CHIP CHARACTERISTICS
FOR
Tektronix TK2048EB4 1645BR04-01

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January 19, 1996

1 General Description

Chip type	: Tektronix TK2048EB4 Grade Engineering, thinned, AR coated, MPP
Chip characteristics	: AR coating: Indium die attach
Chip format	: 2048x2046, 19 pre-scan pixels in horizontal direction
Pixel size	: 24 x 24μm^2
Serial No.	: 1645BR04-01

The cryostat electronic board has special clock shaping capacitors for this CCD (C57–C59, C61–C64 = 100pF; C60 = 1nF; C65, C67, C69, C71 = 270nF; C68, C72 = 220nF).

2 Flatness of the chip

The surface of the CCD can be fitted with a sphere of a radius of 2608mm ± 165mm. The definition is fairly good.

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.

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VLO1 :  -8.05 VHI1 :  1.04 VLO2 :  -8.02 VHI2 :  1.04
HLO1 :  -4.01 HHI1 :  8.02 HLO2 :  -4.02 HHI2 :  8.02
RLO1 :  0.00 RHI1 :  12.98 RLO2 :  -7.99 RHI2 :  3.52
VDD1 :  24.04 VDR1 :  13.77 VDD2 :  24.02 VDR2 :  13.36
VGS1 :  -3.24 VSS1 :  0.01 VGS2 :  -9.01 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)

1.411±0.052 **e$^-$/ADU.** at subpatt 3

The readout-noise is

5.7±0.3 **e$^-$ RMS** at subpatt 3

Amplifier B:

The conversion factor is (at GAIN = 2)

1.566±0.038 **e$^-$/ADU.** at subpatt 3

The readout-noise is

17.4±1.1 **e$^-$ RMS** at subpatt 3

Amplifier C:

The conversion factor is (at GAIN = 2)

2.746±0.065 **e$^-$/ADU.** at subpatt 2

1.389±0.052 **e$^-$/ADU.** at subpatt 3

1.390±0.065 **e$^-$/ADU.** at subpatt 3 and 2x2 binning

The readout-noise is

2.746±0.065 **e$^-$ RMS** at subpatt 2

6.1±0.4 **e$^-$ RMS** at subpatt 3

6.5±0.7 **e$^-$ RMS** at subpatt 3 and 2x2 binning

Amplifier D:

The conversion factor is (at GAIN = 2)

1.455±0.047 **e$^-$/ADU.** at subpatt 3

1.334±0.45 **e$^-$/ADU.** at subpatt 3 and 2x2 binning

0.743±0.035 **e$^-$/ADU.** at subpatt 4

The readout-noise is

7.6±0.2 **e$^-$ RMS** at subpatt 2

6.2±0.3 **e$^-$ RMS** at subpatt 3

7.2±0.2 **e$^-$ RMS** at subpatt 3 and 2x2 binning

8.8±3.9 **e$^-$ RMS** at subpatt 4

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

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CCD SENSITIVITY CALIBRATION:                        22 Jun 1995   15:04:40
============================

Detector ID         : TK20164      Detector            : Tektronix
Calibrated against  : _SDC2_NP_2   Type                : TK2048EB4-ENG
Detector area (cm2) : 5.76E-06     ESO CCD No.         :    1334
e-/[ADU]            :  1.46        Used Output(s)      :     0
System gain         :     2        Subpattern          :     3
Misc.Comments       : tk2048eadmpp_1645BR04-01

CCD System values   :          Scanned CCD area
-----------------   :          ----------------
Hor. act. Pixels    :  2086        First pixel         :    24
Tot. vert. Lines    :  2060        Last pixel          :  2063
Hor.  Binning       :     1        First line          :     5
Vert. Binning       :     1        Last line           :  2042

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  161.2  1169 24.61 24.61   +3.679E-07  +4.013E+06  +2.475E-12
   340   300  0.0  161.2  5915 34.00 28.78   +5.383E-07  +1.470E+07  +8.561E-12
   360   300  8.6  161.2  7750 47.24 29.65   +7.907E-07  +1.386E+07  +7.637E-12
   380    60  8.6  161.2  7918 60.48 36.38   +1.070E-06  +5.531E+07  +2.883E-11
   400    40   .4  161.2  5138 71.65 69.07   +1.328E-06  +4.545E+07  +2.261E-11
   450    10   .4  161.2  5072 69.50 67.57   +1.450E-06  +1.850E+08  +8.175E-11
   500    10   .7  161.2  4530 72.29 72.29   +1.678E-06  +1.588E+08  +6.309E-11
   550    10  1.0  161.2  5866 76.47 63.46   +1.955E-06  +1.944E+08  +7.014E-11
   600    10  1.0  161.3  7615 81.76 50.83   +2.275E-06  +2.361E+08  +7.825E-11
   650    10  1.0  161.2  8333 79.49 44.68   +2.375E-06  +2.657E+08  +8.201E-11
   700    10  1.0  161.3 11046 79.92 32.44   +2.596E-06  +3.503E+08  +9.946E-11
   750    10   .9  161.3  9881 71.27 32.95   +2.479E-06  +3.514E+08  +9.318E-11
   800    10  1.0  161.3  8264 63.53 36.04   +2.358E-06  +3.297E+08  +8.193E-11
   850    10  1.0  161.3  8403 49.08 27.30   +1.939E-06  +4.339E+08  +1.013E-10
   900    10   .8  161.3  7908 34.64 20.65   +1.447E-06  +5.787E+08  +1.278E-10
   950    10   .6  161.3  6292 21.48 16.52   +9.460E-07  +7.425E+08  +1.555E-10
  1000    20   .8  161.3  5807 10.01  8.41   +4.635E-07  +7.355E+08  +1.464E-10
  1040    10   .5  162.1  5012  3.41  3.36   +1.648E-07  +3.729E+09  +7.109E-10
  1080    10  0.0  161.5  6754  1.31   .93   +6.606E-08  +1.306E+10  +2.390E-09
  1100    10  0.0  161.4  9314  1.45   .72   +7.426E-08  +1.623E+10  +2.932E-09
Calibration_error=    1.50%  Conversion_factor_error=   4.46%
_TK20164_25 stored on /users/ms/cali:HFS at 23 Jun 1995 11:57:14
```

Table: RQE measurement protocols for the CCD chip

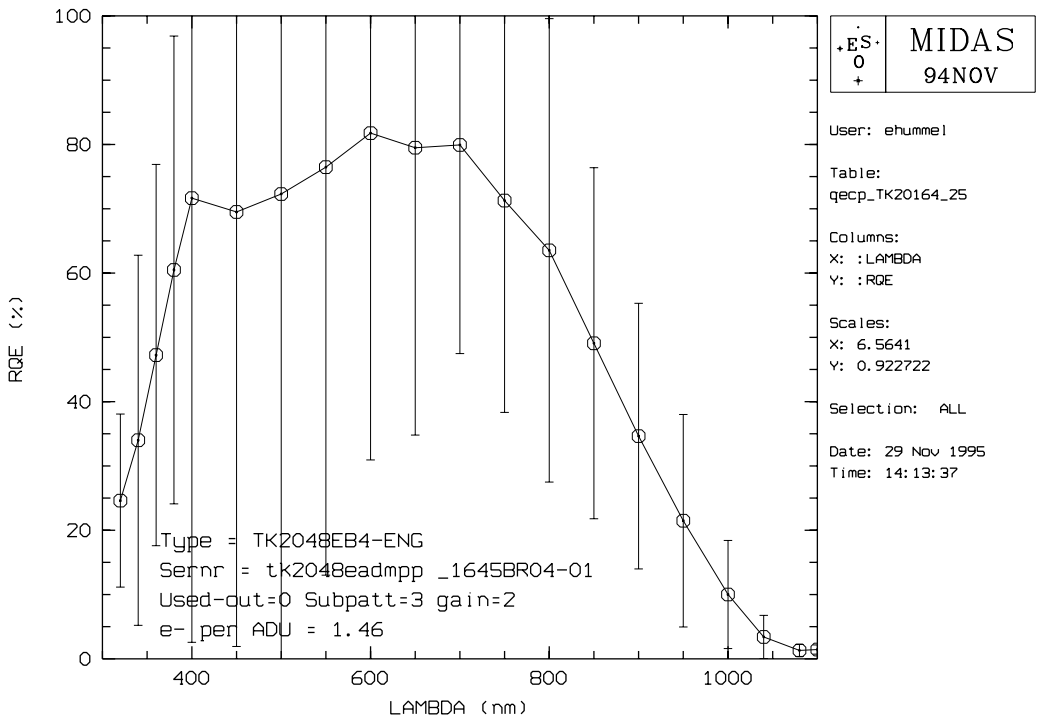

Figure 1: Plot of RQE values of the CCD (complete surface) at 161 K

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 4.46%) 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. 82 % at 600nm.

The high error bars are caused by the many defective columns on the CCD.

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

8 Charge Transfer Efficiency

The CTE was measured using Flat Field exposures and its over-scan regions and gives:

Amplifier A:

Serial CTE = 0.9999986 and Parallel CTE = 0.9999507

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. 7.7 ± 7.5 $e^-/pixel/hour$ at 161 K.

10 Linearity

The CCD was not optimized for linearity. Linearity was measured taking exposures of the same exposure-time at different light levels and at a wavelength of 700 nm.

Amplifier 1:

There is a maximum deviation of less than ±0.5% from the average value within 2.7 decades from 170 to 89470 e^- per pixel.

Amplifier 2:

There is a maximum deviation of less than ±0.9% from the average value within 2.5 decades from 170 to 55600 e^- per pixel.

See figure 2 on page 6 for details.

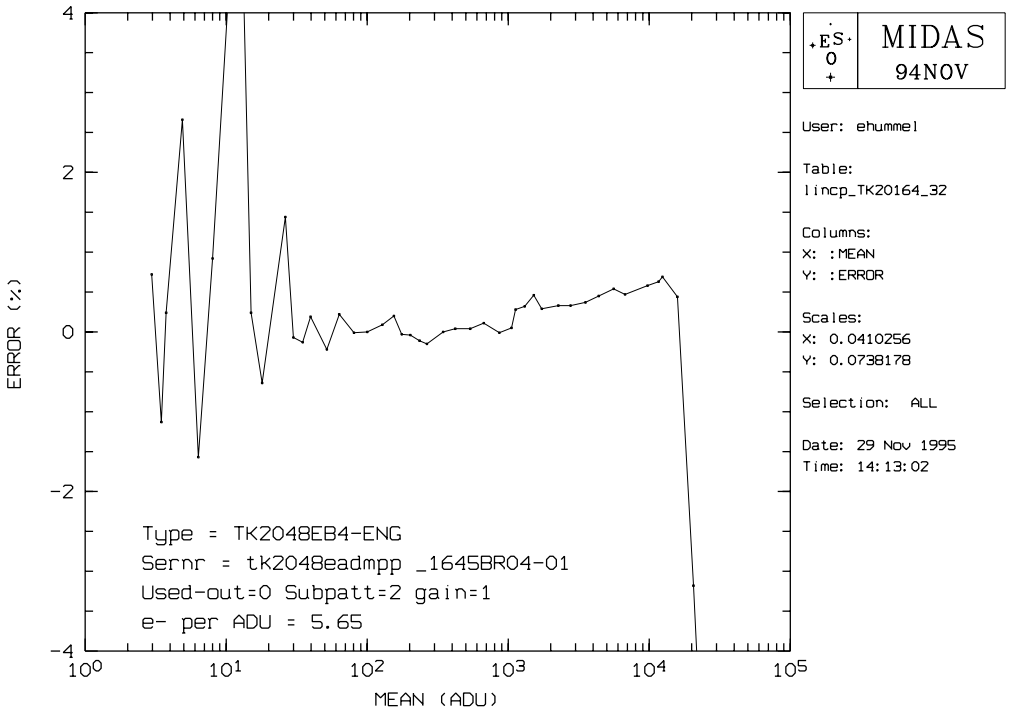

Figure 2: Linearity Measurement with amplifier 1

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 1:

Upper limit of linearity: 80 000 e^-/pixel
Saturation-value: 220 000 e^-/pixel

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

12 Cosmic Ray Events

TBD

13 Blemishes

With the Amplifier 1 we found 62422 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: 7; Hot cluster: 36; Hot columns: 24

Number of dark defects:
Dark pixel: 2; Dark cluster: 1; Dark columns: 3; Traps: 2

Number of all defects: 75
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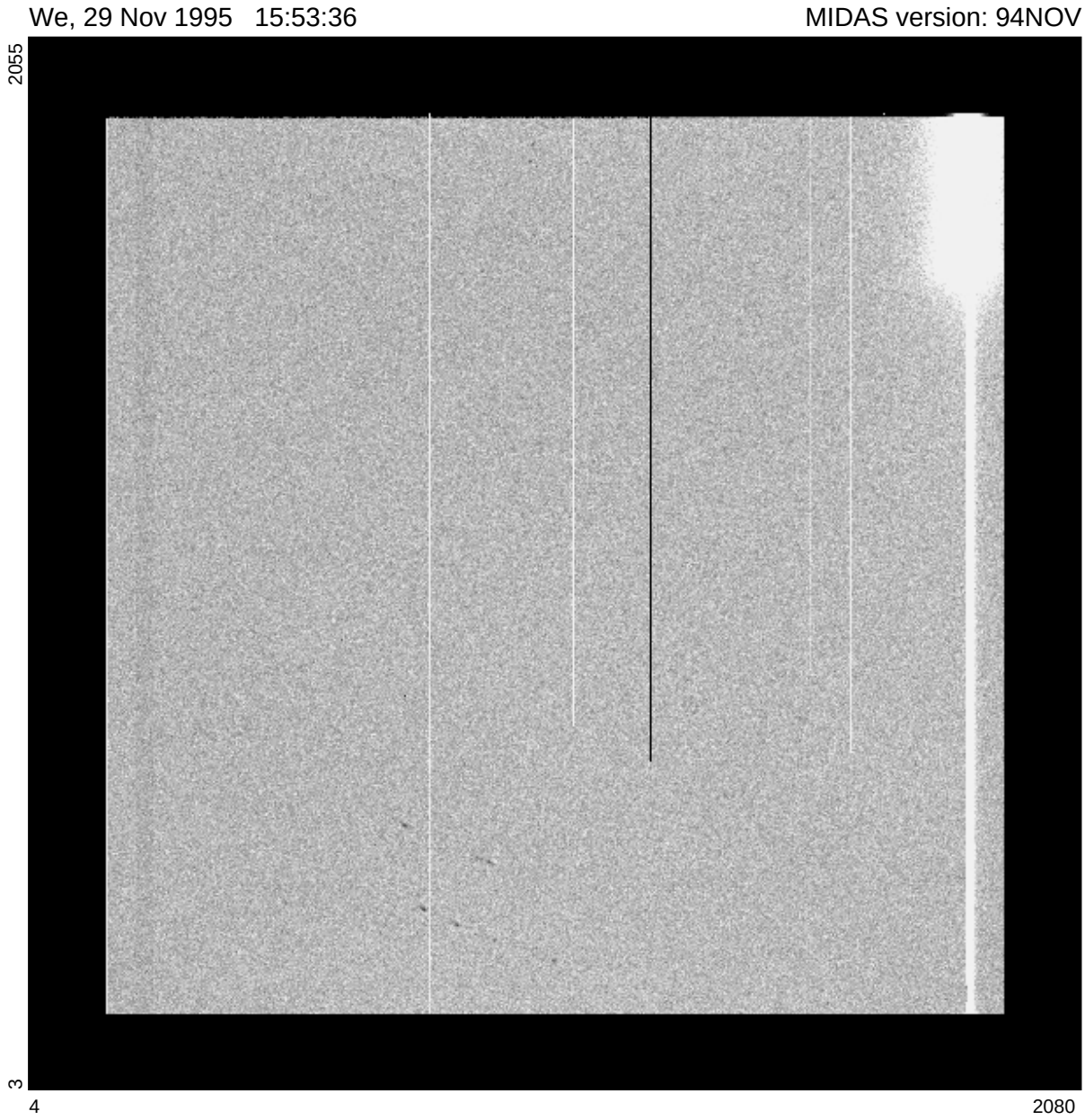

Frame	: ccd2721
Identifier	: FF/10S/700NM/3: Tektronix TK2048EB4-ENG 1645BR04-01 161.3 K
ITT-table	: ramp.itt
Coordinates	: 4, 3 : 2080, 2055
Pixels	: 1, 1 : 600, 600
Cut values	: 368.36, 551.79
User	: ehummel

Figure 3: Weak Flat field (700nm,3.0): approx. 300 e^- per pixel with amplifier 1.

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	461.01
340	84.51
360	62.58
380	59.96
400	96.29
450	97.11
500	109.74
550	82.85
600	62.00
650	56.01
700	40.32
750	45.99
800	56.54
850	55.42
900	59.44
950	76.77
1000	83.93
1040	43.54
1080	43.45
1100	43.43

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)	191200	0.56	—–
DK	600	—	—	0
FF white	1	1682000	4.96	—–
DK	600	—	—	0
DK	600	—	—	0
DK	600	—	—	0
FF white	10	16820000	50	—–
DK	600	—	—	0
DK	600	—	—	0
DK	600	—	—	0

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 oversaturation 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. There is **no** significant remanence with this CCD.

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