

UG0938
User Guide
Gamma Correction



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Contents

1	Revision History	1
1.1	Revision 1.0	1
2	Introduction	2
2.1	Key Features	2
2.2	Supported Families	2
2.3	Inputs and Outputs	3
2.4	Configuration Parameters	3
3	Testbench	4
3.1	License	4
3.1.1	Obfuscated	4
3.1.2	RTL	4
4	Simulation Results	9
4.1	Timing Diagram	9
4.2	Input Image	9
4.3	Output Image	10
5	Resource Utilization	11

Figures

Figure 1	Inputs and Outputs	3
Figure 2	Design Flow	4
Figure 3	Libero SoC Catalog	5
Figure 4	Configurator	5
Figure 5	GAMMA_CORRECTION_C0 Instance	6
Figure 6	SmartDesign Toolbar	6
Figure 7	Import Files	6
Figure 8	Simulation	7
Figure 9	Stimulus Hierarchy	7
Figure 10	ModelSim tool	8
Figure 11	Gamma Correction IP	9
Figure 12	Input Image	9
Figure 13	Output Image	10

Tables

Table 1	Input and Output Ports	3
Table 2	Configuration Parameters	3
Table 3	Testbench Configuration Parameters	4
Table 4	Gamma Correction IP Resource Utilization	11

1 Revision History

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

1.1 Revision 1.0

The first publication of this document.

2 Introduction

A camera sensor converts the light intensity of a pixel into equivalent digital value. The digital value is directly proportional to the light intensity of a pixel and hence has a linear relationship. However, a human eye perceives the images as a logarithmic function of intensity instead of a linear function. If the images from a camera sensor are directly displayed on a display device, then the scene will appear unnatural because of the differences between the camera sensor and human eye perception. To compensate this, the image from the camera sensor goes through the gamma correction.

Gamma correction uses an exponent function to compensate for the logarithmic perception by using the below equation:

$$D_{out} = (D_{in})^{\gamma}$$

Equation 1

where,

D_{out} represents output image data (RGB). Represented in the range of 0 to 1.

D_{in} represents input image data (RGB). Represented in the range of 0 to 1.

γ represents the gamma correction factor. A fixed gamma correction factor of 0.4545 corresponding to a gamma of 2.2 is implemented in the IP.

The Gamma correction IP is implemented using a LUT for exponent function.

The width of the input data determines the number of entries in the LUT. For example, 8-bit input data would require 2^8 (256) entries in the LUT.

This section describes the inputs and outputs and configuration parameters of the Gamma Correction IP.

2.1 Key Features

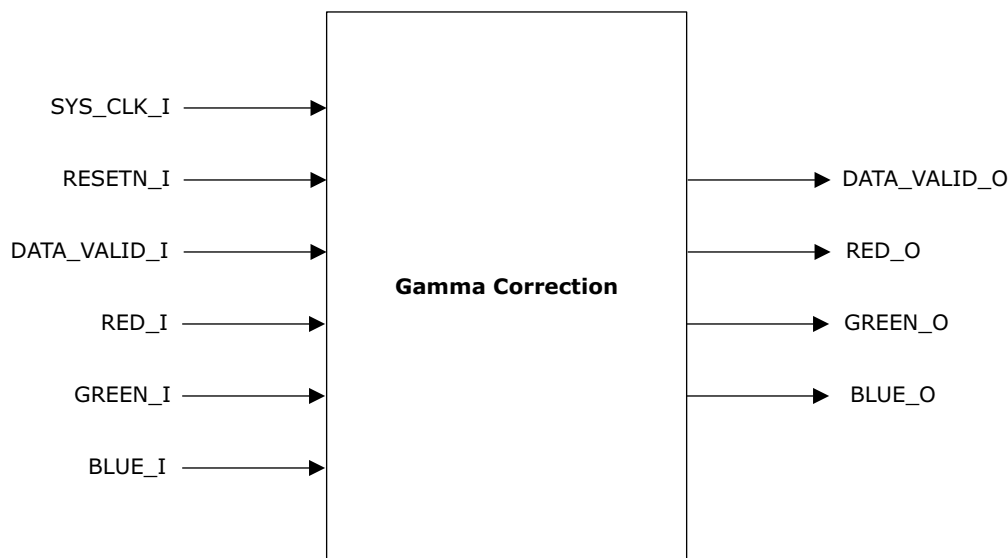
- LUT based gamma correction
- Fixed gamma factor of 2.2
- Supports data width of 8 and 10

2.2 Supported Families

- PolarFire[®] SoC
- PolarFire[®]
- RTG4[™]
- IGLOO[®]2
- SmartFusion[®]2

2.3 Inputs and Outputs

Figure 1 • Inputs and Outputs



The following table lists the input and output ports of the Gamma Correction IP.

Table 1 • Input and Output Ports

Port Name	Direction	Width	Description
SYS_CLK_I	Input	1 bit	System clock.
RESETN_I	Input	1 bit	Active low asynchronous reset signal.
DATA_VALID_I	Input	1 bit	Input data valid signal. This signal should be asserted when the data is valid.
RED_I	Input	8 bits	Input Red pixel data.
GREEN_I	Input	8 bits	Input Green pixel data.
BLUE_I	Input	8 bits	Input Blue pixel data.
DATA_VALID_O	Output	1 bit	Output data valid signal. This signal is asserted when the output data is valid.
RED_O	Output	8 bits	Output Red pixel data.
GREEN_O	Output	8 bits	Output Green pixel data.
BLUE_O	Output	8 bits	Output Blue pixel data.

2.4 Configuration Parameters

The following table lists the configuration parameters used in the hardware implementation of the Gamma correction. These parameters are generic and can be varied based on the application requirement.

Table 2 • Configuration Parameters

Parameter Name	Description
G_DATA_WIDTH	Represents bitwidth of input and output data. Current version supports 8-bit and 10-bit input and output data.

3 Testbench

A testbench is provided to check the functionality of the Gamma Correction IP. To ensure that the testbench works correctly, the configuration parameters listed in Table 3 must be configured at the beginning of the testbench file.

Table 3 • Testbench Configuration Parameters

Name	Description
CLKPERIOD	Clock period
g_DATAWIDTH	Width of each pixel
HEIGHT	Vertical resolution
WIDTH	Horizontal resolution
IMAGE_FILE_NAME	Input image file

3.1 License

Gamma-Correction clear RTL is license locked and the obfuscated RTL available for free.

3.1.1 Obfuscated

Complete RTL code is provided for the core, allowing the core to be instantiated with the SmartDesign tool. Simulation, synthesis, and layout can be performed within Libero® System-on-Chip (SoC). The RTL code for the core is obfuscated.

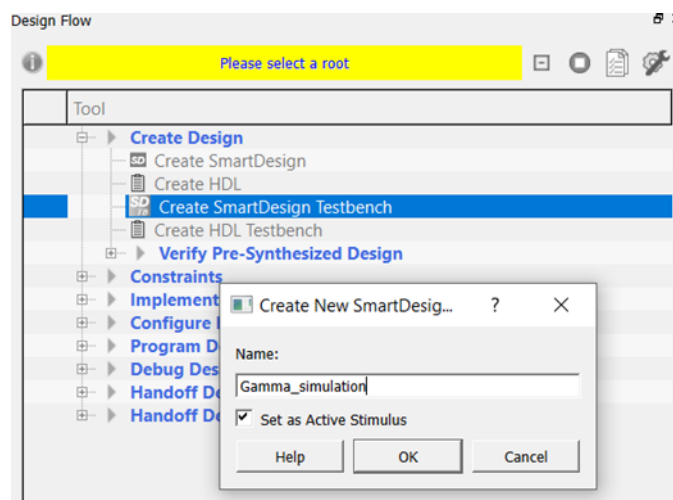
3.1.2 RTL

Complete RTL source code is provided for the core.

The following steps describe how to simulate the core using the testbench. The packaged testbench will gamma correct an input image.

1. In the **Design Flow** window, expand **Create Design**. Right-click **Create SmartDesign testbench** and click **Run**, as shown in the following figure.

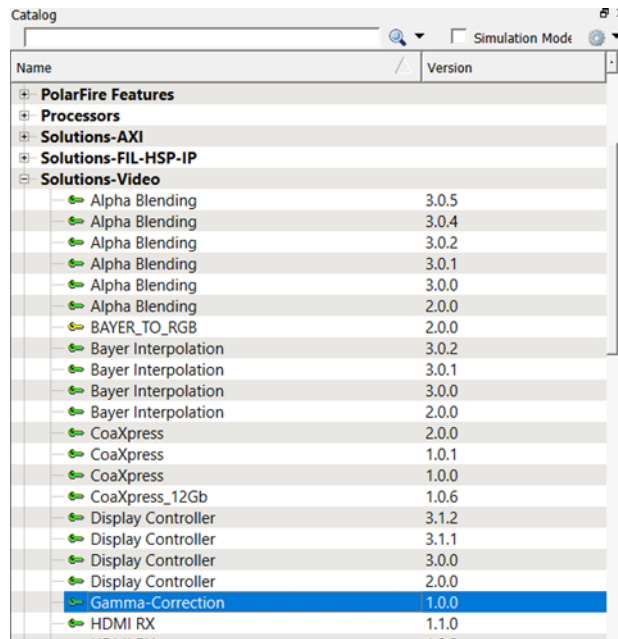
Figure 2 • Design Flow



SmartDesign testbench is created, and a canvas appears to the right of the Design Flow pane.

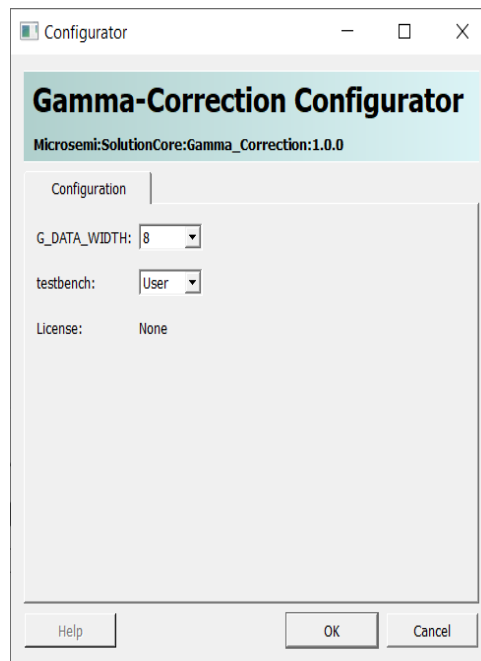
- In the **Libero SoC Catalog (View > Windows > Catalog)**, expand **Solutions-Video**, and drag the **Gamma-Correction** IP core onto the SmartDesign testbench canvas.

Figure 3 • Libero SoC Catalog



- Select the default component name and click **OK**.
- In the **Gamma-Correction Configurator** GUI window, update the **G_DATA_WIDTH** and click **OK**.

Figure 4 • Configurator



- On Design Hierarchy tab, right-click **GAMMA_CORRECTION_C0** and click **Set As Root**.

6. Select all the ports on the GAMMA_CORRECTION_C0 instance, right-click, and select **Promote to Top Level**, as shown in the following figure.

Figure 5 • GAMMA_CORRECTION_C0 Instance

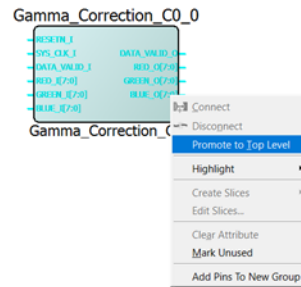
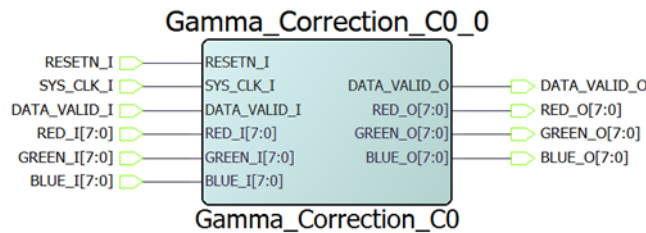
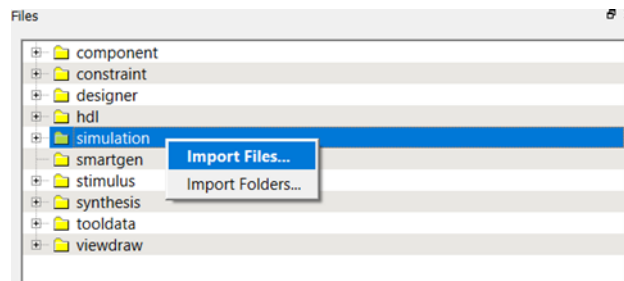


Figure 6 • SmartDesign Toolbar



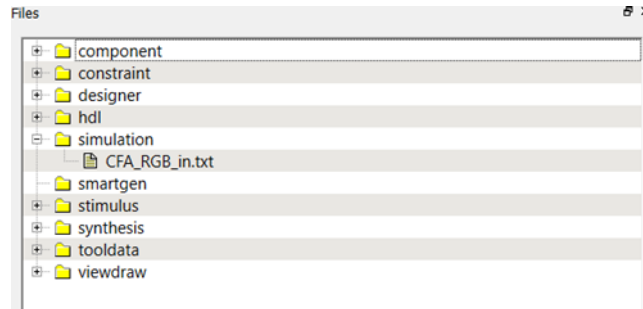
7. Click **Generate Component** from the SmartDesign toolbar.
8. Go to the Files tab and select **simulation > Import Files...**, as shown in the following figure.

Figure 7 • Import Files



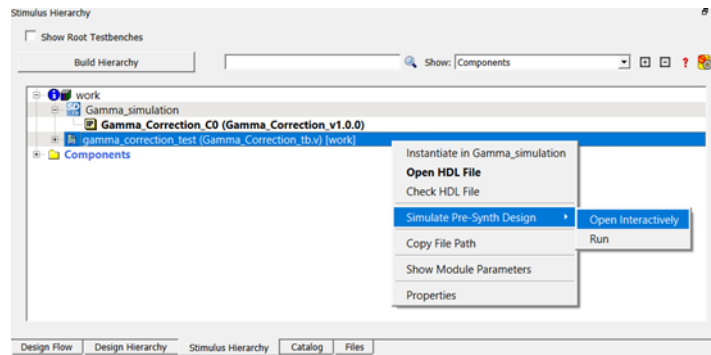
- Import the Input Image file "CFA_RGB_in.txt" from the following path:
..\<Project_name>\component\Microsemi\SolutionCore\Gamma-Correction\1.0.0\Stimulus. To import a different file, browse the folder that contains the required file, and click **Open**. The imported file is listed under simulation as shown in the following figure.

Figure 8 • Simulation



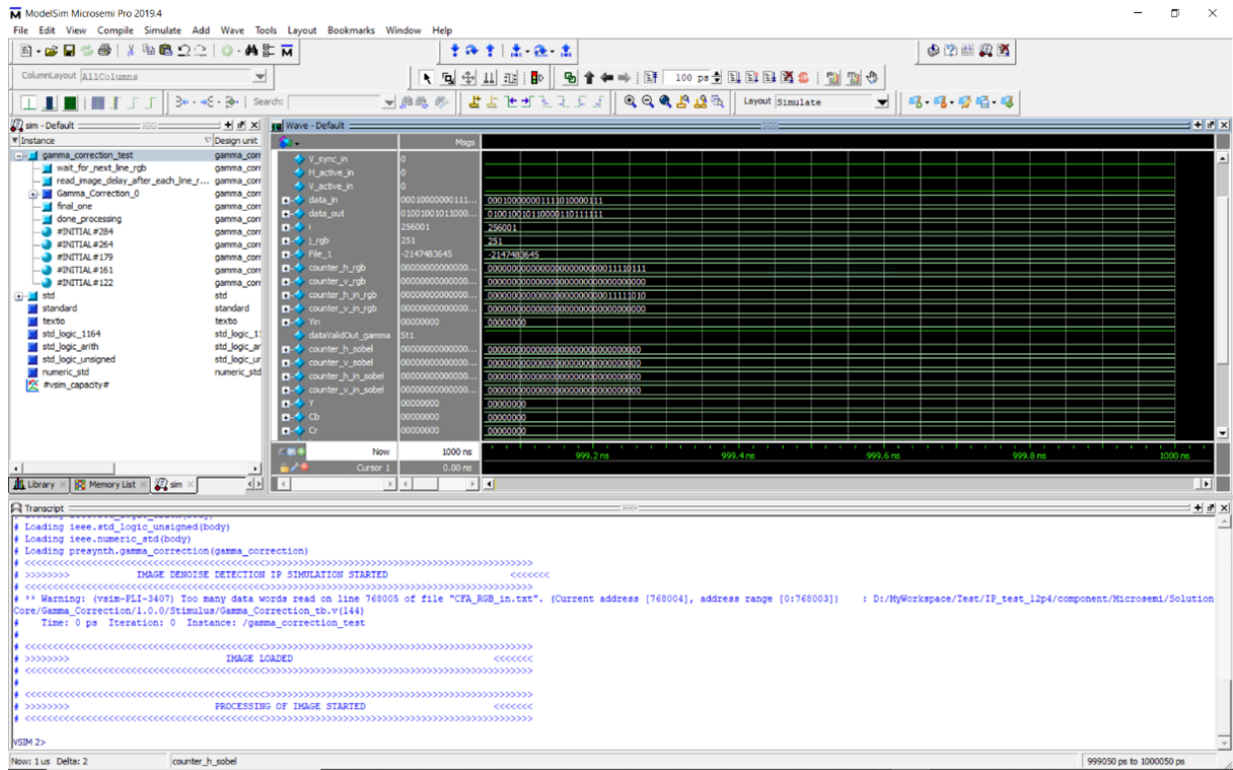
- On Stimulus Hierarchy tab, right-click gamma_correction_test testbench file and click **Open Interactively** from Simulate Pre-Synth Design.

Figure 9 • Stimulus Hierarchy



The ModelSim tool appears with the test bench file loaded onto it, as shown in the following figure.

Figure 10 • ModelSim tool



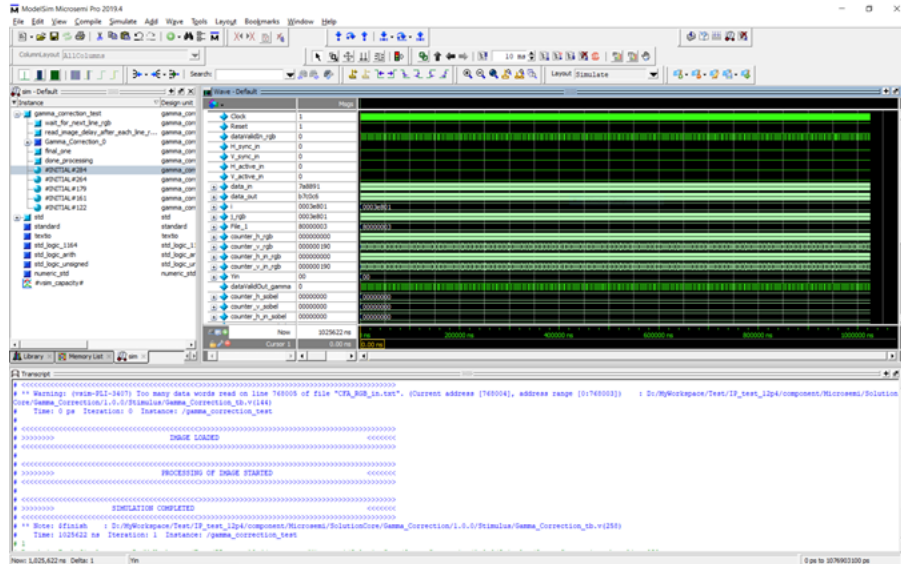
If the simulation is interrupted because of the runtime limit in the DO file, use the run `-all` command to complete the simulation. By default, the output image file is placed in the Files/simulation directory and uses the `CFA_RGB_out.txt`.

4 Simulation Results

4.1 Timing Diagram

The following is the timing diagram for Gamma Correction IP showing video data and output image.

Figure 11 • Gamma Correction IP



4.2 Input Image

Figure 12 • Input Image



4.3 Output Image

Figure 13 • Output Image



5 Resource Utilization

Gamma correction is implemented on PolarFire FPGA (MPF500T -1FCG1152I package). The following table shows the resource utilization report after synthesis.

Table 4 • Gamma Correction IP Resource Utilization

Gamma Correction IP	LUT	DFF	RAM1K20	MACC
G_DATA_WIDTH=8	354	26	0	0
G_DATA_WIDTH=10	1439	32	0	0