5.1.7.2 WAC FM LIGHT LEAK CALIBRATION RESULTS

As reported in Reference 5.1.7.2-1

Reference 5.1.7.2-1 - IOM 388-PAG-CCA98-8, "WAC FM Calibration Results: Light Leak", C. Avis, April 1, 1998

Reference 5.1.7.2-2 - IOM 388-PAG-CCA97-4, "WAC FM Calibration Results: Sensitivity", C. Avis, March 12, 1997

Reference 5.1.7.2-3 - IOM 388-PAG-CCA96-17, "WAC FM Calibration Results: Shutter Offset", C. Avis, December 9, 1996

5.1.7.2.1 INTRODUCTION

The Wide-angle Flight Model thermal/vacuum testing included the acquisition of a set of images for characterization of any light leakage. Light leak is defined as any signal reaching the sensor with the shutter closed. Two sets of image data were taken at Gain 3 in the 1x1 mode at a temperature of +5° C. One set was taken with the shutter at 'reset' position and the other at 'activate'.

5.1.7.2.2 METHOD

Each Light Leak frame was processed to derive the signal above dark-current. The usual method of dark-current subtraction was used. This method subtracts:

- the frame's bias level (as derived from the overclocked pixel values)
- a bias frame (zero-exposure data)
- the dark-current due to the exposure time

The goal is to plot these resulting signal levels (in DN) vs. the energy that the camera was exposed to during the exposure. In this case, 'energy' is used to mean (spectral radiance * exposure time). The radiance was recorded in units of *picoamps* of current measured and exposure in *seconds*. The necessary conversion factor from *picoamps* to *nanowatts/cm^2/sr/nm* incident upon the camera was derived from the lamp calibrations and the attenuation due to the chamber window weighted by the transmission factors of the various subsystem components.

$$C = \frac{\int_{\lambda} S(\lambda) W(\lambda) O(\lambda) Q(\lambda) F_1(\lambda) F_2(\lambda) \partial\lambda}{\int_{\lambda} O(\lambda) Q(\lambda) F_1(\lambda) F_2(\lambda) \partial\lambda}$$

where
- C is the desired conversion factor for this camera and filters
- $S(\lambda)$ is the spectral radiance per *picoamp* from lamp calibration
- $W(\lambda)$ is the transmission factor of the chamber window
- $O(\lambda)$ is the transmission factor of the optics
- $Q(\lambda)$ is the quantum efficiency of the detector
- $F_1(\lambda)$ is the transmission factor of filter 1
- $F_2(\lambda)$ is the transmission factor of filter 2

For the Wide-angle camera with both clear filters, each *picoamp* measured outside the chamber is equivalent to a spectral radiance of 0.1080 *nanowatts/cm^2/sr/nm* incident on the camera optics.

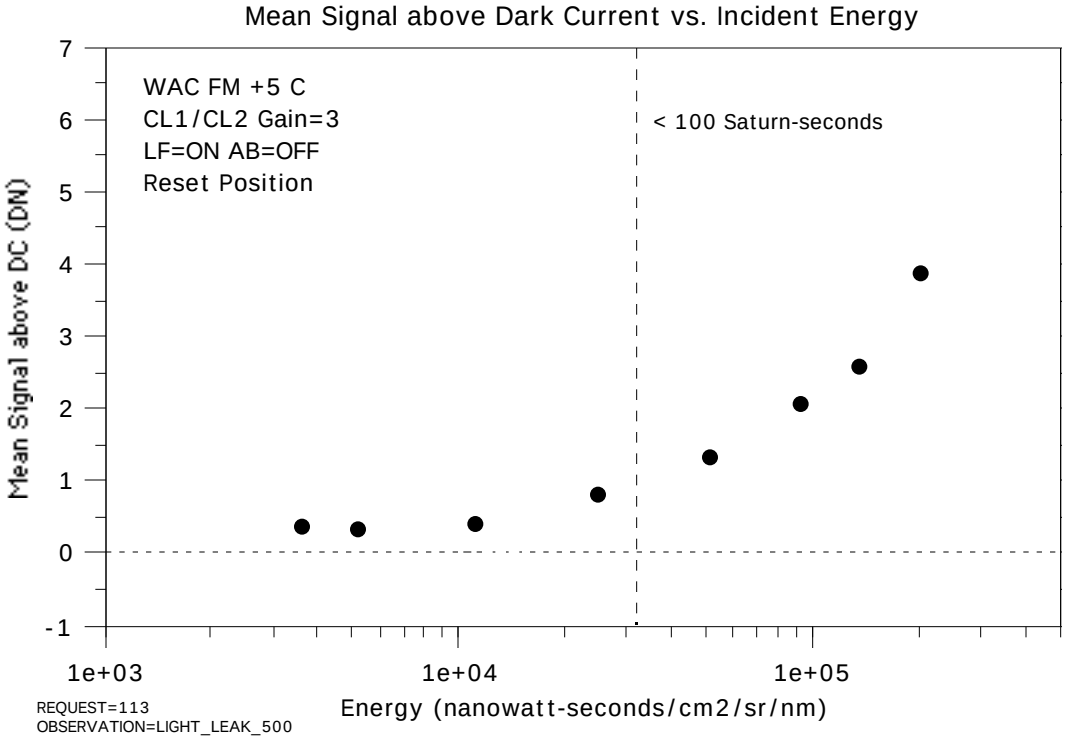
5.1.7.2.3 RESULTS

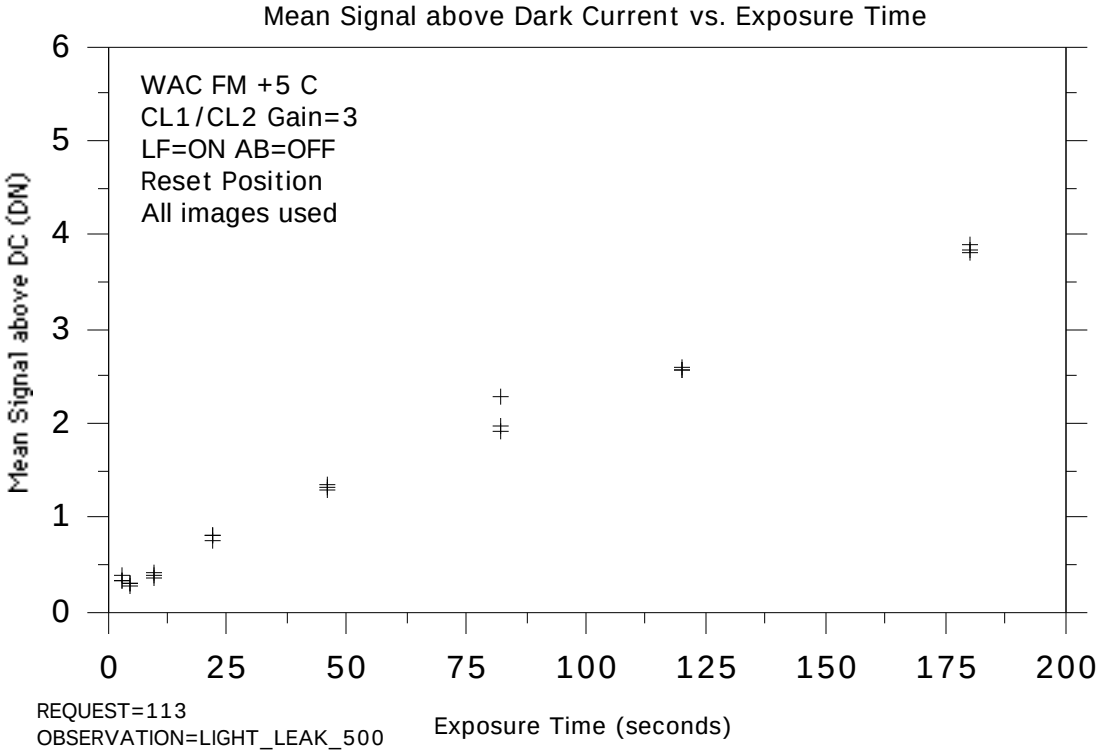
The table below lists the energy in both sets of units as well as the mean and sigma of the measurement at the available light levels. Three images were recorded at each light level (i.e., exposure time). The processed versions of these were combined to generate the listed mean and standard deviation. Also included is the estimate of the energy relative to full-well if the shutter had been enabled for the listed exposure time. This is based upon the mean sensitivity in these filters according to Reference 5.1.7.2-2.

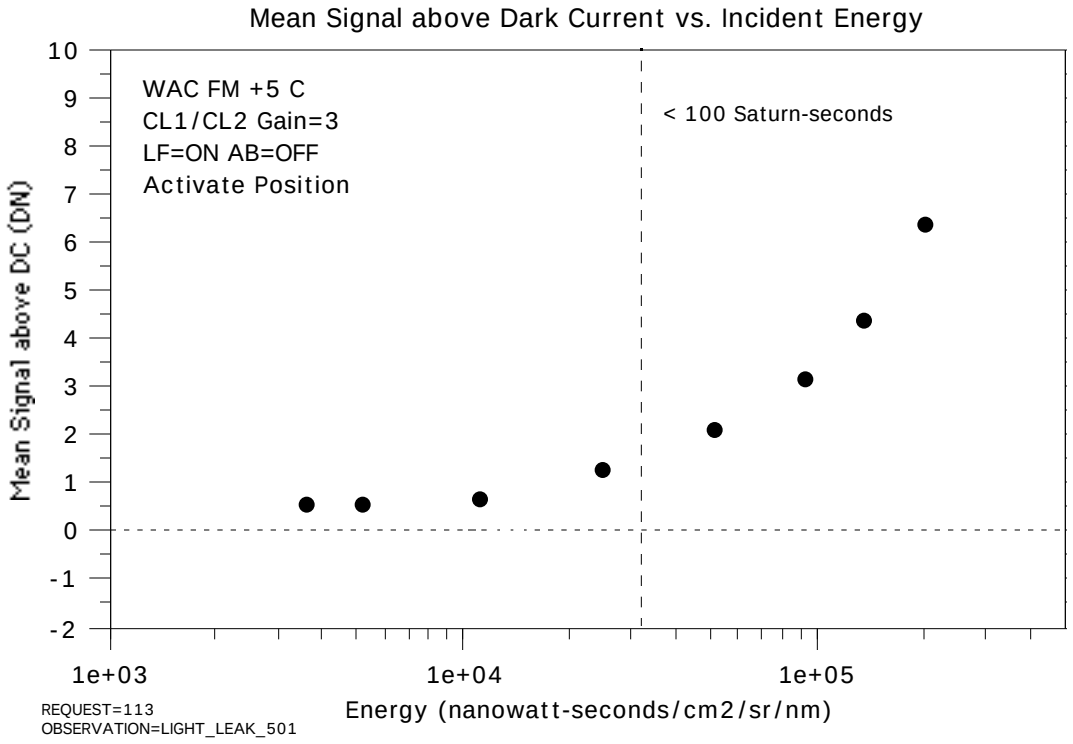
EXPOSURE *seconds*	ENERGY *picoamp-sec*	ENERGY *nw-sec/cm^2/sr/nm*	MEAN SIGNAL (Reset)	SIGMA (Reset)	MEAN SIGNAL (Activate)	SIGMA (Activate)
3.20	33600	3629 (1606 fw)	0.3423	0.0211	0.4971	0.0416
4.60	48300	5216 (2309 fw)	0.2925	0.0152	0.4935	0.0402
10.00	105000	11340 (5019 fw)	0.3806	0.0181	0.6267	0.0397
22.00	231000	24948 (11042 fw)	0.7787	0.0254	1.228	0.0335
46.00	483000	52164 (23090 fw)	1.320	0.0233	2.064	0.0244
82.00	861000	92988 (41156 fw)	2.048	0.1636	3.099	0.0136
120.00	1260000	136080 (60229 fw)	2.573	0.0122	4.316	0.0277
180.00	1890000	204120 (90344 fw)	3.847	0.0365	6.300	0.0289

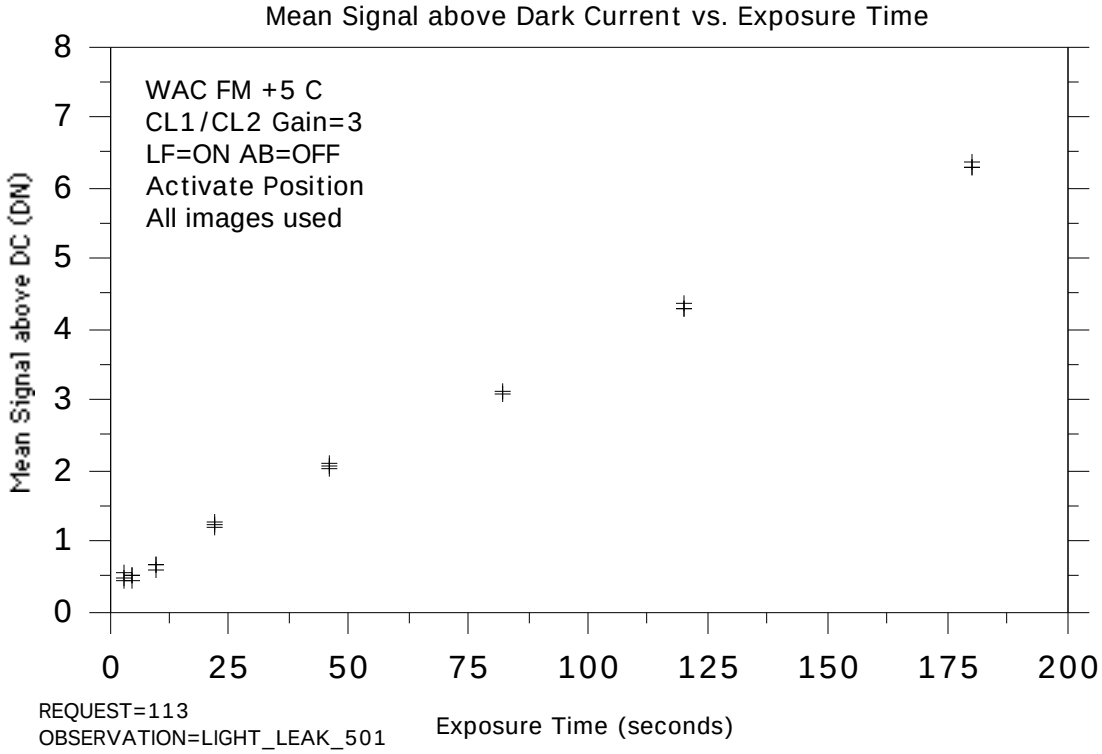
Information from Bob West was used to relate the brightness of the source to that of Saturn. Saturn's radiance is 1.9 *w/m^2/sr* over a bandpass of 300 - 900 nm or 316.7 *nanowatts/cm^2/sr/nm.* An energy value of 100 Saturn-seconds is marked on the plots below as a measure of the required light level of 100 times Saturn.

The following plots show the signal values versus the log of the input energy and versus exposure time. A true light leak should show increased signal as the exposure time increases. The target energy level of 100 times Saturn is indicated as 100 seconds of exposure to Saturn shown on the plots.









5.1.7.2.4 CONCLUSION

1. In both positions, the leakage through the shutter is 1 DN or less out to 100 seconds of exposure to Saturn or 10000 times what would have given a full-well response.
2. There is a linear increase in signal up to about 6 DN at the 10000*full-well level. The increase is at a rates of 1.99×10^{-2} *DN/second* (reset) and 3.28×10^{-2} *DN/second* (activate) for a radiance level of 10500 picoamps or 1134 *nanowatts/cm^2/sr/nm.*
3. The only structure seen in the images was very slight shading at the edges (perhaps due to lightflood effects in the dark-current data not exactly matching that which is in this data). In addition, the low exposure Reset images showed a horizontal band of extraneous signal similar to that discussed in Reference 5.1.7.2-3. This band was swamped by the actual leakage at higher exposures and was not seen in the Activate images.

5.1.7.2.5 IMAGES USED IN LIGHT LEAK ANALYSIS

image	day	eventtime	observation	gain	mode	expos	radiance
130738	197	1:16:32.0	LIGHT_LEAK_500	3(40K)	FULL	260	10500.00
130739	197	1:17:31.0	LIGHT_LEAK_500	3(40K)	FULL	260	10500.00
130740	197	1:18:30.0	LIGHT_LEAK_500	3(40K)	FULL	260	10500.00
130741	197	1:19:29.0	LIGHT_LEAK_500	3(40K)	FULL	560	10500.00
130742	197	1:20:29.0	LIGHT_LEAK_500	3(40K)	FULL	560	10500.00
130743	197	1:21:28.0	LIGHT_LEAK_500	3(40K)	FULL	560	10500.00
130744	197	1:22:27.0	LIGHT_LEAK_500	3(40K)	FULL	1000	10500.00
130745	197	1:23:26.0	LIGHT_LEAK_500	3(40K)	FULL	1000	10500.00
130746	197	1:24:25.0	LIGHT_LEAK_500	3(40K)	FULL	1000	10500.00
130747	197	1:25:43.0	LIGHT_LEAK_500	3(40K)	FULL	3200	10500.00
130748	197	1:26:53.0	LIGHT_LEAK_500	3(40K)	FULL	3200	10500.00
130749	197	1:28:3.0	LIGHT_LEAK_500	3(40K)	FULL	3200	10500.00
130750	197	1:29:13.0	LIGHT_LEAK_500	3(40K)	FULL	4600	10500.00
130751	197	1:30:24.0	LIGHT_LEAK_500	3(40K)	FULL	4600	10500.00
130752	197	1:31:34.0	LIGHT_LEAK_500	3(40K)	FULL	4600	10500.00
130753	197	1:32:44.0	LIGHT_LEAK_500	3(40K)	FULL	10000	10500.00
130754	197	1:33:54.0	LIGHT_LEAK_500	3(40K)	FULL	10000	10500.00
130755	197	1:35:4.0	LIGHT_LEAK_500	3(40K)	FULL	10000	10500.00
130756	197	1:36:44.0	LIGHT_LEAK_500	3(40K)	FULL	22000	10500.00
130757	197	1:38:18.0	LIGHT_LEAK_500	3(40K)	FULL	22000	10500.00
130758	197	1:39:52.0	LIGHT_LEAK_500	3(40K)	FULL	22000	10500.00
130759	197	1:41:51.0	LIGHT_LEAK_500	3(40K)	FULL	46000	10500.00
130760	197	1:43:41.0	LIGHT_LEAK_500	3(40K)	FULL	46000	10500.00
130761	197	1:45:31.0	LIGHT_LEAK_500	3(40K)	FULL	46000	10500.00
130762	197	1:48:2.0	LIGHT_LEAK_500	3(40K)	FULL	82000	10500.00
130763	197	1:50:24.0	LIGHT_LEAK_500	3(40K)	FULL	82000	10500.00
130804	197	3:56:0.0	LIGHT_LEAK_500	3(40K)	FULL	82000	10500.00
130765	197	1:57:4.0	LIGHT_LEAK_500	3(40K)	FULL	120000	10500.00
130766	197	2:1:2.0	LIGHT_LEAK_500	3(40K)	FULL	120000	10500.00
130767	197	2:5:0.0	LIGHT_LEAK_500	3(40K)	FULL	120000	10500.00
130768	197	2:9:7.0	LIGHT_LEAK_500	3(40K)	FULL	180000	10500.00
130769	197	2:13:5.0	LIGHT_LEAK_500	3(40K)	FULL	180000	10500.00
130770	197	2:17:3.0	LIGHT_LEAK_500	3(40K)	FULL	180000	10500.00
130771	197	2:18:36.0	LIGHT_LEAK_501	3(40K)	FULL	260	10500.00
130772	197	2:19:35.0	LIGHT_LEAK_501	3(40K)	FULL	260	10500.00
130773	197	2:20:34.0	LIGHT_LEAK_501	3(40K)	FULL	260	10500.00
130774	197	2:21:33.0	LIGHT_LEAK_501	3(40K)	FULL	560	10500.00
130775	197	2:22:33.0	LIGHT_LEAK_501	3(40K)	FULL	560	10500.00
130805	197	3:57:33.0	LIGHT_LEAK_501	3(40K)	FULL	560	10500.00
130806	197	3:58:32.0	LIGHT_LEAK_501	3(40K)	FULL	1000	10500.00
130807	197	3:59:31.0	LIGHT_LEAK_501	3(40K)	FULL	1000	10500.00
130808	197	4:0:31.0	LIGHT_LEAK_501	3(40K)	FULL	1000	10500.00
130780	197	2:27:55.0	LIGHT_LEAK_501	3(40K)	FULL	3200	10500.00
130781	197	2:29:5.0	LIGHT_LEAK_501	3(40K)	FULL	3200	10500.00
130782	197	2:30:15.0	LIGHT_LEAK_501	3(40K)	FULL	3200	10500.00
130783	197	2:31:25.0	LIGHT_LEAK_501	3(40K)	FULL	4600	10500.00
130784	197	2:32:36.0	LIGHT_LEAK_501	3(40K)	FULL	4600	10500.00
130785	197	2:33:46.0	LIGHT_LEAK_501	3(40K)	FULL	4600	10500.00
130786	197	2:34:56.0	LIGHT_LEAK_501	3(40K)	FULL	10000	10500.00
130787	197	2:36:6.0	LIGHT_LEAK_501	3(40K)	FULL	10000	10500.00
130788	197	2:37:16.0	LIGHT_LEAK_501	3(40K)	FULL	10000	10500.00
130789	197	2:38:56.0	LIGHT_LEAK_501	3(40K)	FULL	22000	10500.00
130790	197	2:40:30.0	LIGHT_LEAK_501	3(40K)	FULL	22000	10500.00
130791	197	2:42:4.0	LIGHT_LEAK_501	3(40K)	FULL	22000	10500.00
130792	197	2:44:1.0	LIGHT_LEAK_501	3(40K)	FULL	46000	10500.00

image	day	eventtime	observation	gain	mode	expos	radiance
130793	197	2:45:51.0	LIGHT_LEAK_501	3(40K)	FULL	46000	10500.00
130794	197	2:47:41.0	LIGHT_LEAK_501	3(40K)	FULL	46000	10500.00
130795	197	2:50:7.0	LIGHT_LEAK_501	3(40K)	FULL	82000	10500.00
130796	197	2:52:29.0	LIGHT_LEAK_501	3(40K)	FULL	82000	10500.00
130798	197	2:58:58.0	LIGHT_LEAK_501	3(40K)	FULL	120000	10500.00
130799	197	3:2:56.0	LIGHT_LEAK_501	3(40K)	FULL	120000	10500.00
130800	197	3:6:54.0	LIGHT_LEAK_501	3(40K)	FULL	120000	10500.00
130801	197	3:11:1.0	LIGHT_LEAK_501	3(40K)	FULL	180000	10500.00
130802	197	3:14:59.0	LIGHT_LEAK_501	3(40K)	FULL	180000	10500.00
130803	197	3:18:57.0	LIGHT_LEAK_501	3(40K)	FULL	180000	10500.00