Converting from Jy/pix to Native WISE Units

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Below we summarize the steps to convert from Jy/pixel to *native* WISE pixel units as expected in the downlink (and hence as will be seen by the WSDS pipelines). The flavor of these units goes something like "scaled DN/SUR + offset", i.e., as will be computed on-board in the Digital Electronics Box (DEB). From hereon, we refer to a native WISE Unit as a WU (pronounced *wooo*...).

Applicable Documents

- WISE Digital Electronics Box (DEB) processing description (SDL/06-070; Jan 2006):
  http://web.ipac.caltech.edu/staff/roc/wise/docs/sdl06-070-.pdf
  (NEWER VERSION KNOWN TO EXIST!)

- WISE Calibration Plan (D-33753; final release; May 5, 2008).

- WISE Pixel Error Model (WSDC D-T001; version 1.0; March 2008):
  http://web.ipac.caltech.edu/staff/fmasci/home/wise/WiseErrorModel.pdf
  Outlines the meaning of the native WISE units and how they relate to real slopes or rates.

Conversion sub-factors and offsets needed (as of 11/25/08)

	W1	**W2**	**W3**	**W4**
JyPix2MJySr [pix/sr]	5625.91	5625.91	5625.91	1406.48
MJySr2esPix [(e^- sr) / (sec pix Jy)]	17	21	49	26
Jy2es [(e^-/sec)/Jy]	9.564E+04	1.181E+05	2.756E+05	3.656E+04
Gain [e^- / DN]	5.74	5.74	8.86	8.86
Tsamp [sec]	1.1	1.1	1.1	1.1
Kn	84	84	60	60
Offset	1024	1024	1024	1024
Trunc [#LSBs]	3	3	2	2

Explanation and Origin of sub-factors

JyPix2MJySr:
Factor to convert the pixel data from Jy/pixel to MegaJansky/steradian (MJy/sr).

MJySr2esPix:
Factor to convert from MJy/sr to (electrons/sec)/pixel [(e-/s)/pix] taken from Section 5.2.1.4 of the WISE Calibration Plan. These were used to compute the number of photo-electrons expected from the Zodiacal background observed by DIRBE.

Jy2es:
Factor to convert from Jy/pixel to (electrons/sec)/pixel. This is just the product: *JyPix2MJySr * MJySr2esPix*.

Gain:
The expected detector gain in a *ramp sample* in electrons/ADU (e-/DN), i.e., the "FEB gain". These values are from Mark Larsen (~Aug 22, 2008). The gain is used to convert from electrons to ramp DN.

Tsamp:
The time interval between ramp samples (or non-destructive reads) in seconds. This is used to convert from *per second* units, to *per sampling-time* units

Kn:
The normalizing factor for the set of SUR weight-coefficients, c_i , used to convert from true rate (or slope) to "WISE native scaled slope" (see Pixel Error Model document referenced above). In general,

$$Kn = \sum_{i=0}^{8} ic_i ,$$

where for W1 and W2:
c_i = {0, -7, -5, -3, -1, 1, 3, 5, 7}.

For W3 and W4:
c_i = {-4, -3, -2, -1, 0, 1, 2, 3, 4}.

Offset:
An offset added to the "WISE native scaled slope" to avoid the result from going negative due to noise and other glitches. Currently the value chosen by SDL for all bands is 1024.

Trunc:
As outlined in the DEB Processing description document, *r* least significant bits (LSBs) are truncated from the final result so it can fit into a 15-bit unsigned value. This operation involves dividing the final result by 2^{Trunc}.

Putting it All Together

Given an input pixel signal in Jy/pixel, S_{in}, the output signal S_{out} in native WISE Units (WUs) in DN/pixel is given by:

$$S_{out} = \frac{1}{2^{Trunc}} \left\{ \left[S_{in} * Jy2es * \left(\frac{1}{Gain} \right) * Tsamp * Kn \right] + Offset \right\} \quad \text{DN},$$

where the conversion factors/offsets for each band are defined in the above table.

Saturation Handling

The maximum value corresponding to a WU is 32,752. Above this (up to 32,767), the values are reserved

to encode sample numbers where ramps saturate or are physically broken. The above conversion may yield values that exceed this maximum. If so, we suggest resetting the value to 32,761. This corresponds to ramps that saturate in the last (9^{th}) sample. This is the simplest approach for now.