NOTE - This report has been edited in 2011

Irradiation Test Report

for

Selected Electronic Components

used in Equipment for ISS/COF

designed by Chevalier Photonics

Project Document No.: PCDF-TR-DO-06

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1 GENERAL INFORMATION

1.1 Scope

This document gives the results of Single Event Latch-up (SEL) testing performed on selected EEE components using the ESA Heavy Ion Test Facility (HIF) at Université catholique de Louvain (UCL) in Louvain-la-Neuve, Belgium. The results include the effective LET levels used for testing each component and the LET levels at which any latch-up occurred up to a level twice that required by the project.

The main purpose of the testing was to give confidence that the SEL Linear Energy Transfer (LET) threshold level of each tested component type was above the minimum of 36 MeV cm²/mg required by the PCDF project Product Assurance Plan. The detection of Single Event Upsets was not a purpose of the testing, even though some of the tested components were potentially sensitive to SEU. Although not a specific purpose of the testing the test configuration allowed for the detection of some other Single Event Effects, such as Single Event Burn-out or Single Event Gate Rupture.

The selection of components to be tested and details of the test plan and procedure are described fully in Astrium GmbH Document “Irradiation Test Plan for Selected Electronic Components used in Equipment for ISS/COF designed by Chevalier Photonics”, ITP/01-01, Issue 1A of 03.05.2001 (Project Document No. PCDF-TP-DO-71). Where it is considered relevant to the understanding and interpretation of the test results this document repeats information already given in the Irradiation Test Plan, e.g. the electrical bias applied during irradiation and the monitoring conditions used to detect any latch-up during irradiation.

1.2 Applicable Documents

ESA/SCC Basic Specification No. 25100, “Single Event Effects Test Method and Guidelines”.

Astrium Proposal A.2000-2124-0-2 dated 19.07.2000. “Project PCDF : SEE Radiation Assessment and Test”.

Astrium Document ITP/01-01 Issue 1A dated 03.05.2001 (PCDF Project Document No. PCDF-TP-DO-71). “Irradiation Test Plan for Selected Electronic Components used in Equipment for ISS/COF designed by Chevalier Photonics”

PCDF Project Document No. PCDF-PL-DO-02. “Product Assurance Plan”

1.3 Definition of Terms

Single Event Latch-Up (SEL):
SEL is defined as the heavy ion induced firing of a parasitic structure inherent in some monolithic integrated circuit technologies which exhibits negative differential resistance. Firing of the structure results in an uncontrolled increase of component supply current which might subsequently lead to component destruction (burnout).

Single Event Burnout (SEB):
SEB occurs if an SEL in a component allows sufficient current to pass to cause irreversible catastrophic damage to the component.
SEB can also be the breakdown and subsequent burnout of the parasitic bipolar transistor inherent in a power MOSFET structure (resulting from a heavy ion hit on the parasitic transistor).

Single Event Gate Rupture (SEGR):
SEGR is defined as direct breakdown and subsequent destructive rupture of the gate dielectric layer of a power MOSFET along the track of a heavy ion hit.

Single Event Upset (SEU):
SEU is a form of soft error. It is expressed by the changed state of a bit due to the impact of a heavy ion or proton. The transition of the charged particle causes ionisation, which in turn leads to the flipping of bits. The effect can be corrected after the transition of the ion or proton.

Single Event Effect (SEE):
SEE is a generic term covering all single event occurrences such as latch-up, burnout, gate rupture, upset, etc.

Linear Energy Transfer (LET):
LET is the energy loss of a particle passing through the material of an absorber with a thickness such that a portion of it with a 1 cm^2 surface area normal to the particle direction has a mass of 1 mg. It is expressed in units of MeV/(mg/cm^2) or MeV cm^2/mg.

Effective LET:

This is the equivalent LET obtained by tilting the device under test so that the beam axis is no longer normal to it, hence increasing the path length of the ion and the total energy deposited. It is calculated by:

$LET_{eff} = LET / \cos\Theta$

where Θ is the tilt angle of the device, i.e. the angle between the beam axis and the normal to the die surface

Threshold LET:

The threshold LET is the LET at which the cross-section has a value of 1% of the saturated cross-section.

Flux:

The rate of incidence of particles on a material is given in terms of the particle flux, expressed in particles/(cm^2/s).

Fluence:

The time integral of the flux is referred to as the particle fluency, expressed in particles/cm².

Total dose:

Total dose is defined as the energy deposited in materials by ionising radiation, expressed in terms of rad (radiation absorbed dose). One rad is equal to an absorbed energy of 100 ergs per gram of the material. Using this unit the material in which the energy is deposited must be specified, e.g. rad(Si) for silicon. The Si unit of absorbed dose is the gray (Gy), which is equal to an absorbed energy of 1 Joule per Kg, or 100 rads.

2 TEST COMPONENT DETAILS

The total number of different component types tested was eighteen. These types were selected as being potentially the most SEL sensitive in the equipment designed for ISS/COF by Chevalier Photonics. All the test samples were supplied by Chevalier Photonics and are from the same component lots as used in the actual flight equipment.

The following list show the types selected and tested, together with the type of package in which they were housed and the number of available samples. In order to retain consistent numbering of component types throughout the various documents produced during the selection and test activities, the eighteen sample types are actually numbered from 1 to 24. This is because six component types included in an earlier list were deleted when further information on existing test results became available. The Part Type numbers given in this list are those used in the original Users' Parts Lists supplied by Chevalier Photonics. Photographs of all these types are included in Appendix A to this document, and details of the complete marking on each supplied component are given in Appendix B.

Item No.	Description	Part Type	Package Type	Available Samples
1	Intersil N-Channel HEXFET 2N6782	JANTXV2N6782	TO-205AF metal can	3
2	International Rectifier P-Channel HEXFET 2N6845	JANTXV2N6845	TO-205AF metal can	3
3	Texas Instrument Line Driver SNJ55ALS194J	5962-8864801EA	16-pin CERDIP	3
4	Texas Instrument Line Receiver SNJ55ALS195J	5962-8864901EA	16-pin CERDIP	3
5	Linear Technology Positive Voltage Regulator LT1086MH/883	5962-8998101YA	TO-39 metal can	3
6	Austin Semiconductor 512k x 8 SRAM	AS5C4008F-25	32-pin flatpack metal lid ceramic	3
7	Analog Devices FET Input Op Amp	AD822AR	8-pin SOIC plastic	4
8	Analog Devices 12-bit CCD Digital Signal Processor	AD9816JS	44-pin MQFP plastic	4
9	DELETED			
10	Corning Frequency Control 20 MHz Oscillator	M55310/28-B11A 20000000	4-pin SMT metal lid ceramic	3
11	DELETED			
12	Micrel 12A CMOS MOSFET Driver	MIC 4452BM	8-pin SOIC plastic	15
13	National Semiconductor CMOS Hex Inverter	54ACTQ04LMQB	20-pin CLCC metal lid ceramic	3

Item No.	Description	Part Type	Package Type	Available Samples
14	Integrated Device Technology 8-bit Bus Transceiver 54FCT245T	5962-9221401MRA	20-pin CERDIP	3
15	National Semiconductor NAND Buffer Driver JD54F38BCA	JM38510/35202BCA	14-pin CERDIP	5
16	Texas Instruments Hex Inverter 54HCT04	JM38510/65751BCA	14-pin CERDIP	3
17	DELETED			
18	DELETED			
19	Analog Devices Instrumentation Op Amp AD620SQ	AD620SQ 883BQ	8-pin CERDIP	8
20	National Semiconductor Voltage Regulator LM2991J-QML	5962-9650501 QEA	16-pin CERDIP	13
21	DELETED			
22	DELETED			
23	Siliconix 16 channel CMOS Analog Multiplexer DG406AK/883	5962-9562301QXA	28-pin CERDIP	3
24	National Semiconductor Voltage Regulator LM117H/883Q	LM117H/883Q	TO-39 metal can	3

3 TEST SET UP

3.1 Irradiation Facility

The test facility used for this testing was the ESA Heavy Ion Test Facility at UCL in Belgium. This uses the CYCLONE accelerator which is a multiparticle, variable energy, cyclotron capable of accelerating protons (up to 85 MeV), alpha particles and heavy ions. For the heavy ions the energy range covered is between 0.6 MeV/AMU and 27.5 MeV/AMU with a maximum energy of 110 Q^2/M, where Q is the ion charge state and M is the mass in Atomic Mass Units. The heavy ions are produced in a single stage (6.4 GHz) Electron Cyclotron Resonance (ECR) source and an analysing magnet is then used to select the desired M/Q ratio before the ions are injected axially for subsequent acceleration. The use of an ECR source allows the production of highly charged ions and of ion "cocktails", composed of ions with the same or similar M/Q ratios, which are accelerated together but extracted separately by fine tuning the magnetic field or slightly changing the RF frequency.

The following ion cocktail from those available at UCL was used for the testing.

Cocktail Number	M/Q	Ion	DUT energy (MeV)	Range (µm Si)	LET (MeV cm²/mg)
1	5.07	$^{132}Xe^{26+}$	459	43	55.9
	4.94	$^{84}Kr^{17+}$	316	43	34
	5	$^{40}Ar^{8+}$	150	42	14.1
		$^{20}Ne^{4+}$	78	45	5.85
		$^{15}N^{3+}$	62	64	2.97
		$^{10}B^{2+}$	41	80	1.7

For each of the ions the effective LET could be increased from the LET value given in the table by tilting the test sample so that the ion beam was no longer normal (perpendicular) to the die surface.

The sample chamber has the general shape of a cylinder lying on its side and stretched vertically, with internal dimensions of 71 cm high, 54 cm wide and 76 cm deep. The opening end of the cylinder can be moved 1 m away from the cylinder on a rail system for sample installation. It also supports an internal frame for holding the test samples and contains connectors for electrical connections. During operation the complete chamber can pump down to operating vacuum in less than ten minutes. Photographs showing the chamber set up for the PCDF component testing are included in Appendix C to this report.

To set up, control and monitor the beam flux and homogeneity a box in front of the chamber contains a Faraday cup, four scintillators and two parallel plate avalanche counters (PPAC). Two additional surface barrier detectors are placed in the test chamber.

3.2 Preparation of Components

All of the component samples were serialised and then subjected to some basic parametric measurements to check that they were functional. One component of each type was retained as a control and two of the remaining components were opened using appropriate mechanical or chemical techniques to expose the die surface. After they were opened the components were again subjected to the basic parametric measurements to determine if there were any significant changes which might indicate that they had been damaged by opening.

Photographs of one opened component of each type are shown in Appendix A to this report.

3.3 Test Sockets and Printed Circuit Board Layout

The test chamber is able to take a printed circuit board up to 250 x 250 mm, of which an area of 250 x 120 mm can be scanned by the heavy ion beam. Although the remaining board area cannot be irradiated, and therefore is unusable for mounting test components, it can be used for any connectors or components needed for the biasing and monitoring of the test components.

For testing the PCDF components in the vacuum chamber a “piggy-back” configuration was used with one mother board and separate daughter boards for each component type to be tested. The mother board had four identical socket pairs into which four individual daughter boards could be plugged. The daughter boards contained the components to be irradiated and also any wire links, resistors or capacitors necessary for the correct biasing and monitoring of the test samples. A photograph of the mother board with four daughter boards is included in Appendix C to this report and is shown schematically in Appendix D.

Based on the availability of suitable sockets, and the requirements for providing additional mechanical stability for some plastic packages before opening them, the test samples were either plugged into sockets on the daughter boards or were soldered to small carrier boards which were then mounted on the daughter boards.

3.4 Biasing and Monitoring Circuit

The basic biasing and monitoring circuit was located in a box outside the vacuum chamber and had been designed to fulfil the following main functions:

- To supply to the piggy-backed daughter boards the necessary positive, negative and ground voltages for biasing the components under test.
- To monitor the currents flowing in the positive and negative supply lines.
- To allow preset limits to be set for the supply currents using controls on the monitor box.
- To remove the bias voltages from the components under test if the monitored currents exceed the preset limits.
- To indicate using LEDs outside the chamber when the preset negative and/or positive current limits have been exceeded.
- To allow the circuit to be reset from outside the vacuum chamber thereby re-applying biasing to the components under test.

It should be noted that the circuit could be switched between the different test components which were in the chamber at the same time and was used to bias and monitor only the one component which was being irradiated. Therefore if a latch-up occurred it was obvious which component had failed as only one component was being biased, irradiated and monitored at any one time. As the circuit was designed to remove the biasing before any permanent damage could occur it was possible to re-apply the bias as soon as the component which latched-up was no longer being irradiated.

The circuitry on the daughter boards was intended only to direct the bias voltages to the correct pins on the component under test and to provide any necessary load resistors or capacitors.

The biasing and monitoring circuit is shown schematically in Appendix D at the end of this document and a photograph is included in Appendix C. Part type specific information and schematics of the daughter board circuits for each component type are given in Appendix E.

4 TEST PERFORMANCE

4.1 Electrical Check at UCL

Immediately before the components were placed in the vacuum chamber at UCL they were subjected to a very simple electrical check based on the measurement of supply currents and, where appropriate, output voltages. This was performed to ensure that the components were functional and to allow for selection of a suitable current monitoring threshold.

4.2 Heavy Ion Irradiation with Monitoring for SEL

The test samples on the appropriate daughter boards were mounted four at a time on the mother board and placed in the vacuum chamber where they could be individually exposed to a calibrated heavy ion beam. Each sample was subjected to a number of different LET_{eff} levels which were obtained by using different ion species and various tilts of the die with reference to the axis of the impinging ion beam. At each LET_{eff} level the irradiation was continued until a fluence of 10^6 particles/cm² had been reached or until a latch-up had been detected. The initial and subsequent LET_{eff} levels used for the irradiation of each component were individually decided using engineering judgement together with available information covering:

- Existing SEL sensitivity results for other devices manufactured using similar technology
- Results of previous test runs on the same component at other LET_{eff} levels
- Results of testing the first component of a particular type if a second component of the same type was being tested
- Results of test runs on other PCDF components

During exposure each component was biased using conditions which were based on those which it would experience in the PCDF project and those which were most likely to support latch-up. These bias conditions were defined and agreed in the “test plan” and are shown for each component type in Appendix E of this report. During testing the supply current(s) to the irradiated component were monitored to detect any large and sudden increase which would indicate the occurrence of a latch-up. For each component type an appropriate latch-up threshold current level was selected and if the current increased above this level the voltage biasing was automatically cut off to prevent permanent device damage due to latch-up. The threshold levels were all set in the mA range and where possible were about an order of magnitude higher than the measured pre-irradiation supply current.

If the biasing to a component was automatically cut off by the monitoring circuit the irradiating heavy ion beam was closed. The biasing was then re-applied to check whether the current increase was due

to a reversible latch-up or whether permanent damage had been caused by any other effect such as device burnout, SEB, SEGR, etc. Reapplying the irradiating beam to the component with the biasing applied then allowed an assessment to be made of whether it was only noise in the system which had triggered the monitoring circuit.

Each component was tested up to an LET level at which latch-up clearly occurred, or up to a level at least twice the PCDF project required threshold of 36 MeV cm²/mg. For each component an assessment was also made of the total radiation dose which it had experienced during exposure to the heavy ion beam.

Two components of each type were exposed to the heavy ion irradiation, even though Astrium Proposal A.2000.2124-0-2 from Astrium GmbH, Ottobrunn to Astrium GmbH, Friedrichshafen required the irradiation of only one component. Testing of a second component within the originally agreed costs and schedule was possible because the test samples were opened very carefully to avoid damaging any of them and because the available beam time was used very efficiently.

All irradiation test activities were performed in accordance with the requirements of ESA/SCC Basic Specification No. 25100 except where the Astrium GmbH Irradiation Test Plan gave an alternative.

4.3 Astrium GmbH, Ottobrunn Responsibilities

Astrium was responsible for supplying all the necessary test samples, test boards, biasing and monitoring circuits, power supplies, and the test equipment needed for setting up and checking the test circuits. Astrium was also responsible for performing the actual testing including all controlling of the irradiation facility which could be performed using the BOARD POSITION, DATA BEAM and BEAM LINE screens on the user interface system.

4.4 UCL Responsibilities

A qualified operator for the HIF was present at all times that the beam was operational and was responsible for all operations which could not be controlled using the BOARD POSITION, DATA BEAM and BEAM LINE screens on the user interface system. The UCL operator was also responsible for ensuring that the Astrium personnel did not inadvertently misuse the system due to inadequate information or instructions.

5 TEST RESULTS

5.1 Summary of Test Results

The following table summarises the test results obtained for the individual components.

Item No.	Part Type	Serial No.	SEL Detected?	Minimum LET_{eff} which caused SEL (if detected) (MeV.cm²/mg)	Maximum LET_{eff} used which did not cause SEL (MeV.cm²/mg)	Total Dose (over all test runs) (Rad)	Comments
1	JANTXV2N2782	011	No		73.0	3.5 krad	See Note 1
		012	No		73.0	3.4 krad	
2	JANTXV2N6845	021	No		73.0	3.4 krad	
		022	No		73.0	3.4 krad	
3	5962-8864801EA (SNJ55ALS194J)	031	No		73.0	3.4 krad	
		032	No		73.0	3.4 krad	
4	5962-8864901EA (SNJ55ALS195J)	041	No		73.0	3.4 krad	
		042	No		73.0	3.4 krad	
5	5962-8998101YA (LT1086MH/883)	051	Yes	34.0	28.2	1.4 krad	See Note 2
		052	Yes	34.0	28.2	1.7 krad	See Note 3
6	5962-9560003M9A (AS5C4008F-25)	061	No		73.0	2.5 krad	
		062	No		73.0	2.5 krad	
7	AD822AR	071	No		73.0	2.5 krad	
		072	No		73.0	2.5 krad	
8	AD9816JS	081	Yes	14.1	9.1	0.3 krad	See Note 4
		082	Yes	14.1	9.1	0.3 krad	See Note 4
10	M55310/28-B11A 20000000	101	No		73.0	2.5 krad	
		102	No		73.0	2.5 krad	
12	MIC4452BM	121	No		73.0	2.5 krad	
		122	No		73.0	2.5 krad	
13	5962-89734012A (54ACTQ04LMQB)	131	No		73.0	2.5 krad	
		132	No		73.0	2.5 krad	
14	5962-9221401MRA (54FCT245T)	141	No		73.0	2.7 krad	See Note 5
		142	No		73.0	2.5 krad	
15	JM38510/35202BCA (JD54F38BCA)	151	No		73.0	2.5 rad	
		152	No		73.0	2.5 krad	
16	JM38510/65751BCA (54HCT04)	161	No		73.0	2.5 krad	
		162	No		73.0	2.5 krad	
19	AD620SQ 883BQ	191	No		73.0	2.5 krad	
		192	No		73.0	2.5 krad	

Item No.	Part Type	Serial No.	SEL Detected?	Minimum LET_{eff} which caused SEL (if detected) (MeV.cm²/mg)	Maximum LET_{eff} used which did not cause SEL (MeV.cm²/mg)	Total Dose (over all test runs) (Rad)	Comments
20	5962-9650501QEA (LM2991J-QML)	201		-		38 rad	
		202		-		48 rad	
23	5962-9562301QXA (DG406AK/883)	231	No		73.0	2.5 krad	
		232	No		73.0	2.5 krad	
24	LM117/883Q	241				0.4 krad	
		242				0.3 krad	

Notes

1. A latch-up was apparently detected at an LET_{eff} of 48.1 MeV cm²/mg but this did not recur when the test was repeated at the same LET_{eff} level nor was any latch-up detected at LET_{eff} levels of 55.9 and 73.0 MeV cm²/mg. It was concluded that the latch-up detection circuit had originally been triggered in error by noise in the system.
2. Latch-up was detected during two test runs at 34.0 MeV cm²/mg but no latch-up was detected at 14.1, 19.9 and 28.2 MeV cm²/mg.
3. Latch-up was detected during one test run at 34.0 MeV cm²/mg but not during a repeat run at the same level. An apparent latch-up (probably due to noise in the system) was detected during one run at 14.1 MeV cm²/mg but not during a repeat run at the same level or during test runs at 19.9 and 28.2 MeV cm²/mg.
4. Latch-ups were detected at 14.1 and 34.0 MeV cm²/mg, but not during runs at 5.85 and 9.1 MeV cm²/mg.
5. A latch-up was apparently detected at an LET_{eff} of 34.0 MeV cm²/mg but this did not recur when the test was repeated at the same LET_{eff} level nor was any latch-up detected at LET_{eff} levels of 48.1 and 73.0 MeV cm²/mg. It was concluded that the latch-up detection circuit had originally been triggered in error by noise in the system.

These results indicate that there could be a latch-up problem with the following component types if they are subjected to the minimum levels of heavy ion irradiation specified for the PCDF project.

Sensitive:

- Linear Technology positive voltage regulator type 5962-8998101YA (LT1086MH/883)

-
-
-

5.2 Detailed Test Results

A table giving details of all the irradiation test runs carried out on the sample components is given in Appendix F at the end of this report. In this table the test runs are not listed in the order in which they were actually carried out, but are ordered by Item No., Item Serial No. and LET_{eff}. Individual test sheets showing electrical conditions and results for each Item No. are included in Appendix G.

6 CONCLUSIONS

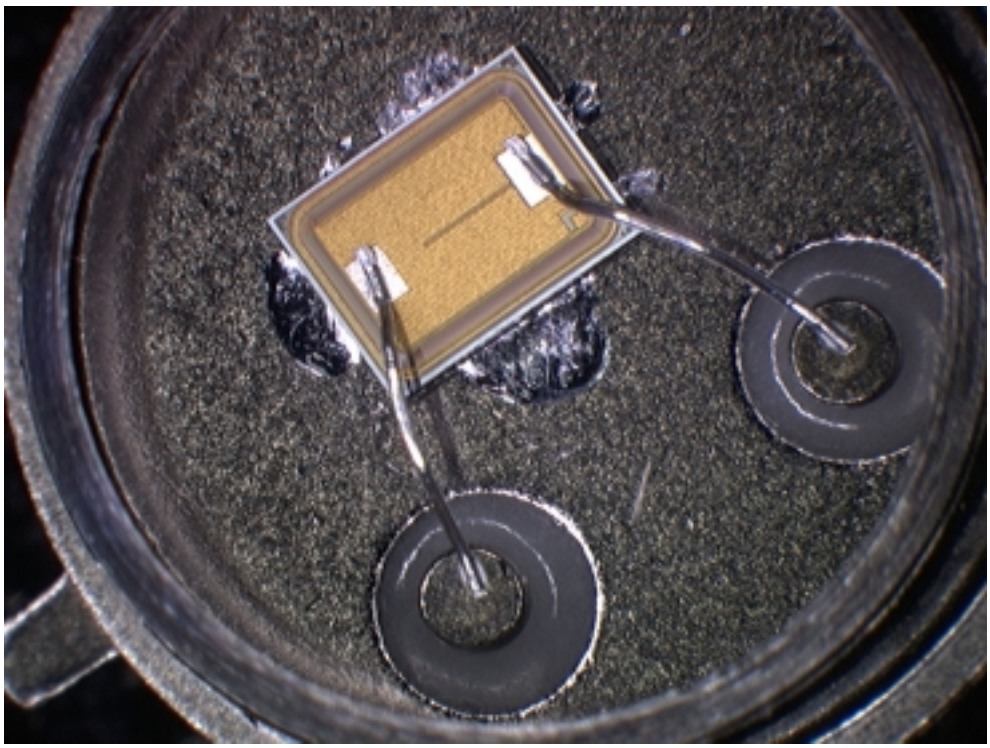
On the basis of the testing performed on the supplied samples it is possible to conclude that sixteen of the tested part types have an SEL LET threshold >73 MeV cm²/mg and therefore the parts meet the PCDF project requirement of 36 MeV cm²/mg.
The following four part types, listed in descending order of resistance to SEL, had a threshold below the minimum limit required for the PCDF project and therefore further assessment of the use of these parts is recommended.

- Linear Technology positive voltage regulator type 5962-8998101YA (LT1086MH/883)
  SEL occurred at 34.0 MeV cm²/mg but not at 28.2 Mev cm²/mg
- Analog Devices 12-bit CCD digital signal processor type AD9816JS
  SEL occurred at 14.1 MeV cm²/mg but not at 9.1 Mev cm²/mg

As the estimated total radiation dose seen by all the test samples was extremely low (typically 2.5 krad and a maximum of 3.5 krad) it was not considered sufficient to allow any meaningful assessment of total radiation dose effects.

APPENDIX A – TEST COMPONENT PHOTOGRAPHS

Item No. 1 – JANTXV2N6782



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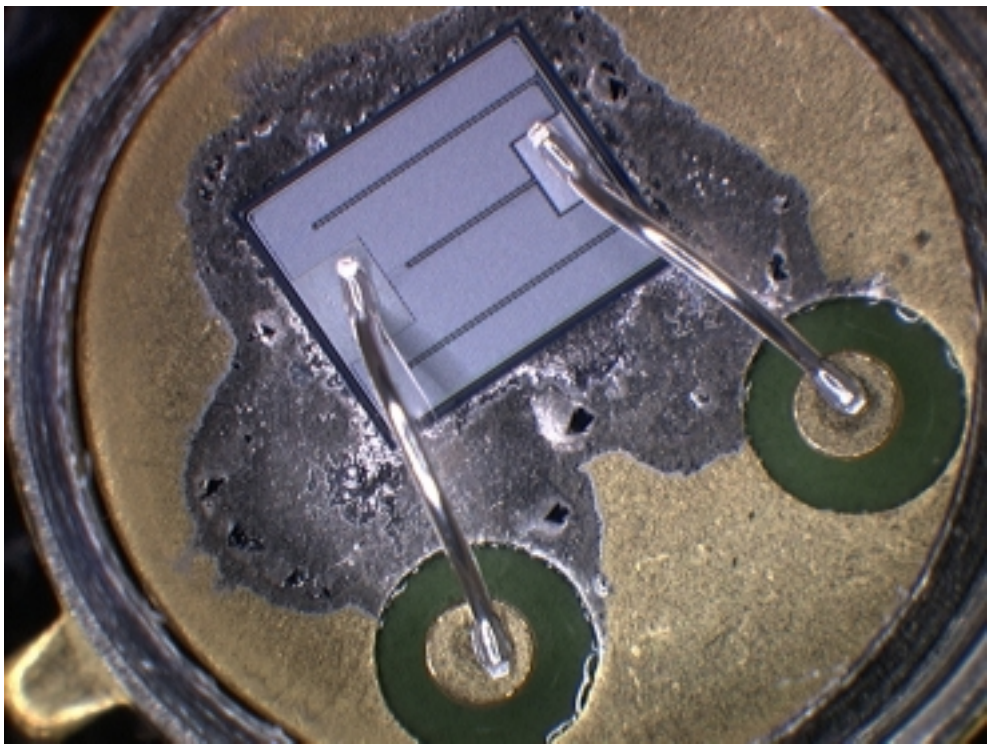
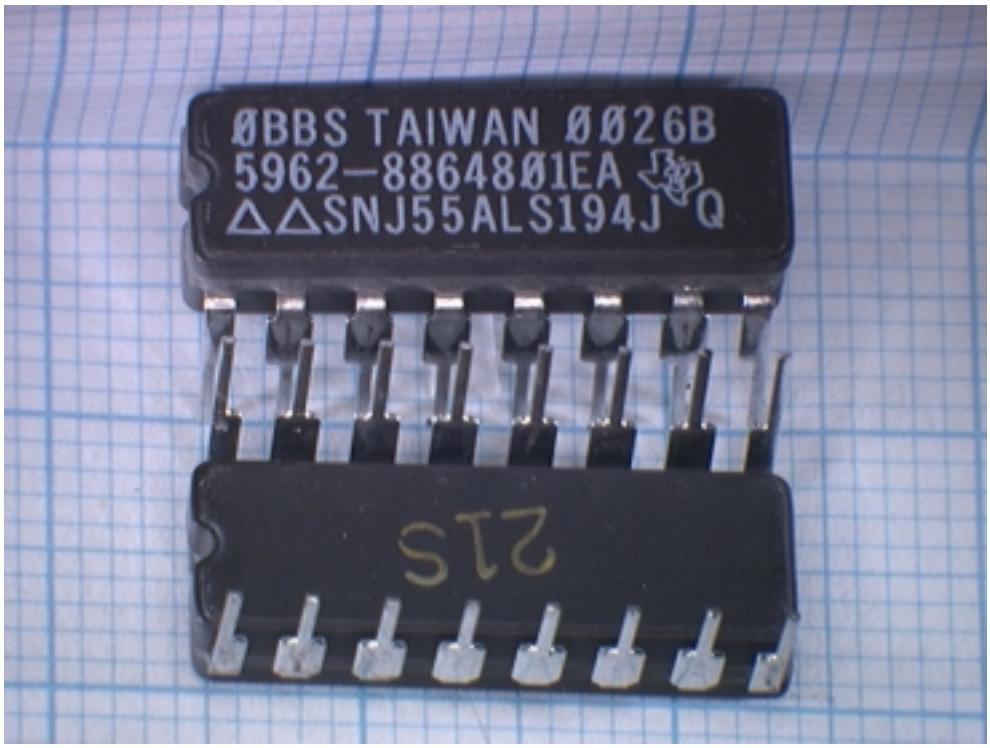
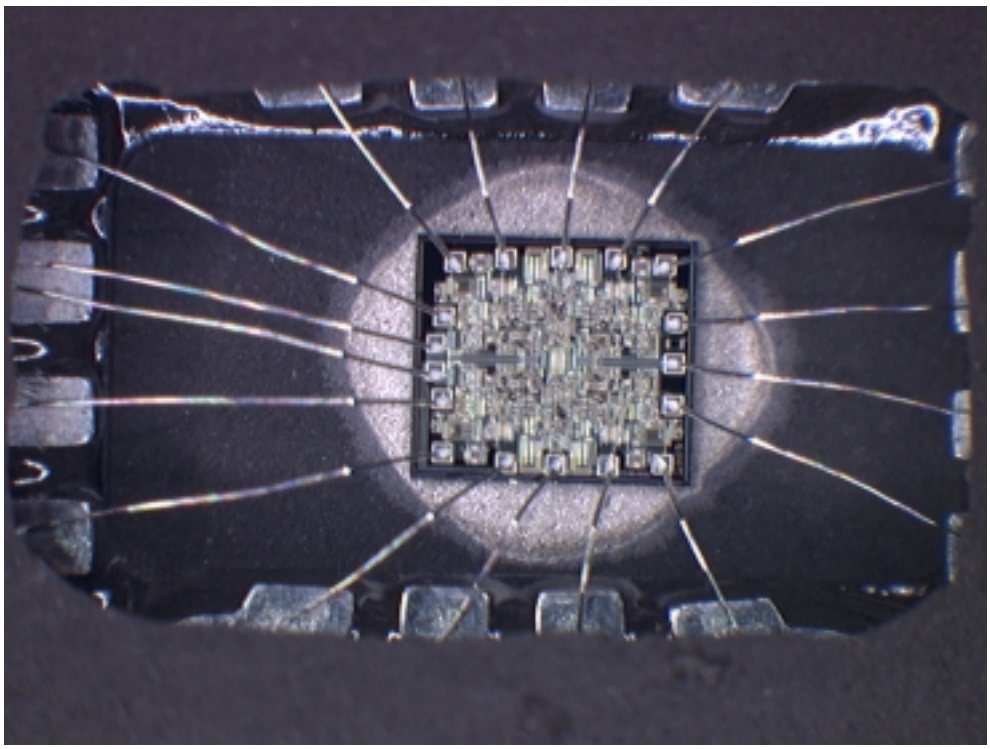


Item No. 3 – 5962-8864801EA (SNJ55ALS194J)





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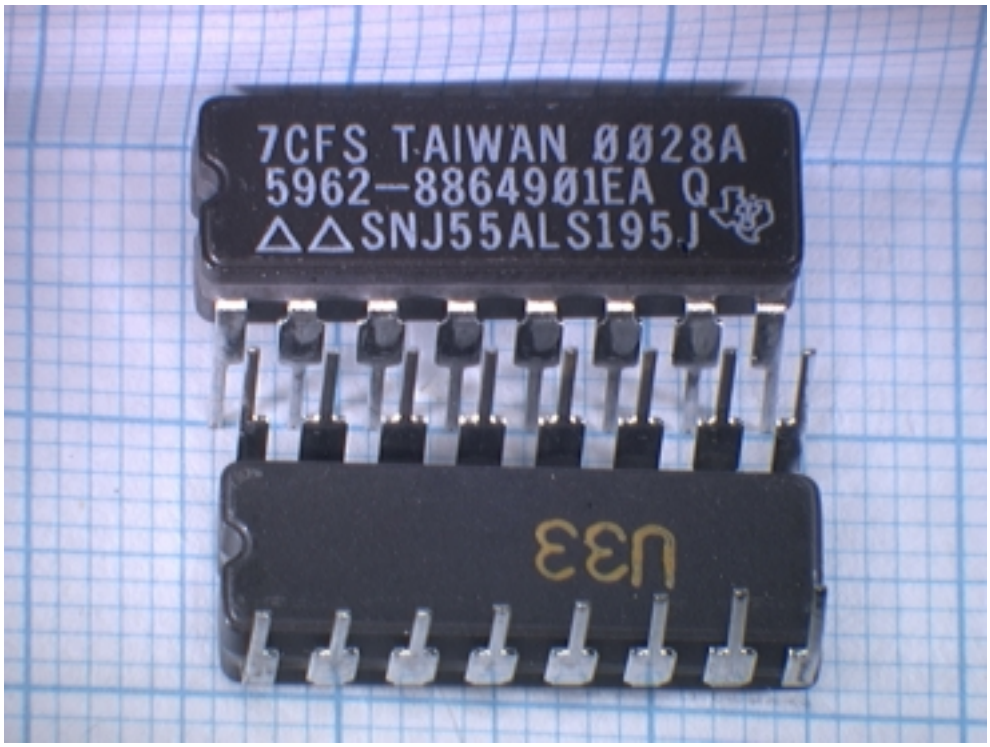
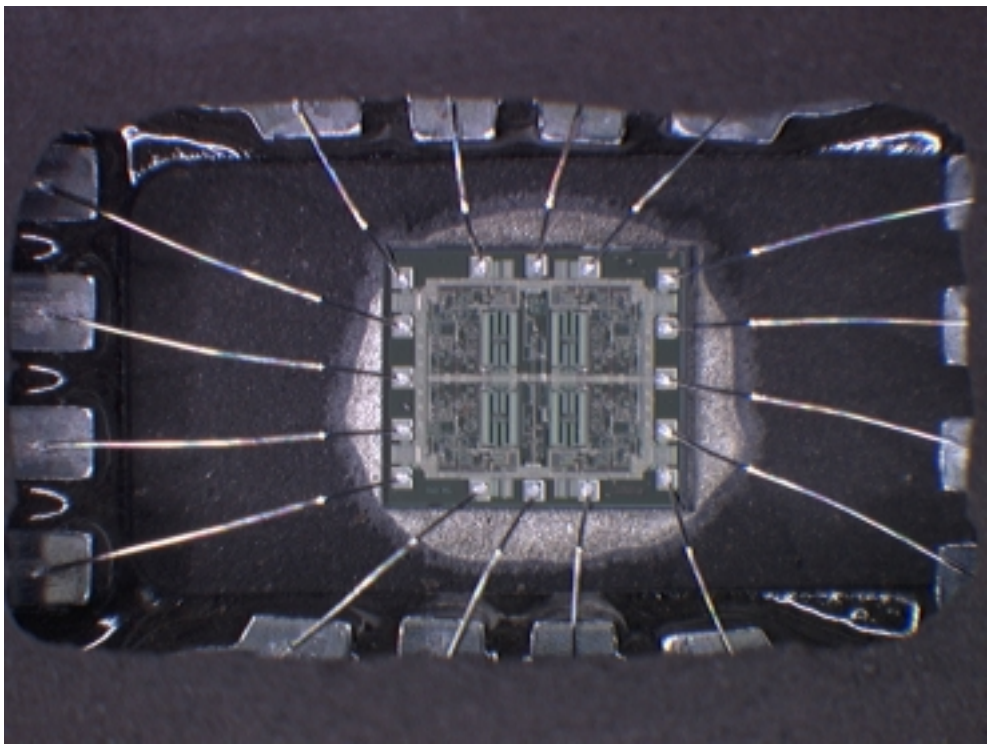
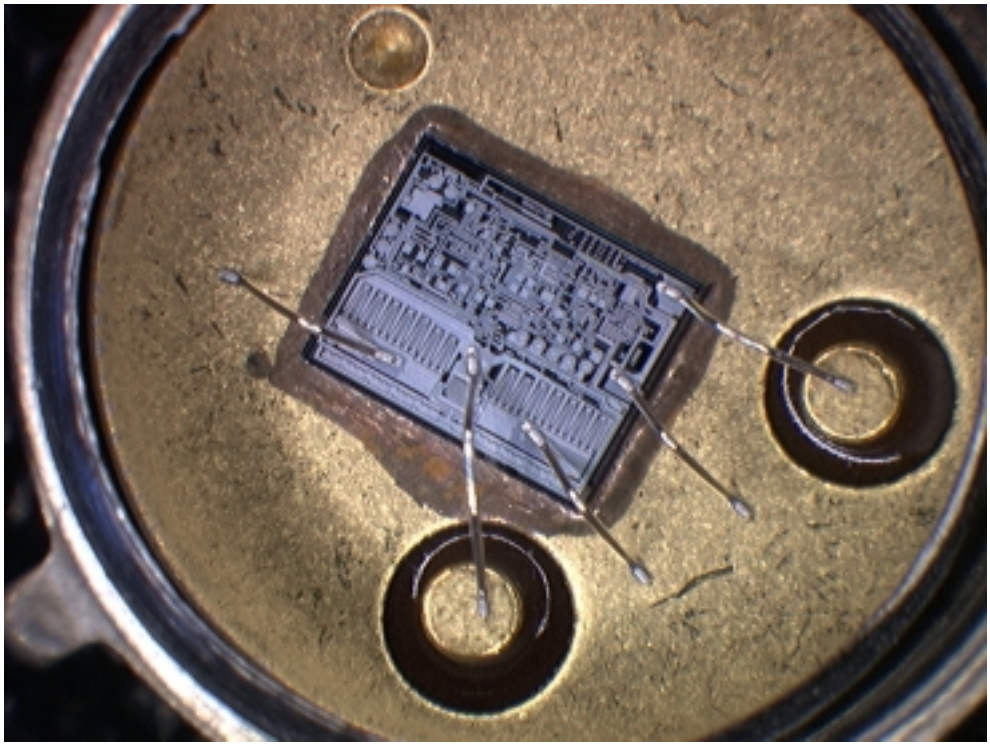
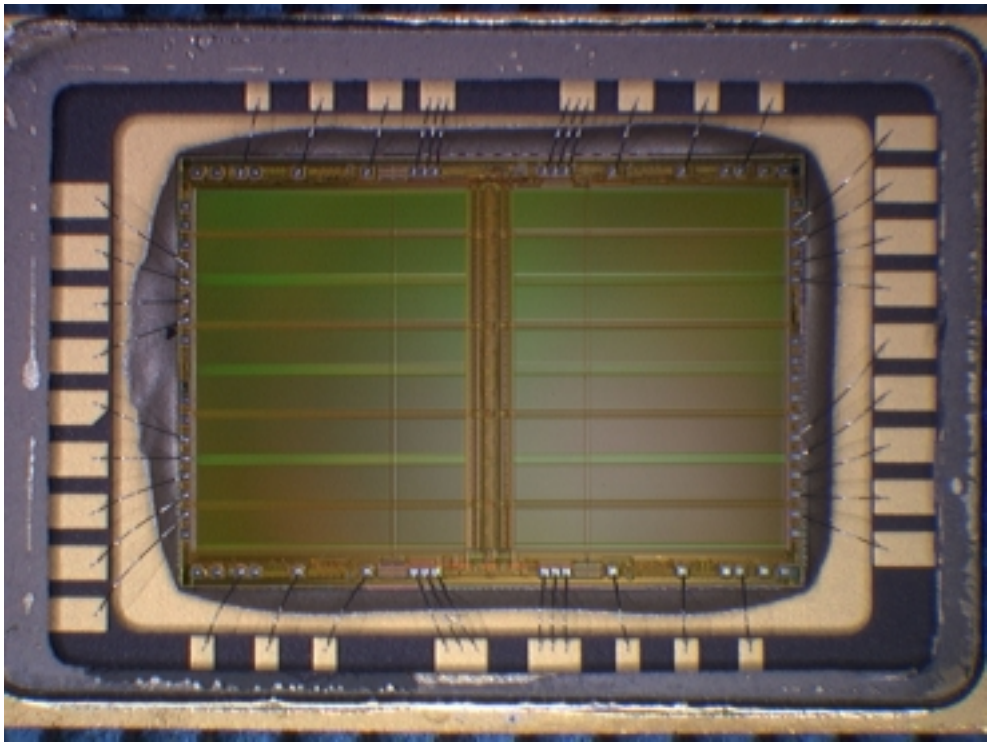




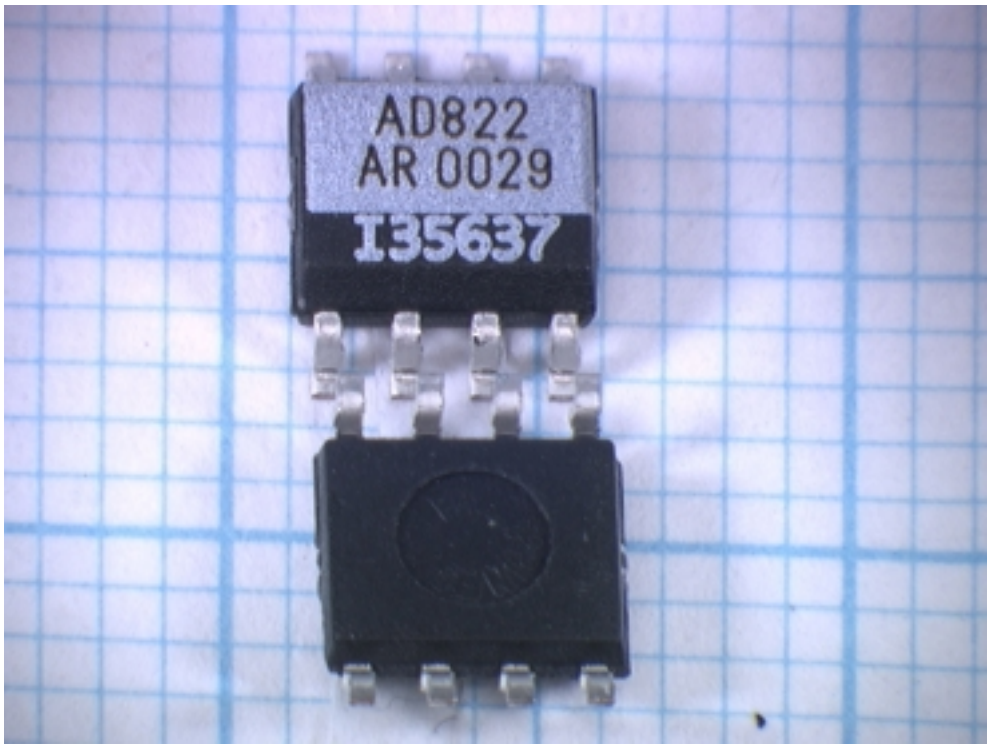
Item No. 5 – 5962-8998101YA (LT1086MH/883)

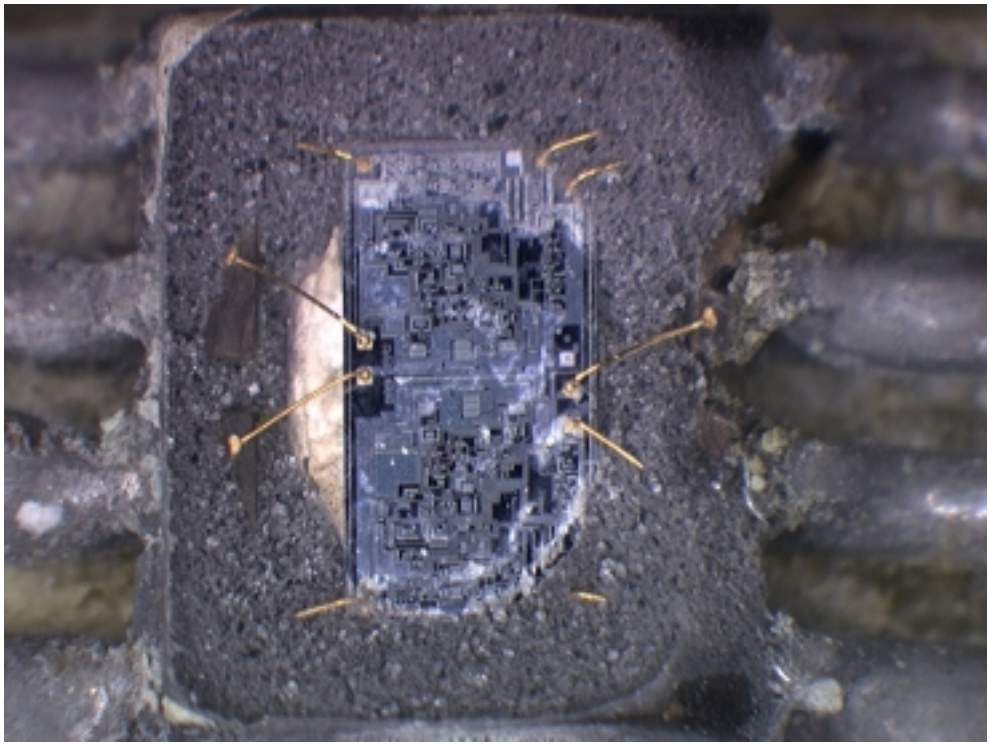


Item No. 6 – 5962-9560003M9A (AS5C4008F-25)

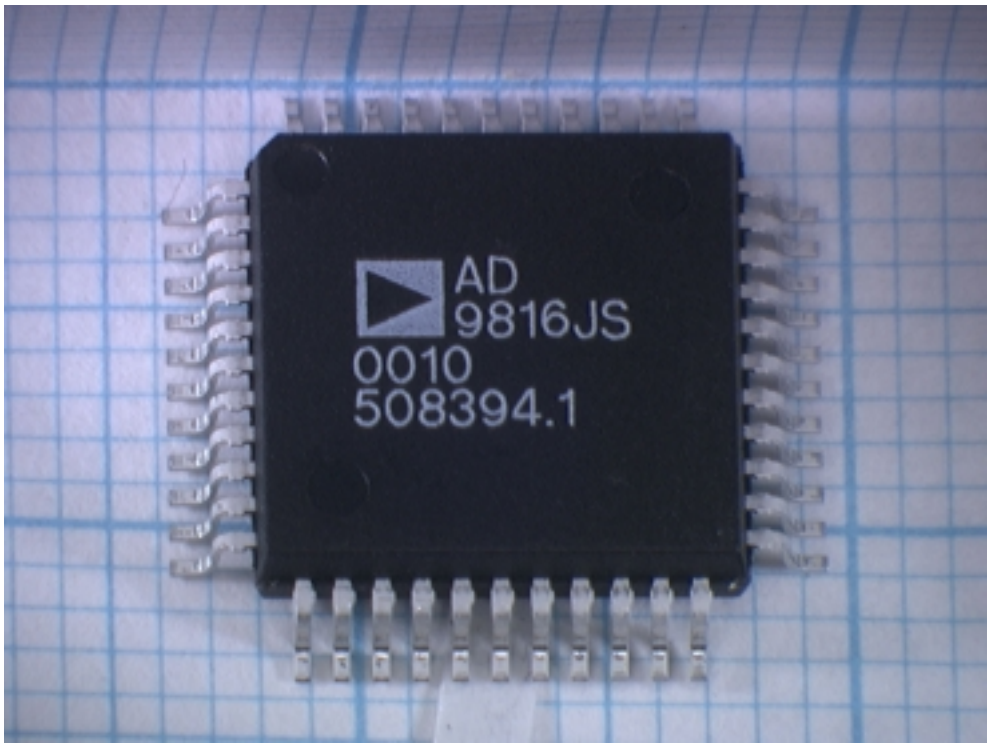


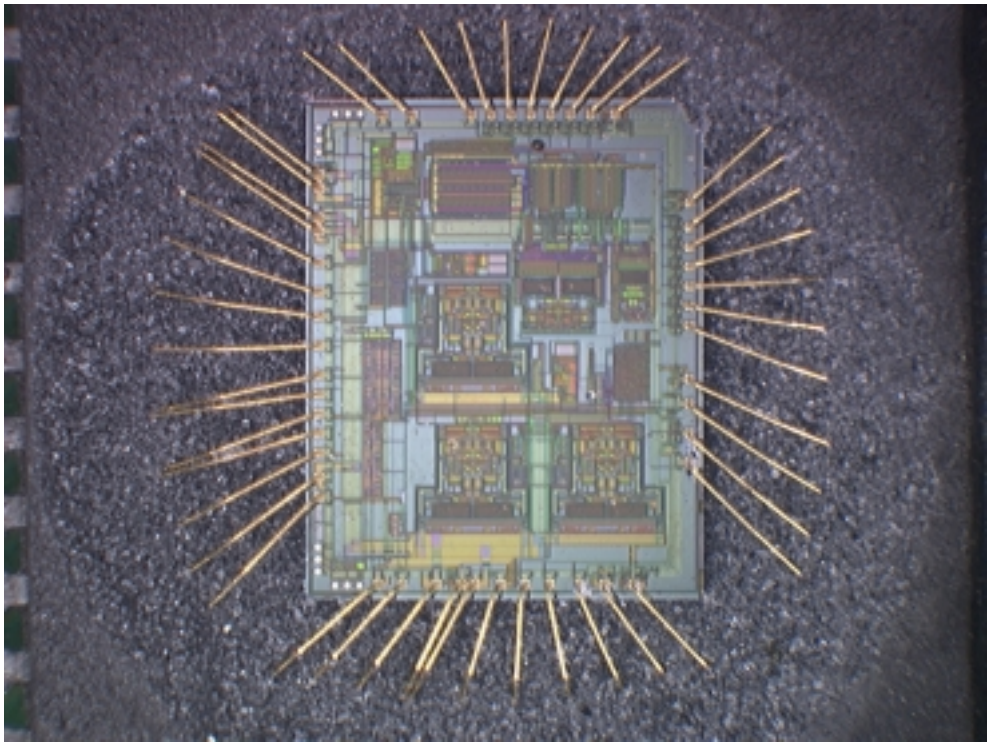
Item No. 7 – AD8222AR



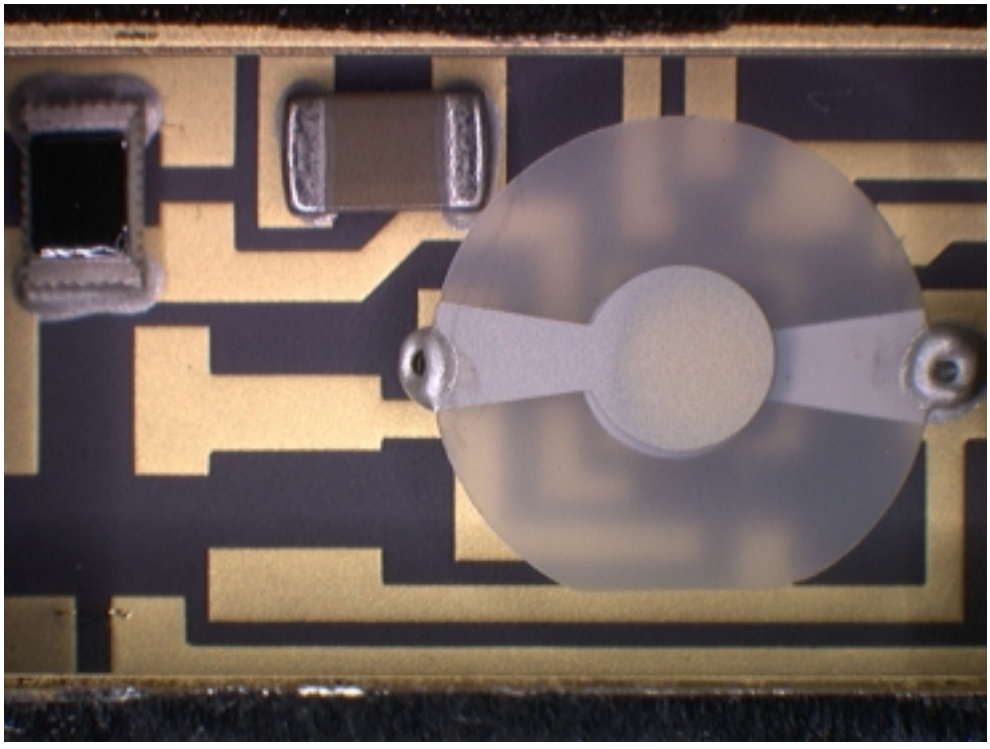


Item No. 8 – AD9816JS

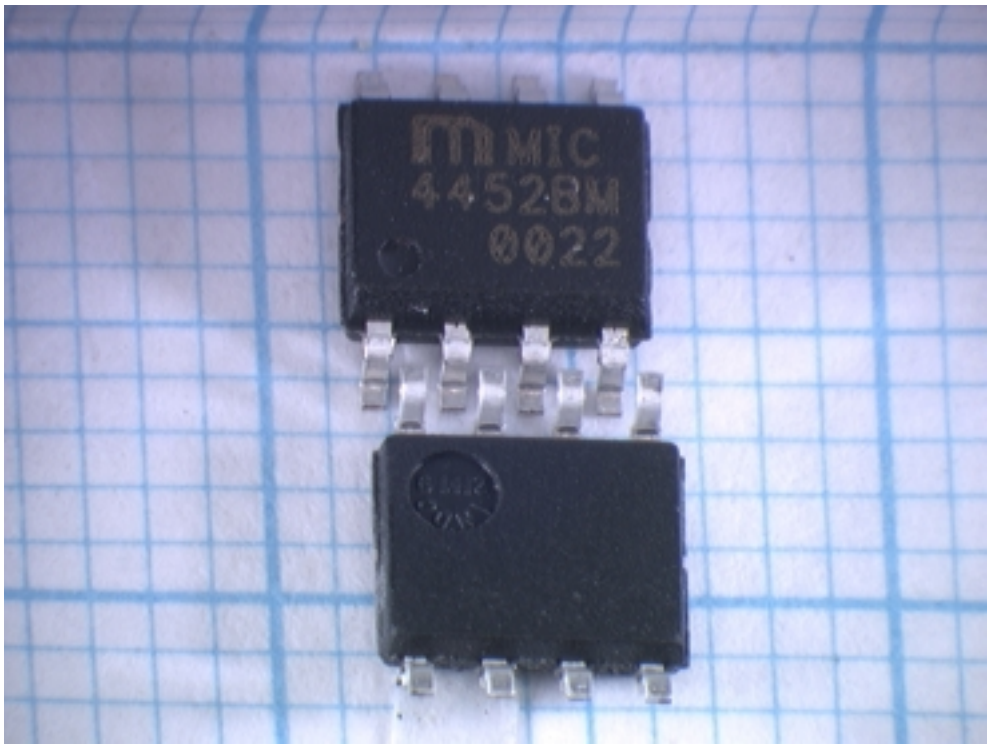


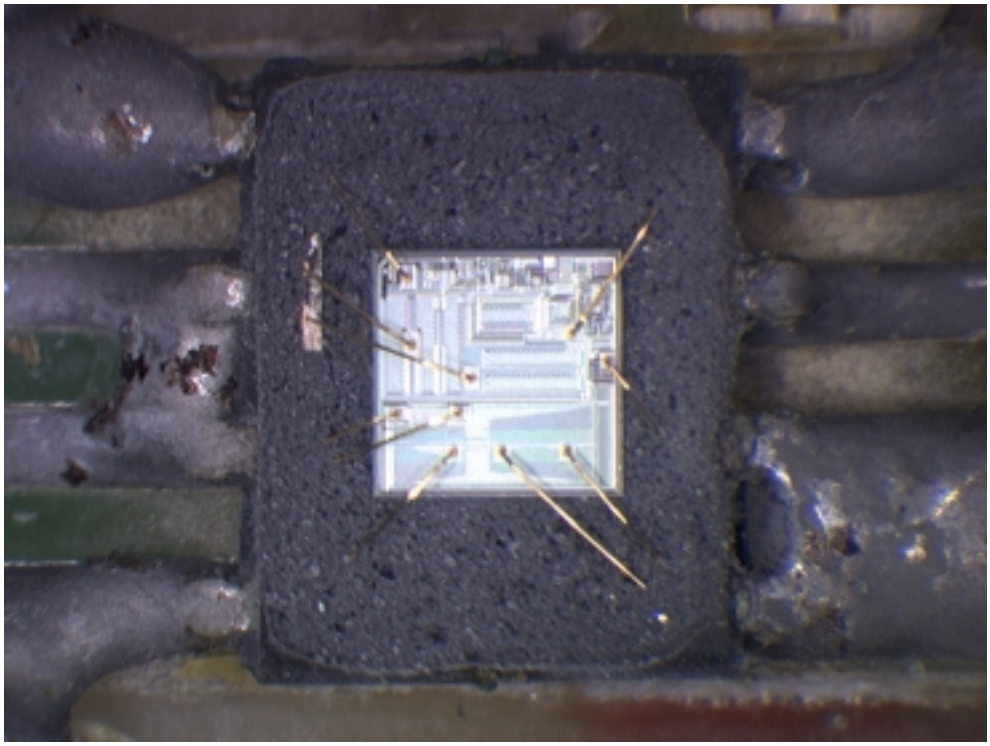


Item No. 10 – M55310/28-B11A 20000000

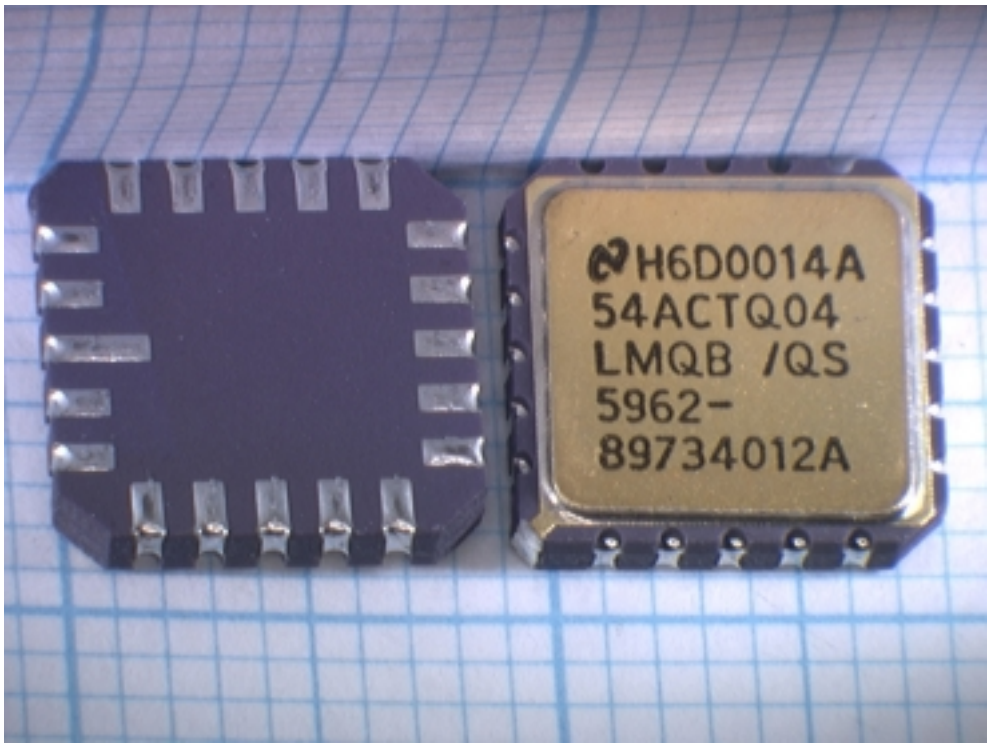


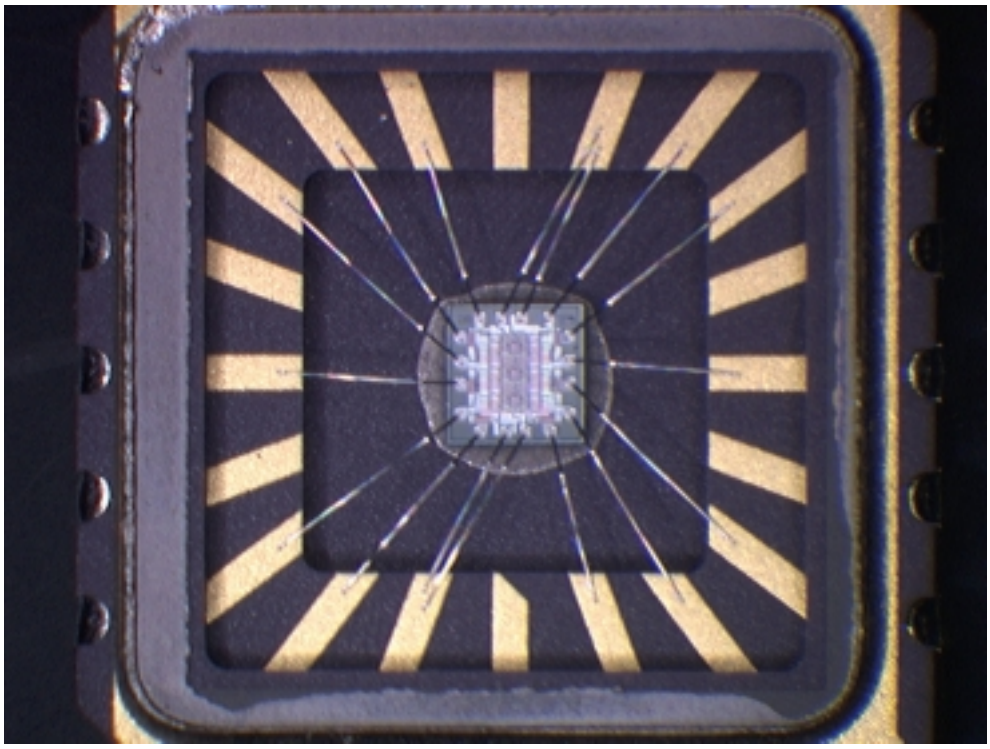
Item No. 12 – MIC4452BM



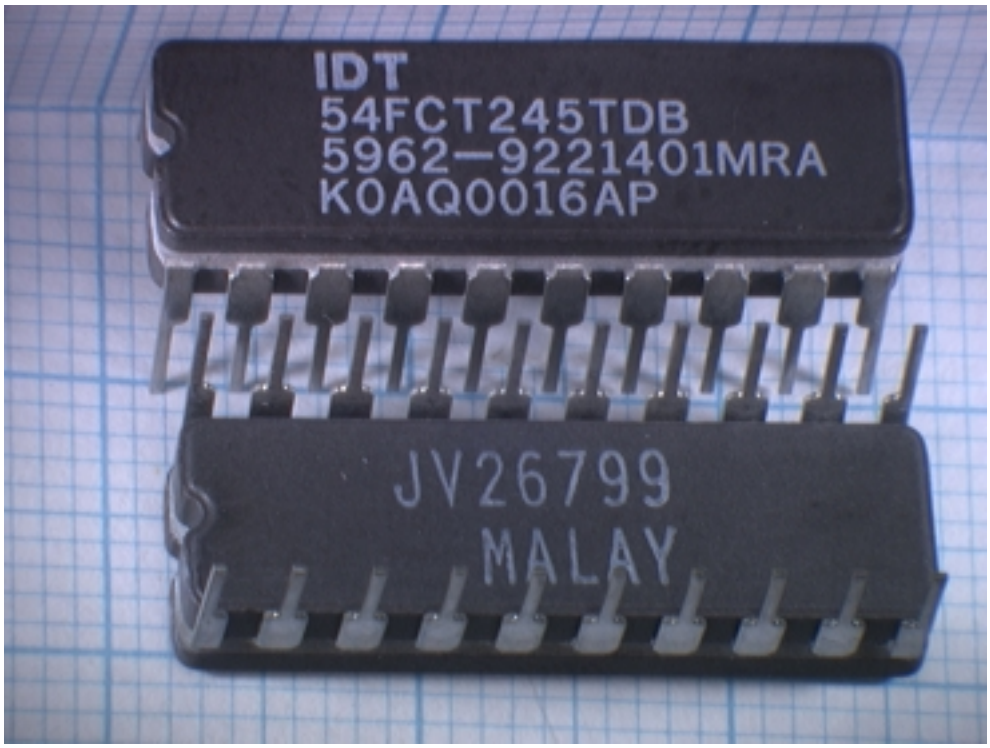


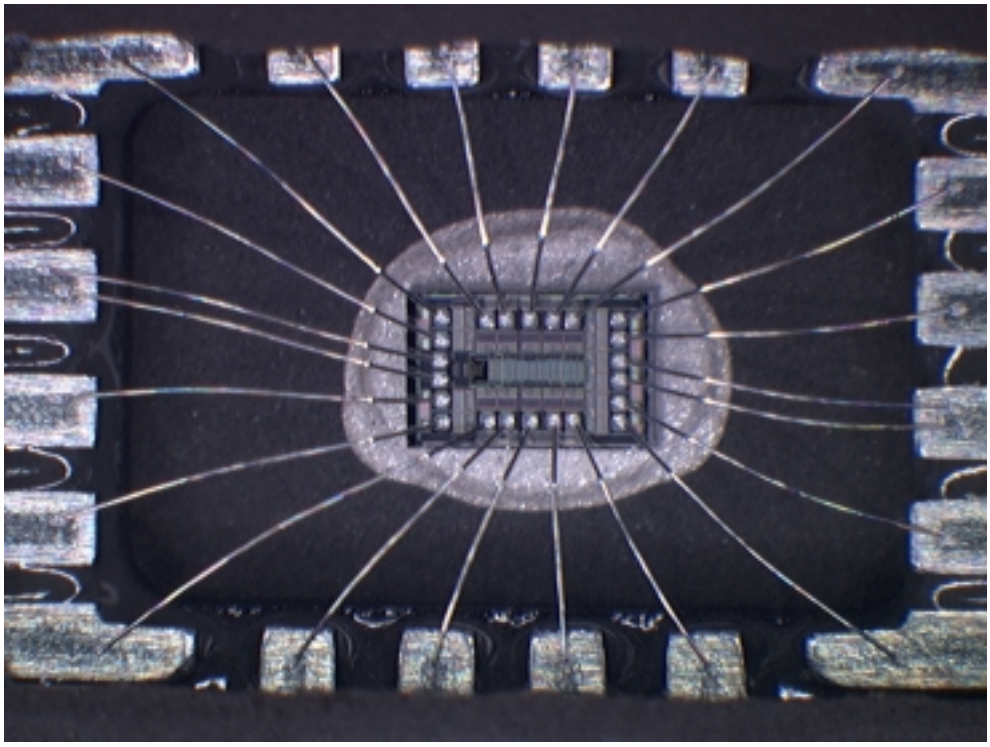
Item No. 13 – 5962-89734012A (54ACTQ04LMQB)



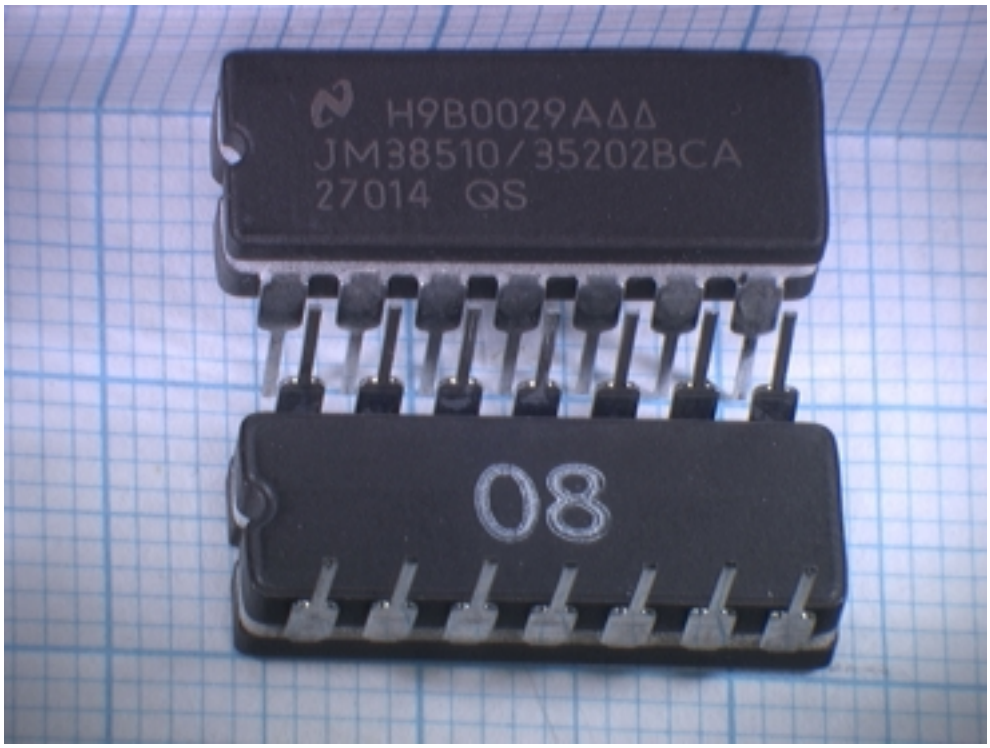


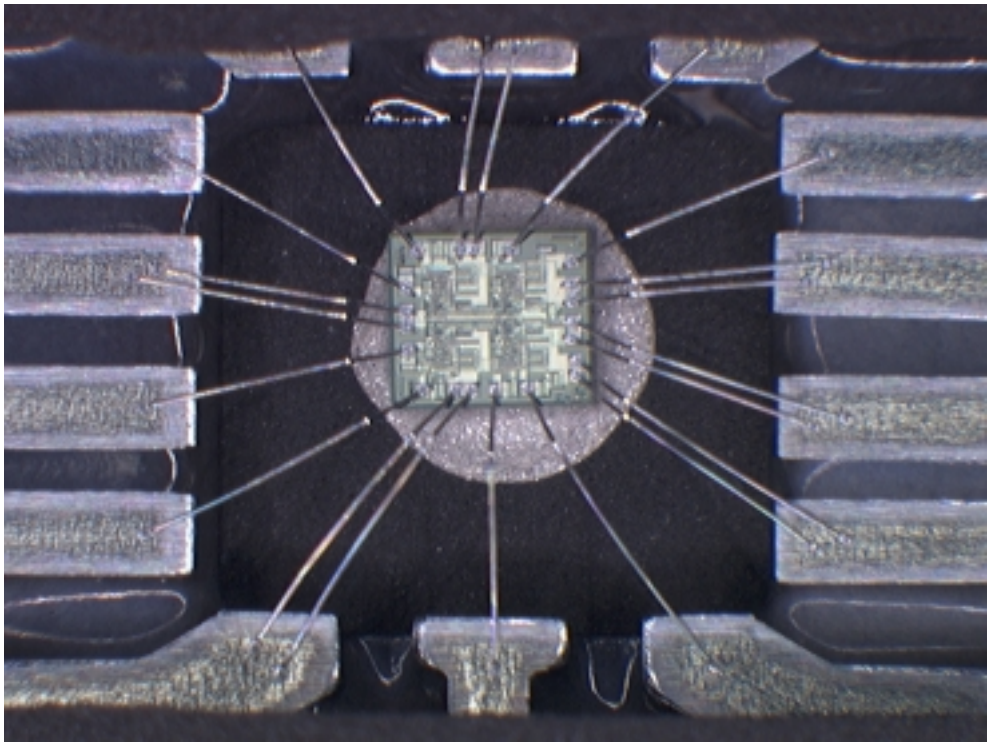
Item No. 14 – 5962-9221401MRA (54FCT245T)



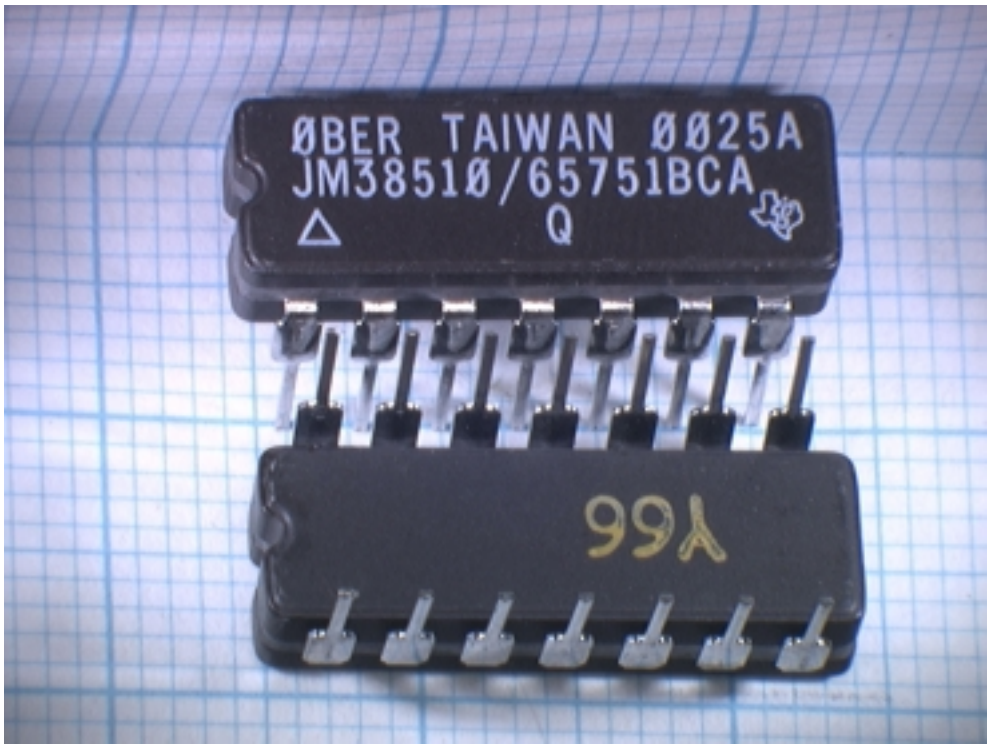


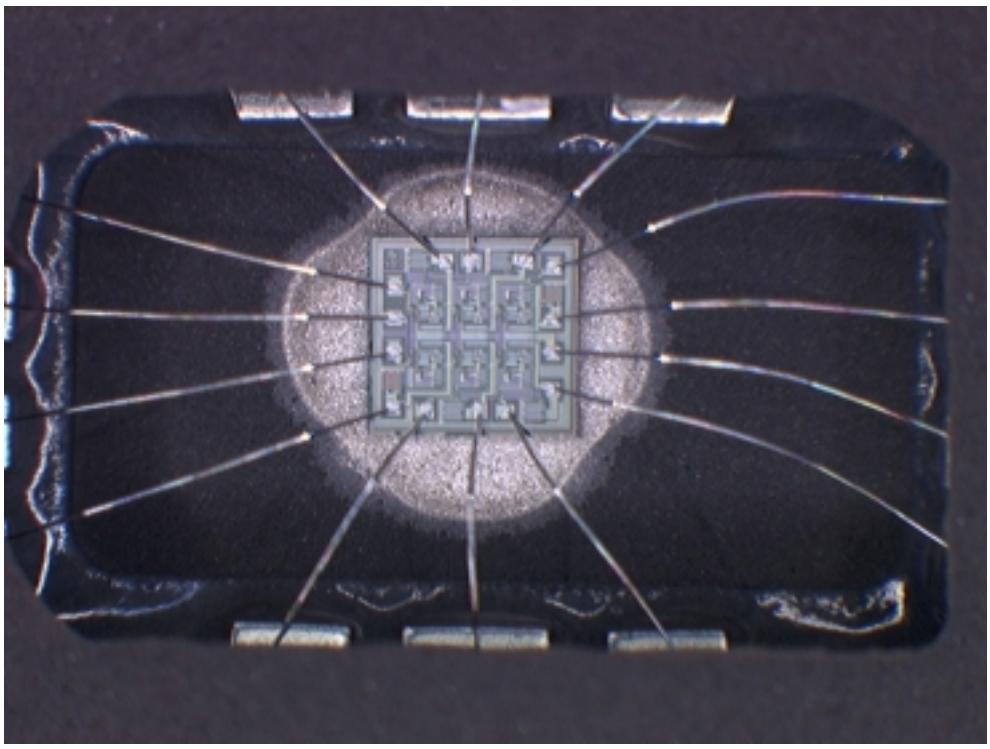
Item No. 15 – JM38510/35202BCA (JD54F38BCA)



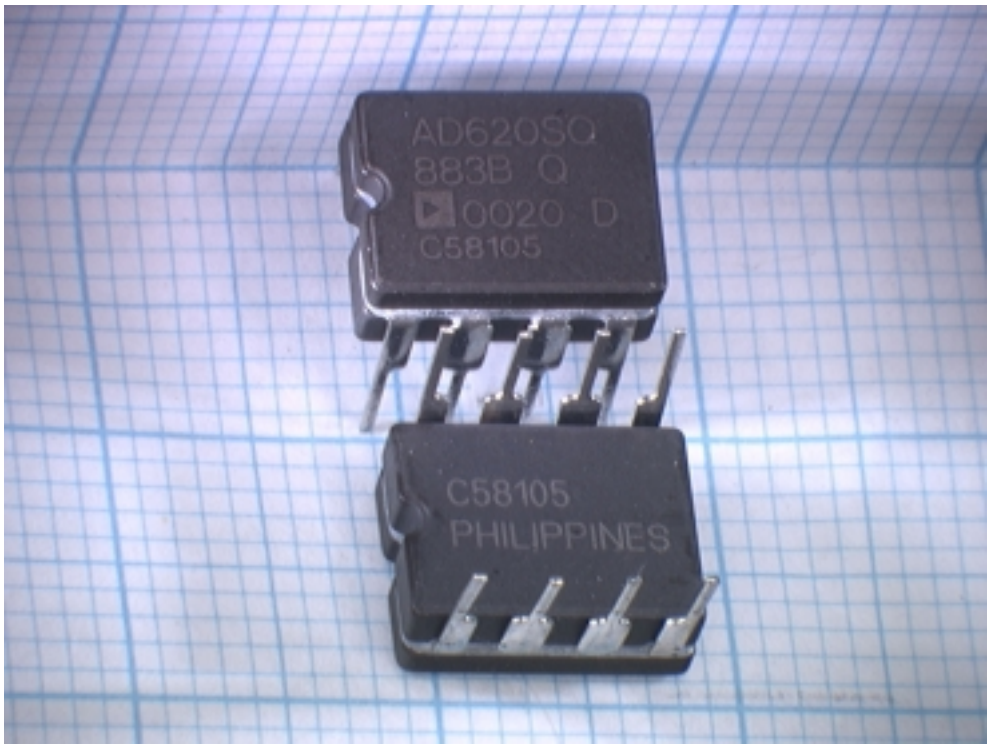


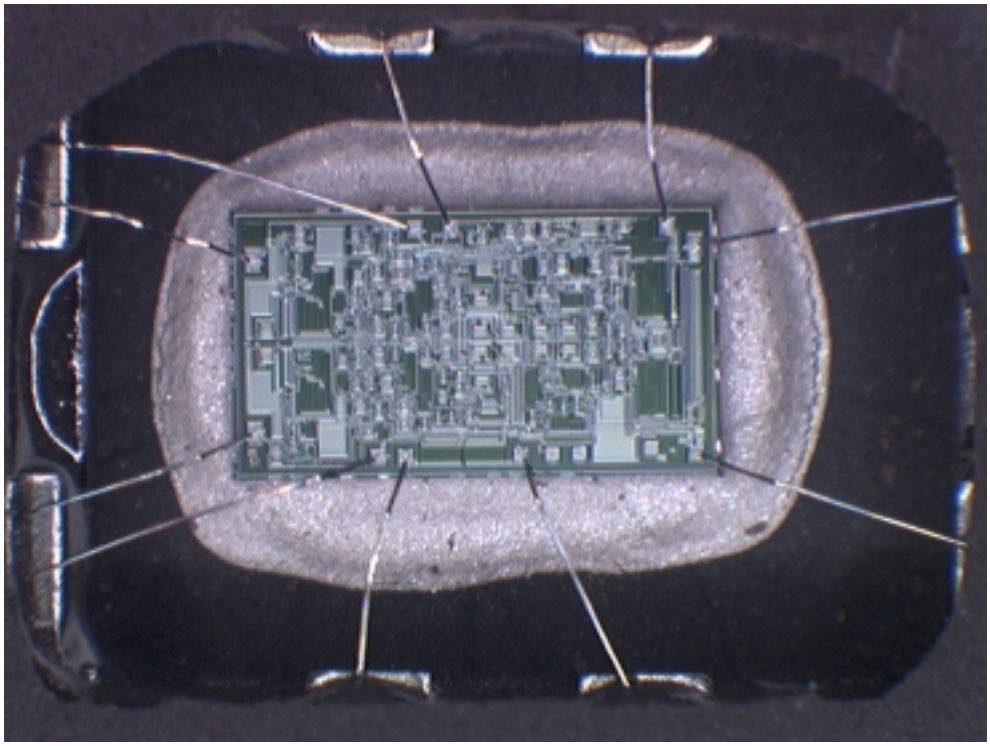
Item No. 16 – JM38510/65751BCA (54HCT04)



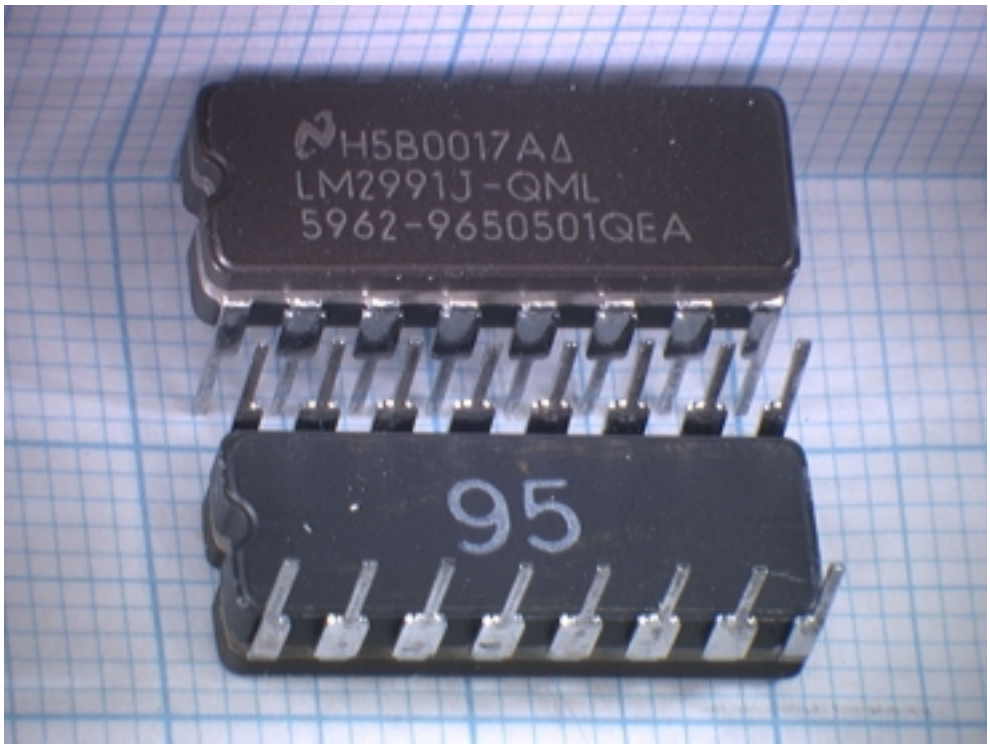


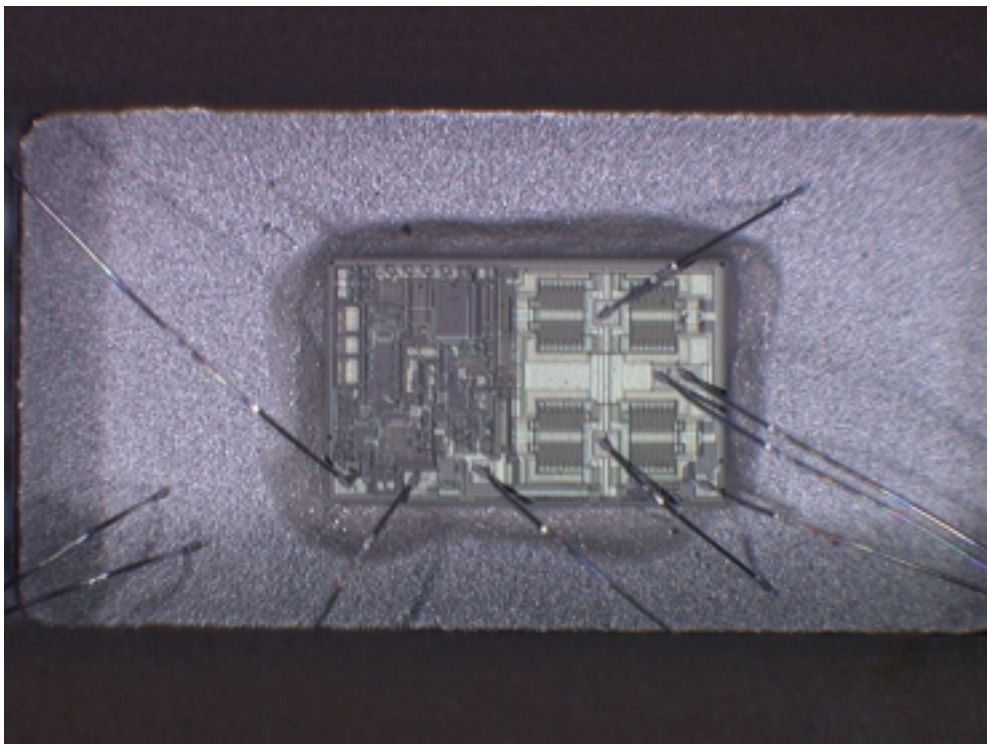
Item No. 19 – AD620SQ 883BQ



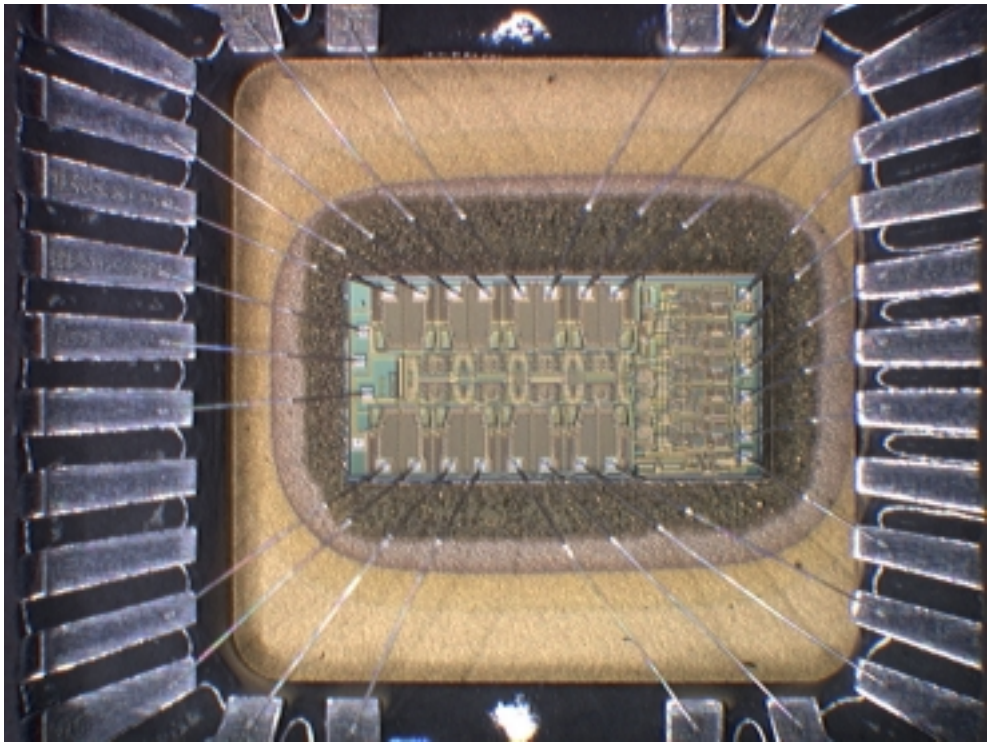


Item No. 20 – 5962-9650501QEA (LM2991J-QML)

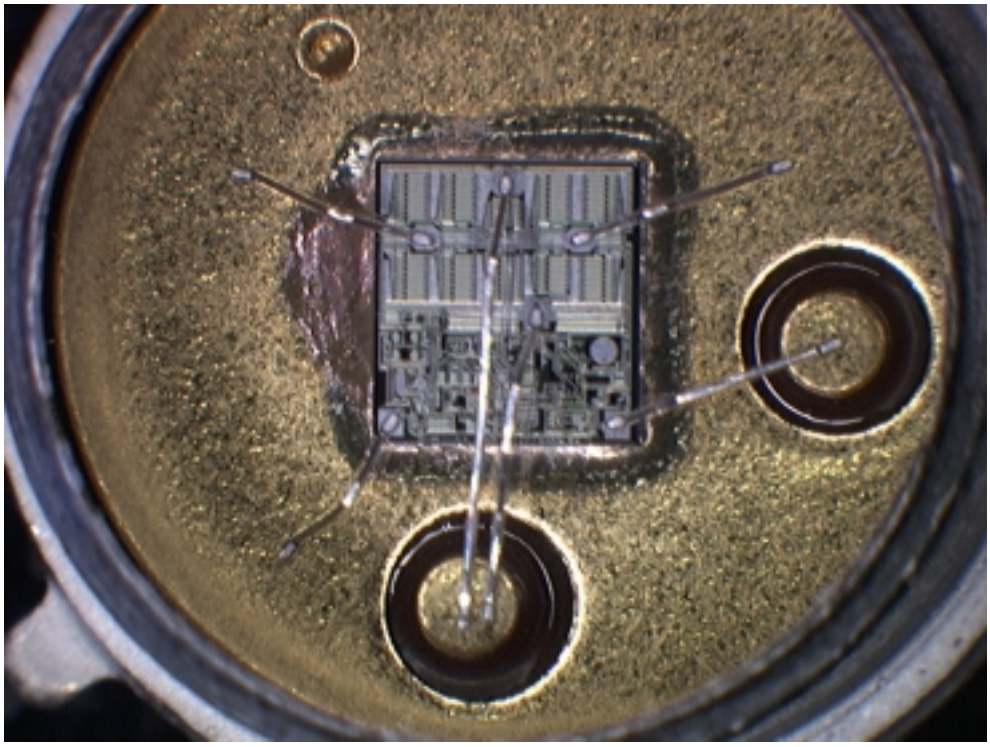




Item No. 23 – 5962-9562301QXA (DG406AK/883)



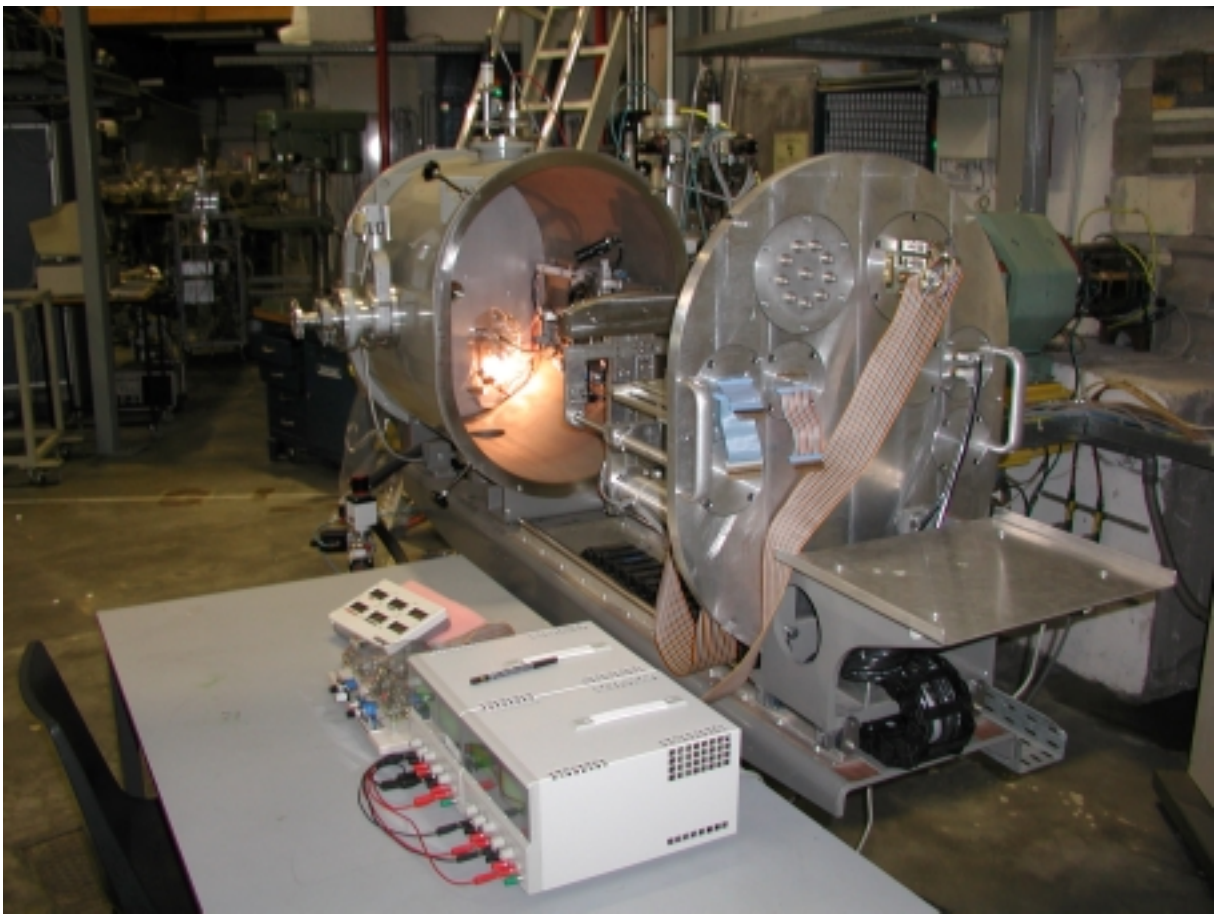
Item No. 24 – LM117/883Q



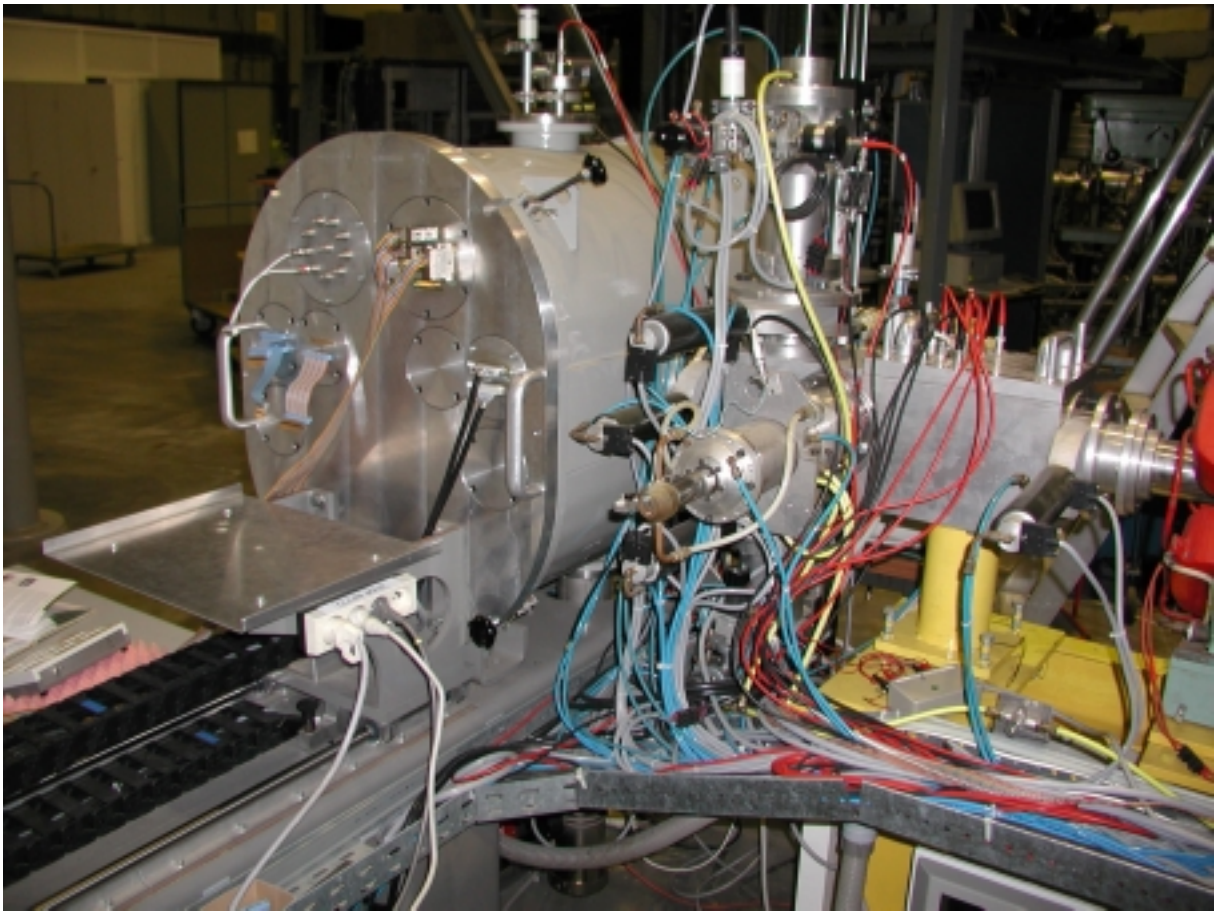
APPENDIX B – MARKING ON EACH COMPONENT

Item No.	Manufacturer	Top View	Bottom View
1	Intersil	JV2N6782 H0022GN	MALAY GV63C (x2) MALAY GV32C (x1) (info on side of package)
2	International Rectifier	CBXJANTXV2N6845 A 0031	
3	Texas Instruments	0BBS TAIWAN 0026B 5962 - 8864801EA SNJ55ALS194J Q	21S
4	Texas Instruments	7CFS - TAIWAN 0028A 5962 - 8864901EA Q SNJ55ALS195J	U33
5	Linear Technology	5962 - 8998101YA OA0016B	PHILIPPINES E09790 (info on side of package)
6	Austin Semiconductor	ASI OEU86883CQ AS5C4008F-25 9A001 USA 5962 9560003M9A (x1)	477 451
7	Analog Devices	AD822 AR 0029 I35637	
8	Analog Devices	AD9816JS 0019 508403.2 (x2) 0010 508394.1 (x1)	
10	Corning Frequency Control Inc	OFC 00136 0030J M55310/28 - B11A 20M00000	
12	Micrel	MIC 4452BM 0022	INDO 2H19 (x1) INDO 2J19 (x1) INDO 2J20 (x1)
13	National Semiconductor	H6D 0014A 54ACTQ04 LMQB /QS 5962 - 89734012A	
14	Integrated Device Technology	IDT 54FCT245TDB 5962 - 9221401MRA KOAQ0016AP	JV 26799 MALAY
15	National Semiconductor	H9B0029A JM38510 / 35202BCA 27014 QS	08
16	Texas Instruments	0BER TAIWAN 0025A JM38510 / 65751BCA	Y66
19	Analog Devices	AD620SQ 883BQ 0020D C58105	C58105 PHILIPPENES
20	National Semiconductor	H5B0017A LM2991J - QML 5962 - 9650501 QEA	
23	Siliconix	5962 - 9562301QXA DG 406AK / 883 PHILS Q 66B 9933	
24	National Semiconductor	H8D0025A LM117H / 883Q	

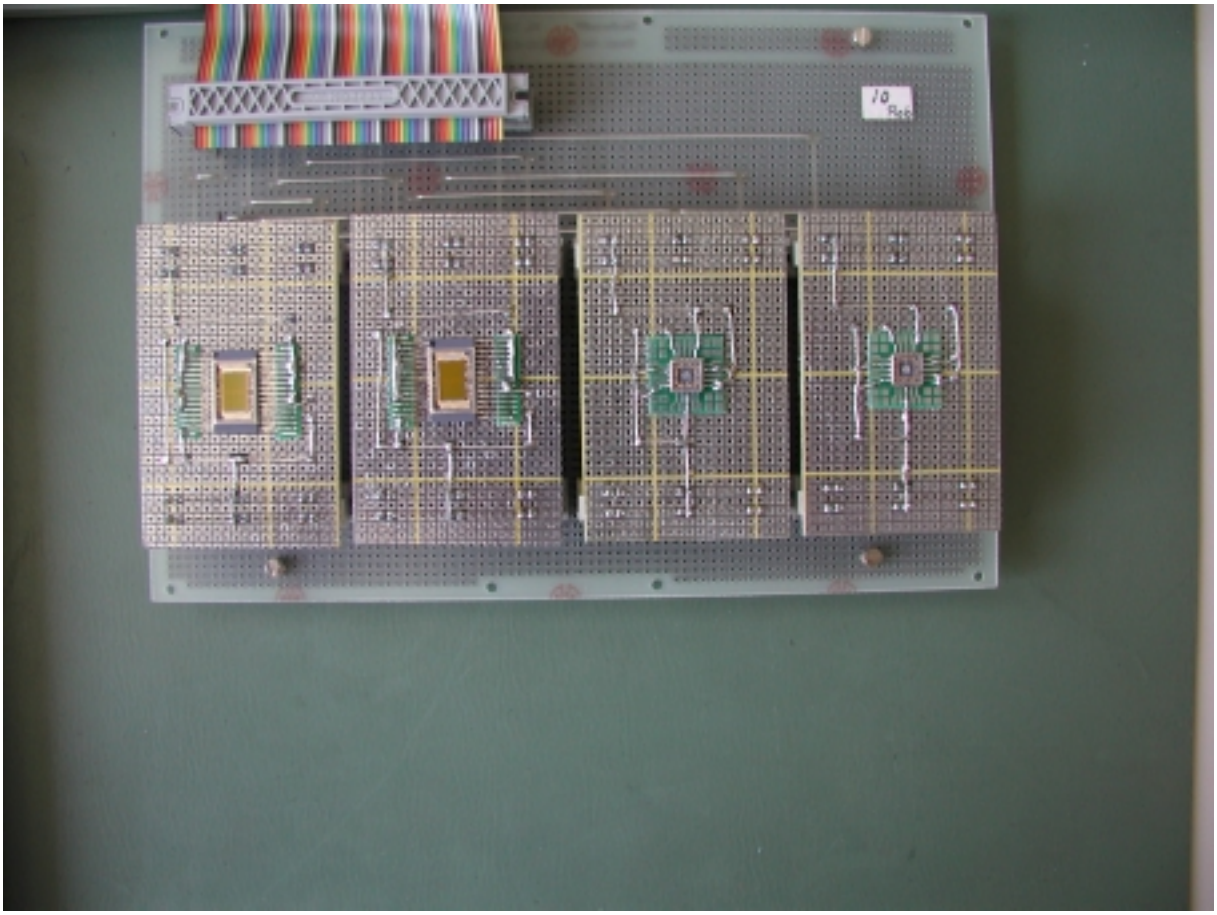
APPENDIX C – TEST HARDWARE PHOTOGRAPHS



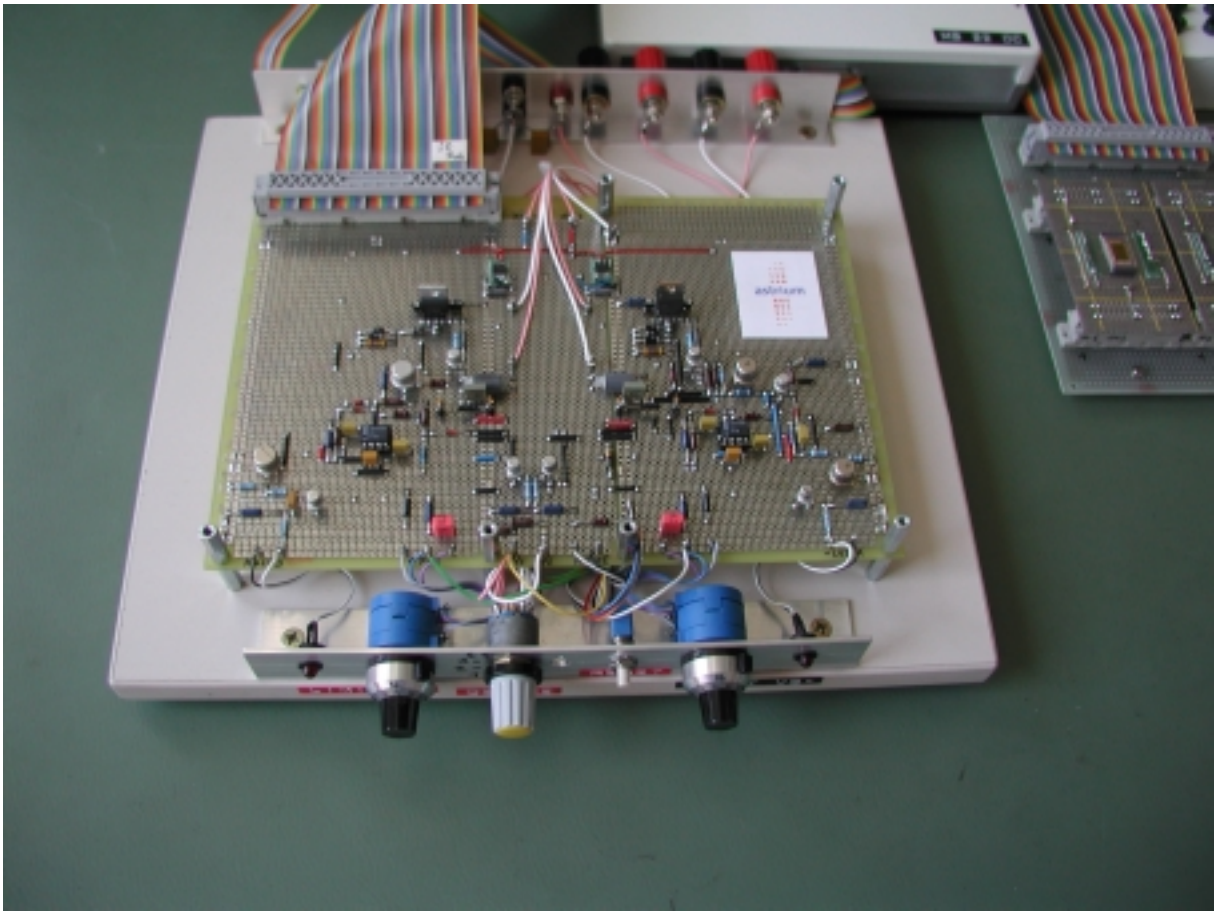
Photograph 1 – Open irradiation chamber with mother and daughter boards mounted inside open door, and biasing and monitoring circuitry on table in foreground



Photograph 2 – Closed irradiation chamber during test run showing where heavy ion beam enters chamber on the right

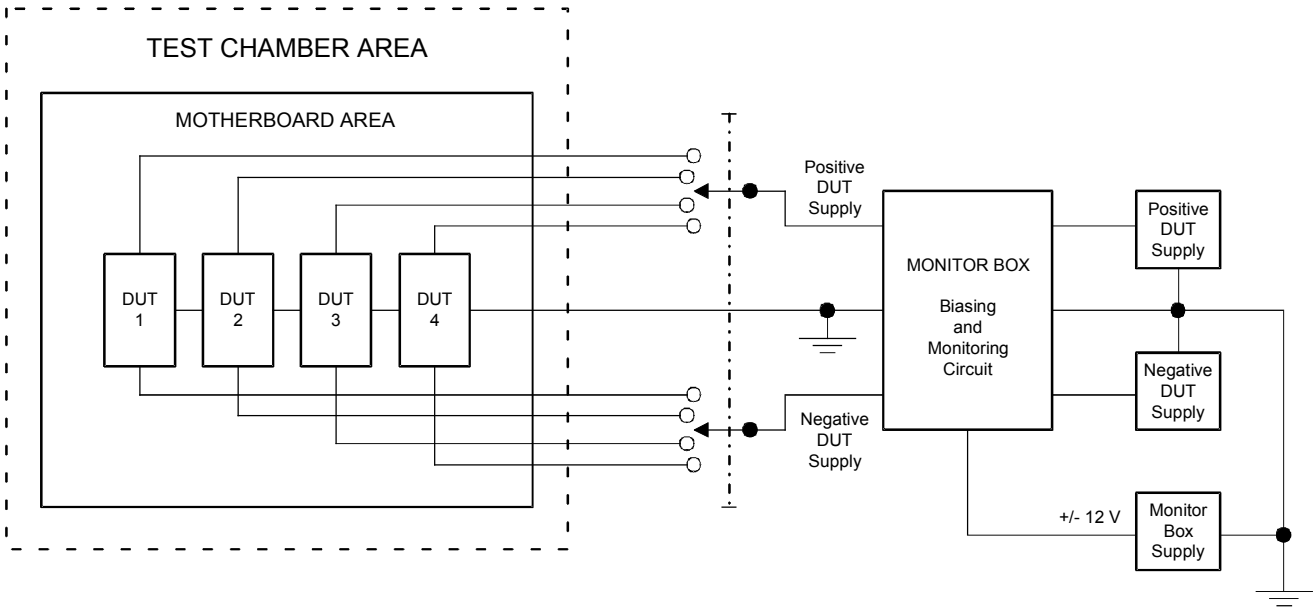


Photograph 3 – Mother board and four daughter boards with mounted components before being placed in the irradiation chamber



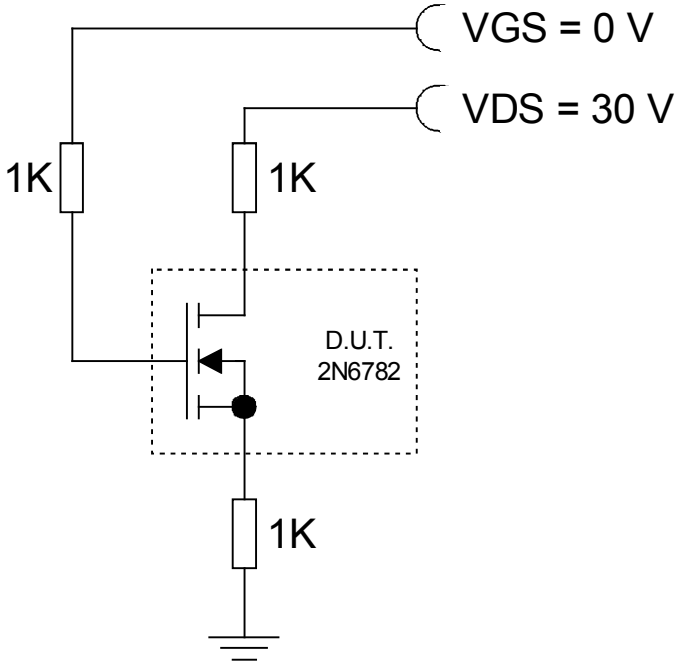
Photograph 4 – Monitoring and biasing circuit (power supplies not shown)

Appendix D – General test schematic



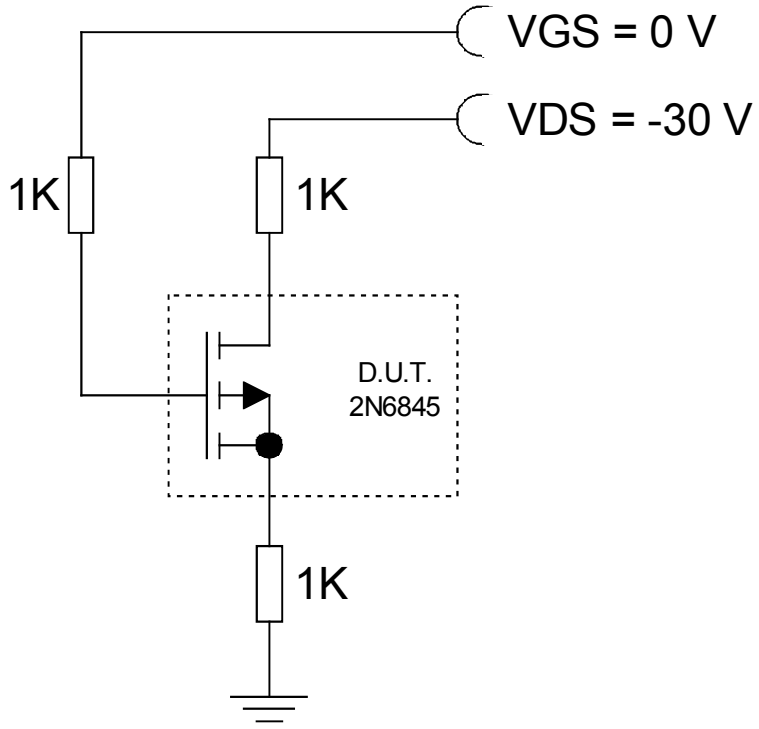
APPENDIX E – PART TYPE SPECIFIC SCHEMATICS

- Item No.: 1
- Component Type: JANTXV2N6782
- Component Package: TO-205AF
- Irradiation Bias Conditions:



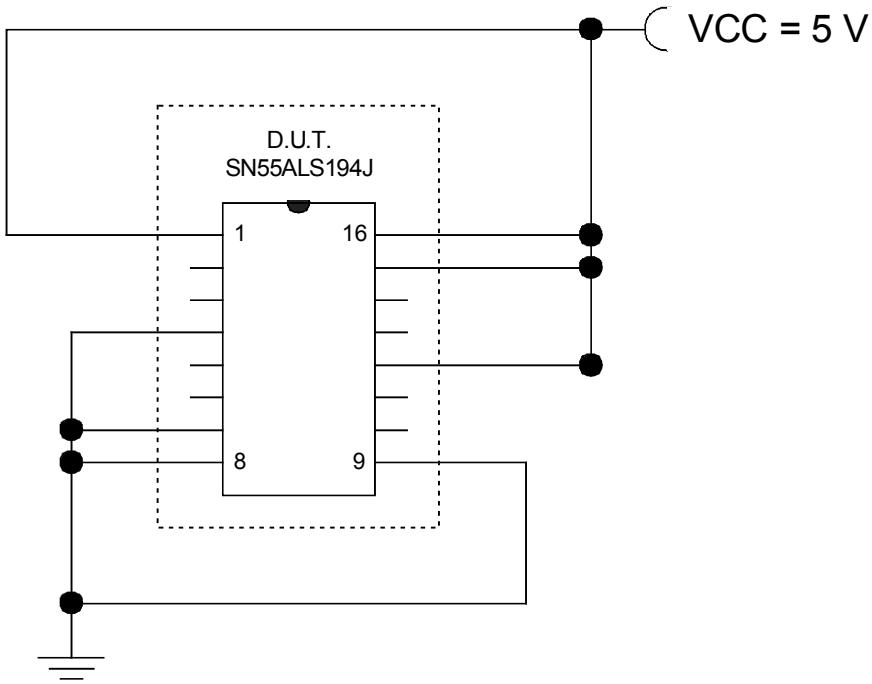
- Bias Conditions:
  VGS = 0V initially, then, as option,
  VGS = -5V for additional results using the same heavy ions
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of VDS and ID in “ON” condition

- Item No.: 2
- Component Type: JANTXV2N6845
- Component Package: TO-205AF
- Irradiation Bias Conditions:



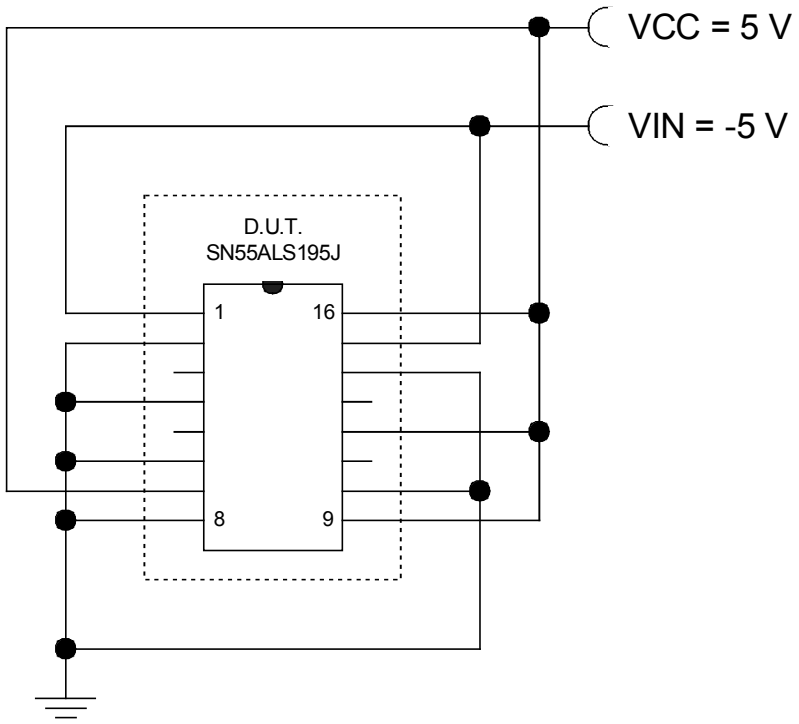
- Bias Conditions:
  VGS = 0V (but other VGS values could be considered)
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of VDS and ID in “ON” condition

- Item No.: 3
- Component Type: SNJ55ALS194J (5962-8864801EA)
- Component Package: 16-pin CERDIP
- Irradiation Bias Conditions:



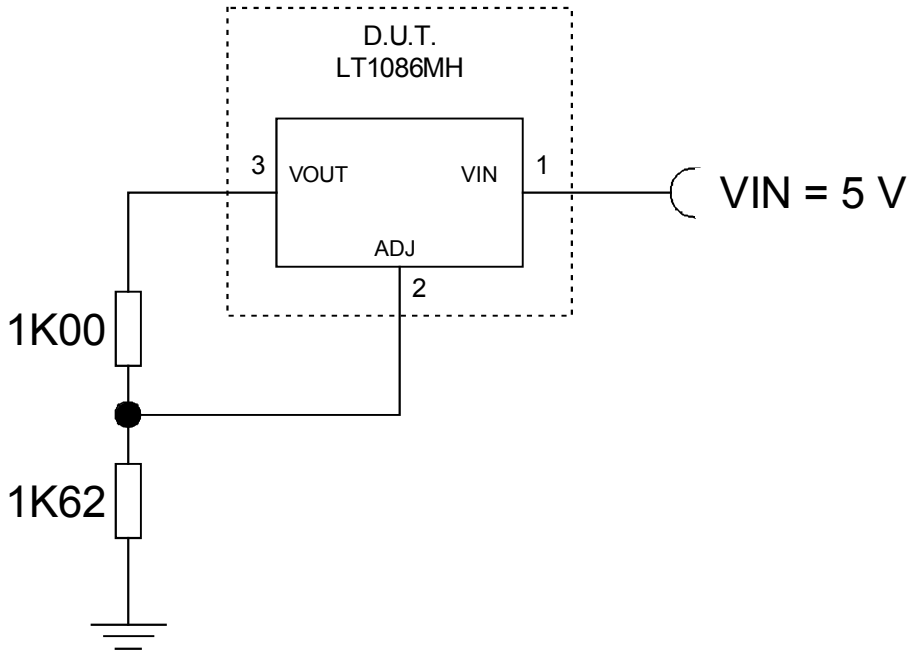
- Bias Conditions:
  One port (1,2) disabled; other port enabled (3,4);
  One input low and one input high on each driver
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000 or Credence) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of ICC

- Item No.: 4
- Component Type: SNJ55ALS195J (5962-8864901EA)
- Component Package: 16-pin CERDIP
- Irradiation Bias Conditions:



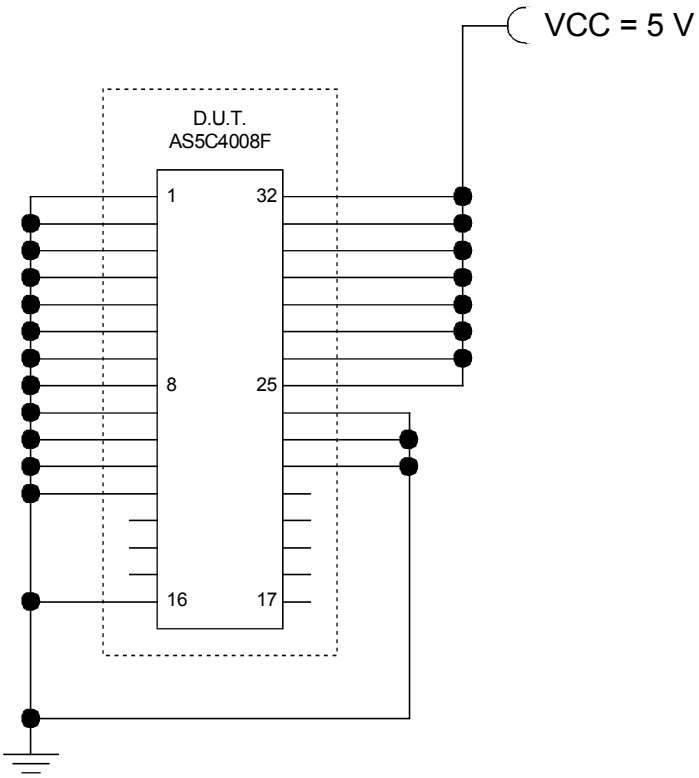
- Bias Conditions:
  One port disabled; one port enabled;
  One receiver low and one receiver high of each pair
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000 or Credence) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of current in both lines

- Item No.: 5
- Component Type: LT1086MH/883 (5962-8998101YA)
- Component Package: TO-39
- Irradiation Bias Conditions:



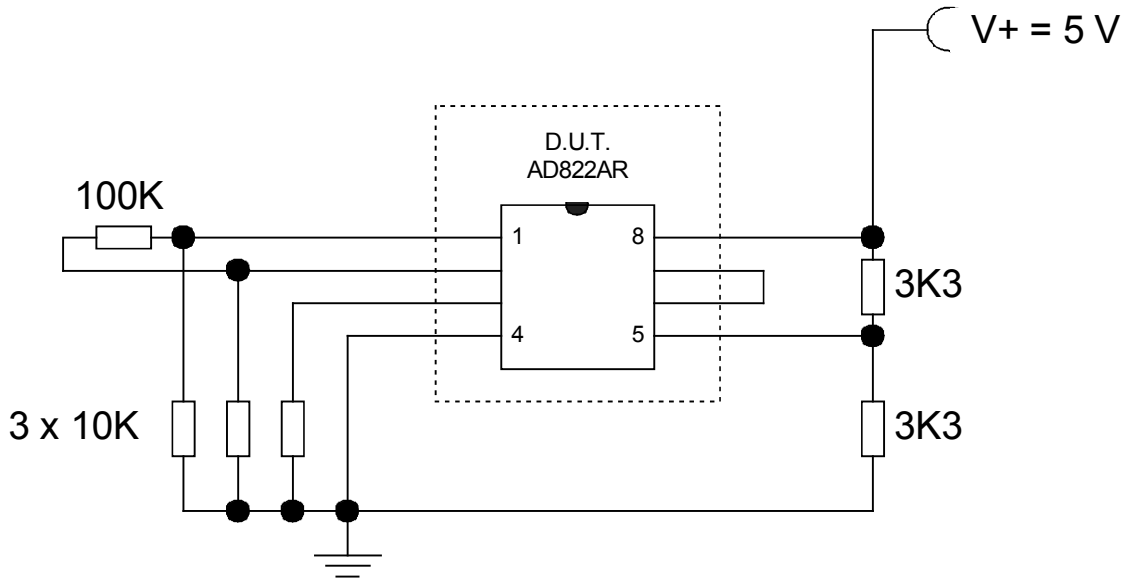
- Bias Conditions:
  Bias provides a 3.3V output voltage (application condition)
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of input current
  Measurement of output voltage

- Item No.: 6
- Component Type: AS5C4008F-25
- Component Package: 32-pin flatpack
- Irradiation Bias Conditions:



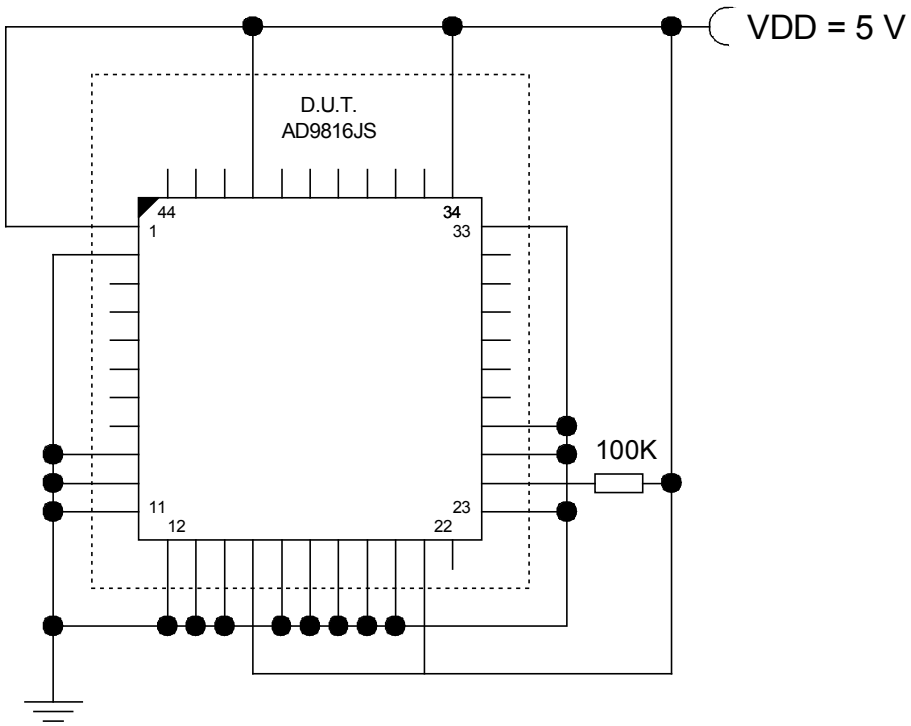
- Bias Options:
  None
- Electrical Tests Before and After Opening:
  Measurement of ICC
- Electrical Tests Before and After Irradiation:
  Measurement of ICC

- Item No.: 7
- Component Type: AD822AR
- Component Package: 8-pin SOIC
- Irradiation Bias Conditions:



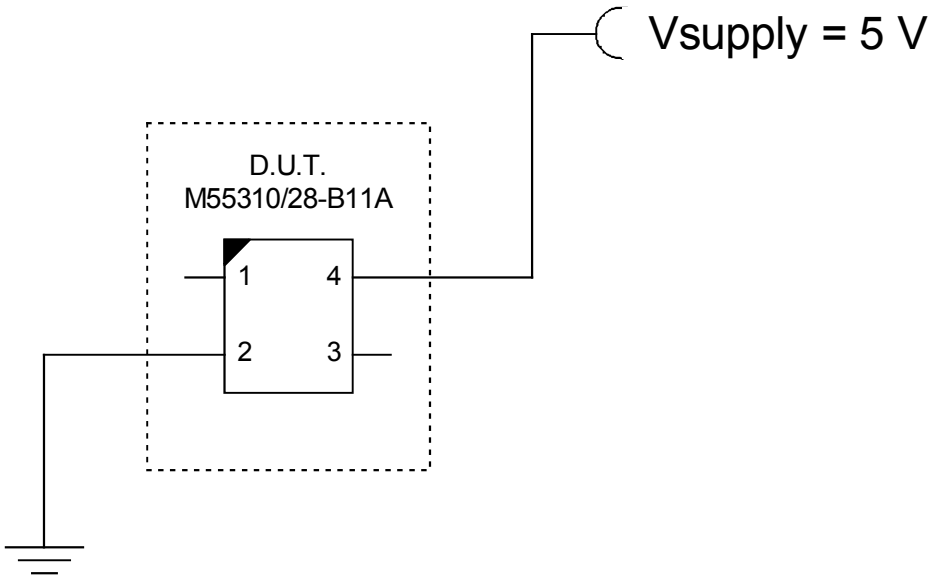
- Bias Options:
  Testing could be repeated with another supply voltage, e.g. 15V
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of supply current
  Measurement of output voltage

- Item No.: 8
- Component Type: AD9816JS
- Component Package: 44-pin MQFP
- Irradiation Bias Conditions:



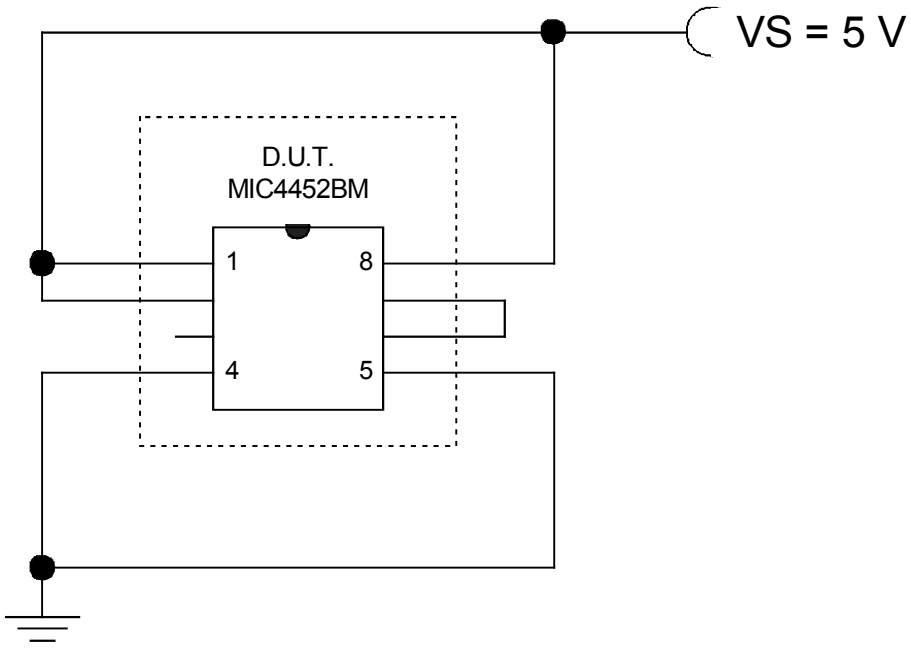
- Bias Options:
  None
- Electrical Tests Before and After Opening:
  Measurement of supply current
- Electrical Tests Before and After Irradiation:
  Measurement of supply current

- Item No.: 10
- Component Type: M55310/28-B11A 20000000
- Component Package: 4-pin SMT
- Irradiation Bias Conditions:



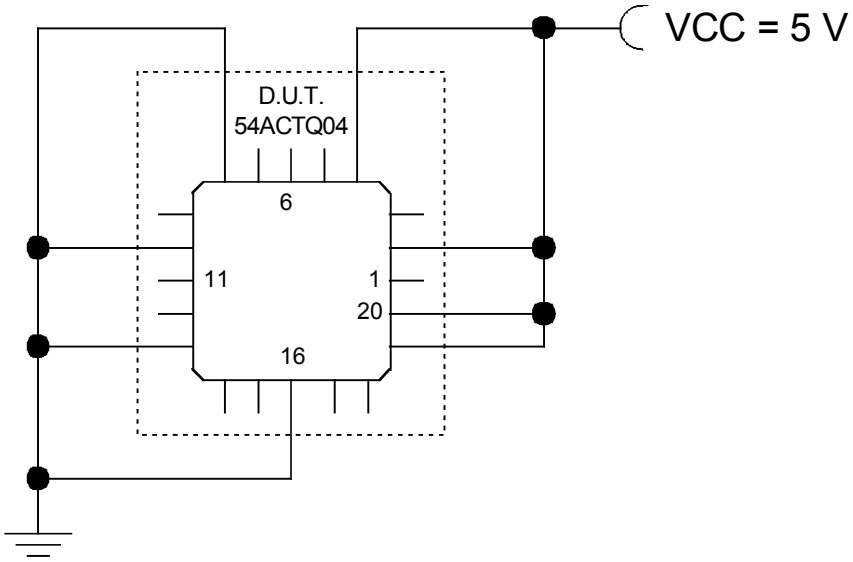
- Bias Options:
  None
- Electrical Tests Before and After Opening:
  Measurement of supply current
  Measurement of frequency
- Electrical Tests Before and After Irradiation:
  Measurement of supply current
  Measurement of frequency

- Item No.: 12
- Component Type: MIC 4452BM
- Component Package: 8-pin SOIC
- Irradiation Bias Conditions:



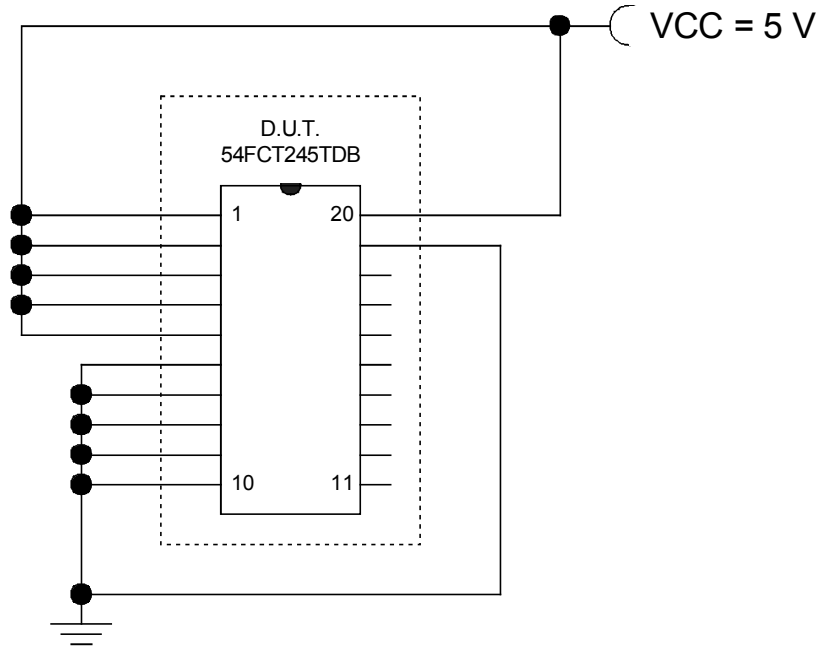
- Bias Options:
  Testing could be repeated with another supply voltage, e.g. 15V
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of supply current
  Measurement of output voltages

- Item No.: 13
- Component Type: 54ACTQ04LMQB
- Component Package: 20-pin CLCC
- Irradiation Bias Conditions:



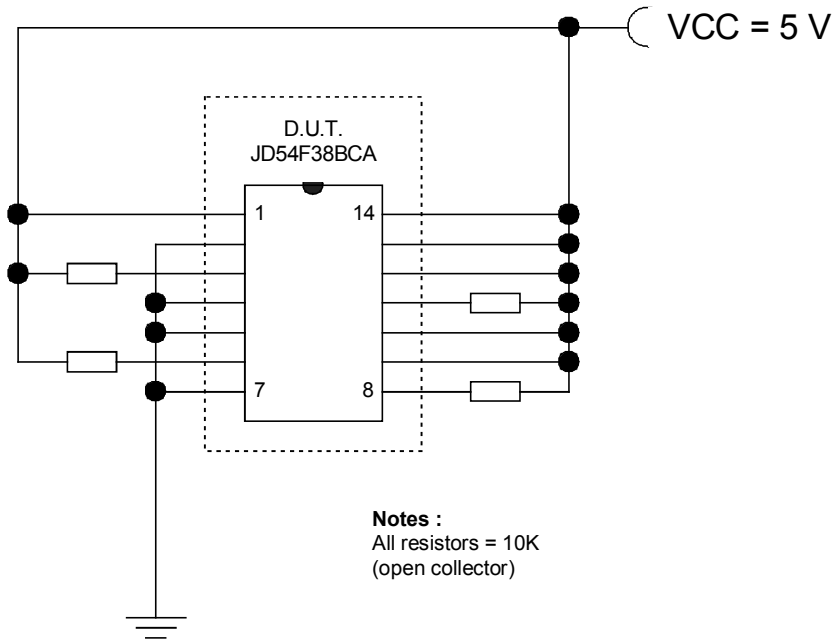
- Bias Conditions:
  3 inverters “LOW”; 3 inverters “HIGH” during irradiation
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of supply currents
  Measurement of output voltages

- Item No.: 14
- Component Type: 54FCT245T (5962-9221401MRA)
- Component Package: 20-pin CERDIP
- Irradiation Bias Conditions:



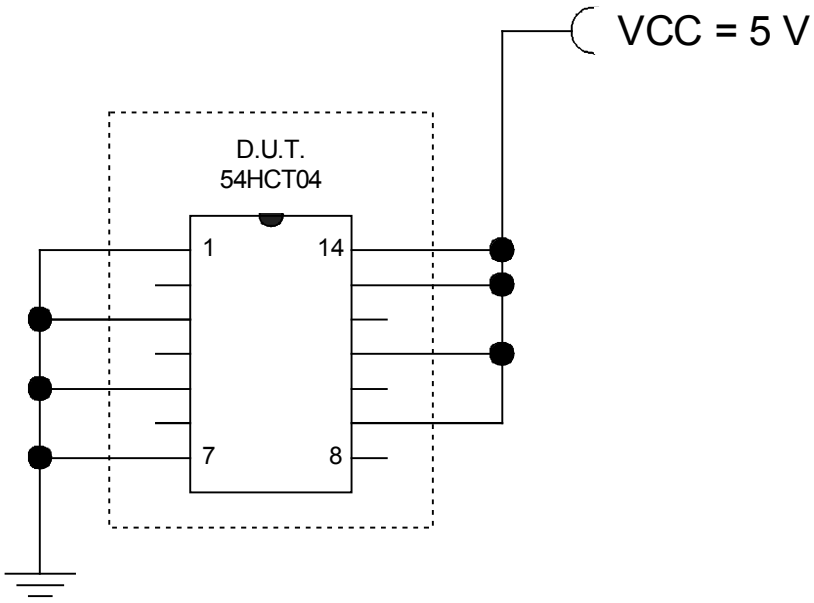
- Bias Conditions:
  Bus A data to Bus B
  Half the inputs high; remaining inputs low
  Outputs enabled
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000 or Credence) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of supply current
  Measurement of output voltages

- Item No.: 15
- Component Type: JD54F38BCA (JM38510/35202BCA)
- Component Package: 14-pin CERDIP
- Irradiation Bias Conditions:



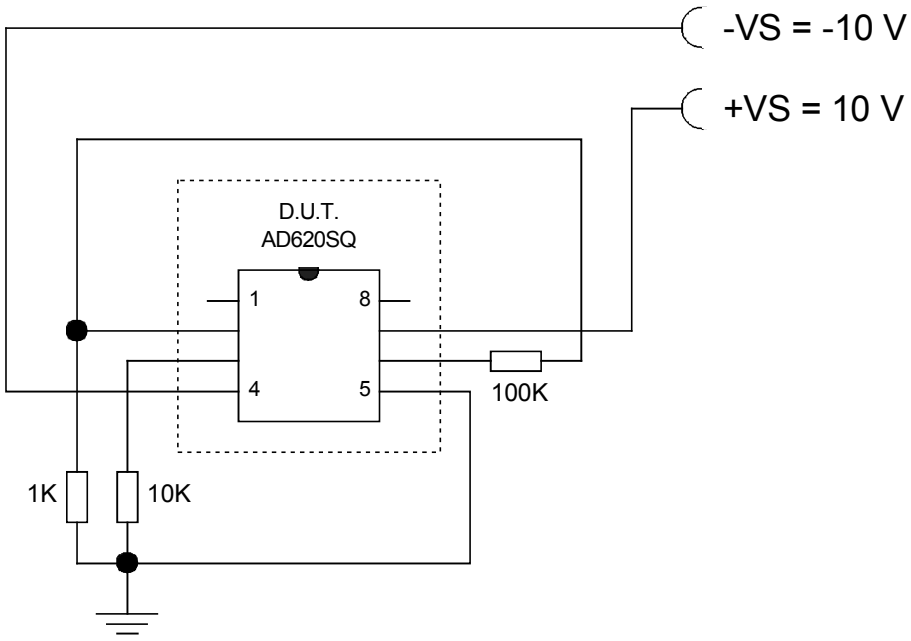
- Bias Conditions:
  2 gates with output “LOW”; 2 gates with output “HIGH” (different input conditions)
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000 or Credence) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of supply current
  Measurement of output voltages

- Item No.: 16
- Component Type: 54HCT04 (JM38510/65751BCA)
- Component Package: 14-pin CERDIP
- Irradiation Bias Conditions:



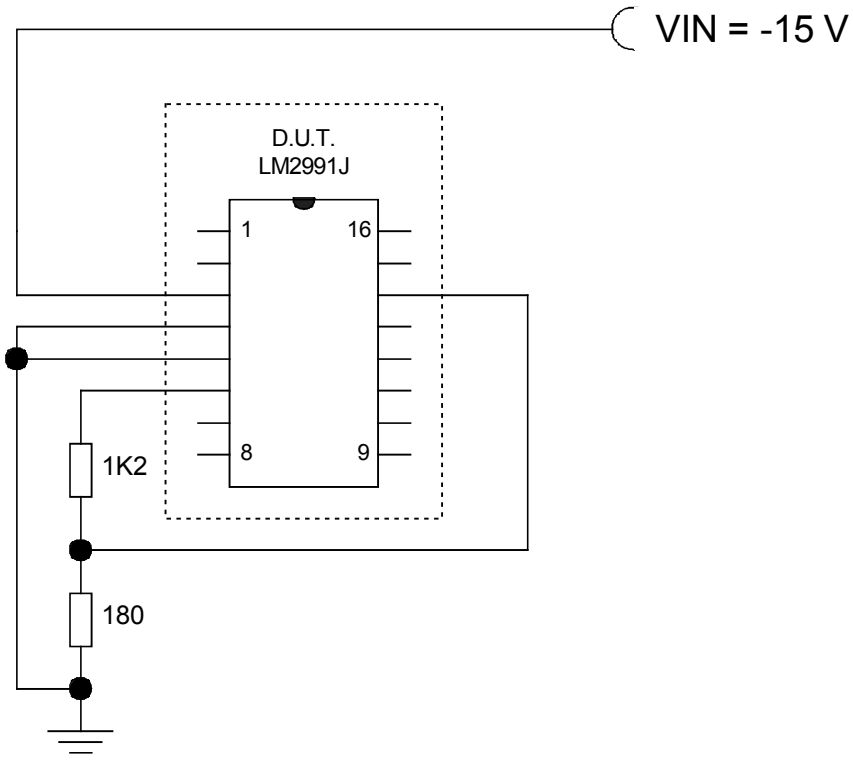
- Bias Conditions:
  Half the inverters “LOW”; remaining inverters “HIGH”
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000 or Credence) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of supply current
  Measurement of output voltages

- Item No.: 19
- Component Type: AD620SQ 883BQ
- Component Package: 8-pin CERDIP
- Irradiation Bias Conditions:



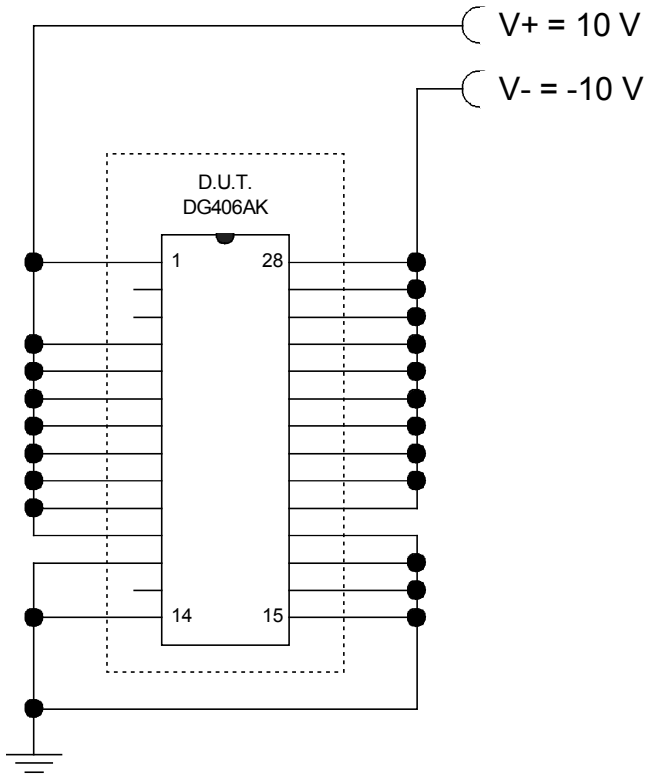
- Bias Options:
  Other supply conditions could be applied for additional results, e.g. ± 5V or ± 15V
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of supply currents
  Measurement of output voltages

- Item No.: 20
- Component Type: LM2991J-QML (5962-9650501 QEA)
- Component Package: 16-pin CERDIP
- Irradiation Bias Conditions:



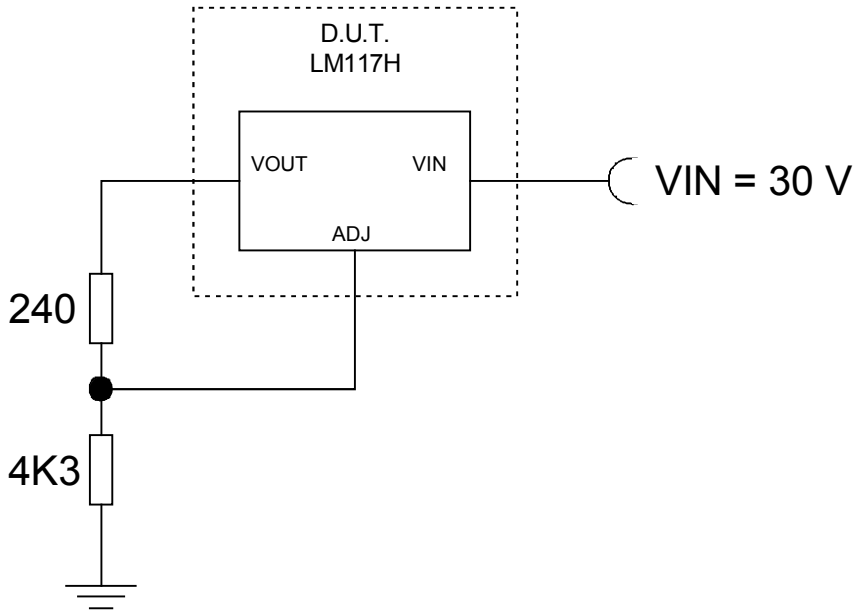
- Bias Conditions:
  Bias provides a –9.2V output voltage (application condition)
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of supply current
  Measurement of output voltages

- Item No.: 23
- Component Type: DG406AK/883 (5962-9562301QXA)
- Component Package: 28-pin CERDIP
- Irradiation Bias Conditions:



- Bias Conditions:
  None of the switches are selected but maximum voltage stress is applied over half the switches.
  Other supply conditions can be applied, e.g. ± 5V or ± 15V
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000 or Credence) using simple test program
- Electrical Tests Before and After Irradiation:
  Measurement of supply currents

- Item No.: 24
- Component Type: LM117H/883Q
- Component Package: TO-39
- Irradiation Bias Conditions:



- Bias Conditions:
  Bias provides a 23V output voltage (application condition)
- Electrical Tests Before and After Opening:
  Automated Test Equipment (SZ3000) using existing test program
- Electrical Tests Before and After Irradiation:
  Measurement of input current
  Measurement of output voltage

APPENDIX F – DETAILS OF ALL IRRADIATION TEST RUNS

PCDF SEL TEST RUN DATA												
ITEM (#)	**ITEM (S/N)**	**ION**	**TILT [°]**	**LETeff [MeV cm²/mg]**	**TEST RUN**	**TEST DATE**	**TEST START**	**Test Time (sec)**	**FLUENCE [cm²]**	**DOSE (rad)**	**SEL (P/F)**	**COMMENTS**
1	011	Kr	0	34.0	001	04/07/01	4:28	101	1000000	544	P	
1	011	Kr	45	48.1	005	04/07/01	4:40	39	200056	154	**F**	**Latch-up !! (noise?)**
1	011	Kr	45	48.1	009	04/07/01	4:55	208	1000000	770	P	2nd test at 48,1 MeV
1	011	Xe	0	55.9	103	06/07/01	23:24	129	1000000	894	P	
1	011	Xe	40	73.0	107	06/07/01	23:40	180	1000000	1168	P	
1	012	Kr	0	34.0	002	04/07/01	4:30	103	1000000	544	P	
1	012	Kr	45	48.1	006	04/07/01	4:44	218	1000000	770	P	
1	012	Xe	0	55.9	104	06/07/01	23:27	126	1000000	894	P	
1	012	Xe	40	73.0	108	06/07/01	23:44	174	1000000	1168	P	
2	021	Kr	0	34.0	003	04/07/01	4:32	125	1000000	544	P	
2	021	Kr	45	48.1	007	04/07/01	4:47	194	1000000	770	P	
2	021	Xe	0	55.9	105	06/07/01	23:32	126	1000000	894	P	
2	021	Xe	40	73.0	109	06/07/01	23:47	182	1000000	1168	P	
2	022	Kr	0	34.0	004	04/07/01	4:34	130	1000000	544	P	
2	022	Kr	45	48.1	008	04/07/01	4:52	184	1000000	770	P	
2	022	Xe	0	55.9	106	06/07/01	23:35	131	1000000	894	P	
2	022	Xe	40	73.0	110	06/07/01	23:51	161	1000000	1168	P	
3	031	Kr	0	34.0	010	04/07/01	5:27	140	1000000	544	P	
3	031	Kr	45	48.1	014	04/07/01	7:25	177	1000000	770	P	
3	031	Xe	0	55.9	111	07/07/01	0:15	162	1000000	894	P	
3	031	Xe	40	73.0	115	07/07/01	0:51	215	1000000	1168	P	
3	032	Kr	0	34.0	011	04/07/01	7:06	96	1000000	544	P	
3	032	Kr	45	48.1	015	04/07/01	7:32	185	1000000	770	P	
3	032	Xe	0	55.9	112	07/07/01	0:20	197	1000000	894	P	
3	032	Xe	40	73.0	116	07/07/01	0:56	194	1000000	1168	P	
4	041	Kr	0	34.0	012	04/07/01	7:09	106	1000000	544	P	
4	041	Kr	45	48.1	016	04/07/01	7:36	171	1000000	770	P	
4	041	Xe	0	55.9	113	07/07/01	0:42	148	1000000	894	P	
4	041	Xe	40	73.0	117	07/07/01	1:00	195	1000000	1168	P	
4	042	Kr	0	34.0	013	04/07/01	7:21	117	1000000	544	P	
4	042	Kr	45	48.1	017	04/07/01	7:40	169	1000000	770	P	
4	042	Xe	0	55.9	114	07/07/01	0:47	162	1000000	894	P	
4	042	Xe	40	73.0	118	07/07/01	1:03	199	1000000	1168	P	
5	051	Ar	0	14.1	079	05/07/01	15:30	67	1000000	226	P	
5	051	Ar	45	19.9	087	05/07/01	15:55	395	1000000	318	P	
5	051	Ar	60	28.2	089	05/07/01	16:09	329	1000000	451	P	
5	051	Kr	0	34.0	018	04/07/01	7:58	41	234742	128	**F**	**Latch-up !!!**
5	051	Kr	0	34.0	019	04/07/01	8:08	49	503393	274	**F**	**Latch-up !!!**
5	052	Ar	0	14.1	080	05/07/01	15:33	34	242277	55	**F**	**Latch-up !!!**
5	052	Ar	0	14.1	081	05/07/01	15:36	70	1000000	226	P	
5	052	Ar	45	19.9	088	05/07/01	16:02	327	1000000	318	P	
5	052	Ar	60	28.2	090	05/07/01	16:15	394	1000000	451	P	
5	052	Kr	0	34.0	020	04/07/01	8:11	4	122544	67	**F**	**Latch-up !!!**
5	052	Kr	0	34.0	021	04/07/01	8:13	92	1000000	544	P	
6	061	Kr	0	34.0	034	04/07/01	10:21	123	1000000	544	P	
6	061	Kr	45	48.1	038	04/07/01	10:36	178	1000000	770	P	
6	061	Xe	40	73.0	123	07/07/01	2:18	197	1000000	1168	P	
6	062	Kr	0	34.0	035	04/07/01	10:24	125	1000000	544	P	
6	062	Kr	45	48.1	039	04/07/01	10:40	183	1000000	770	P	
6	062	Xe	40	73.0	124	07/07/01	2:22	165	1000000	1168	P	
7	071	Kr	0	34.0	059	05/07/01	10:54	154	1000000	544	P	
7	071	Kr	45	48.1	063	05/07/01	11:09	221	1000000	770	P	
7	071	Xe	40	73.0	135	07/07/01	4:15	181	1000000	1168	P	
7	072	Kr	0	34.0	060	05/07/01	10:58	137	1000000	544	P	
7	072	Kr	45	48.1	064	05/07/01	11:14	212	1000000	770	P	
7	072	Xe	40	73.0	136	07/07/01	4:19	139	1000000	1168	P	
8	081	Ne	0	5.85	095	05/07/01	18:09	119	1000000	94	P	
8	081	Ne	50	9.10	097	05/07/01	18:16	182	1000000	146	P	
8	081	Ar	0	14.1	073	05/07/01	14:22	15	164164	37	**F**	**Latch-up !!!**
8	081	Ar	0	14.1	074	05/07/01	14:24	5	122257	28	**F**	**Latch-up !!!**
8	081	Kr	0	34.0	067	05/07/01	12:27	65	8642	5	**F**	**Latch-up !!!**
8	081	Kr	0	34.0	068	05/07/01	13:12	9	23282	13	**F**	**Latch-up !!!**
8	082	Ne	0	5.85	096	05/07/01	18:12	124	1000000	94	P	
8	082	Ne	50	9.10	098	05/07/01	18:21	174	1000000	146	P	
8	082	Ar	0	14.1	075	05/07/01	14:25	1	19326	4	**F**	**Latch-up !!!**
8	082	Kr	0	34.0	069	05/07/01	13:14	5	14160	8	**F**	**Latch-up !!!**

10	101	Kr	0	34.0	026	04/07/01	9:23	261	1000000	544	P	
10	101	Kr	45	48.1	030	04/07/01	9:41	161	1000000	770	P	
10	101	Xe	40	73.0	119	07/07/01	1:42	182	1000000	1168	P	
10	102	Kr	0	34.0	027	04/07/01	9:30	125	1000000	544	P	
10	102	Kr	45	48.1	031	04/07/01	9:45	161	1000000	770	P	
10	102	Xe	40	73.0	120	07/07/01	1:45	152	1000000	1168	P	
12	121	Kr	0	34.0	061	05/07/01	11:02	139	1000000	544	P	
12	121	Kr	45	48.1	065	05/07/01	11:18	219	1000000	770	P	
12	121	Xe	40	73.0	137	07/07/01	4:22	136	1000000	1168	P	
12	122	Kr	0	34.0	062	05/07/01	11:05	158	1000000	544	P	
12	122	Kr	45	48.1	066	05/07/01	11:22	239	1000000	770	P	
12	122	Xe	40	73.0	138	07/07/01	4:25	143	1000000	1168	P	
13	131	Kr	0	34.0	036	04/07/01	10:28	126	1000000	544	P	
13	131	Kr	45	48.1	040	04/07/01	10:44	185	1000000	770	P	
13	131	Xe	40	73.0	125	07/07/01	2:27	178	1000000	1168	P	
13	132	Kr	0	34.0	037	04/07/01	10:32	125	1000000	544	P	
13	132	Kr	45	48.1	041	04/07/01	10:49	189	1000000	770	P	
13	132	Xe	40	73.0	126	07/07/01	2:30	199	1000000	1168	P	
14	141	Kr	0	34.0	042	04/07/01	11:15	50	440497	240	**F**	**Latch-up !! (noise?)**
14	141	Kr	0	34.0	044	04/07/01	11:25	102	1000000	544	P	2nd test at 34 MeV
14	141	Kr	45	48.1	047	04/07/01	11:35	151	1000000	770	P	
14	141	Xe	40	73.0	127	07/07/01	3:12	199	1000000	1168	P	
14	142	Kr	0	34.0	043	04/07/01	11:22	93	1000000	544	P	
14	142	Kr	45	48.1	048	04/07/01	11:39	150	1000000	770	P	
14	142	Xe	40	73.0	128	07/07/01	3:17	138	1000000	1168	P	
15	151	Kr	0	34.0	045	04/07/01	11:27	103	1000000	544	P	
15	151	Kr	45	48.1	049	04/07/01	11:42	153	1000000	770	P	
15	151	Xe	40	73.0	129	07/07/01	3:20	144	1000000	1168	P	
15	152	Kr	0	34.0	046	04/07/01	11:31	106	1000000	544	P	
15	152	Kr	45	48.1	050	04/07/01	11:46	157	1000000	770	P	
15	152	Xe	40	73.0	130	07/07/01	3:23	147	1000000	1168	P	
16	161	Kr	0	34.0	051	04/07/01	12:15	124	1000000	544	P	
16	161	Kr	45	48.1	055	04/07/01	12:29	200	1000000	770	P	
16	161	Xe	40	73.0	131	07/07/01	3:40	180	1000000	1168	P	
16	162	Kr	0	34.0	052	04/07/01	12:19	129	1000000	544	P	
16	162	Kr	45	48.1	056	04/07/01	12:33	209	1000000	770	P	
16	162	Xe	40	73.0	132	07/07/01	3:45	176	1000000	1168	P	
19	191	Kr	0	34.0	028	04/07/01	9:34	120	1000000	544	P	
19	191	Kr	45	48.1	032	04/07/01	9:48	164	1000000	770	P	
19	191	Xe	40	73.0	121	07/07/01	1:49	157	1000000	1168	P	
19	192	Kr	0	34.0	029	04/07/01	9:37	118	1000000	544	P	
19	192	Kr	45	48.1	033	04/07/01	9:52	165	1000000	770	P	
19	192	Xe	40	73.0	122	07/07/01	1:53	180	1000000	1168	P	
20	201	Ne	0	5.85	099	05/07/01	18:25	5	59787	6	**F**	**Latch-up !!!**
20	201	Ne	0	5.85	100	05/07/01	18:29	2	106708	10	**F**	**Latch-up !!!**
20	201	Ar	0	14.1	076	05/07/01	14:27	2	23637	5	**F**	**Latch-up !!!**
20	201	Ar	0	14.1	077	05/07/01	14:28	2	17052	4	**F**	**Latch-up !!!**
20	201	Kr	0	34.0	070	05/07/01	13:15	3	7502	4	**F**	**Latch-up !!!**
20	201	Kr	0	34.0	071	05/07/01	13:17	1	16252	9	**F**	**Latch-up !!!**
20	202	Ne	0	5.85	101	05/07/01	18:33	30	393411	37	**F**	**Latch-up !!!**
20	202	Ne	0	5.85	102	05/07/01	18:35	2	33319	3	**F**	**Latch-up !!!**
20	202	Ar	0	14.1	078	05/07/01	14:40	3	20283	5	**F**	**Latch-up !!!**
20	202	Kr	0	34.0	072	05/07/01	13:19	2	4770	3	**F**	**Latch-up !!!**
23	231	Kr	0	34.0	053	04/07/01	12:22	136	1000000	544	P	
23	231	Kr	45	48.1	057	04/07/01	12:38	207	1000000	770	P	
23	231	Xe	40	73.0	133	07/07/01	3:53	166	1000000	1168	P	
23	232	Kr	0	34.0	054	04/07/01	12:25	148	1000000	544	P	
23	232	Kr	45	48.1	058	04/07/01	12:42	203	1000000	770	P	
23	232	Xe	40	73.0	134	07/07/01	3:56	190	1000000	1168	P	
24	241	Ne	0	5.85	091	05/07/01	17:16	141	1000000	94	P	
24	241	Ne	50	9.10	093	05/07/01	17:24	204	1000000	146	P	
24	241	Ar	0	14.1	082	05/07/01	15:40	3	43043	10	**F**	**Latch-up !!!**
24	241	Ar	0	14.1	083	05/07/01	15:43	1	124955	28	**F**	**Latch-up !!!**
24	241	Ar	0	14.1	084	05/07/01	15:47	11	72923	16	**F**	**Latch-up !!!**
24	241	Kr	0	34.0	022	04/07/01	8:16	6	164571	90	**F**	**Latch-up !!!**
24	241	Kr	0	34.0	023	04/07/01	8:18	2	33186	18	**F**	**Latch-up !!!**
24	242	Ne	0	5.85	092	05/07/01	17:19	139	1000000	94	P	
24	242	Ne	50	9.10	094	05/07/01	17:28	192	1000000	146	P	
24	242	Ar	0	14.1	085	05/07/01	15:50	13	8120	2	**F**	**Latch-up !!!**
24	242	Ar	0	14.1	086	05/07/01	15:51	10	17015	4	**F**	**Latch-up !!!**
24	242	Kr	0	34.0	024	04/07/01	8:21	2	65972	36	**F**	**Latch-up !!!**
24	242	Kr	0	34.0	025	04/07/01	8:26	1	12453	7	**F**	**Latch-up !!!**

APPENDIX G – INDIVIDUAL TEST SHEETS FOR EACH ITEM NUMBER

Note that for all component types S/N XX3 is the unopened control

PCDF SEL TEST RECORD FOR ITEM 1
(JANTXV 2N6782)

TEST DETAILS		S/N: 011		S/N: 012		S/N: 013		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	VDS (V)	ID (A)	VDS (V)	ID (A)	VDS (V)	ID (A)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		-	-	-	-	-	-	A	Y	Tested on SZ, results OK
Test **after** opening		-	-	-	-	-	-	A	Y	Tested on SZ, results OK
Test **before** irradiation		-	< 0,0 uA	-	< 0,0 uA	-	< 0,0 uA	A	N	
001	34.0									S/N 011 tested, no latch-up
002	34.0									S/N 012 tested, no latch-up
005	48.1									S/N 011 tested, **latch-up !!**
006	48.1									S/N 012 tested, no latch-up
009	48.1									S/N 011 tested, no latch-up
103	55.9									S/N 011 tested, no latch-up
104	55.9									S/N 012 tested, no latch-up
107	73.0									S/N 011 tested, no latch-up
108	73.0									S/N 012 tested, no latch-up

Additional Comments :

Bias condition A : Test Board #01; VDS = 30V, VGS = 0V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 2
(JANTXV 2N6845)

TEST DETAILS		S/N: 021		S/N: 022		S/N: 023		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	VDS (V)	ID (A)	VDS (V)	ID (A)	VDS (V)	ID (A)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		-	-	-	-	-	-	A	Y	Tested on SZ, results OK
Test **after** opening		-	-	-	-	-	-	A	Y	Tested on SZ, results OK
Test **before** irradiation		-	< 0,0 uA	-	< 0,0 uA	-	< 0,0 uA	A	N	
003	34.0									S/N 021 tested, no latch-up
004	34.0									S/N 022 tested, no latch-up
007	48.1									S/N 021 tested, no latch-up
008	48.1									S/N 022 tested, no latch-up
105	55.9									S/N 021 tested, no latch-up
106	55.9									S/N 022 tested, no latch-up
109	73.0									S/N 021 tested, no latch-up
110	73.0									S/N 022 tested, no latch-up

Additional Comments :

Bias condition A : Test Board #02; VDS = -30V, VGS = 0V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 3
(SNJ55ALS194J)

TEST DETAILS		S/N: 031		S/N: 032		S/N: 033		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	ICC (A)		ICC (A)		ICC (A)		CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		23,24 mA		23,40 mA		23,42 mA		A	N	
Test **after** opening		24,45 mA		24,31 mA		24,35 mA		A	N	
Test **before** irradiation		24,48 mA		24,35 mA		24,31mA		A	N	
010	34.0									S/N 031 tested, no latch-up
011	34.0									S/N 032 tested, no latch-up
014	48.1									S/N 031 tested, no latch-up
015	48.1									S/N 032 tested, no latch-up
111	55.9									S/N 031 tested, no latch-up
112	55.9									S/N 032 tested, no latch-up
115	73.0									S/N 031 tested, no latch-up
116	73.0									S/N 032 tested, no latch-up

Additional Comments : Output pins 11 and 14 shall be high (>2,5V), output pins 10 and 13 shall be low (<0,5V).

Bias condition A : Test Board #03; VCC = 5V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 4
(SNJ55ALS195J)

TEST DETAILS		S/N: 041		S/N: 042		S/N: 043		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	ICC (A)	IIN (A)	ICC (A)	IIN (A)	N	IIN (A)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		28,25 mA	-0,70 mA	28,14 mA	-0,70 mA	27,98 mA	-0,70 mA	A	N	
Test **after** opening		28,95 mA	-0,71 mA	28,97 mA	-0,71 mA	28,83 mA	-0,71 mA	A	N	
Test **before** irradiation		28,45 mA	-0,71 mA	28,65 mA	-0,71 mA	28,79 mA	-0,71 mA	A	N	
012	34.0									S/N 041 tested, no latch-up
013	34.0									S/N 042 tested, no latch-up
016	48.1									S/N 041 tested, no latch-up
017	48.1									S/N 042 tested, no latch-up
113	55.9									S/N 041 tested, no latch-up
114	55.9									S/N 042 tested, no latch-up
117	73.0									S/N 041 tested, no latch-up
118	73.0									S/N 042 tested, no latch-up

Additional Comments : Output pin 11 shall be low (<0,45V), output pin 13 shall be high (>2,5V).

Bias condition A : Test Board #04; VCC = 5V, VIN = -5V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 5
(LT1086MH/883)

TEST DETAILS		S/N: 051		S/N: 052		S/N: 053		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	VOUT (V)	IIN (A)	VOUT (V)	IIN (A)	VOUT (V)	IIN (A)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		3,354 V	4,67 mA	3,357 V	4,67 mA	3,354 V	4,66 mA	A	N	Add. hand-measurements performed
Test **after** opening		3,356 V	4,67 mA	3,360 V	4,67 mA	3,355 V	4,67 mA	A	N	
Test **before** irradiation		3,354 V	4,67 mA	3,358 V	4,67 mA	3,354 V	4,66 mA	A	N	
079	14.1									S/N 051 tested, no latch-up
080	14.1									S/N 052 tested, **latch-up !!**
081	14.1									S/N 052 tested, no latch-up
087	19.9									S/N 051 tested, no latch-up
088	19.9									S/N 052 tested, no latch-up
089	28.2									S/N 051 tested, no latch-up
090	28.2									S/N 052 tested, no latch-up
018	34.0									S/N 051 tested, **latch-up !!**
019	34.0									S/N 051 tested, **latch-up !!**
020	34.0									S/N 052 tested, **latch-up !!**
021	34.0									S/N 052 tested, no latch-up

Additional Comments : VOUT = pin 3

Bias condition A : Test Board #05; VIN = 5V (NOTE: The bias condition provides a 3.3V output voltage)
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 6
(AS5C4008F-25)

TEST DETAILS		S/N: 061		S/N: 062		S/N: 063		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	ICC (A)		ICC (A)		ICC (A)		CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		*)		*)		**)		A	N	
Test **after** opening		85,3 mA		89,5 mA		**)		A	N	
Test **before** irradiation		83,2 mA		87,3 mA		**)		A	N	
034	34.0									S/N 061 tested, no latch-up
035	34.0									S/N 062 tested, no latch-up
038	48.1									S/N 061 tested, no latch-up
039	48.1									S/N 062 tested, no latch-up
123	73.0									S/N 061 tested, no latch-up
124	73.0									S/N 062 tested, no latch-up

Additional Comments : *) Parts not tested before opening because no test socket was available.
**) Part damaged during opening.

Bias condition A : Test Board #06; VCC = 5V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 7
(AD822AR)

TEST DETAILS		S/N: 71			S/N: 72			S/N: 73			BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	VOUT1 (V)	VOUT2 (V)	ISUP+ (A)	VOUT1 (V)	VOUT2 (V)	ISUP+ (A)	VOUT1 (V)	VOUT2 (V)	ISUP+ (A)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		5,0 mV	2,53 V	1,95 mA	4,87 mV	2,53 V	1,97 mA	4,85 mV	2,53 V	1,96 mA	A	N	
Test **after** opening		15,4 mV	2,51 V	2,35 mA	5,3 mV	2,52 V	2,44 mA	22,8 mV	2,51 V	1,95 mA	A	N	
Test **before** irradiation		5,0 mV	2,53 V	2,36 mA	5,3 mV	2,53 V	2,66 mA				A	N	
059	34.0												S/N 071 tested, no latch-up
060	34.0												S/N 072 tested, no latch-up
063	48.1												S/N 071 tested, no latch-up
064	48.1												S/N 072 tested, no latch-up
135	73.0												S/N 071 tested, no latch-up
136	73.0												S/N 072 tested, no latch-up

Additional Comments : VOUT1 = pin 1 and VOUT2 = pin 7.

Bias condition A : Test Board #07; VSUP+ = 5V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 8
(AD9816JS)

TEST DETAILS		S/N: 081		S/N: 082		S/N: 083		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	IDD (A)		IDD (A)		IDD (A)		CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		*)		*)		*)		A	N	
Test **after** opening		39,01 mA	**)	41,90 mA	**)	41,75 mA	***)	A	N	
Test **before** irradiation		39,6 mA		45,0 mA				A	N	
095	5.85									S/N 081 tested, no latch-up
096	5.85									S/N 082 tested, no latch-up
097	9.1									S/N 081 tested, no latch-up
098	9.1									S/N 082 tested, no latch-up
073	14.1									S/N 081 tested, **latch-up !!!**
074	14.1									S/N 081 tested, **latch-up !!!**
075	14.1									S/N 082 tested, **latch-up !!!**
067	34.0									S/N 081 tested, **latch-up !!!**
068	34.0									S/N 081 tested, **latch-up !!!**
069	34.0									

Additional Comments : *) Parts not tested before opening because no test socket was available.
**) Measurement stable after approx. 30 sec.
***) Measurement stable after approx. 4 min.

Bias condition A : Test Board #08; VDD = 5V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 10
(M55310/28-B11A 20000000)

TEST DETAILS		S/N: 101		S/N: 102		S/N: 103		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	ISUP (A)	FREQ. (Hz)	ISUP (A)	FREQ. (Hz)	ISUP (A)	FREQ. (Hz)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		6,07 mA	19,999,939	6,17 mA	19,999,946	6,08 mA	19,999,901	A	N	
Test **after** opening		7,49 mA	19,999,657	7,52 mA	19,999,737	7,54 mA	19,999,906	A	N	
Test **before** irradiation		7,46 mA	Functional	7,52 mA	Functional			A	N	
026	34.0									S/N 101 tested, no latch-up
027	34.0									S/N 102 tested, no latch-up
030	48.1									S/N 101 tested, no latch-up
031	48.1									S/N 102 tested, no latch-up
119	73.0									S/N 101 tested, no latch-up
120	73.0									S/N 102 tested, no latch-up

Additional Comments :

Bias condition A : Test Board #10; VSUP = 5V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 12
(MIC4452BM)

TEST DETAILS		S/N: 121		S/N: 122		S/N: 123		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	VOUT (V)	IVS (A)	VOUT (V)	IVS (A)	VOUT (V)	IVS (A)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		VS = 5,0 V	321 uA	VS = 5,0 V	275 uA	VS = 5,0 V	402 uA	A	N	
Test **after** opening		VS = 5,0 V	338 uA	VS = 5,0 V	607 uA	VS = 5,0 V	401 uA	A	N	
Test **before** irradiation		VS = 5,0 V	340 uA	VS = 5,0 V	640 uA			A	N	
061	34.0									S/N 121 tested, no latch-up
062	34.0									S/N 122 tested, no latch-up
065	48.1									S/N 121 tested, no latch-up
066	48.1									S/N 122 tested, no latch-up
137	73.0									S/N 121 tested, no latch-up
138	73.0									S/N 122 tested, no latch-up

Additional Comments : VOUT = pins 6 and 7 (connected together!)

Bias condition A : Test Board #12; VS = 5V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 13
(54ACTQ04LMQB)

TEST DETAILS		S/N: 131		S/N: 132		S/N: 133		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	ICC (A)	VOUT (see note)	ICC (A)	VOUT (see note)	ICC (A)	VOUT (see note)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		< 0,05 uA	OK	< 0,05 uA	OK	< 0,05 uA	OK	A	N	
Test **after** opening		< 0,05 uA	OK	< 0,05 uA	OK	< 0,05 uA	OK	A	N	
Test **before** irradiation		< 0,05 uA	OK	< 0,05 uA	OK			A	N	
036	34.0									S/N 131 tested, no latch-up
037	34.0									S/N 132 tested, no latch-up
040	48.1									S/N 131 tested, no latch-up
041	48.1									S/N 132 tested, no latch-up
125	73.0									S/N 131 tested, no latch-up
126	73.0									S/N 132 tested, no latch-up

Additional Comments : NOTE: Output voltages are checked without recording (pins 9, 12, 14 = high; pins 3, 6 and 18 = low).

Bias condition A : Test Board #13; VCC = 5V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 14
(54FCT245T)

TEST DETAILS		S/N: 141		S/N: 142		S/N: 143		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	ICC (A)	VOUT (see note)	ICC (A)	VOUT (see note)	ICC (A)	VOUT (see note)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		< 0,00 uA	OK	< 0,00 uA	OK	< 0,00 uA	OK	A	N	
Test **after** opening		< 0,00 uA	OK	< 0,00 uA	OK	< 0,00 uA	OK	A	N	
Test **before** irradiation		< 0,00 uA	OK	< 0,00 uA	OK			A	N	
042	34.0									S/N 141 tested, **latch-up !!!**
043	34.0									S/N 142 tested, no latch-up
044	34.0									S/N 141 tested, no latch-up
047	48.1									S/N 141 tested, no latch-up
048	48.1									S/N 142 tested, no latch-up
127	73.0									S/N 141 tested, no latch-up
128	73.0									S/N 142 tested, no latch-up

Additional Comments : NOTE: Output voltages are checked without recording (pins 15 to 18 = high (about 4,3V); pins 11 to 14 = low).

Bias condition A : Test Board #14; VCC = 5V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 15
(JD54F38BCA)

TEST DETAILS		S/N: 151		S/N: 152		S/N: 153		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	ICC (A)	VOUT (see note)	ICC (A)	VOUT (see note)	ICC (A)	VOUT (see note)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		12,55 mA	OK	12,21 mA	OK	12,45 mA	OK	A	N	
Test **after** opening		12,80 mA	OK	12,79 mA	OK	12,84 mA	OK	A	N	
Test **before** irradiation		12,66 mA	OK	12,54 mA	OK			A	N	
045	34.0									S/N 151 tested, no latch-up
046	34.0									S/N 152 tested, no latch-up
049	48.1									S/N 151 tested, no latch-up
050	48.1									S/N 152 tested, no latch-up
129	73.0									S/N 151 tested, no latch-up
130	73.0									S/N 152 tested, no latch-up

Additional Comments : NOTE: Output voltages are checked without recording (pins 3 and 6 = high; pins 8 and 11 = low).

Bias condition A : Test Board #15; VCC = 5V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 16
(54HCT04)

TEST DETAILS		S/N: 161		S/N: 162		S/N: 163		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	ICC (A)	VOUT (see note)	ICC (A)	VOUT (see note)	ICC (A)	VOUT (see note)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		< 0,00 uA	OK	< 0,00 uA	OK	< 0,00 uA	OK	A	N	
Test **after** opening		< 0,00 uA	OK	< 0,00 uA	OK	< 0,00 uA	OK	A	N	
Test **before** irradiation		< 0,00 uA	OK	< 0,00 uA	OK			A	N	
051	34.0									S/N 161 tested, no latch-up
052	34.0									S/N 162 tested, no latch-up
055	48.1									S/N 161 tested, no latch-up
056	48.1									S/N 162 tested, no latch-up
131	73.0									S/N 161 tested, no latch-up
132	73.0									S/N 162 tested, no latch-up

Additional Comments : NOTE: Output voltages are checked without recording (pins 2, 4, 6 = high; pins 8, 10, 12 = low).

Bias condition A : Test Board #16; VCC = 5V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 19
(AD620SQ)

TEST DETAILS		S/N: 191			S/N: 192			S/N: 193			BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	IVS+ (A)	IVS- (A)	VOUT (V)	IVS+ (A)	IVS- (A)	VOUT (V)	IVS+ (A)	IVS- (A)	VOUT (V)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		870 uA	919 uA	0,14 mV	914 uA	966 uA	-0,04 mV	902 uA	952 uA	0,17 mV	A	N	
Test **after** opening		871 uA	919 uA	0,14 mV	916 uA	967 uA	-0,04 mV	903 uA	952 uA	0,17 mV	A	N	
Test **before** irradiation		869 uA	917 uA	0,13 mV	913 uA	965 uA	-0,04 mV				A	N	
028	34.0												S/N 191 tested, no latch-up
029	34.0												S/N 192 tested, no latch-up
032	48.1												S/N 191 tested, no latch-up
033	48.1												S/N 192 tested, no latch-up
121	73.0												S/N 191 tested, no latch-up
122	73.0												S/N 192 tested, no latch-up

Additional Comments : VOUT = pin 6.

Bias condition A : Test Board #19; VS+ = 10V, VS- = -10V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 20
(LM2991J-QML)

TEST DETAILS		S/N: 201		S/N: 202		S/N: 203		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	VOUT (V)	IIN (A)	VOUT (V)	IIN (A)	VOUT (V)	IIN (A)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		-9,715 V	7,48 mA	-9,649 V	7,43 mA	-9,624 V	7,60 mA	A	N	Add. hand-measurements performed
Test **after** opening		-9,706 V	7,48 mA	-9.639 V	7,45 mA	-9,621 V	7,62 mA	A	N	
Test **before** irradiation		-9,704 V	7,50 mA	-9.627 V	7,44 mA			A	N	
099	5.85									
100	5.85									
101	5.85									
102	5.85									
076	14.1									
077	14.1									
078	14.1									
070	34.0									
071	34.0									
072	34.0									

Additional Comments : VOUT = pin 6

Bias condition A : Test Board #20; VIN = -15V (NOTE: The bias condition provides a -9.2V output voltage)
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 23
(DG406AK/883)

TEST DETAILS		S/N: 231		S/N: 232		S/N: 233		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	IV+ (A)	IV- (A)	IV+ (A)	IV- (A)	IV+ (A)	IV- (A)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		10,5 uA	< 0,0 uA	10,3 uA	< 0,0 uA	8,9 uA	< 0,0 uA	A	N	
Test **after** opening		10,6 uA	< 0,0 uA	10,4 uA	< 0,0 uA	8,9 uA	< 0,0 uA	A	N	
Test **before** irradiation		10,7 uA	< 0,0 uA	10,5 uA	< 0,0 uA			A	N	
053	34.0									S/N 231 tested, no latch-up
054	34.0									S/N 232 tested, no latch-up
057	48.1									S/N 231 tested, no latch-up
058	48.1									S/N 232 tested, no latch-up
133	73.0									S/N 231 tested, no latch-up
134	73.0									S/N 232 tested, no latch-up

Additional Comments :

Bias condition A : Test Board #23; V+ = 10V, V- = -10V
Bias condition B :

PCDF SEL TEST RECORD FOR ITEM 24
(LM117H/883Q)

TEST DETAILS		S/N: 241		S/N: 242		S/N: 243		BIAS	ATE	COMMENTS
TEST RUN	LETeff (MeV cm²/mg)	VOUT (V)	IIN (A)	VOUT (V)	IIN (A)	VOUT (V)	IIN (A)	CONDITION (see below)	TESTED (Yes or No)	
Test **before** opening		24,00 V	5,27 mA	23,97 V	5,26 mA	24,01 V	5,27 mA	A	Y	Additional tested on SZ
Test **after** opening		24,00 V	5,27 mA	23,96 V	5,26 mA	24,01 V	5,27 mA	A	N	
Test **before** irradiation		24,00 V	5,27 mA	23,95 V	5,26 mA	24,01 V	5,27 mA	A	N	
091	5.85									
092	5.85									
093	9.1									
094	9.1									
082	14.1									
083	14.1									
084	14.1									
085	14.1									
086	14.1									
022	34.0									
023	34.0									
024	34.0									
025	34.0									

Additional Comments : VOUT = pin 3