IRONKERNEL EMBEDDED

H.264 Video over Ethernet

Three IronKernel FPGA cores carry video from a MIPI CSI-2 camera to a network stream: IronCapture receives the camera, IronH264 encodes 720p30 or 1080p30, and RTLNet sends MPEG-TS over UDP to VLC or ffplay on a PC.

System brief · Revision 11-21-2026

The chain runs on two AMD boards: a Digilent Nexys Video (Artix-7 XC7A200T) and a Digilent Zybo Z7-20 (Zynq-7000 XC7Z020). A prebuilt Nexys Video bitstream shows the stream on a PC with no build step.

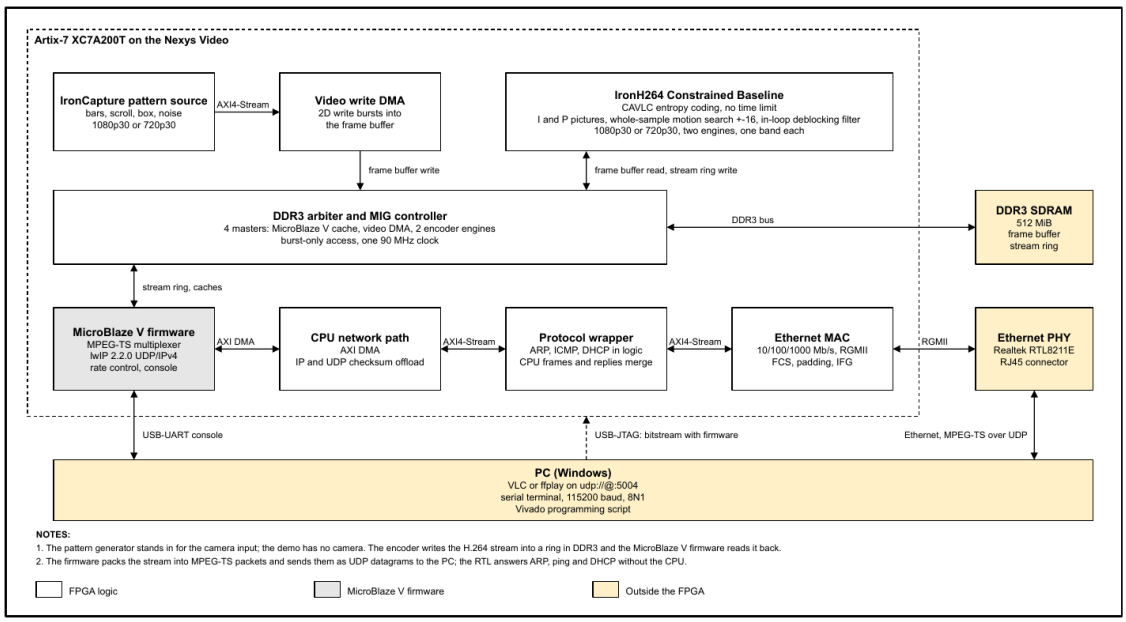

Figure 1. The Nexys Video H.264 Baseline design. The pattern generator stands in for the camera input in this build.

Stage	Core	Function
Camera in	IronCapture	Two-lane MIPI CSI-2 RAW10 through a Bayer image pipeline to packed YUYV frames in DDR, with no CPU in the pixel path. A pattern generator supports bring-up with the sensor idle.
Encode	IronH264	H.264 Constrained Baseline: I and P pictures, CAVLC, in-loop deblocking. Reads YUYV from DDR and writes indexed Annex B NAL units back to memory. One to four engines.
Lower bit rate (option)	IronH264 High Profile	A netlist extension to IronH264 that adds CABAC entropy coding and the 8 × 8 transform.
Packetize	Firmware or Linux	Reads the encoded pictures, multiplexes MPEG-TS and sends UDP datagrams to port 5004.
Network out	RTLNet	Ethernet MAC (RGMII or MII), ARP, ping, DHCP and UDP in FPGA logic, with a firewall in front of the processor.
Local display (option)	IronVideo	Scans a framebuffer from DDR to HDMI or an LCD while the stream runs.

Measured on two boards

Both columns are recorded board measurements from the IronH264 and RTLNet specifications. The two builds differ, and the table states the differences.

	Digilent Nexys Video	Digilent Zybo Z7-20
FPGA	AMD Artix-7 XC7A200T-1	AMD Zynq-7000 XC7Z020-1
Video source	IronCapture pattern generator (camera input tied off)	Pcam 5C camera (OV5640) through IronCapture
Encoder	Two IronH264 engines at 90 MHz, one band each	One IronH264 engine at 121.85 MHz
Processor and software	MicroBlaze V firmware, lwIP	Two Cortex-A9 cores, IronForge Linux, `ironforge-stream`
Ethernet	RTLNet RGMII MAC, 1 Gb/s	The Zynq processor's Gigabit Ethernet
1080p30 result	18,002 pictures in a 10-minute soak, zero dropped, minimum PSNR 44.28 dB at QP 28	1,800 of 1,800 pictures encoded and decoded, 30.00 pictures/s, zero continuity errors
Bit rate	Rate control holds 7.99–8.02 Mb/s at an 8 Mb/s target and 15.99–16.01 Mb/s at 16 Mb/s	20.45 Mb/s H.264 and 21.02 Mb/s MPEG-TS for the measured scene at QP 28
720p30	18.17 Mb/s at QP 28, zero pictures dropped	120 of 120 camera frames captured

Bit rates are averages for the measured scene and settings. Picture rate depends on content, engine count, encoder clock, QP and memory service.

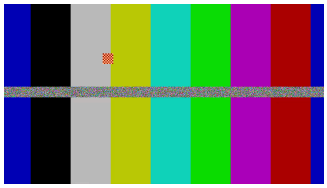

Figure 2. A frame decoded from the Nexys Baseline stream at 1080p30, QP 28. The bars expose color or packing errors, the moving checkerboard exercises inter prediction, and the noise band raises the bit demand.

Run the prebuilt demo

The Nexys Video image holds the whole chain with the firmware inside the bitstream. Download the zip from **ironkernel.com/ip-cores/h264-video-over-ethernet/**.

Step	Action
1. Program	Load `rtlnet_nexys_video.bit` over JTAG with Vivado 2026.1 (free license). The image loads into the FPGA only; a power cycle removes it.
2. Connect	Open the UART port at 115200 baud, 8N1. `show ip` prints the address from DHCP.
3. Play	On the PC: `ffplay -fflags nobuffer udp://@:5004`, or open `udp://@:5004` in VLC. Let UDP port 5004 through the PC firewall.
4. Stream	On the console: `enable`, `camera mode 1080p30`, `camera pattern all 4`, `encoder bitrate 8000`, `stream h264 <PC address> 5004`.
5. Measure	`show stream` and `show encoder` print picture counts, bit rate and dropped pictures. `stream stop` ends the stream.

High Profile option

IronH264 High Profile is a netlist extension to the publicly available IronH264 core. It adds CABAC entropy coding and the inter 8 × 8 transform inside each encoder engine and uses the same DDR buffers, registers and bitstream rings. A timed Nexys Video bitstream runs High Profile for 30 minutes after each configuration, then continues the same stream in Constrained Baseline.

Nexys Video, 1080p30, QP 28	Baseline CAVLC	High Profile CABAC
Combined motion and noise pattern	27.23 Mb/s	23.83 Mb/s
Scrolling bars	0.52 Mb/s	0.25 Mb/s
Ten-minute soak	18,002 pictures, zero dropped	18,002 pictures, zero dropped

These bit rates describe the named synthetic scenes. In recorded simulation, one short 1080p sequence uses fewer bits with Baseline, so evaluate with scenes that represent the product.

Cores, source and licenses

IronCapture, IronH264, IronVideo and RTLNet are public on GitHub (github.com/ironkernel01) under the IronKernel source-available license. Evaluation, research, teaching and personal use cost nothing. An Open Product ships free when its complete design sources are published. A product with private design sources needs a commercial license. Fees are one time, in USD, per product/SKU, with no royalties and no per-unit fees.

License	Includes	Price
Streaming bundle	IronCapture, IronH264 Baseline and RTLNet Full, with full source	$20,000
Streaming bundle with High Profile	The bundle plus the High Profile netlist for the FPGA part; maintenance $5,000/year	$30,000
IronVideo added to a bundle	HDMI or LCD output next to the stream	+$1,500
IronH264	H.264 Constrained Baseline encoder, full source	$15,000
IronH264 High Profile	Netlist extension, IronH264 Baseline included; maintenance $5,000/year	$25,000
IronCapture	MIPI CSI-2 receiver, image pipeline, V4L2 driver, full source	$3,500
RTLNet	UDP step $3,500; Full step $7,500; 10G step $12,500	from $3,500
IronVideo	HDMI and LCD video output, full source	$2,500

Each bundle costs $6,000 less than its cores bought separately. A paid single-core license is credited in full toward a bundle. Enterprise licensing for multiple products/SKUs is by quote. H.264 patent licensing for a shipped product is the licensee's responsibility.

Documents. The IronH264, IronH264 High Profile, IronCapture, IronVideo and RTLNet specifications and the Zybo Z7-20 board brief are at **ironkernel.com/ip-cores/**.

Contact IronKernel

For a video-over-Ethernet design, include the FPGA part, camera or video source, resolution, frame rate and target bit rate.

IronKernel provides FPGA design and design review, board bring-up, bare-metal firmware, embedded Linux drivers and application development. For integration support, a reference design or a custom development proposal, send your target board and project goal.

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