ESA-QCA0026S-C

Detailed SEU/Latchup Test Results for Crystal ADC (CS5016)

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Prepared for
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Greenbelt, Maryland 20771

CRYSTAL
Semiconductor Corporation

CS5016

16-Bit, 16 us Self-Calibrating A/D Converter

Features

- Monolithic CMOS A/D converter
  - Microprocessor Compatible
  - Parallel and Serial Output
  - Inherent Track/Hold Input
- True 16-Bit Precision
  - Linearity Error: 0.001% FS
  - No Missing Codes
- Ultra-Low Distortion
  - Total Harmonic Distortion: 0.001%
  - Peak Harmonic or Noise: -104 dB
- 16.25 µs Conversion Time
  - Sample Rates up to 50 kHz
- Self Calibration Maintains Accuracy Over Time and Temperature
- Low Power Dissipation: 120 mW
- Pin Compatible with CS5012/CS5014

General Description

The CS5016 is a 16-bit monolithic analog to digital converter with a 16.25 µs conversion time. Unique self-calibration circuitry insures maximum nonlinearity of 0.001% FS and no missing codes. This insures low distortion and maintains good signal to noise performance with low-level signals. Offset and full scale errors are kept within 1 LSB, eliminating the need for manual calibration of any kind. Unipolar and bipolar input ranges are digitally selectable.

The CS5016 consists of a DAC, conversion and calibration microcontroller, oscillator, comparator, microprocessor compatible 3-state I/O, and calibration circuitry. The input track-and-hold, inherent to the device's sampling architecture, acquires the analog input signal after each conversion within 3.75 µs to 0.01%, allowing throughput rates up to 50 kHz.

An evaluation board (CDB5016) is available for the CS5016 which can be easily configured to simulate any combination of operating conditions to greatly simplify system design and testing.

ORDERING INFORMATION: Page 8-94

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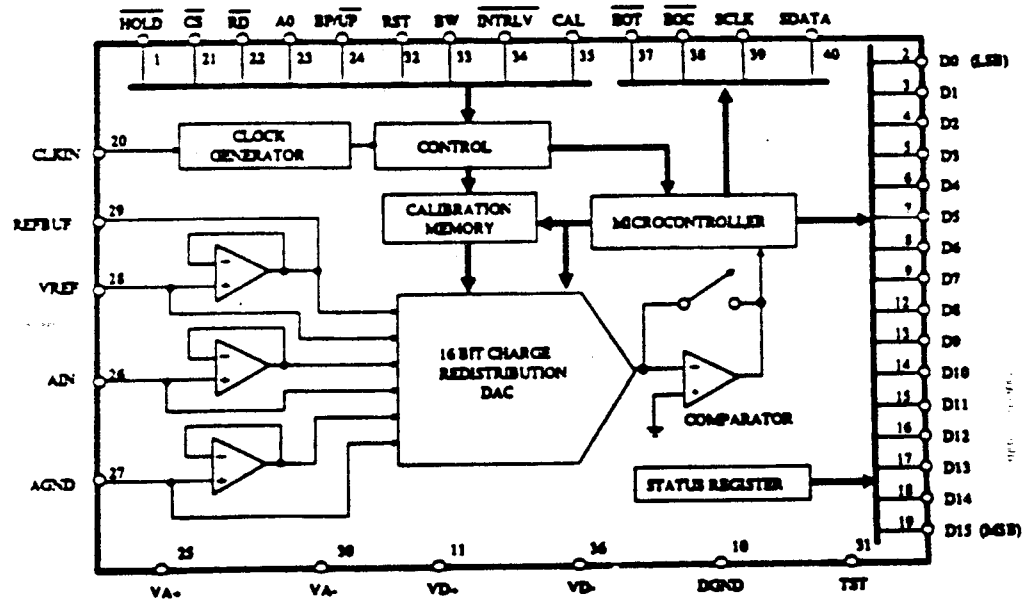


Crystal Semiconductor Corporation
P.O. Box 17847, Austin, TX 78760
(512) 445-7222 TWX: 910-874-1352

Possible SEU sites

- Microcontoller
- Calibration memory
- Internal comparator
- Control logic

Calibration

THEORY OF OPERATION

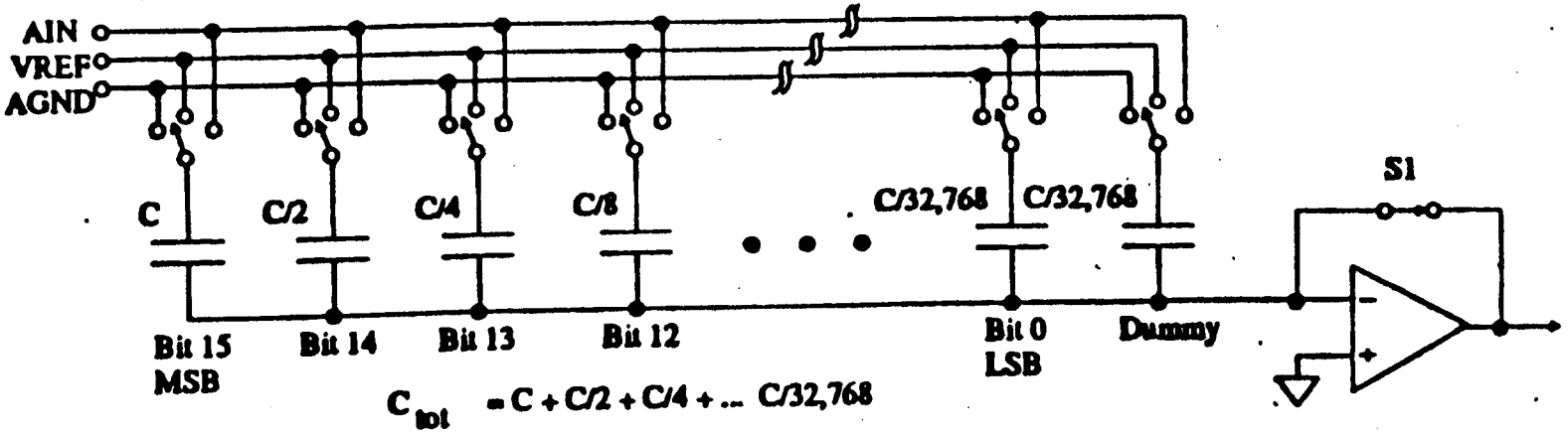
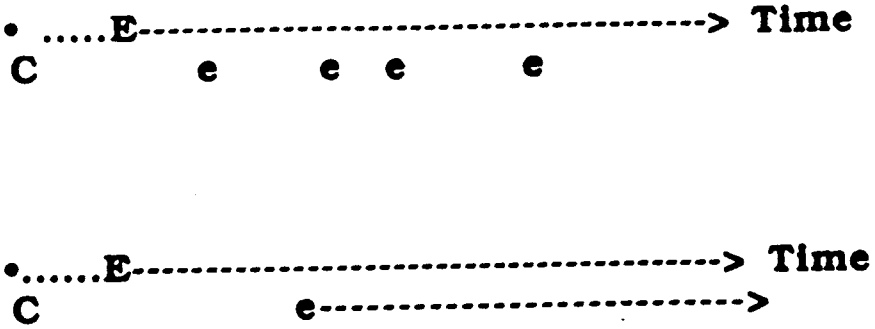
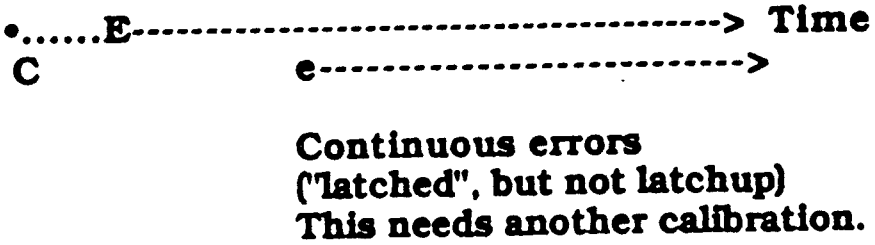


Figure 1. Charge Redistribution DAC

Types of SEUs during exposure



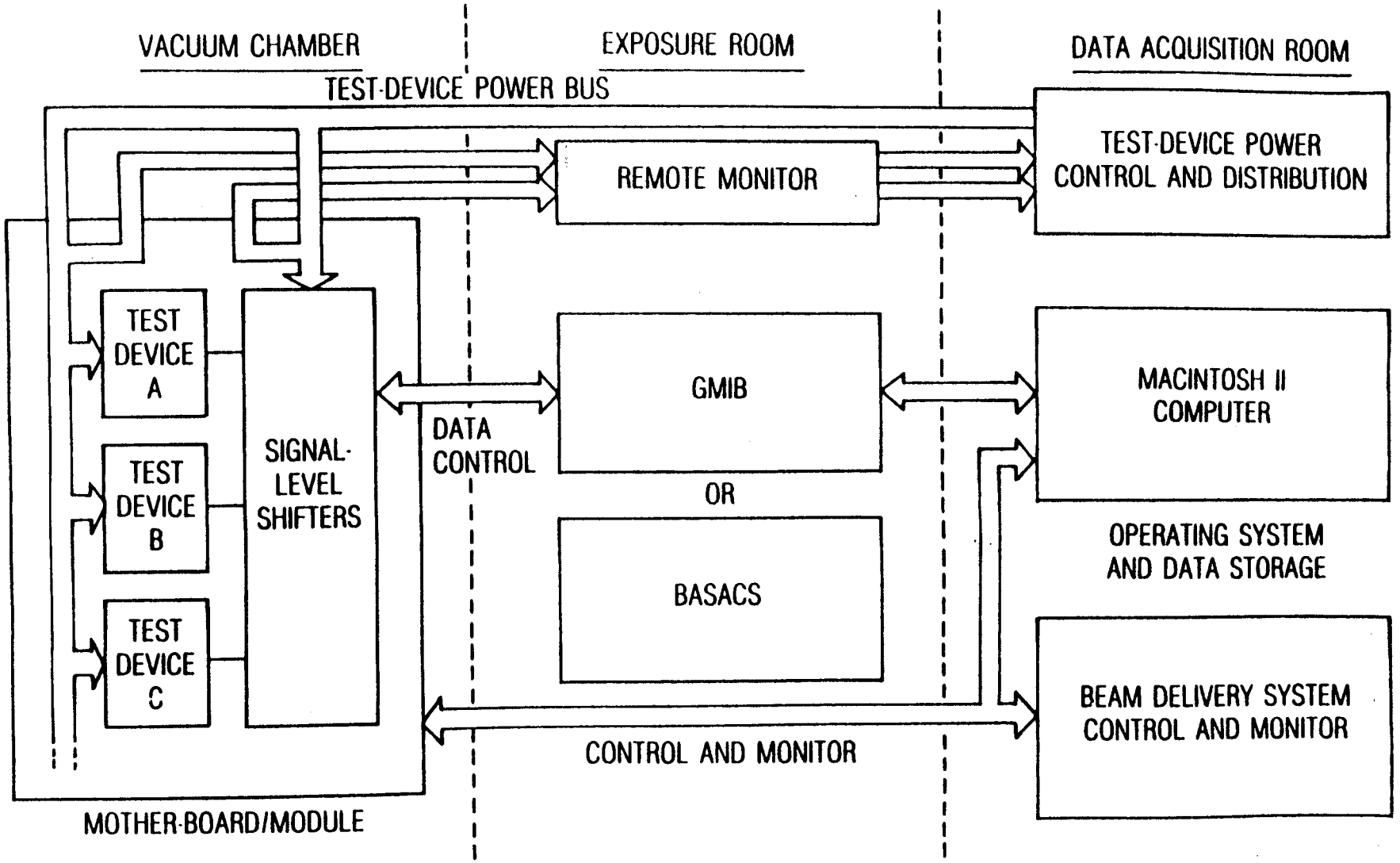


C : calibration
E : exposure starts
e : error

Crystal ADC SEU

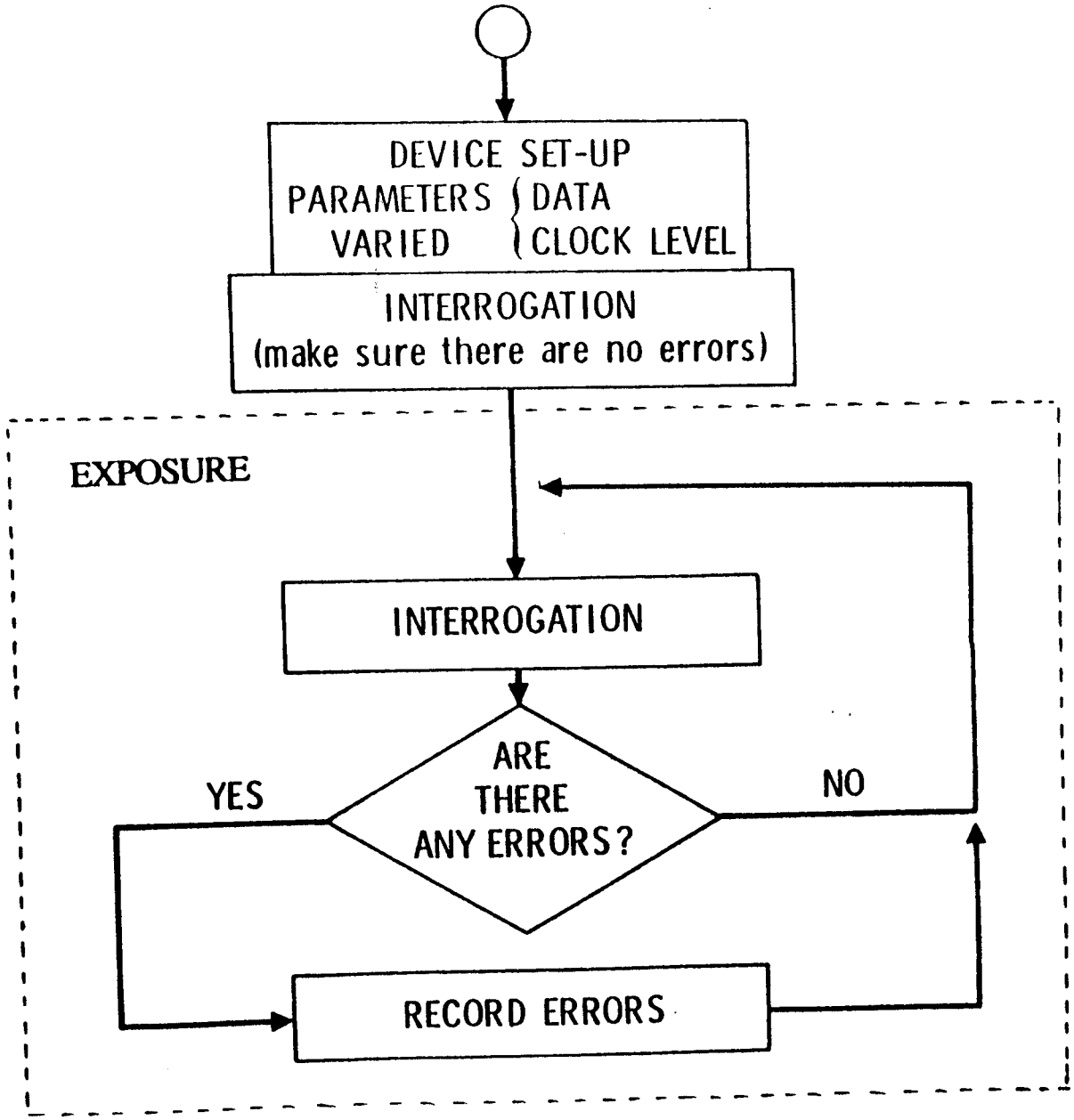
- **Setup**
  - DM0D20 Module
  - Mother Board
  - BASACS
  - Mac II Computer
  - HP6624A Power Supply

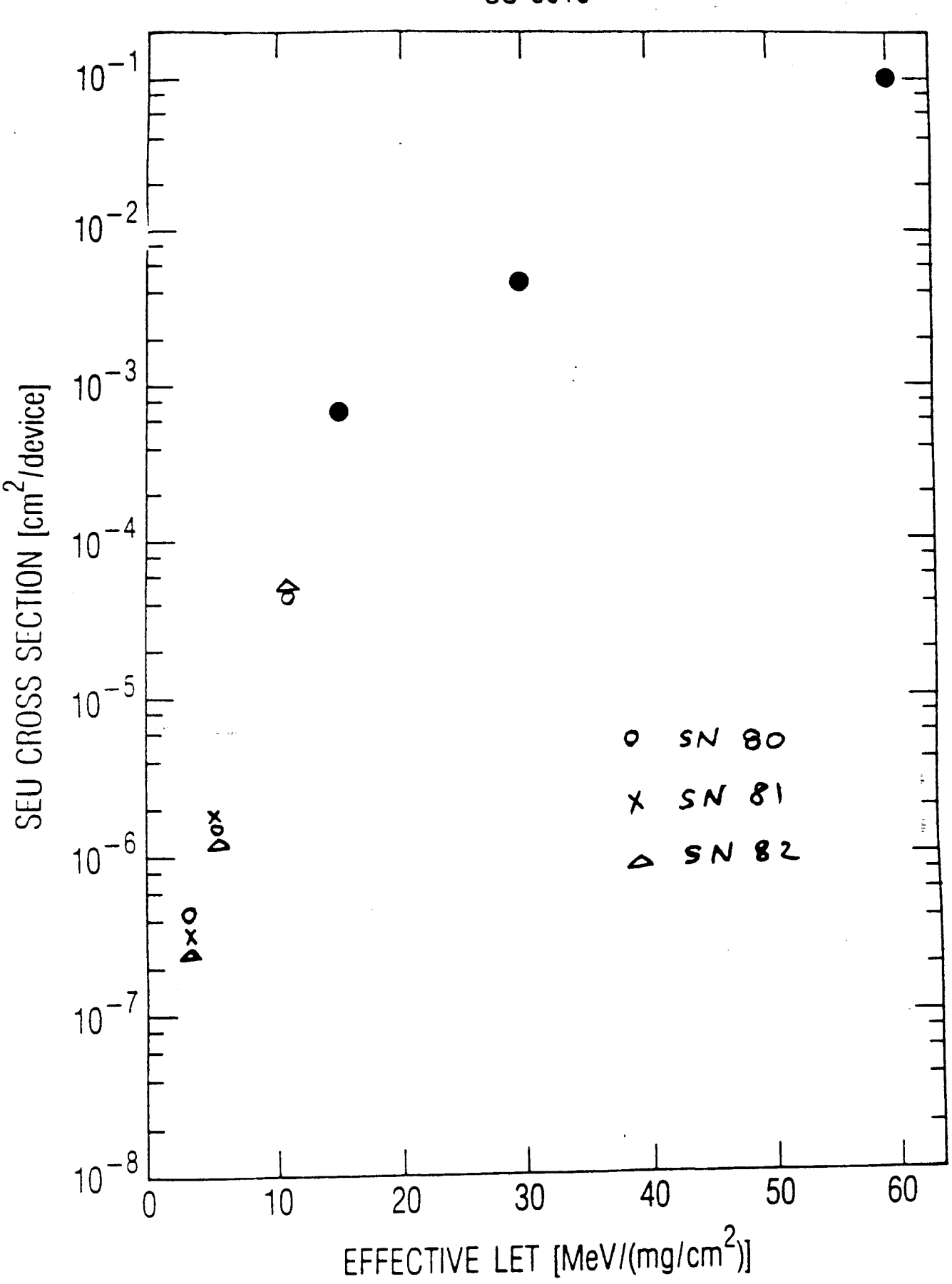
- **Currents**
  - Normal supply current
    - +5V....10-20 mA
    - -5V.....10-20 mA
  - Latchup Detect Current
    - 200 mA


VACUUM CHAMBER
EXPOSURE ROOM
DATA ACQUISITION ROOM
TEST-DEVICE POWER BUS
REMOTE MONITOR
TEST-DEVICE POWER CONTROL AND DISTRIBUTION
TEST DEVICE A
TEST DEVICE B
TEST DEVICE C
SIGNAL-LEVEL SHIFTERS
DATA CONTROL
GMIB
OR
BASACS
MACINTOSH II COMPUTER
OPERATING SYSTEM AND DATA STORAGE
BEAM DELIVERY SYSTEM CONTROL AND MONITOR
CONTROL AND MONITOR
MOTHER-BOARD/MODULE

Crystal ADC Module (BM0D20)

- 4 DUT positions per module.
- 3 positions were used during the test.
- Clock frequency was 1 MHz.
- Conversion time was 88 cycles / conversion.
  (11364 conversions / second)


DEVICE SET-UP
PARAMETERS { DATA
VARIED { CLOCK LEVEL
INTERROGATION
(make sure there are no errors)
EXPOSURE
INTERROGATION
ARE
THERE
ANY ERRORS?
YES
NO
RECORD ERRORS


CS 5016
SEU CROSS SECTION [cm²/device]
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
10⁻⁸
0
10
20
30
40
50
60
EFFECTIVE LET [MeV/(mg/cm²)]
o SN 80
x SN 81
Δ SN 82

RUN #	DEVICE NAME	BIN #	S/N	BOARD NAME	ION	ENERGY	ANGLE	LET	DUT POS	DUT [V]	I [mA]	TEMP [C]	START TIME	RUN [SEC]	PMT COUNT	RESULTS		
																TOTAL ERRORS	X-SECT	COMMENT
621	CS5016-TD16M	592	80	BM0D20	Ar	180	0°	15	1	5V	-	Room	23:05		1.23e6	0	shutter closed 2.9e-6	
622	"	"	"	"	N	67	0°	3	"	"		"	23:10	126.9	2006	5	4.5e-7	1.0V
623	"	"	"	"	Ne	90	"	5.6	"	"		"	23:14	146.9	2006	14	1.26e-6	"
624	"	"	"	"	"	90	60°	"	"	"		"		8.0	42363	1	4.2e-5	"
625	"	"	"	"	Ar	180	0°	15	"	"		Room	Room					
626	"	"	"	"	Ar	180	0	15	"	"		"	00:24	4	1256	1	1.4e-3	Catching on the edge of A

DATE _____

RUN #	DEVICE NAME	BIN #	S/N	BOARD NAME	ION	ENERGY	ANGLE	LET	DUT POS	DUT [V]	I [mA]	TEMP [C]	START TIME	RUN [SEC]	PMT COUNT	RESULTS		
																TOTAL ERRORS	X-SECT	COMMENTS
10	CS5016-TD16M	592	81	BM10DUT	N	67	0	3	2	5V		Room		130	20e6	6	5.4e-7	2.0V
11	"	"	81	"	Ne	90	0°	5.6	2	"		"		151	20e6	19	1.7e-6	"
12	"	"	82	"	Ne	90	0°	5.6	3	"		"		155	20e6	12	1.1e-6	"
13	"	"	82	"	N	67	0°	3	3	"		"		144	20e6	4	3.6e-7	"
14	"	"	82	"	Ne	90	60°	11	3	"		"		20	3.2e6	42	4.7e-5	"

G	Run #	Device ID	Bin #	S-N	Board	Tester	Subst	Ion	Total E	Angle	LET	Eff. LET
	621	CS5016-TD16M	592	80	BMOD20	BASACS	Si	Ar	175	0.0	14.9	14.9
	622	CS5016-TD16M	592	80	BMOD20	BASACS	Si	N	67	1.0	3.2	3.20047
	623	CS5016-TD16M	592	80	BMOD20	BASACS	Si	Ne	89	1.0	5.6	5.60082
	624	CS5016-TD16M	592	80	BMOD20	BASACS	Si	Ne	89	59.7	5.6	11.0909
	626	CS5016-TD16M	592	80	BMOD20	BASACS	Si	Ar	175	0.0	14.9	14.9
	627	CS5016-TD16M	592	81	BMOD20	HP LatchUp	Si	Ar	175	0.0	14.9	14.9

Pos	DUT Volts	DUT Amps	Beg Addr	Addr Count	Even	Odd	Ignore	DUT Speed	TestMode	Temp °C	Cycles	St
1	5.003	0.0749	0	50	00	00	00	2	AD1.0proc	25.0	0/2	
1	5.003	0.0749	0	50	00	00	00	2	AD1.0proc	25.0	0/2	
1	5.003	0.0749	0	50	00	00	00	2	AD1.0proc	25.0	0/2	
1	5.003	0.0749	0	50	00	00	00	2	AD1.0proc	25.0	0/2	
1	5.003	0.0749	0	31	00	00	00	1	Untitled	0.0	05/	
2	5.003	0.0749	0	1024	00	01	FE	1140	Correct	0.0	05/	

Start Time	Run Secs	Counts	Errors	Cross Section	0-1	1-0 E	Bit E	Hard	Total	TDC (BASACS)
/24/90 23:14:27	4.62	1231872	0	2.8939E-06	0	0	0	0	0	000000000000
/24/90 23:18:14	126.97	20026373	5	4.4947E-07	0	0	0	0	0	000000000000
/24/90 23:23:20	146.57	20050032	14	1.2570E-06	0	0	0	0	0	000000000000
/24/90 23:28:24	7.80	42363	1	4.2490E-05	0	0	0	0	172	000000000000
5/25/90 0:24:37	3.87	1256	1	1.4331E-03	0	0	0	0	72	000000000000
5/25/90 0:26:28	9.48	2921	90	5.5460E-02	0	0	0	0	0	000000000000

Run 622

rror #	Loop Count	Error Type	Bus Access	DUT All Data	Gold All Data
1	0364252	SEU	25	FFFFFFFFFFFFFFFFFFFFFFFFFFFF3BD5	FFFFFFFFFFFFFFFFFFFFFFFFFFFF3AC
4	2738653	SEU	11	FFFFFFFFFFFFFFFFFFFFFFFFFFFF3B58	FFFFFFFFFFFFFFFFFFFFFFFFFFFF3AC
2	8492039	SEU	31	FFFFFFFFFFFFFFFFFFFFFFFFFFFF3BD8	FFFFFFFFFFFFFFFFFFFFFFFFFFFF3AC
6	8330641	SEU	16	FFFFFFFFFFFFFFFFFFFFFFFFFFFF3B5C	FFFFFFFFFFFFFFFFFFFFFFFFFFFF3AC
8	5609887	SEU	3	FFFFFFFFFFFFFFFFFFFFFFFFFFFF3BD2	FFFFFFFFFFFFFFFFFFFFFFFFFFFF3AC

3AC7

Crystal ADC

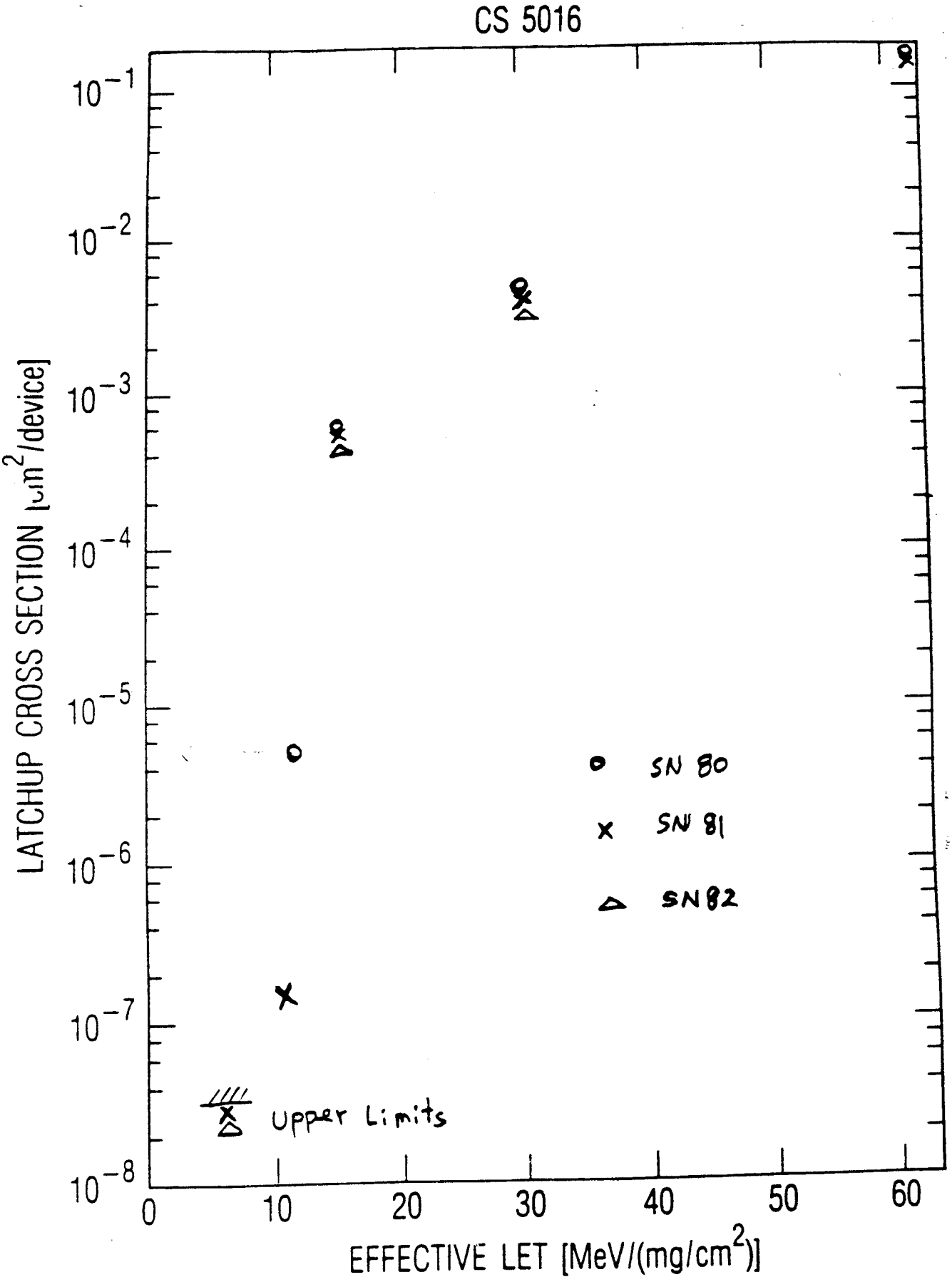
Run 622

1)	3AC7	0011 1010 1100 0111	
	3BD5	0011 1011 1101 0101	
		x x x	3 bits
2)P	3AC7	0011 1010 1100 0111	
	3B58	0011 1011 0101 1000	
		x x x xxxx	7 bits
3)	3AC7	0011 1010 1100 0111	
	3BD8	0011 1011 1101 1000	
		x x xxxx	6 bits
4)	3AC7	0011 1010 1100 0111	
	3B5C	0011 1011 0101 1100	
		x x x x x x	6 bits
5)	3AC7	0011 1010 1100 0111	
	3BD2	0011 1011 1101 0010	
		x x x x	4 bits

Crystal ADC Latchup

- Setup
  - DM0D20 Module
  - Mother Board
  - BASACS
  - Mac II Computer
  - HP6624A Power Supply

- Currents
  - Normal supply current
    - +5V....10-20 mA
    - -5V.....10-20 mA
  - Latchup current
    - About 600 mA for both lines
  - Latchup Detect Current
    - 200 mA
  - Holding Current
    - +5V.....4.5 mA
    - -5V.....5.5 mA


CS 5016
LATCHUP CROSS SECTION [μm²/device]
EFFECTIVE LET [MeV/(mg/cm²)]
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
10⁻⁸
0
10
20
30
40
50
60
SN 80
SN 81
SN 82
Upper Limits

DATE Mar 3-24 '95 SII: LASL 80

DEVICE NAME	BIN #	S/N	BOARD NAME	ION	ENERGY	ANGLE	LET	DUT POS	DUT [V]	I [mA]	TEMP [C]	START TIME	RUN [SEC]	PMT COUNT	RESULTS		
															TOTAL ERRORS	X-SECT	COMMENTS
CD5016	592	81	BM0D20	Ar	180	0°	15	2	5V		Room			2.0e4	7	6.3×10^{-4}	$I_{th} = 200mA$
"	"	"	"	Cu	290	0°	30	"	"		"			4.4e3	11	$4.5e^{-3}$	
"	"	"	"	Ne	90	0°	5.6	"	"		"			5.0e7	0	$< 4 \times 10^{-8}$	
"	"	"	"	Ne	90	60°	11	"	"		"			1.0e8	4	$1.4e^{-7}$	
"	"	"	"	Xe	603	0°	63	"	"		"			2190	130	$1.1e^{-1}$	
CD5016	592	80	BM0D20	Xe	603	0°	63	1	5V		Room			2194	146	$1.2e^{-1}$	
	"	"	"	Cu	290	0°	30	"	"		"			3245	9	$5.0e^{-3}$	
	"	"	"	Ar	180	0°	15	"	"		"			24278	9	$6.7e^{-4}$	
	"	"	"	Ne	90	65°	13	"	"		"			8.4e6	10	$5.1e^{-6}$	

DATE Test 5-24-90 SITE LBL 88"

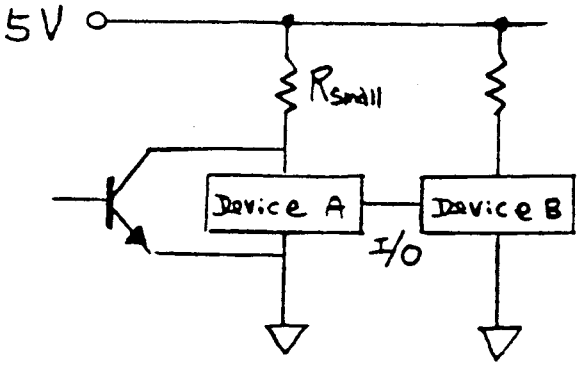
DEVICE NAME	BIN #	S/N	BOARD NAME	ION	ENERGY	ANGLE	LET	DUT POS	DUT [V]	I [mA]	TEMP [C]	START TIME	RUN [SEC]	PMT COUNT	RESULTS		
															TOTAL ERRORS	X-SECT	COMMENTS
CD5016	592	82	BHMD20	Cu	290	0°	30	3	5V		Room			4135	9	$3.7e^{-3}$	
"	"	"	"	Ar	180	0°	15	"	"		"			38,502	8	$4.2e^{-4}$	
"	"	"	"	Ne	90	0°	5.6	"	"		"			50e6	ϕ	$<3.6e^{-8}$	

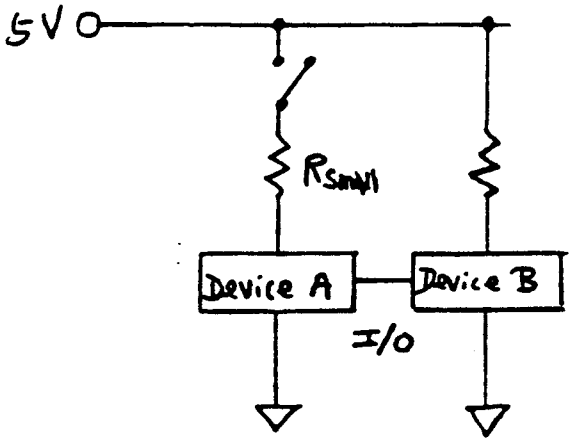
Latchup Detection

- Detect a high current condition
  - Threshold
- Measure the duration of disturbance
  - Avoid spikes
  - Use a timer

Latchup Termination

- **Avoid local control**
  - **a)Shunt**
  - **b)Open/Close**





- **Apply global control**
  - **a) Crowbar (shunt for dt)**
  - **b) Open/Close (less practical?)**