

DATE: Feb.7, 1997  
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 SUBJECT: Radiation Report on: 16 MBit DRAMs, TI TMS416400  
           Project: EO1  
           Control #: 15548  
           Job #: EE71384/EE71401

PPM-97-006

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A radiation evaluation was performed on TMS416400(16 Mbit DRAMs, 5-volt) to determine the total dose tolerance of these parts. A brief summary of the test results is provided below. For detailed information, refer to Figure 1 and Tables I through IV.

The total dose testing was performed using a Co<sup>60</sup> gamma ray source. During the radiation testing, five parts of each type were irradiated under bias (see Figure 1 for bias configuration) and one part of each type was used as a control sample. The total dose radiation levels were 5, 10, and 12.5, krad<sup>\*</sup>. The dose rate was between 0.04 and 0.12 krad/hour (see Table II for radiation schedule. Between the radiation steps of 10 and 12.5 krad, parts were annealed under bias at 25 c for 600 hours to determine if the parts would show significant recovery in the very low dose rate space environment). After each radiation exposure and annealing steps, parts were electrically tested according to the test conditions and the specification limits\*\* listed in Table III. The electrical tests included six functional tests. These were as follows: 1. SIMPLE FUNCTIONAL TEST (which consists of randomly accessing two addresses without using the algorithmic pattern generator), 2. COL\_ADDRESS, 3. ALL\_ONES, 4. ALL\_ZEROS, 5. CHECKERBOARD & INVERSE CHECKERBOARD, 6. SURROUND.

All irradiated parts passed all functional and electrical tests initially and on irradiation to 5 krad irradiation level. No significant degradation was observed in any DC or AC parameter.

After 10 krad irradiation, SN#46, 48 and 49 failed all functional tests and number of VIH\_ and VIL tests and timing parameters. The parts also showed significant increase in ICC1, ICC2, ICC3, ICC4, ICC5 and ICC6. The readings for ICC1, ICC3, ICC4 and ICC6 ranged from 27 to 128 mA against the specification limit of 80 mA. The readings for ICC2 and ICC5 ranged from 1.7 to 16 mA against the specification limit of 2.0 and 1.0 mA respectively. Please note that 128 mA and 16 mA was the preset limit of the Automatic Test Equipment. This implies that some of the failing parts could have ICC1, ICC3, ICC4 and ICC6 readings higher than 128 mA and ICC2 and ICC5 readings higher than 16 mA. Although SN# 47 passed all functional tests, it showed significant increases in ICC4 and ICC5.

The part was kept under annealing @ 25°C for 600 Hours (≈ three weeks) to see if it would show functional recovery and decrease in ICC parameters. Electrical measurements were made after 24, 48, 120 and 600 Hours to monitor any recovery in the parts. It was found that parts passed all functional tests after 120 hours of annealing and showed significant reduction in the ICC parameters although some parts still exceeded the specification limits. Also two parts continued to fail VIH-MIN tests. The electrical measurements after 600 hours, showed further recovery in the parts. All parts passed all functional tests and DC/ AC tests except the readings for ICC5 ranged from 1.1 to 1.7

\* The term rads, as used in this document, means rads(SiO<sub>2</sub>). All radiation levels cited are cumulative.

\*\* These are manufacturer's pre-irradiation data specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.

mA against the specification limit of 1 mA. The annealing results indicate that in the low dose rate space environment, these parts should pass up to 10 krad.

The parts were further irradiated to 12.5 krad. All parts failed all functional tests and showed very significant increase in all ICC parameters. Parts also failed a number of other DC and AC tests. Some recovery was observed on annealing for 96 hours at 25°C. However, it was clear that these parts could not be used at this level.

Finally the parts were annealed at 100°C for 240 hours to look for any reverse recovery or rebound that can occur for some technologies. No reverse recovery or rebound was observed.

Table IV provides a summary of the mean and standard deviation values for each parameter after each irradiation exposure and annealing step.

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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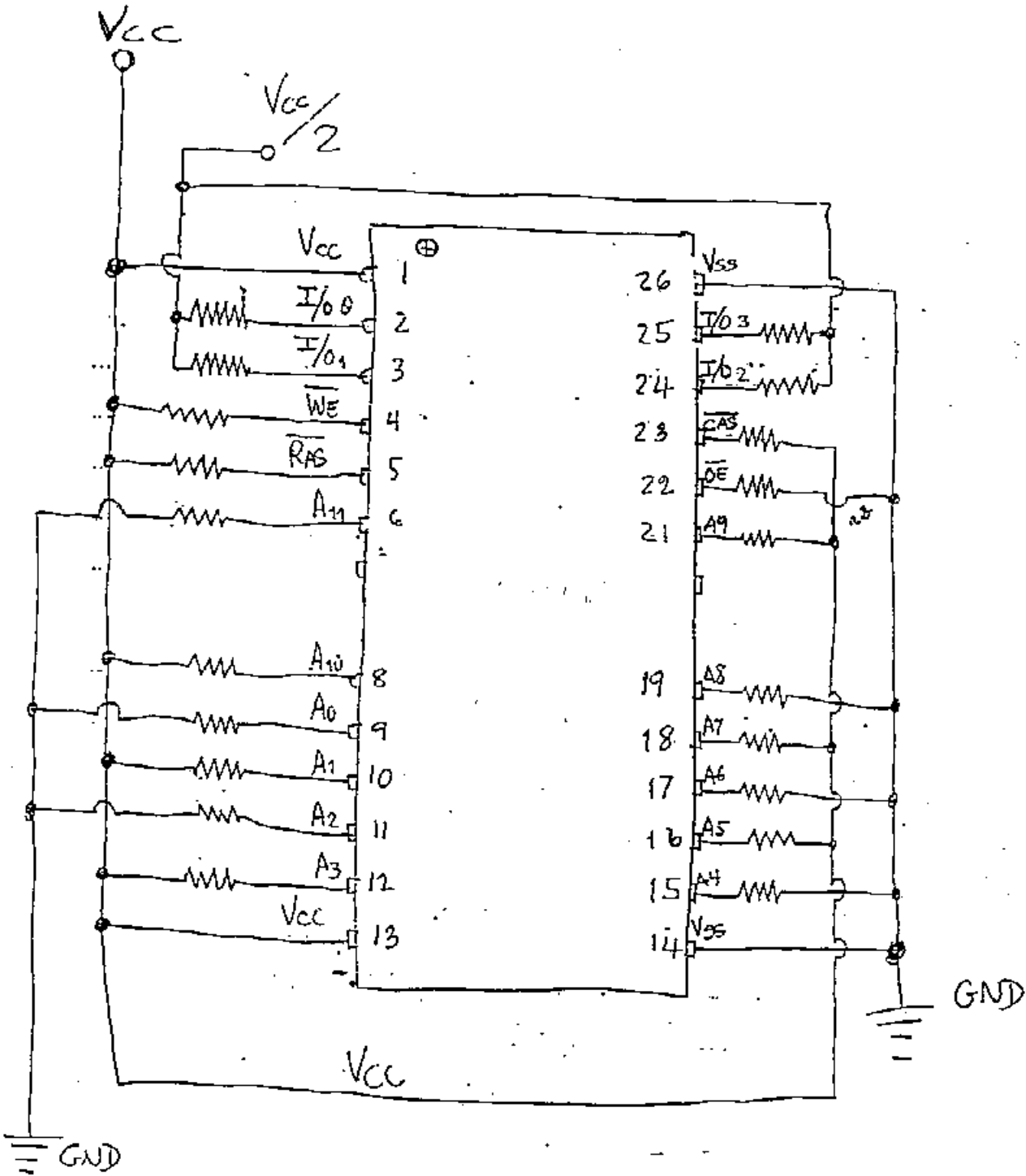
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Figure 1. Radiation Bias Circuit for TMS416400



Vcc=+5.0V ± 0.1 V, Vcc/2 = 2.5V ± 0.1 V, GND=0V ± 0V, R=2KΩ ± 10%.

TABLE I. Part Information

Generic Part Numbers:	TMS416400
Part Numbers	TMS416400
Control Number:	15548
Charge Number:	M71384
Manufacturer:	TI
Lot Date Codes (LDC):	Not Marked on Parts
Quantities Tested:	5
Serial Numbers of Control Samples:	45
Serial Numbers of Radiation Samples:	46,47,48,49
Part Function:	16 MBit DRAM
Part Technology:	CMOS
Package Style:	24-pin SOJ (plastic)
Test Equipment:	S-50
Engineer:	A. Duvalsaint

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

TABLE II. Radiation Schedule for TMS416400

EVENT.....	DATE
1) INITIAL ELECTRICAL MEASUREMENTS.....	12/13/96
2) 5 KRAD IRRADIATION (0.12 KRADS/HOUR).....	12/14/96
POST-5 KRAD ELECTRICAL MEASUREMENT.....	12/16/96
3) 10 KRAD IRRADIATION (0.12 KRADS/HOUR).....	12/16/96
POST-10 KRAD ELECTRICAL MEASUREMENT.....	12/18/96
14) 120-HOUR ANNEALING @25°C.....	12/18/96
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT.....	12/23/96
14) 600-HOUR ANNEALING @25°C.....	12/23/96
POST-600 HOUR ANNEAL ELECTRICAL MEASUREMENT.....	01/09/97
5) 12.5 KRAD IRRADIATION (0.04 KRADS/HOUR).....	01/10/97
POST-12.5 KRAD ELECTRICAL MEASUREMENT.....	01/13/97
4) 96-HOUR ANNEALING @25°C.....	01/13/97
POST-96 HOUR ANNEAL ELECTRICAL MEASUREMENT.....	01/17/96
15) 240-HOUR ANNEALING @ 100°C.....	01/17/96
POST-240 HOUR ANNEAL ELECTRICAL MEASUREMENT.....	01/27/96

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 All parts were irradiated and annealed under bias. See Figure 1

Table IIIa. Electrical Characteristics of TMS416400

FUNCTIONAL TESTS									
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS	25C		
FUNCTION # 1	5.0V	0.0V	5.0V	FREQ = 5.000MHZ	ALL I/O	VOL < 1.0V	> VOHV > 2.0V		
FUNCTION # 3	5.0V	0.0V	5.0V	FREQ = 5.000MHZ	ALL I/O	VOL < 1.0V	> VOHV > 2.0V		
FUNCTION # 4	5.0V	0.0V	5.0V	FREQ = 5.000MHZ	ALL I/O	VOL < 1.0V	> VOHV > 2.0V		
FUNCTION # 5	5.0V	0.0V	5.0V	FREQ = 5.000MHZ	ALL I/O	VOL < 1.0V	> VOHV > 2.0V		
FUNCTION # 6	5.0V	0.0V	5.0V	FREQ = 5.000MHZ	ALL I/O	VOL < 1.0V	> VOHV > 2.0V		

DC PARAMETRIC TESTS									
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS	25C		
VIH	4.5V	N/A	N/A	FREQ = 5MHZ	INS	> +0.0V	< +2.4V		
VIH	5.0V	N/A	N/A	FREQ = 5MHZ	INS	> +0.0V	< +2.4V		
VIL	4.5V	N/A	N/A	FREQ = 5MHZ	INS	> +0.0V	< +4.5V		
VIL	5.0V	N/A	N/A	FREQ = 5MHZ	INS	> +0.0V	< +5.5V		
VIOL	0.0V	0.0V	0.0V	VIN = 5.0V	INS	> -10.0UA	< +10.0UA		
VOIL	0.0V	0.0V	0.0V	VIN = 0.0V	INS	> -10.0UA	< +10.0UA		
VIOL	0.0V	0.0V	0.0V	VOUT = 0.0V	OUT	> -10.0UA	< +10.0UA		
VOIL	0.0V	0.0V	0.0V	VOUT = 0.0V	OUT	> -10.0UA	< +10.0UA		
CC1	0.0V	0.0V	0.0V	FR = 1/TOTL	MIN	> 0.0OMA	< +7.0OMA		
CC2	0.0V	0.0V	0.0V	FR = 1/TOTL	MIN	> 0.0OMA	< +7.0OMA		
CC3	0.0V	0.0V	0.0V	FR = 1/TOTL	MIN	> 0.0OMA	< +7.0OMA		
CC4	0.0V	0.0V	0.0V	FR = 1/TOTL	MIN	> 0.0OMA	< +7.0OMA		
CC5	0.0V	0.0V	0.0V	FR = 1/TOTL	MIN	> 0.0OMA	< +7.0OMA		
CC6	0.0V	0.0V	0.0V	FR = 1/TOTL	MIN	> 0.0OMA	< +7.0OMA		

AC PARAMETRIC TESTS									
PARAMETER	VCC	VIL	VIH	CONDITIONS	OUTPUTS	LIMITS	25C		
TAA	4.5V	0.0V	5.0V	F = 5.0MHZ / VOMP = 1.5V	OUTS	> 0NS	< 35NS		
TAL	4.5V	0.0V	5.0V	F = 5.0MHZ / VOMP = 1.5V	OUTS	> 0NS	< 35NS		

COMMENTS/EXCEPTIONS

- (1) FUNCTIONAL TESTS ARE PERFORMED AT VCC = 5.0V ONLY
- (2) FUNCTIONAL TESTS CONSIST OF THE FOLLOWING PATTERNS :
  - 1 - ALL LOGIC FUNCTIONS
  - 2 - ALL LOGIC FUNCTIONS
  - 3 - CHECK ADDRESS DECODE
  - 4 - CHECK DATA DECODE
  - 5 - CHECK ADDRESS DECODE
  - 6 - CHECK DATA DECODE
- (3) VIL & VIH WERE TESTED DYNAMICALLY DURING FUNCTIONAL TESTING
- (4) VOL & VOH WERE TESTED DYNAMICALLY DURING SPLIT TESTING
- (5) AC TESTS NOT PERFORMED OR DONE GO/NOGO :
  - ONLY FOUR TEST POINTS ARE USED FOR DELAYS
  - ALL OTHER AC TESTS ARE NOT BEING PERFORMED DUE TO LIMITED TEST POINTS
- (6) THIS PROGRAM TESTS FOR CONTINUITY TEST.

**TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for TMS416400(see Notes 1-5 below)**

Functional Tests / 2 / 3	Total Dose Exposure (krads)										Annealing				Total Dose (krads)		Annealing			
	Initial		5				10				120 hrs@25°C / 600 hrs@25°C				12.5		90hrs@25°C / 240 hrs @ 100°C			
	P	4/					3P/1P				4P		4P		3F/1P		4F		4P	
Vcc=5.0V, VIL=0.0V, VIH=5.0V, Freq=5MHz	P														3F/1P		4F		4P	
Vcc=5.0V, VIL=0.0V, VIH=5.0V, Freq=5MHz	P		P												3F/1P		4F		4P	
Vcc=5.0V, VIL=0.0V, VIH=5.0V, Freq=5MHz	P		P												3F/1P		4F		4P	
Vcc=5.0V, VIL=0.0V, VIH=5.0V, Freq=5MHz	P		P												3F/1P		4F		4P	
Vcc=5.0V, VIL=0.0V, VIH=5.0V, Freq=5MHz	F		P												3F/1P		4F		4P	
Vcc=5.0V, VIL=0.0V, VIH=5.0V, Freq=5MHz	F		P												3F/1P		4F		4P	
Parameters		Spec. Lims. 5																		
	Units	min	max																	
VIH_MIN_4.5V	V	0	2.4	2.10	0.04	4/			2P/2F		2P/2F		2.1	0.02	4F		2P/2F		2.1	0.03
VIH_MIN_5.5V	V	0	2.4	1.95	0.05	4/			3P/1P		3F/1P		2.0	0.02	4F		2P/2F		2.0	0.3
VIL_MAX_4.5V	V	-1.0	2.0	1.1	0.18	0.3	0.6	4P		4P		0.23	0.18	0.7	0.3	0.7	0.3	1.2	0.2	
VIL_MAX_5.5V	V	-1.0	2.0	0.50	0.17	-0.1	0.0	4P		4P		0.21	0.16	0.4	0.2	0.4	0.2	0.5	0.2	
I1H	µA	-10.0	10.0	0.0	0.0	0.0	0.0	9.6	26.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
I1L	µA	-10.0	10.0	0.0	0.0	0.0	0.0	0.7	0.60	0.7	0.45	0.12	0.18	0.12	0.15	0.11	0.32	0.0	0.0	
IOZH	µA	-10.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
IOZL	µA	-10.0	10.0	0.0	0.0	0.0	0.0	-0.7	0.7	-0.53	0.43	0.56	0.45	0.72	0.34	0.41	0.32	0.0	0.0	
ICC1	mA	0	70.0	42.9	0.43	31.6	1.5	46.0	4.1	45.2	2.1	18.0	0.2	92	33.7	88	34.1	37.2	5.7	
ICC2	mA	0	2.0	0.18	0.1	0.18	0.07	12.4	7.2	5.4	2.2	1.1	0.2	16.0	0.01	12.3	3.4	0.18	0.03	
ICC3	mA	0	70.0	27.9	0.33	28.0	0.3	86.2	47.0	34.2	5.6	29.2	0.3	68.8	34.6	61.1	33.4	25.3	0.32	
ICC4	mA	0	60.0	10.5	0.21	10.2	0.4	128	0.0	15.4	5.4	10.5	0.2	128	0.0	70.3	34.4	11.3	0.34	
ICC5	mA	0	1.0	0.18	0.01	0.18	0.07	16.0	0.1	1.5	0.3	1.1	0.2	16.0	0.1	18.2	3.2	0.18	0.42	
ICC6	mA	0	70.0	42.9	0.46	32.9	2.1	64.7	48.8	45.2	1.5	17.3	0.3	75.0	24.3	63.1	22.2	39.6	5.4	
TAA_LH	ns	0	35.0	15.5	0.1	15.5	0.5	3P/1P		4P		4P		4F		2P/2P		4/		
TAA_HL	ns	0	35.0	15.5	0.2	16.0	0.2	3P/1P		4P		4P		4F		2P/2P		4/		

1/ The mean and standard deviation values were calculated over the four parts irradiated in this testing.  
 2/ The control samples remained constant throughout the testing are are not included in this table.  
 3/"P" indicates that all parts passed this test at this irradiation or annealing level. "F" indicates that all parts failed this test at this irradiation or annealing level. "nPmF" indicates that n parts passed and m parts failed this test at this irradiation or annealing level.  
 4/ No reliable measurements could be obtained for this test at this level.  
 5/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.