

Companion to article 5.8 of Block 5. Print on A4 or US Letter.

## The five stages and the data they pass

Stage	Input	Output	CPU share	What it does
<b>Demux</b>	bytes	packets	<1%	Unpacks the container (MP4, MKV) into streams
<b>Decode</b>	packets	frames	8-15%	Decompresses packets back into pixels or samples
<b>Filter</b>	frames	frames	5-15%	Scale, deinterlace, colour, denoise, overlay
<b>Encode</b>	frames	packets	70-85%	Compresses pixels into the target codec
<b>Mux</b>	packets	bytes	<1%	Interleaves and writes the output container

## First decision: do you actually need to transcode?

Change container only (MKV -> MP4, MP4 -> TS)? -> REMUX. No decode, no encode.

```
ffmpeg -i in.mkv -c copy out.mp4
```

Change codec, resolution, bitrate, colour? -> TRANSCODE. Full pipeline.

## FFmpeg recipes you will actually use

### VOD H.264 1080p, x264 slow, CRF 21:

```
ffmpeg -i in.mov -c:v libx264 -preset slow -crf 21 -c:a aac -b:a 128k out.mp4
```

### 3-rung ABR ladder (1080/720/480) in one command:

```
ffmpeg -i in.mov -filter_complex "[0:v]split=3[a][b][c];\ [a]scale=1920:1080[v1];[b]scale=1280:720[v2];[c]scale=854:480[v3]" \ -map "[v1]" -c:v:0 libx264 -crf 21 -map "[v2]" -c:v:1 libx264 -crf 22 \ -map "[v3]" -c:v:2 libx264 -crf 23 out_%v.mp4
```

### GPU pipeline (NVDEC -> scale\_npp -> NVENC), no PCIe round-trip:

```
ffmpeg -hwaccel cuda -hwaccel_output_format cuda -i in.mp4 \ -vf "scale_npp=1920:1080" -c:v h264_nvenc -preset p5 -cq 23 out.mp4
```

### Live ingest cleanup (regenerate timestamps):

```
ffmpeg -fflags +genpts -avoid_negative_ts make_zero -i in.ts out.mp4
```

## Four pitfalls to avoid

1. Re-encoding when you only needed to remux. Always ask: change container or change pixels?
2. Mixing CPU and GPU stages. Pick one device for the whole pipeline; PCIe copies kill speed.
3. Forgetting -map 0:a. Audio silently dropped is the most common output-is-silent bug.
4. Trusting live ingest timestamps. Use -fflags +genpts and -avoid\_negative\_ts make\_zero.

## Free 2-3x speedup on many-core machines

Upgrade past FFmpeg 7.0. Per-stage scheduler runs every demuxer, decoder, filter, encoder and muxer on its own thread, with bounded queues. No command change required.