

# CHIP CHARACTERISTICS FOR Tektronix tk1024 TK1752BR07-03

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February 19, 1997

## 1 General Description

Chip type : Tektronix tk1024  
Chip characteristics: Grade 1,  
: thinned, AR coated, MPP  
Chip format : 1024x1024, 50 pre-scan pixels in horizontal direction  
Pixel size :  $24 \times 24 \mu m^2$   
Serial No. : TK1752BR07-03

## 2 Flatness of the chip

TBD

## 3 System Setup

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

The clock-pattern tk1024admpp 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.

VL01 : -8.01 VHI1 : 2.99 VL02 : -8.00 VHI2 : 3.02  
 HL01 : -2.00 HHI1 : 9.99 HL02 : -2.01 HHI2 : 10.00  
 RL01 : 0.000 RHI1 : 12.00 RL02 : 0.000 RHI2 : 12.01  
 VDD1 : 23.00 VDR1 : 13.18 VDD2 : 23.03 VDR2 : 13.20  
 VGS1 : 0.51 VSS1 : 0.00 VGS2 : 0.53 VSS2 : 0.00

Table 1: Telemetry values

## 5 Noise and Gain

Amplifier 1:

The conversion factor is (at GAIN = 2)

**3.303** $\pm$ 0.101 e<sup>-</sup>/ADU. at subpatt 2

**1.637** $\pm$ 0.016 e<sup>-</sup>/ADU. at subpatt 3

**1.617** $\pm$ 0.065 e<sup>-</sup>/ADU. at subpatt 3 and 2x2 binning

**0.81** $\pm$ 0.014 e<sup>-</sup>/ADU. at subpatt 4

The readout-noise is

**6.6** $\pm$ 0.2 e<sup>-</sup> RMS at subpatt 2

**5.4** $\pm$ 0.2 e<sup>-</sup> RMS at subpatt 3

**6.5** $\pm$ 0.3 e<sup>-</sup> RMS at subpatt 3 and 2x2 binning

**4.4** $\pm$ 0.2 e<sup>-</sup> RMS at subpatt 4

Amplifier 2:

The conversion factor is (at GAIN = 2)

**3.427** $\pm$ 0.098 e<sup>-</sup>/ADU. at subpatt 2

**1.664** $\pm$ 0.017 e<sup>-</sup>/ADU. at subpatt 3

**1.513** $\pm$ 0.067 e<sup>-</sup>/ADU. at subpatt 3 and 2x2 binning

**0.787** $\pm$ 0.080 e<sup>-</sup>/ADU. at subpatt 4

The readout-noise is

**6.6** $\pm$ 0.2 e<sup>-</sup> RMS at subpatt 2

**5.1±0.2 e<sup>-</sup> RMS** at subpatt 3

**5.7±0.2 e<sup>-</sup> RMS** at subpatt 3 and 2x2 binning

**3.9±0.4 e<sup>-</sup> 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 at short dark exposures.

## 7 Quantum Efficiency

CCD SENSITIVITY CALIBRATION:

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Detector ID      : TK11752      Detector      : Tektronix
Calibrated against : _SDC2_NP_2  Type         : TK1024
Detector area (cm2) : 5.76E-06    ESO CCD No.  : 1210
e-/[ADU]        : 1.66        Used Output(s) : 1
System gain     : 2          Subpattern    : 3
Misc.Comments   : tk1024admpp1_752BR07-03

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CCD System values :           Scanned CCD area
-----          :           -----
Hor. act. Pixels  : 1124      First pixel   : 70
Tot. vert. Lines : 1050      Last pixel    : 1056
Hor. Binning     : 1        First line    : 20
Vert. Binning    : 1        Last line     : 1006

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Lambda [nm]	Time [sec]	Dens [log]	Temp [K]	Counts [ADU]	RQE [%]	+/- [%]	Sensitivity [A/(W/cm2)]	Photon flux [Phot/cm2]	Irradiance [W/cm2]
320	300	0.0	172.6	767	22.16	.89	+3.313E-07	+3.332E+06	+2.055E-12
340	300	0.0	172.7	3569	29.78	.83	+4.715E-07	+1.154E+07	+6.718E-12
360	300	8.6	172.6	4533	40.30	1.43	+6.746E-07	+1.083E+07	+5.964E-12
380	60	8.6	172.6	4268	50.07	1.20	+8.858E-07	+4.101E+07	+2.138E-11
400	20	0.0	172.6	3484	60.10	1.46	+1.114E-06	+8.369E+07	+4.164E-11
450	10	0.0	172.6	6765	59.66	1.33	+1.245E-06	+3.274E+08	+1.447E-10
500	10	.3	172.6	6688	62.68	1.40	+1.455E-06	+3.081E+08	+1.224E-10
550	10	.8	172.6	5702	66.78	1.52	+1.707E-06	+2.465E+08	+8.894E-11
600	10	.9	172.6	5818	72.46	1.65	+2.016E-06	+2.318E+08	+7.684E-11
650	10	.9	172.6	6302	70.77	1.56	+2.114E-06	+2.571E+08	+7.936E-11
700	10	.9	172.6	8242	72.19	1.54	+2.345E-06	+3.297E+08	+9.359E-11
750	10	.9	172.6	5242	64.92	1.51	+2.258E-06	+2.332E+08	+6.183E-11
800	10	.6	172.6	9283	55.75	1.32	+2.069E-06	+4.808E+08	+1.195E-10
850	10	.9	172.6	5675	45.00	1.22	+1.778E-06	+3.641E+08	+8.498E-11
900	10	.6	172.6	5628	32.05	.91	+1.339E-06	+5.070E+08	+1.119E-10
950	10	.4	172.6	5650	19.75	.57	+8.699E-07	+8.259E+08	+1.729E-10
1000	10	0.0	172.6	7350	9.25	.29	+4.284E-07	+2.295E+09	+4.568E-10
1040	10	0.0	172.6	7518	3.10	.10	+1.501E-07	+6.998E+09	+1.334E-09
1080	10	0.0	172.6	3475	1.16	.04	+5.851E-08	+8.639E+09	+1.581E-09
1100	10	0.0	172.6	5106	1.35	.04	+6.876E-08	+1.095E+10	+1.977E-09

Calibration\_error= 1.50% Conversion\_factor\_error= .46%

\_TK11752\_27 stored on /users/ms/cali:HFS at 30 Jan 1997 22:24:33

Table: RQE measurement protocols for the CCD chip

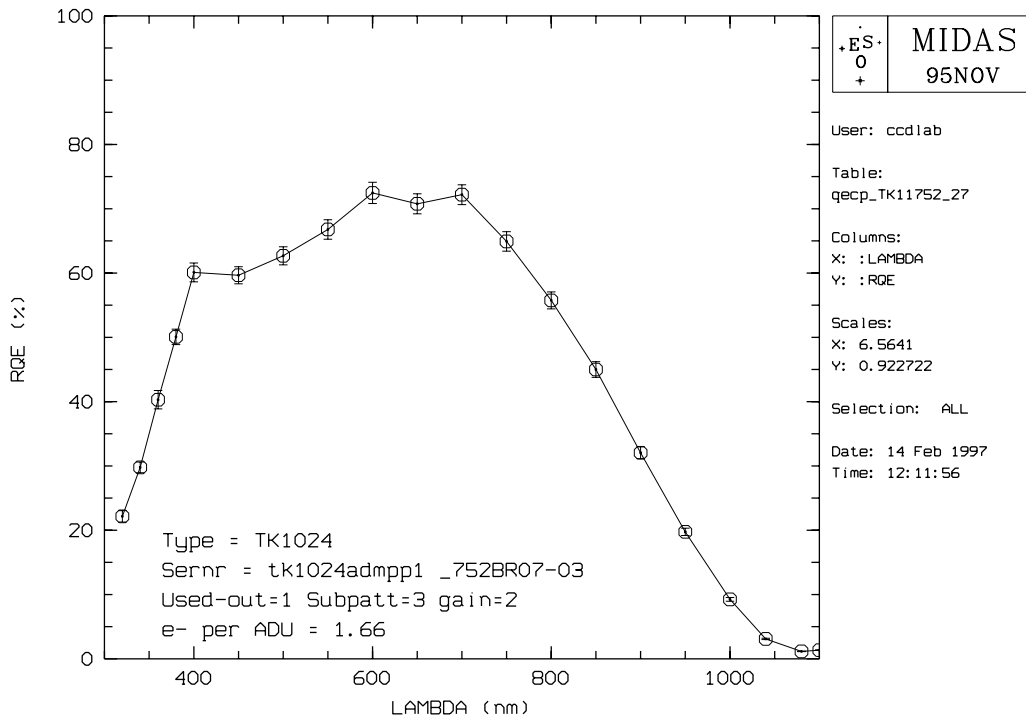


Figure 1: Plot of RQE values of the CCD (complete surface) at 170 K

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 0.46%) 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. 72 % at 600nm.

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

## 8 Charge Transfer Efficiency

CTE measurements could not be done with the EPER method because of the wax regions at the edge of the CCD.

Amplifier 1:

Serial CTE = 0.999998 and Parallel CTE = 0.999998

Amplifier 2:

Serial CTE = 0.999999 and Parallel CTE = 0.999997

## 9 Dark Current

The dark current was measured with a 20 minutes dark exposures without MPP-mode after more than 5 hours in the dark wiping the CCD every minute.

The mean dark current rate is approx.  $3.0 \pm 1.5 e^-/pixel/hour$  at 170 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 1:

There is a maximum deviation of less than  $\pm 0.94\%$  from the average value within 4.0 decades from 18 to 180100  $e^-$  per pixel.

### Amplifier 2:

There is a maximum deviation of less than  $\pm 0.4\%$  from the average value within 2.9 decades from 213 to 172700  $e^-$  per pixel.

See figure 2 on page 6 for details.

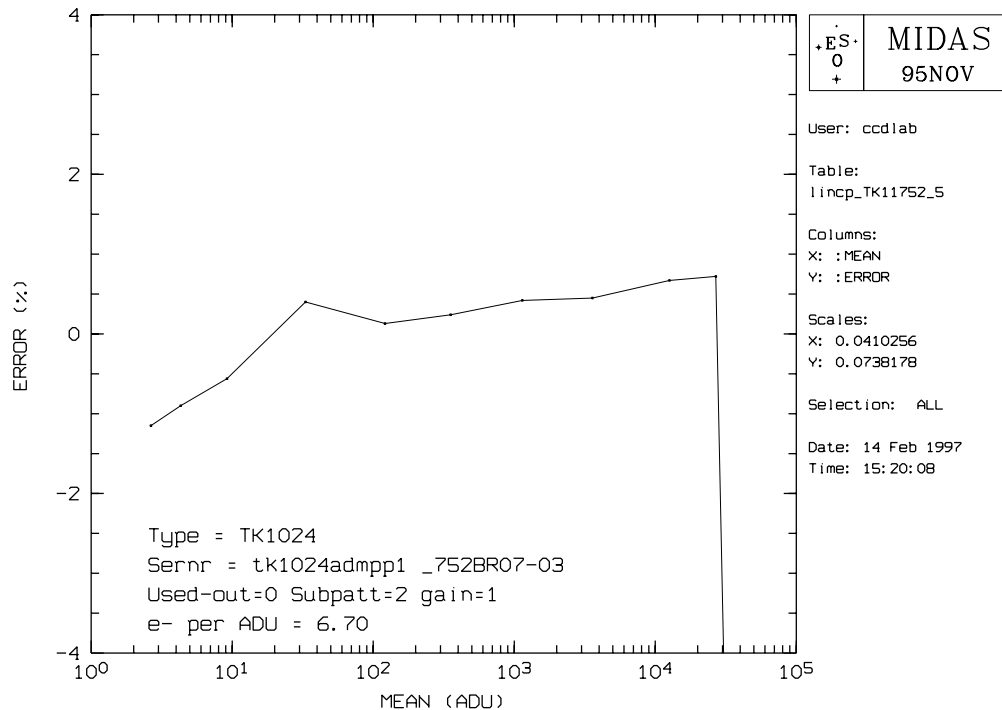


Figure 2: Linearity Measurement with amplifier 1

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: 170 000 e<sup>-</sup>/pixel**  
**Saturation-value: 284 000 e<sup>-</sup>/pixel**

**Amplifier 2:**

**Upper limit of linearity: 209 000 e<sup>-</sup>/pixel**  
**Saturation-value: 299 000 e<sup>-</sup>/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  $2.97 + 0.2 - 0.2$  events/min/cm<sup>2</sup>.**

## 13 Blemishes

With the Amplifier 1 we found 8 defective pixels. This was measured using three weak light images with a level of approximate 443 e<sup>-</sup> 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: 1; Hot columns: 0

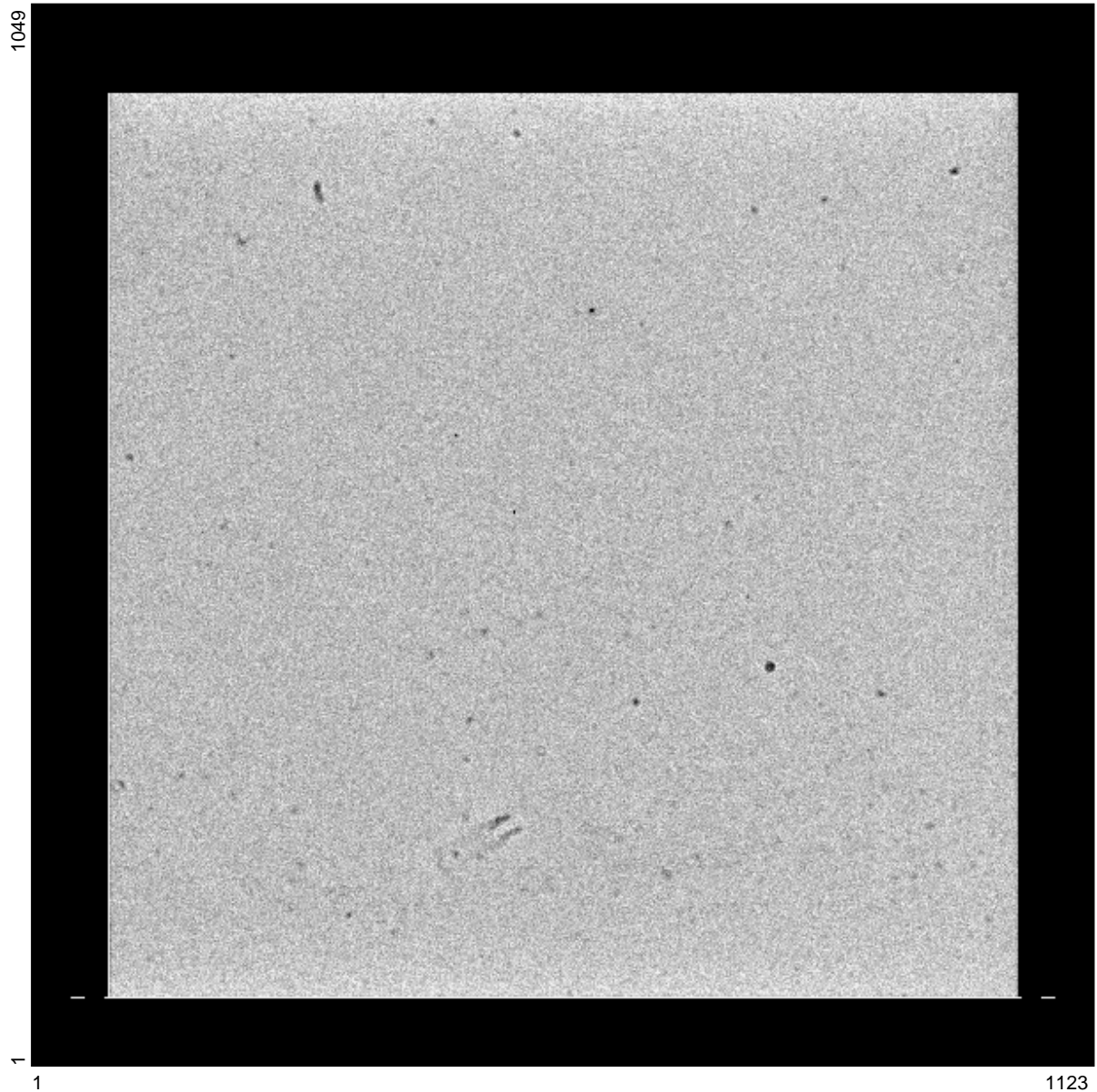
Number of dark defects:

Dark pixel: 1; Dark cluster: 0; Dark columns: 0; Traps: 1

Number of all defects: 3

Fr, 14 Feb 1997 16:10:08

MIDAS version: 95NOV



Frame : weakmean  
Identifier : average frame  
ITT-table : ramp.itt  
Coordinates : 1, 1 : 1123, 1049  
Pixels : 1, 1 : 600, 600  
Cut values : 572.44, 678.13  
User : ccclab

Figure 3: Weak Flat field (700nm,2.5): approx.  $443 e^-$  per pixel with amplifier 2.

With the Amplifier 2 we found 14 defective pixels.



Number of hot defects:

Hot spots: 0; Hot cluster: 0; Hot columns: 0

Number of dark defects:

Dark pixel: 1; Dark cluster: 1; Dark columns: 0; Traps: 3

Number of all defects: 5

## 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	3.72
340	2.31
360	3.18
380	1.82
400	1.86
450	1.58
500	1.59
550	1.64
600	1.65
650	1.55
700	1.45
750	1.71
800	1.76
850	2.20
900	2.38
950	2.45
1000	2.66
1040	2.97
1080	2.98
1100	2.60

Table 2: Uniformity of the CCD

## 15 Remanence

The Remanence test was made after 10 hours in the dark and periodical wiping at at temperature of 170 K. After a high level flat field with white light which give over-

Exposure Type	Exposure Time in [sec]	Illumination in [photons/pixel]	CCD Saturation	Remanence in [e <sup>-</sup> per pixel]
FF white	1(Dens=1)	135000	0.39	—
DK	600	—	—	1
FF white	1	1188000	3.41	—
DK	600	—	—	9
DK	600	—	—	1
DK	600	—	—	1
FF white	10	11880000	34.1	—
DK	600	—	—	2
DK	600	—	—	0
DK	600	—	—	4

Table 3: Remanence of the CCD at 170 K

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<sup>-</sup> per pixel has been calculated. The results can be seen in table 3 on page 10. There is 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