**Abstract**

DMA verification is usually done by senior verification engineer because even a single bus protocol violation could hang up the whole SoC. In this paper, we introduce a DMA verification platform for multimedia IP that could be easily used by verification beginners and could accumulate DMA verification knowledge how of experienced engineers without much effort.

Through this platform, even a novice verification engineer could develop a new DMA testbench in 30 minutes and we could verify several DMA instances at the same time with sufficient verification quality.

**What is MDVP**

MDVP is UVM-based verification platform specialized for multimedia IP DMA. MDVP consists of:

A) Input data generator with compressed data format
   - Random data generator
   - Pattern data generator
   - Compressed data generator

B) DMA reference model for multimedia IP DMA
   - For various data formats
   - For AXI slave and master interfaces

C) Reusable testbench that can be shared among different DMA instances

D) Configurable UVM testbench according to the specification of the multimedia DMA

- Total number of supported OTF interfaces : 16
- Total number of embedded UVCs : 54

**Introduction**

For many years, DMA verification has been usually carried out by senior verification engineer because it could cause system hang if a bug escape related bus exists. So one senior verification engineer had to verify up to 1 or 2 multimedia IP DMA simultaneously in SoC project.

But recently, Exynos mobile SoC has embedded various types of multimedia IP in order to provide differentiated multimedia function such as image fusion, TOF(time-of-flight) camera, HDR(high Dynamic Range) etc. and since the most multimedia IPs have the form shown in Figure 1, increasing the number of multimedia IPs leads to the number of DMA to be verified.

**Input Data Generation**

Generally, the behavior of the multimedia IP DMA does not vary depending on the patterns of data to write or read. So random data is usually used for DMA verification. However, in case of DMA which has data compressor, random data pattern can cause limited behavior of DMA according to the compression algorithm. So in order to make various behavior of DMA which include data compressor, we have to use various natural image as well.

For creating various natural images to test, MDVP randomly selects one of about 10,000 natural image DB and then converts the selected image into an image with a desired format and resolution by ImageMagick[3].

**DMA reference model**

When developing model of multimedia IP, DMA model can also be developed to compare the behavior of hardware exactly. In this case, the DMA model can be used as the DMA reference model in the DMA verification. However, if input or output form of DMA model does not match, modification is required to use the model as DMA reference model.

So we developed newly DMA reference model for DMA verification that supports all kinds of memory format for multimedia IP in Exynos mobile SoC through analyzing every multimedia IP's DMA. This allows verification engineer using MDVP to reduce testbench development time by using a well verified DMA reference model.

The main outputs of DMA reference model in MDVP are valid address information and formatted data using given pixel and DMA configurations such as base address, stride, pixel format and memory format.

Figure 2 and 3 show how the DMA reference model is used in WDMA and RDMA verification environment.

**Reusable testbench**

Most of the multimedia IP DMA have a similar structure and the majority of testbench can be reused by using DUT wrapper that instantiates DMA to be verified as shown Figure 4.

**Conclusion**

We investigated the specification about all OTF interfaces to create super-set DMA verification environment. Before implementing each UVC corresponding OTF interface, we defined common sequence item for UVC to facilitate the maintenance if it is necessary to modify or create UVC.

As a result, the configurable testbench of MDVP has 54 UVCs that correspond to 16 kinds of OTF interfaces. And it also provides common methods, that is used for all DMA verification such as input data generator / DMA reference model, UVC linking methods between DMA sequence and sequence item of UVC and UVM testbench skeleton.

Therefore even novice verification engineer who is not familiar with UVM can create new and stable DMA testbench based on MDVP quickly without much difficulty.

**Table 1:** The effect of applying MDVP

<table>
<thead>
<tr>
<th>Test scenarios</th>
<th>Without MDVP</th>
<th>With first MDVP</th>
<th>With second MDVP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junior</td>
<td>1~2</td>
<td>Average 4</td>
<td>Average 5</td>
</tr>
<tr>
<td>Senior</td>
<td>2~3</td>
<td>Average 10</td>
<td>Average 15</td>
</tr>
</tbody>
</table>

**Table 2:** The effect of applying MDVP

<table>
<thead>
<tr>
<th>Sequence Item</th>
<th>Without MDVP</th>
<th>With first MDVP</th>
<th>With second MDVP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test scenario</td>
<td></td>
<td>Average 4</td>
<td>Average 5</td>
</tr>
<tr>
<td>Time</td>
<td></td>
<td>Average 10</td>
<td>Average 15</td>
</tr>
</tbody>
</table>

MDVP has been developed to get a multimedia IP DMA which has sufficient verification quality with small manpower within the project schedule. Since its first release, MDVP has been successfully used for multimedia IP DMA verification of 6 SoC projects so far.