ESA-QCA00118T-C

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european space research and technology centre

Components Division
Laboratory Support Group

RADIATION ANALYSIS

REPORT NUMBER

RA 072

Part Type : **Integrated Circuit**

Type No : **M 54 HC 373**

Manufacturer : **ST**

Project : **Soho**

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Content:

1. Introduction.

Due to the unknown radiation performance of these parts, the radiation effects were investigated.

Marking: M54HC373D

Date code: 9123

Manufacturer: ST

Case: Ceramic Dual-in-line

The parts were serialized at ESTEC.

Sample identification and test results can be found in the appendix, while this section describes radiation source and conditions and includes a discussion on the test results.

2. Aims and objectives.

The aim of the test was investigate the electrical performance under total dose radiation conditions.
The objective of the work was to build and design biasing circuitry, expose the samples to ionizing radiation and perform subsequent full parametric DC test.

3. The radiation source and dosimetry.

The 1460 Curie Co-60 facility in ESTEC was used for exposing the samples to ionizing radiation (1.25 MeV gamma radiation). The dose rate can be varied by placing the samples at different distance from the Co-60 pellets.
The dose rate chosen for the radiation in this test was 158.3 rad/min (H2O) for all devices up to a dose of 20k rad and 209 rad/min from 20 to 50k rad.

The dose was monitored by a Ionex Dosemaster equipped with a 0.6 cc ion probe placed at the same distance from the Co-60 source as the samples. The Ionex Dosemaster is calibrated to +/- 0.5 %.

Time schedule on 9 juli: 10.40 from 0k Rad to 10k Rad
12.20 from 10k Rad to 20k Rad
14.50 from 20k Rad to 50k Rad

4. The electrical measurements.

The electrical measurements were performed at ESTEC on the Tektronix S-3275 general purpose tester.

5. The biasing circuitry and sample allocation.

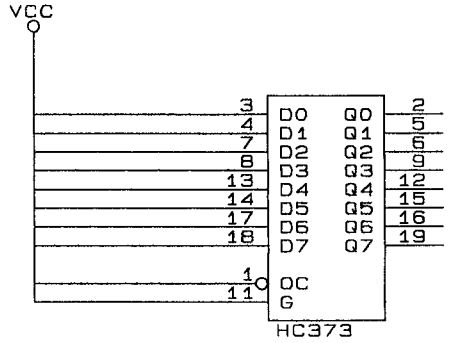
Due to an uncertainty of exactly what bias condition would be worst case, 3 different sets of conditions were applied with Vcc = 6V.

- Condition A, whereby all inputs are tied to Vcc and all outputs are left floating.
- Condition B, whereby half of the inputs are tied to ground and the other half to VCC and all outputs are tied to VCC or Ground with a 2K2 load.
- Condition C, whereby half of the inputs are tied to ground and the other half to VCC and all outputs are left floating.

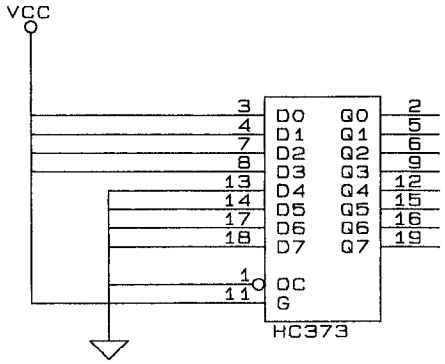
Condition A is used for devices 1 & 2, Condition B for 3 & 4 and Condition C for 5 & 6.

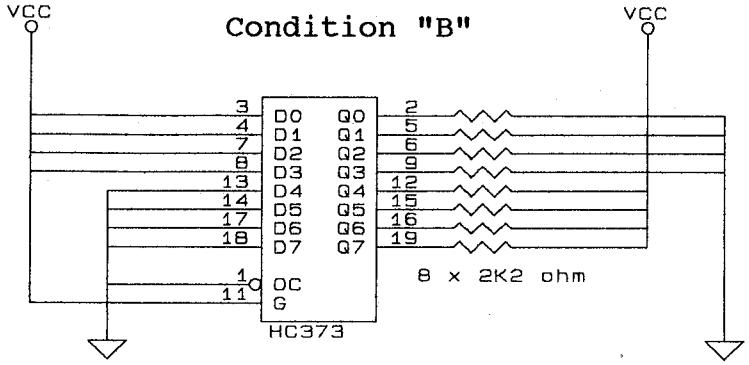
The biasing circuitry is shown below and on the next page.

Condition "A"



Condition "C"





6.The test sequence and test data limits.

SIC02-037 Detail Specification issue 2 is used to test the ST devices.
Characterisation is performed at 25°C.

Table of performed tests:

VTHN	Threshold Voltage N-Channel
VTHP	Threshold Voltage P-Channel
VIC+	Input Clamp Voltage (+)
VIC-	Input Clamp Voltage (-)

at 2.0V

VOL	Output voltage at low current
VOH	Output voltage at low current
TPHL	Propagation Delay High to Low
TPLH	Propagation Delay Low to High
TTHL	Transition Time High to Low
TTLH	Transition Time Low to High
TPZL	Output Enable Time
TPLZ	Output Disable Time
TPZH	Output Enable Time
TPHZ	Output Disable Time
	Functional tests

at 4.5V

VOL1	Output voltage at low current
VOH1	Output voltage at low current
VOL2	Output voltage at high current
VOH2	Output voltage at high current
TPHL	Propagation Delay High to Low
TPLH	Propagation Delay Low to High
TTHL	Transition Time High to Low
TTLH	Transition Time Low to High
TPZL	Output Enable Time
TPLZ	Output Disable Time
TPZH	Output Enable Time
TPHZ	Output Disable Time
	Functional tests

at 6.0V

VOL1	Output voltage at low current
VOH1	Output voltage at low current
VOL2	Output voltage at high current
VOH2	Output voltage at high current
IILL	Input leakage to ground with all inputs low
IILH	Input leakage to ground with all inputs high
IIHL	Input leakage to Vcc with all inputs low
IIHH	Input leakage to Vcc with all inputs high
IDD1	Quiescent Supply current with all inputs low
IDD2	Quiescent Supply current with all inputs high
TPHL	Propagation Delay High to Low
TPLH	Propagation Delay Low to High
TTHL	Transition Time High to Low
TTLH	Transition Time Low to High
TPZL	Output Enable Time
TPLZ	Output Disable Time
TPZH	Output Enable Time
TPHZ	Output Disable Time
	Functional tests

7. Test results.

All raw data is stored on disk at ESTEC for any future requirement for further data analysis.
As can be derived from this data (partly in the appendix), the most sensitive parameters to ionizing radiation are V_{THP}, IDD1 and IDD2.
See pages 6 to 7.
V_{THN} can also be found in that data.

Considering the large amount of test data generated from the electrical measurements, only the full test data of device 1 with a radiation dose of 50k Radiation with no anneal time are given in the appendix at pages 8 to 13.

8. Conclusion.

- The 6 devices passed all tests.
  The ionizing radiation had some effect on V_{THN}, IDD1 and IDD2, but no limits were crossed.
  The 6 devices recovered after 718 hour anneal time and stayed within their specifications.
- Other parameters were hardly affected during radiation.
- The bias condition of the devices under test has little impact on the sensitivity to total dose of ionizing radiation.

Considering the test results the ST M54HC373 is considered to be of low sensitivity to total dose of ionizing radiation.

9. Appendix

Device	M 54HC373	OCTAL D-TYPE LATCH	
Manufacturer	ST	Date	9 july 91
Lot	9123	Temperature	25°C

Threshold Voltage N-channel OE: -450.mV <--> -1.45 V

	Radiation dose					
Ser.	0k	10k	20k	50k	50k 16 h ann.	50k 718 h
1	-1.14 V	-1.12 V	-1.11 V	-1.07 V	-1.08 V	-1.10 V
2	-1.14 V	-1.13 V	-1.12 V	-1.09 V	-1.09 V	-1.10 V
3	-1.14 V	-1.13 V	-1.12 V	-1.08 V	-1.10 V	-1.10 V
4	-1.14 V	-1.13 V	-1.12 V	-1.08 V	-1.09 V	-1.10 V
5	-1.13 V	-1.13 V	-1.12 V	-1.08 V	-1.09 V	-1.10 V
6	-1.14 V	-1.13 V	-1.12 V	-1.09 V	-1.10 V	-1.10 V

Threshold Voltage P-channel OE: 450.mV <--> 1.35 V

	Radiation dose					
Ser.	0k	10k	20k	50k	50k 16 h ann.	50k 718 h
1	670.mV	770.mV	850.mV	1.03 V	1.02 V	1.02 V
2	690.mV	775.mV	850.mV	1.01 V	1.00 V	985.mV
3	675.mV	735.mV	790.mV	950.mV	950.mV	930.mV
4	685.mV	740.mV	795.mV	950.mV	945.mV	925.mV
5	690.mV	745.mV	800.mV	960.mV	960.mV	935.mV
6	705.mV	760.mV	815.mV	965.mV	960.mV	950.mV

Device	M 54HC373	OCTAL D-TYPE LATCH	
Manufacturer	ST	Date	9 july 91
Lot	9123	Temperature	25°C

Quiescent Current with all inputs low (limit = 4.0uA)

Radiation dose

Ser.	0k	10k	20k	50k	50k 16 h ann.	50k 718 h
1	9.600nA	8.000nA	19.00nA	19.15nA	7.150nA	-8.050nA
2	-400.0pA	12.70nA	25.40nA	57.60nA	24.80nA	350.0pA
3	50.00pA	-800.0pA	51.20nA	127.5nA	63.50nA	28.75nA
4	4.800nA	12.75nA	9.550nA	63.00nA	64.00nA	25.65nA
5	6.350nA	8.350nA	57.55nA	151.5nA	76.75nA	mea.err
6	2.350nA	12.80nA	112.0nA	131.5nA	80.00nA	mea.err

Quiescent Current with all inputs high (limit = 4.0uA)

Radiation dose

Ser.	0k	10k	20k	50k	50k 16 h ann.	50k 718 h
1	-12.75nA	6.400nA	12.75nA	64.00nA	38.40nA	38.00nA
2	1.550nA	6.300nA	47.95nA	127.5nA	95.50nA	68.00nA
3	-6.500nA	25.55nA	71.50nA	223.5nA	96.00nA	mea.err
4	0.000 A	-8.050nA	19.20nA	63.50nA	44.40nA	mea.err
5	-9.600nA	52.00nA	127.5nA	255.0nA	63.50nA	mea.err
6	11.20nA	25.55nA	131.5nA	287.5nA	95.50nA	mea.err

M 54HC373 OCTAL D-TYPE LATCH

MANUFACTURER	ST	DATE	09 JUL 91
SERIAL	1	TIME	17:22:18
LOT	9123	TEMPERATURE	25C

CURRENT: -10.0UA - 10.0UA

	LIMITS	ACTUAL
THRESHOLD VOLTAGE N-CHANNEL OE:	-450.MV <--> -1.45 V	-1.07 V
THRESHOLD VOLTAGE P-CHANNEL OE:	450.MV <--> 1.35 V	1.03 V

	VIC-		VIC+	
LIMIT	400.MV	<-->	900.MV	ABSOLUTE LEVELS
CURRENT	100.UA		100.UA	
D0	-633.MV		663.MV	
D1	-633.MV		663.MV	
D2	-634.MV		663.MV	
D3	-634.MV		666.MV	
D4	-633.MV		670.MV	
D5	-633.MV		666.MV	
D6	-634.MV		666.MV	
D7	-633.MV		674.MV	
LE	-633.MV		666.MV	
OE	-633.MV		662.MV	

VCC : 2.00 V

	VOL	VOH
LIMIT	100.MV	1.90 V
CURRENT	20.0UA	-20.0UA
Q0	2.95MV	2.00 V
Q1	2.75MV	2.00 V
Q2	3.00MV	2.00 V
Q3	2.55MV	2.00 V
Q4	2.95MV	2.00 V
Q5	2.65MV	2.00 V
Q6	2.85MV	2.00 V
Q7	2.70MV	2.00 V

M 54HC373 OCTAL D-TYPE LATCH

MANUFACTURER	ST	DATE	09 JUL 91
SERIAL	1	TIME	17:22:21
LOT	9123	TEMPERATURE	25C

VCC : 2.00 V PROPAGATION DELAYS

	TTHL	TTLH
LIMIT	60.0NS	60.0NS
Q0	17.5NS	17.0NS
Q1	16.0NS	17.0NS
Q2	16.5NS	17.0NS
Q3	17.0NS	18.0NS
Q4	16.0NS	17.5NS
Q5	15.5NS	16.5NS
Q6	15.5NS	16.5NS
Q7	16.5NS	17.0NS

	TPHL LE	TPLH	TPHL DATI	TPLH
LIMIT	175.NS	175.NS	145.NS	145.NS
Q0	56.5NS	51.5NS	59.5NS	58.0NS
Q1	59.0NS	52.5NS	61.0NS	58.5NS
Q2	58.5NS	52.0NS	62.0NS	59.0NS
Q3	57.0NS	50.5NS	59.5NS	56.5NS
Q4	56.0NS	50.0NS	59.5NS	55.5NS
Q5	56.0NS	51.0NS	58.5NS	57.0NS
Q6	55.5NS	51.0NS	59.5NS	57.0NS
Q7	55.5NS	50.5NS	58.0NS	56.5NS

	TPZL OE	TPLZ	TPZH OE	TPHZ
LIMIT	150.NS	150.NS	150.NS	150.NS
Q0	44.5NS	26.5NS	53.0NS	25.0NS
Q1	47.5NS	26.0NS	53.5NS	25.0NS
Q2	47.5NS	25.5NS	53.5NS	25.5NS
Q3	46.5NS	25.0NS	51.0NS	25.5NS
Q4	45.5NS	26.0NS	51.0NS	27.0NS
Q5	45.0NS	27.0NS	52.5NS	26.0NS
Q6	44.5NS	26.5NS	52.0NS	26.5NS
Q7	44.0NS	26.5NS	51.5NS	26.5NS

400.MV IS ADDED TO VOL1 AND 400.MV IS DEDUCTED FROM VOH1

VIL 500.MV VIH 1.50 V VOL 500.MV VOH 1.50 V

FUNCTIONAL TEST PASSED ** TOTAL ERRORS : 0 **

M 54HC373 OCTAL D-TYPE LATCH

MANUFACTURER	ST	DATE	09 JUL 91
SERIAL	1	TIME	17:22:24
LOT	9123	TEMPERATURE	25C

VCC : 4.50 V

	VOL1	VOH1	VOL2	VOH2
LIMIT	100.MV	4.40 V	260.MV	4.18 V
CURRENT	20.0UA	-20.0UA	6.00MA	-6.00MA
Q0	2.25MV	4.49 V	132.MV	4.35 V
Q1	2.05MV	4.50 V	134.MV	4.35 V
Q2	2.15MV	4.50 V	131.MV	4.35 V
Q3	2.05MV	4.49 V	126.MV	4.35 V
Q4	2.05MV	4.49 V	126.MV	4.36 V
Q5	2.05MV	4.50 V	127.MV	4.36 V
Q6	2.20MV	4.50 V	128.MV	4.36 V
Q7	2.00MV	4.50 V	128.MV	4.36 V

M 54HC373 OCTAL D-TYPE LATCH

MANUFACTURER	ST	DATE	09 JUL 91
SERIAL	1	TIME	17:22:26
LOT	9123	TEMPERATURE	25C

VCC : 4.50 V PROPAGATION DELAYS

	TTHL	TTLH
LIMIT	12.0NS	12.0NS
Q0	8.00NS	8.00NS
Q1	7.00NS	8.50NS
Q2	8.00NS	8.50NS
Q3	8.00NS	9.00NS
Q4	8.00NS	9.50NS
Q5	7.50NS	9.00NS
Q6	7.50NS	9.00NS
Q7	8.00NS	9.00NS

	TPHL	LE	TPLH	TPHL	DATI	TPLH
LIMIT	35.0NS		35.0NS	29.0NS		29.0NS
Q0	17.4NS		17.2NS	18.9NS		19.7NS
Q1	18.1NS		17.9NS	19.1NS		19.8NS
Q2	17.8NS		17.5NS	18.7NS		19.7NS
Q3	17.4NS		17.0NS	18.3NS		19.1NS
Q4	17.5NS		17.0NS	18.6NS		18.9NS
Q5	17.3NS		17.4NS	18.2NS		19.1NS
Q6	17.7NS		17.7NS	18.9NS		19.5NS
Q7	17.7NS		17.0NS	18.8NS		18.8NS

	TPZL	OE	TPLZ	TPZH	OE	TPHZ
LIMIT	30.0NS		30.0NS	30.0NS		30.0NS
Q0	14.8NS		14.9NS	17.7NS		14.5NS
Q1	15.8NS		14.5NS	18.1NS		14.2NS
Q2	15.7NS		13.9NS	17.8NS		14.4NS
Q3	15.3NS		13.8NS	17.2NS		14.2NS
Q4	15.3NS		14.5NS	17.6NS		15.0NS
Q5	15.3NS		14.8NS	17.9NS		14.7NS
Q6	15.3NS		14.3NS	18.0NS		14.7NS
Q7	15.7NS		14.1NS	17.7NS		16.1NS

400.MV IS ADDED TO VOL1 AND 400.MV IS DEDUCTED FROM VOH1

VIL 1.35 V VIH 3.15 V VOL 500.MV VOH 4.00 V

FUNCTIONAL TEST PASSED ** TOTAL ERRORS : 0 **

M 54HC373 OCTAL D-TYPE LATCH

MANUFACTURER	ST	DATE	09 JUL 91
SERIAL	1	TIME	17:22:29
LOT	9123	TEMPERATURE	25C

VCC : 6.00 V

	VOL1	VOH1	VOL2	VOH2
LIMIT	100.MV	5.90 V	260.MV	5.68 V
CURRENT	20.0UA	-20.0UA	8.80MA	-8.80MA
Q0	2.20MV	5.99 V	146.MV	5.82 V
Q1	2.15MV	5.99 V	148.MV	5.82 V
Q2	2.10MV	5.99 V	145.MV	5.82 V
Q3	1.95MV	5.99 V	141.MV	5.82 V
Q4	2.15MV	5.99 V	141.MV	5.82 V
Q5	2.00MV	5.99 V	141.MV	5.82 V
Q6	2.10MV	5.99 V	144.MV	5.82 V
Q7	2.10MV	5.99 V	144.MV	5.83 V

INPUT-LEAKAGE CURRENT LIMIT : 50.0NA

PIN	IILL	IILH	IIHL	IIHH
D0	-100.PA	50.0PA	1.60NA	1.00NA
D1	250.PA	-650.PA	700.PA	1.50NA
D2	-100.PA	0.00 A	850.PA	800.PA
D3	0.00 A	-400.PA	150.PA	1.20NA
D4	800.PA	350.PA	750.PA	50.0PA
D5	-50.0PA	0.00 A	150.PA	750.PA
D6	150.PA	-700.PA	1.20NA	200.PA
D7	0.00 A	0.00 A	550.PA	500.PA
LE	300.PA	-450.PA	750.PA	50.0PA
OE	0.00 A	100.PA	400.PA	1.25NA

QUIESCENT CURRENT - ALL INPUTS HIGH : 19.15NA LIMIT : 4.00UA
QUIESCENT CURRENT - ALL INPUTS LOW : 64.00NA LIMIT : 4.00UA

M 54HC373 OCTAL D-TYPE LATCH

MANUFACTURER	ST	DATE	09 JUL 91
SERIAL	1	TIME	17:22:36
LOT	9123	TEMPERATURE	25C

VCC : 6.00 V PROPAGATION DELAYS

	TTHL	TTLH
LIMIT	10.0NS	10.0NS
Q0	6.00NS	9.00NS
Q1	6.50NS	8.50NS
Q2	6.50NS	8.50NS
Q3	8.00NS	9.00NS
Q4	6.50NS	9.50NS
Q5	6.50NS	10.0NS
Q6	7.00NS	9.50NS
Q7	7.50NS	10.0NS

	TPHL LE	TPLH	TPHL DATI	TPLH
LIMIT	30.0NS	30.0NS	25.0NS	25.0NS
Q0	12.9NS	13.6NS	14.8NS	15.7NS
Q1	13.3NS	14.2NS	15.0NS	15.8NS
Q2	13.3NS	13.9NS	14.6NS	15.5NS
Q3	12.7NS	13.6NS	14.3NS	15.2NS
Q4	13.4NS	13.4NS	14.5NS	14.9NS
Q5	13.5NS	13.9NS	14.3NS	15.0NS
Q6	13.4NS	14.1NS	14.9NS	15.5NS
Q7	13.8NS	13.5NS	14.9NS	14.8NS

	TPZL OE	TPLZ	TPZH OE	TPHZ
LIMIT	26.0NS	26.0NS	26.0NS	26.0NS
Q0	11.5NS	17.9NS	14.9NS	15.8NS
Q1	12.4NS	17.5NS	15.6NS	12.4NS
Q2	12.2NS	15.8NS	15.3NS	15.1NS
Q3	11.8NS	16.7NS	15.0NS	14.1NS
Q4	12.5NS	13.3NS	14.9NS	15.9NS
Q5	12.5NS	13.0NS	15.6NS	14.5NS
Q6	12.4NS	14.2NS	15.3NS	15.5NS
Q7	12.8NS	12.9NS	15.3NS	15.9NS

400.MV IS ADDED TO VOL1 AND 400.MV IS DEDUCTED FROM VOH1

VIL 1.80 V VIH 4.20 V VOL 500.MV VOH 5.50 V

FUNCTIONAL TEST PASSED ** TOTAL ERRORS : 0 **