Hybrid Video Codec Architecture — Cheat Sheet

The nine stages every codec from MPEG-2 to AV1 shares

Companion to article 4.1 of Block 4. Print on A4 or US Letter. (c) 2026 Fora Soft - 250+ shipped video projects since 2005

The nine stages, in order

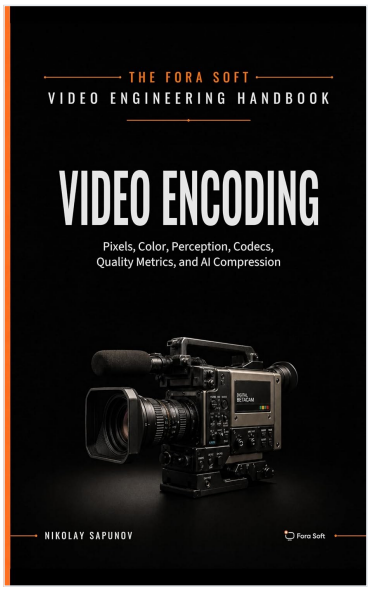
1. Partitioning	Split frame into blocks. Larger for flat regions, smaller for detail.
2. Prediction	Intra (from same frame) or Inter (from past frame + motion vector).
3. Residual	Original minus prediction. Most bits in a stream describe residuals.
4. Transform	DCT / ADST. Rotates residual into frequency coefficients. Lossless.
5. Quantization	Divide each coefficient by Qstep. *** **Only stage where info is lost.** ***
6. Entropy coding	CABAC / multi-symbol arithmetic. Lossless final pack.
7. Inverse quant + transform	Encoder runs decoder inside itself to stay aligned.
8. In-loop filter	Deblocking + SAO/CDEF/ALF. Smooths block edges on the reference.
9. Reference buffer	Decoded Picture Buffer - feeds future inter-predictions.

What changed in each generation

Stage	MPEG-2 (1994)	H.264 (2003)	HEVC (2013)	AV1 (2018)
Block size	16x16 fixed	16x16 + 8x8 + 4x4	CTU 64x64 quad-tree	Superblock 128x128
Intra modes	DC only	9 modes	35 angular	95 (incl. CfL, Paeth)
Motion precision	Half-pel	Quarter-pel	Quarter-pel	Eighth-pel
Reference frames	1-2	Up to 16	Up to 16	Up to 8 + compound
Transform	8x8 DCT	4x4 / 8x8 int. DCT	4x4 to 32x32 DCT+DST	4x4 to 64x64 + ADST
Entropy coder	VLC	CAVLC or CABAC	CABAC	Multi-symbol arith.
In-loop filters	None	Deblocking	Deblock + SAO	Deblock + CDEF + LR
1080p30 typical	8-15 Mbps	3-5 Mbps	1.5-3 Mbps	0.8-1.6 Mbps

Common gotchas when reasoning about codecs

- **Standard != encoder:** H.264 specifies bitstream syntax, not encoder behaviour. Two H.264 encoders produce different files.
- **Quant is the only lossy step:** Everything else - prediction, transform, entropy - is invertible. Tune Qstep, not the rest.
- **Encoder runs a decoder inside:** Reconstruction loop keeps encoder and decoder pixel-identical across thousands of frames.
- **In-loop filters compound:** They improve the reference, not the displayed frame. Gains accumulate across the GOP.
- **RDO dominates encoder CPU:** J = D + lambda*R. Search space grows fast with each generation; that is where minutes go.
- **Decoder is always cheaper:** Standards push decoder complexity down so phones can play 4K at 1x real time.



GO DEEPER · VOLUME 1 OF 7

Video Encoding: A Complete Guide to Video Compression

From Pixels and Color to H.264, HEVC, AV1, Quality Metrics, and AI

By Nikolay Sapunov, CEO at Fora Soft · 1,522 pages · Kindle & paperback on Amazon

Read it on Amazon → amazon.com/dp/B0HF52B65R

This sheet lays out the nine stages every hybrid codec shares and how each generation changed them. Volume 1 walks through every stage in depth: partitioning, intra and inter prediction, transforms and quantization, entropy coding and in-loop filters, with H.264, HEVC and AV1 compared side by side.

WHAT YOU WILL FIND INSIDE

- Block partitioning from macroblocks to superblocks
- Intra and inter prediction and motion vectors
- Transforms, quantization and rate-distortion optimisation
- Entropy coding and in-loop filters

THE FULL HANDBOOK · 7 VOLUMES · 9,000+ PAGES · ALL ON AMAZON

Vol. 1 · Video Encoding — pixels and color to H.264, HEVC, AV1, quality metrics and AI
Vol. 2 · Video Streaming I — network transport, contribution and ingest, HLS, MPEG-DASH, CMAF
Vol. 3 · Video Streaming II — ABR, CDNs, players, WebRTC, DRM and the economics of delivery
Vol. 4 · Audio for Video I — PCM, codecs, loudness, accessibility, real-time voice processing
Vol. 5 · Audio for Video II — jitter buffers, lip sync, Atmos, quality metrics, neural codecs
Vol. 6 · AI for Video I — models and inference, computer vision, speech, search, generative video
Vol. 7 · AI for Video II — real-time pipelines, agents, serving, cost, compliance, verticals

Need engineers who understand codecs from the bitstream up?

We will review your encoding pipeline stage by stage and fix the settings and tooling that cost you bitrate or compute. 250+ video products shipped since 2005.

Book a 30-min call → **WhatsApp →** **Email us →**