CHIP CHARACTERISTICS
FOR
Tektronix TK2048EB 1522BR07-01

Sebastian Deiries   Olaf Iwert   Evi Hummel

ESO Garching

Optical Detector Laboratory

January 19, 1996

1 General Description

Chip type	: Tektronix TK2048EB Grade Engineering, thinned, AR coated, MPP
Chip characteristics:	AR coating: ,
Chip format	: 2048x2046, 19 pre-scan pixels in horizontal direction
Pixel size	: 24 x 24μm^2
Serial No.	: 1522BR07-01

The cryostat electronic board has special clock shaping capacitors for this CCD (C57-60: 1000pF, C61-64: open, C65-68: 150nF, C69-72: 2.2nF).

2 Flatness of the chip

The surface of the CCD can be fitted with a sphere of a radius of 2050mm ± 190mm. The definition is bad.

3 System Setup

This chip has been tested with the ESO-VME CCD camera system.

The clock-pattern tk2048eadmpp with MPP–mode have been used for the tests.

Parameters are set to SUBPATT 3 and GAIN 2, if not otherwise mentioned.

All tests were performed between 160 K and 180 K, if not otherwise mentioned.

4 Voltage Setup

See table 1 on page 2 for all voltage values.

```
VLO1 :  -8.00 VHI1 :  3.02 VLO2 :  -8.00 VHI2 :  3.03
HLO1 :  -4.01 HHI1 :  6.07 HLO2 :  -4.02 HHI2 :  6.07
RLO1 :  0.007 RHI1 :  13.00 RLO2 :  -8.01 RHI2 :  6.03
VDD1 :  23.48 VDR1 :  15.25 VDD2 :  22.83 VDR2 :  14.16
VGS1 :  -2.16 VSS1 :  0.00 VGS2 :  -9.02 VSS2 :  0.00
```

Table 1: Telemetry values for A, B, C and D amplifier

5 Noise and Gain

Amplifier A:

The conversion factor is (at GAIN = 2)

2.634±0.086 **e$^-$/ADU.** at subpatt 3

The readout-noise is

7.5±0.4 **e$^-$ RMS** at subpatt 3

Amplifier B:

The conversion factor is (at GAIN = 2)

1.695±0.136 **e$^-$/ADU.** at subpatt 3

The readout-noise is

5.6±0.6 **e$^-$ RMS** at subpatt 3

Amplifier C:

The conversion factor is (at GAIN = 2)

10.000±0.761 **e$^-$/ADU.** at subpatt 1

5.239±0.130 **e$^-$/ADU.** at subpatt 2

2.693$\pm$0.050 **e$^-$/ADU.** at subpatt 3

2.635$\pm$0.158 **e$^-$/ADU.** at subpatt 3 and 2x2 binning

1.335$\pm$0.044 **e$^-$/ADU.** at subpatt 4

The readout-noise is

11.2$\pm$1.3 **e$^-$ RMS** at subpatt 1

8.8$\pm$0.4 **e$^-$ RMS** at subpatt 2

7.4$\pm$0.2 **e$^-$ RMS** at subpatt 3

7.8$\pm$0.7 **e$^-$ RMS** at subpatt 3 and 2x2 binning

6.3$\pm$0.5 **e$^-$ RMS** at subpatt 4

Amplifier D:

The conversion factor is (at GAIN = 2)

2.496$\pm$0.074 **e$^-$/ADU.** at subpatt 3

The readout-noise is

9.4$\pm$0.5 **e$^-$ RMS** at subpatt 3

The noise and gain was measured using the HP-desktop procedure "MEASURE CONFACT" at different illumination levels. This procedure takes two equal dark– and two equal flat-field exposures calculating noise and gain independent from the light level with the variance of the difference of the two flat-fields.

6 Pick-up Noise

At slow-mode pick-up noise could be seen very weak at short dark exposures.

7 Quantum Efficiency

```
CCD SENSITIVITY CALIBRATION:                    16 Jun 1995   00:53:41
============================

Detector ID          : TK20152      Detector           : Tektronix
Calibrated against   : _SDC1_NP_1   Type               : TK2048EB
Detector area (cm2)  : 5.76E-06     ESO CCD No.        :    1333
e-/[ADU]             :  2.69        Used Output(s)     :     0
System gain          :     2        Subpattern         :     3
Misc.Comments        : tk2048ecbmpp_1522CR07-01

CCD System values    :          Scanned CCD area
-----------------    :          ----------------
Hor. act. Pixels     :  2086        First pixel        :    25
Tot. vert. Lines     :  2060        Last pixel         :  2063
Hor.  Binning        :     1        First line         :     5
Vert. Binning        :     1        Last line          :  2043

Lambda Time  Dens  Temp Counts  RQE  +/-    Sensitivity Photon flux  Irradiance
  [nm] [sec] [log]  [K]  [ADU]  [%]   [%]   [A/(W/cm2)]  [Phot/cm2]   [W/cm2]
******************************************************************************
   320   300  0.0  161.8    621 23.48  1.66   +3.511E-07  +4.123E+06  +2.543E-12
   340   300  0.0  161.8   3208 32.81  2.95   +5.195E-07  +1.524E+07  +8.876E-12
   360   300  8.6  161.8   4222 43.51  4.35   +7.283E-07  +1.513E+07  +8.333E-12
   380    60  8.6  161.8   4104 54.99  5.43   +9.728E-07  +5.817E+07  +3.032E-11
   400    40  0.0  161.8   6094 65.40  5.72   +1.212E-06  +1.089E+08  +5.419E-11
   450    10  0.0  161.8   5841 64.02  3.62   +1.336E-06  +4.266E+08  +1.885E-10
   500    10   .3  161.8   5948 68.20  2.85   +1.583E-06  +4.078E+08  +1.620E-10
   550    10   .8  161.8   5246 71.75  2.71   +1.834E-06  +3.419E+08  +1.234E-10
   600    10   .9  161.8   5508 75.39  2.70   +2.097E-06  +3.416E+08  +1.132E-10
   650    10   .9  161.8   6225 76.76  2.55   +2.294E-06  +3.792E+08  +1.170E-10
   700    10   .9  161.8   8293 77.56  2.44   +2.519E-06  +5.000E+08  +1.419E-10
   750    10   .9  161.8   5274 70.56  2.28   +2.454E-06  +3.495E+08  +9.267E-11
   800    10   .9  161.8   6705 64.81  2.16   +2.405E-06  +4.838E+08  +1.202E-10
   850    10   .9  161.8   6846 51.86  1.92   +2.049E-06  +6.172E+08  +1.440E-10
   900    10   .6  161.8   5925 37.41  1.60   +1.562E-06  +7.406E+08  +1.635E-10
   950    10   .4  161.8   6245 24.43  1.23   +1.076E-06  +1.195E+09  +2.503E-10
  1000    20   .5  161.8   6153 11.34   .72   +5.253E-07  +1.269E+09  +2.525E-10
Calibration_error=    1.50%  Conversion_factor_error=   1.85%
_TK20152_21 stored on /users/ms/cali:HFS at 16 Jun 1995 07:25:33
```

Table: RQE measurement protocols for the CCD chip

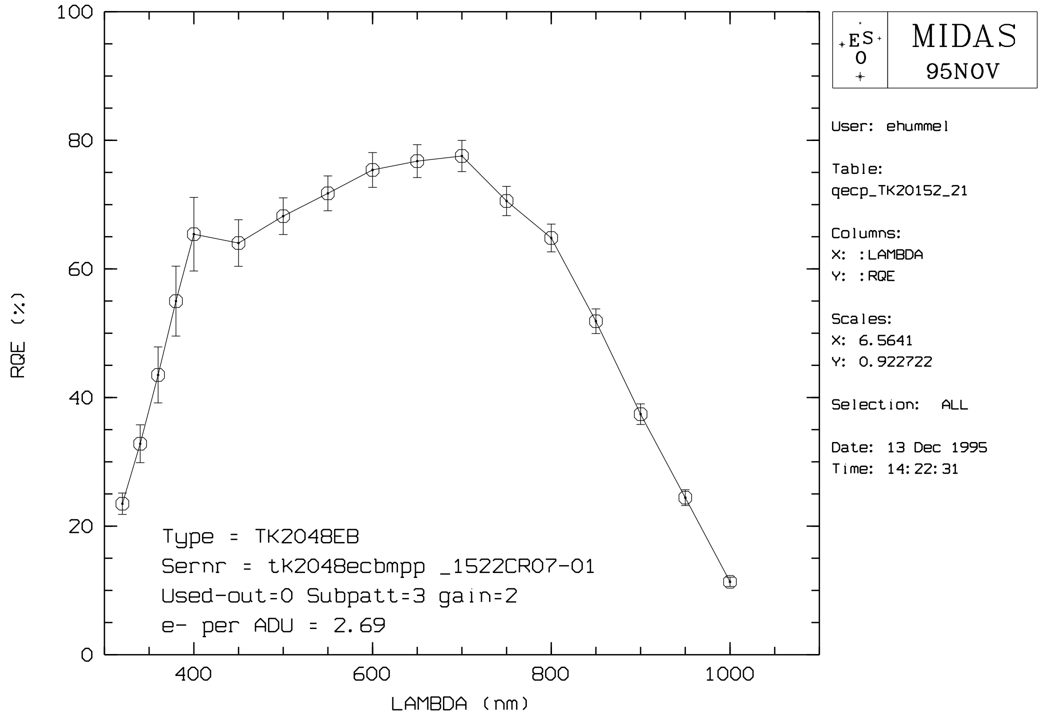


Figure 1: Plot of RQE values of the CCD (complete surface) at 161 K

The RQE was measured in an automatic mode using the test-bench computer. The quantum-efficiency values and their errors are listed below. The given error is the geometrical sum of the error of test-bench calibration (approximate 1.5 %), the error of the CCD conversion factor measurement (approximate 1.85 %) and of the variation of the quantum-efficiency over the whole chip surface (dependent from the light wavelength). The variation of quantum efficiency over the chip can be seen in detail in the homogeneity measurement in section 14 on page 9.
The peak value for RQE of CCD was approx. 77 % at 700nm.

Figure 1 on page 5 shows the plot of QE for the CCD.

8 Charge Transfer Efficiency

TBD

9 Dark Current

The dark current was measured with a 20 minutes dark exposures with MPP–mode after more than 5 hours in the dark wiping the CCD every minute.

The mean dark current rate is approx. $6.95 \pm 1.9\ e^{-}/pixel/hour$ at 161 K.

10 Linearity

Linearity was measured taking exposures of the same exposure-time at different light levels and at a wavelength of 700 nm.

Amplifier A:

There is a maximum deviation of less than ±0.93% from the average value within 1.73 decades from 480 to 26000 e^- per pixel.

Amplifier B:

There is a maximum deviation of less than ±0.94% from the average value within 3.1 decades from 54 to 66550 e^- per pixel.

Amplifier C:

There is a maximum deviation of less than ±0.94% from the average value within 2.2 decades from 284 to 48300 e^- per pixel.

Amplifier D:

There is a maximum deviation of less than ±0.88% from the average value within 3.15 decades from 45 to 63510 e^- per pixel.

See figure 2 on page 6 for details.

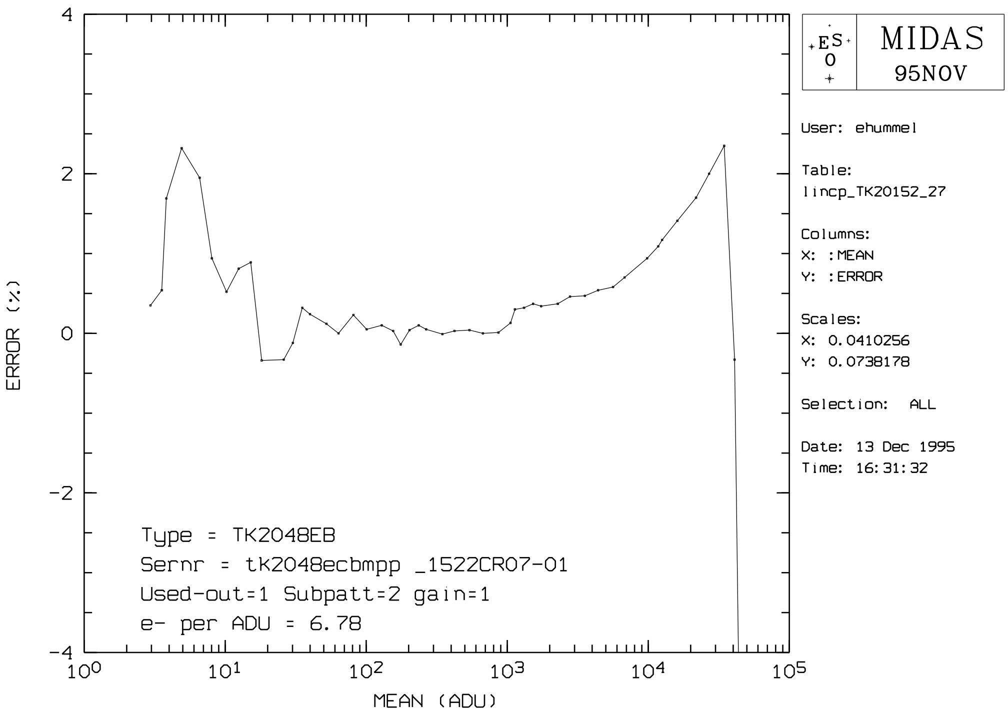


Figure 2: Linearity Measurement with amplifier B

In view of the other problems with this CCD, the linearity was not optimized with the voltage setup.

11 Full well capacity

The full well capacity was measured with flat-field exposures of high intensities in MPP–mode. The limit of linearity is reached, if at higher intensities the deviation from linearity starts to get larger than the given maximum deviation in the section 10 on page 6.

Amplifier B:

Upper limit of linearity: 222 000 e^-/pixel
Saturation-value: 351 000 e^-/pixel

Amplifier C:

Upper limit of linearity: 266 000 e^-/pixel
Saturation-value: 470 000 e^-/pixel

Horizontal voltage has to be adjusted to prevent charge smearing at high illumination values.

12 Cosmic Ray Events

The Cosmic Ray Event rate was measured using our standard method (MIDAS Batch: COSMIC) to count *events* independently of their actual size.

The cosmic ray event rate is $2.83 + 0.2 - 0.2$ $events/min/cm^2$**.**

13 Blemishes

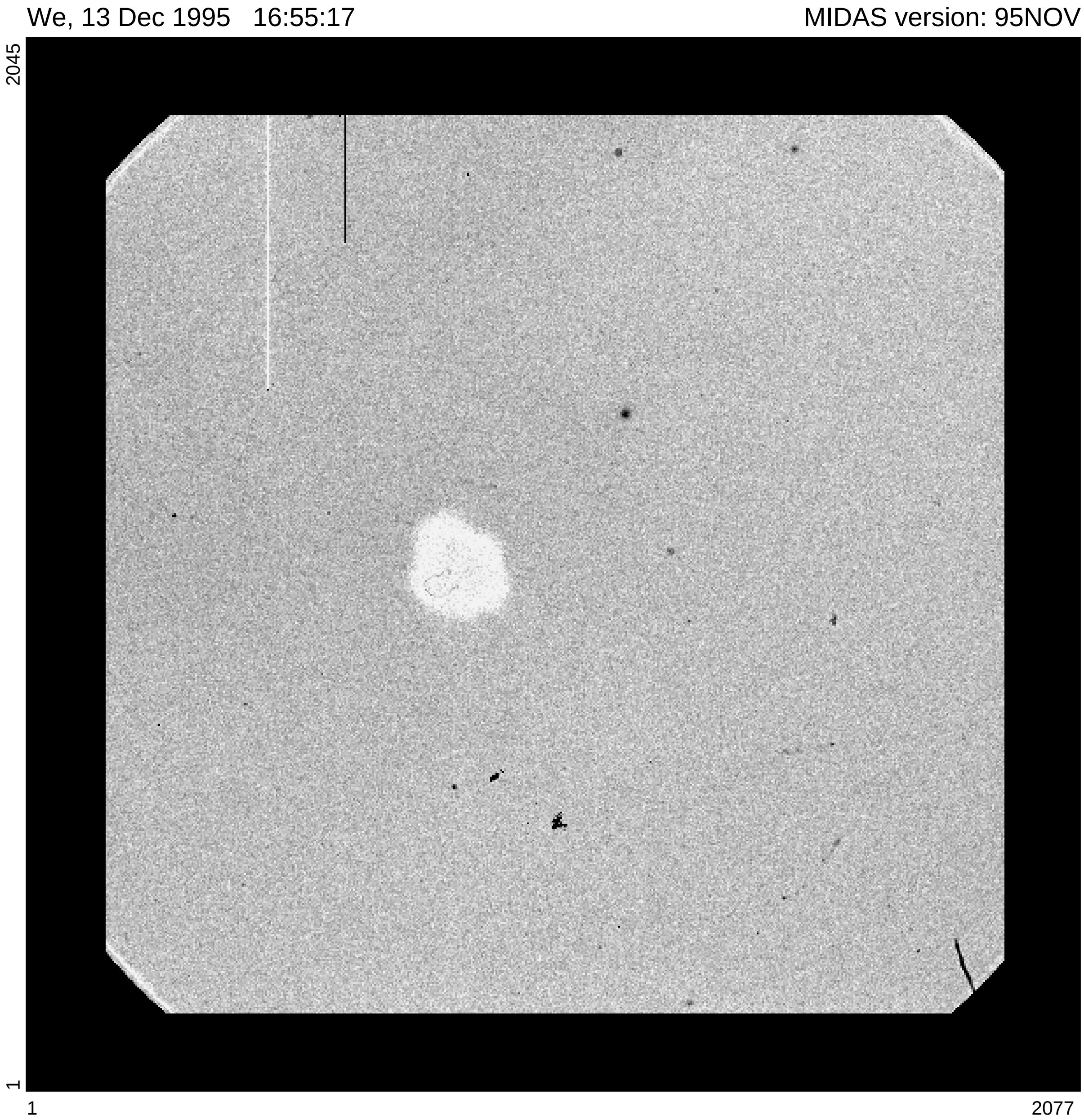
With the Amplifier A we found 35589 defective pixels. This was measured using three weak light images with a level of approximate 300 e^- per pixel (see page 8) and an automatic MIDAS-procedure to identify and catalogue the defects.

This test is very sensitive: A column defect is any defect which is longer than 10 pixels and a defect is any pixel which is lower than 50 % or higher than 200 % of the mean level of a weak light flat field exposure.

```
Number of hot defects:
Hot spots: 0; Hot cluster: 0; Hot columns: 0

Number of dark defects:
Dark pixel: 2; Dark cluster: 85; Dark columns: 175; Traps: 116

Number of all defects: 378
```



Frame	: weakmean
Identifier	: average frame
ITT-table	: ramp.itt
Coordinates	: 1, 1 : 2077, 2045
Pixels	: 1, 1 : 600, 600
Cut values	: 315.53, 372.86
User	: ehummel

Figure 3: Weak Flat field (700nm,2.5): approx. 300 e^- per pixel with amplifier A.

14 Uniformity

The homogeneity was measured using a standard method of sampling the whole sensitive area and using the RMS value of it. Values of deviations from homogeneity are given in table 2 on page 9.

Flat-field exposure at a wavelength in [nm]	Maximal RMS Deviation from mean value in [%]
320	6.67
340	8.66
360	9.70
380	9.59
400	8.41
450	5.13
500	3.44
550	2.94
600	2.67
650	2.31
700	2.05
750	2.19
800	2.33
850	2.83
900	3.56
950	4.42
1000	5.88

Table 2: Uniformity of the CCD

15 Remanence

Exposure Type	Exposure Time in [sec]	Illumination in [photons/pixel]	CCD Saturation	Remanence in [e$^-$ per pixel]
FF white	1(Dens=1)	203000	0.28	—
DK	600	—	—	5
FF white	1	1786000	2.47	—
DK	600	—	—	7
DK	600	—	—	6
DK	600	—	—	5
FF white	10	17860000	24.7	—
DK	600	—	—	—
DK	600	—	—	—
DK	600	—	—	—

Table 3: Remanence of the CCD at 161 K

The Remanence test was made after 10 hours in the dark and periodical wiping at at temperature of 161 K. After a high level flat field with white light which give over-saturation on the CCD, several ten minutes dark exposures have been taken. The mean level in the centre of these dark exposures was compared with the mean level of a ten minute dark before these saturations and the remanence in e$^-$ per pixel has been calculated. The results can be seen in table 3 on page 10.

References

[1] S. Deiries, M. Cullum: ESO Maintenance Manual No.5 July 89, CCD Cryostat for new VME-based Control Camera.

[2] J. Janesick, JPL: Private communication