**CMOS Camera specifications**

* **Product name:** *FL3-U3-120S3C-C Sony IMX172*
* **Resolution:** *4000 pixels x 3000 pixels*
* **Frame Rate:** *15 FPS*
* **MegaPixels:** *12 MP*
* **Sensor Format:** [In digital photography, the image sensor format is the shape and size of the image sensor.](https://en.wikipedia.org/wiki/Digital_photography)
  + ***Type - 1/2.3”***
  + ***Diagonal - 7.66 or 7.87 mm***
  + ***Width - 6.17 or 6.30 mm***
  + ***Height - 4.55 or 4.72 mm***
  + ***Area - 28.50 or 29.73 mm***
* **Pixel size: *1.55 𝝻m x 1.55 𝝻m (microns)***
* **ADC(Analog to Digital Conversion):** ***12 bit*** *( 2^12 = 4096 levels)*
* **Quantum Efficiency:** Ratio of electrons generated during digitization of photons
  + ***QE(blue): 60%***
  + ***QE(Green): 72%***
  + ***QE(Red): 51%***
* **Signal:** Charge in well (Well = the pixel area)
  + Function of the light reflected from the object’s surface(photons/ 𝝻m2) incident on the CMOS sensor which in turn depends on the irradiance of the LEDs
* **Temporal Dark Noise:** Error associated with signal measurement
  + ***TDN = 3e (measured as electrons as unit)***
* **Gain range:** The setting that controls the amplification of the signal from the camera sensor
  + ***0 dB to 24.5 dB***
* **Dynamic Range:** Ratio of noise and signal (there are many kinds of noises - Dark noise, shot noise etc) Here the noise considered is Temporal Dark noise
  + ***66.46 dB***
* **Exposure Range(Electronic shutter time):** The minimum time it takes for some photons to be incident and product a signal. If the shutter is closed on before the minimum time specified then we would get a black image.
  + ***Minimum time: 0.162 ms = 0.000162 s***
  + ***Maximum time: 0.99 s***

These measurements are ideal for freezing extremely fast subject motion and also for low light image capturing. Based on the time window we have ~300 ms our image capturing capabilities lie in between this range.

* **Camera interface ability:** Digital interface via USB 3.0
  + **Pin interface** : 8 pin GPIO configuration can be done on a Raspberry Pi.
  + **OS requirements :** Linux (Kernel of Raspberry Pi is identical version of a Linux OS but a stripped down version - meaning removing all the heavy features of a full fledged OS and only keeping the required functions)
* **Image buffer:** 32 MB

(If this memory is less, then it is the scenario where you have to wait for the camera to save the image and can’t click another image till the previous one is saved) This functionality here depends on the size of image(MB) captured during our experimentation.

(Generally an image 4000 x 3000 pixels would account for an image size of ~5MB, hence we can 5 images back to back until a point where we have to wait for the camera to save the image)

* **Color Processing:**  On-camera in YUV or RGB format, or on- PC in Raw format
* **Sensitivity to Near Infrared:** CMOS sensors can detect wavelengths such as 850 nm but their sensitivity goes on decreasing as the wavelength increases(0 at 1100 nm)

This sensitivity is as measured as QE/ Dark noise.

An answer on some forum when I was looking for CMOS’s sensitivity to NIR or IR:

*“A camera doesn't really convert from infrared to visible light. The camera will record the intensity of light on each pixel. If you filter out the non-infrared light then the intensity distribution that remains will be the infrared. This just makes a grayscale image where the high and low ends are usually arbitrarily assigned to white and black respectively.*

*Most cameras allow one range of light (Red, green and blue ranges usually) to fall on the camera pixels at a time, and then reconstruct the color image from the intensity of each range at each pixel”*

**White LED Specifications**

* **Product name: MWWHL4 Thorlabs Warm white LED**
* **Color:** *Warm White*
* **CCT (Correlated Color Temperature):** Defines the color appearance of a white LED. (Measured in Kelvin)
  + ***3000K***
* **Test Current/Max Current:** *1000 mA*
* **Electrical Power:** *3000 mW*
* **Viewing angle:** *120o*
* **Emitter size:** *1mm x 1mm*
* **Power output:**
  + ***Typical: 570 mW***
  + ***Max: 640 mW***
* **Forward Voltage:** 
  + ***Typical: 2.85 V***
  + ***Max: 3 V***
* **Max Irradiance:** To avoid confusion people call it **INTENSITY**
  + ***9.4 𝝻W/mm2***

**NIR LED Specifications**

* **Product name: M850LP1 Thorlabs NIR LED**
* **Color:** *Infrared*
* **Wavelength:** *850 nm*
* **BandWidth:** *30 nm*
* **Test Current/Max Current:** *1500 mA*
* **Electrical Power:**  *5770 mW*
* **Viewing angle:** *150o*
* **Emitter size:** *1mm x 1mm*
* **Power output:**
  + ***Typical: 1400 mW***
  + ***Max: 1600 mW***
* **Forward Voltage:** 
  + ***Typical: 3.35 V***
  + ***Max: 3.85 V***
* **Max Irradiance:** To avoid confusion people call it **INTENSITY**
  + ***19.4 𝝻W/mm2***