D/AVE HD Improvements 2022

Overview

Oct 2022

Summary: 2022 Improvements in D/AVE HD (1/3)

- BC1 Texture Compression - allowing to apply all BLIT operations including stretch- and rotation-BLITs to BC1 compressed textures
  - Note: The so far supported RLE texture compression format can only be used with standard BLITs without performance degradation
  - Requires Backpressure on AXI read interface
- Framebuffer Compression
  - Uncompressed 4byte/pixel -> 1 byte/pixel (w/o alpha) or 2 byte/pixel (w. alpha)
  - TES proprietary image compression algorithm – requires decoder at Display Controller (available in TES CDC family)
  - *Note: "FB Compression" to 2 byte/pixel (w/o alpha) or 3 byte/pixel (w. alpha) is possible by applying the new TES proprietary XOR- and Bayer_s dithering algorithms to standard RGB-565 format. This requires no special decoder at the Display Controller. See "Advanced Dithering Formats" on next slide.*

Summary: 2022 Improvements in D/AVE HD (2/3)

- Additional input (texture) and output (framebuffer) color formats:
  - 24-bit formats: RGB-888, BGR-888, ARGB-8565, RGBA-5658
    - Requires Backpressure on AXI read interface
  - 8-bit formats: ARGB-2222, RGBA-2222
- Advanced Dithering Formats
  - All based on TES proprietary STABLE dithering algorithms which can be applied unlimited times without degrading the image
  - “XOR”- and “Bayer_s” – Dithering
    - Applicable for all color formats with <8bit per channel
    - Allows “50% Framebuffer Compression” with high image quality by using standard RGB-565 format in combination with “Stable Dithering”. No FB-Decoder needed in this case.
  - **on request only:** bayer_s_8, bayer_8, bayer_n_4, bayer_n_8
    - Especially useful for ARGB-2222 and RGBA-2222

Summary: 2022 Improvements in D/AVE HD (3/3)

System Features:

- All memories on top level
  - The memory signals from the D/AVE HD submodules are propagated to top level so that the memories can be instantiated either in the submodules or on top level
- IRQ_O on top level
  - for convenience a new irq output is added to the toplevel which is a OR combination of the other 3 interrupts: irq_o <= pause_irq OR sync_irq OR special_irq
- AXI burst length limitation
  - The AXI burst lengths can be limited to a programmable number of beats. The maximum burst length that D/AVE HD can generate is 16 (configurable at synthesis time). The burst length limitation is applied to the master read interfaces of TXC and RLD. FBC and ZSC have already measures to limit their bursts.

D/AVE HD texture compression

Texture Compression - Introduction

- Requirements / Properties
  - Simple, fast decompressor ideally with random access to pixels
  - Offline compression tool – can be complex
  - Support of alpha channel
- Options:
  - Lossless compression format – leads to variable size of compressed image depending on content of texture
  - Lossy compression format – allows fixed size of compressed image

D/AVE Texture Compression Option 1: RLE

- Run Length Encoding (RLE) Texture compression
  - RLE is a **lossless** format but cannot guarantee a certain size reduction.
    - Good for textures with lots of equal or similar pixels: reduction of 32bit ARGB textures down to 2-4 bit per pixel possible for typical icons
    - Bad for textures with lots of details or noise (can even increase size)
  - Format: run-length-encoded Targa format (*.tga files)
    - Any standard Targa compressor tool can be used
  - Only usable for “normal” BLIT operations (with no scaling or rotations) without performance degradation
  - Implicit advantage: Saves memory transfers and thus increases performance

D/AVE Texture Compression Option 2: BC1

- BC1 Texture compression
  - **Lossy compression** with **fixed compression rate: 4bit/pixel**
  - According to BC1/S3TC/DXT1 block compression format
    - See: https://en.wikipedia.org/wiki/S3_Texture_Compression
    - Input: 24bit RGB
    - Supports 1-bit pre-multiplied Alpha
  - Compression Tool: Free-of-charge of-the-shelf tools available, e.g., AMDs Compressonator, GIMP,…
  - Usable with all type of BLIT and texture mapping operations (scaling, rotation, perspective..)
  - Implicit advantage: Lowers memory requirements, saves memory transfers and thus increases performance

D/AVE HD framebuffer compression

Introduction

Framebuffer Compression Intro - Required Properties

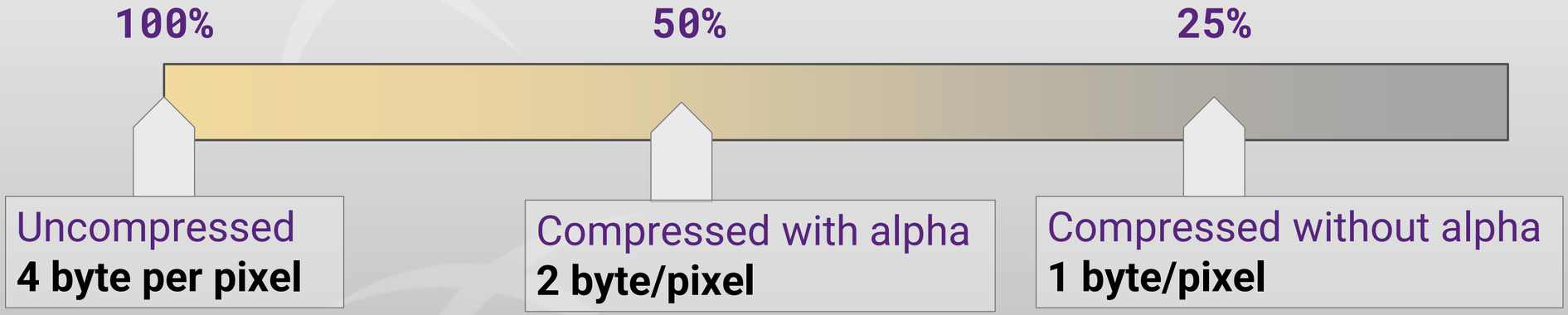
- **Random read/write access**
  - variable length/ entropy coding can be applied in small blocks only
- **Fixed rate compression**
  - this implies approximate / lossy compression
- **Symmetric encoder/decoder complexity**
  - techniques with fast decoding but very slow encoding (eg. vector quantization) are not suitable
- **Bounded maximum error**
  - *unbounded* errors can easily occur when recompressing the same data multiple times

Framebuffer Compression Intro - Well Known Solutions

- **Direct Quantization**
  - just dropping bits like the good old rgb565
- **Decorrelation and Quantization**
  - dropping bits in another colorspace like chroma subsampling in yuv420
- **Indirection using a global color lookup table (CLUT)**
  - indexed color buffers are possibly the oldest known ‘compression’
- **Block based compression**
  - apply a local CLUT to each 4x4 block (usually 4 or 8 entries)
  - difficult to apply symmetrically

D/AVE Framebuffer Compression

- Compression Modes



- Compression selectable for each render target
  - render_to_texture during frame creation is no problem
- Framebuffer Decoder required on Display Controller side
  - Offered together with TES CDC family

D/AVE Framebuffer Compression - Advantages

- **Perfectly stable under repeated application**
  - each pixel drops/retains the same components every time
- **Trivial encoding in HW**
  - can encode each pixel independently and with minimal logic
- **Decoding required *only* on display out**
  - pixels that have only component 1 will never write components 2 and 3, so they don’t have to decode & blend them either
- **No need to complete an entire tile prior to compression**
  - saving additional memory bandwidth (no need to retain full display list)