Building an Area-optimized Multi-format Video Encoder IP

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Allegro DVT

Founded in 2003
Privately owned, based in Grenoble (France)

Two product lines:

1) Industry de-facto standard video compliance streams
   Decoder syntax, performance and error resilience streams for H.264|MVC, H.265/SHVC, VP9, AVS2 and AV1
   System compliance streams

2) Leading semiconductor video IP
   Multi-format encoder IP for H.264, H.265, VP9, JPEG
   Multi-format decoder IP for H.264, H.265, VP9, JPEG
   WiGig IEEE 802.11ad WDE CODEC IP
Evolution of Video Coding Standards

International standards defined by standardization bodies such as ITU-T and ISO/IEC

- H.261 (1990)
- MPEG-1 (1993)
- H.263 (1996)
- MPEG-4 Part 2 (1999)
- H.265 / HEVC (2013)

Future Video Coding ("FVC")

- MPEG and ISO "Preliminary Joint Call for Evidence on Video Compression with Capability beyond HEVC." (202?)

Incremental improvements of transform-based & motion-compensated hybrid video coding schemes to meet the ever increasing resolution and frame rate requirements
Regional Video Standards

- SMPTE standards in the US
  - VC-1 (2006)
  - VC-2 (2008)

- China Information Industry Department standards
  - AVS (2005)
  - AVS+ (2012)
  - AVS2.0 (2016)
Proprietary Video Formats

- Sorenson Spark
- On2 VP6, VP7
- RealVideo
- DivX

Popular in the past partly due to technical merits but mainly due to more suitable licensing schemes to a given application than standard video video formats with their patent royalties.
Royalty-free Video Formats

- Xiph.org Foundation
  - Theora (2004) was the first free and open video compression format

- WebM project initiated by Google
  - Open-source, royalty-free video formats
    - VP8 (2010)
    - VP9 (2013)

- Alliance for Open Media (AOM)
  - Founded by Amazon, Cisco, Google, Intel Corporation, Microsoft, Mozilla and Netflix in 2015
  - Combining efforts of Xiph.org’s Daala, Cisco’s Thor and Google’s VP10
  - Next-generation interoperable and open video format (AV1)
AV1 Schedule

Original target:
- Improvement of 50 percent over VP9/HEVC with reasonable increases in encoding and playback complexity.
- Royalty-free for both commercial and non-commercial content, including user-generated content.
- Bitstream freeze by end of 2016

Revised target:
- Materially" better than VP9 or HEVC and plays on a reasonable number of modern computers.
- Bitstream freeze by end of 2017

Allegro is an active member of AOM
- Working on Syntax, performance and error resilience compliance streams
Need for a Multi-format Encoder

- Several co-existing video codecs
  - Different applications
  - Geographical area requirements
  - Legacy constraints

- Main standards currently in use
  - MPEG-2
  - H.264/AVC
  - H.265/HEVC
  - VP9
  - AVS/AVS+/AVS2.0
Encoder Differentiation

- Video standards specify only decoding schemes
  - All decoders must be bit-exact
  - Compliance streams
  - Differentiation only in Power, Performance and Area ("PPA")

- Video encoders can be very different
  - Encoding quality
  - Latency
  - Power, Performance and Area ("PPA")
    - Flexibility through scalable architecture
    - Minimal silicon area through a true multi-format architecture
Comparison of Encoders

- **Benchmarks**
  - Test sequences
    - E.g. JCT-VC
    - Application specific streams
  - Metrics
    - PSNR & SSIM curves (functions of bitrate)
    - Bjøntegaard-Delta (BD-rate, average bitrate reduction)
    - *Subjective testing*

- **Encoding quality vs PPA trade-offs**
  - Allegro 10+ year know-how in video encoding algorithms, architectures and low-power design
Building an Efficient Video Encoder

- Difficult to build a video encoder IP with a quality close to a full-feature software reference model
  - Requires complex tools
    - intra prediction
    - inter prediction
    - several transform sizes
    - RDO (Rate-Distortion Optimization)
      - algorithm selecting the best macroblock type & parameters
    - rate control & low-latency rate control

- Selecting cost vs quality trade-off requires deep technical know-how and experience
Best-in-class Video Quality

Targeting applications where encoding quality / bitrate matters
- Surveillance cameras
- IP cameras
- Drones
- Action cameras
- Transcoding

CBR, VBR
- Region-of-Interest and other tools for smart encoding
Movidius

- A licensee of Allegro DVT's multi-format H.264/AVC, H.265/HEVC and JPEG encoder IP (Press release in October 2016)
  - Targeted at Movidius next-generation ultra-low power machine vision platforms (Myriad X).
  - The Movidius award-winning Myriad family of vision processing units (VPUs) feature advanced machine intelligence algorithms implemented in a unique parallel programming architecture specifically targeted at vision processing applications.

- Acquired by Intel in September 2016
Latency

- System latency is critical in many applications
  - Automotive/ADAS
  - Remote control for surveillance and drones
  - Wireless docking, virtual reality, etc.

- Latency requirement can vary from several seconds down to few milliseconds
Encoder architecture and algorithm choices have a great impact, especially on the decoding latency.
Performance Evolution

From SD (Standard Definition) to HD (High Definition) to UHD (Ultra High Definition)

- Larger resolutions:
  - "4K" = 3840x2160 / 4096x2160
  - more than 20x SD

- Higher bit depths:
  - 10 bits per component (vs 8-bit)

- Higher frame rates:
  - progressive 60fps to 120fps (vs p30 / i60)

Exponentially increasing performance requirements impacting encoder design

Allegro’s truly scalable multi-core architecture

- 4K120 / 8K possible today
- Smart caching for best-in-class bus bandwidth
At IFA2017, Sharp's AQUOS 8K Series of 8K-compatible TVs and displays was announced.


In 2016 Sharp released the advanced wideband digital satellite broadcast receiver compatible with 8K ultra-high-definition (UHD) broadcasts.

Photo: Sharp
Allegro encoder IPs support multiple video standards in a deeply optimized way by using multi-format hardware blocks.
True Multi-format Architecture

- Multi-standard hardware and memory sharing
- Dedicated hardware for each standard

Input Video

- Reference picture

Inter Pred

- Motion Comp

- Mode Decision

- Transform Quantization

- Entropy
  - AVC
  - HEVC
  - VP9

- Bitstream

- Reconstructed picture

De-blocking

- Intra Pred

- Inv. Transform
  - Inv. Quantization

- Residual
Area Savings

RTL design is configurable at synthesis in order to include/remove support for various standards and features.

Additional area for AVC and VP9 support, compared to the size of the HEVC-only encoder configuration:

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Total Area</th>
</tr>
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<tbody>
<tr>
<td>HEVC only</td>
<td>T</td>
</tr>
<tr>
<td>HEVC + AVC</td>
<td>1.13 * T</td>
</tr>
<tr>
<td>HEVC + AVC + VP9</td>
<td>1.49 * T</td>
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Allegro Encoder IP Products

AL-E110
- High-end Multi-format Encoder
  - H.264/AVC, H.265/HEVC and VP9
  - Best-in-class visual quality at very low power consumption and silicon area
  - Support for 4:2:2
  - Scalable architecture from HD to 4K/8K resolutions

AL-E110L
- Area-optimized architecture
  - H.264/AVC, H.265/HEVC and VP9
  - Great visual quality for consumer applications
  - Industry leading silicon area for 4K30 in 28 nm
  - Attractive silicon area for high-end performance points (4K120)
THANK YOU!