Real-Time Open Source Video Processing and Communications

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Wiki.PythonLinks.info

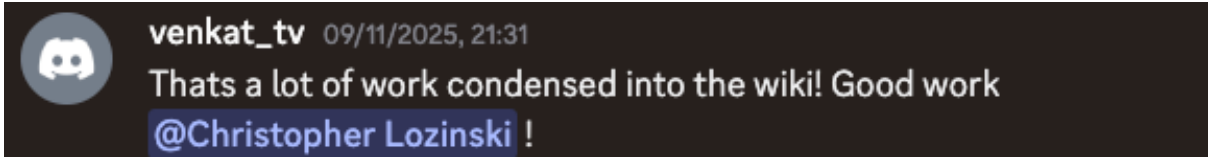
Discord Channel

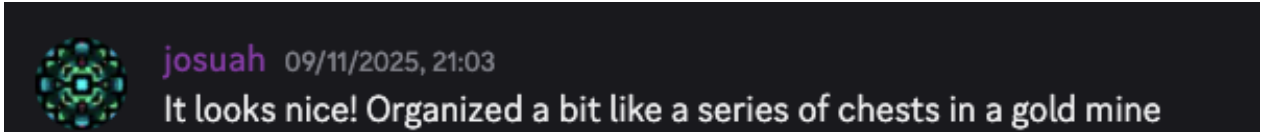
Article

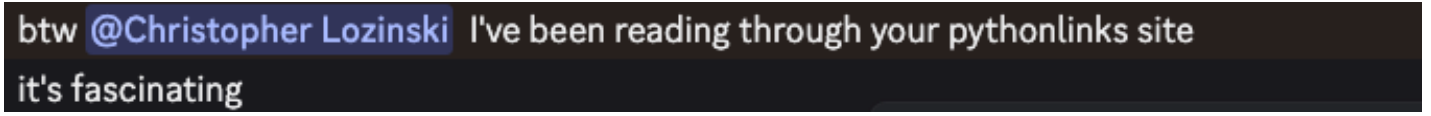

Diese Website ist eine Installation von Qucosa - Quality Content of Saxony!
Publikationsserver
der Hochschule für Technik und Wirtschaft Dresden
Volltext (PDF)
Nutzungshinweise für die digitalen Objekte in Qucosa

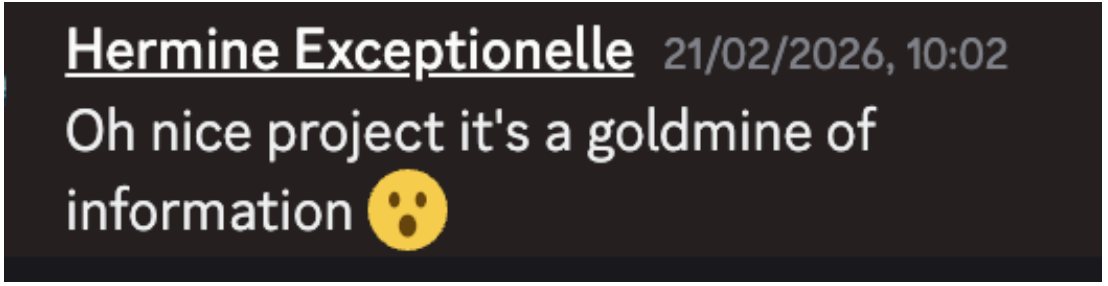
Wiki.PythonLinks.info

Feedback on the Wiki









Topics

- Applications
- Cameras
- Image Processes
- FPGAs
- Communications
- Recommendations

Not a class on FPGA development

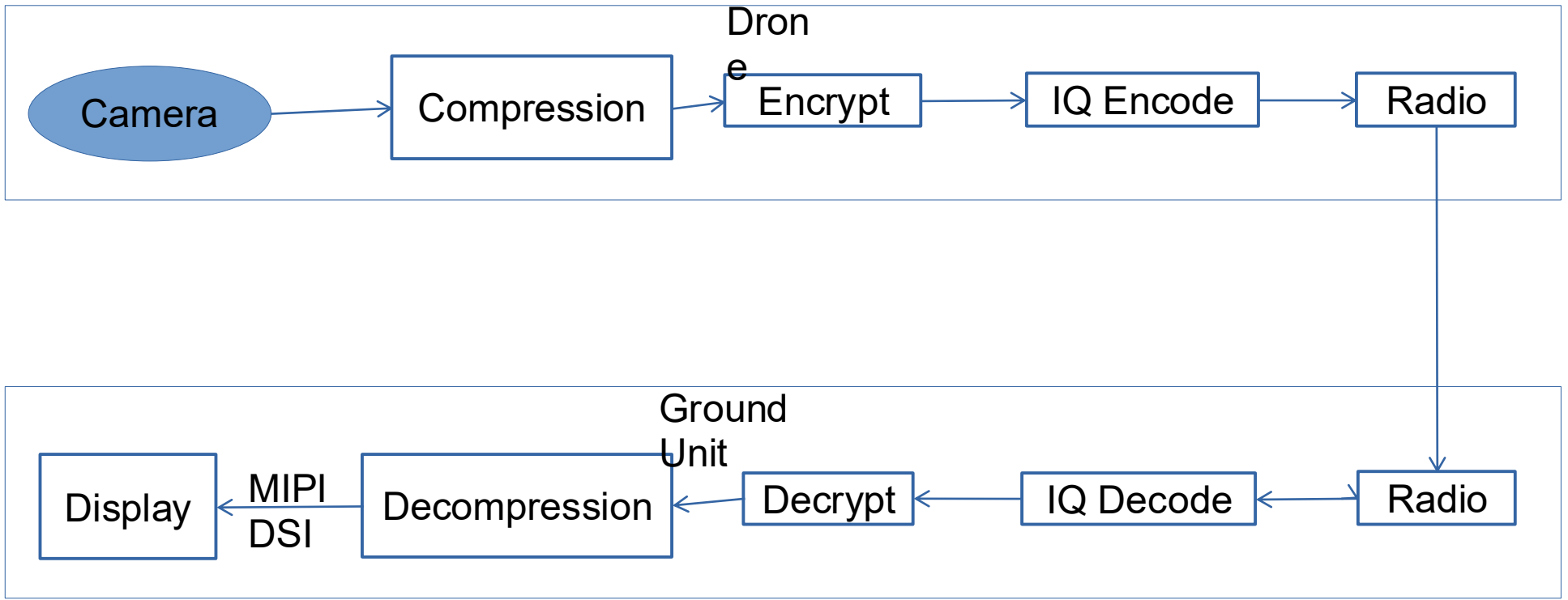
Politechnika Śląska

Wydział Automatyki, Elektroniki i Informatyki

Mikroinformatyka systemów cyfrowych, studia magisterskie (stacjonarne)

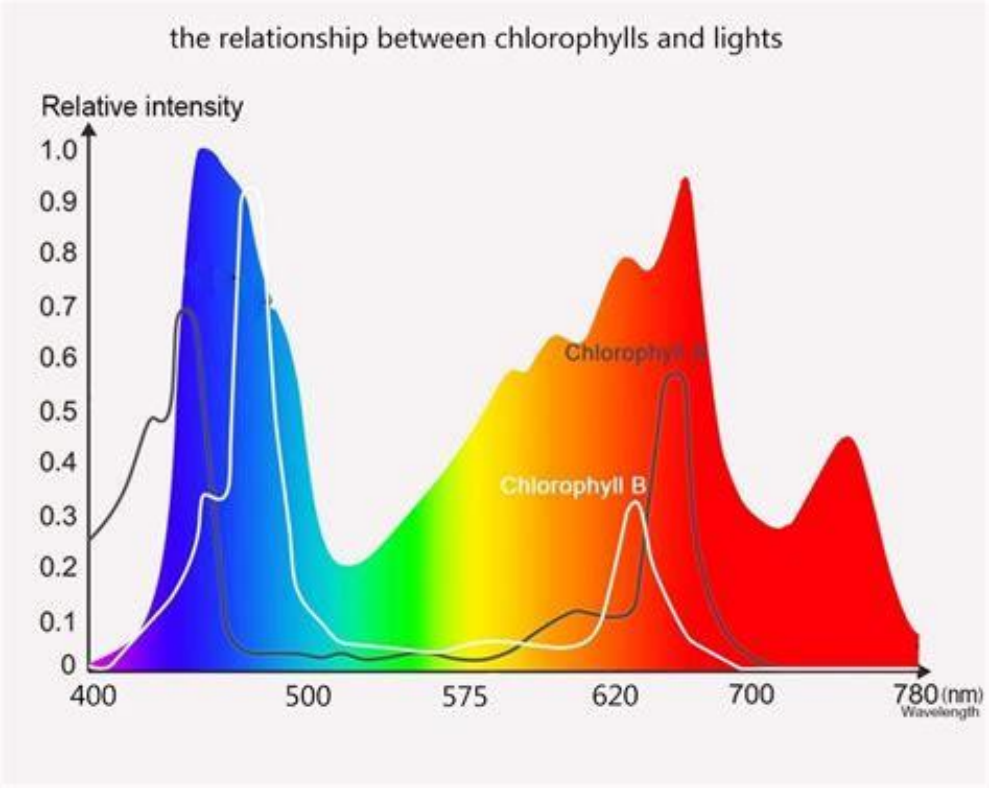
FishEye Dewarping

Drone Video Pipeline



Vehicle Detection

PhotoSynthesis Spectrum

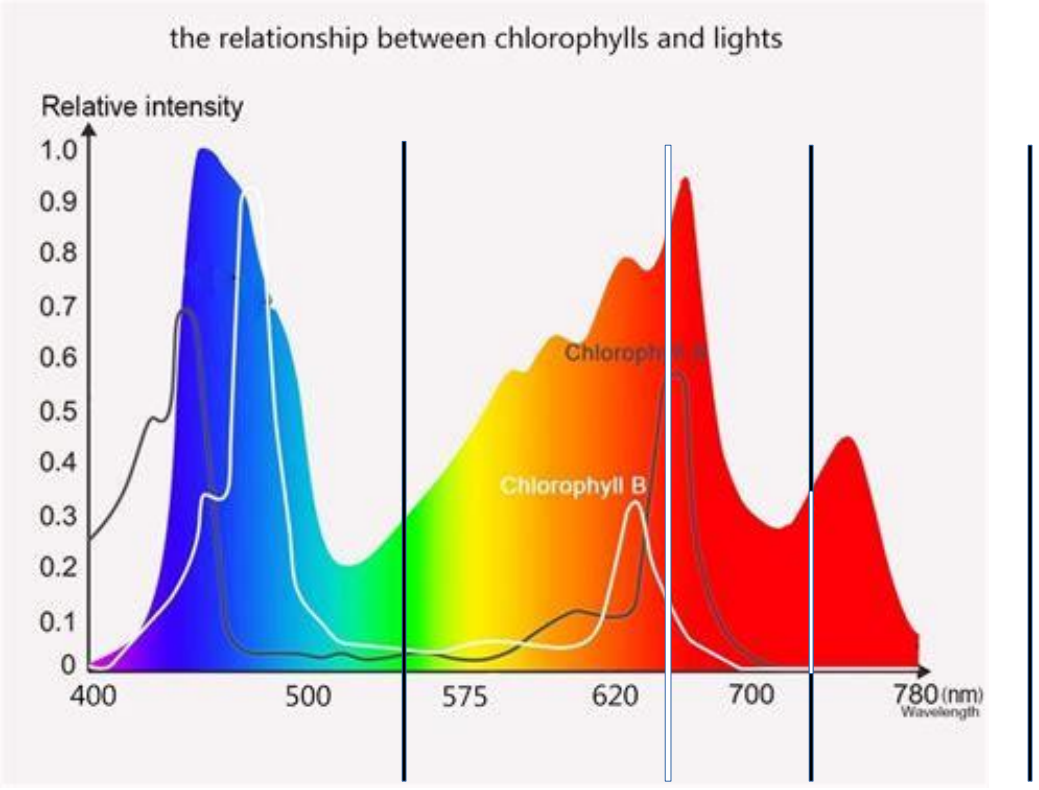


DJI Cameras operate at
- 860nm
- 730nm
- 650nm
- 560m,

560 nm 650nm 730nm 860nm

DJI Multispectral Cameras

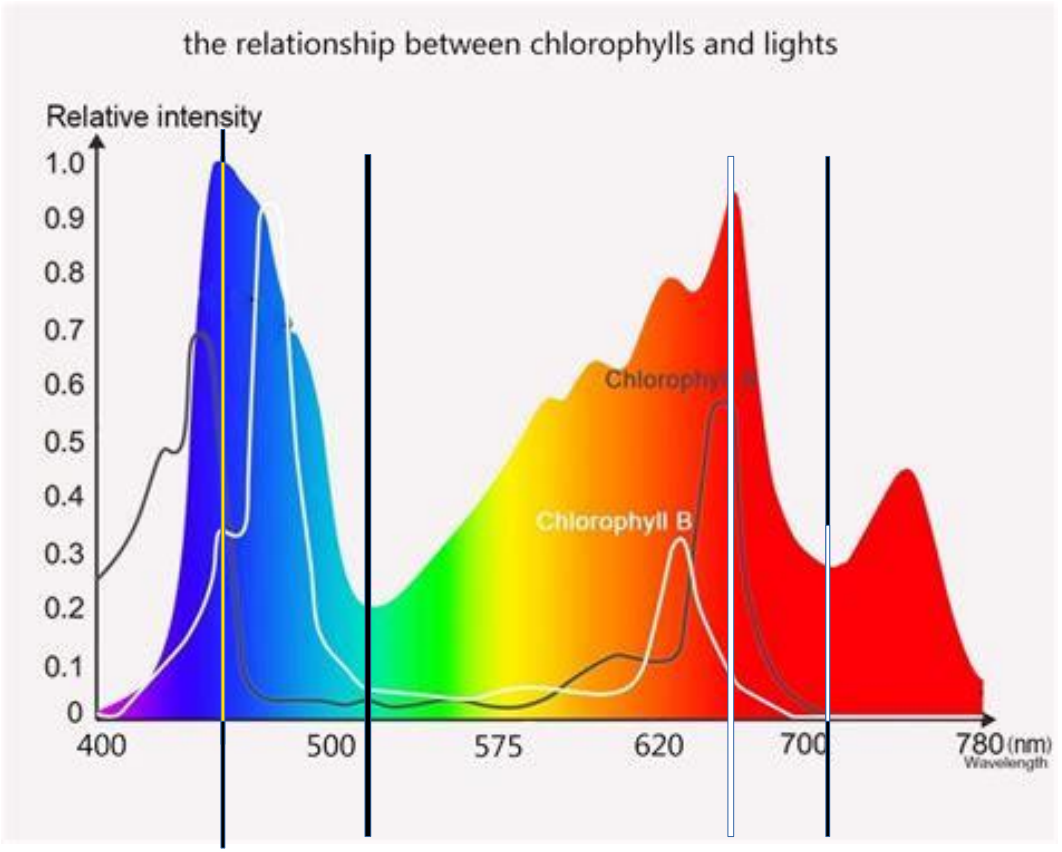
DJI MultiSpectral Camera Frequencies



560 nm 650nm 730nm 860nm

DJI Cameras operate at
860nm
730nm
650nm
560m,

PhotoSynthesis Spectrum



DJI Cameras operate at

860nm

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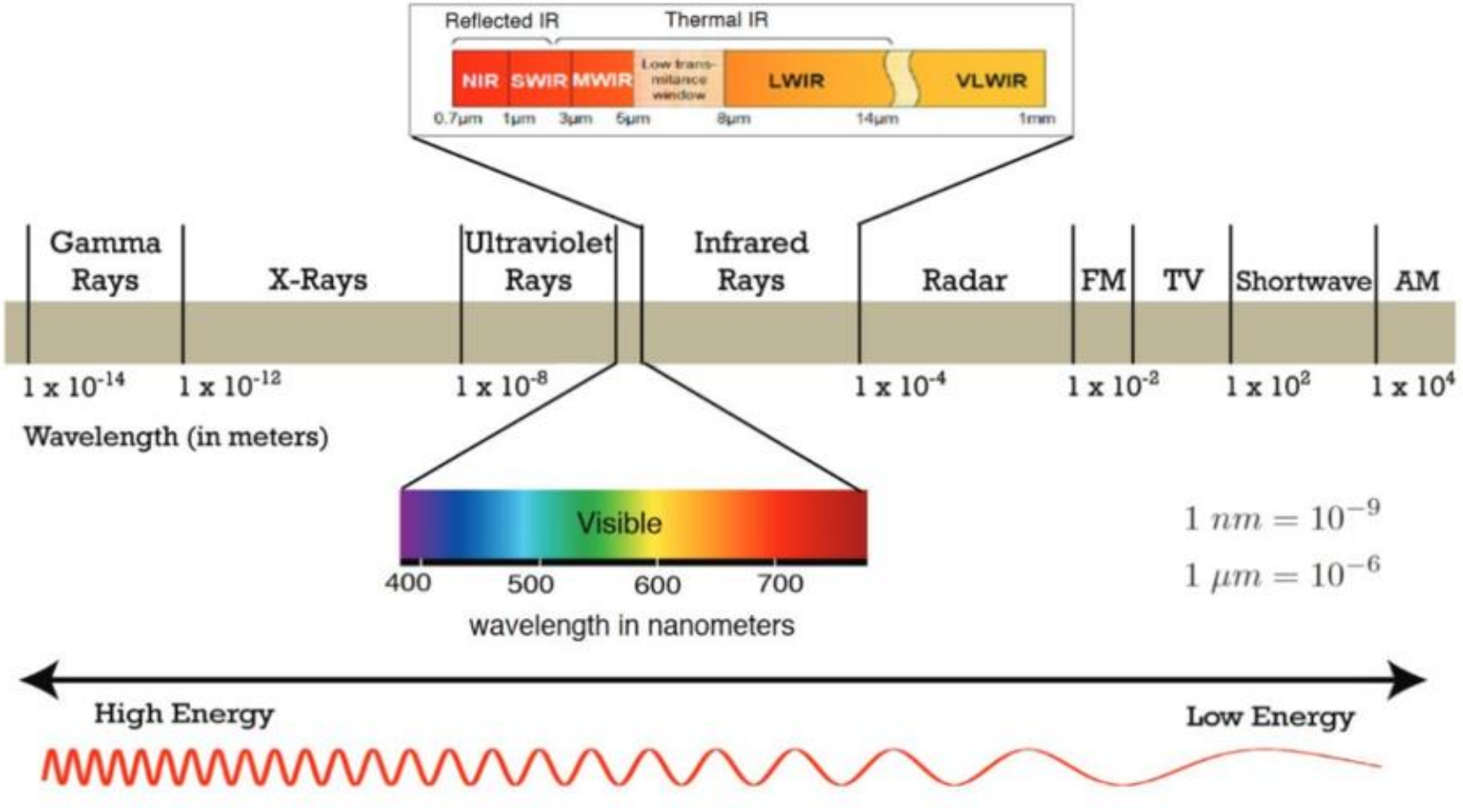
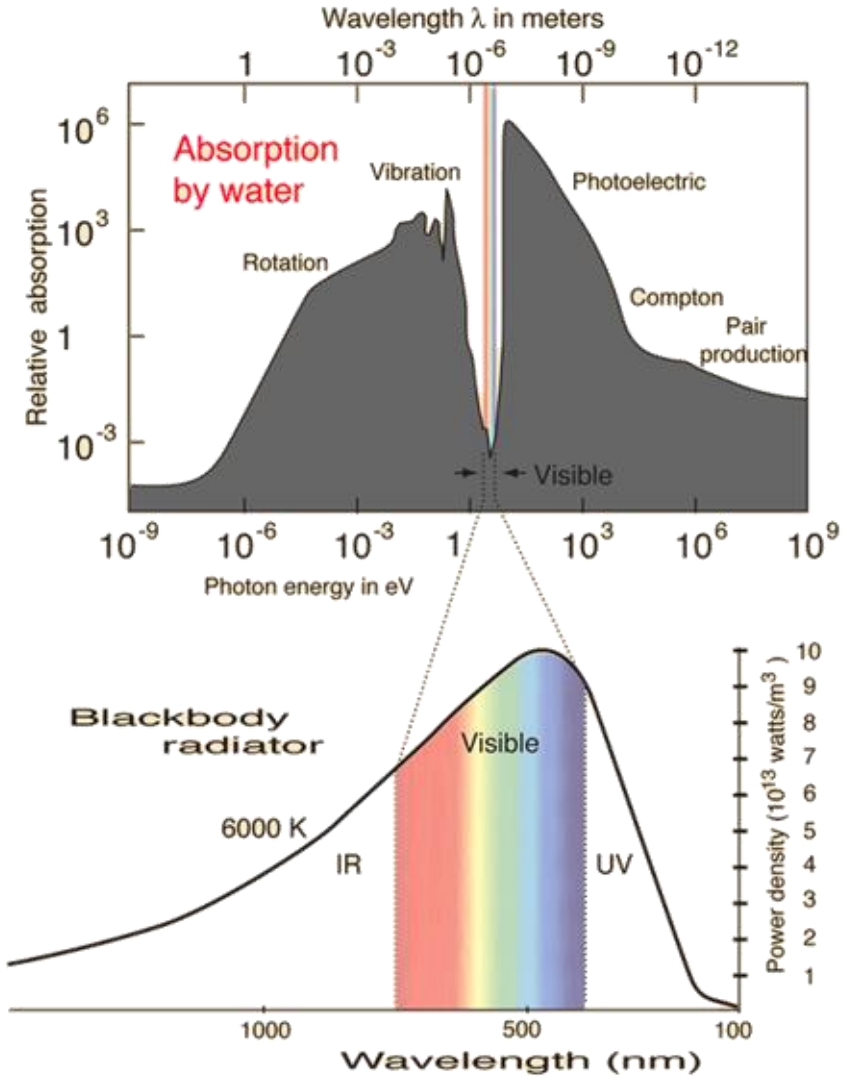
650nm

560m,

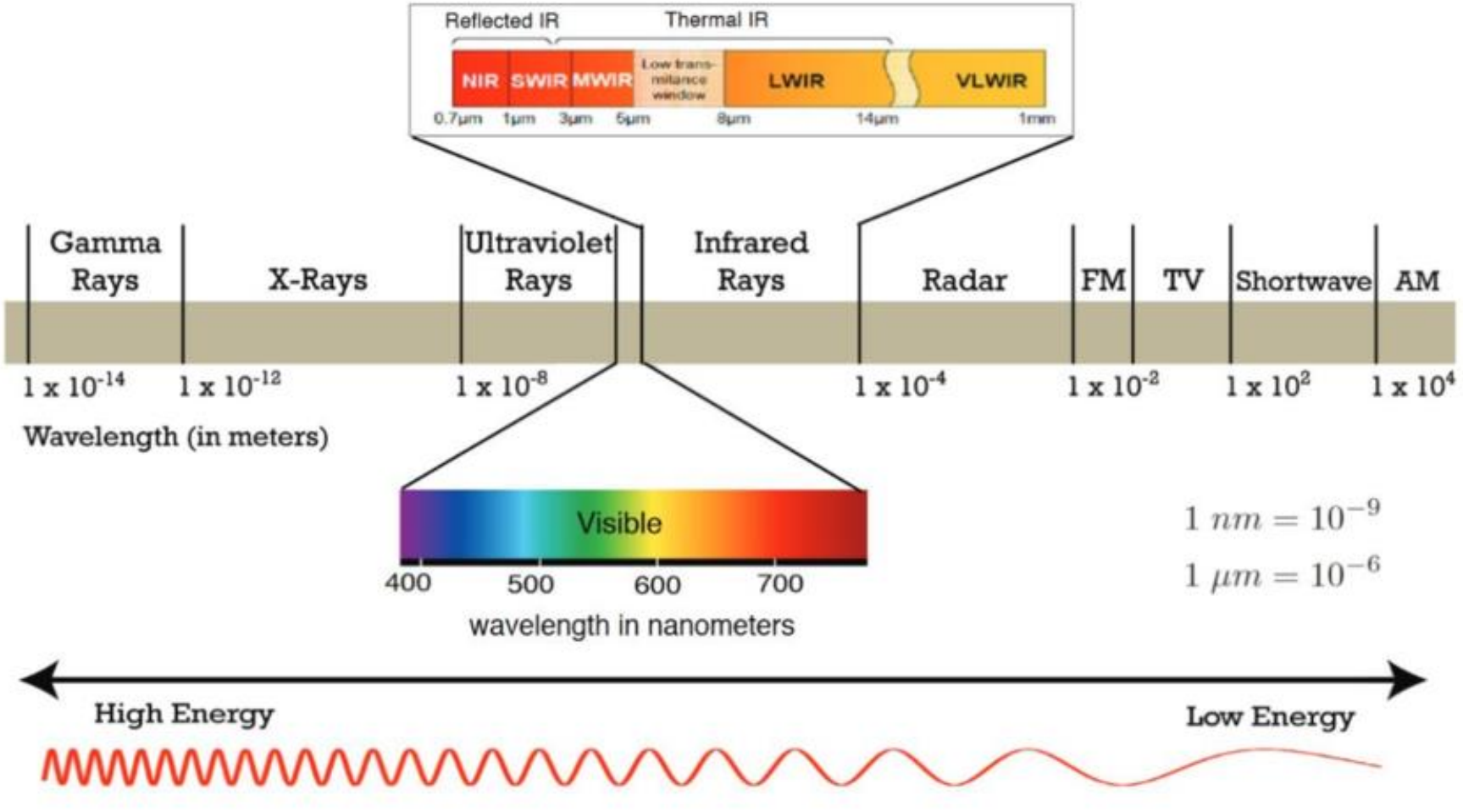
Spectrum


Reflected IR
Thermal IR
NIR
SWIR
MWIR
Low trans-mittance window
LWIR
VLWIR
0.7μm
1μm
3μm
5μm
8μm
14μm
1mm
Gamma Rays
X-Rays
Ultraviolet Rays
Infrared Rays
Radar
FM
TV
Shortwave
AM
1 x 10-14
1 x 10-12
1 x 10-8
1 x 10-4
1 x 10-2
1 x 102
1 x 104
Wavelength (in meters)
Visible
400
500
600
700
wavelength in nanometers
1 nm = 10−9
1 μm = 10−6
High Energy
Low Energy



Water Absorption Spectrum

Spectrum


Reflected IR
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Wavelength (in meters)
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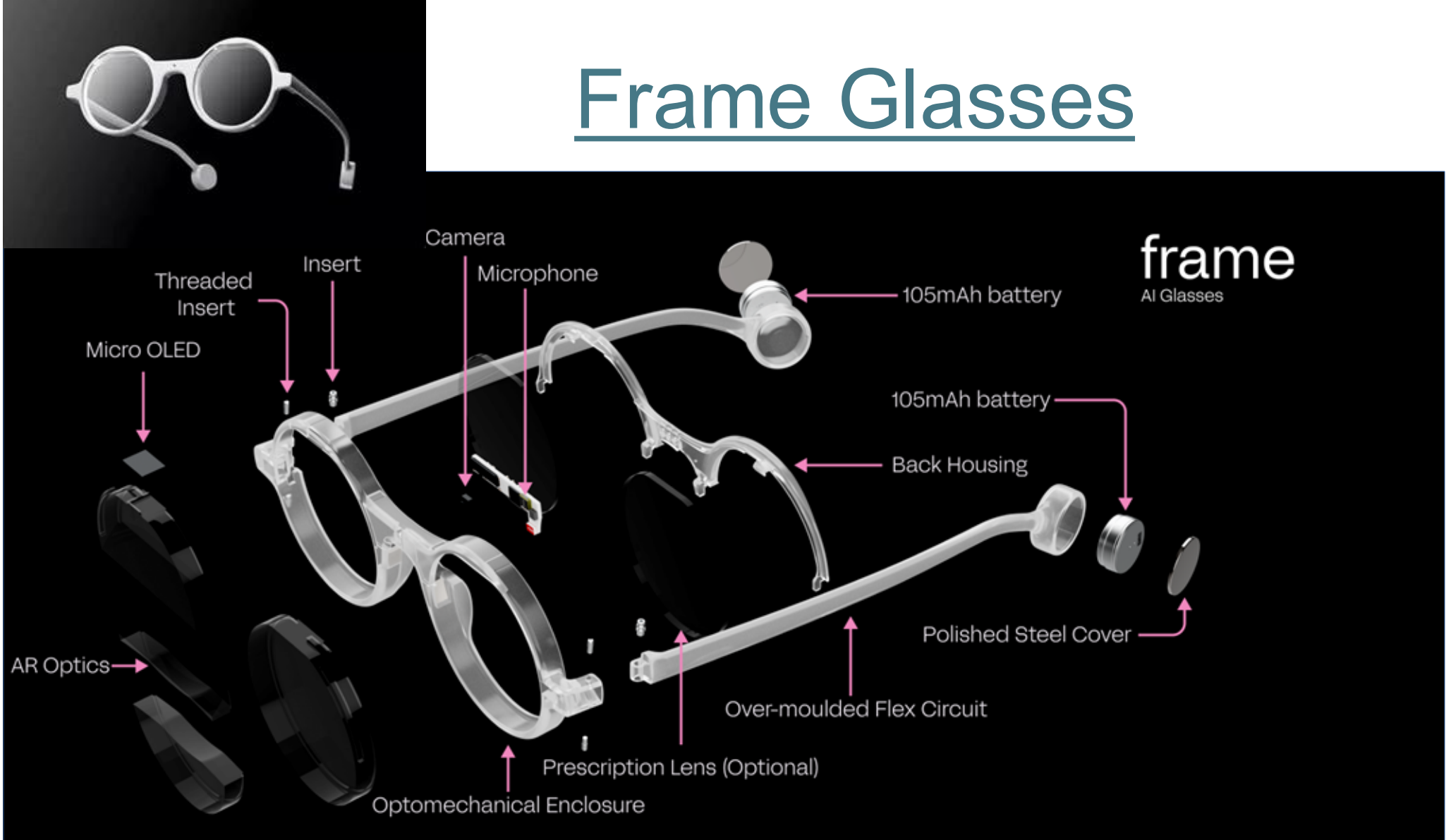
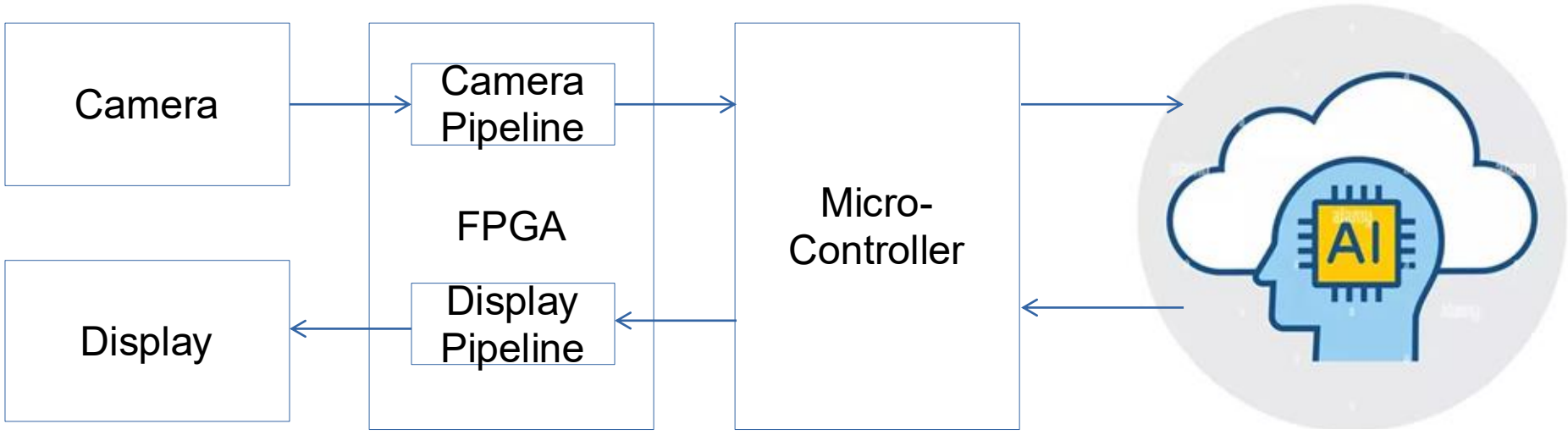
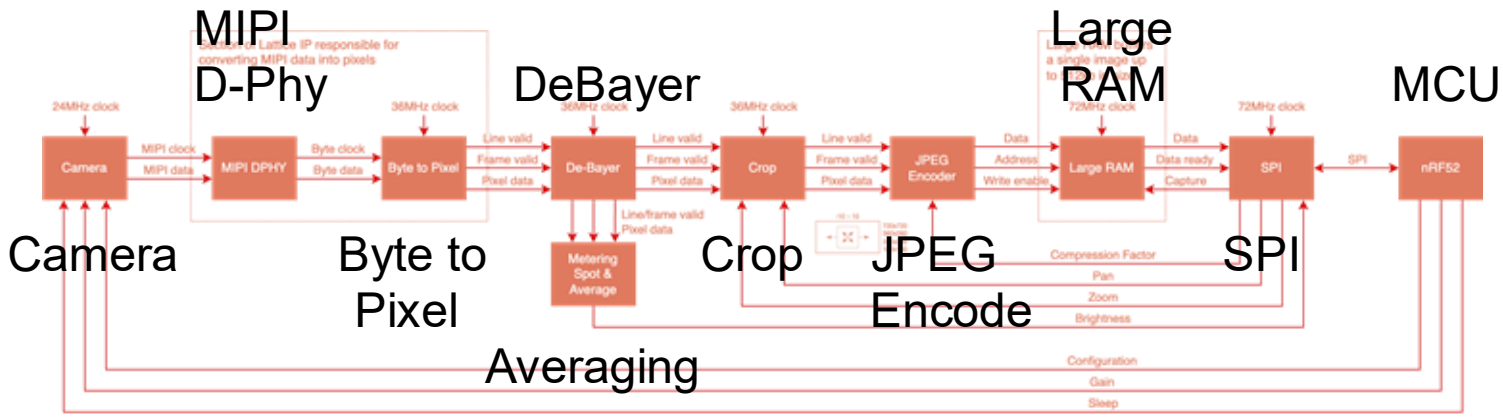
Frame Glasses



Frame Pipeline

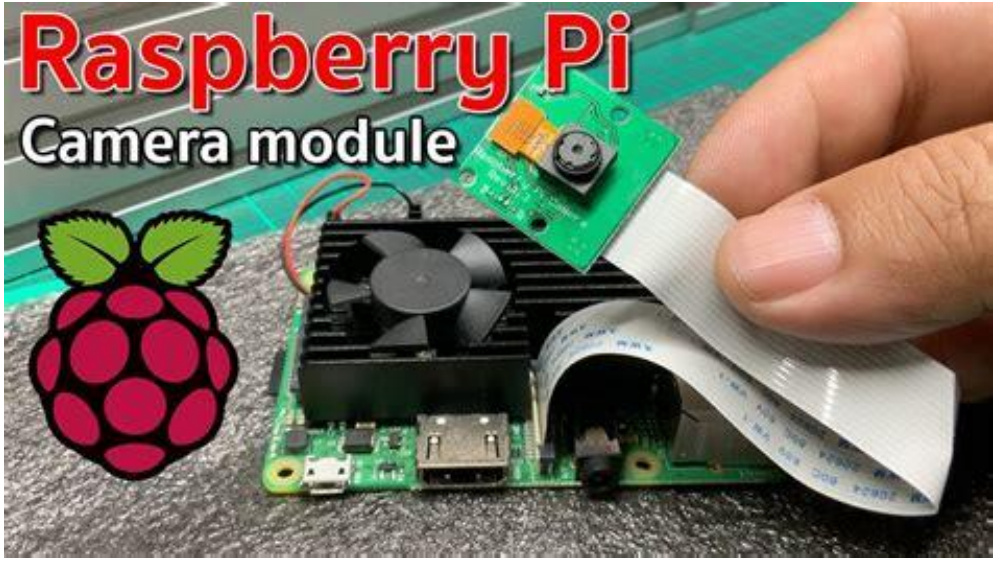


Frame Camera Pipeline



Cameras

Raspberry Pi Camera



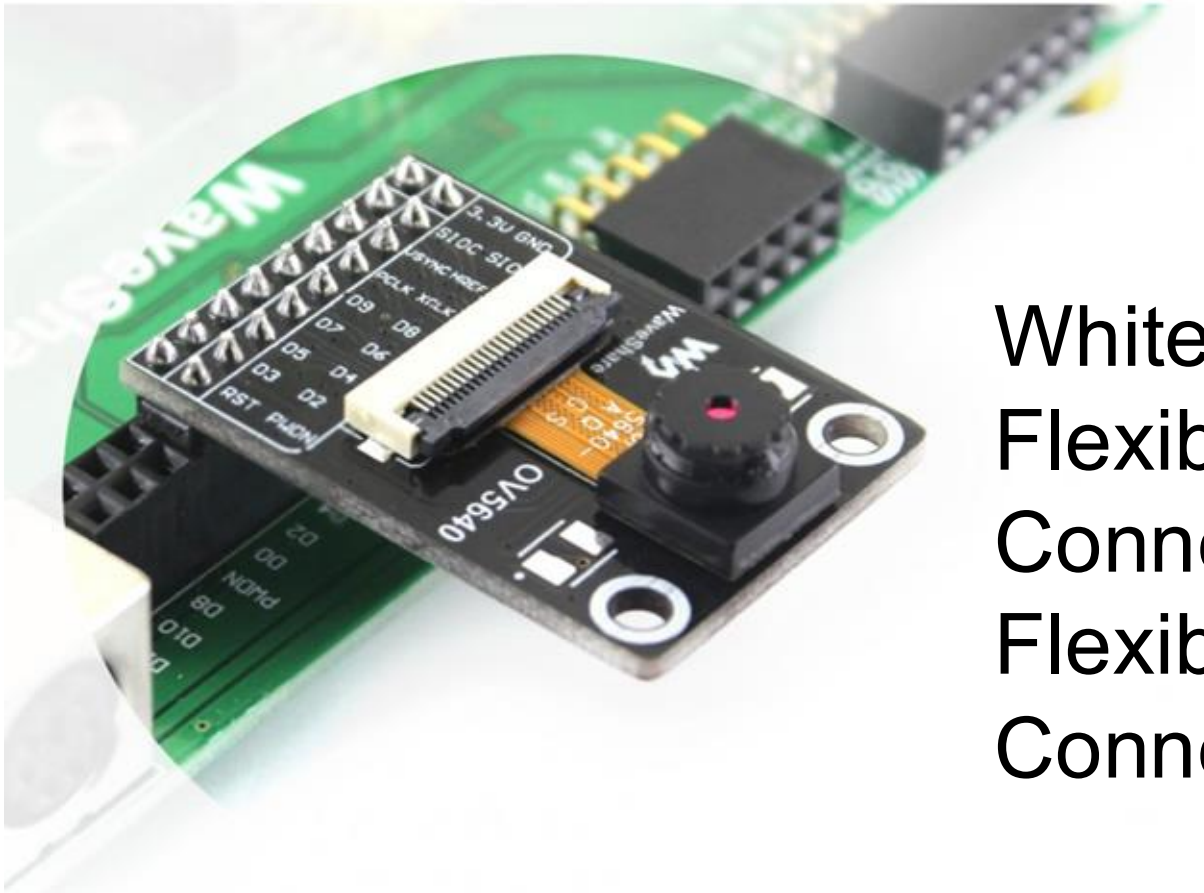
An engineer thinks of a camera as a sensor with some wires.

$17 WaveShare OV5640

Fisheye $16.60

Rectilinear Lens +
AutoFocus + Flash $26.00

Zoomed In View

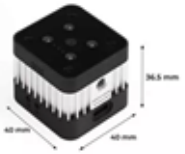


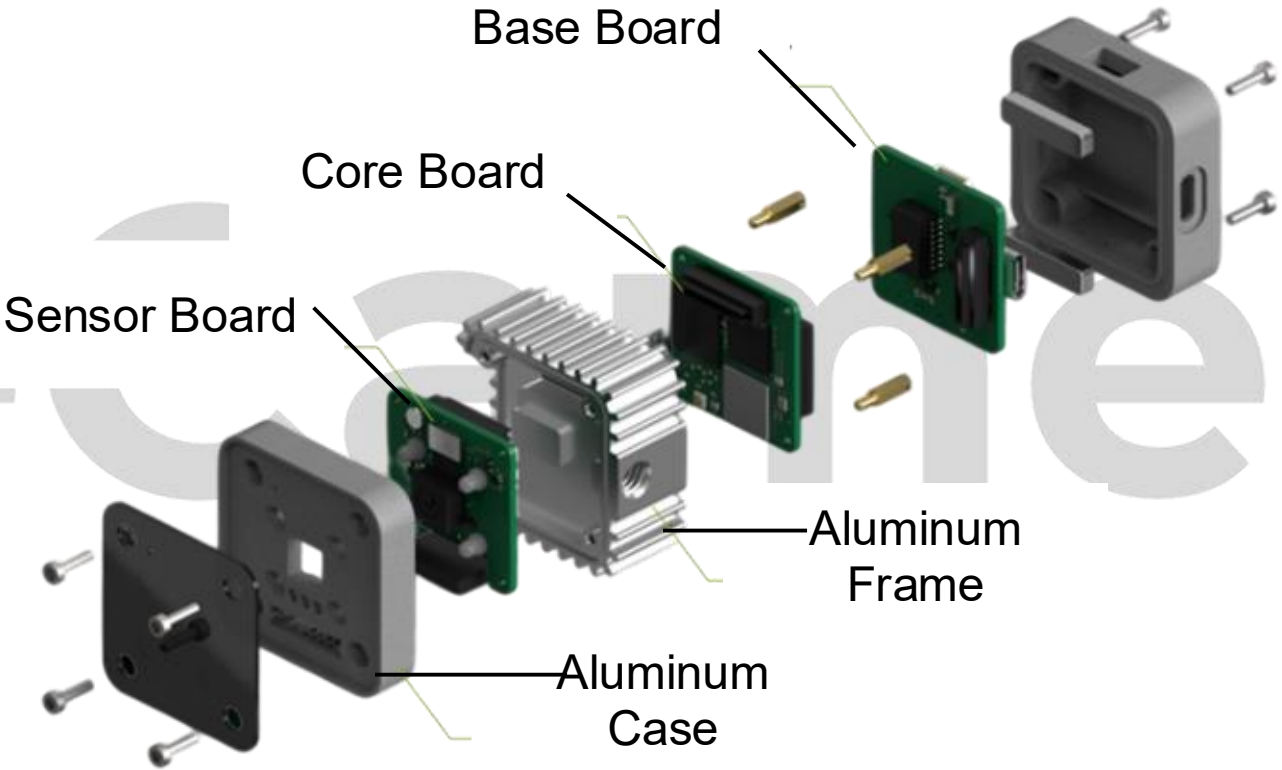
White strip is a 38 Pin Flexible Flat Connector (FFC) or Flexible Printed Connector (FPC)

Arducam USB Shield

Arducam Parallel
Camera Adapter Board

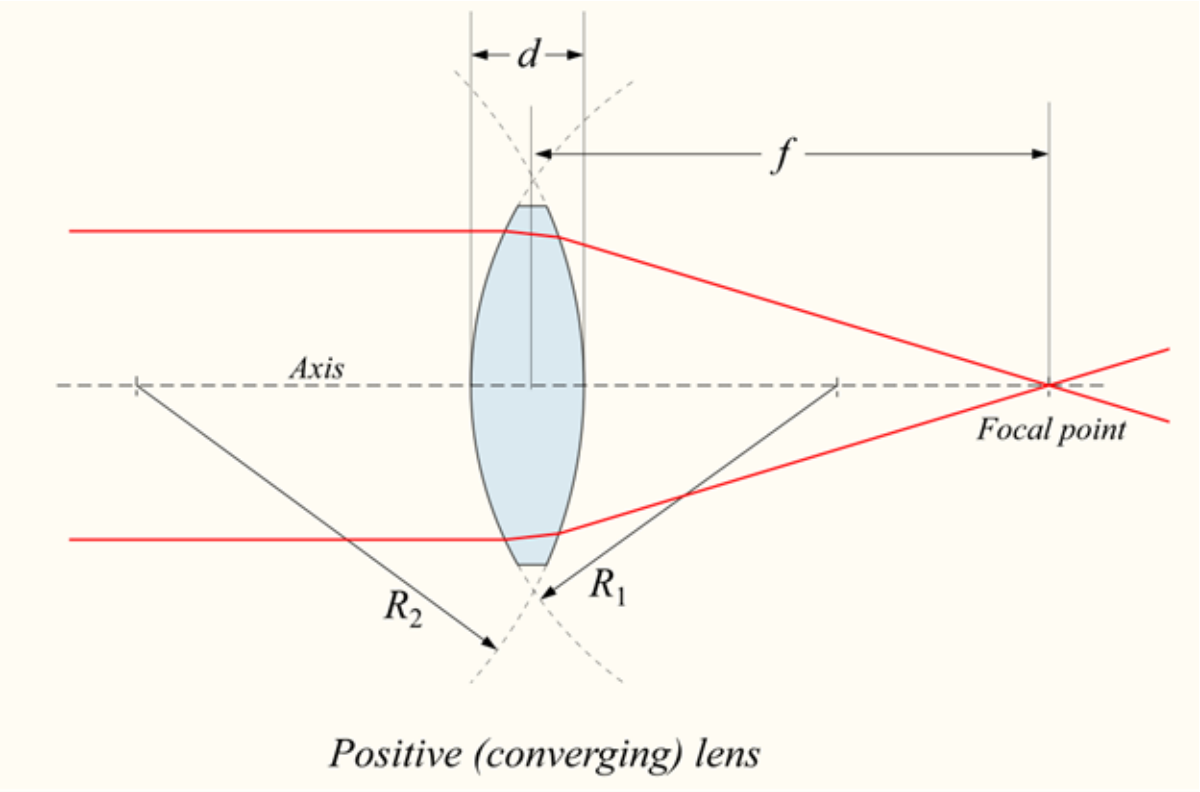
ReCamera





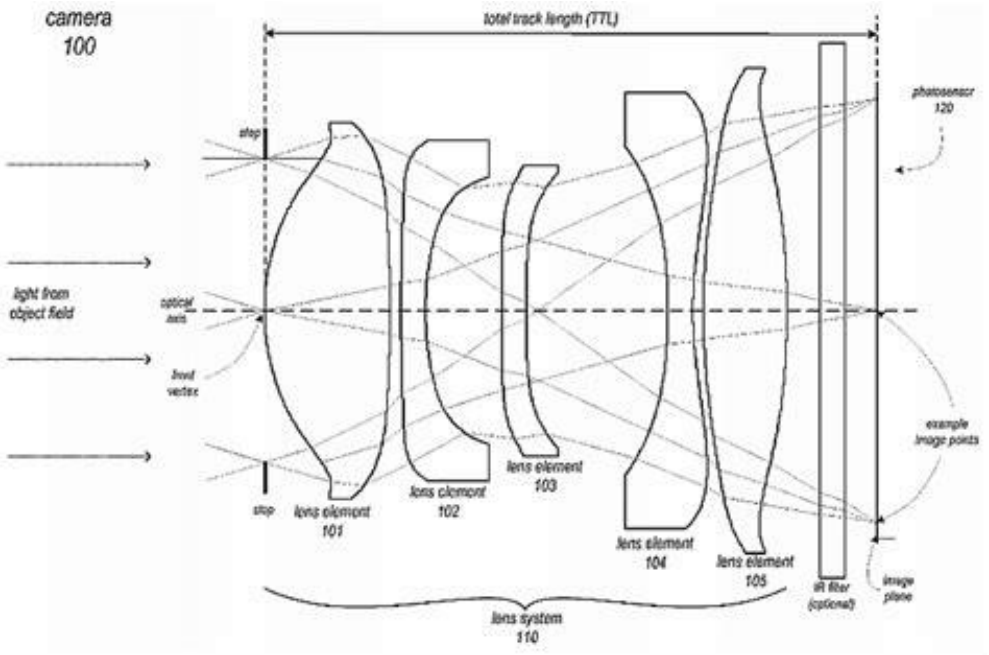
An open source camera stack from Seeed studios. Apache-2 license.

Basic Lens



We think of lenses as being quite simple.

2016 iPhone Lens Patent



Like everything else, lenses are getting more and more complex.

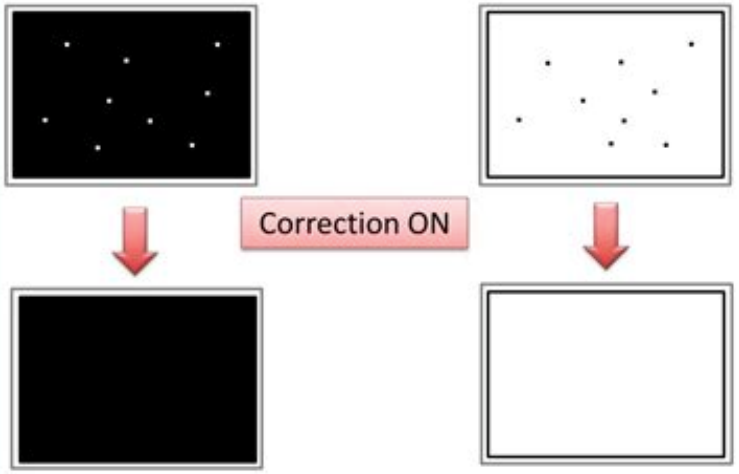
874 Image Sensors

onsemi OMNIVISION SONY GALAXYCORE Himax SMARTSENS

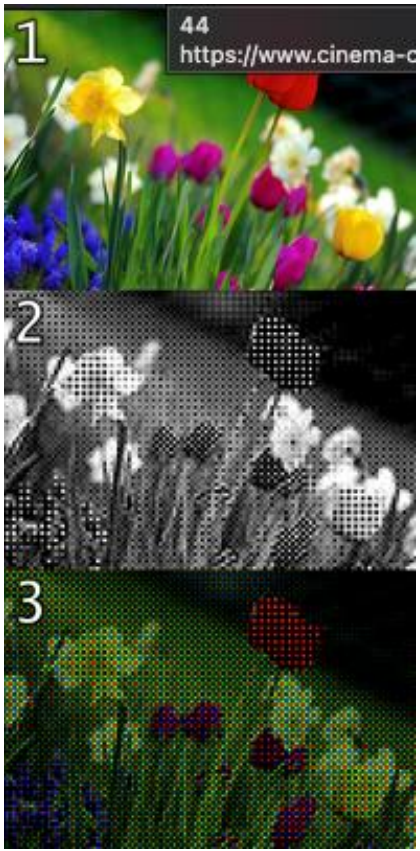
☐	Brigates	RV400	0,25	2.8	BSI
☐	Brigates	BG0851	2,35	13	FSI
☐	Brigates	BG0808	2.1	3	BSI
☐	Brigates	BG0836	2.1	3	FSI
☐	BYD	BF2K21	50	0.72	BSI
☐	BYD	BF2D31	13	1,12	BSI

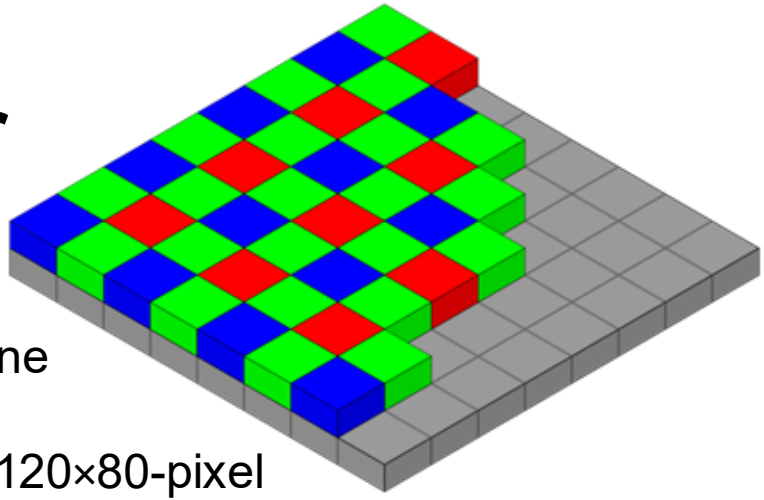
Camemaker.com is a database of 874 image sensors from 12 vendors. Does not even include AMS OSRAM, Gpixel, Nuvoton, Renesas, Samsung, STMicroelectronics, Teledyne and Tepedyne Flir.

Defective Pixel Correction



Bayer Filter





1)Original scene

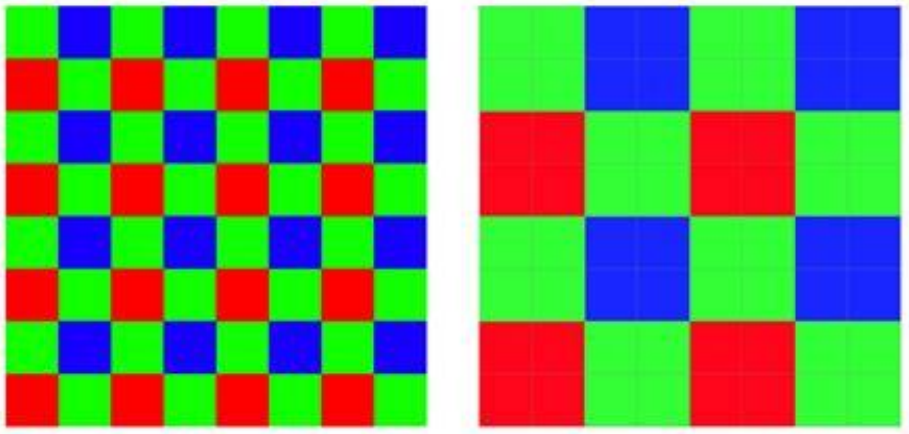
2)Output of a 120×80-pixel sensor with a Bayer filter

3)Output color-coded with Bayer filter colors

4)Reconstructed image after interpolating missing color information

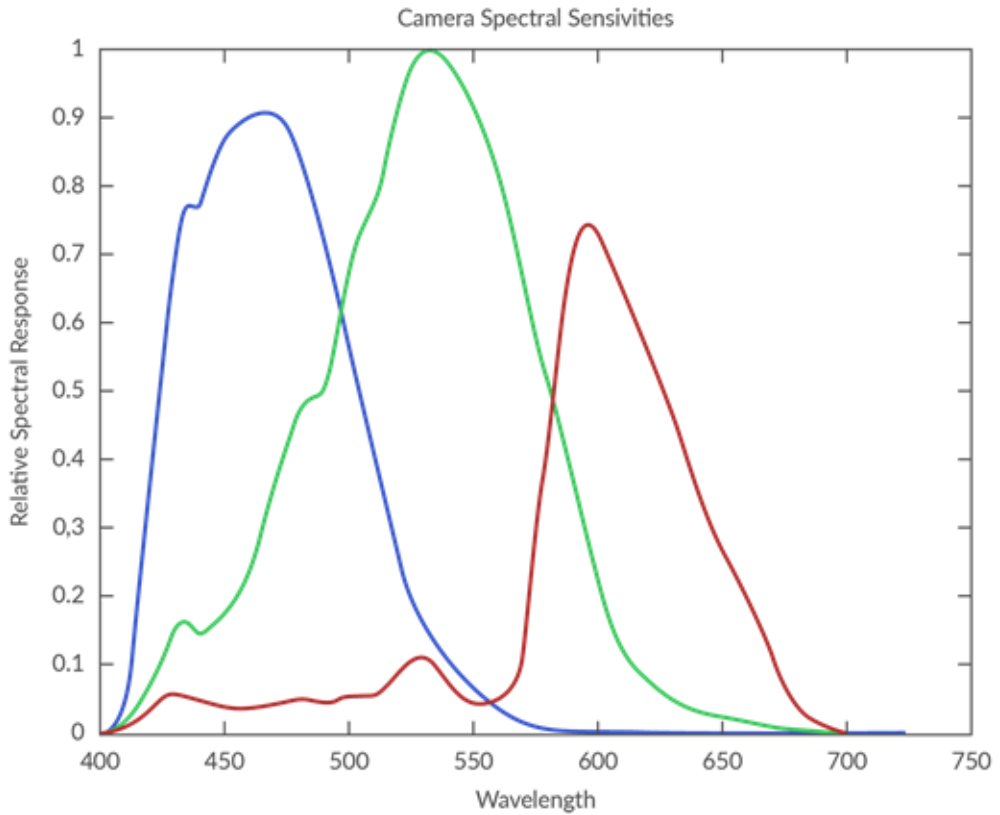
5)Full RGB version at 120×80-pixels for comparison (e.g. as a film scan, Foveon or pixel

Pixel Binning



- Pixel Binning averages together multiple measurements.

Camera Spectral Response



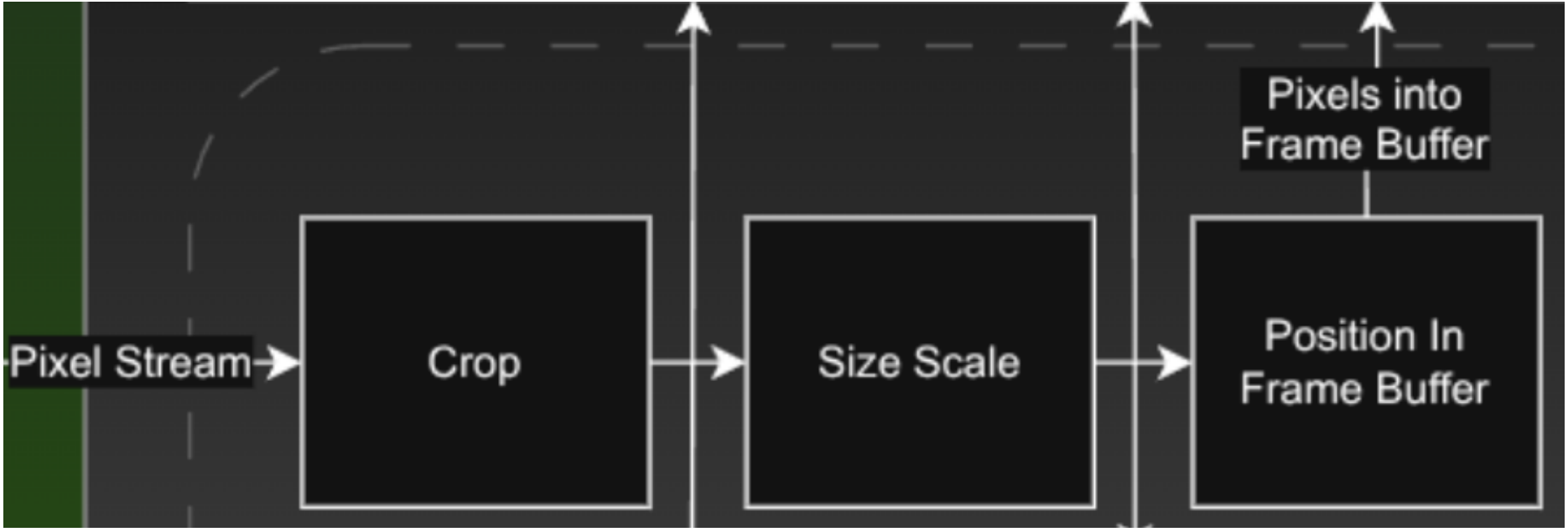
Sensors, displays and human eyes have different spectral responses.

Color Balance

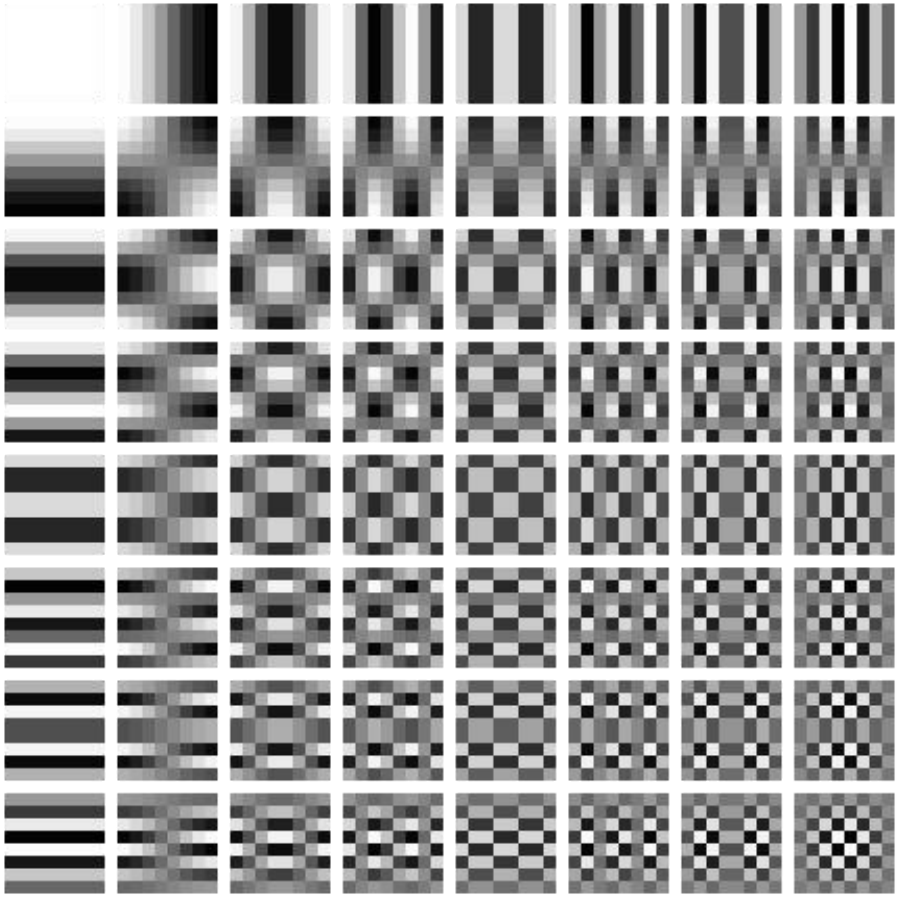
Video Cropping or Digital Zoom

More complex than photo cropping because suddenly you have different size frames In the pipeline.

Video Cropping in PipelineC

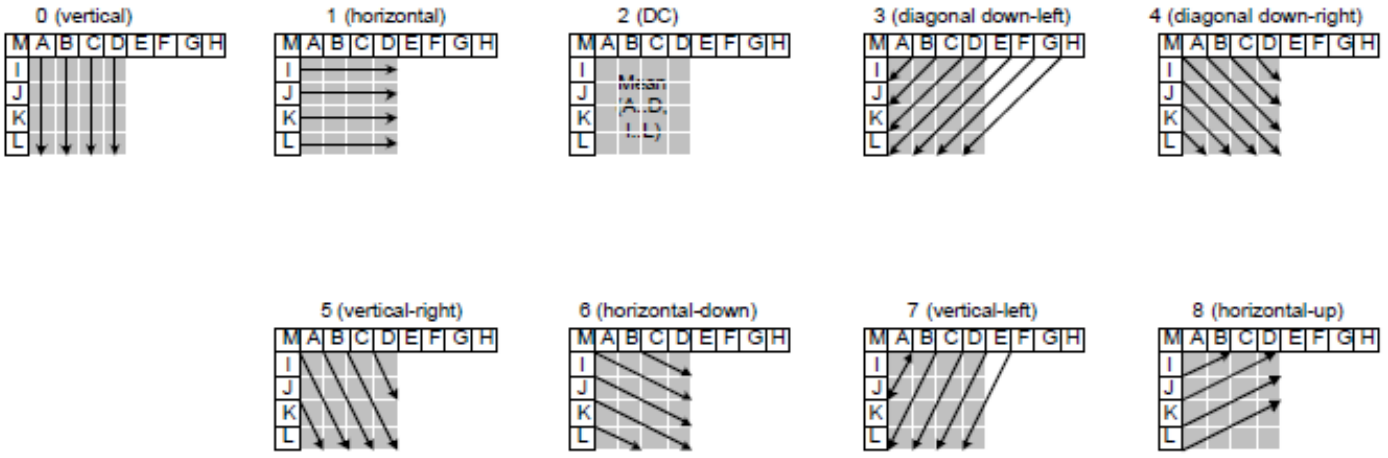


JPEG Compression



JPEG Compression represents one color in an array of 8x8 pixels using just a few of the cosign transforms shown on the left.

H264/H265 Compression



Compensates for motion.

RGB to Gray Scale

$$Y_{\text{linear}} = 0.2126R_{\text{linear}} + 0.7152G_{\text{linear}} + 0.0722B_{\text{linear}}\,.$$

Note that green is more heavily weighted. For evolutionary reasons our eyes are more sensitive to green.

Sobel Edge Detection

$$\mathbf{G}_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * \mathbf{A}$$

$$\mathbf{G}_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * \mathbf{A}$$

1968 Paper
Well Known
Too much math
Edges can be different widths
Edges are smaller in dark regions

Canny Edge Detector

$$H_{ij} = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{(i-(k+1))^2 + (j-(k+1))^2}{2\sigma^2}\right); 1 \leq i, j \leq (2k+1)$$

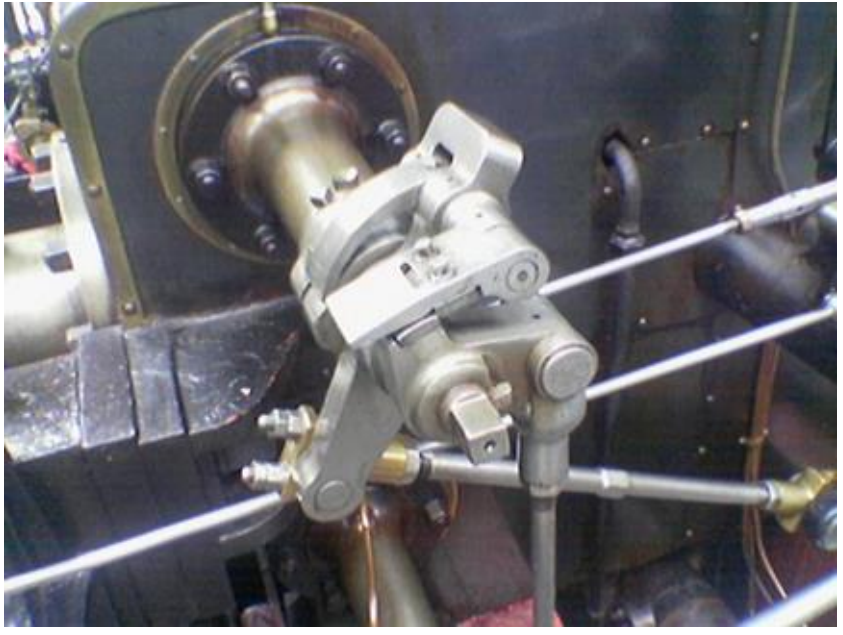
$$\mathbf{B} = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} * \mathbf{A}.$$

A good academic concept
But not that practical on FPGAs.

Step 1 is a gaussian filter.
How do you divide by 159 on an FPGA?

20 Minutes

Canny Edge Detector



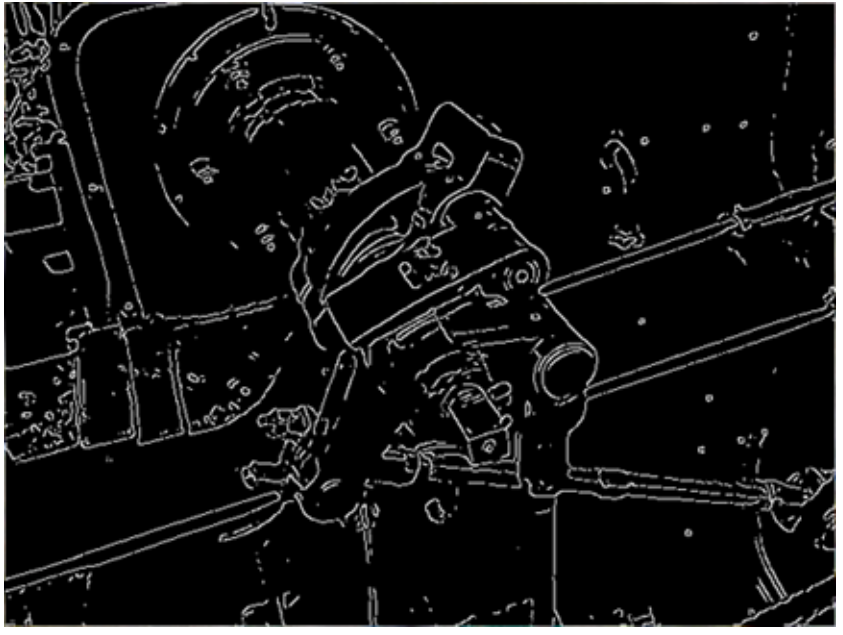
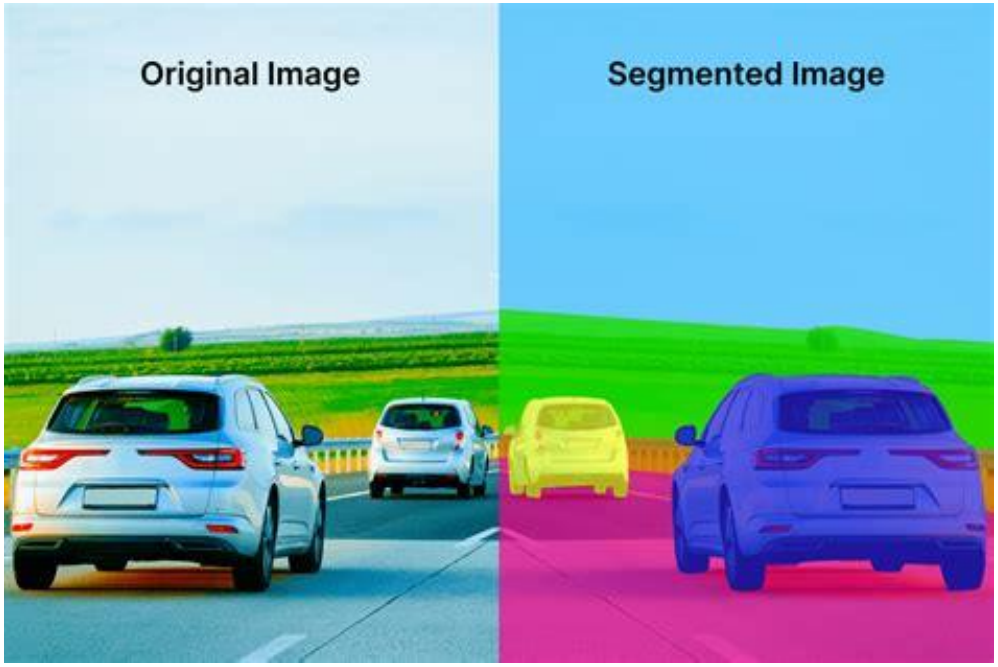
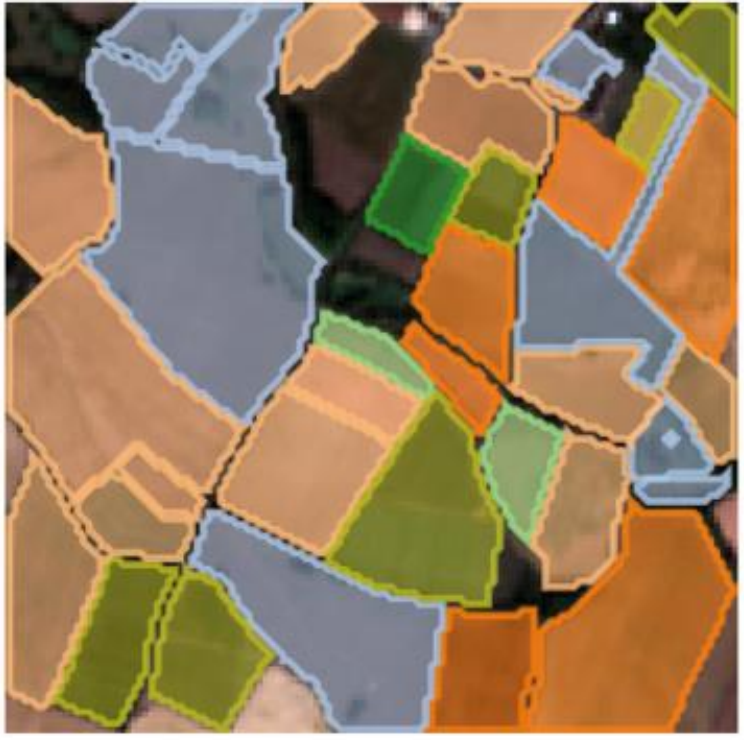


Image Segmentation



Agricultural SegmentationData Set



RGB to YUV

YUV 4:4:4, YUV 4:2:2, YUV 4:2:0, and YUV 4:1:1

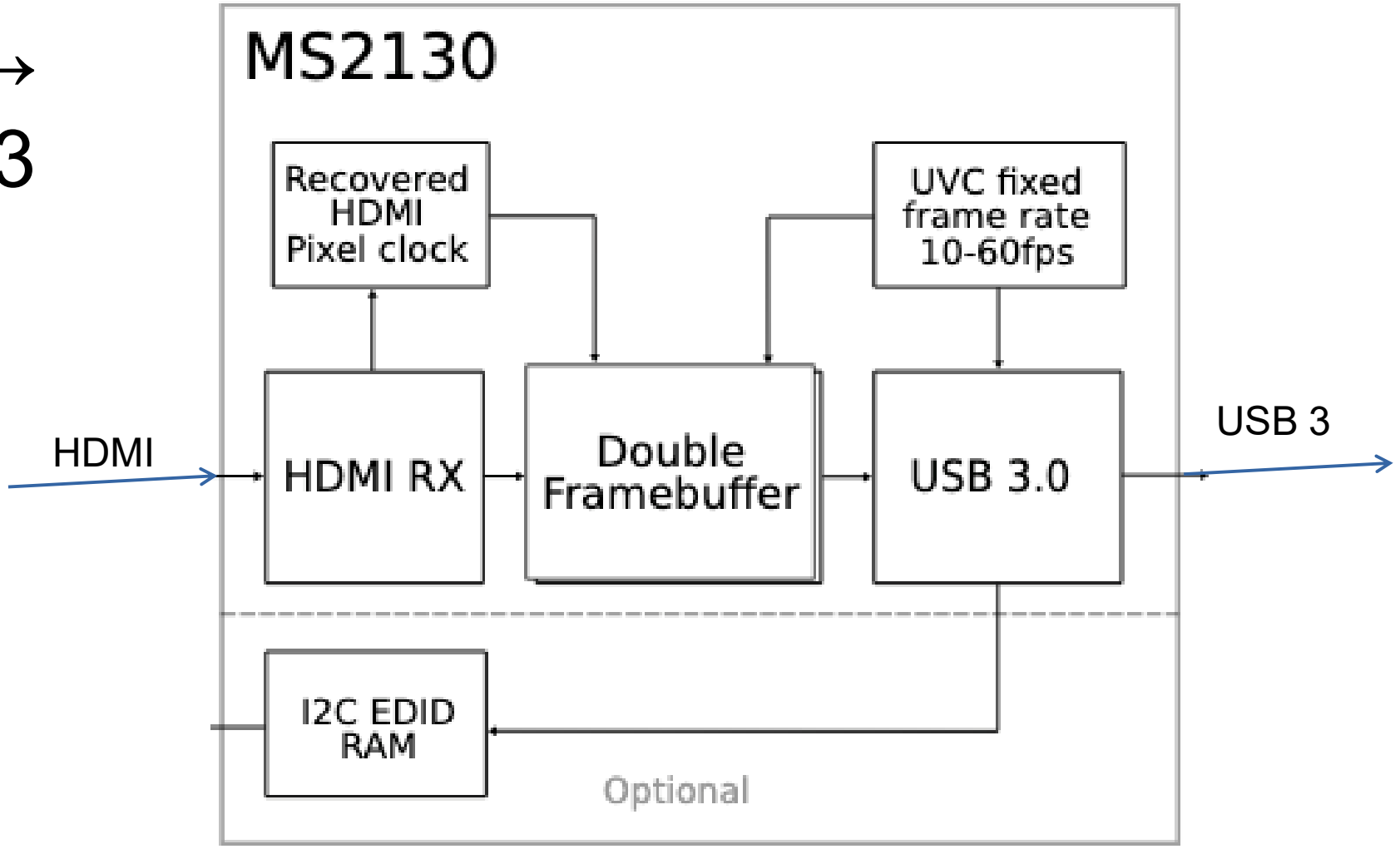
$$\begin{bmatrix} Y' \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.14713 & -0.28886 & 0.436 \\ 0.615 & -0.51499 & -0.10001 \end{bmatrix} \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix},$$

DVI TO USB-3 Dongles

USB-3 Runs at 5 Gbits/s

< $10 Devices

DVI → USB 3


MS2130
Recovered HDMI Pixel clock
UVC fixed frame rate 10-60fps
HDMI
HDMI RX
Double Framebuffer
USB 3.0
USB 3
I2C EDID RAM
Optional

Libmpix on Zephyr OS

Libmpix supports auto exposure, black level correction, white balance, debayer, color calibration, gamma correction, gaussian blur, median denoise, sharpen, sobel edge detection, resizing, image statistics, sampling, and JPEG compression. SIMD coming soon.


ALTERA


XILINX


TOP 10
FPGA Manufacturers in China

Efinix = Pango

EFINIX®

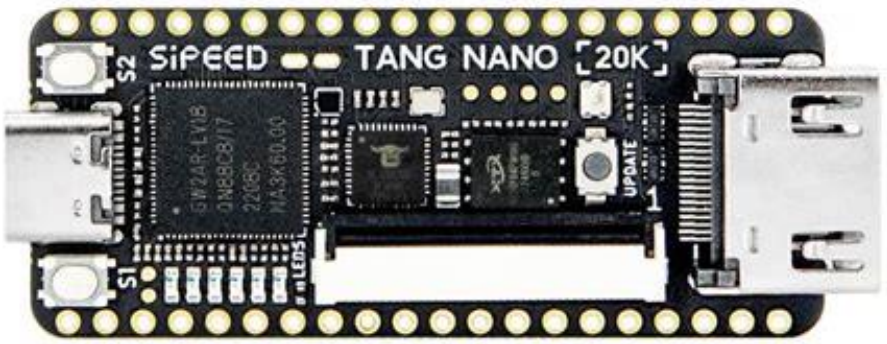
Yosys Open SYnthesis Suite (Yosys)

A framework for RTL synthesis

Currently Yosys and Nextpnr support:

- Lattice iCE40 devices supported by Project IceStorm
- Lattice ECP5 devices supported by Project Trellis
- Lattice Nexus devices supported by Project Oxide
- Gowin LittleBee devices supported by Project Apicula
- NanoXplore NG-Ultra devices supported by Project Beyond
- Cologne Chip GateMate devices supported by Project Peppercorn

Gowin + Tang Nano 20K



PLN 66.00 = EUR 15.43

- 20K Luts
- DVI/HDMI
- 64Mbits SDRAM
- MIPI DPI

- Ice40, Underpowered compared to RP2350
- ECP5, great ecosystem, supports 1920p DVI/HDMI
- CrossLink NX 17/33/40 MIPI enabled.

Open Source FPGA Vendors with MIPI

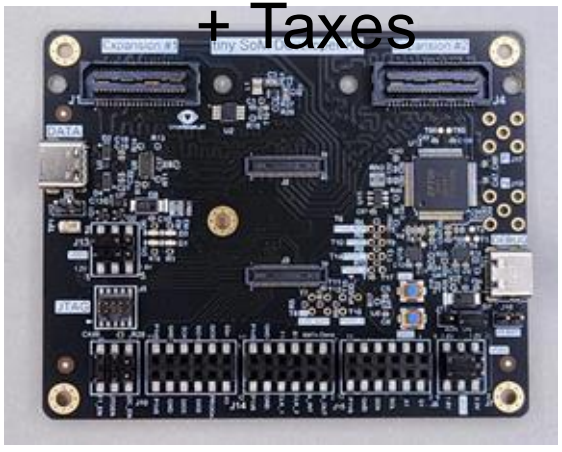
Lattice NX 17/33/40 MIPI Blocs

- Two MIPI Hard Cores.
- 2.5 Gbits/s
- Can be configured to support either Camera Serial Interface (CSI-2) or Display Serial Interface (DSI) applications as either transmitter or receiver.

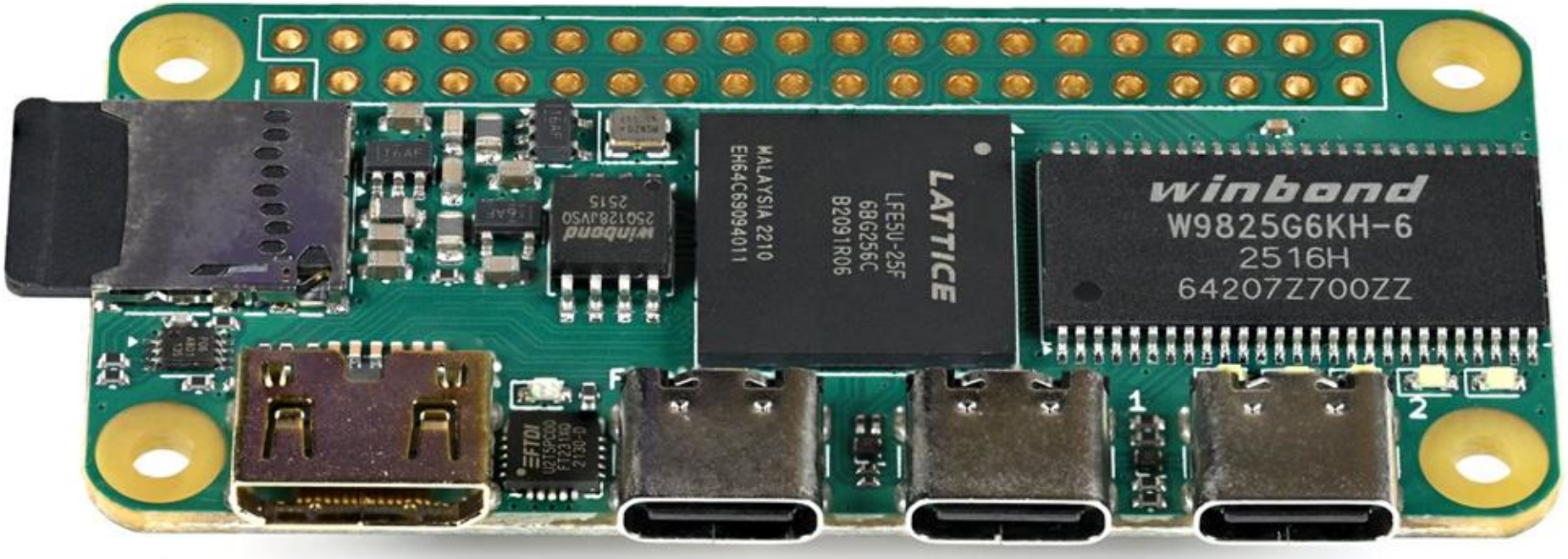
TinyVision.ai CLUNX33 Developer Kit

MIPI to USB

PLN 923.00 = EUR 217 + Taxes



$79 IcePi Zero



Raspberry Pi Zero Mipi Bridge

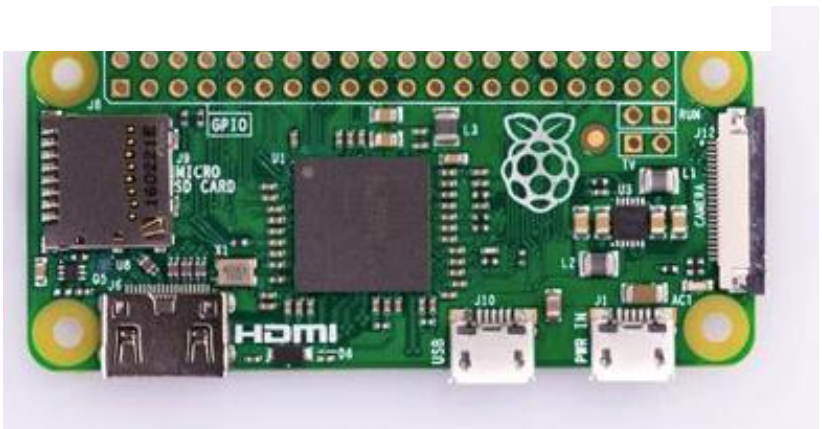
RPI Zero $10

RPI Zero 2W $15

MIPI-CSI
USB-2
DVI
DPI

$79 Ice Pi Zero +

$15 Raspberry Pi Zero

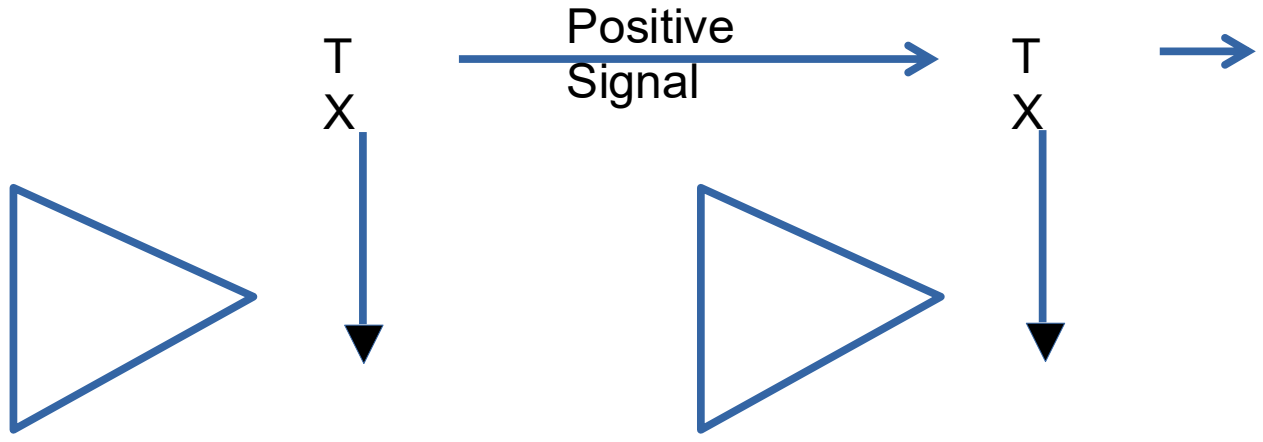


In January the $79 IcePi Zero will ship. Pin compatible With the Raspbery Pi Zero. Just click them together.
MIPI
Camera port, And DVI out!

2.7Gbits/s

European Cologne Chips GateMate Evaluation Board 209 € = 885 Zl

Single Ended Signal

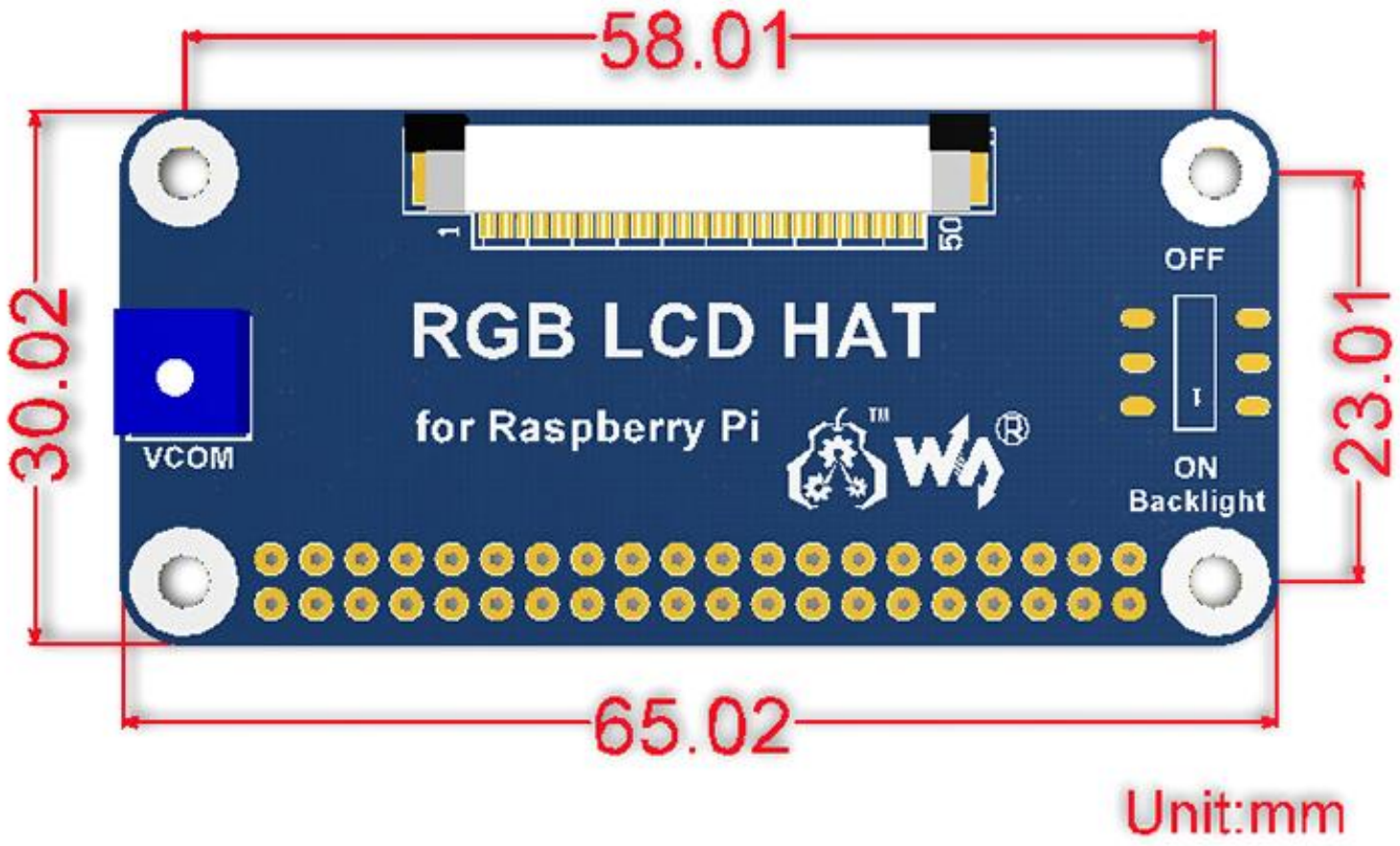


Camera to Processor
Digital Video Port(DVP)

Camera to Display
Digital Parallel Interface
(DPI) or RGB.

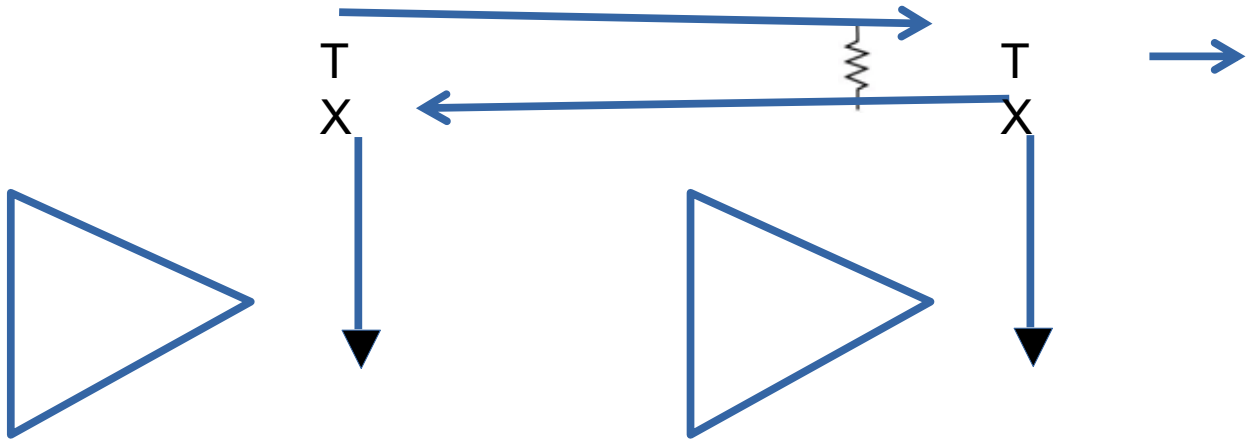
30
Minutes

Parallel RGB or DPI



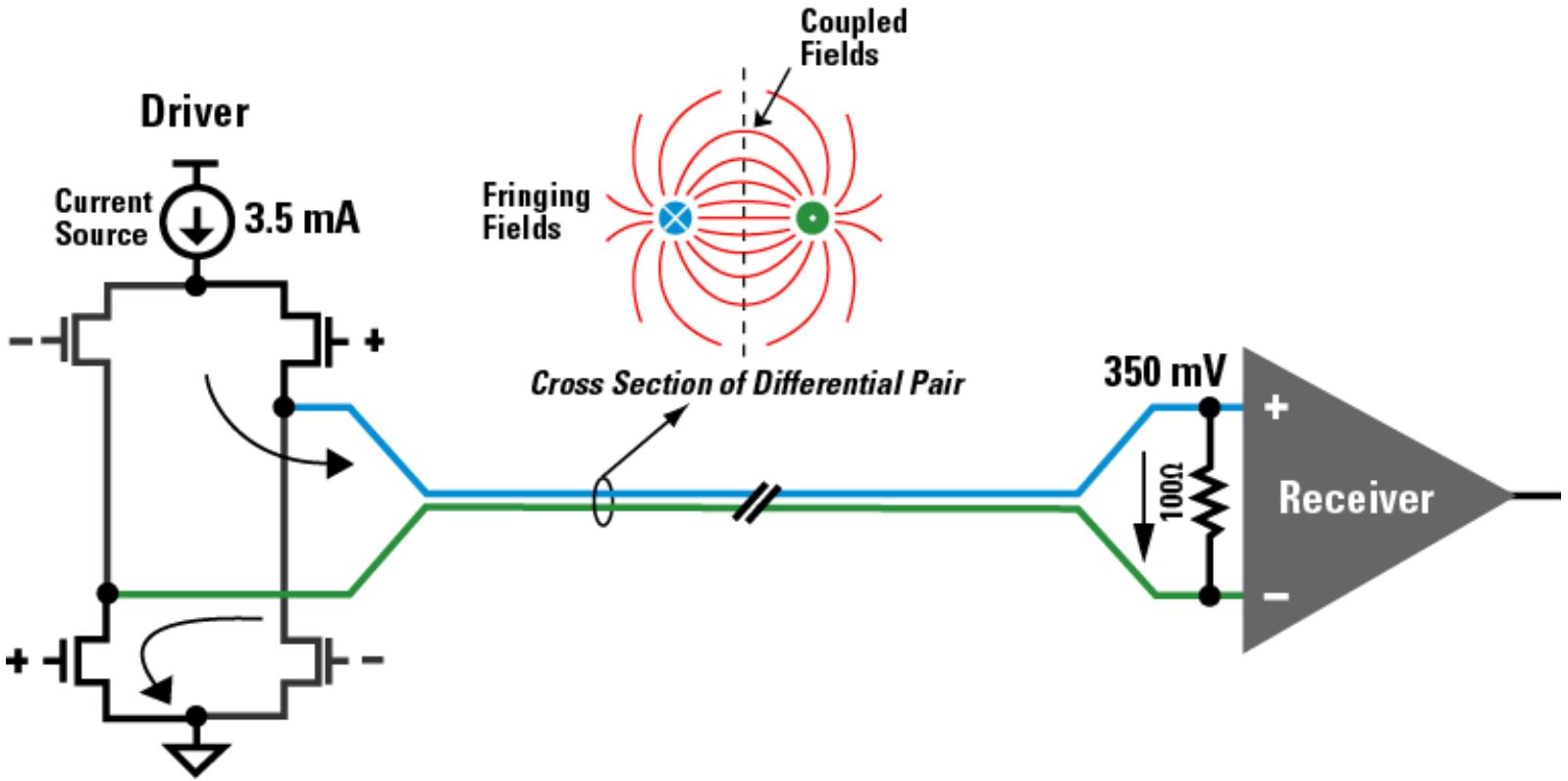
Differential Signaling

DVI, HDMI, USB, MIPI, DisplayPort, PCIe, DDR SDRAM, Ethernet, LVDS, SubLVDS, SLVS-EC, CameraLink,

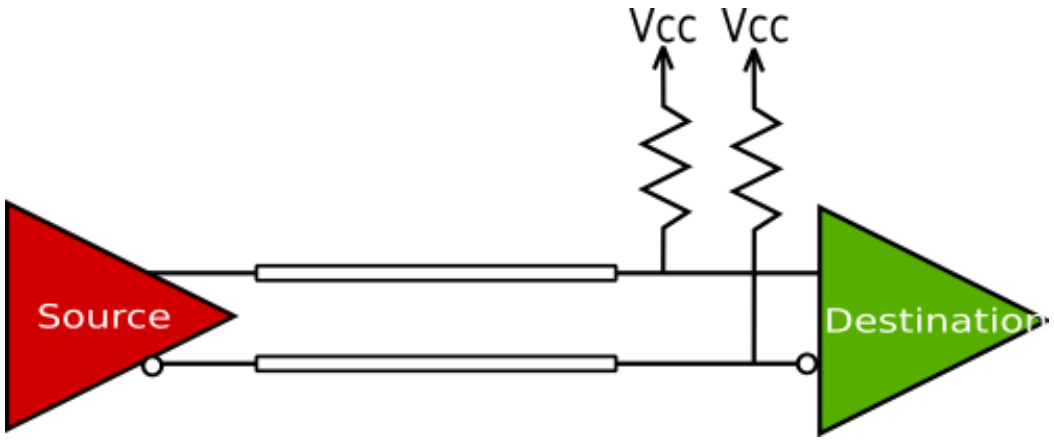


LVDS

MIPI, USB, DisplayPort, PCIe, DDR SDRAM, Ethernet, LVDS, SubLVDS, SLVS-EC, CameraLink

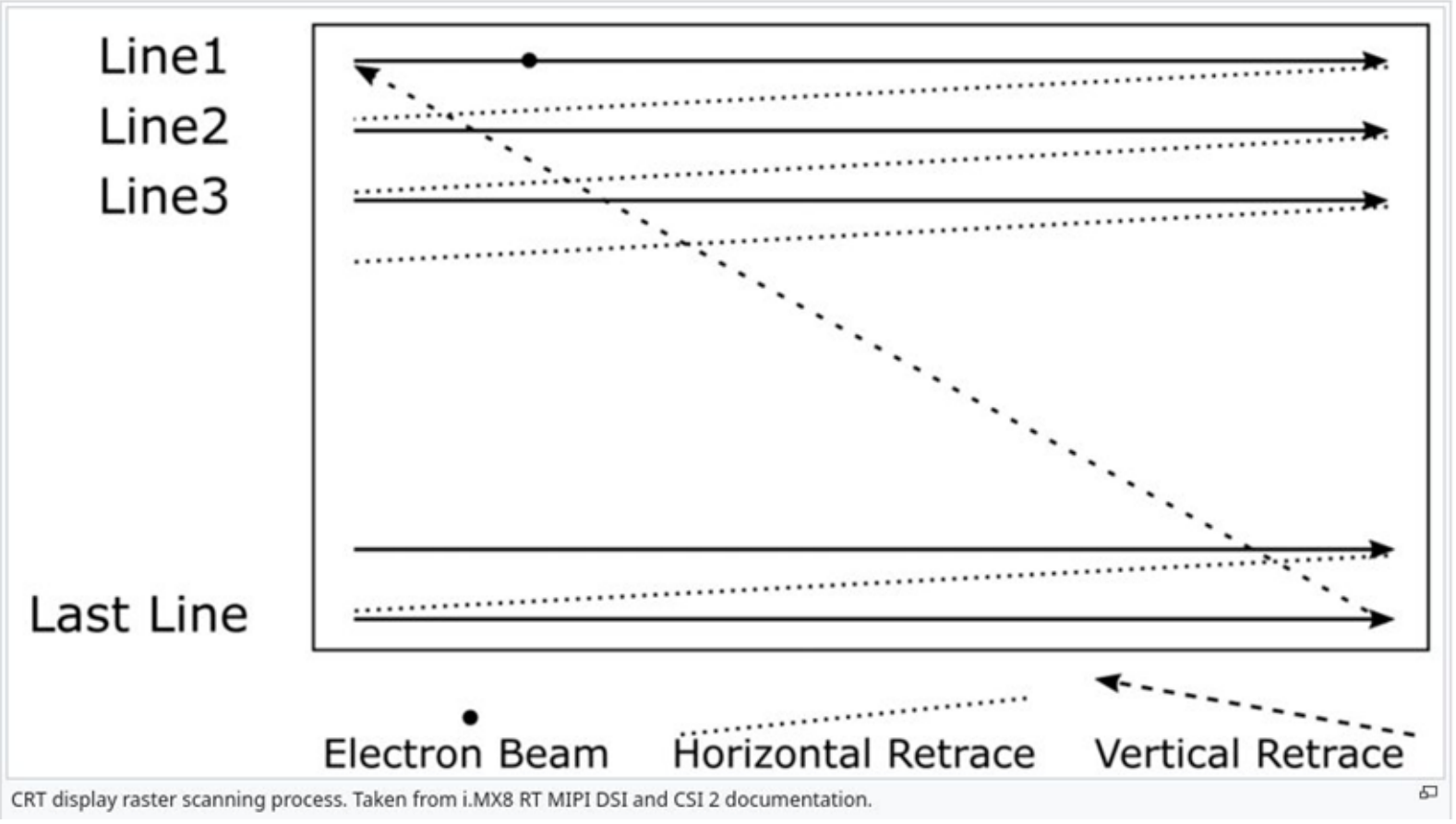


DVI/HDMI over Current Mode Logic (CML)



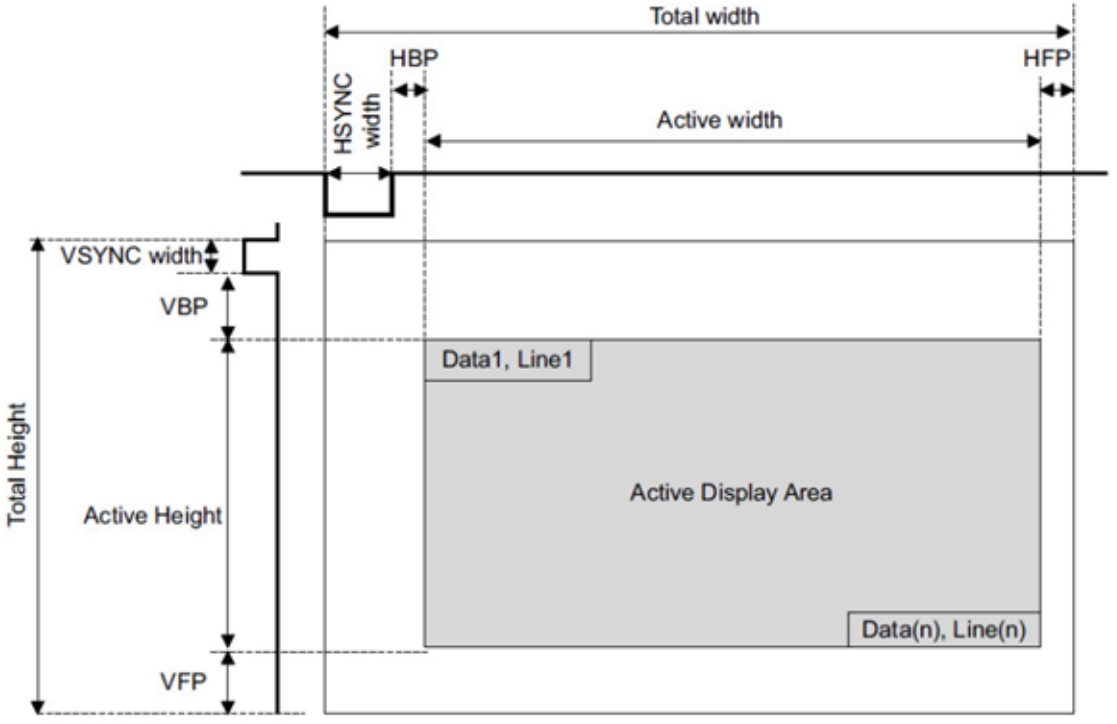
Display Interfaces

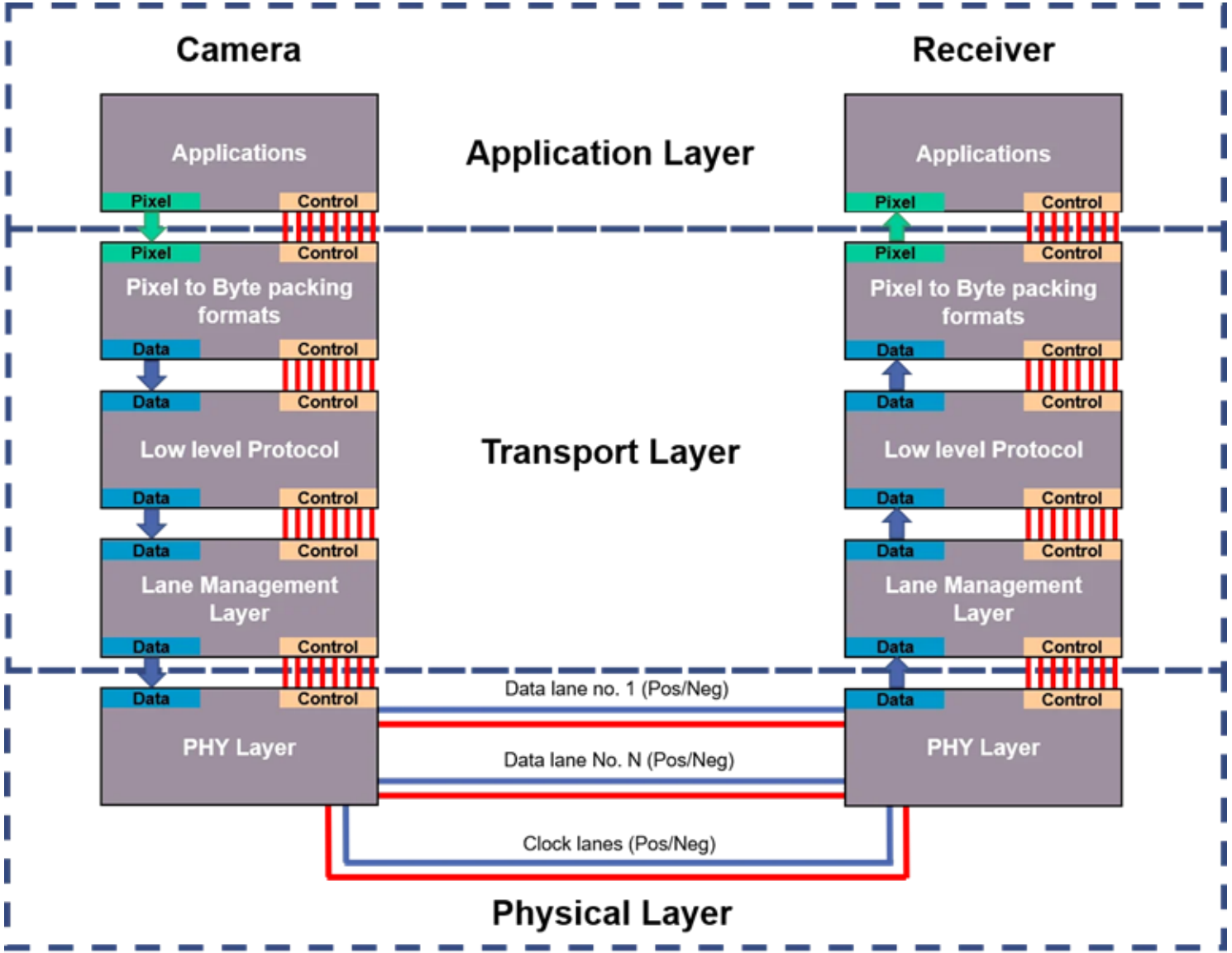
VGA Display Technologies



CRT display raster scanning process. Taken from i.MX8 RT MIPI DSI and CSI 2 documentation.

Front and Back Porch




Camera
Receiver
Applications
Application Layer
Applications
Pixel
Control
Pixel
Control
Pixel
Control
Pixel to Byte packing formats
Pixel to Byte packing formats
Data
Control
Data
Control
Data
Control
Low level Protocol
Transport Layer
Low level Protocol
Data
Control
Data
Control
Data
Control
Lane Management Layer
Lane Management Layer
Data
Control
Data
Control
Data
Control
Data lane no. 1 (Pos/Neg)
PHY Layer
Data lane No. N (Pos/Neg)
PHY Layer
Clock lanes (Pos/Neg)
Physical Layer

MIPI CSI-2

SLVS-EC IP Vendors

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USB and Ethernet

- USB 2. 5 Meters, 480 Mbits/sec 320Mbs Useable
- USB 3. 3 Meters 5Gbs
- USB 4. Up to 40 Gbs
- Gigabit Ethernet Up to 1 Gbps
- 10G Ethernet

For Cables up to 15 Meters Long

- MIPI C-phy
- ASA Motion Link
- MIPI A-Phy
- Gigabit Multimedia
- Serial Link (GMSL)

RunCam WifiLink V2

RunCam receives DVI video input and transmits it wireless.
Completely open source hardware and software.

Maia SDR

- Adam Pluto Device
- Zynq FPGA + ARM SoC
- Amaranth HDL
- Python Language

Blade RF

BladeRF is a Software Defined Radio (SDR) platform designed to enable a community of hobbyists, and professionals to explore and experiment with the multidisciplinary facets of RF communication.

Blade RF

Recommendations

Camera Chip or ASIC with the needed functionality.

Cheapest Libmpix on Zephyr OS on a Microcontroller

Raspberry Pi MIPI-CSI to DVP to any FPGA. (1.5 Gbps DVP)

Lattice NX 17/33/40 with MIPI-CSI and DSI.

Questions?

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