APM 93-63

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## Memorandum

PPM-93-063

DATE: June 16, 1993
TO: B. Fafaul/311.0
FROM: K. Sahu/300.1
SUBJECT: Radiation Report on FAST/MU3
Part No. OW628128CD (128Kx8 RAM)
Control No. 7867

cc: R. Kolecki/740.4
T. Miccolis/300.1
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SMEX, PPM File

A radiation evaluation was performed on OW628128CD (128Kx8 CMOS RAM) to determine the total dose tolerance of these parts. A brief summary of the test results is provided below. For detailed information, refer to Tables I through VI and Figure 1.

The total dose testing was performed using a cobalt-60 gamma ray source. During the radiation testing, eight parts were irradiated under bias (see Figure 1 for bias configuration), and two parts were used as control samples. The total dose radiation levels were 5, 10, 15, 25, 50, 75 and 100 krads*. After 5 krads, 10 krads, 25 and 100 krads, the parts were annealed at 25°C for 96, 120, 540 and 264 hours, respectively. The dose rate was between 0.24 and 1.82 krads/hour, depending on the total dose level (see Table II for radiation schedule). After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits** listed in Table III. Electrical tests included two functional tests at Vcc = 5.00 VDC, one at 1 MHz and one at 10 MHz. The functional tests were performed using an Algorithm Pattern Generator (APG) and consist of both simple and complex functional tests. Details of the functional tests are provided in Table IV.

The simple functional tests (Read/Write ones, Zeroes and Checkerboard) detect individual cell failures, while the complex functional tests (March, Row and Column Address, Sliding Diagonal, Ping-Pong, Surround and Row and Column Galloping) detect pattern sensitive failures.

There were no Read/Write Ones and Zeroes failures during the entire radiation evaluation up to 100 krads exposure. There were intermittent failures in complex functional tests, such as March, Ping Pong, etc., after the 5, 10, 15, 25, 50, 75 and 100 krad irradiations. The results of the functional testing are shown in detail in Table V. However, when the parts were annealed at 25°C for intervals varying from 96 to 504 hours, most of the parts showed recovery in functional tests. For more details on intermittent failures, refer to note 3 on Table V.

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*The term rads, as used in this document, means rads(silicon). All radiation levels cited are cumulative.
**These are manufacturers' non-irradiated data specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.

Table VI provides mean and standard deviation values for each parameter (VOH, VOL, IIH, IIL, IOH, IOL, ISBH, ISBL, ISB1H, ISB1L AND ICCD) after different irradiation exposures and annealing steps. All parts stayed within the specification limits for all parameters except IIL. All parts exceeded the specification limit of -5.0 μA after 25 and 50 krads exposure, with typical readings between -5.0 μA and -10 μA. However, all parts recovered to within specification limits after annealing for 240 hours.

Any further details about this evaluation can be obtained upon request. If you have any questions, please call me at (301) 731-8954.

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TABLE I. Part Information

| | |
|---|---|
| Generic Part Number: | OW62128CD |
| Part Number: | OW62128CD* |
| FAST/MU3 Control Number: | 7867 |
| Charge Number: | C33331 |
| Manufacturer: | Hitachi |
| Packaging: | Omniwave |
| Lot Date Code: | 9049 |
| Quantity Tested: | 10 |
| Serial Numbers of Radiation Samples: | 353 through 360 |
| Serial Numbers of Control Samples: | 351, 352 |
| Part Function: | 128K X 8 CMOS RAM |
| Part Technology: | CMOS |
| Package Style: | 32-pin Ceramic DIP |
| Test Equipment: | Schlumberger S-50 |
| Test Engineer: | A. Karygiannis |

* No radiation tolerance/hardness was guaranteed by the manufacturer for this part.

TABLE II. Radiation Schedule for OW628128CD

| EVENTS | DATE |
|---|---|
| 1) INITIAL ELECTRICAL MEASUREMENTS | 04/06/93 |
| 2) 5 KRAD IRRADIATION (0.12 KRADS/HOUR)<br>POST-5 KRAD ELECTRICAL MEASUREMENT | 04/06/93<br>04/08/93 |
| 3) 96 HOUR ANNEALING @25°C<br>POST-96 HOUR ANNEAL ELECTRICAL MEASUREMENT | 04/08/93<br>04/12/93 |
| 4) 10 KRAD IRRADIATION (0.12 KRADS/HOUR)<br>POST-10 KRAD ELECTRICAL MEASUREMENT | 04/12/93<br>04/14/93 |
| 5) 120 HOUR ANNEALING @25°C<br>POST-120 HOUR ANNEAL ELECTRICAL MEASUREMENT | 04/14/93<br>04/19/93 |
| 6) 15 KRAD IRRADIATION (0.071 KRADS/HOUR)<br>POST-15 KRAD ELECTRICAL MEASUREMENT | 04/20/93<br>04/23/93 |
| 7) 25 KRAD IRRADIATION (0.12 KRADS/HOUR)<br>POST-25 KRAD ELECTRICAL MEASUREMENT | 04/23/93<br>04/26/93 |
| 8) 96 HOUR ANNEALING @25°C<br>POST-96 HOUR ANNEAL ELECTRICAL MEASUREMENT | 04/26/93<br>04/30/93 |
| 9) 336 HOUR (CUMULATIVE) ANNEALING @25°C<br>POST-336 HOUR ANNEAL ELECTRICAL MEASUREMENT | 04/30/93<br>05/10/93 |
| 10) 504 HOUR (CUMULATIVE)ANNEALING @25°C<br>POST-504 HOUR ANNEAL ELECTRICAL MEASUREMENT | 05/10/93<br>05/17/93 |
| 11) 50 KRAD IRRADIATION (0.284 KRADS/HOUR)<br>POST-50 KRAD ELECTRICAL MEASUREMENT | 05/19/93<br>05/24/93 |
| 12) 75 KRAD IRRADIATION (0.284 KRADS/HOUR)<br>POST-75 KRAD ELECTRICAL MEASUREMENT | 05/24/93<br>05/28/93 |
| 13) 100 KRAD IRRADIATION (0.284 KRADS/HOUR)<br>POST-100 KRAD ELECTRICAL MEASUREMENT | 06/01/93<br>06/04/93 |
| 14) 264 HOUR ANNEALING &25°C<br>POST-264 HOUR ANNEAL ELECTRICAL MEASUREMENT | 06/04/93<br>06/15/93 |

ALL ELECTRICAL MEASUREMENTS WERE PERFORMED AT 25°C.

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS; SEE FIGURE 1.

Table III. Electrical Characteristics of OW628128CD

| Parameter | Units | Spec. Limits | | Test Conditions |
|---|---|---|---|---|
| | | Min. | Max. | |
| FUNC1/1 | | | | Vil = 0, Vih = 5.0V, FREQ = 1 MHz |
| FUNC2/1 | | | | Vil + 0, Vih = 5.0V, FREQ =10 MHz |
| VOH | V | 2.40 | 5.50 | Vil = 0, Vih = 4.5V, Load = -1 mA |
| VOL | mV | 0 | 400 | Vil = 0, Vih = 4.5V, Load =2.1 mA |
| IIH | µA | 0 | 5.00 | Vil = 0, Vih = 5.5V, VTST = 5.5V |
| IIL | µA | -5.00 | 0 | Vil = 0, Vih = 5.5V, VTST = 0V |
| IOH | µA | -5.00 | 5.00 | Vil = 0, Vih = 5.5V, VOUT = 5.5V |
| IOL | µA | -5.00 | 5.00 | Vil = 0, Vih = 5.5V, VOUT = 0.5V |
| ISBH | mA | 0 | 20.0 | Vil = 0, Vih = 5.5V, VIN = GND |
| ISBL | mA | 0 | 20.0 | Vil = 0, Vih = 5.5V, VIN = VCC |
| ISB1H | mA | 0 | 5.00 | Vil = 0.2, Vih = 5.3V, VIN = GND |
| ISB1L | mA | 0 | 5.00 | Vil = 0.2, Vih = 5.3V, VIN = VCC |
| ICCD | mA | 0 | 95.0 | Vil = 0, Vih = 5.5V |

1/ Functional testing consists of the following:

1 - ALL_ONES
2 - ALL_ZEROS
3 - CHECKERBOARD
4 - INVERSE CHECKERBOARD
5 - "10N" MARCH
6 - ROW_ADDRESS
7 - COL_ADDRESS
8 - SLIDING_DIAGONALLY
9 - PING_PONG
10 - SURROUND
11 - ROW_GALPAT
12 - COL_GALPAT

2/ VIL and VIH are tested GO/NOGO in the VOH and VOL tests.

Table IV. AUTOMATIC PATTERN GENERATOR (APG)
TEST PATTERNS AND FAILURE DESCRIPTION

| PATTERN NAME | TYPE OF FAILURES DETECTED BY PATTERN |
|---|---|
| ALL ZEROES & ALL ONES | – Opposite Logic State, Minimal Functional testing, Minimal check on Cell Interactions. |
| +CHECKERBOARD & -CHECKERBOARD | – Faulty operation of device address decoders, Minimal Functional testing. |
| MARCH | – Tests whether each DUT cell (bit) can be accessed and written into with a Zero and One. |
| ROW ADDRESS & COLUMN ADDRESS | – Faulty Access or Write into a cell.<br>– Faulty Noise Coupling within a Column.<br>– Faulty Noise Coupling within a Row.<br>– Slow Sense–Amplifier Recovery.<br>– Faulty Address Transitions between each Cell and Cells row.<br>– Faulty Address Transitions between each Cell and Cells Column.<br>– Faulty Refresh Sensitivity in Dynamic RAMS. |
| SLIDE DIAGONAL | – Faulty Internal multiple–address selection.<br>– Destruction of stored data due to noise coupling.<br>– Faulty Sense Amplifiers.<br>– Slow Sense–Amplifier Recovery. |
| PING PONG | – Unsatisfactory address transitions between each Cell and every other Cell.<br>– Slow Sense–Amplifier Recovery.<br>– Destruction of stored data due to noise coupling between cells within a column.<br>– Destruction of stored data due to noise coupling between cells within a row.<br>– Faulty Refresh Sensitivity in Dynamic RAMS. |
| SURROUND | – Destruction of stored data within a cell due to opposite state writes to surrounding cells.<br>– Faulty Access or Write into a cell.<br>– Slow Sense–Amplifier Recovery. |
| ROW GALPAT & COLUMN GALPAT | – Uncovers internal multiple–address selection.<br>– Slow Sense–Amplifier Recovery.<br>– Destruction of stored data due to noise coupling between column and/or rows. |

JRL 06–14–93

Table V. Functional Test Results for OW628128CD after Total Dose Irradiations and Annealings @ +25°C/1

| Functional Pattern | Test Freq | Initial EM's /2 | Post 5Krad /1 | Post 96Hr Annealing | Post 10Krad | Post 120Hr Annealing | Post 15Krad | Post 25Krad | Post 504Hr Annealing | Post 50Krad | Post 100Krad | Post 264Hr Annealing/3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All Ones | 1 MHz | | | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P |
| All Ones | 10 MHz | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P |
| All Zeroes | 1 MHz | | | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P |
| All Zeroes | 10 MHz | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P |
| Checkerboard | 1 MHz | | | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P |
| Checkerboard | 10 MHz | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 7P/1F | 8P |
| Inv Checkerboard | 1 MHz | | | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P |
| Inv Checkerboard | 10 MHz | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P |
| March | 1 MHz | | | 8P | 6P/2F | 8P | 8P | 8P | 8P | 8P | 8P | 8P |
| March | 10 MHz | 8P | 7P/1F | 8P | 7P/1F | 8P | 8P | 8P | 8P | 8P | 7P/1F | 8P |
| Row Address | 1 MHz | | | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P |
| Row Address | 10 MHz | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 7P/1F | 8P |
| Column Address | 1 MHz | | | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P |
| Column Address | 10 MHz | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 8P | 7P/1F | 8P |
| Sliding Diagonal | 1 MHz | | | 8P | 7P/1F | 8P | 8P | 8P | 8P | 8P | 3P/5F | 8P |
| Sliding Diagonal | 10 MHz | 8P | 7P/1F | 8P | 7P/1F | 8P | 8P | 8P | 8P | 8P | 7P/1F | 8P |
| Ping Pong | 1 MHz | | | 8P | 8P | 8P | 6P/2F | 0P/8F | 3P/5F | 0P/8F | 8P | 8P |
| Ping Pong | 10 MHz | 8P | 8P | 8P | 7P/1F | 8P | 8P | 4P/4F | 8P | 0P/8F | 7P/1F | 8P |
| Surround | 1 MHz | | | 8P | 6P/2F | 8P | 8P | 8P | 8P | 8P | 8P | 8P |
| Surround | 10 MHz | 8P | 8P | 8P | 6P/2F | 8P | 8P | 8P | 8P | 8P | 7P/1F | 8P |
| Row Galpat | 1 MHz | | | 8P | 2P/6F | 8P | 8P | 8P | 8P | 8P | 7P/1F | 8P |
| Row Galpat | 10 MHz | 8P | 5P/3F | 8P | 3P/5F | 8P | 8P | 8P | 8P | 8P | 7P/1F | 8P |
| Column Galpat | 1 MHz | | | 8P | 3P/5F | 8P | 8P | 8P | 8P | 8P | 7P/1F | 8P |
| Column Galpat | 10 MHz | 8P | 5P/3F | 8P | 3P/5F | 8P | 8P | 8P | 8P | 8P | 7P/1F | 8P |

NOTES :

1/ "P" means that all parts passed this functional test at this irradiation or annealing level. "F" means that all parts failed this functional test at this irradiation or annealing level. "nP/mF" means that n parts passed and m parts failed this functional test at this irradiation or annealing level.

2/ The 1 MHz functional test was not performed during the Initial and Post 5 Krad Electrical Measurements.

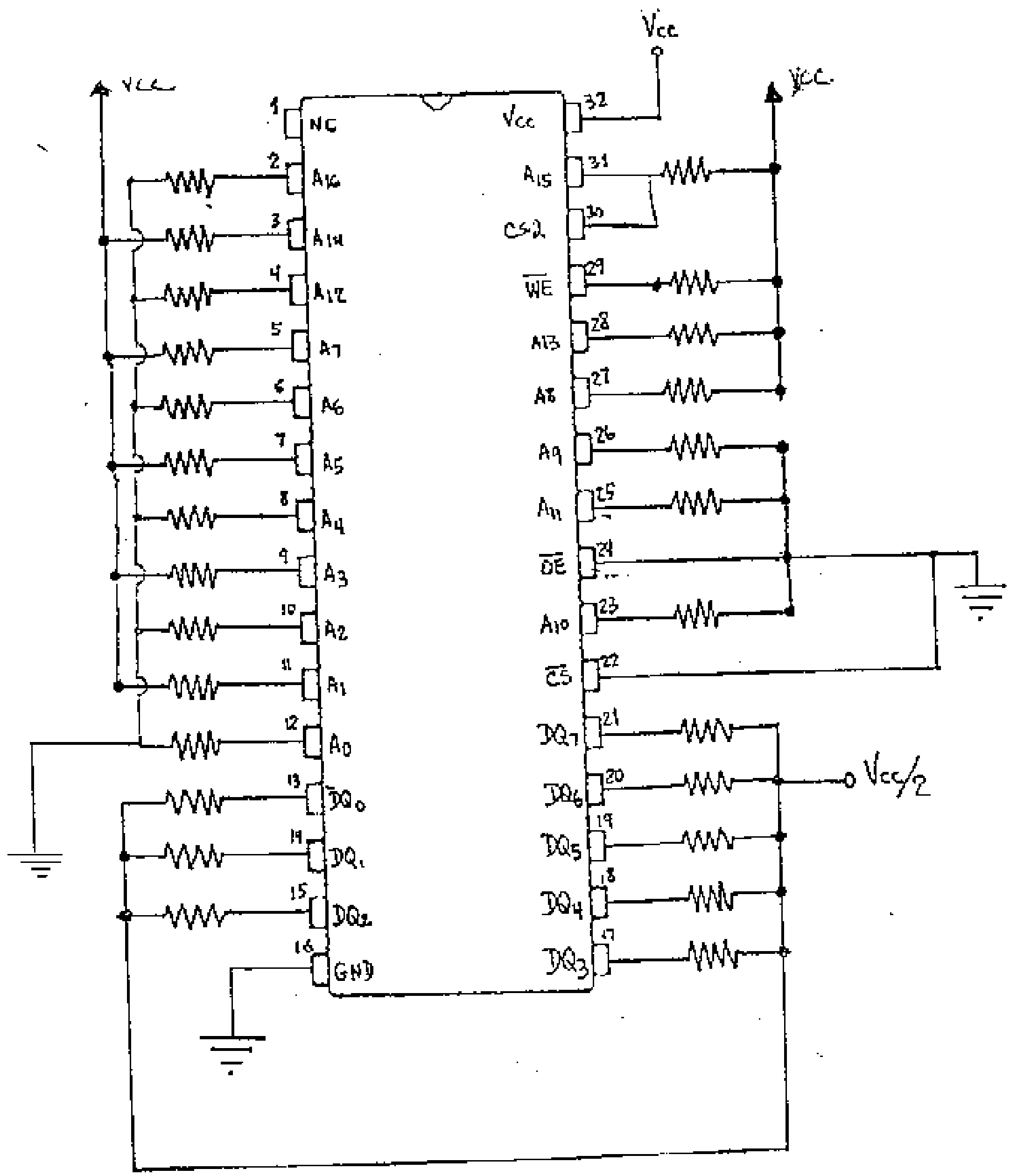
3/ The intermittent failures in complex functional test patterns, such as March, Ping Pong, etc., could be due to an increase in ambient temperature of the ATE Lab beyond the operating specifications of the equipment for a short interval of time. However, it is also possible that some parts indeed failed these tests at intermediate radiation exposures, but recovered on annealing @ 25°C for intervals ranging from 96–504 hours, depending upon the total dose level. Note that in the natural space environment, the parts would not see 100 Krads in more than 3 years (>25,000 hours), thereby allowing significant annealing to occur.

## TABLE VI: Summary of Electrical Measurements After Selected Total Dose Exposures and Annealing for OW628128CD 1/

| | | Spec. Lim./3 | | TDE/2 Initial 0 | | TDE 10 krads | | TDE 15 krads | | TDE 25 krads | | Anneal 504 hrs @25°C | | TDE 50 krads | | TDE 100 krads | | Anneal 264 hrs @25°C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameters | | min | max | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd | mean | sd |
| VOH | V | 2.40 | 5.50 | 3.55 | .01 | 3.55 | .01 | 3.55 | .01 | 3.54 | .01 | 3.55 | .01 | 3.54 | .81 | 3.53 | .81 | 3.54 | .81 |
| VOL | mV | 0 | 400 | 179 | 4.9 | 181 | 5.0 | 178 | 4.8 | 178 | 5.0 | 178 | 4.8 | 180 | 5.0 | 181 | 4.6 | 180 | 5.0 |
| IIH | µA | 0 | 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .01 | 0 | 0 | 0.03 | .03 | 0.07 | .08 | 0.04 | .05 |
| IIL | µA | -5.00 | 0 | 0 | 0 | 0 | .01 | -.15 | .25 | -1.6 | 2.5 | -.88 | 1.3 | -2.3 | 3.6 | -.93 | 1.2 | -.52 | .67 |
| IOH | µA | -5.00 | 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IOL | µA | -5.00 | 5.00 | 0 | 0 | 0 | 0 | 0 | .01 | -.01 | .01 | 0 | 0 | -.01 | .02 | -.01 | .02 | 0 | .01 |
| ISBH | mA | 0 | 20.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ISBL | mA | 0 | 20.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.05 | .03 | 0 | 0 | 0.04 | .05 | 0.01 | .03 | 0.02 | .03 |
| ISB1H | mA | 0 | 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ISB1L | mA | 0 | 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ICCD | mA | 0 | 95.0 | 33.9 | .44 | 33.8 | .44 | 34.1 | .43 | 34.2 | .45 | 34.2 | .74 | 34.0 | .44 | 33.5 | .57 | 33.8 | .43 |

1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.
2/ Total Dose Exposure
3/ These are manufacturers' non-irradiated data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

Figure 1. Radiation Bias Circuit for OW628128CD




1) Vcc = +5.0 VDC ± 10%

2) Vcc/2 = +2.5 VCD ± 10%

3) All resistor values are 2K Ohms ± 10%, 1/4 W minimum.