

Bitrate Math — One-Page Reference

Companion to the article 'Why We Compress Video: The Math of Bitrate'.

1. Uncompressed bitrate formula

bitrate (bps) = width × height × bits-per-pixel × frames-per-second

Worked example: 1080p30, 8-bit RGB

1920 × 1080 × 24 × 30 = 1,492,992,000 bps ≈ 1.49 Gbps

2. Uncompressed bitrate by format

Format	Bits/pixel	Bitrate	Pipe required
1080p30 8-bit RGB	24	1.49 Gbps	≥ 10 GbE / Thunderbolt
1080p60 10-bit 4:2:0	15	3.73 Gbps	≥ 10 GbE / SDI
4K60 10-bit 4:2:0	15	7.46 Gbps	12G-SDI / HDMI 2.1
4K60 12-bit 4:4:4	36	11.94 Gbps	HDMI 2.1 / TB4
8K120 12-bit RGB	36	143 Gbps	Studio-only

3. The four-lever mental model for compressed bitrate

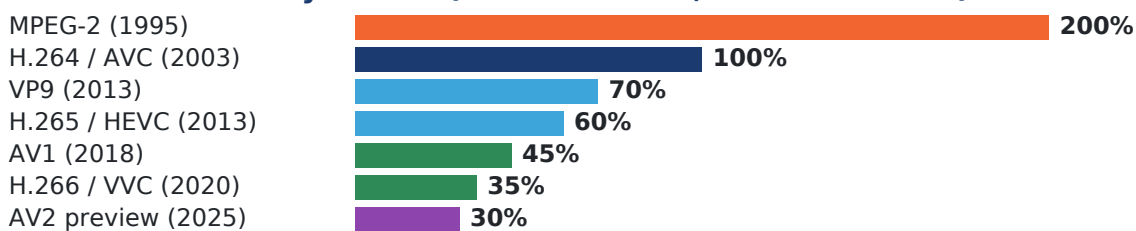
bitrate ≈ (target quality × scene complexity × resolution × frame rate) ÷ codec efficiency

- **Target quality:** VMAF 95 streaming, 75 video call
- **Scene complexity:** Talking head vs stadium: 5-10× spread
- **Resolution:** Doubling each side ⇒ 4× bitrate
- **Frame rate:** Linear: 60 fps doubles 30 fps
- **Codec efficiency:** H.264 → H.265: ~50% off; → AV1: ~50% more off

4. What real services ship (2026)

Service	Codec	Bitrate	Compression ratio
Netflix 1080p	H.264	4-6 Mbps	~300×
Netflix 4K HDR	H.265 / DO	8-16 Mbps avg	~1,000×
YouTube 1080p60 upload	H.264	12 Mbps	~250×
YouTube 4K60 upload	H.264	53-68 Mbps	~200×
Zoom 1080p video call	H.264 / VP8	1.2-3 Mbps	~600×
4K Blu-ray disc	H.265	up to 128 Mbps	~100×

5. Codec efficiency ladder (H.264 = 100%, lower is better)



6. Eight production rules of thumb

1. Mbps ÷ 8 = MBps. Bits and bytes differ by 8×; vendors get this wrong.
2. Double resolution ⇒ ~4× bitrate at the same codec & quality.
3. Double frame rate ⇒ ~2× bitrate. Frame rate is linear.
4. Each codec generation buys ~30-50% bitrate at the same quality.
5. AV1 over H.264 typically saves ~50% bitrate at matched VMAF.
6. Plan for peak bitrate, not average; VBR peaks at 1.5-2× the average.
7. Action scenes need 3-5× the bitrate of talking-head at the same VMAF.
8. Per-shot encoding (Netflix DO) cuts ~50% bitrate at the same VMAF.