A Survey of CCD's Used In Astro-Video Cameras

by

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Table of Contents

List of Figures

List of Tables

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Sony Corporation (www.sony.net) for their CCD data sheets.

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1.0 Introduction

The field of Video Astronomy grows day by day, with new cameras coming on to the market at an ever increasing rate. The growing list of astro-video camera manufacturers and models is providing amateur astronomers with more choices, but it is also making it more difficult to choose the right camera for one's particular application. An important component in an astro-video camera is the sensor, which in most cases is a Charge-Coupled Device (CCD). In an effort to help with the camera selection process, I have compiled this survey of CCD's which are used in commercially available astro-video and astrophotography cameras today. The list of CCD's presented here is by no means a complete list, but is at least representative of the range of CCD's in use today. I have limited my survey to Sony brand CCD's as they are the most common, and the technical data for these devices is readily available online.

2.0 Background

There are two main types of electro-optical sensors used in cameras: the Charge-Coupled Device (CCD) and the Complementary Metal Oxide Semiconductor (CMOS). Each device goes about the business of converting photons into an electrical signal differently. The CCD was invented by Bell Labs in 1969, and consists of a silicon chip with an array of photosensitive sites called "pixels". Figure 1 illustrates a typical cross section of a CCD pixel. Note that later in this report the term "pixel size" refers to the "sensor aperture" shown in Figure 1, and the "chip size" divided by the "resolution" gives the "unit pixel" size which includes both the sensor aperture and the associated read-out circuitry.

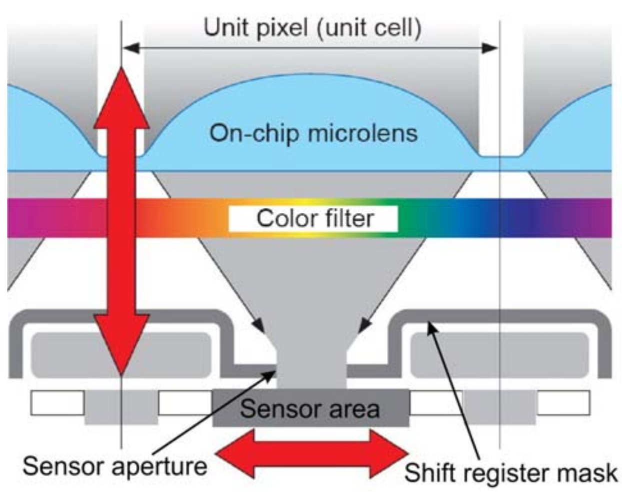

Figure 1 Cross Section of a CCD Pixel (courtesy Sony Corporation)

When a photon strikes a pixel in the array, it is converted to an electron which then accumulates in the pixel over the course of an exposure. At the end of the desired exposure time, the accumulated charge in each pixel is read out by moving the charges along the chip using a clock pulse timed shift register; basically a bucket brigade where each pixel's charge is passed along row by row and column by column until each pixel has been read (see Figure 2). As a result the CCD is an analog device, with its output often converted immediately to digital off-chip before further processing is applied. The disadvantage of the charge-coupled scheme is that CCD's have slower refresh rates than CMOS detectors. The advantage however is that they are more sensitive and have better pixel-to-pixel uniformity than CMOS. CCD's are also prone to blooming, where if the charge capacity of a pixel is exceeded the excess charge can spill over into neighbouring pixels. To improve the sensitivity of CCDs it is very common to use microlenses over each pixel. Sensitivity has been further improved by designing the photoreceptors to respond more efficiently in the red and infrared end of the spectrum, a technology developed by Sony called EXview. Another technological advancement patented by Sony is the Hole Accumulation Diode (HAD), an extra semiconductor layer below the surface of the CCD that accumulates stray charge on the chip, greatly reducing dark current noise.

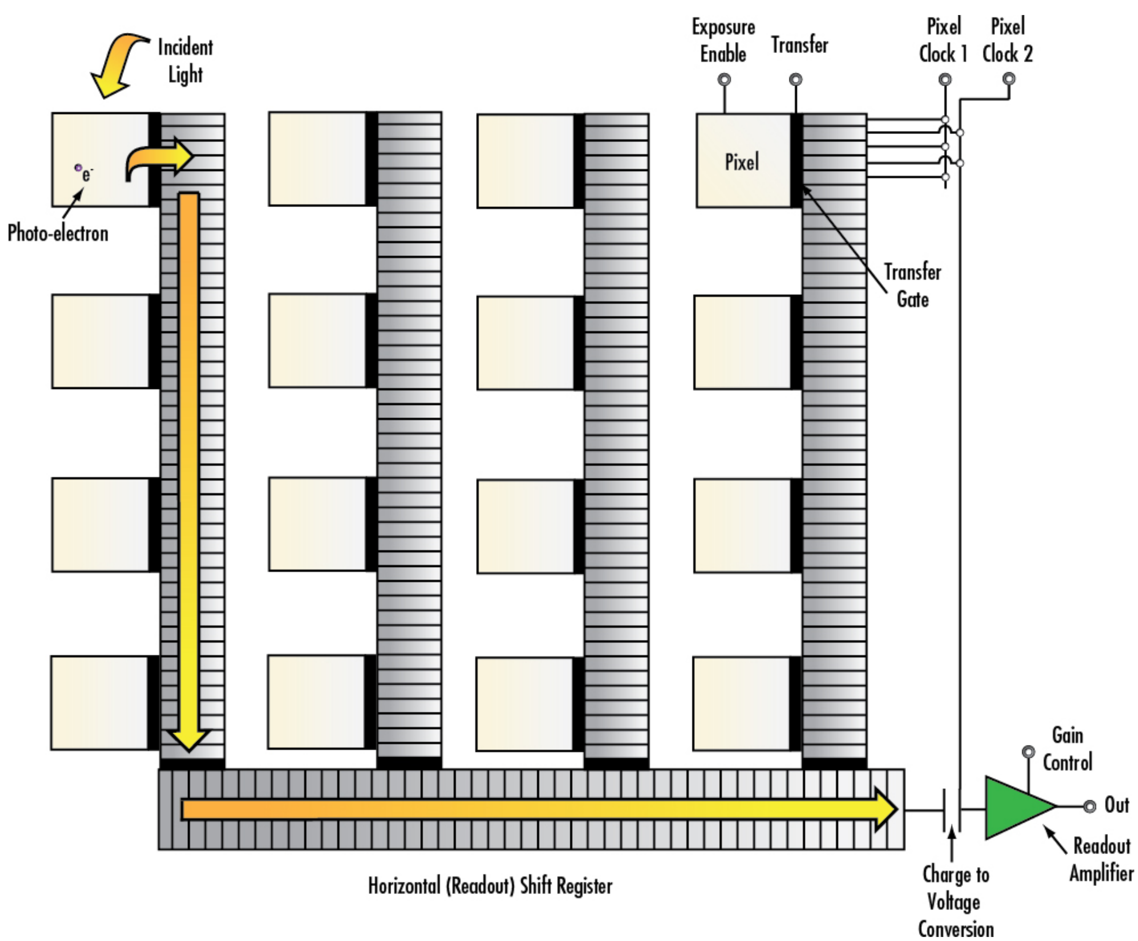

Figure 2 Block Diagram of a CCD (courtesy Edmund Optics)

The CMOS imaging sensor was invented by Frank Wanlass in 1963, but it did not see wide spread use in cameras until the 1990's. In a CMOS sensor the accumulated charge is converted directly to a voltage at the pixel site, and then is multiplexed by row and column to multiple on-chip digital-to-analog converters (DACs). As a result the CMOS sensor is an inherently digital device. Each pixel site on the chip is able to perform the task of resetting the pixel, amplification and charge conversion, and multiplexing, resulting in very high read speeds. The drawback of the design is high fixed-pattern noise due to difficulties manufacturing each of the thousands of voltage conversion circuits exactly the same. The multi-layer MOS fabrication process also does not allow for the addition of microlenses on the chip to improve sensitivity, making CMOS sensors generally much less sensitive than CCDs. CMOS sensors are better able to handle high light levels than CCDs without blooming, making them useful for high dynamic range applications. CMOS based cameras also tend to be smaller in size, and consume less power. Recent advances in CMOS technology, most notably the new Scientific CMOS (sCMOS) sensors, have greatly improved the signal-to-noise ratios that are achievable over earlier CMOS designs. As a result sCMOS sensors are slowly becoming more popular in astro-video cameras.

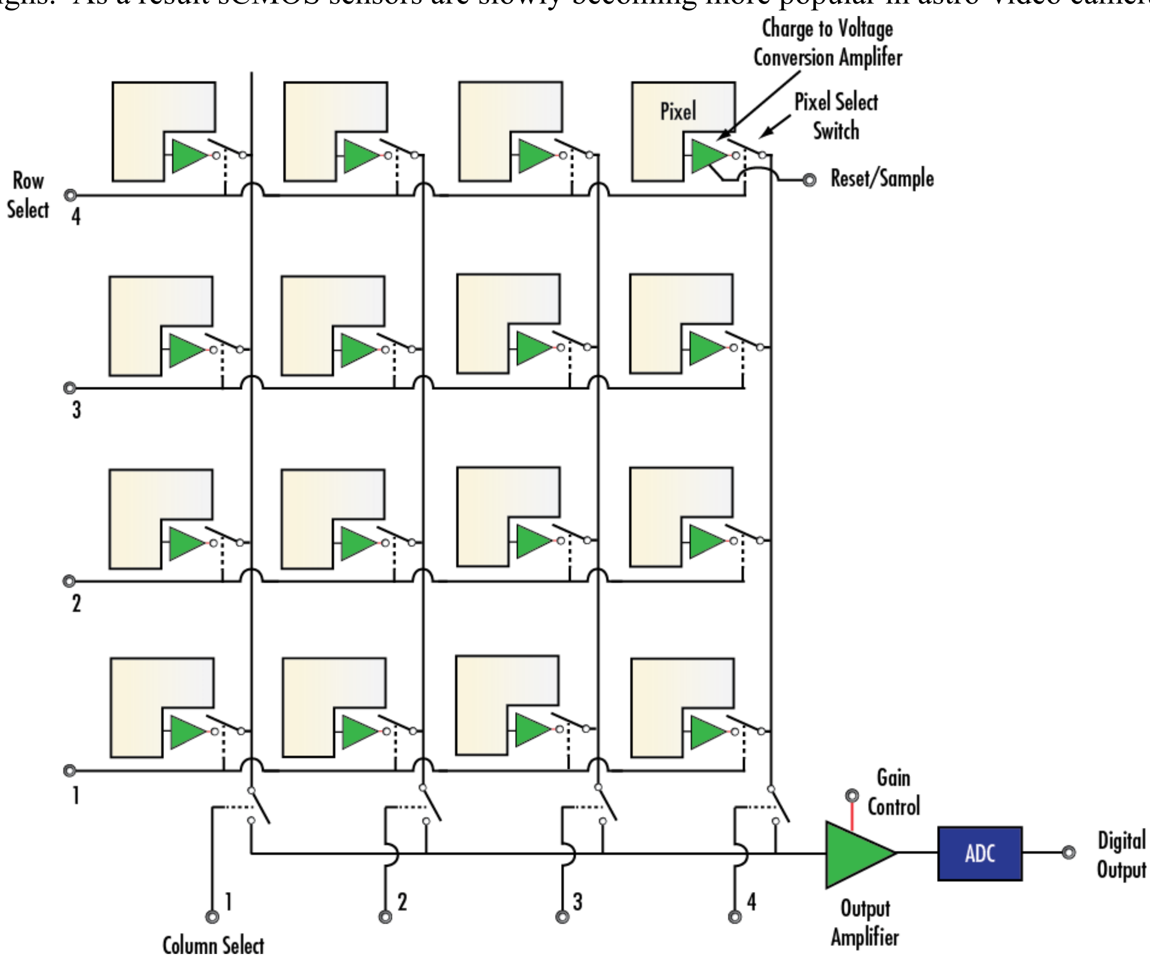

Figure 3 ***Block Diagram of a CMOS (courtesy Edmund Optics)***

In live video observing of deep-sky objects, sensitivity and low noise are key. As a result CCD based cameras currently dominate the astro-video market. The selection of the best CCD chip to use in a camera for video astronomy is not as simple as picking the one with the highest sensitivity, you also need to consider a number of other parameters:

- *Dark Current Noise*: When the sensor is hidden from all sources of outside light, there still tends to be a small signal detected. This signal is a result of stray electrical charge or heat given off by the rest of the CCD circuitry. The “dark current” rating on a CCD is a measure of this stray “noise”, with a lower dark current being better. When CCD’s are run continuously and/or at their maximum sensor well capacity, they generate a lot of heat which increases dark current noise. Having a low dark current is very important when trying to view low contrast targets like nebulae or galaxies. To achieve the best low noise signal from the CCD, chip cooling will likely need to be applied.
- *Pixel Size*: The pixel size is analogous to aperture in a telescope. A large pixel size will result in more light being brought in per refresh for that pixel, resulting in a corresponding increase in sensitivity of the sensor. When viewing dim objects the bigger the pixel size the better. If viewing solar system objects like the Sun or Moon however, resolving power is more important than sensitivity, so a small pixel size is better.
- *Resolution*: Within a fixed field of view, a higher resolution of pixels will result in more detail being visible. High resolution is very useful when viewing planets or the Moon where the surface details are numerous and small in size. Associated with a higher resolution is a larger burden on resources since the rate of data flow is higher per frame. As a result, large resolution cameras often have slower refresh rates.
- *Image Size*: The size of the image on the chip is a function of the pixel size and resolution of the CCD. When used with a telescope or lens system, the image size affects the field of view you will achieve. A larger image size will have a larger field of view for the same optics. For reference, the maximum diameter of the fully dilated human pupil is 7mm.

Later in this report I compare the above listed CCD characteristics amongst a list of commonly used Sony brand CCDs. I place a lot of emphasis on sensitivity as a point of comparison, but that really only tells part of the story. Tables and graphs from the CCD manufacturer can only tell us the potential of a particular chip. Once a chip is selected it is up to the camera manufacturer to design and build the supporting circuitry necessary to realize the CCDs full potential.

Figure 4 presents a schematic for a typical CCD astrovideo camera. Each component of the camera (not just the CCD alone) plays a vital role in the overall performance.

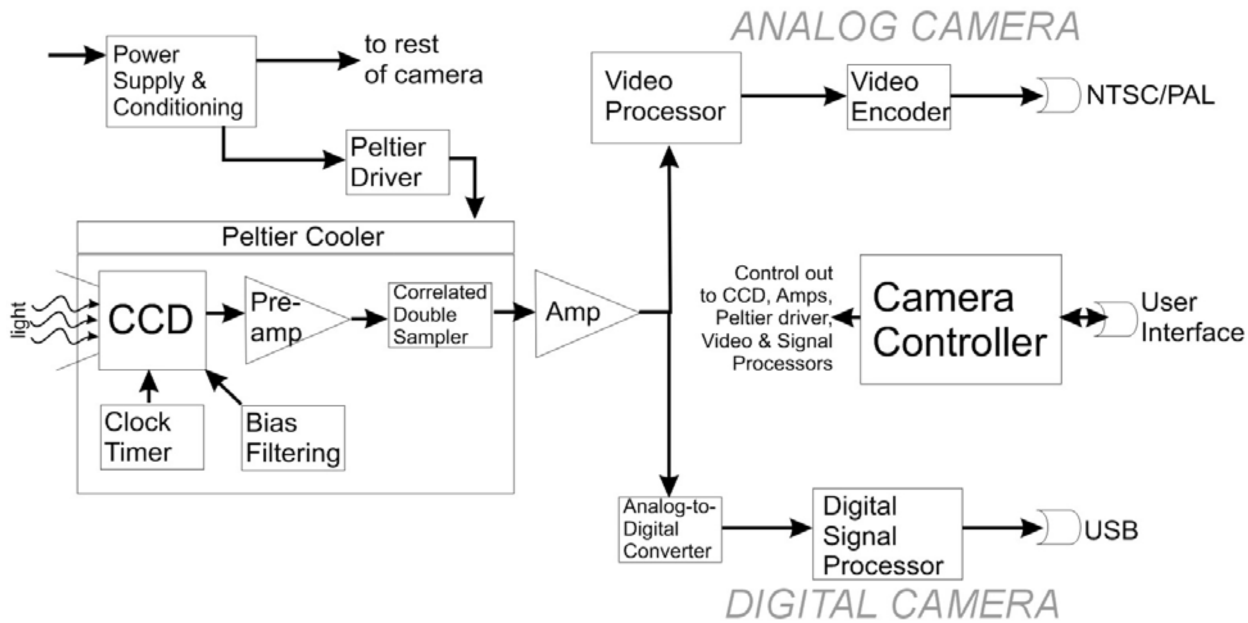

Figure 4 Typical Astro-Video Camera Schematic Diagram

Specific aspects of the camera design requiring careful attention include:

- *Cooling*: In order to reduce dark current noise many cameras use some type of sensor cooling. Inexpensive systems simply allow the CCD to conduct heat away through the circuit board and the limited amount of air inside the camera casing. More sophisticated cameras use custom designed thermal fingers to conduct heat directly from the CCD to the camera casing. The highest performing cameras have active sensor cooling using a Peltier cooler; a simple solid state electrical device that moves heat from a cool reservoir (the CCD) to a warm one (the camera casing) when you apply a DC current in the right direction. The design of the chip cooling system is very important to the performance of the camera. Top grade components must be used to ensure no noise is introduced to the camera signal. The level of cooling must also be carefully controlled in order to achieve the maximum cooling without overcooling and potentially cracking the CCD chip.
- *Duty Cycle*: Most components, whether electrical or mechanical, are designed to function at a rated performance level for some percentage of the time. For example an electric motor may be rated to deliver 1 hp output power, but will also have a percentage duty cycle associated with it. If the motor is used more frequently at full load than it is rated, its performance will gradually decline until eventually the motor fails entirely. The same is true of an astrovideo camera, which essentially operates at a 100% duty cycle. The constant generation of frame-after-frame, exposure-after-exposure in an astrovideo camera is much more taxing on the camera's components

than what a typical imaging camera would see. As a result careful design, component selection and assembly are necessary in order to ensure reliable and consistent performance.

- *Sensor Loading/Gain*: As mentioned earlier, running the CCD at or near its charge capacity generates a lot of heat and thus a lot of dark current noise. Additionally, running the on-chip output amplifier continuously at high gain results in additional heat which shows up in the sensor image as "amp glow". Amp glow and dark current noise is reduced in imaging cameras by reducing the gain and sensor loading, thus trading away sensitivity for a cleaner image. In an astrovideo camera, it is necessary to use all of the available sensor sensitivity in order to see dim objects live, so sensor loading and gain are typically run at maximum. The highest quality and best performing cameras allow the user to tune this balance between high sensitivity and noisy image.
- *Sensor Class*: As you may imagine, the mass production of CCDs is a complicated and expensive task. The cost to produce CCDs is kept reasonable by accepting the fact that there will be a range in the quality of CCDs coming off the assembly line. Statistically a large percentage of the chips produced perform at the average rated level, but the some perform either considerably better or considerably worse. CCD manufacturers categorize the sensors that come off their assembly lines into "classes" and price them accordingly. The class generally identifies how well the chip performs relative to its design specification. Class 0 is the best, and represents chips that exceed the design spec for sensitivity, dark current noise, and other factors such as "hot pixels". Hot pixels are pixels in the array that for some reason or another are not responding correctly and show up generally as a pixel that is always "on". Class 1 sensors are generally considered very good professional grade sensors. Inexpensive commercial cameras tend to have Class 2, 3 or 4 sensors as the class of sensor directly affects its cost. In order to achieve the highest sensitivity and lowest noise, Class 0 or 1 sensors are a must for astrovideo cameras.
- *Component Grade*: There are many other components in an astrovideo camera other than the sensor. There are amps, filters, video processors, voltage regulators, analog-to-digital converters, and much more. The quality and performance rating of these components used in the camera will directly affect its reliability and overall performance. The use of scientific Grade 1 electronic components over commercial grade can reduce electrical noise by as much as 50%. To have a reliable high performance astrovideo camera, it is worth the extra cost to have Grade 1 components.
- *Enhancement Circuitry*: There are numerous opportunities in the design of an astrovideo camera to add special customized circuitry that would not be found in a standard CCD camera, which has the purpose of further improving the performance of the camera. Circuits that boost camera sensitivity (such as the Mallincam Hyper

circuit) or that recognize noise and further reduce it may be added to enhance overall camera performance. The designer of these enhancements must have an intimate knowledge of the capabilities of sensor and signal processing technology, as well as a clear understanding of what the video astronomer needs for performance in their astrovideo camera.

All of the above listed things must come together to produce an astrovideo camera.

3.0 Scope

My main interest is in comparing the base sensitivities between the various CCD chips used by astro-video camera manufacturers. The spectral sensitivity data provided by Sony in their technical specs provide some information about CCD performance, but that data is normalized and non-dimensional, so comparing one chip to another directly is not possible. Also, sensitivity data for the colour versions of the CCD's in the infrared band are not provided in the Sony data, but it is for the black and white (b+w) versions. The objective of this report is to take the available technical data for the CCD's used in astro-video cameras, and process it into a form that will allow direct comparison between them. That means extrapolating the spectral responses into the UV and IR bands, and properly scaling the curves into absolute values of sensitivity. Note that this report can only compare the sensitivity "potential" of each CCD. After that it is up to the camera manufacturer to design a suitable camera around the sensor in order to fully realize the CCDs potential.

Table 1 below lists the CCD's included in my survey, as well as the camera(s) in which they are commonly used. My list is not exhaustive, but gives you an idea of the range of cameras and CCD's that are commonly used today. Note that many of the cameras in Table 1 are not purely astro-video cameras; they are mostly astrophotography cameras and auto-guiders (AG). Table 2 organizes the cameras listed in Table 1 by the application they were designed for. Although many of the imaging cameras have a "live view" capability, they are not designed specifically for video astronomy and so they perform poorly in that role. It is interesting to note that of the cameras I found information for, smaller megapixel cameras all seem to use a Sony CCD, and larger megapixel cameras all use a Kodak CCD. I have not been able to find the same level of technical information on Kodak CCD's as I have found for Sony CCD's.

CCD Model #	Technology	Camera(s)	Notes
Black & White			
ICX205AL	Super HAD	Imaging Source DMK41AU02.AS, Starlight Xpress Superstar AG mono, Lumenera SKYnyx 2-1 mono, ATIK 314E mono, Apogee Ascent A205 mono	
ICX274AL	Super HAD	Imaging Source DMK51AU02.AS, ATIK 420M, ATIK 320E, Lumenera SKYnyx 2-2 mono	
ICX285AL	EXview HAD	ATIK 314L+ mono, Starlight Xpress SXVR-H9, Farpoint OpticStar DS-145M ICE, Apogee Ascent A285 mono, Orion StarShoot Deep Space III mono	
ICX418ALL	HAD?	StellaCam3, Watec WAT-120N	
ICX424AL	HAD	ATIK Titan mono, Lumenera SKYnyx 2-0 mono	
ICX428ALL	EXview HAD	all b&w Mallincam models (MCHP, VSS, VSS+, Xtreme), QHY6	ICX429 is PAL version of ICX428
ICX618ALA	EXview HAD	Imaging Source DMK21AU618.AS	
Full Colour			
ICX205AK	Super HAD	Imaging Source DFK41AU02.AS, Starlight Xpress Superstar AG colour, Lumenera SKYnyx 2-1 colour, ATIK 314EC, Apogee Ascent A205 colour	I believe CCD also in Toshiba IK-WB11A but not confirmed
ICX274AQ	Super HAD	Imaging Source DFK51AU02.AS, ATIK 420MC, Lumenera SKYnyx 2-2 colour, ATIK 320EC	
ICX285AQ	EXview HAD	Orion StarShoot Deep Space III colour, ATIK 314LC+, Apogee Ascent A285C, FLI MLX285C	
ICX413AQ	Super HAD	Mallincam Universe*, Orion StarShoot Pro V2.0, Starlight Xpress SXVR-M25C, QHY8	also used in DSLR's like Nikon D40, used in scientific instrument cameras
ICX418AKL	HAD?	all colour Mallincam models except Junior (MCHP, VSS, VSS+, Xtreme), Orion StarShoot G3	ICX419 is PAL version of ICX418
ICX424AQ	HAD	ATIK Titan colour, Lumenera SKYnyx 2-0 colour	
ICX428AKL	EXview HAD	Mallincam Junior, optional on all other colour Mallincam models (MCHP, VSS, VSS+, Xtreme), Orion Starshoot Deep Space Video II**	ICX429 is PAL version of ICX428
ICX618AQA	EXview HAD	Imaging Source DFK21AU618.AS	

*Mallincam Universe uses a Class 0 scientific grade version of this model CCD (ICX413AQS).

**Camera doc's say Mintron 72S85HN-EX-R, but tech specs for the Mintron CCD match the Sony ICX428AKL.

Table 1 Sony CCD Models and Camera Used In

Deep-Sky Astrophotography	Solar System Live Video Observing/Imaging	Deep-Sky Live Video Observing	Auto-Guider
Black & White			
- ATIK 314E mono - Apogee Ascent A205 mono - ATIK 420M - ATIK 320E - ATIK 314L+ mono -Orion StarShoot Deep Space III mono - Starlight Xpress SXVR-H9 - Farpoint OpticStar DS-145M ICE - Apogee Ascent A285 mono - ATIK Titan mono - QHY6	- Imaging Source DMK41AU02.AS - Lumenera SKYnyx 2-1 mono - Imaging Source DMK51AU02.AS - Lumenera SKYnyx 2-2 mono - Lumenera SKYnyx 2-0 mono - Imaging Source DMK21AU618.AS	- StellaCam3 - Watec WAT-120N - Mallincam MCHP b+w - Mallincam VSS b+w - Mallincam VSS+ b+w - Mallincam Xtreme b+w	- Starlight Xpress Superstar AG mono
Full Colour			
- ATIK 314EC - Apogee Ascent A205 colour - ATIK 420MC - ATIK 320EC -Orion StarShoot Deep Space III colour - ATIK 314LC+ - Apogee Ascent A285C - FLI MLX285C -Mallincam Universe* - Orion StarShoot Pro V2.0 - Starlight Xpress SXVR-M25C - QHY8 - Orion StarShoot G3 - ATIK Titan colour	- Imaging Source DFK41AU02.AS - Lumenera SKYnyx 2-1 colour - Imaging Source DFK51AU02.AS - Lumenera SKYnyx 2-2 colour - Lumenera SKYnyx 2-0 colour - Imaging Source DFK21AU618.AS	- Mallincam Junior** - Mallincam MCHP colour - Mallincam VSS colour - Mallincam VSS+ colour - Mallincam Xtreme colour - Orion StarShoot Deep Space Video II	- Starlight Xpress Superstar AG colour

*Mallincam Universe has “live view” mode for live observing, some other cameras have limited live view capability

**Mallincam cameras also suitable for solar system live video observing

Table 2 Application CCD Cameras Designed For

4.0 Input Data

The Sony datasheets provide spectral sensitivity plots for each of the CCD models. Examples of the curves provided are shown in Figures 5 and 6. All of the spectral response data is normalized to have a peak “relative response” of 1.0. The SONY published curves for each of the CCD’s in this survey can be found in Appendix A. Also included in the SONY datasheets is information on sensitivity, dark current, and pixel size. This additional information has been summarized in Table 3. The “sensitivity calculation” column in Table 3 defines the equation used by Sony to convert the mV signal they measured during their testing into the “sensitivity” number quoted in their datasheet.

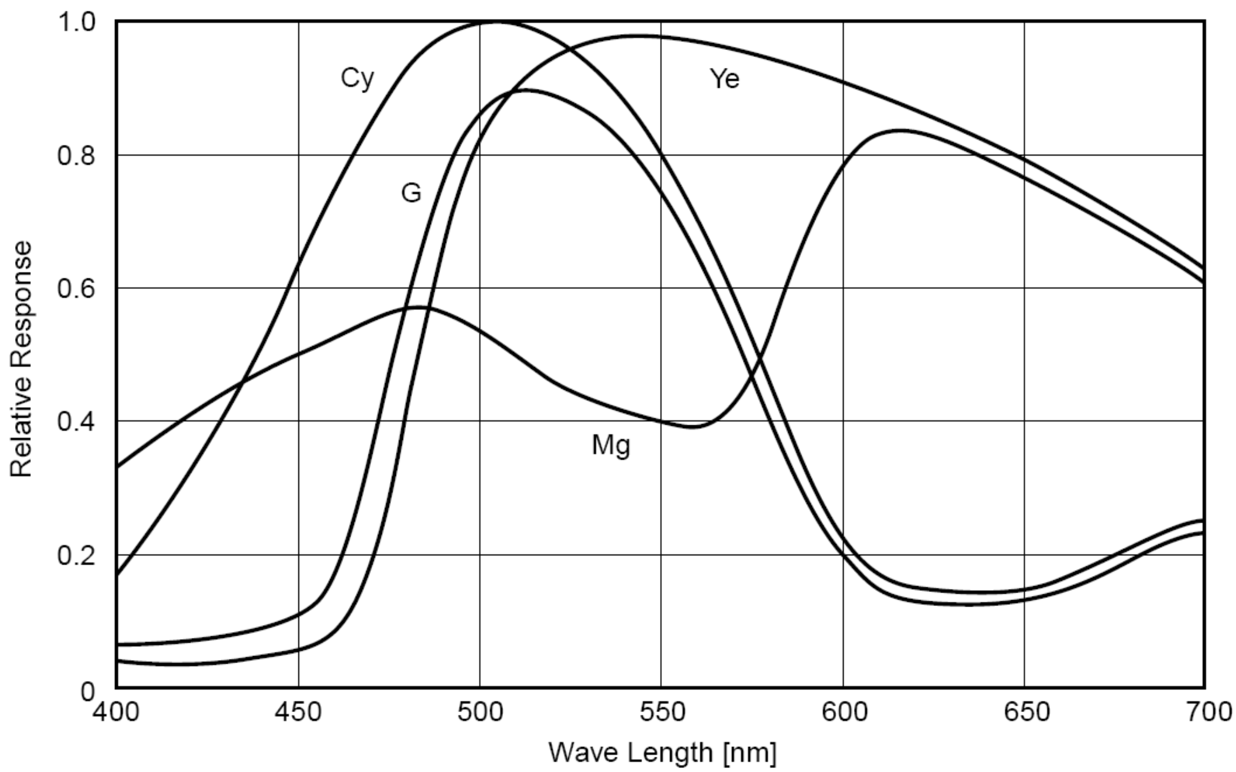

Figure 5 Spectral Sensitivity for ICX418AKL (colour)

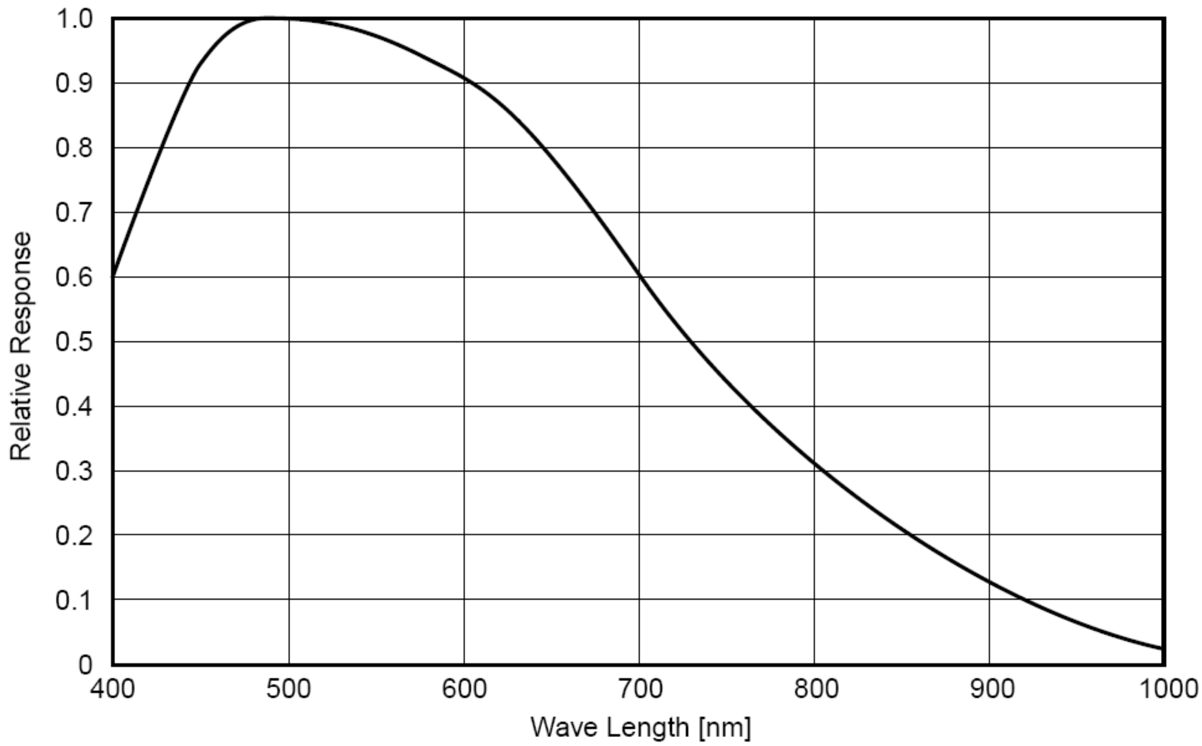

Figure 6 Spectral Sensitivity for ICX418ALL (b+w)

CCD Model #	Chip Size [mm]	Effective Resolution [pixels]	Pixel Size [µm]	Colour Matrix	Typical Sensitivity [mV]	Dark Current [mV]	Sensitivity Calculation
Black & White							
ICX205AL	8	1392x1040	4.65x4.65	mono	450	16	Vs * 250/30
ICX274AL	8.923	1628x1236	4.40x4.40	mono	420	8	Vs * 250/30
ICX285AL	11	1392x1040	6.45x6.45	mono	1300	11	Vs * 100/30
ICX418ALL	8	768x494	8.4x9.8	mono	1100	2	Vs * 250/60
ICX424AL	6	659x494	7.4x7.4	mono	880	2	Vs * 250/30
ICX428ALL	8	768x494	8.4x9.8	mono	1400	2	Vs * 250/60
ICX618ALA	4.5	659x494	5.6x5.6	mono	1200	4	Vs * 100/30
Full Colour							
ICX205AK	8	1392x1040	4.65x4.65	rgbg	400	16	avg(Vg)* 100/30
ICX274AQ	8.923	1628x1236	4.40x4.40	rgbg	420	8	avg(Vg)* 100/30
ICX285AQ	11	1392x1040	6.45x6.45	rgbg	1240	10	avg(Vg)* 100/30
ICX413AQ	28.40	3040x2024	7.8x7.8	rgbg	1000††	4	avg(Vg)* 100/30
ICX418AKL	8	768x494	8.4x9.8	cmyg	1300	2	Ys * 250/60†
ICX424AQ	6	659x494	7.4x7.4	rgbg	750	2	avg(Vg)* 100/30
ICX428AKL	8	768x494	8.4x9.8	cmyg	1600	2	Ys * 250/60†
ICX618AQA	4.5	659x494	5.6x5.6	rgbg	1000	4	avg(Vg)* 100/30

† Ys = (C + M + Y + G) / 2 †† Scientific grade version has sensitivity of 1250mV

Table 3 Sony CCD Physical Properties

5.0 Methodology

The sensitivity data provided by Sony is interesting, but it is not useful in the form presented in the datasheets. The method used to measure the sensitivity of each chip was slightly different in each case, and the definition of sensitivity changes depending on whether it is a colour or b+w chip. To convert the provided data into absolute sensitivity, which is directly comparable between sensors, I had to numerically reproduce the conditions of Sony's sensitivity measurement. Luckily Sony provided enough information to allow this to happen.

The measurement process consists of measuring the voltage output from the CCD when looking at a calibrated light source. In Sony's case, they used a halogen light source with colour temperature 3200K (see Figure 7). Sony also uses an industry standard IR cut filter during their measurements called a CM500S, for which I was easily able to locate the spectral response (see Figure 7). The resulting voltage output is passed through a simple calculation that accounts for shutter speed and other CCD settings in order to give the sensitivity values quoted in Table 3.

To back out the original measured sensitivity for each chip, I first combined the colour and b+w spectral response curves to come up with the total sensor response across the full spectrum, from 200 to 1200nm. I assumed the b+w curve as the limit under which the colour curves had to be, ie. the physical detector is the same regardless of whether it is colour or b+w with the only difference in response being due to the colour matrix filters. I made educated guesses as to the shape of the curve where there was missing information. An example of the resulting curves is shown below in Figure 8. Fitted curves for all the sensors can be found in Appendix B. On each curve the thin dotted lines mark where I've sketched in the missing data. The average response of the colour CCD is also shown with the orange line. Plotting the colour sensor curves together with the b+w curve helps to understand in general terms how much sensitivity is lost due to the addition of the colour matrix filters to the chip.

My next step was to pass the emission spectrum from the halogen light through the IR filter and then finally through my CCD full spectrum curves. When I add up the area under the remaining curve, it equals the sensitivity values in Table 3 times some constant. Once I've found that constant for each CCD, I can apply it directly to the original spectral response curves to scale them into absolute units of sensitivity.

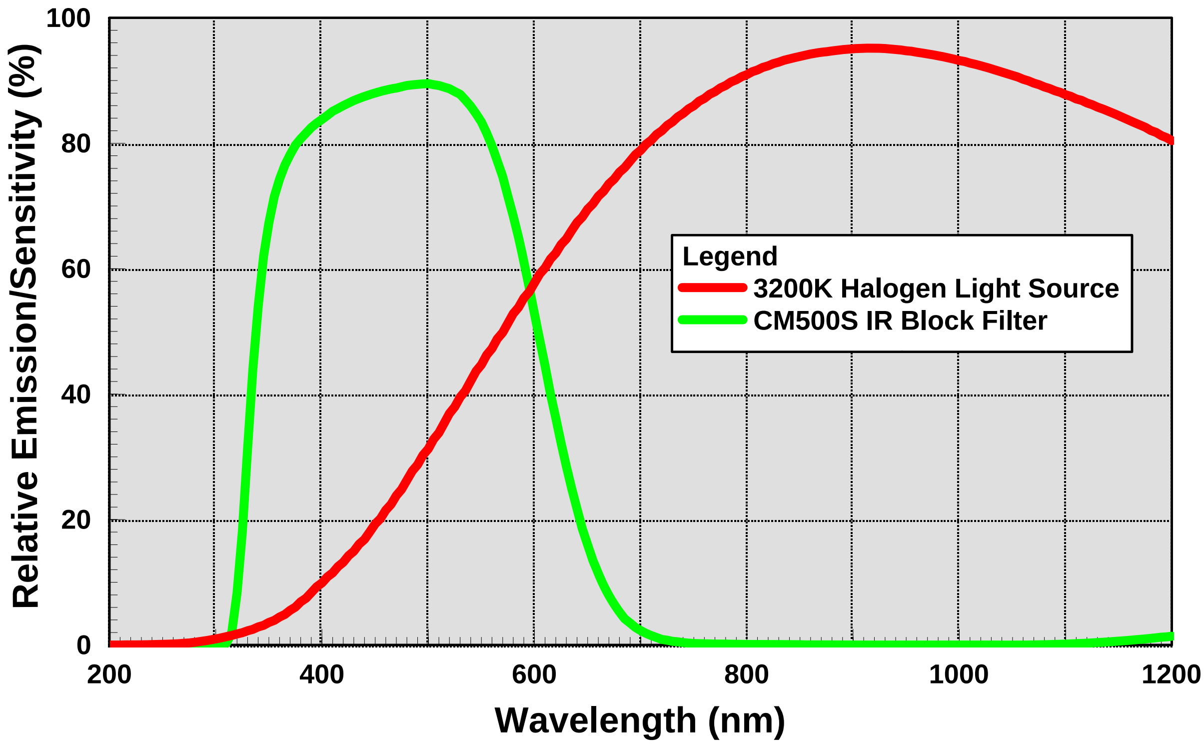

Figure 7 Spectral Emission from Halogen Light/Sensitivity of CM500S Filter

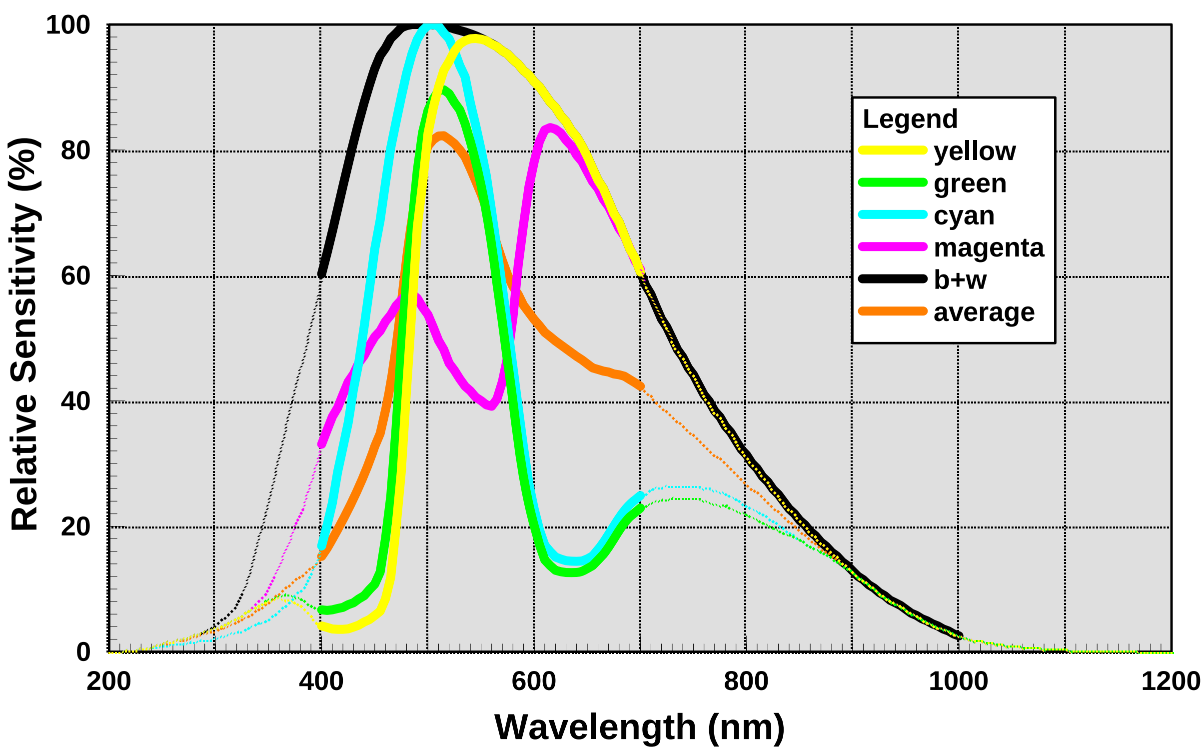

Figure 8 Full Spectral Sensitivity for ICX418AKL & ALL

6.0 Results

The result of my calculation is the spectral sensitivity of each CCD in absolute, and directly comparable terms. Figures 9 and 10 present the resulting spectral sensitivity for the b+w and colour CCD's respectively. Looking first at the b+w curves, we can see that all of the curves have generally the same shape but vary considerably in sensitivity. The variation in sensitivity is due in large part to the different pixel sizes as well as the technology being used (HAD, Super HAD, or EXview HAD). It is clear that the three CCD's that use EXview HAD technology are by far the most sensitive. The EXview HAD chips also tend to have their peak sensitivity shifted more towards the red end of the spectrum compared to other CCD's. Interestingly all the CCD's considered here have reasonably good sensitivity in the near infrared band (700 to 1000 nm), so users should take the time to consider how they are going to manage IR when using their camera.

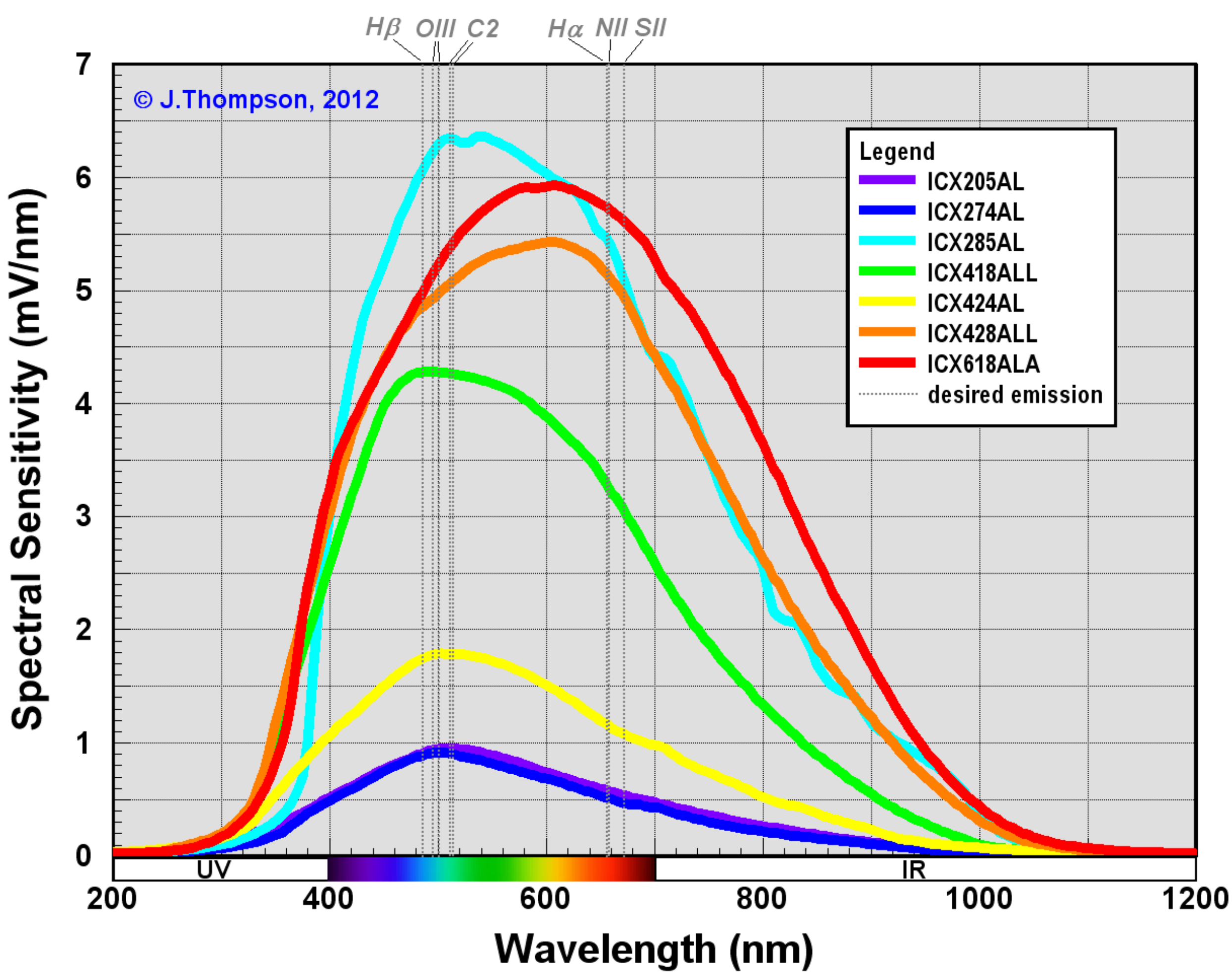

Figure 9 Comparison of Properly Scaled B+W Spectral Sensitivities

The colour CCD curves have a different shape than the b+w curves due to the combined effect of the colour matrix filters that have been applied to the chip. Depending on the colour matrix, RGBG (red-green-blue-green) or CMYG (cyan-magenta-yellow-green), the resulting CCD sensitivity is weighted more peaky on green (RGBG) or is spread out between cyan and red (CMYG). The more spread out spectral distribution of the CMYG chips seems to align better with the two nebula emission bands of interest, Hβ/O-III and Hα/N-II/S-II-alpha.

Another interesting change between the b+w and colour CCD curves is the large drop in sensitivity. The addition of the colour matrix filters to the CCD result in an unavoidable drop in sensitivity. For an RGBG matrix the loss in sensitivity is about 2/3, and for CMYG the loss is significantly less at around 1/3. As a result, the two EXview HAD chips ICX285 and ICX618 that were the most sensitive in their b+w version are less sensitive in their colour versions than the ICX428 EXview HAD chip or even the ICX418 non-EXview HAD chip.

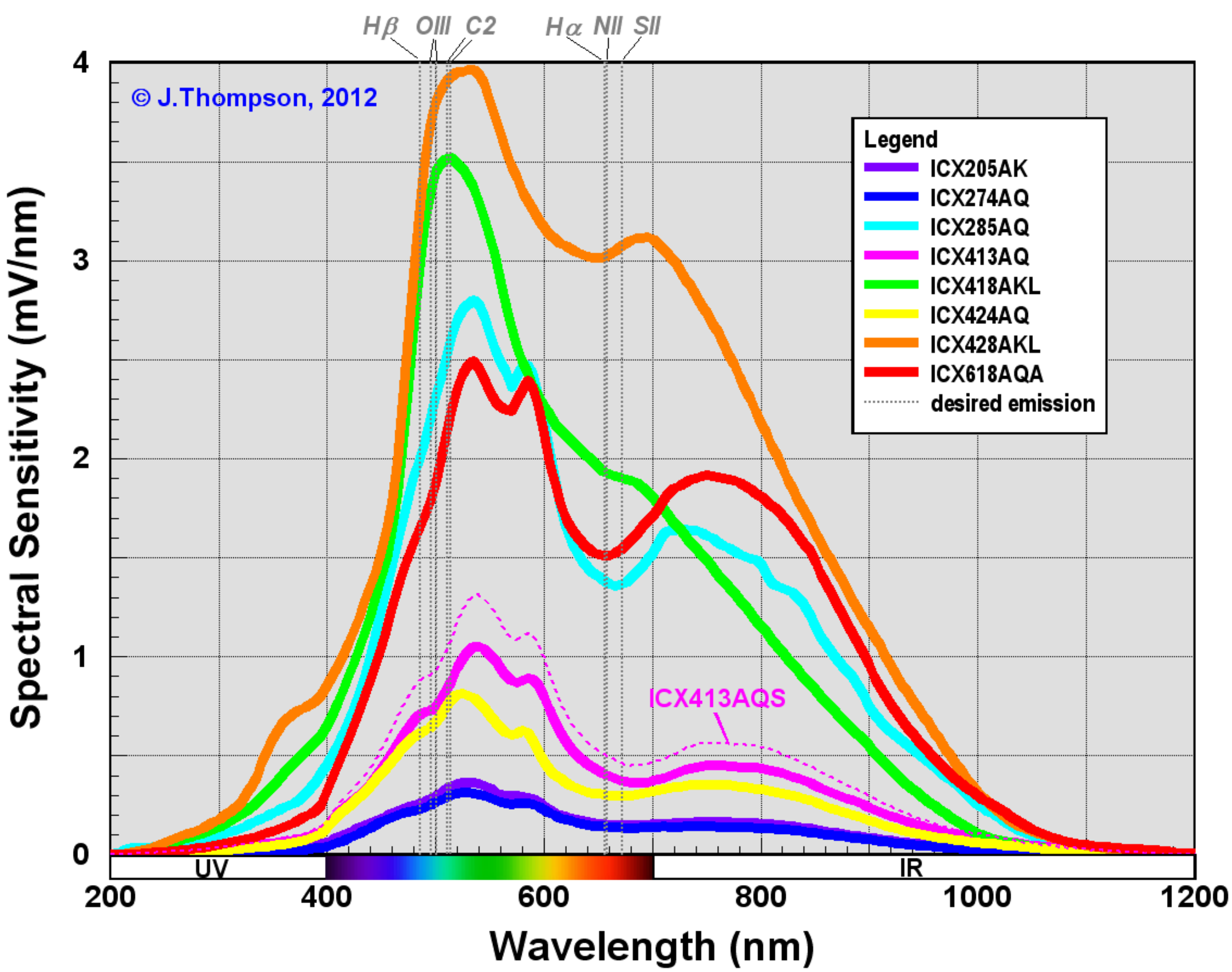

Figure 10 Comparison of Properly Scaled Colour Spectral Sensitivities

To help further compare the different CCD models, I have calculated from the spectral sensitivity curves how each sensor would respond to a number of different light sources:

- full CCD band, 200-1200 nm
- visual band, 400-700 nm
- light pollution band, 400-440 and 540-640 nm
- near infrared band, 700-1200 nm
- typical dual band LP filter, 470-510 and 650-670 nm
- typical Hα filter, 650-670 nm

Figures 11 and 12 summarize the results of this calculation for the b+w and colour CCD's respectively. The total CCD sensitivity (in mV) is plotted on a logarithmic scale to better allow for direct visual comparison between the chips and different wavelength bands. Tables of the plotted values can be found in Appendix C. Note that these total sensitivities do not include any signal boosting from electronic gain or Hyper circuitry, just the typical CCD response.

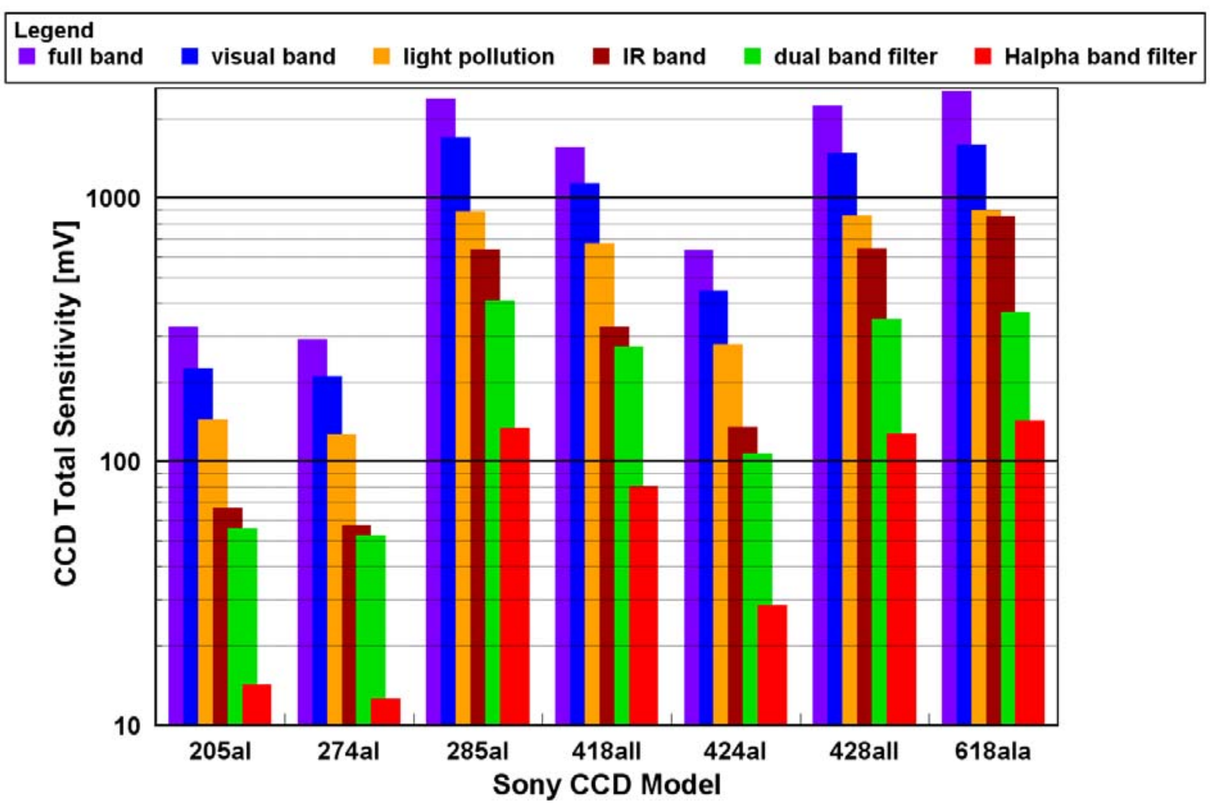

Figure 11 Sensitivity Comparison for Different Light Sources – B+W

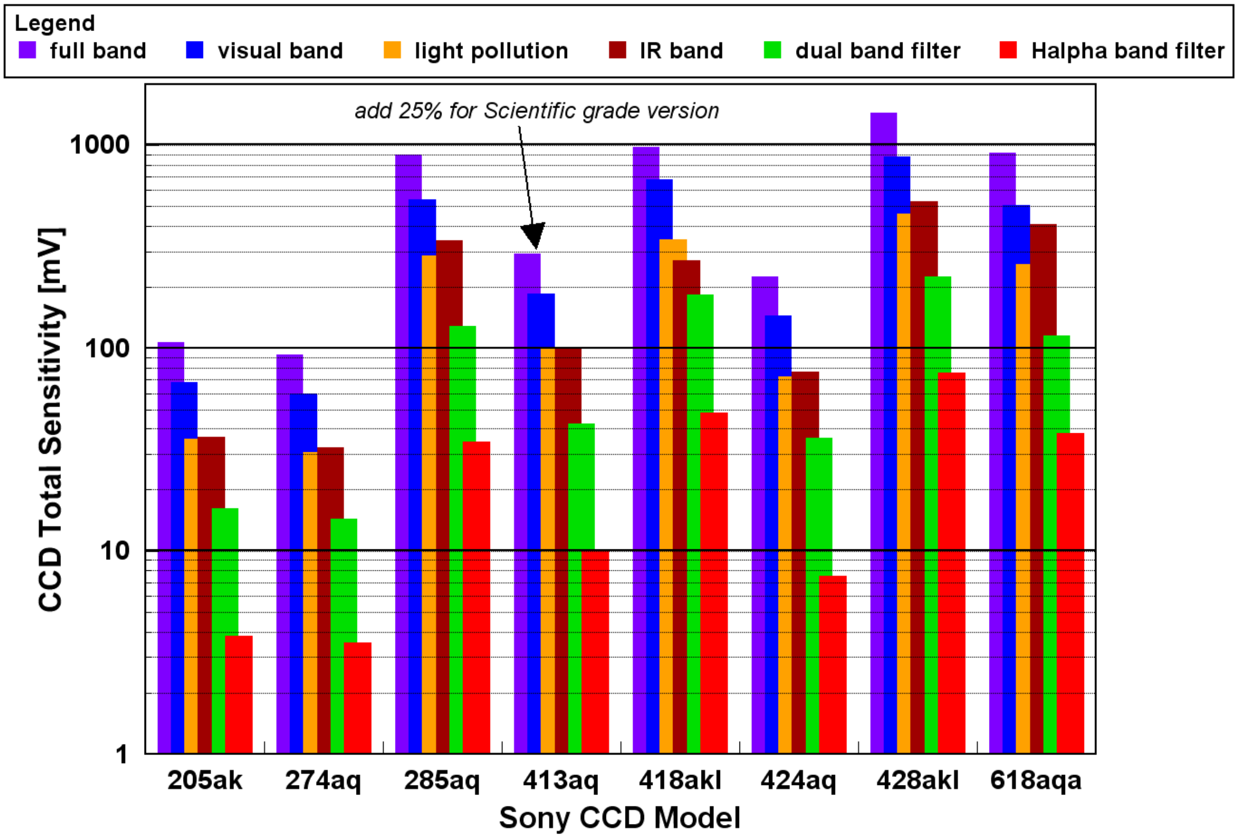

Figure 12 Sensitivity Comparison for Different Light Sources – Colour

I personally have a vested interest in the performance of the ICX418AKL as it is the CCD in my primary astro-video camera, a Mallincam Xtreme. Based on my analysis it would appear to be a superior choice both for sensitivity and dark current noise, second only to the EXview HAD ICX428AKL. Even if my camera was a B+W version, I would probably choose the ICX428ALL over the ICX285AL or ICX618ALA since the increase in sensitivity of the later two would not make up for the increase in dark current noise (also the ICX618 has only roughly half the field of view due to the chip size). As for planetary and lunar observation I recently upgraded from a camera with the ICX205AK sensor to one with the ICX274AQ sensor. The result was an increase in resolution, an increase in field of view, and a decrease in dark current noise, all of which I have found has resulted in a significant improvement in the quality of my images/video.

A newcomer in 2012 to the amateur astronomy market is the Mallincam Universe. It uses a Class 0 version of the scientific grade sensor ICX413AQS. It has a very high resolution with low dark current noise and sensitivity better than other high resolution CCD's. The pairing of the ICX413AQS CCD with an effective chip cooling system and the unique Hyper circuit to boost sensitivity, makes this camera a powerful contender in a sea of astrophotography cameras. The Universe's CCD is however roughly 1/3 as sensitive as that in the Mallincam Hyper, VSS, and Xtreme (non-EXview HAD), 1/4 as sensitive when using LP filters, so the Universe will never replace these cameras for live viewing of faint deep sky objects.

7.0 Conclusions

I hope that my results help to clarify somewhat the differences in sensitivity between the many different models of CCD commonly used in astro-video cameras. It is important to note however that pure sensitivity alone is not enough information to determine what camera will provide you with the best image. Dark current plays a very important role in the signal to noise ratio you are able to achieve. CCD's with low dark current values will provide very smooth noise free images. The dark current values quoted by Sony are all at a specific chip ambient temperature of 60°C. As the temperature of the chip rises, due to either self generated heat or the ambient conditions, so does the dark current noise. This noise can be minimized by cooling the CCD, but the cooling must be done correctly to avoid condensation or even failure of the sensor.

Equally important as the selection of the best CCD is the design and fabrication of the rest of the camera that houses it. A good chip requires equally good quality control (hot pixels!), signal conditioning, signal amplification, chip cooling, video post processing, etc. or else the camera will not be able to take advantage of the good chip. A good CCD chip in a low quality camera will likely give disappointing performance. A good CCD chip demands high quality all the way!

If you have any questions, please feel free to contact me at: karmalimbo@yahoo.ca.

Cheers,

Jim Thompson
AbbeyRoadObservatory

Appendix A – Sony Spectral Sensitivity Plots

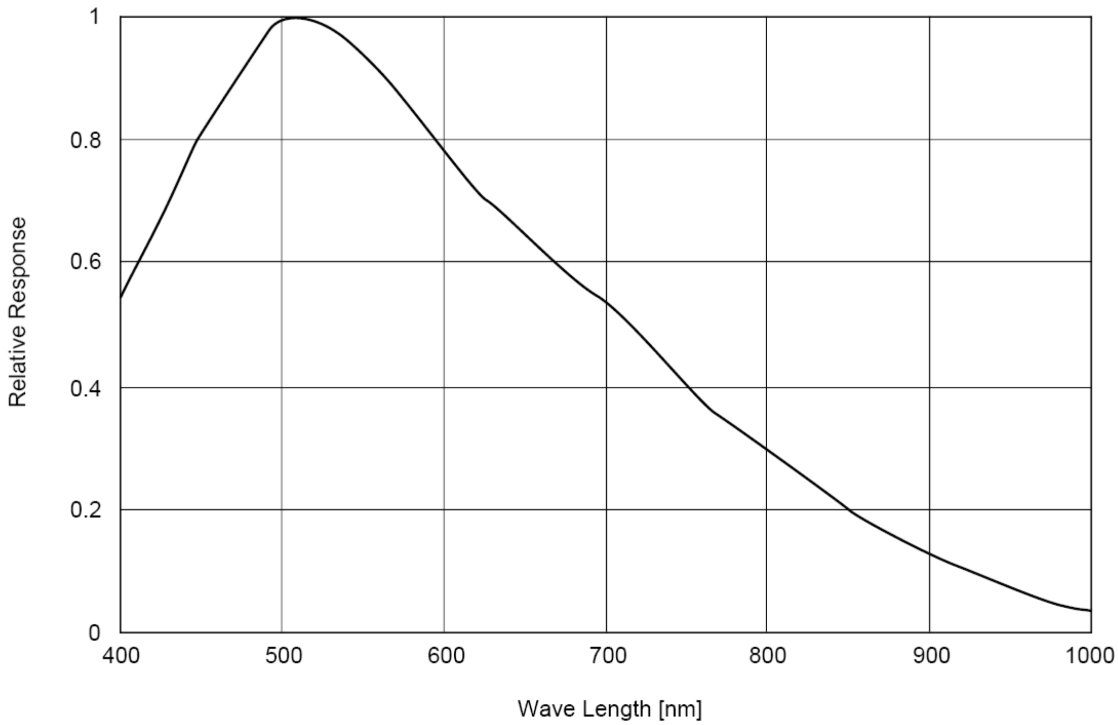

Figure A1 Spectral Sensitivity for ICX205AL (b+w)

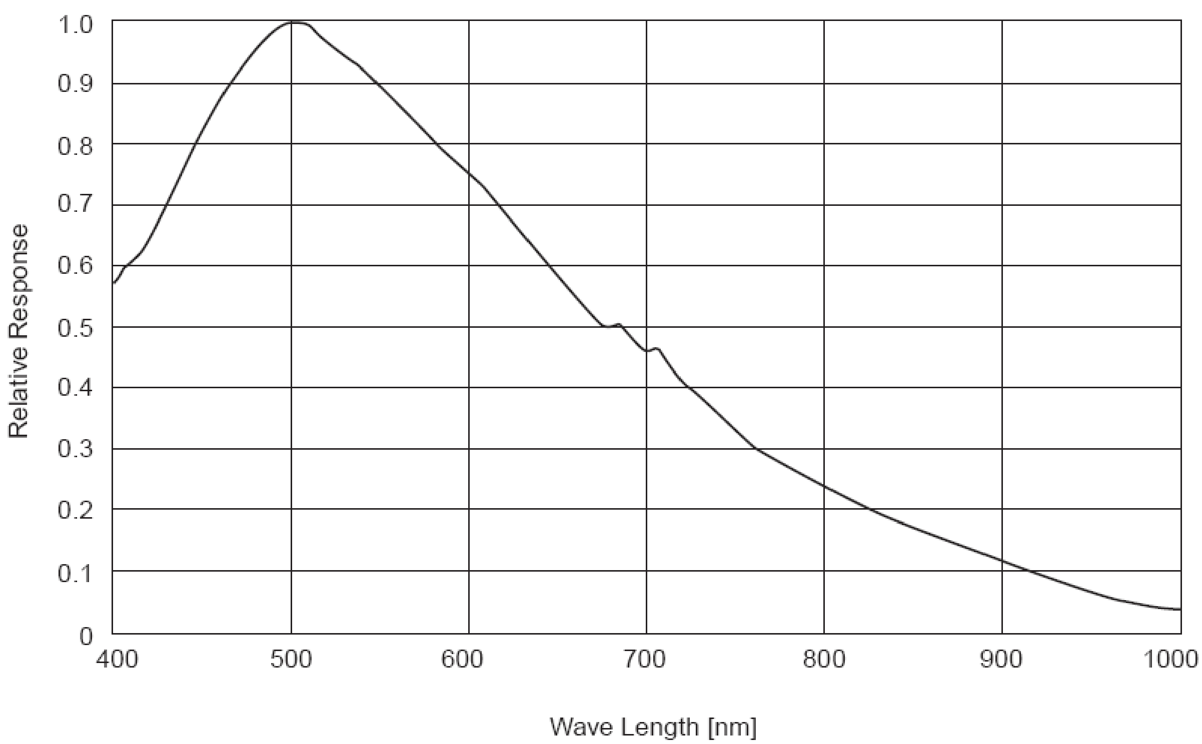

Figure A2 Spectral Sensitivity for ICX274AL (b+w)

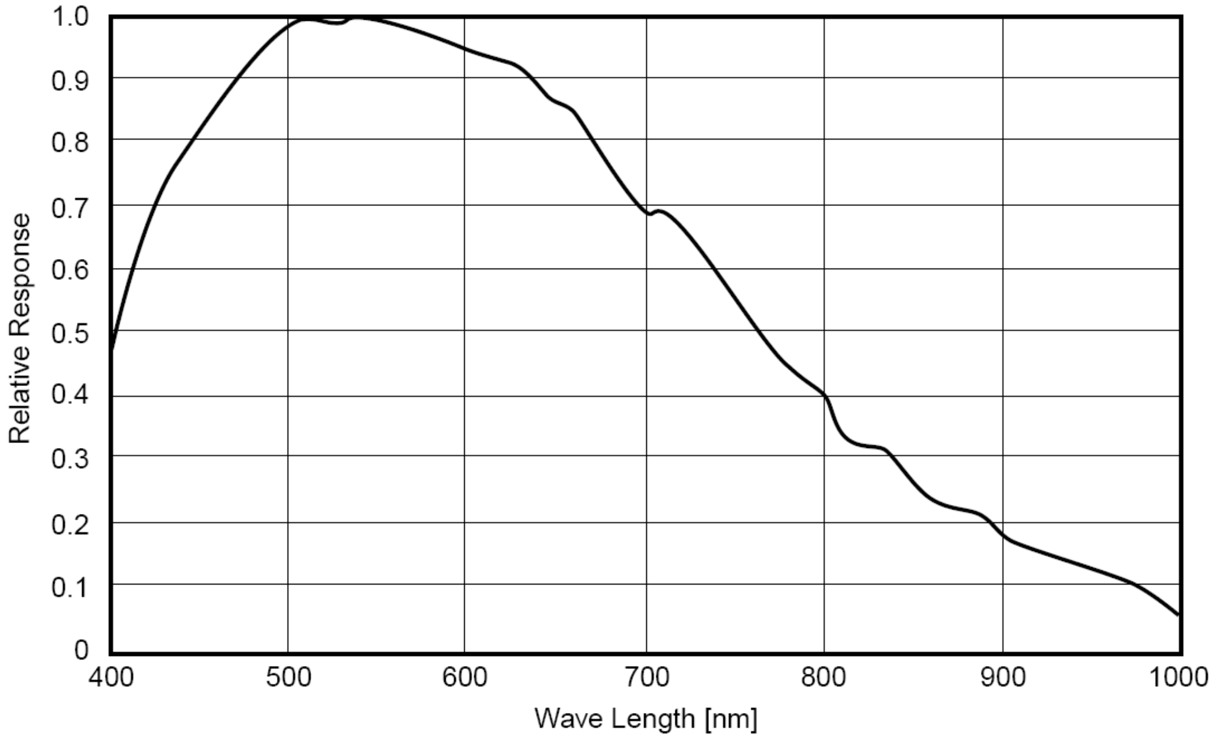

Figure A3 Spectral Sensitivity for ICX285AL (b+w)

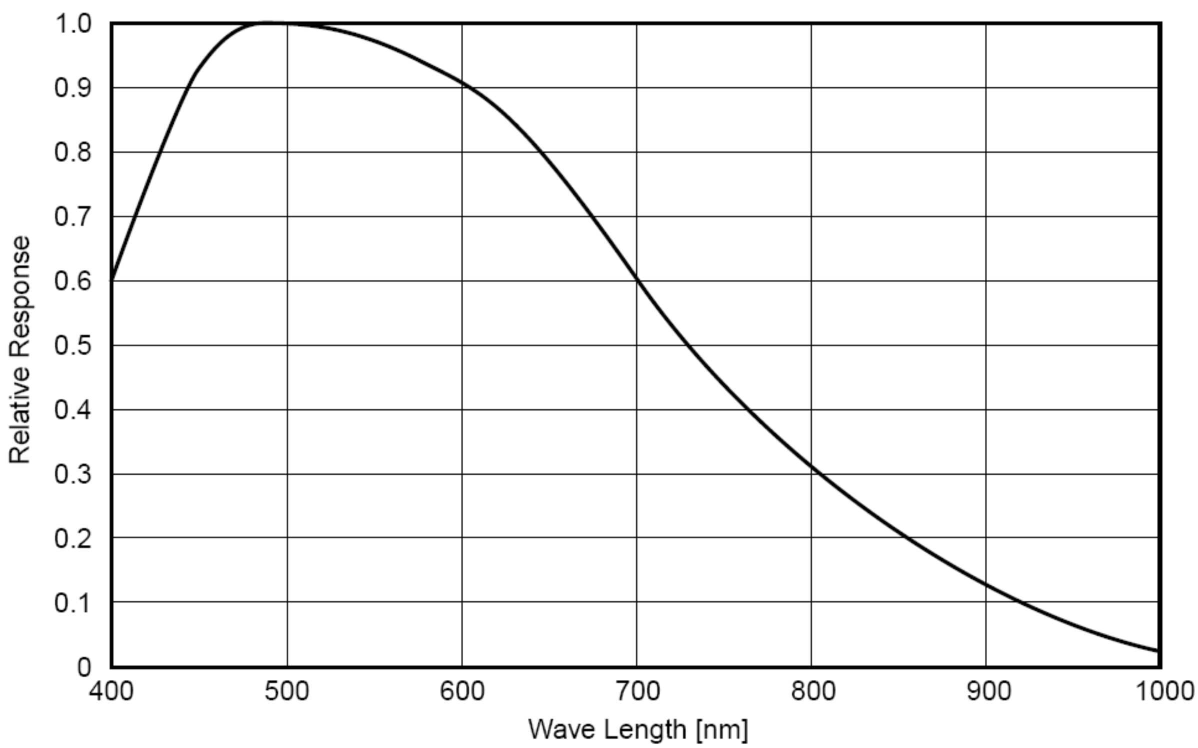

Figure A4 Spectral Sensitivity for ICX418ALL (b+w)

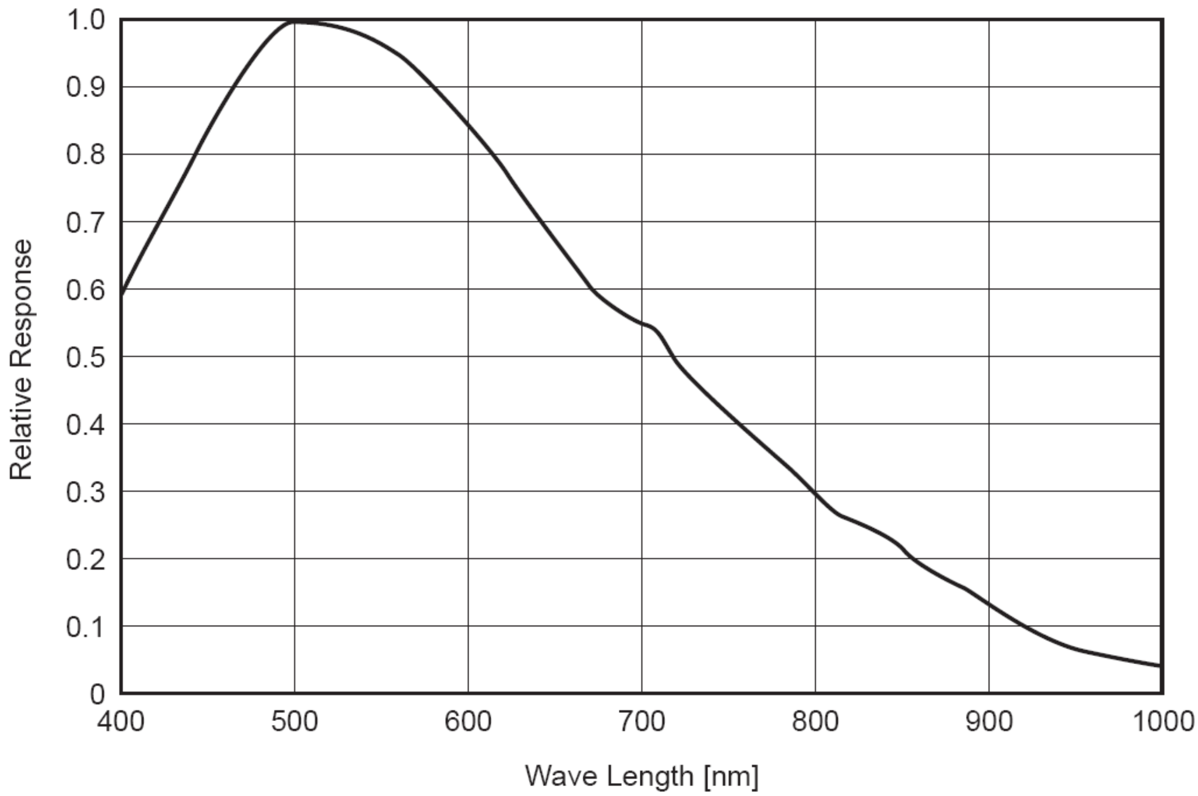

Figure A5 Spectral Sensitivity for ICX424AL (b+w)

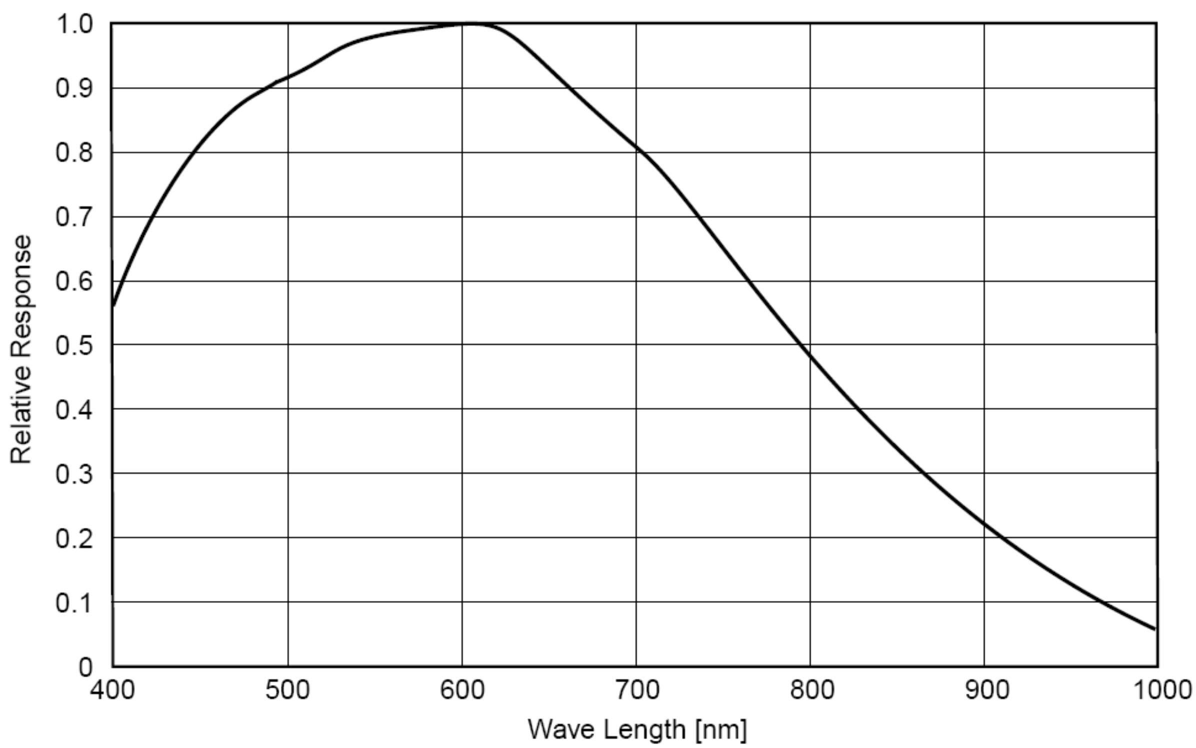

Figure A6 Spectral Sensitivity for ICX428ALL (b+w)

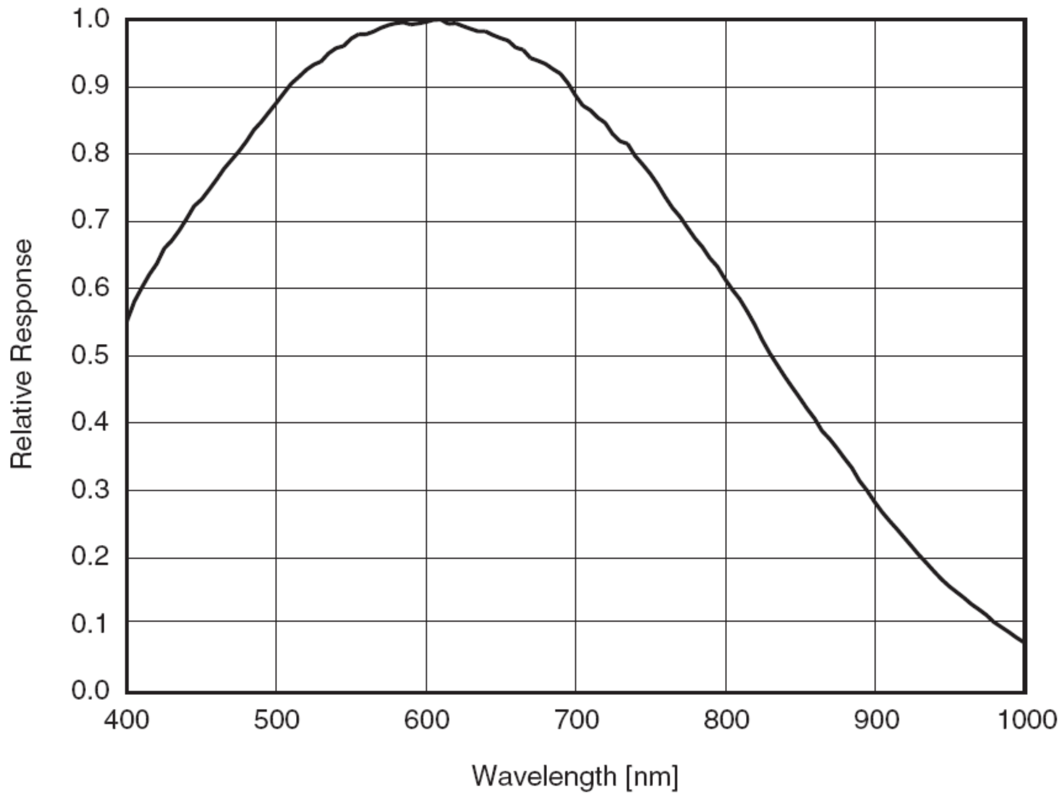

Figure A7 Spectral Sensitivity for ICX618ALA (b+w)

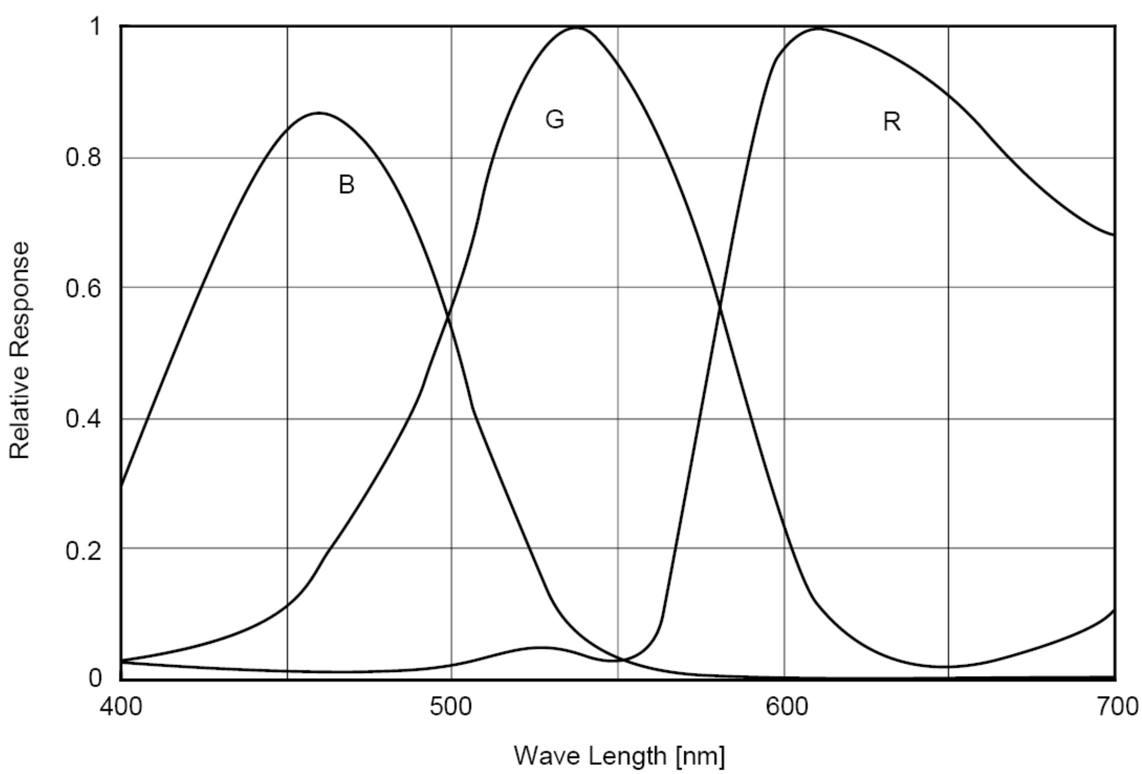

Figure A8 Spectral Sensitivity for ICX205AK (colour)

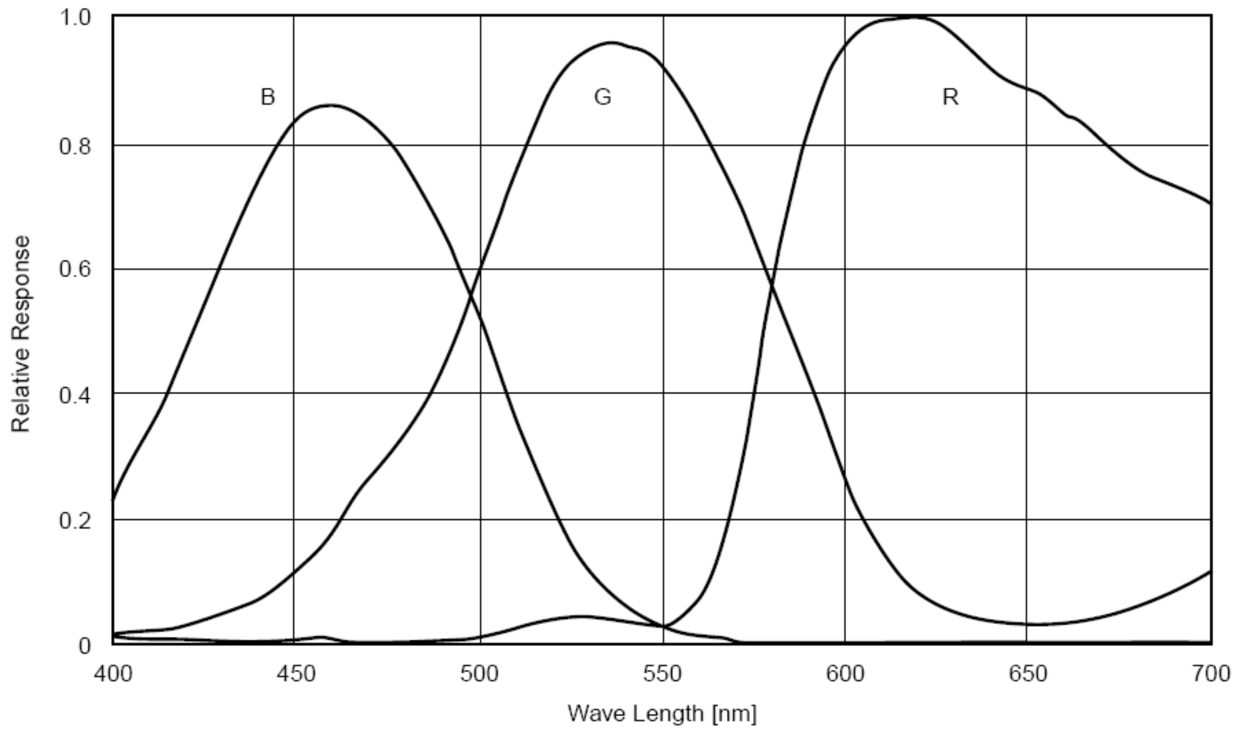

Figure A9 Spectral Sensitivity for ICX274AQ (colour)

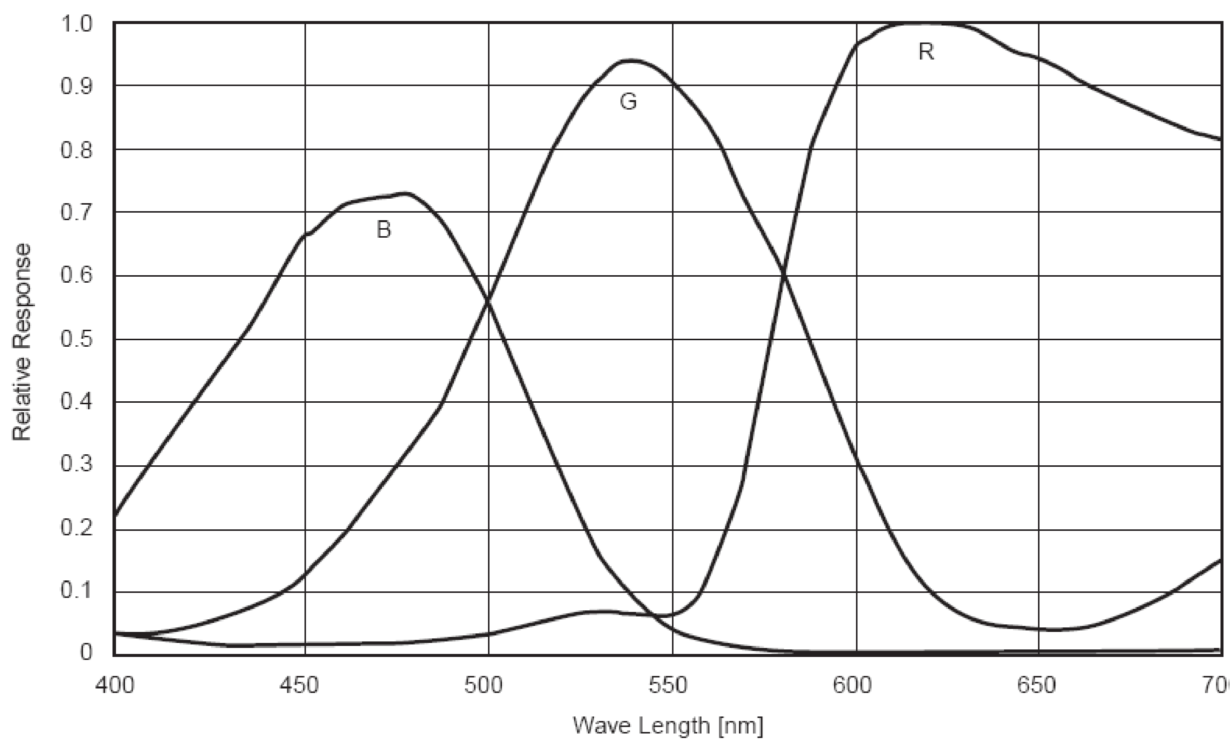

Figure A10 Spectral Sensitivity for ICX285AQ (colour)

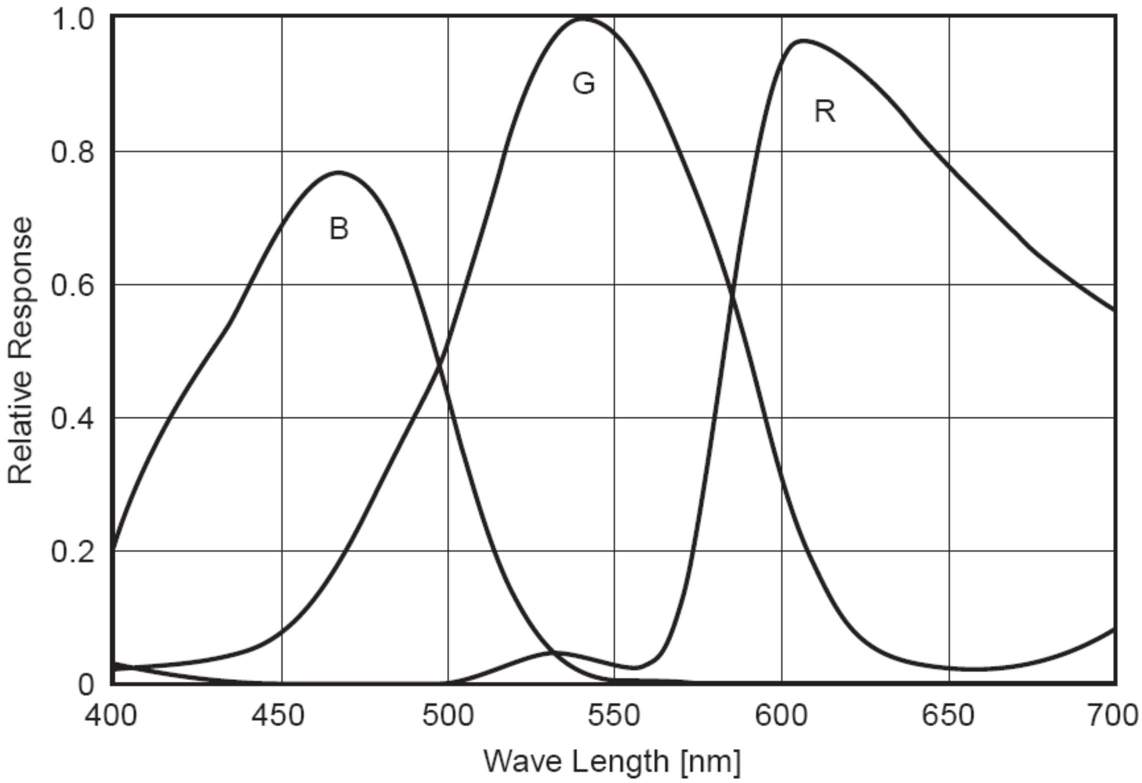

Figure A11   Spectral Sensitivity for ICX413AQ (colour)

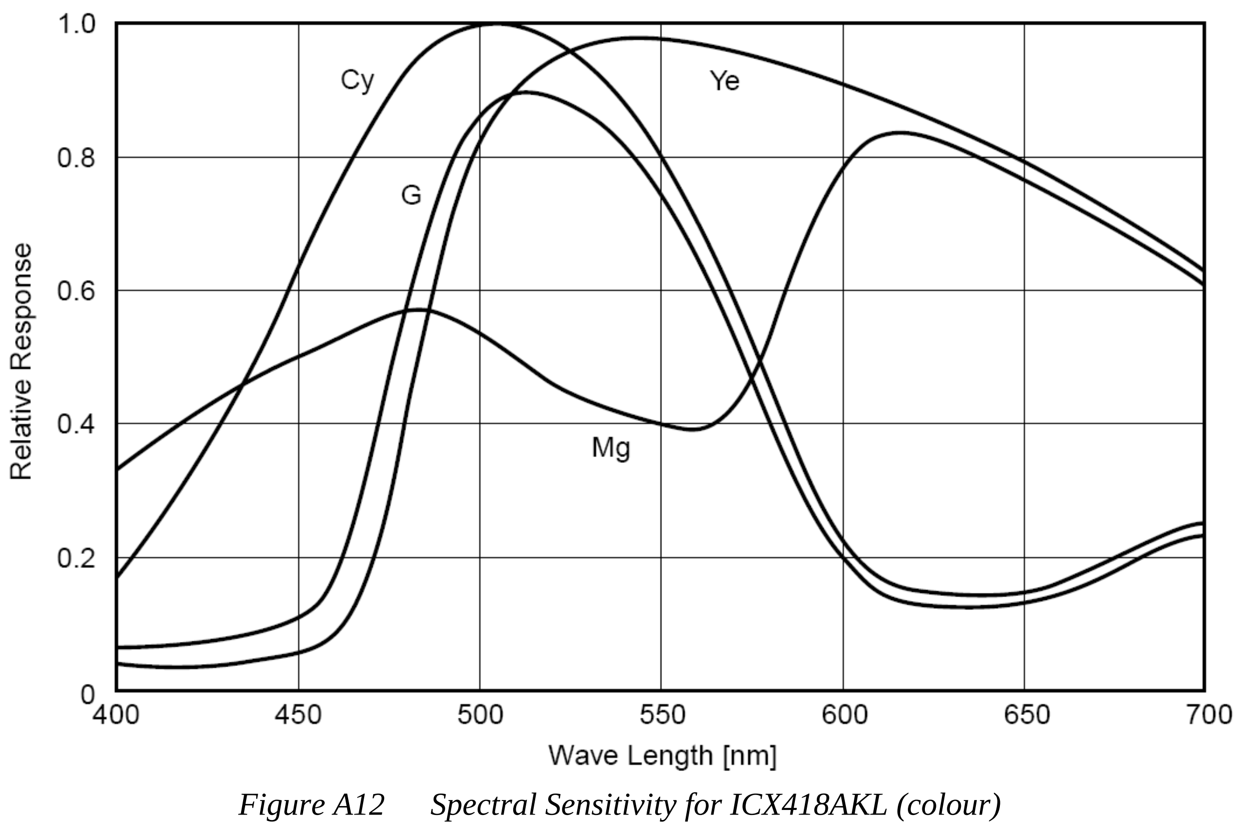

Figure A12   Spectral Sensitivity for ICX418AKL (colour)

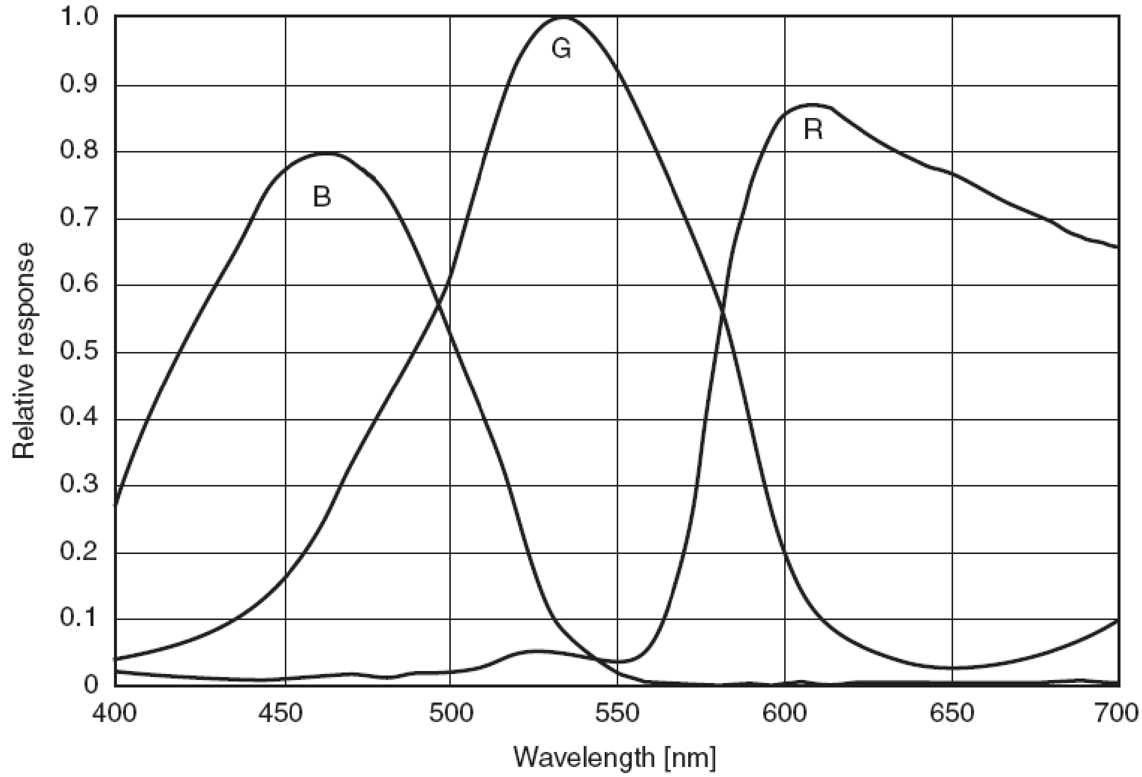

Figure A13 Spectral Sensitivity for ICX424AQ (colour)

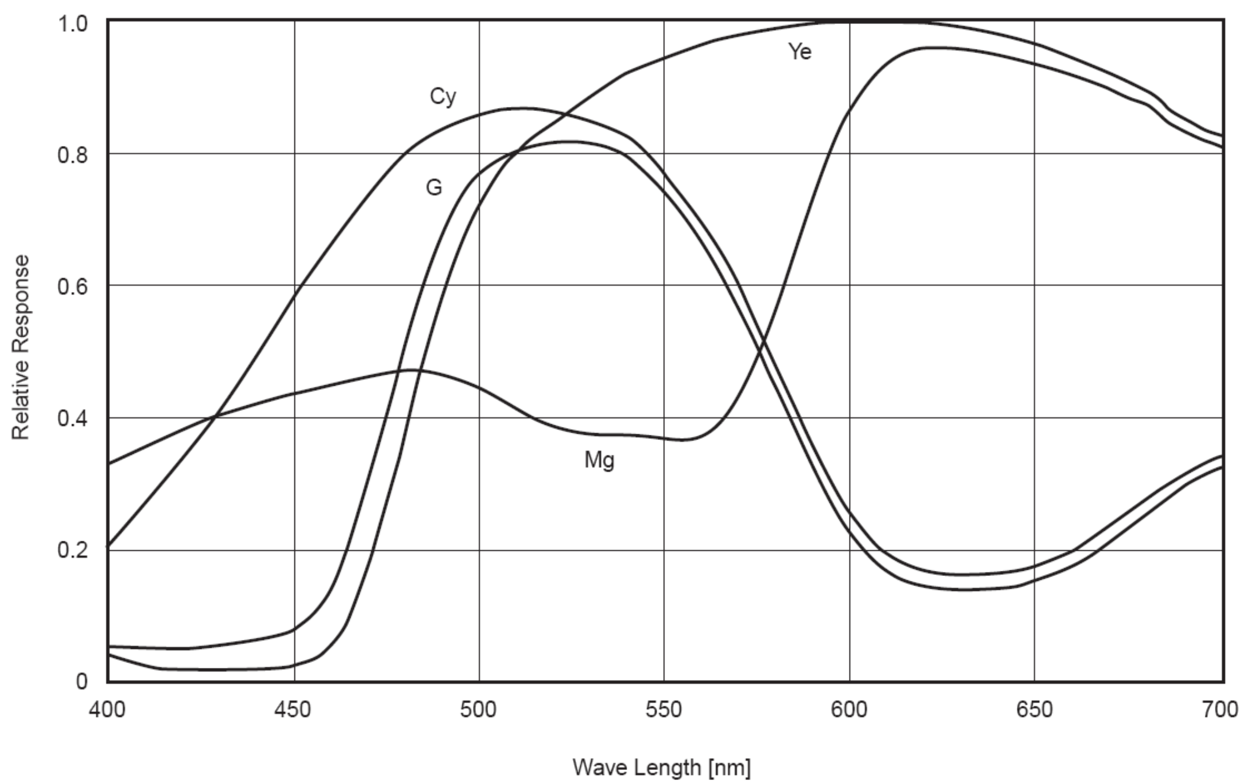

Figure A14 Spectral Sensitivity for ICX428AKL (colour)

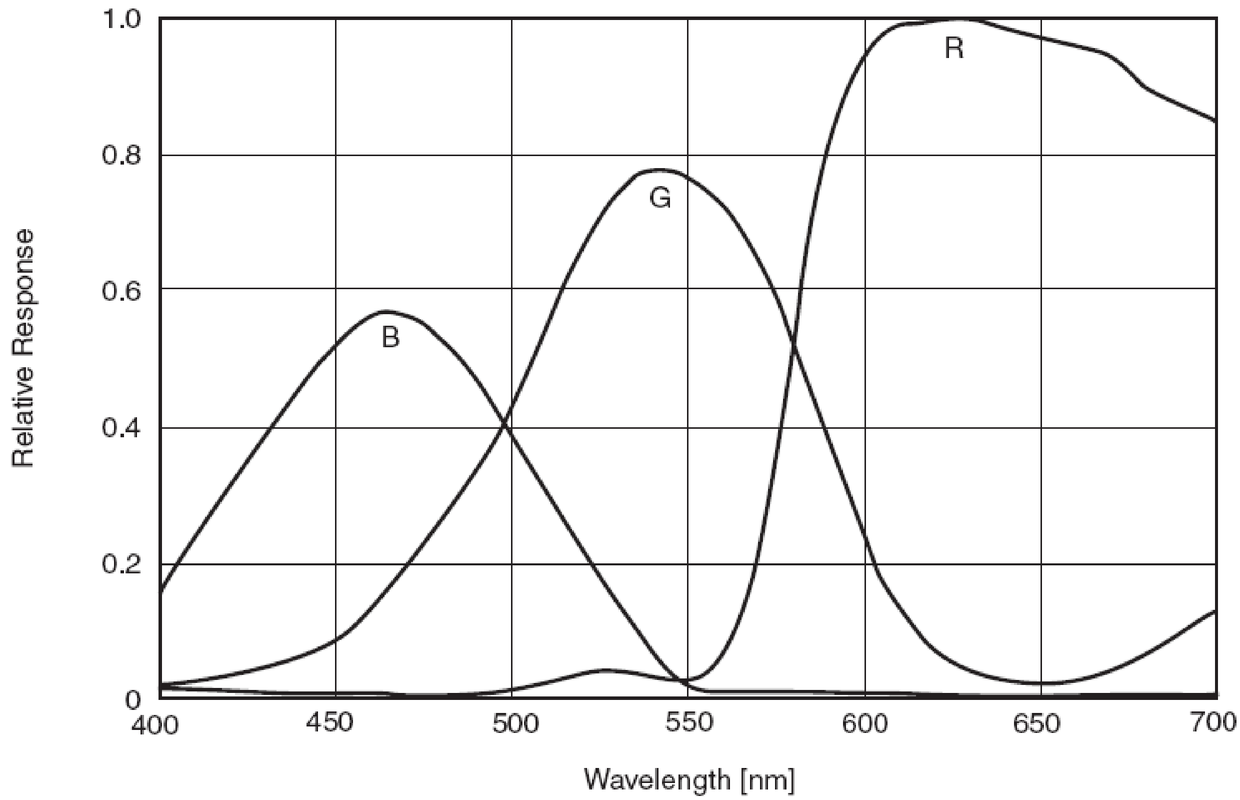

Figure A15 Spectral Sensitivity for ICX618AQA (colour)

Appendix B – Extrapolated Spectral Sensitivity Plots

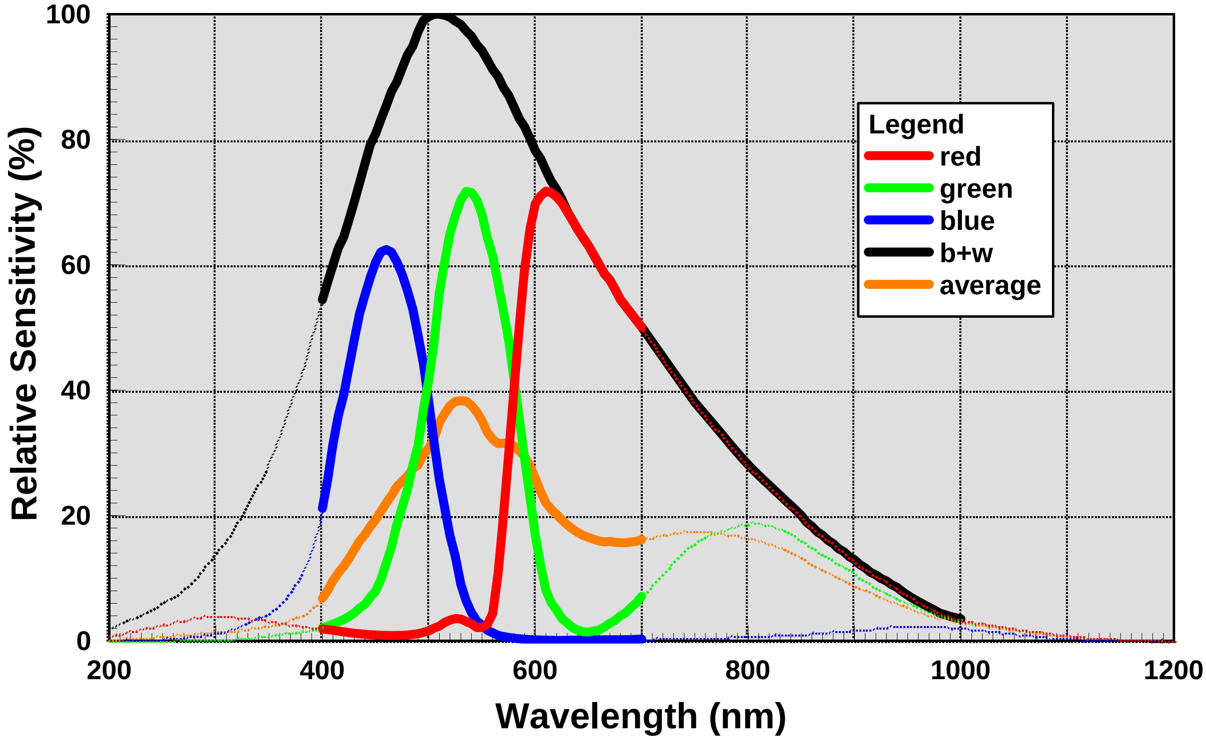

Figure B1 Extrapolated Spectral Sensitivity for ICX205

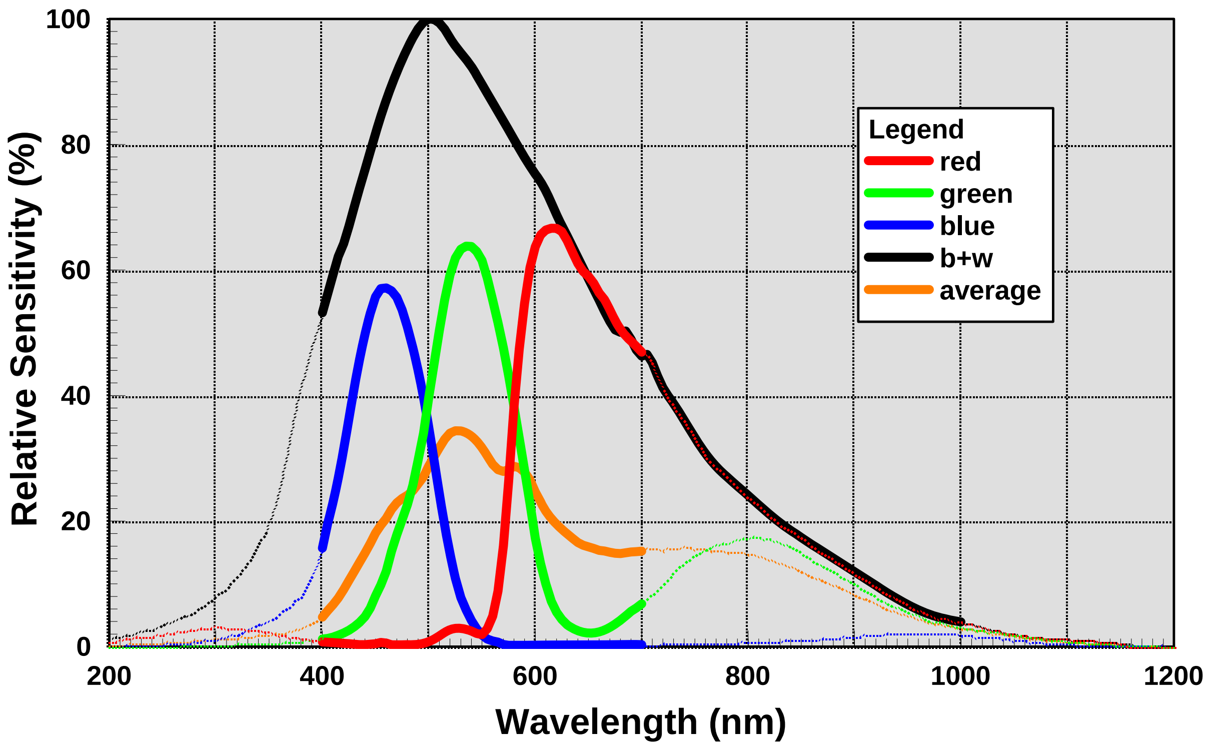

Figure B2 Extrapolated Spectral Sensitivity for ICX274

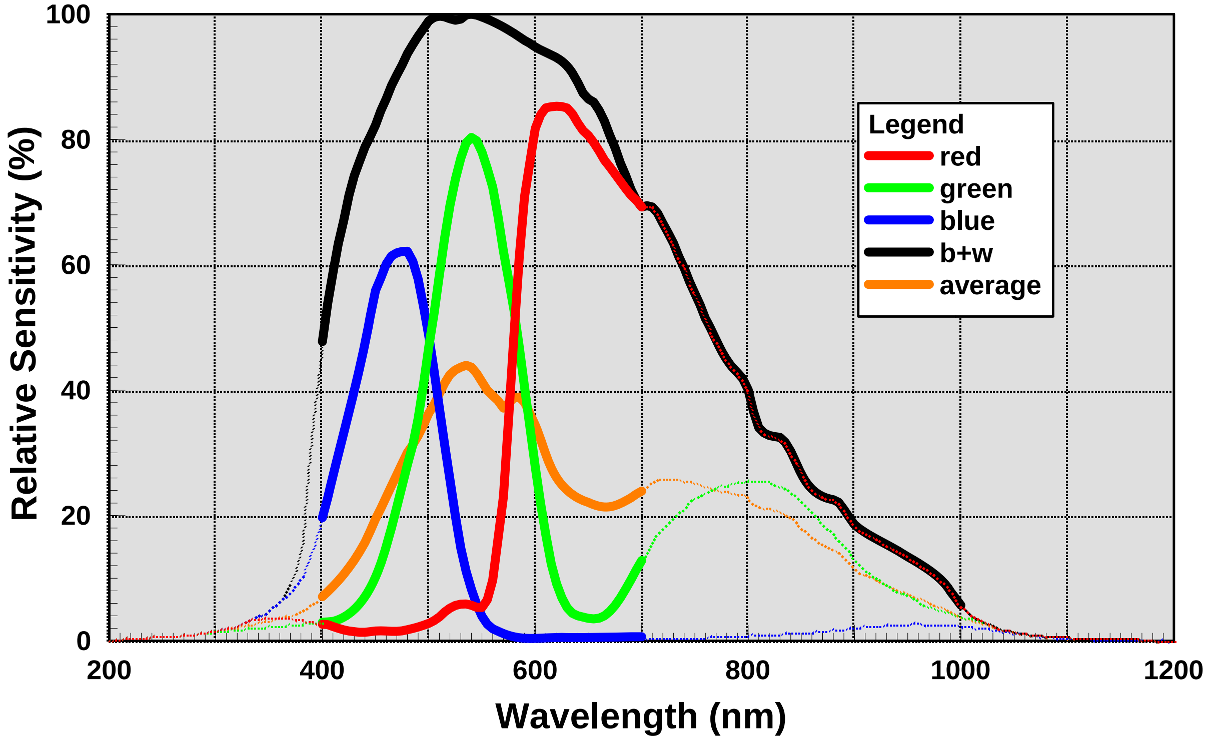

Figure B3 Extrapolated Spectral Sensitivity for ICX285

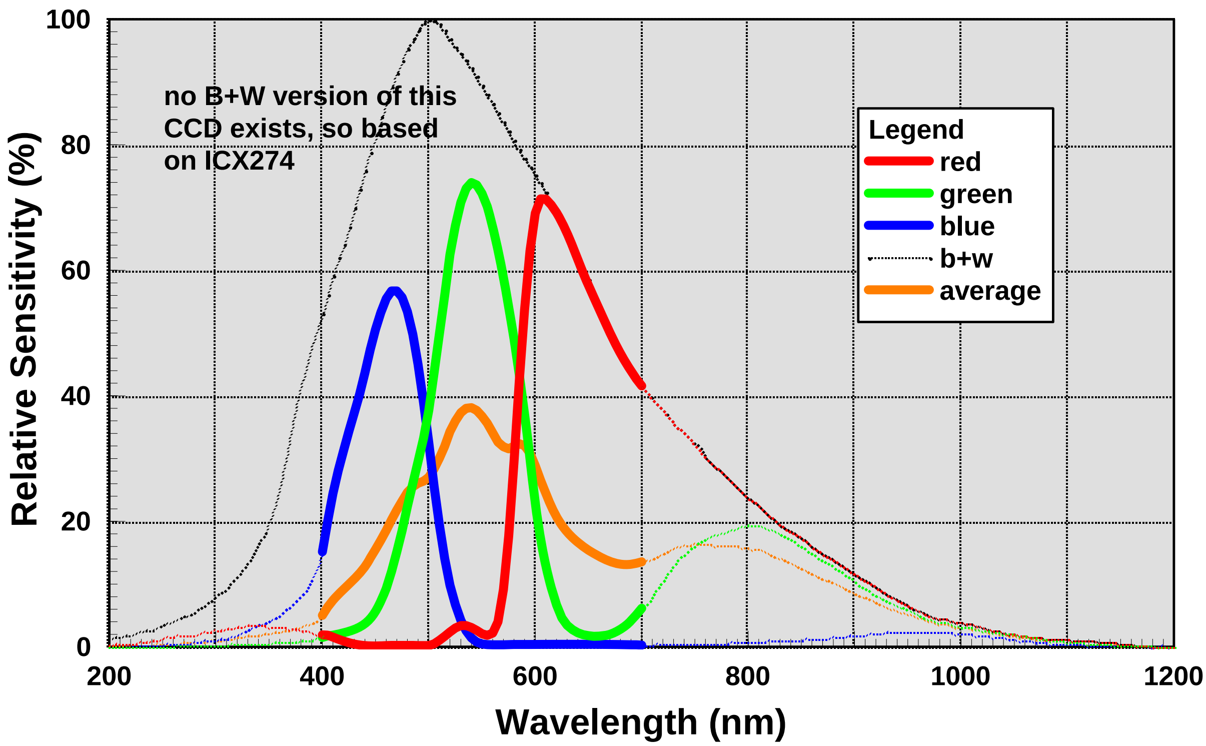

Figure B4 Extrapolated Spectral Sensitivity for ICX413

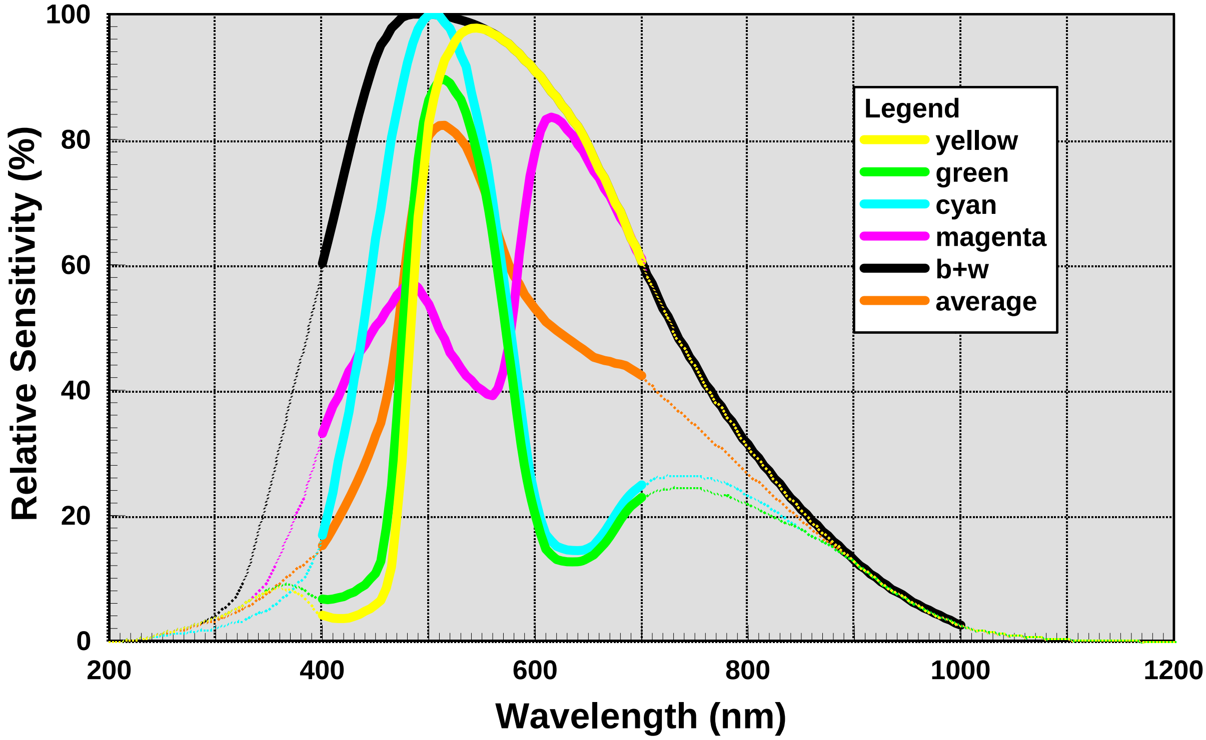

Figure B5 Extrapolated Spectral Sensitivity for ICX418

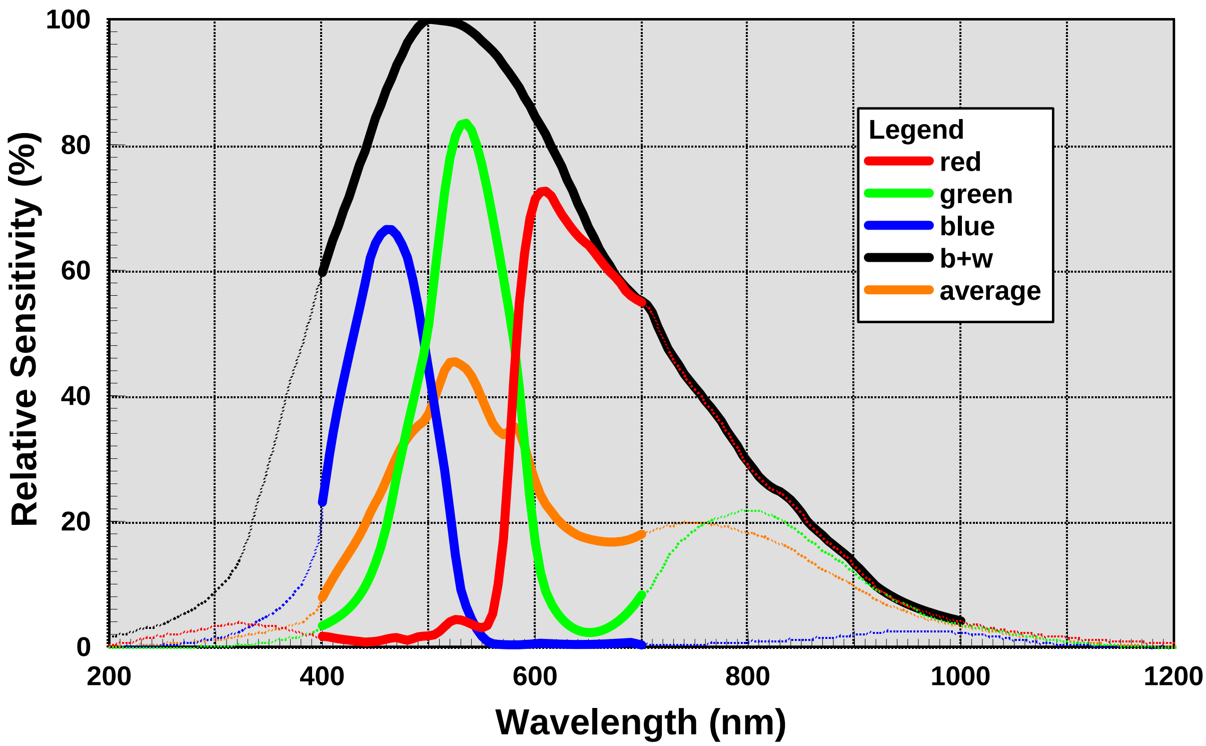

Figure B6 Extrapolated Spectral Sensitivity for ICX424

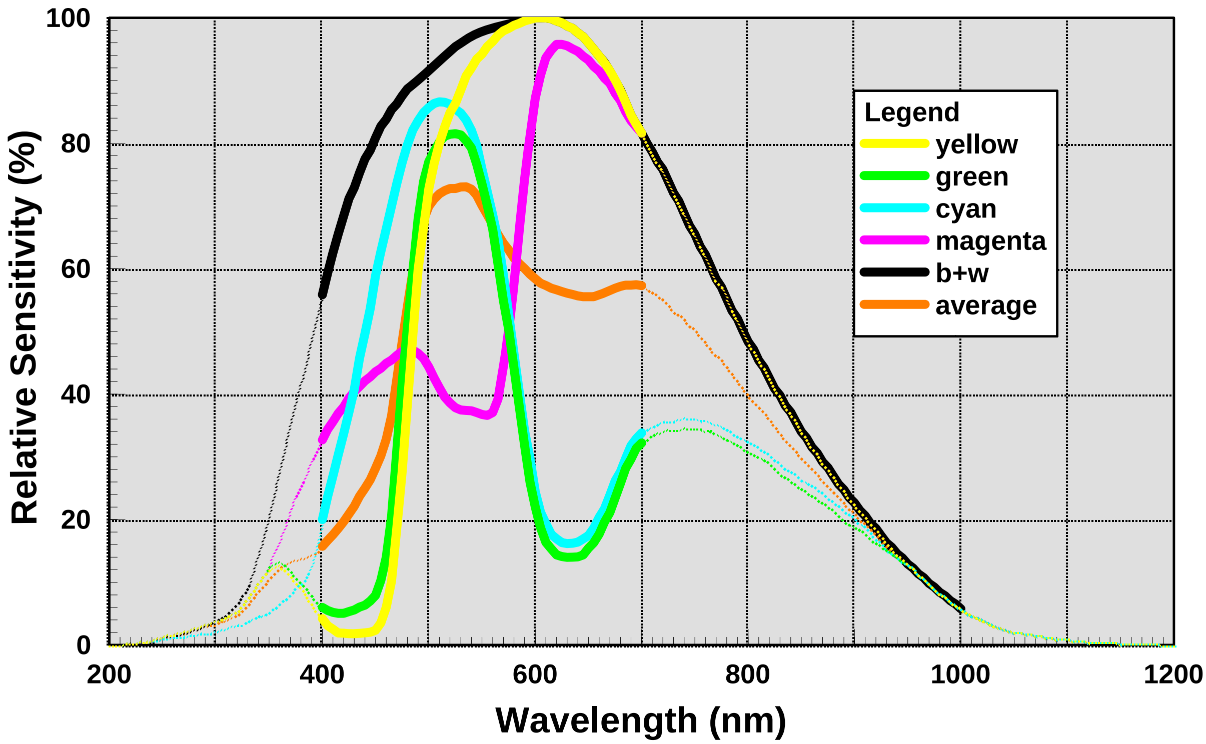

Figure B7 Extrapolated Spectral Sensitivity for ICX428

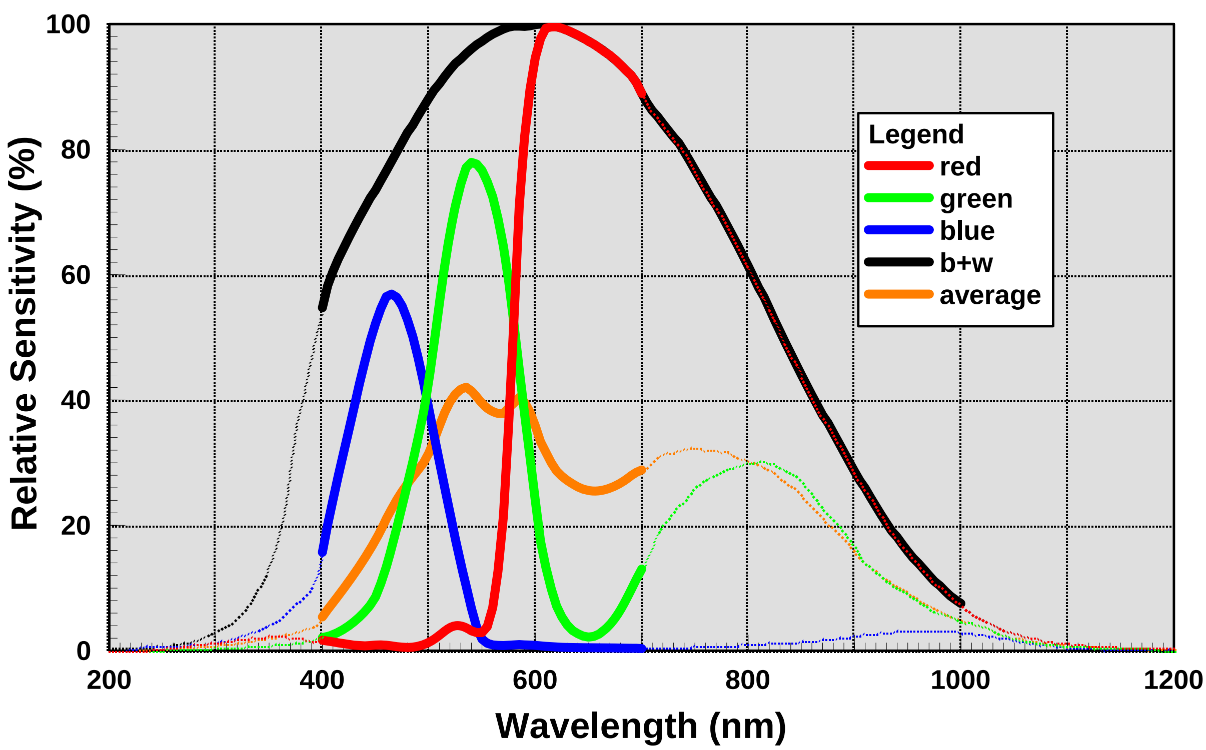

Figure B8 Extrapolated Spectral Sensitivity for ICX618

Appendix C – Total Sensitivity for Different Light Sources

CCD	full band	visual band	light pollution	IR band	dual band LP	Halpha band LP
205al	324.9	226.3	143.8	66.5	55.5	14.3
274al	291.5	211.1	126.3	57.4	52.6	12.6
285al	2379.1	1696.8	892.8	639.1	408.6	133.9
418all	1562.3	1135.6	670.2	324.3	272.5	80.6
424al	636.0	444.7	279.2	135.1	107.0	28.5
428all	2234.4	1482.7	859.8	642.7	347.1	127.4
618ala	2542.7	1598.1	905.8	850.7	370.0	142.5

Table C1 Total Sensitivities for Different Light Sources – B+W

CCD	full band	visual band	light pollution	IR band	dual band LP	Halpha band LP
205ak	106.9	67.8	35.7	36.6	16.2	3.8
274aq	93.5	59.7	30.6	32.1	14.4	3.5
285aq	897.7	540.8	285.6	338.5	128.9	34.4
413aq	291.1	185.6	101.4	100.0	42.1	10.0
413aqs	*363.9*	*232.0*	*126.8*	*125.0*	*52.6*	*12.5*
418akl	979.7	676.2	342.4	272.6	183.4	48.2
424aq	225.5	144.3	72.5	76.7	36.1	7.5
428akl	1446.0	874.3	458.1	529.5	225.0	75.9
618aqa	922.4	506.8	259.7	409.8	116.1	38.0

Table C2 Total Sensitivities for Different Light Sources – Colour