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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 3.0
The resource utilization reports were updated. For more information, see Resource Utilization, page 5.

1.2 Revision 2.0
The following is a summary of changes made in this revision.
• Updated Figure 1, page 3 and Table 1, page 3. For more information, see Figure 1, page 3.

1.3 Revision 1.0
The first publication of this document.
2 Introduction

Image Enhancement IP enables you to adjust the brightness, contrast and color balance of a final video Image according to personal preferences. These calculations are done in the RGB domain.

The inputs to Image Enhancement IP in terms of brightness and contrast are as follows:

\[
R_{\text{CONST}} = \frac{R_{\text{gain}} \times \text{contrast factor}}{10}
\]

\[
G_{\text{CONST}} = \frac{G_{\text{gain}} \times \text{contrast factor}}{10}
\]

\[
B_{\text{CONST}} = \frac{B_{\text{gain}} \times \text{contrast factor}}{10}
\]

\[
\text{COMMON CONST} = 128 \times (\text{brightness} - ((128 \times \text{contrast factor})/10))
\]

where,

\[
\text{contrast factor} = \frac{325 \times (\text{contrast} + 128)}{387 - \text{contrast}} \times 32
\]

\(R_{\text{gain}}, G_{\text{gain}}, \text{ and } B_{\text{gain}}\) are the red, green, and blue gain values.

The output RGB values are calculated from the above inputs based on the following equations:

\[
R_{\text{out}} = \text{COMMON CONST} + R_{\text{CONST}} \times R_{\text{in}}
\]

\[
G_{\text{out}} = \text{COMMON CONST} + G_{\text{CONST}} \times G_{\text{in}}
\]

\[
B_{\text{out}} = \text{COMMON CONST} + B_{\text{CONST}} \times B_{\text{in}}
\]

Where,

\(R_{\text{in}}, G_{\text{in}}, \text{ and } B_{\text{in}}\) are the red, green and blue values of input data.

\(R_{\text{out}}, G_{\text{out}}, \text{ and } B_{\text{out}}\) are the red, green and blue values of output data.
3 Hardware Implementation

This section describes the design description and inputs and outputs of the Image Enhancement IP.

3.1 Design Description

The following figure shows the block diagram of the Image Enhancement IP.

*Figure 1* • Block Diagram

When the ENABLE_I and DATA_VALID_I signal goes high the R, G and B values of the output is computed from the inputs according to the formula given in introduction section. DATA_O is valid when DATA_VALID_O (which is equivalent to DATA_VALID_I with two clock cycle delay) goes high.

3.2 Inputs and Outputs

The following table lists the input and output ports of the Image Enhancement IP.

*Table 1* • Inputs and Outputs

<table>
<thead>
<tr>
<th>Port Name</th>
<th>Direction</th>
<th>Width</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESETN_I</td>
<td>Input</td>
<td>1 bit</td>
<td>Active low asynchronous reset signal to design</td>
</tr>
<tr>
<td>SYS_CLK_I</td>
<td>Input</td>
<td>1 bit</td>
<td>System clock</td>
</tr>
<tr>
<td>DATA_VALID_I</td>
<td>Input</td>
<td>1 bit</td>
<td>Input data valid signal This signal is asserted high when the data is valid</td>
</tr>
<tr>
<td>ENABLE_I</td>
<td>Input</td>
<td>1 bit</td>
<td>Enable signal Should be '1' to enable image enhancement operation</td>
</tr>
</tbody>
</table>
3.3 Configuration Parameters

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

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G_PIXEL_WIDTH</td>
<td>Bit width of each pixel</td>
</tr>
</tbody>
</table>

3.4 Timing Diagrams

The following figure shows the timing diagram of the Image Enhancement IP.

Figure 2 • Timing Diagram
3.5 Resource Utilization

The Image Enhancement IP is implemented on SmartFusion®2 system-on-chip (SoC) field programmable gate array (FPGA) device (M2S150T-1152 FC package) and PolarFire® FPGA (MPF300TS-1FCG1152E package).

**Table 3 • Resource Utilization on PolarFire**

<table>
<thead>
<tr>
<th>Resource</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFFs</td>
<td>173</td>
</tr>
<tr>
<td>4-input LUTs</td>
<td>139</td>
</tr>
<tr>
<td>MACC</td>
<td>3</td>
</tr>
<tr>
<td>RAM1Kx18</td>
<td>0</td>
</tr>
<tr>
<td>RAM64x18</td>
<td>0</td>
</tr>
</tbody>
</table>

1. For G_PIXEL_WIDTH = 8.

**Table 4 • Resource Utilization on SmartFusion2**

<table>
<thead>
<tr>
<th>Resource</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFFs</td>
<td>173</td>
</tr>
<tr>
<td>4-input LUTs</td>
<td>141</td>
</tr>
<tr>
<td>MACC</td>
<td>3</td>
</tr>
<tr>
<td>RAM1Kx18</td>
<td>0</td>
</tr>
<tr>
<td>RAM64x18</td>
<td>0</td>
</tr>
</tbody>
</table>

1. For G_PIXEL_WIDTH = 8.