

# SOC H.264 AVC Video/Audio Encoder IP Core Datasheet

Standard version  
I-Frame Version  
Slim Version

(Integration information is provided in the IP core Integration Sheet)

System-On-Chip (SOC) Technologies

## 1. Product Overview

The SOC H.264/AVC video encoder IP core is a single chip solution that supports single or multi-stream H.264 video encoding for all industrial standard resolutions including QVGA, SD and HD up to 1080p/60fps. The 1080@120, 4k and 8k H.264 encoder IP cores are released as separated products.

The SOC H.264 video encoder IP core supports FPGAs of both Xilinx and Intel. SOC also supplies all-in-one encoder modules based on the same H.264 video encoder IP core. Refer to the Product Brief and Datasheet for SOC MPEG codec modules for details.

The SOC-Mcodec Chipsets are “ASICs” based on FPGAs and SOC codec IP cores, which allow the customers to drop on their PCB exactly the same way as traditional ASICs. Refer to the Product Brief and Datasheet (Chip Selection Sheet) for details.

The SOC H.264 AVC video encoder is implemented based on SOC’s proprietary single-clock driven all-hardware technology (without microprocessors or embedded software), which has significant advantages of high-speed (low latency), small footprint (low power), high video quality, and high resolution. The encoder can fit into a low-end FPGA, for example, the low end Xilinx Spartan-6 series, such as the XC6SLX150.

The SOC H.264 AVC video encoder (all of the versions) is at high profile, with baseline and main profiles available. The encoder encodes either 4:2:0 or 4:2:2 streams whichever is desirable. The encoder has both 8-bit and 10-bit versions. The 8-bit encoder is most suited for consumer products, while the 10-bit is for high-end applications such as broadcast, digital cinema, military, and medical devices. There is also a lower power version which is designed for smartphones and mobile devices.

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The SOC H.264 AVC video encoder comes with a user API which allows the user to control the operations of the encoder, including CBR or VBR, bit rate, etc. The API user manual is shipped with the evaluation and product development kit.

The H.264 encoder IP core is customized into the following versions:

1. Standard Version:  
A balanced system optimized for key factors of logic resource utilization and performance.
2. I-Frame Version:  
The I-frame version implements intra-prediction (I-frames) only, without motion vector predictions, which reduces the logic resources and simplifies decoder complexity. But, the compression ratio is lower.
3. Slim Version:  
The slim version encoder is optimized for low logic resources, which uses about 50% of the logic resources compared to the standard version. The compression ratio is higher than that of the I-frame version but lower than the compression ratio of the standard version.

Other special versions of the SOC H.264 video encoder, such as multiple channels and dual core for 3D HD TVs, are also available, as special releases. Please contact SOC for product details.

The SOC 4k and 8k H.264 encoder IP cores are released as separated products. Please refer to the H.264 4k and 8k encoder datasheets for details. The 1080@120 is the same core of the 4k@30.

The SOC encoder series can be integrated with an audio encoder to provide an all-in-one encoding solution. Two solutions are available:

1. FPGA+DSP with the external DSP for audio encoding;
2. A single chip solution using FPGAs that have an ARM processor, such as the Xilinx Zynq-7 series and Altera SoC FPGAs. The SOC MPEG encoder IP cores can be licensed for either video or audio only or both video and audio encoding as a system.

The MPEG Transport Encoder (multiplexer) is usually included in an encoder IP core. SOC also provides network modules, TCP/UDP-IP, Ethernet MAC IP cores, which can be licensed along with the H.264 video/audio encoder IP cores. Customized versions of these products are available on request.

SOC also provides integration services for its customers. Contact SOC sales, [sales@soctechnologies.com](mailto:sales@soctechnologies.com), for information.

## 2. The SOC H.264 AVC Video Encoder Architecture

Fig. 1 is the block diagram of the SOC H.264 AVC video encoder. It is a self-contained FPGA IP core that can be either placed into a single FPGA or integrated with other logic blocks in the same FPGA for system-on-chip solutions.

All of the blocks in the design, shown in Fig. 1, are implemented in hardware without embedded processors or embedded software, which offers high speed, low logic resource consumption, and low power. Input to the encoder is standard raw video stream in 4:2:0, 4:2:2 (or 4:4:4) format. The output of the encoder is H.264 elementary stream. SOC also provides an MPEG transport encoder to allow the output of the encoder to be in the form of MPEG transport streams.

The SOC H.264 video encoder requires two external clock sources, one at 100MHz and the second at the video clock frequency (13.5-148.5MHz). The encoder also requires an external DDR3 (or DDR2) memory of minimum of 256MB for 1080p resolution (for both 30fps and 60fps).

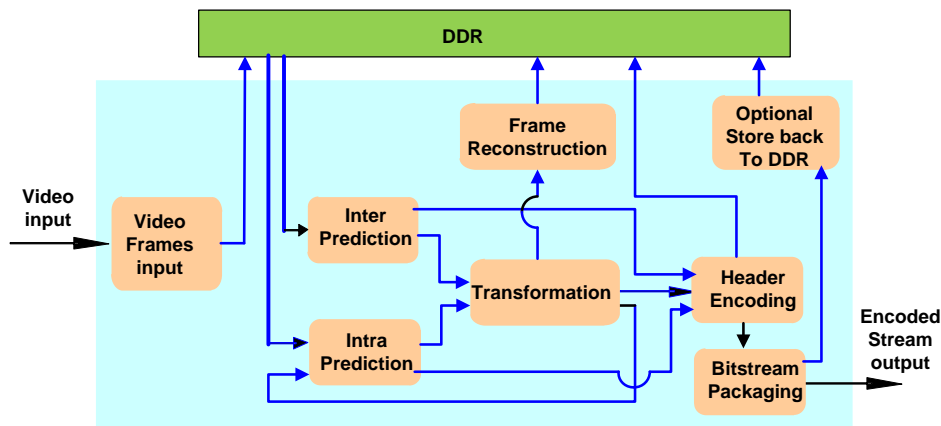


Fig. 1 Block Diagram of SOC H.264 AVC video encoder

## 3. The H.264 AVC and AAC Video/Audio Encoder Solutions

SOC provides two H.264 and AAC video/audio encoder solutions:

- (1) FPGA-DSP solution – for FPGAs that do not have an embedded ARM processor, an external DSP is used for audio encoding. Fig. 2 shows the architecture. The audio signal is sent to the external DSP (the Blackfin BF512) for encoding. The encoded AAC stream is sent back to the FPGA, which is encoded into the transport stream by the transport encoder in the FPGA.
- (2) Single FPGA Solution – for FPGAs that have the ARM embedded processors, the ARM processor is used for audio encoding. The video encoder IP core uses the logic part of the FPGA. Fig. 3 provides a block diagram for this single chip solution.

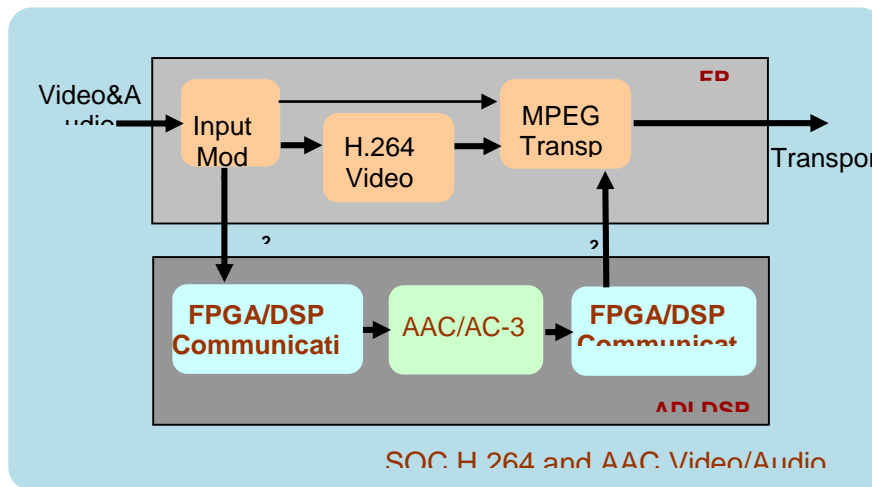


Fig. 2 Block Diagram of FPGA-DSP video/audio encoder solution

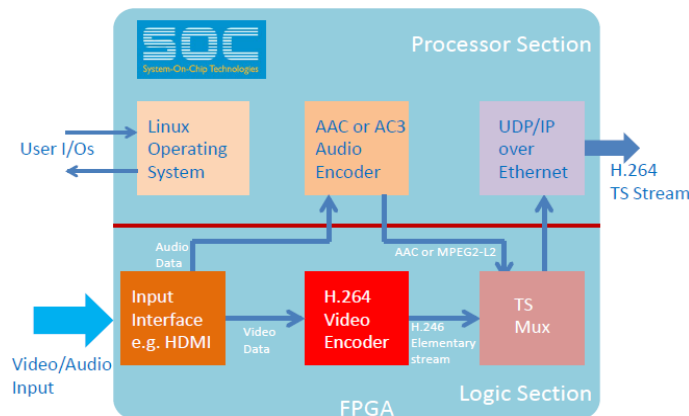


Fig. 3 Block Diagram of Single FPGA video/audio encoder solution

## 4. Technical Specifications

### Conformance Standard:

Video: H.264/AVC (ISO/IEC14496-10)

Audio: HE-AAC (ISO/IEC 14496-3), can be MPEG-2 Layer-2

### Profiles:

The SOC H.264 video encoder supports:

- High Profile
- Main Profile
- Baseline Profile

**Chroma Format:**

- 4:2:0
- 4:2:2
- 4:4:4 (on request)

**Precision:**

- 8 bits
- 10 bits.

**Frame Rate:**

- 10fps
- 24fps
- 25fps
- 29.97fps
- 30fps
- 50fps
- 59.95fps
- 60fps
- 120fps

**Inter Frames:**

The SOC H.264 video encoder supports:

- I frame
- I&P frame
- I&P&B frame (available, but not recommended)

**Audio Sample Rate:**

32 Hz, 44.1 kHz and 48 kHz.

**Audio Bit Rate** (total for all channels in v2 stereo encoding mode):

16-18 kbps (32 kHz), 16-36 kbps (44.1 kHz and 48 kHz).

**Latency:**

- |                      |        |
|----------------------|--------|
| 1. Standard Version: | 0.25ms |
| 2. Slim Version:     | 0.25ms |
| 3. I-Frame Version:  | 0.25ms |

**Output Stream Format:**

- Constant Bit Rate – User controllable through API
- Variable Bit Rate – User controllable through API.

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### Typical Bit Rate:

1. Standard Version: 2Mbps or higher (for 1080@30)
2. I-Frame Version: 15Mbps or higher (for 1080@30)
3. Slim Version: 5Mbps or higher (for 1080@30)

### Logic Resources on Xilinx FPGAs:

The logic resources required on Xilinx FPGAs by the H.264 encoder IP cores are listed in Table-1

Resources type	Standard Version	Slim Version	I-Frame version
LUTs	110k	50k	45k
Logic cells	200k	100k	80k
B-RAM	10Mbits	5Mbits	4Mbits
DSPs	235	210	140

Table-1 Logic resource utilization of the H.264 encoder for up to 60fps

### Logic Resources on Altera FPGAs:

The logic resources required on Altera FPGAs by the H.264 encoder IP core is listed in Table-2

Resources type	Standard Version	Slim Version	I-Frame Version
ALM	73k	35k	27k
B-RAM	6Mbits	5Mbits	4Mbits
DSPs	239	210	140

Table-2 Logic resource utilization of the H.264 encoder for up to 60fps

### Power (IP core only):

1. Standard Version: 800mw
2. I-Frame Version: 500mw
3. Slim Version: 600mw

The power consumptions are produced by the Xilinx and Intel power estimators.

## 5. Targeted FPGAs

The SOC H.264 video encoder fits most of the Xilinx FPGAs, including:

- Spartan-6
- Artix-7
- Kortex-7
- Zynq-7
- Virtex-7
- Ultrascale

Encoder IP cores are also available for Altera FPGAs, including:

- Cyclone-V
- Arria-5
- Arria-10
- Stratix-IV
- Stratix-V

### FPGA Examples:

The following Table-3 shows the FPGA examples for 1080p@30, 1080p@60, and 1080p@120 resolutions. Other FPGAs are also supported, as long as the logic resources and clock speed meet the requirement.

Resolution@frame-rate	Xilinx FPGA Example	Altera FPGA Example
1080p@30	Spartan-6 LX150	Cyclone-5 5CGTD9
1080p@60	Artix-7 XC7A200T	Arria-10 GX220
1080p@120	Zynq-7 Z7045	Arria-10 GX480

Table-3 Examples for Xilinx and Altera FPGAs

## 6. Applications

- Broadcast Equipment
- Satellite video/audio transmission equipment
- Cable TV headend
- Medical imaging devices
- IPTVs distributing
- Video surveillance cameras
- Video conferencing devices
- Digital cinemas.

## 7. Product Formats

SOC provides three formats to customers, which allows ease-of-use of the product. These formats include:

1. FPGA IP cores
  - Self-contained IP cores for FPGA users, in either bit file or encrypted netlist. An integration datasheet will be provided with the delivery of the netlist.

## 2. SOC MPEG Codec Modules

SOC provides all its codecs on small circuit boards that integrates all required components for video, audio or both video and audio encoding. The codec module connects to a host device via a PCB connector. SOC also provides evaluation/development boards.

## 3. Chipsets – The SOC-Mcodec

The SOC codec chipsets, SOC-Mcodec, are FPGA based ASICs. The SOC IP cores are used to configure the chipsets. The SOC-Mcodec offers a convenient way for customer product production.

## 4. Customized system-on-chip solutions surrounding the encoder

SOC provides integration with other IP cores to produce a system-on-chip solution.

Technical data for using each of the above formats are described in the following Sections.

## 8. H.264 Video Encoder IP Core Integration Sheet

When the encoder is delivered in IP core format, it is a ready-to-use “netlist” core for FPGAs. Fig. 4 shows the inputs and outputs of the encoder core.

The H.264 video encoder IP core integration details are provided in a separate document under the title of “H.264 Video Encoder IP Core Integration Sheet”.

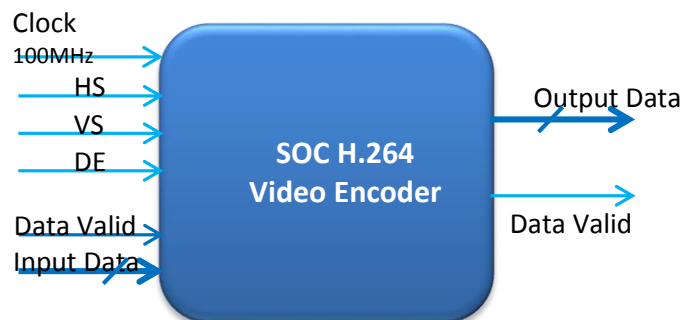


Fig. 4 The inputs and outputs of the H.264 video encoder IP Core

## 9. SOC MPEG Codec Modules

SOC supplies all its MPEG2 and MPEG4-AVC/H.264 encoders and decoders on a 2.7”x1.7” or 2.7”x2.0” module (card), as shown in Fig. 5. The modules provide complete function of video/audio encoding or



decoding. The module connects to the host product/PCB via a device-to-PCB connector, as shown in Fig. 6.

Refer to the Product Brief and Datasheet of SOC MPEG Codec Modules for technical details.



Fig. 5 SOC MPEG Codec Module



Fig. 6. Device-to-PCB connectors

The SOC MPEG Codec Modules can be directly connected to I/O interface chips for product fabrication, as shown in Fig. 7, or connected to an FPGA or a Microcontroller for user system integrations, as shown in Fig. 8.

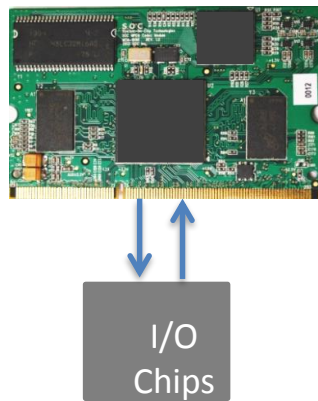


Fig. 7 SOC MPEG Codec Module directly connects to I/O interfaces in user product

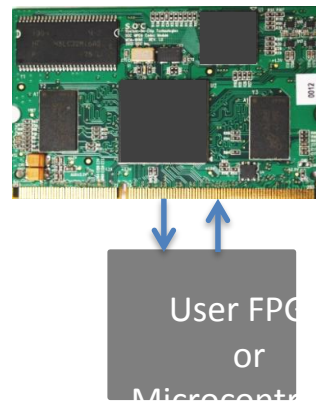


Fig. 8 SOC MPEG Codec Module connects to FPGA/microcontroller for user integration

## 10. The H.264 Encoder Chipset



SOC Technologies provides a series of CODEC chipsets, the SOC-Mcodec family, which can be dropped onto user PCBs as ASIC video encoders and decoders. The SOC-Mcodec family of chipsets

support all MPEG standards, including H.264, H.265, and MPEG-2, and all industrial standard resolutions, including SD, 720, 1080, 4K, and 8K, with frame rates of up to 120 fps.

The SOC H.264 HD Encoder Chipset includes an FPGA and FLASH preconfigured with SOC's H.264 HD Encoder IP Core. It is an ASIC that receives raw video/audio and outputs an H.264 video stream with optional AAC/MP2/MP3 audio compression. It supports resolutions up HD at 120 fps.

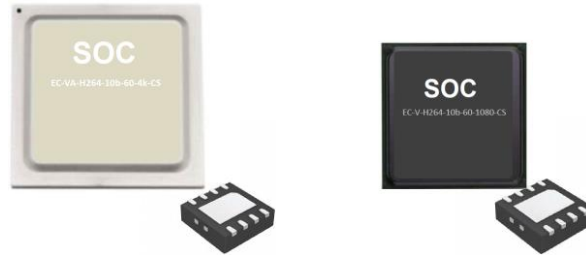


Fig. 9 SOC-Mcodec chipsets

SOC CODEC Chipsets are fully pre-configured FPGA chips that are designed to function just like traditional ASIC chipsets, integrated onto user PCB by connecting the pins.

The Chipset I/O interfaces can be customized to virtually any customer specifications, making them the most flexible CODEC chipsets on the market. This is especially useful if your system demands non-standard I/O interfaces - let us tailor the interfaces to work in harmony with your system.

Unlike traditional ASICs, SOC's CODEC chipset firmware may be updated to change its functionality or I/O interfaces if needed.

The SOC CODEC Chipsets are built using SOC Technologies' portfolio of ultra-high-performance CODEC and peripheral IP Cores. You can expect high quality, high speed, low latency, and low power-consumption.

With high volume productions of FPGAs, today's FPGAs are fabricated using the most current silicon technologies that are used for computer CPUs, such as the new 10nm silicon class. This makes the FPGA based ASICs away ahead of the traditional MPEG codec ASICs, especially in power consumption, speed, and cost.

## 11. Customized System-on-Chip Solutions Surrounding the Encoder

SOC also provides customized system-on-chip integrations based on the H.264 video/audio encoders. Fig. 10 shows an example of an integrated encoder solution for HD video over the Internet with HDMI input.

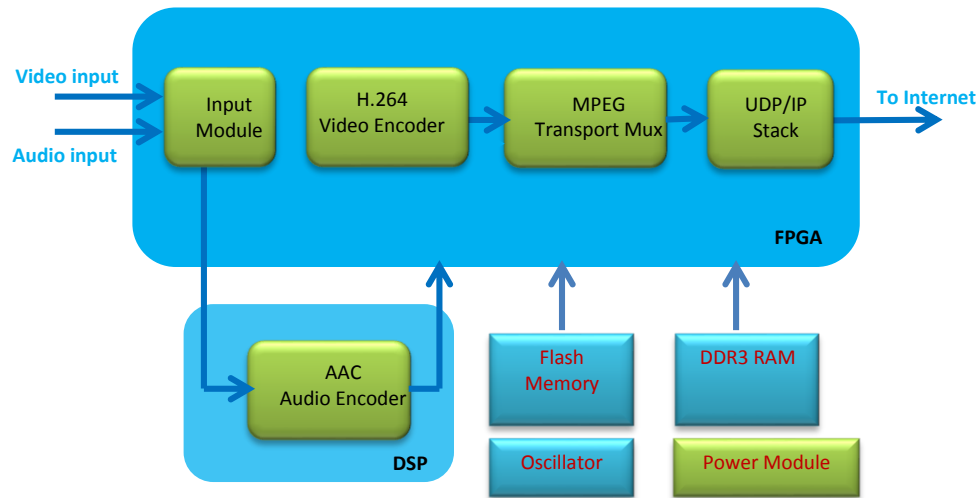


Fig. 10 Example system-on-chip solution – HD-over-IP encoder

## 12. User API

The encoder (IP core, module, or chipset) is controllable through a user API, which allows the user to control the operations of the encoder through setting the control registers at runtime. Refer to the “H.264 Video/Audio Encoder API Manual” for details.

## 13. Related Documents

1. Integration Sheet – Encoder IP Cores
2. API Manual – H.264 Encoder IP Core
3. Datasheet – MPEG Video-Audio Codec Modules - Standard Version -V3.0
4. Datasheet – MPEG Video-Audio Codec Chipset

## 14. Technical Support

SOC provides technical support for all its products, which include documentation, e-mail based, and telephone based support. Additional support services, such as on-site training services, can be subscribed from SOC as a service contract.

## 15. IP core upgrading

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Upgrades to the IP core are available to all the delivery formats discussed in Sections 6. Upgrade is usually a part of the technical support contract signed individually. On-line automatic upgrading can also be arranged if desirable.

## 16. Related Information

The SOC MPEG-2 and H.264 video decoders are implemented based on the same technology of this H.264 encoder. Refer to the datasheets of SOC MPEG-2 and H.264 video decoders for details.

## 17. Ordering Information

Fig. 11 shows the Product Code format for the SOC Codec IP cores, modules, and chipset. It is noted identifiers for FPGA type, temperature, and latency grade in the product code are optional.

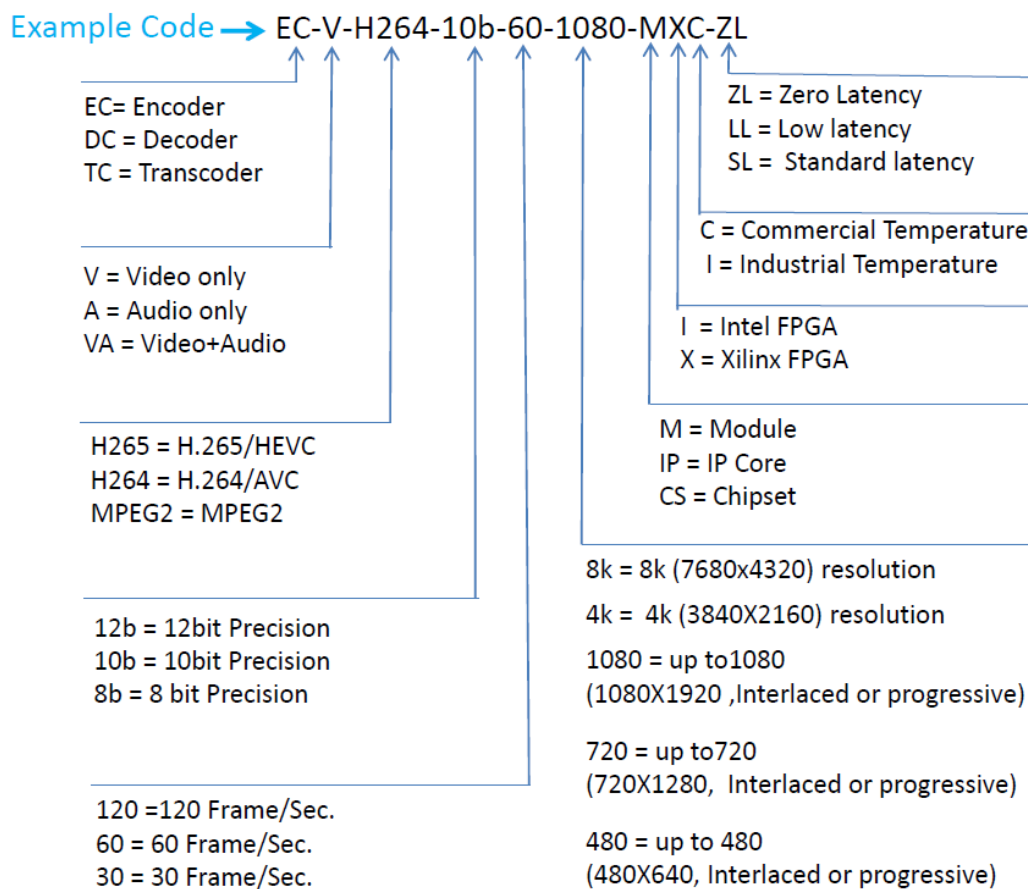


Fig. 11 SOC MPEG codec product code for IP cores, modules, and chipsets

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The SOC H.264 video/audio encoder IP cores are available for licensing, or one-time fee purchase, or a combination of one-time fee plus reduced royalty payments. Appendix-A lists all of the standard H.264 encoder IP cores. Non-standard encoder IP cores are also available. Contact SOC [sales@soctechnologies.com](mailto:sales@soctechnologies.com) for details.

The SOC H.264 video/audio encoder module is complete solution for video and audio encoding at low cost. It is sold on unit by unit basis.

SOC also provides integration of the H.264 encoder with other functional IP cores of SOC or customer provided IP cores. A combination of NRE and licensing royalties is normally considered, which is negotiated on case by case basis.

Please contact SOC sales by telephone +1 519 880-8609 or e-mail: [sales@soctechnologies.com](mailto:sales@soctechnologies.com)

### 19. Document Revisions

Version #	Revision Date	Notes
V.1.0	2010/02/15	First release
V.1.1	2011/08/10	
V.2.0	2012/03/15	Major revision
V.2.1	2013/05/15	
V.3.0	2013/11/15	Major revision
V.3.1	2014/08/10	
V.4.0	2015/03/15	Major revision
V.4.1	2015/11/10	
V.5.0	2016/05/16	Major revision
V.6.0	2018/06/25	Major revision

## Appendix-A Standard H.264 Encoder IP Cores

### H.264 HD (720@30, 720@60,1080@30, and 1080@60) Encoder IP Cores

Table-A-1 provides a list of standard H.264 HD video (without audio) Encoder IP Cores. Table-A-2 provides a list of standard H.264 HD video&audio Encoder IP cores. The product code and specifications are listed in the table. The Encoder IP cores are used to make the encoder modules as well, by pre-configuring the SOC SOM modules, refer to the [Datasheet – MPEG Video-Audio Codec Modules - Standard Version](#) for details. The SOM used for the Codec Module is also provided in Table-A.1 and A.2.

**Table-A.1: H.264 HD Video Encoder IP Cores (video only without audio):**

Product #	Specifications							SOM
	Standard	Profile	Resolution	Chroma	Precision	Frame Rate	Audio	
EC-V-H264-8b-30-720-IP	H.264	up to High	up to 720i/p	4:2:0/4:2:2	8 bits	up to 30fps	no	SOM-X-A200T
EC-V-H264-8b-60-720-IP	H.264	up to High	up to 720i/p	4:2:0/4:2:2	8 bits	up to 60fps	no	SOM-X-A200T
EC-V-H264-8b-30-1080-IP	H.264	up to High	up to 1080i/p	4:2:0/4:2:2	8 bits	up to 30fps	no	SOM-X-A200T
EC-V-H264-10b-30-1080-IP	H.264	up to High	up to 1080i/p	4:2:0/4:2:2	up to 10 bits	up to 30fps	no	SOM-X-A200T
EC-V-H264-8b-60-1080-IP	H.264	up to High	up to 1080i/p	4:2:0/4:2:2	8 bits	up to 60fps	no	SOM-X-A200T
EC-V-H264-10b-60-1080-IP	H.264	up to High	up to 1080i/p	4:2:0/4:2:2	up to 10 bits	up to 60fps	no	SOM-X-A200T

**Table-A.2: H.264 HD Video/Audio Encoder IP Cores (both video and audio):**

Product #	Specifications							SOM
	Standard	Profile	Resolution	Chroma	Precision	Frame Rate	Audio	
EC-VA-H264-8b-30-720-IP	H.264	up to High	up to 720i/p	4:2:0/4:2:2	8 bits	up to 30fps	AAC	SOM-X-A200T
EC-VA-H264-8b-60-720-IP	H.264	up to High	up to 720i/p	4:2:0/4:2:2	8 bits	up to 60fps	AAC	SOM-X-A200T
EC-VA-H264-8b-30-1080-IP	H.264	up to High	up to 1080i/p	4:2:0/4:2:2	8 bits	up to 30fps	AAC	SOM-X-A200T
EC-VA-H264-10b-30-1080-IP	H.264	up to High	up to 1080i/p	4:2:0/4:2:2	up to 10 bits	up to 30fps	AAC	SOM-X-A200T
EC-VA-H264-8b-60-1080-IP	H.264	up to High	up to 1080i/p	4:2:0/4:2:2	8 bits	up to 60fps	AAC	SOM-X-A200T
EC-VA-H264-10b-60-1080-IP	H.264	up to High	up to 1080i/p	4:2:0/4:2:2	up to 10 bits	up to 60fps	AAC	SOM-X-A200T