# Olympus E-300 EVOLT Digital Single Lens Reflex Camera Transfer Function and Dynamic Range ©


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I have measured the dynamic range and transfer function (ADU/electron, *where ADU is analog to digital unit*) for an Olympus E-300 EVOLT Digital Single Lens Reflex camera. This information is useful for understanding the performance limits of the EVOLT for astrophotography and other demanding photographic applications as determined by CCD readout noise and camera ISO settings.

## The measurement conditions were:

Shutter Speed = 1/200 second
Color Temperature = 6000 K
Aperture blocked (no light or dark frame)
Image File Format = RAW
Air temperature = 72 F

## The data collection technique:

**1. After allowing the camera to come to thermal equilibrium, shoot one RAW image each at ISO value (i.e., 100, 200, 400, 800, 1600)**

## The data reduction techniques are as follows:

**1. Create a FITS image from an Olympus RAW image file (*.ORF)**

To process Olympus E-300 (EVOLT) RAW files use the freeware IRIS 4.32 astronomical image processing program. IRIS reads RAW Olympus files (*.ORF) and can convert the 12 bit *.ORF image into a gray scale 16 bit FITS image or a 48 bit color FITS image. FITS is the standard file format for astronomy. The IRIS process is:

**FILE MENU** - LOAD RAW file - *.ORF
**DIGITAL PHOTO MENU** - Convert 16 bit to 48 bit
**DIGITAL PHOTO MENU** - Convert a CFA - converts Bayer RGB color filter array data to a color file

**DIGITAL PHOTO MENU** - RGB Separation - separates file into 3 files (R, G, B) Save as FITS - three separate (red, green and blue) 16 bit FITS images are saved. Each FITS file is 16.335 MB.

**2. Create a numerical representation of the noise image**

To view the table of integers that represents the green FITS image, use FITS Viewer, FV. Open the FITS file with FV and select TABLE. Each pixel is a 16-bit number, labeled by row and column in each color plane. Select and EXPORT AS TEXT one column of the image displayed in FV. Make sure the column is not in the amplifier glow region. Label and SAVE text file. Import text file into EXCEL for each dark frame (ISO 100, 200, 400, 800, 1600).

**3. Calculate the rms noise value and average offset of the image**

EXCEL is used to perform a statistical analysis on the data in the single column. The standard deviation is the rms noise in ADUs and the mean value is the image offset in ADUs.

## The Results

The key fact that is needed to analyze the above data is the readout noise specification provided by Kodak for the KAF8300CE RGB color CCD circuit. The KAF8300CE specification for readout noise is 16 electrons rms. By equating the rms electron value to the calculated standard deviation, the transfer function of the EVOLT can be calculated as a function of ISO. The ISO setting is an amplifier gain setting. It amplifies the signal and the noise. If ISO 100 is assumed to be a gain of 1, then ISO 200 is a relative gain of 2, ISO 400 is a relative gain of 4, ISO 800 is a relative gain of 8 and ISO 1600 is a relative gain of 16. The results are plotted in the following graphs. This data allows modeling of image exposure requirements for astrophotography based on telescope aperture, focal length, CCD parameters, optics and filter spectral transmission and stellar magnitude.

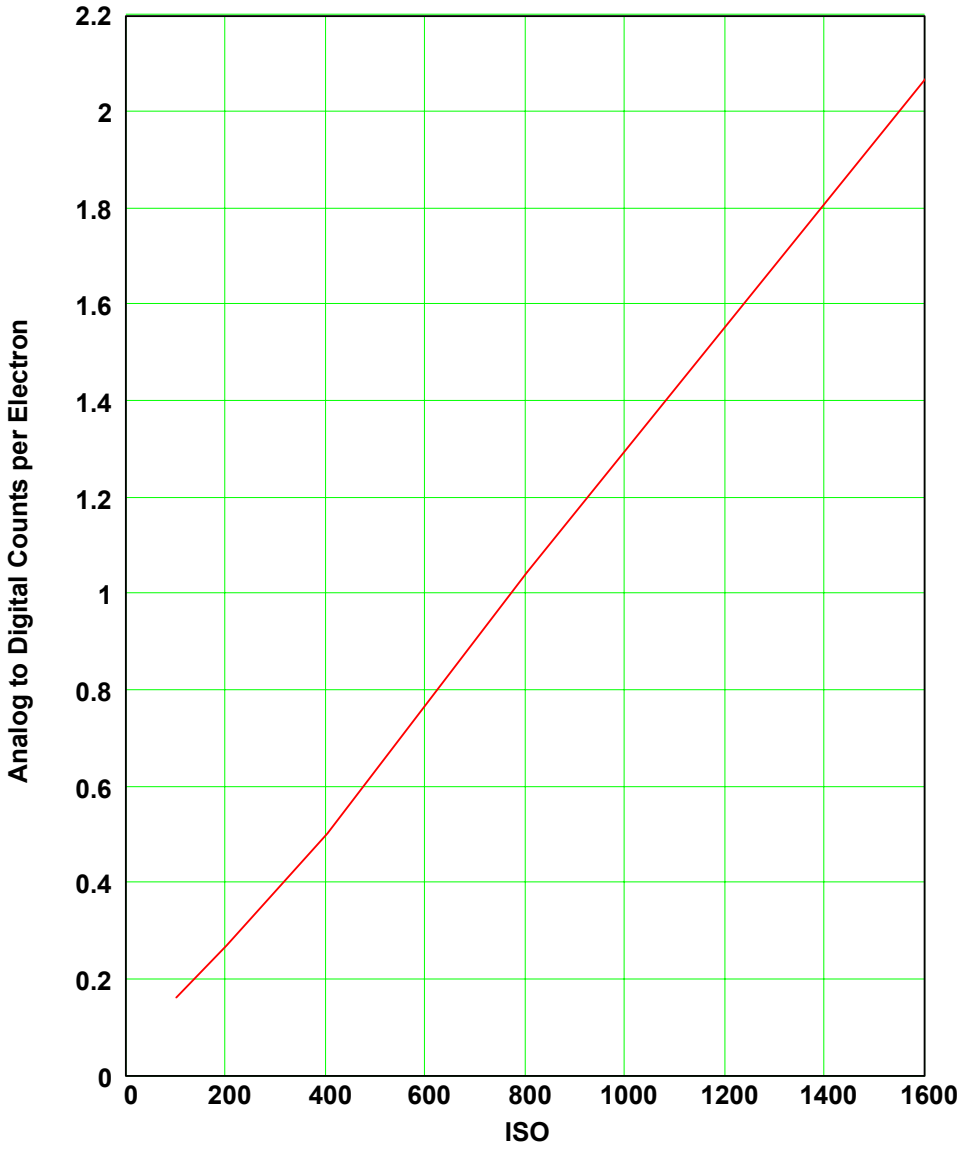


**Figure 1. The transfer characteristic of the Olympus E-300 EVOLT DSLR measured in analog to digital counts per photoelectron (ADU/electron versus ISO or gain setting). Note ~1 ADU/photoelectron at ISO = 800.**

The Olympus E-300 EVOLT DSLR uses a 12-bit analog to digital converter (ADC) to create RAW images. The ADC represents individual pixels intensity values as integer numbers from 0 to 4095. The Kodak KAF-8300CE can store a maximum charge of 25,000 electrons per pixel in linear operation. The maximum CCD linear dynamic range is then:

**CCD Dynamic Range = 20log(25500/16) dB, or 64.04 dB.**

The linear dynamic range of the EVOLT camera as a function of ISO setting (gain setting) as limited by maximum charge storage per pixel can now be calculated.

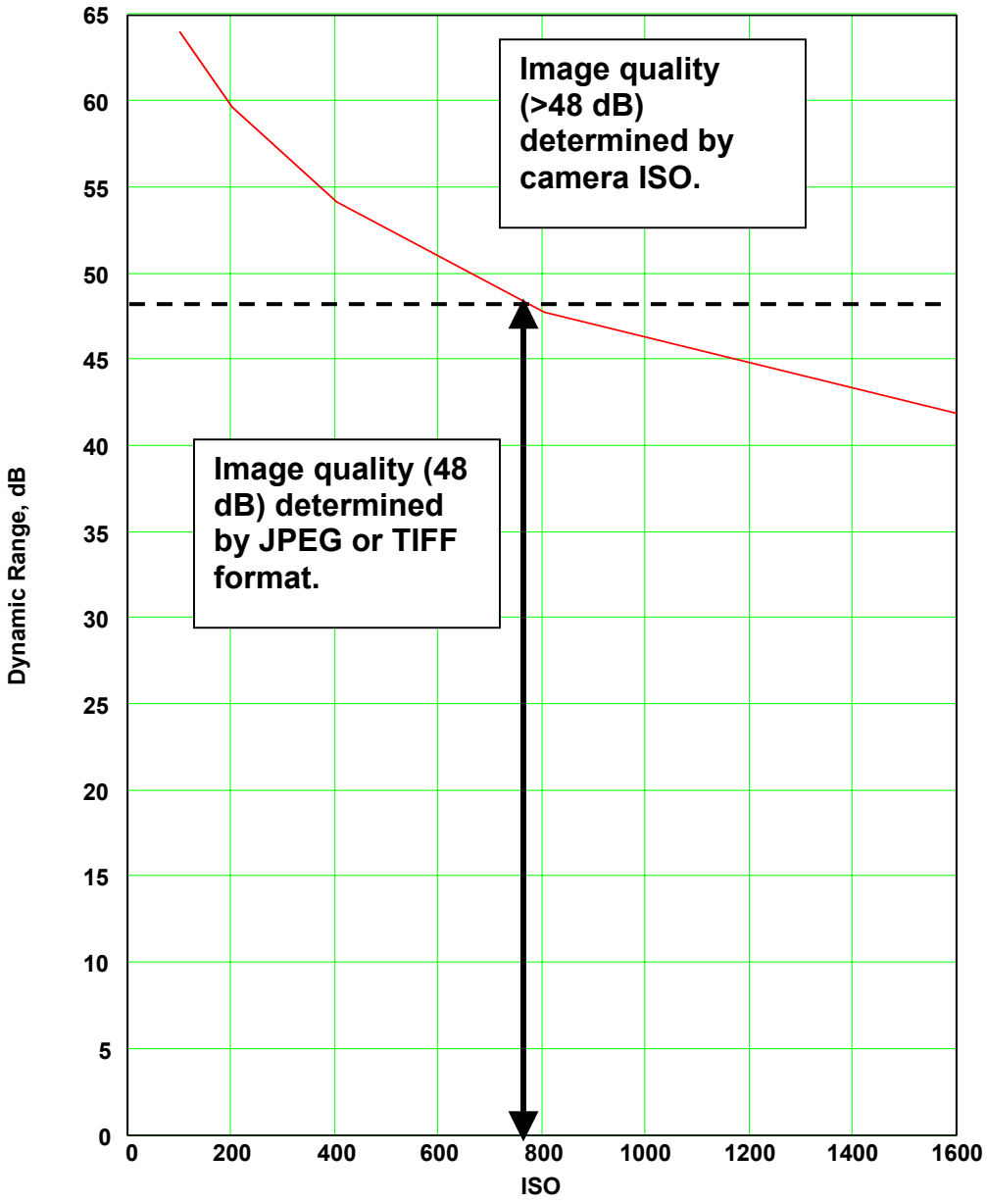


**Figure 2. The maximum linear dynamic range of the Olympus E-300 EVOLT DSLR as determined by maximum linear exposure (CCD well storage and readout noise) and camera ISO setting (gain setting). The maximum linear dynamic range was measured to be 63.55 dB versus the CCD specification of 64.04 dB. Note that both JPEG and TIFF image dynamic range are 48 dB (8 bits/color) and that around and above ISO 800, noise is visible in JPEG images.**

The final measurement is the image offset that is created by the EVOLT image processor. Interestingly enough the offset value in ADU is nearly constant as a function of ISO setting.

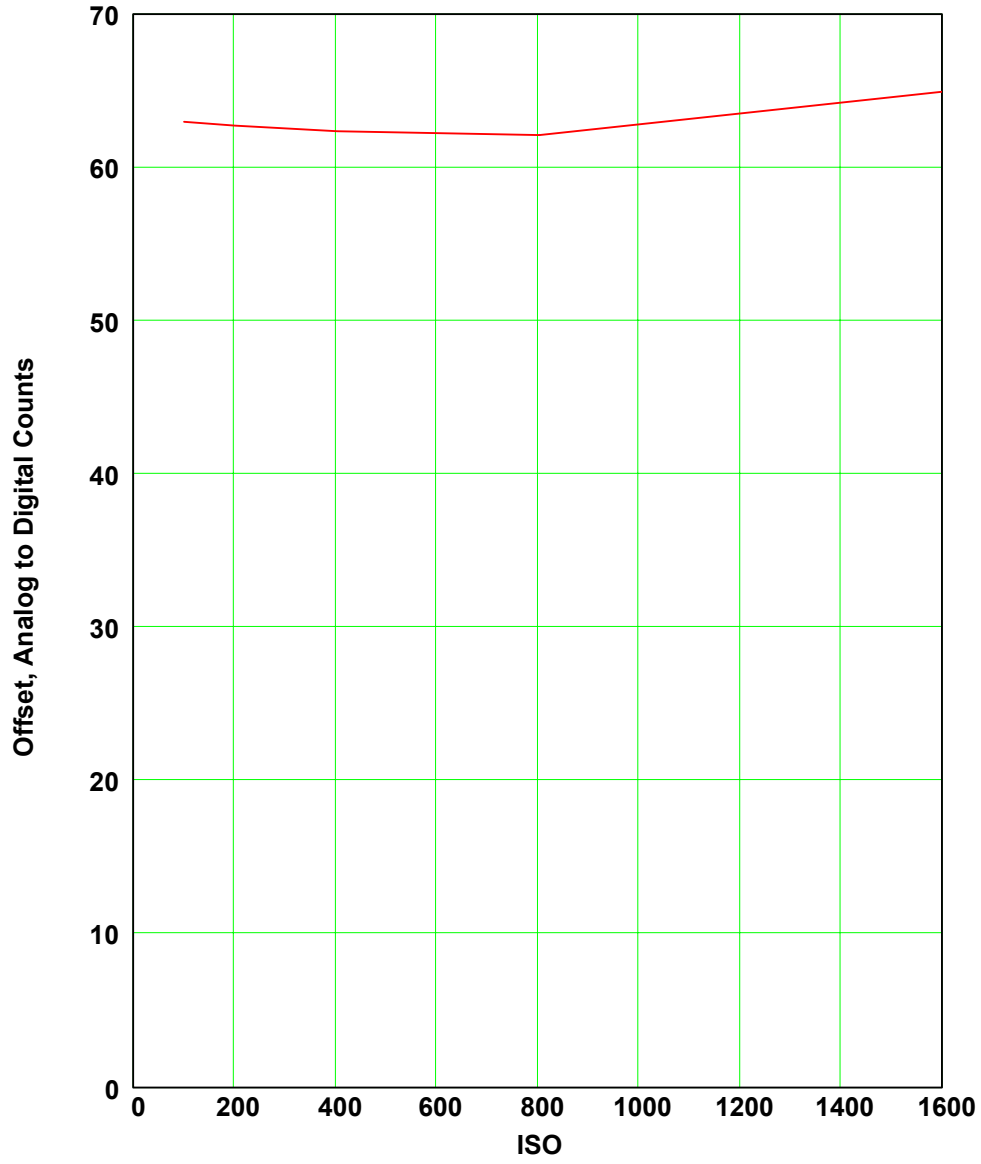


**Figure 3. The RAW image offset value in ADU present in EVOLT photos as a function of ISO setting. The image offset is essentially independent of ISO setting and is visible in detailed histogram displays of EVOLT images.**