 Max. Frequency

The maximum frequency of Gowin Color Correction Matrix IP is mainly determined by the speed grade of the devices and configuration parameters. Taking GW2A-18 series of FPGA devices as an example, it

can reach up to 200MHz.

2.4 Latency

The latency of the Gowin Color Correction Matrix IP is generally 5 clock cycles.

2.5 Resource Utilization

Gowin Color Correction Matrix IP resource utilization mainly depends on the size of image, etc. The resource utilization may be different with different devices.

Taking GW2A-18 series of FPGA devices as an example, Gowin Color Correction Matrix IP resource utilization in different configurations is shown in Table 2-2.

Table 2-2 Resource Utilization (GW2A-18 C8/I7)

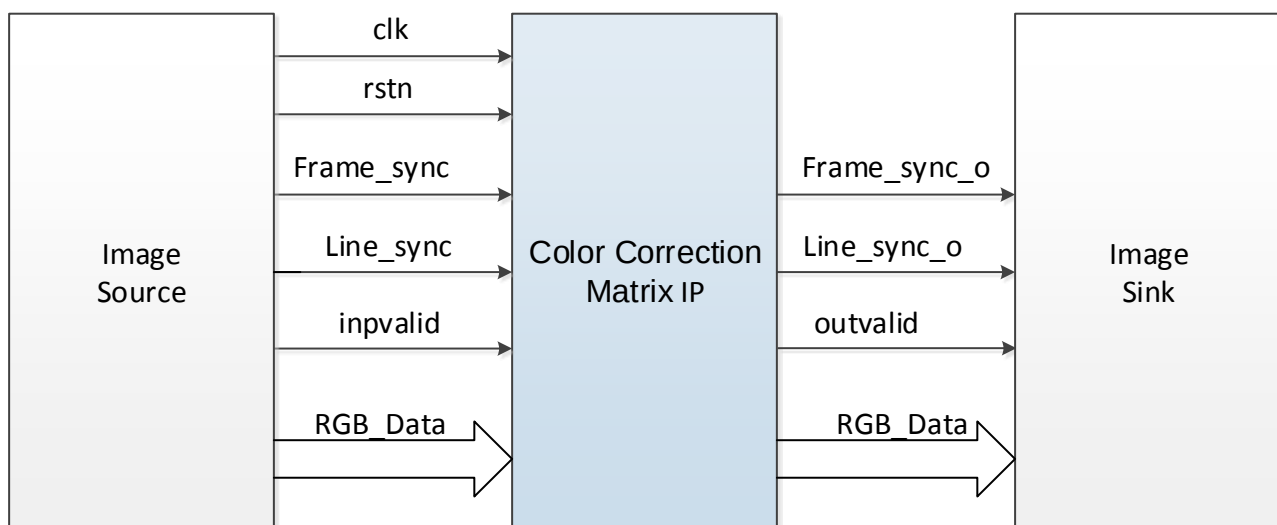
Frame Size	Data Width	LOGICS	REGS	DSP Macros	BSRAMS
640* 480	8	485	896	3	0

3 Functional Description

3.1 Block Diagram

In Gowin Color Correction Matrix IP, the data comes from RGB data of the image source, and outputs after operating based on the selected coefficient matrix and offset. The block diagram is shown Figure 3-1.

Figure 3-1 Block Diagram



3.2 Algorithm Introduction

Color Correction Matrix is to correct the color error caused by the color penetration between the color blocks at the filter plate, so that the mapped color is more in line with the human perception.

The color correction is calculated by comparing the image captured by the image sensor with a standard image to obtain a correction matrix. This matrix is the color correction matrix (CCM) of the image sensor. In the application of the image sensor, this matrix can be used to correct all the images taken by the image sensor to obtain the images closest to the real

color of the objects.

Figure 3-2 Before Color Correction

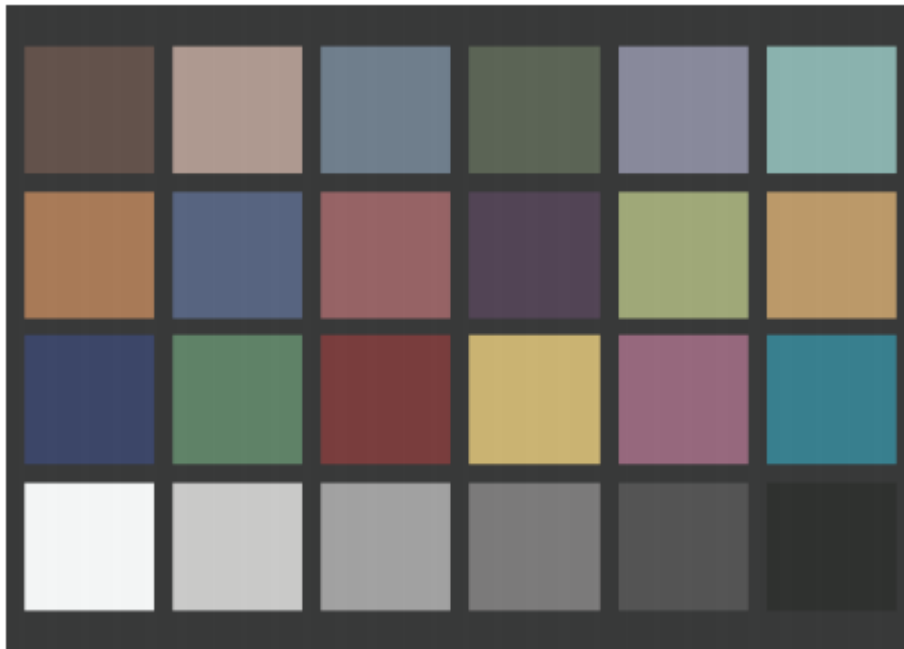
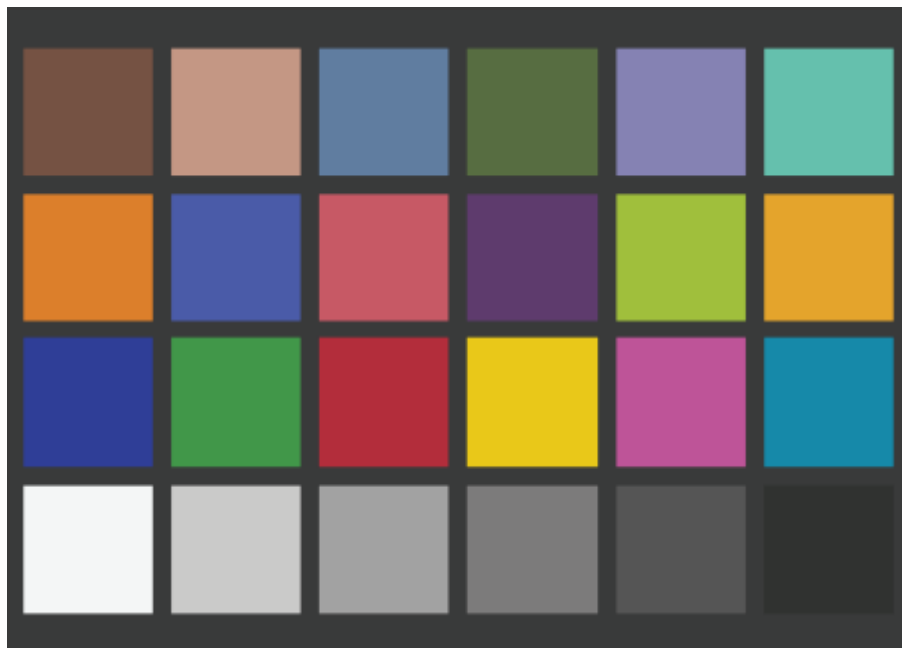


Figure 3-3 After Color Correction



Gowin Color Correction Matrix IP uses a 3x3 matrix to linearly map an input pixel value (r, g, b) to a new pixel value (r', g', b'), and adds a 1x3 offset matrix.

The formulas are as follows:

$$\begin{pmatrix} r' \\ g' \\ b' \end{pmatrix} = \begin{pmatrix} m_{rr} & m_{rg} & m_{rb} \\ m_{gr} & m_{gg} & m_{gb} \\ m_{br} & m_{bg} & m_{bb} \end{pmatrix} \begin{pmatrix} r \\ g \\ b \end{pmatrix} + \begin{pmatrix} n_r \\ n_g \\ n_b \end{pmatrix}$$

In the above formulas, r, g, b are the input pixel values, r', g', b' are the output pixel values, m is the matrix coefficient, and n is the matrix offset.

4 Port Description

The IO ports of Gowin Color Correction Matrix IP are shown in Figure 4-1. For the details, you can see Table 4-1.

Figure 4-1 Ports Diagram of Gowin Color Correction Matrix IP

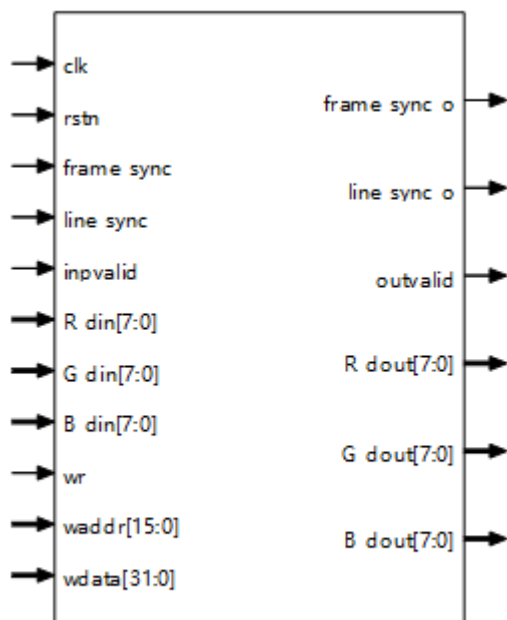


Table 4-1 I/O Port List of Gowin Color Correction Matrix IP

Signal	I/O	Data Width	Description
clk	I	1	Input clock signal
rstn	I	1	Reset signal, active-low
frame_sync	I	1	Input frame synchronization signal
line_sync	I	1	Input line synchronization signal
inpvalid	I	1	Input data valid signal
R_din	I	Changeable	Input image data signal
G_din	I	Changeable	Input image data signal
B_din	I	Changeable	Input image data signal
wr	I	1	Write signal

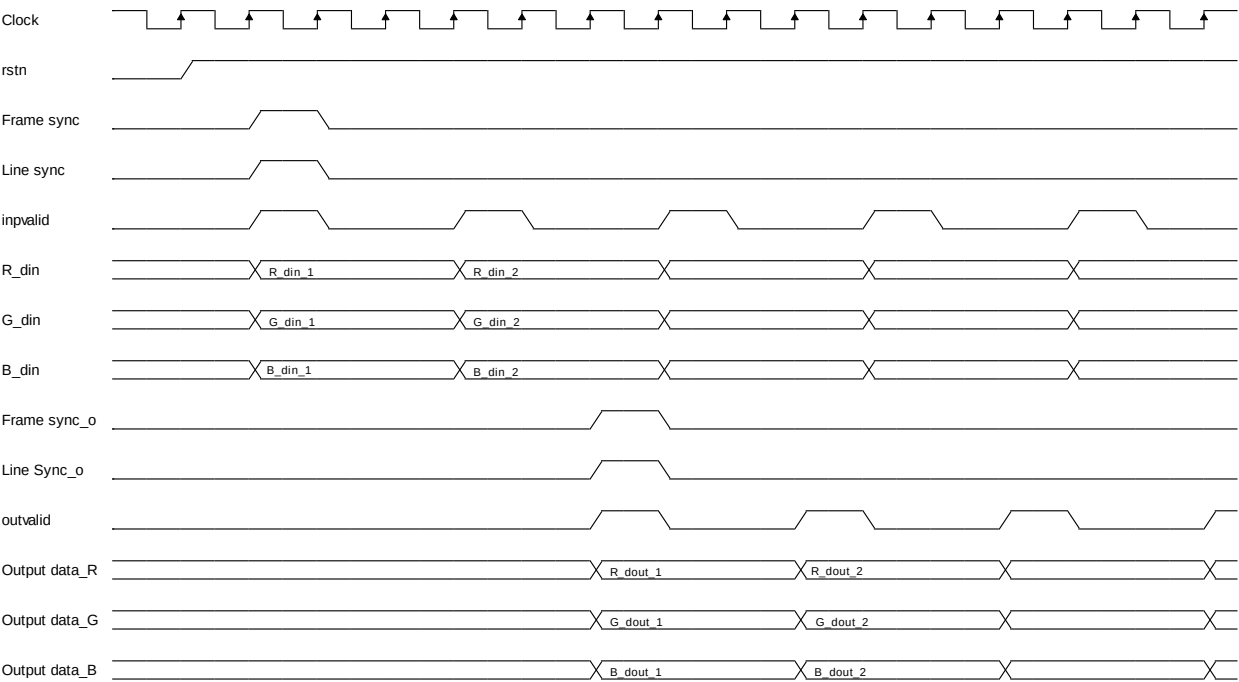
Signal	I/O	Data Width	Description
waddr	I	16	Write address signal
wdata	I	32	Write data signal
frame_sync_o	O	1	Output frame synchronization signal
line_sync_o	O	1	Output line synchronization signal
outvalid	O	1	Output valid signal, active-high.
R_dout	O	Changeable	Output image data signal
G_dout	O	Changeable	Output image data signal
B_dout	O	Changeable	Output image data signal

5 Timing Description

This chapter mainly introduces the timing of Gowin Color Correction Matrix IP.

After operating, the data outputs with latency of five clock cycles. The input data requires at least three cycles to be stable. The timing diagram is as shown in Figure 5-1.

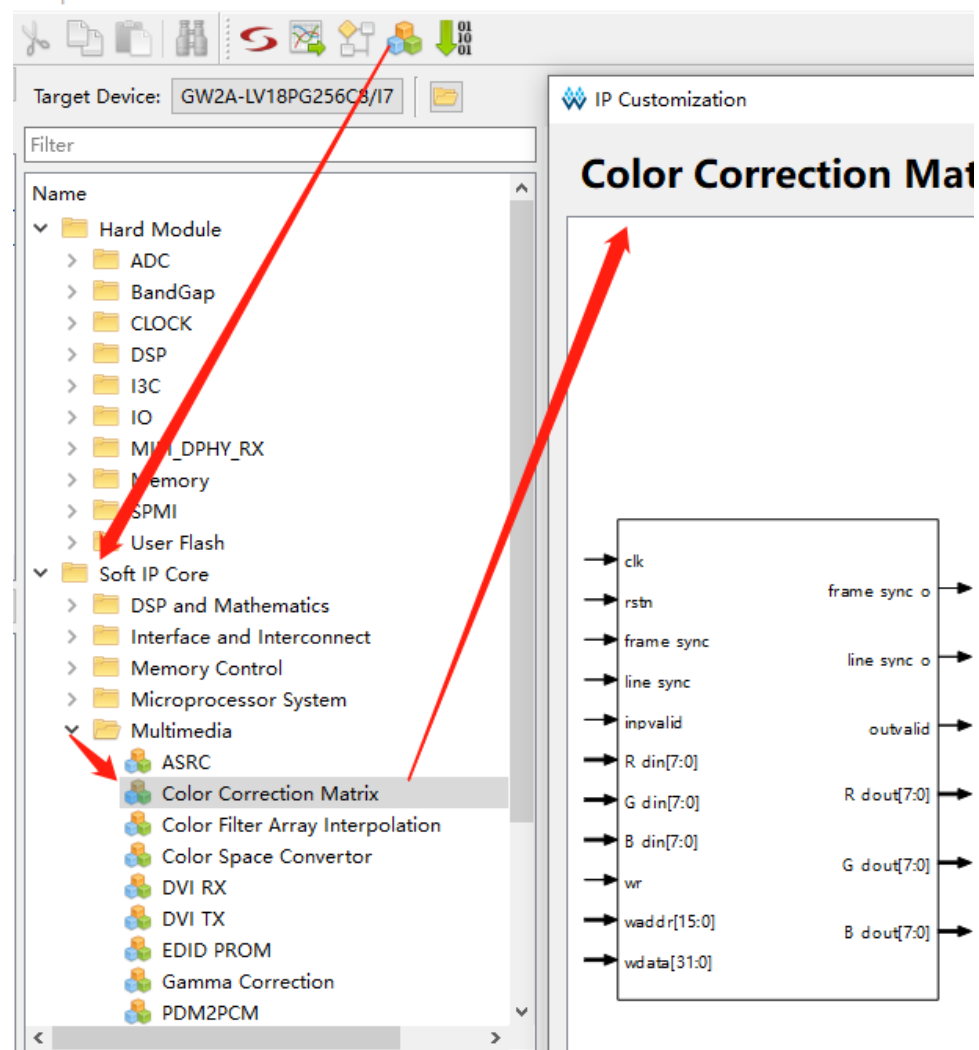
Figure 5-1 Timing Diagram



6 GUI

Click "Tools > IP Core Generator > Multimedia > Color Correction Matrix" to call and configure Gowin Color Correction Matrix IP. Toolbar icon is also available as shown in Figure 6-1.

Figure 6-1 Open GUI Via Icon



The configuration interface of Gowin Color Correction Matrix IP is as

shown in Figure 6-2.

Figure 6-2 Gowin Color Correction Matrix IP Configuration

Color Correction Matrix

General

Device: GW2A-18 Part Number: GW2A-LV18PG256C8/I7

Create In: C:\Users\fgpa_project\src\color_correction_matrix

File Name: color_correction_matrix Module Name: Color_Correction_Matrix_Top

Language: Verilog Synthesis Tool: GowinSynthesis

Options

Input Frame Dimension

Maximum Number of Columns: 8 (8~7680) Input Data Width: 8

Maximum Number of Rows: 8 (8~4320)

Output Frame Dimension

Output Data Width: 8

Coefficient Matrix

Coefficient Data Width: 20

K11: 1.260878 K21: -0.028948 K31: 0.064674

K12: -0.231445 K22: 1.356893 K32: 0.053179

K13: 0.102901 K23: -0.539042 K33: 1.607306

Offset Matrix

O1: -66.518367 O2: -69.268287 O3: -65.430404

Generation Config

☒ Disable I/O Insertion

OK Cancel Help

- You can configure the generated file name by modifying the File Name.
- You can configure the module name by modifying the Module Name.
- You can configure IP working mode and other options by Options.

The configuration options are shown in Table 6-1.

Table 6-1 Configuration Options

Options	Description
Maximum Number of Columns	Number of input image columns
Maximum Number of Rows	Number of input image rows
Input Data Width	Input data bit width, 8/10/12/16 bits
Output Data Width	Output data width, 8/10/12/16bits
Coefficient Matrix	Coefficient matrix, K11-K33 can be configured independently, and the range is -8~8.
Offset Matrix	Offset matrix, O1-O3 can be configured independently, and the range is -255~255.

7 Reference Design

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

8 File Delivery

The delivery file for Gowin Color Correction Matrix IP includes documents and reference design.

8.1 Documents

The folder mainly contains the user guide in PDF.

Table 8-1 Documents List

Name	Description
IPUG766, Gowin Color Correction Matrix IP User Guide	Gowin IP User Guide, namely this one
Gowin Color Correction Matrix IP	–

8.2 Reference Design

The Ref. Design folder contains the netlist file, the user reference design, the constraint file, the top file, the project folder, etc.

Table 8-2 Ref. Design Folder

Name	Description
ccm_exp.v	Top module and excitation generation module of reference design
color_correction_matrix.vo	Netlist file
demo.cst	CCM Physical Constraints File
fpga_project.gao	Capture output data of CCM
color_correction_matrix	CCM IP project folder

