TOTAL DOSE RADIATION TEST

I. INTRODUCTION

Total dose radiation tests are designed to characterize changes in device performance due to total dose radiation. These tests are not intended to classify maximum radiation tolerance of any particular device, rather, they simply show trends in the critical parameters as a function of total dose. Whether a device meets tolerance requirements is left up to the designer. In many occasions, designers have the ability to circumvent radiation effects by adding appropriate shielding or compensating for the variations in performance.

MIL-STD-883 method 1019 is used as a guideline for these tests. National's gamma radiation source is kept in compliance with method 1019 and radiation test samples are irradiated under dose rate condition A, which tests for total-dose effects. Samples are kept biased while irradiating. Dose rate is maintained between 50 - 300 Rads(Si)/sec and all samples are exposed to a total dose of 200 kRads(Si).

II. RADIATION SOURCE

A. Type

Atomic Energy of Canada Limited cobalt 60 irradiation unit model Gammacell 220 is used to irradiate the devices under test. The Gammacell 220 produces gamma radiation photons approximately 1.25MeV in energy. Dose rate in the gammacell is maintained between 50 and 300 Rads(Si)/sec with an accuracy of +/- 10%.

B. Dosimetery

Thermoluminescence Dosimetery is performed according to MIL-STD-883 method 1019. Actual dose rate for individual test is calculated from the exponential decay approximation of the dosimetery data.

III. TEST SETUP AND PROCEDURE

A. Pre-radiation Electrical Test

All test samples are verified to be functionally and parameterically working prior to irradiation. They are subject to group A qualification test including burn in. Samples are also verified to be within room temperature acceptance limits.

B. Test Environment

Samples are enclosed in a lead/aluminum container vertically aligned with the source of radiation while being irradiated. Ambient temperature throughout the test is approximately 25^{o}C.

C. Biasing

All devices under test are kept biased during irradiation. Bias circuit used for burn-in is also used for irradiation.

C. Electrical Test

Remote electrical tests are performed on the irradiated devices at several total dose levels. All samples are short circuited while transporting to the automatic electrical tester. Electrical tests are completed within two hours of each irradiation step.

IV. DATA PRESENTATION

A Test Summary sheet provides details on the origins of test samples, dose rate, list of parameters tested and total variation in those parameters. Details of the test consists of select device parameter plotted and tabulated as a function of total dose. Test conditions for each parameter are also specified. Acceptance limits specified in RETS or MDS are also plotted on the graph for reference purpose.

This RHA report is supplied only as a guideline to demonstrate the characteristics of our product in a Total Dose Radiation environment. The results reported are representative only of the lot tested in this specific sample and should not be used as generic RHA qualification data. National Semiconductor uses different process flows for different product qualification levels, and National Semiconductor will not guarantee the RHA performance of any product unless National Semiconductor has tested and certified the specific manufacturing lot. At each radiation exposure level, minimum and maximum shows a plausible variation in the parameter values. It is important to remember that this variation includes variation due to radiation exposure as well as variation between lots and variation between wafers. Measurement variation is assumed insignificant. Whenever possible, radiation test reports will provide an estimate of the percentage of total variation that can be attributed to radiation exposure. This estimate is calculated by analysis of variance (ANOVA) or similar statistical method.

LM6172 Total Dose Radiation Test Report

November 8, 1996

LM6172 was irradiated up to 800k Rads(Si) and all eight samples were functional after the exposure. Input Offset voltage appears to be the most sensitive parameter. At 300k Rads total dose, V_{IO} began to fall off and at 400k Rads total dose, V_{IO} with V_S = 5V dropped below the minimum allowed by the specs. Input bias current also shows some sensitivity to radiation. It also started to rise at 300k Rads total dose, however, the increase was gradual and all parts met the room temperature spec limits at 800k Rads total dose. CMRR with V_S = 5V had a wide distribution throughout the test. However, on average individual parts did not have a large drift, roughly 3dB change from prerad to post 800k rad. Slew rate, due to poor reproducibility should be interpreted with caution,. Rising edge slew rate was consistently higher than the falling edge and both slew rates met the room temperature electrical specs throughout the test. The poor reproducibility was a result of ringing in the test system and was not due to the samples being tested. This temporary ringing problem could not be resolved at the time of the test due to two hour window to carryout the test. It has been resolved since.

Delta Summary:

Parameter	Prerad Average	800k Rad Average	Delta	Unit	Parameter	Prerad Average	800k Rad Average	Delta	Unit
V_S = +/-15V					V_S = +/-5V				
Pos. I_S	4.534	4.497	-0.037	mA	Pos. I_S	4	4.065	-0.057	mA
Neg. I_S	4.54	4.502	-0.038	mA	Neg. I_S	4.132	4.077	-0.055	mA
V_{IO}	-0.983	0.343	1.326	mV	V_{IO}	0.031	-1.311	-1.342	mV
I_{IO}	0.024	0.04	0.016	µA	I_{IO}	0.024	0.043	0.019	µA
Pos. I_{IB}	-0.992	-0.514	0.478	µA	Pos. I_{IB}	-1.086	-0.609	0.477	µA
Neg. I_{IB}	-1.016	-0.554	0.462	µA	Neg. I_{IB}	-1.11	-0.652	0.458	µA
CMRR	112.77	108.64	-4.13	dB	CMRR	116.6	113.9	-2.7	dB
A_{VS}	86.65	84.94	-1.71	dB	A_{VS}	82.9	81.1	-1.8	dB
+ Swing	13.25	13.16	-0.09	V	+ Swing	3.447	3.367	-0.08	V
- Swing	-13.17	-13.09	0.08	V	- Swing	-3.39	-3.313	0.077	V
SR[!]	2794	2581	-213	V/µS	PSRR	95.78	95.44	-0.34	dB
GBW	98.2	97.33	-0.87	MHz					

[!] Only side A rising edge data is shown.

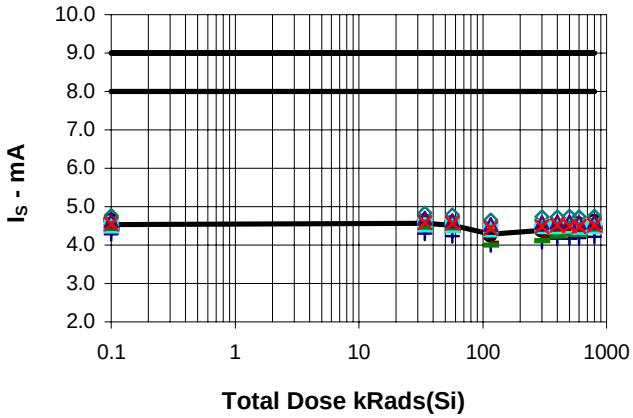
Test Details:

Sample Size:	8	Dose Rate:	115.10 Rads(Si)/sec
Lot No:	STM64892 (1 - 4), STM64893 (5 - 8)	Date Code:	9602
Wafer Run No:	A0063E21 (1 - 4), A0062E14 (5 - 8)	Bias Circuit:	6086HR
MDS:	MNLM6172AM-X Rev 0A0	Test Program:	RAD6172RA
Test Date:	November 6, 1996		

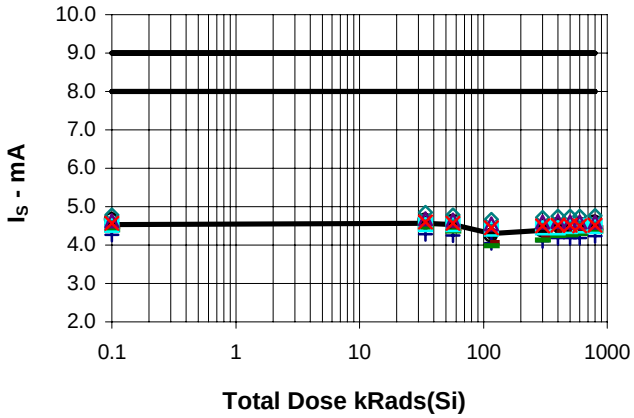
LM6172J
Total Dose Radiation Test Characteristics

November 8, 1996

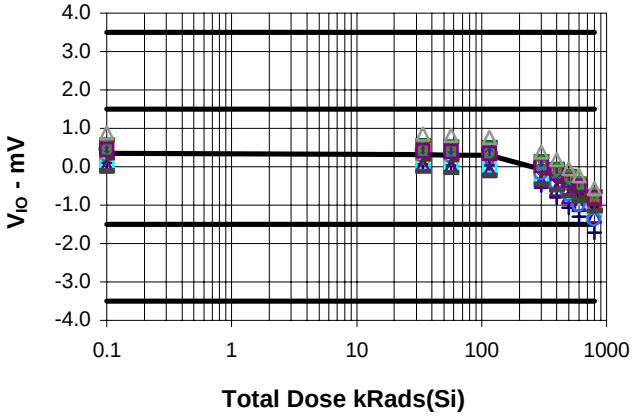
Positive Supply Current vs Total Dose



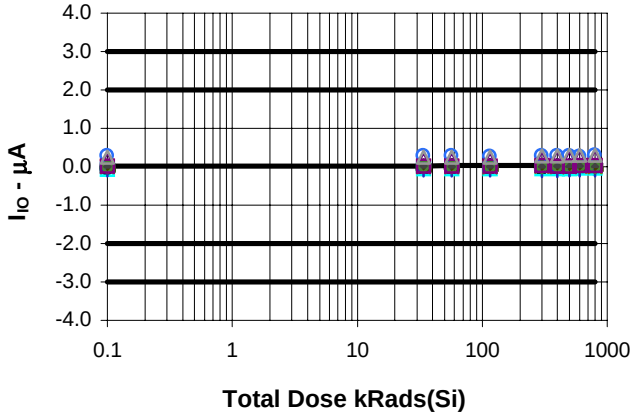
Negative Supply Current vs Total Dose



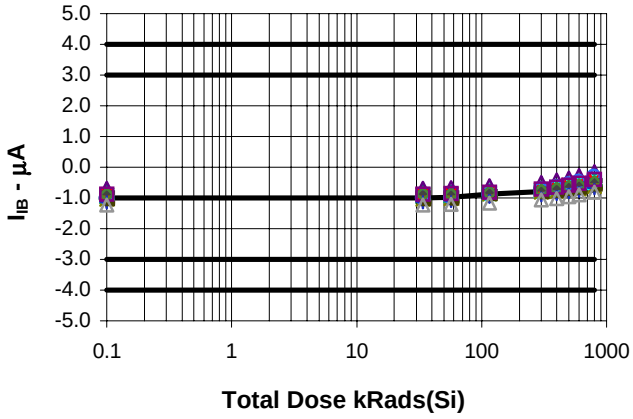
Input Offset Voltage vs Total Dose



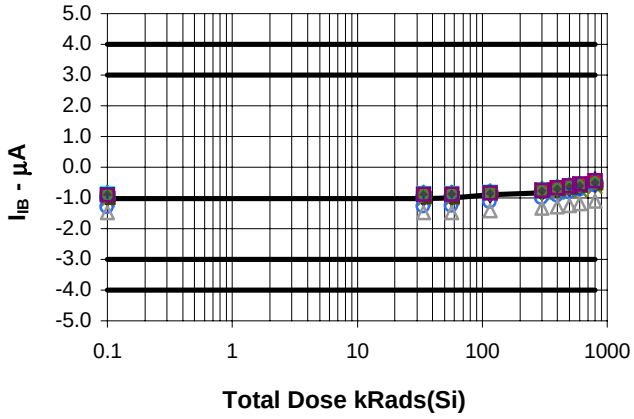
Input Offset Current vs Total Dose



Positive Input Bias Current vs Total Dose



Negative Input Bias Current vs Total Dose



Dose Rate: 115.10 Rads(Si)/sec, see table page for standard conditions.

LM6172J
Total Dose Radiation Test Characteristics

November 8, 1996

Positive Supply Current vs
Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	4.534	4.278	4.775	0.156	0
34.0	4.571	4.305	4.840	0.161	0
57.1	4.517	4.240	4.780	0.167	0
115.6	4.292	4.000	4.650	0.253	0
300.0	4.385	4.088	4.727	0.226	0
400.0	4.446	4.170	4.735	0.188	0
500.0	4.462	4.175	4.744	0.182	0
600.0	4.455	4.180	4.735	0.177	0
800.0	4.497	4.220	4.744	0.163	0

Negative Supply Current vs
Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	4.540	4.264	4.782	0.160	0
34.0	4.573	4.289	4.847	0.165	0
57.1	4.526	4.249	4.789	0.171	0
115.6	4.305	3.985	4.669	0.252	0
300.0	4.389	4.092	4.717	0.223	0
400.0	4.459	4.177	4.757	0.191	0
500.0	4.460	4.182	4.752	0.185	0
600.0	4.470	4.182	4.749	0.179	0
800.0	4.502	4.227	4.774	0.164	0

Input Offset Voltage vs
Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.343	-0.106	0.887	0.256	0
34.0	0.321	-0.121	0.856	0.251	0
57.1	0.302	-0.145	0.818	0.249	0
115.6	0.294	-0.209	0.761	0.254	0
300.0	-0.065	-0.489	0.382	0.247	0
400.0	-0.275	-0.795	0.179	0.261	0
500.0	-0.474	-1.064	-0.045	0.273	0
600.0	-0.661	-1.298	-0.231	0.288	0
800.0	-0.983	-1.717	-0.560	0.310	1

Input Offset Current vs
Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.024	-0.088	0.282	0.117	0
34.0	0.023	-0.090	0.284	0.117	0
57.1	0.025	-0.090	0.279	0.117	0
115.6	0.026	-0.083	0.262	0.112	0
300.0	0.030	-0.093	0.277	0.122	0
400.0	0.032	-0.095	0.287	0.124	0
500.0	0.033	-0.075	0.292	0.125	0
600.0	0.034	-0.090	0.297	0.127	0
800.0	0.040	-0.085	0.304	0.130	0

Positive Input Bias Current vs
Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-0.992	-1.221	-0.681	0.152	0
34.0	-0.991	-1.226	-0.681	0.153	0
57.1	-0.974	-1.218	-0.666	0.148	0
115.6	-0.880	-1.165	-0.608	0.122	0
300.0	-0.795	-1.062	-0.497	0.129	0
400.0	-0.742	-1.016	-0.419	0.140	0
500.0	-0.678	-0.951	-0.347	0.146	0
600.0	-0.619	-0.896	-0.269	0.157	0
800.0	-0.514	-0.803	-0.140	0.172	0

Negative Input Bias Current vs
Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-1.016	-1.470	-0.820	0.177	0
34.0	-1.013	-1.472	-0.810	0.177	0
57.1	-0.999	-1.472	-0.810	0.175	0
115.6	-0.906	-1.414	-0.768	0.162	0
300.0	-0.824	-1.339	-0.690	0.158	0
400.0	-0.774	-1.293	-0.634	0.161	0
500.0	-0.711	-1.243	-0.569	0.163	0
600.0	-0.653	-1.192	-0.511	0.164	0
800.0	-0.554	-1.107	-0.385	0.171	0

Dose Rate: 115.10 Rads(Si)/sec.

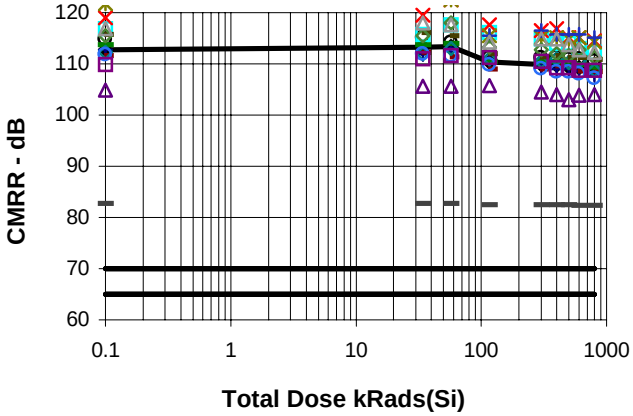
V_S = +/-15V, V_{CM} = 0V, R_L = 1kΩ unless specified otherwise.

Note 1: Number of devices that were outside MDS sub group 1 limits.

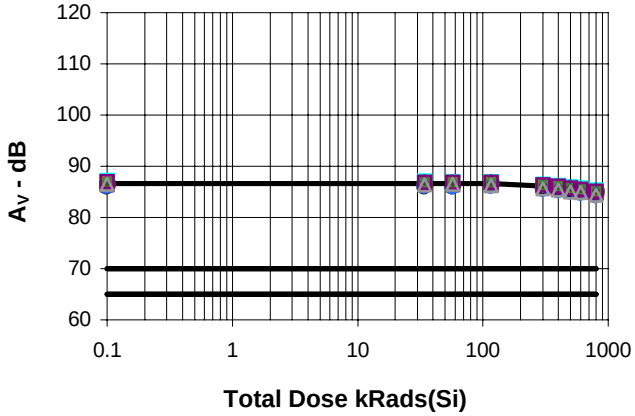
LM6172J
Total Dose Radiation Test Characteristics

November 8, 1996

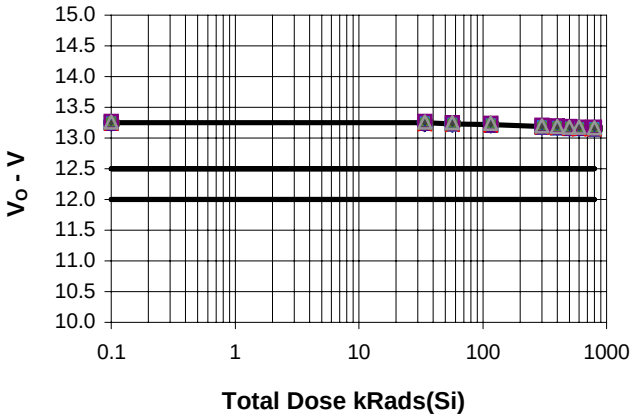
Common Mode Rejection Ratio vs Total Dose (V_{CM} = +/-10V)



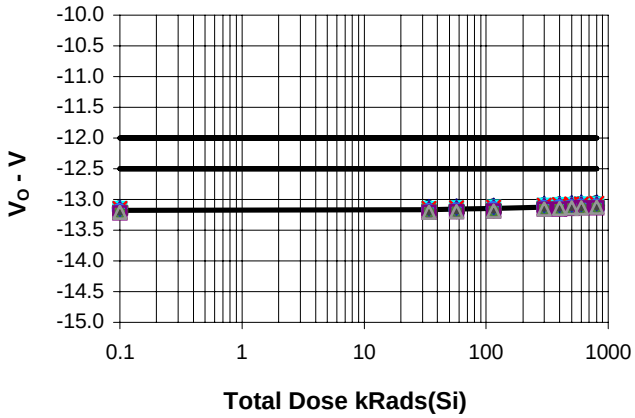
Open Loop Gain vs Total Dose (R_L = 1kΩ)



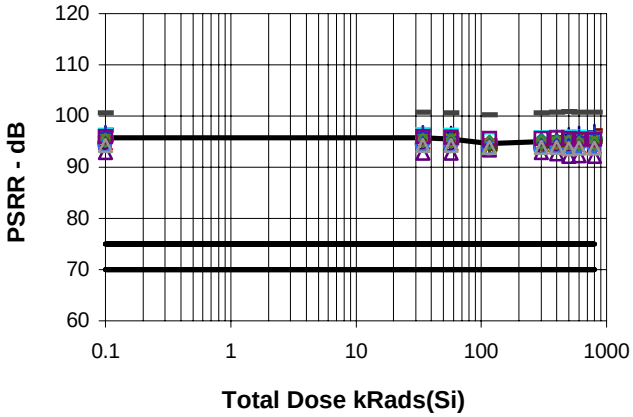
Positive Swing vs Total Dose (R_L = 1kΩ)



Negative Swing vs Total Dose (R_L = 1kΩ)



PSRR vs Total Dose (V_S = +/-15V to +/-5V)



Dose Rate: 115.10 Rads(Si)/sec, see table page for standard conditions.

LM6172J
Total Dose Radiation Test Characteristics

November 8, 1996

Common Mode Rejection Ratio
vs Total Dose (V_{CM} = +/-10V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	112.77	82.73	124.08	9.23	0
34	113.21	82.78	126.02	9.53	0
57.1	113.38	82.75	123.25	9.44	0
115.6	110.33	82.53	117.64	8.02	0
300	109.93	82.52	116.48	7.98	0
400	109.75	82.52	116.85	7.96	0
500	109.34	82.46	115.78	7.85	0
600	109.24	82.43	115.78	7.78	0
800	108.64	82.36	115.14	7.60	0

Open Loop Gain vs
Total Dose (RL = 1kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	86.65	85.91	87.20	0.37	0
34	86.61	85.87	87.18	0.37	0
57.1	86.58	85.85	87.05	0.36	0
115.6	86.64	86.00	87.05	0.33	0
300	86.13	85.39	86.56	0.34	0
400	85.84	85.09	86.24	0.34	0
500	85.59	84.84	85.97	0.35	0
600	85.34	84.58	85.80	0.35	0
800	84.94	84.18	85.41	0.37	0

Positive Swing vs
Total Dose (RL = 1kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	13.25	13.23	13.27	0.01	0
34	13.25	13.22	13.27	0.02	0
57.1	13.23	13.21	13.25	0.01	0
115.6	13.22	13.20	13.24	0.01	0
300	13.19	13.17	13.21	0.01	0
400	13.18	13.16	13.20	0.01	0
500	13.17	13.15	13.19	0.01	0
600	13.16	13.14	13.18	0.01	0
800	13.16	13.14	13.17	0.01	0

Negative Swing vs
Total Dose (RL = 1kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-13.17	-13.22	-13.12	0.03	0
34	-13.17	-13.22	-13.12	0.03	0
57.1	-13.16	-13.20	-13.11	0.03	0
115.6	-13.15	-13.19	-13.10	0.03	0
300	-13.12	-13.16	-13.07	0.03	0
400	-13.11	-13.16	-13.06	0.03	0
500	-13.11	-13.15	-13.05	0.03	0
600	-13.10	-13.14	-13.05	0.03	0
800	-13.09	-13.14	-13.05	0.03	0

PSRR vs Total Dose
(V_S = +/-15V to +/-5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	95.78	92.86	100.62	1.72	0
34	95.78	92.76	100.73	1.75	0
57.1	95.51	92.74	100.67	1.71	0
115.6	94.69	93.35	100.22	1.64	0
300	94.98	92.88	100.62	1.70	0
400	95.15	92.60	100.79	1.77	0
500	95.17	92.15	100.91	1.86	0
600	95.30	92.28	100.79	1.84	0
800	95.44	92.10	100.79	1.92	0

Dose Rate: 115.10 Rads(Si)/sec.

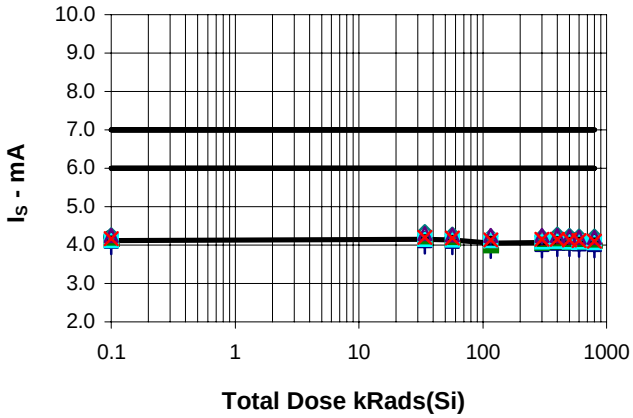
V_S = +/-15V, V_{CM} = 0V, R_L = 1kΩ unless specified otherwise.

Note 1: Number of devices that were outside MDS sub group 1 limits.

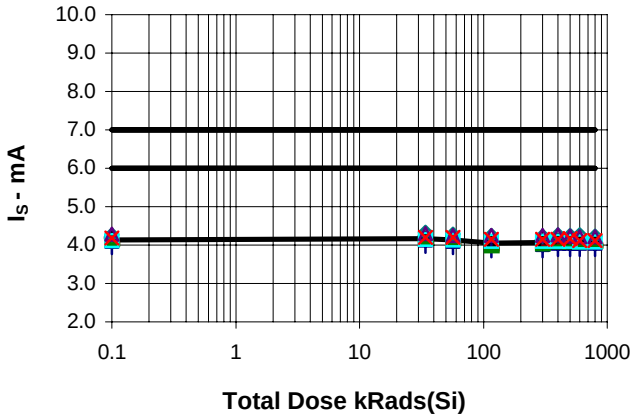
LM6172J
Total Dose Radiation Test Characteristics

November 8, 1996

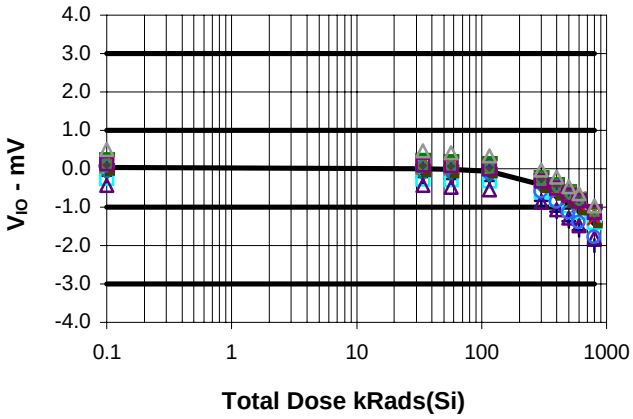
Positive Supply Current vs Total Dose (V_S = +/-5V)



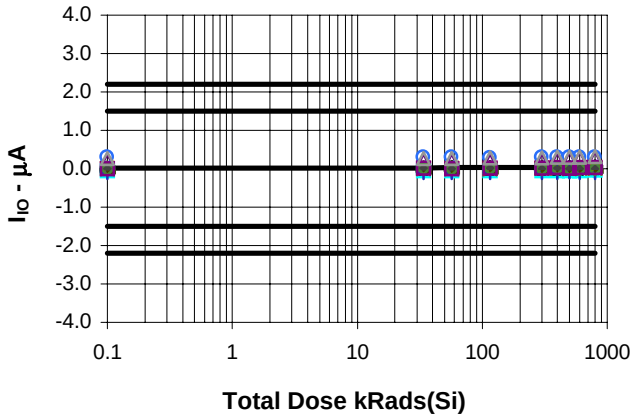
Negative Supply Current vs Total Dose (V_S = +/-5V)



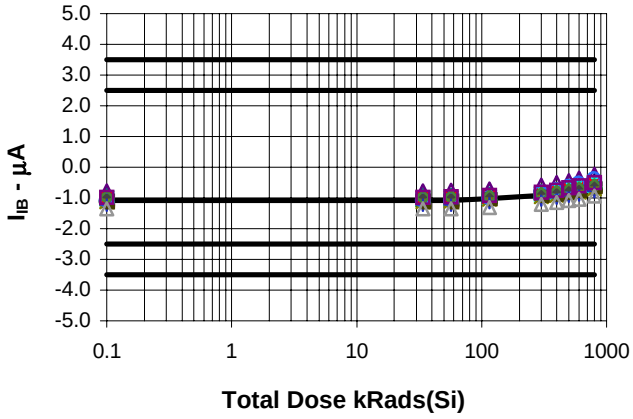
Input Offset Voltage vs Total Dose (V_S = +/-5V)



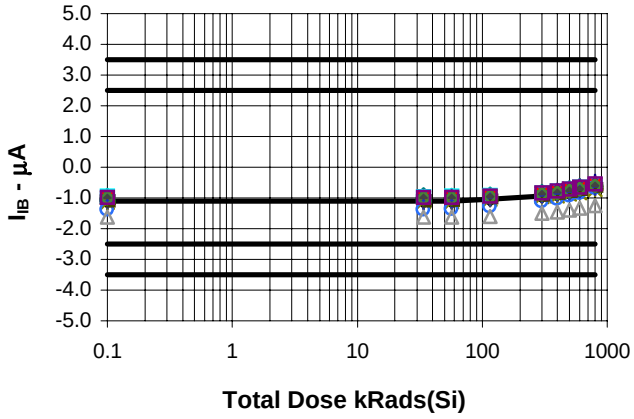
Input Offset Current vs Total Dose (V_S = +/-5V)



Positive Input Bias Current vs Total Dose (V_S = +/-5V)



Negative Input Bias Current vs Total Dose (V_S = +/-5V)



Dose Rate: 115.10 Rads(Si)/sec, see table page for standard conditions.

LM6172J
Total Dose Radiation Test Characteristics

November 8, 1996

Positive Supply Current vs
Total Dose (V_S = +/-5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	4.122	3.930	4.268	0.123	0
34	4.156	3.955	4.355	0.129	0
57.1	4.125	3.925	4.278	0.123	0
115.6	4.043	3.835	4.255	0.171	0
300	4.058	3.853	4.243	0.148	0
400	4.087	3.885	4.278	0.139	0
500	4.074	3.878	4.253	0.135	0
600	4.064	3.860	4.233	0.129	0
800	4.065	3.850	4.233	0.125	0

Negative Supply Current vs
Total Dose (V_S = +/-5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	4.132	3.934	4.287	0.124	0
34	4.163	3.962	4.334	0.122	0
57.1	4.132	3.937	4.284	0.118	0
115.6	4.046	3.852	4.247	0.165	0
300	4.065	3.855	4.249	0.151	0
400	4.093	3.878	4.267	0.141	0
500	4.084	3.880	4.255	0.135	0
600	4.074	3.880	4.260	0.131	0
800	4.077	3.880	4.237	0.121	0

Input Offset Voltage vs
Total Dose (V_S = +/-5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.031	-0.440	0.494	0.224	0
34	0.007	-0.430	0.464	0.220	0
57.1	-0.021	-0.486	0.422	0.221	0
115.6	-0.064	-0.555	0.335	0.219	0
300	-0.413	-0.860	-0.026	0.232	0
400	-0.613	-1.113	-0.225	0.253	2
500	-0.813	-1.374	-0.464	0.273	2
600	-0.995	-1.598	-0.642	0.294	4
800	-1.311	-2.000	-0.970	0.318	8

Input Offset Current vs
Total Dose (V_S = +/-5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.024	-0.098	0.292	0.124	0
34	0.024	-0.095	0.297	0.124	0
57.1	0.026	-0.093	0.304	0.125	0
115.6	0.027	-0.095	0.287	0.125	0
300	0.031	-0.095	0.292	0.127	0
400	0.034	-0.095	0.307	0.132	0
500	0.035	-0.088	0.304	0.132	0
600	0.036	-0.093	0.307	0.134	0
800	0.043	-0.093	0.317	0.134	0

Positive Input Bias Current vs
Total Dose (V_S = +/-5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-1.086	-1.344	-0.764	0.154	0
34	-1.086	-1.351	-0.766	0.153	0
57.1	-1.077	-1.346	-0.751	0.154	0
115.6	-1.020	-1.316	-0.714	0.140	0
300	-0.914	-1.215	-0.588	0.145	0
400	-0.851	-1.145	-0.507	0.152	0
500	-0.785	-1.092	-0.430	0.159	0
600	-0.722	-1.032	-0.352	0.166	0
800	-0.609	-0.933	-0.226	0.178	0

Negative Input Bias Current vs
Total Dose (V_S = +/-5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-1.110	-1.618	-0.918	0.184	0
34	-1.110	-1.618	-0.906	0.182	0
57.1	-1.103	-1.618	-0.916	0.183	0
115.6	-1.047	-1.595	-0.883	0.177	0
300	-0.945	-1.502	-0.795	0.172	0
400	-0.885	-1.451	-0.740	0.173	0
500	-0.819	-1.396	-0.672	0.175	0
600	-0.758	-1.338	-0.614	0.175	0
800	-0.652	-1.250	-0.458	0.180	0

Dose Rate: 115.10 Rads(Si)/sec.

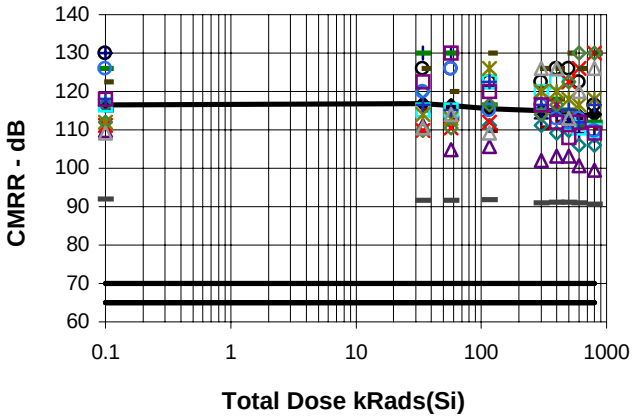
V_S = +/-15V, V_{CM} = 0V, R_L = 1kΩ unless specified otherwise.

Note 1: Number of devices that were outside MDS sub group 1 limits.

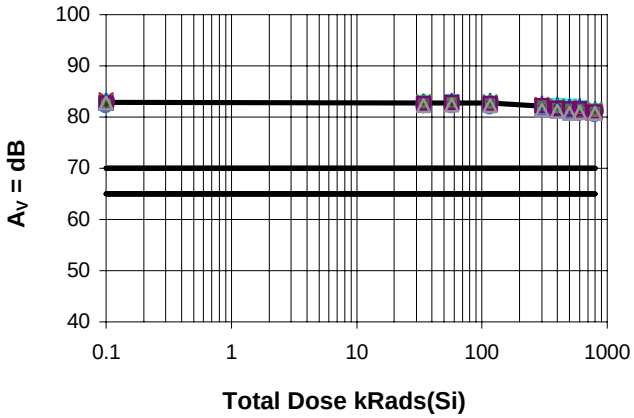
LM6172J
Total Dose Radiation Test Characteristics

November 8, 1996

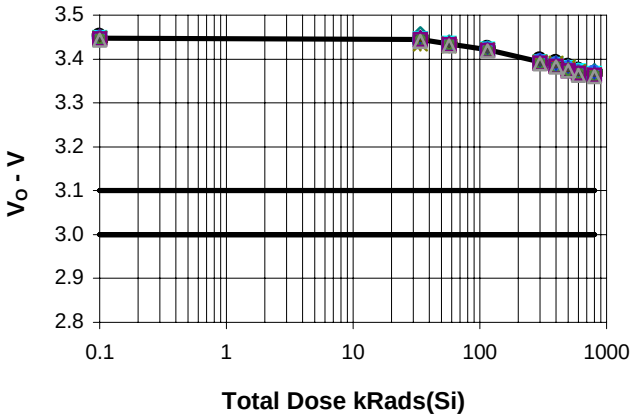
CMRR vs Total Dose
(V_S = +/-5V, V_{CM} = +/-10V)



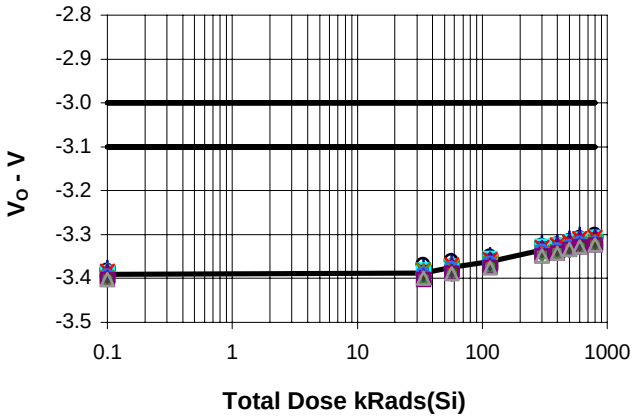
Open Loop Gain vs Total Dose
(V_S = +/-5V, R_L = 1kΩ)



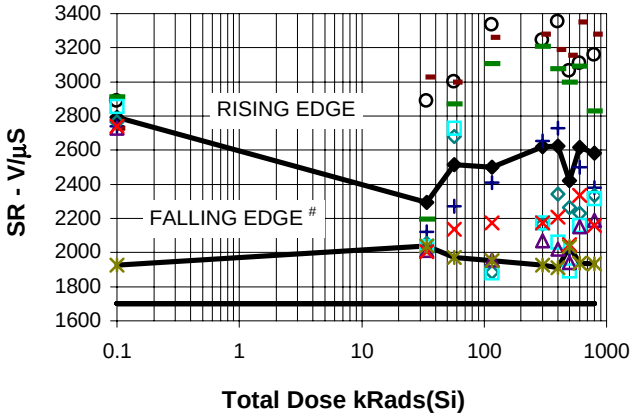
Positive Output Swing vs
Total Dose (V_S = +/-5V)



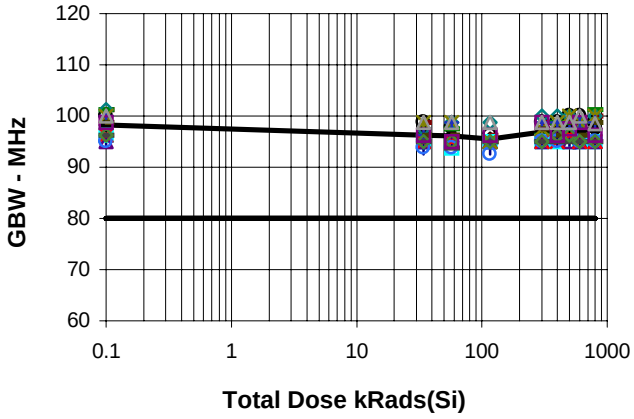
Negative Output Swing vs
Total Dose (V_S = +/-5V)



Slew Rate vs
Total Dose (Amplifier-A Only)



Gain Bandwidth
vs Total Dose



Only averaged data is shown for the falling edge.

Dose Rate: 115.10 Rads(Si)/sec, see table page for standard conditions.

LM6172J
Total Dose Radiation Test Characteristics

November 8, 1996

CMRR vs Total Dose

(V_S = +/-5V, V_{CM} = +/-10V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	116.6	92.0	130.0	9.5	0
34	116.8	91.7	130.0	9.6	0
57.1	116.4	91.6	130.0	10.4	0
115.6	115.5	91.8	130.0	9.1	0
300	115.0	91.1	126.0	8.8	0
400	115.1	91.2	126.0	9.0	0
500	114.0	91.2	130.0	9.2	0
600	113.6	91.1	130.0	10.0	0
800	113.9	90.7	130.0	11.1	0

Open Loop Gain vs Total Dose

(V_S = +/-5V, R_L = 1kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	82.9	82.1	83.3	0.4	0
34	82.8	82.1	83.2	0.3	0
57.1	82.8	82.1	83.3	0.3	0
115.6	82.7	81.9	83.3	0.4	0
300	82.1	81.4	82.8	0.4	0
400	81.9	81.0	82.5	0.4	0
500	81.6	80.8	82.1	0.5	0
600	81.5	80.7	82.2	0.4	0
800	81.1	80.4	81.6	0.3	0

Positive Output Swing vs

Total Dose (VS = +/-5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	3.447	3.441	3.454	0.003	0
34	3.445	3.435	3.458	0.005	0
57.1	3.434	3.430	3.440	0.003	0
115.6	3.422	3.419	3.425	0.002	0
300	3.394	3.389	3.399	0.003	0
400	3.388	3.381	3.394	0.004	0
500	3.379	3.372	3.385	0.004	0
600	3.371	3.364	3.376	0.004	0
800	3.367	3.360	3.374	0.004	0

Negative Output Swing vs

Total Dose (VS = +/-5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-3.390	-3.405	-3.374	0.011	0
34	-3.387	-3.410	-3.368	0.012	0
57.1	-3.375	-3.390	-3.358	0.011	0
115.6	-3.362	-3.376	-3.346	0.011	0
300	-3.335	-3.349	-3.318	0.010	0
400	-3.331	-3.346	-3.316	0.010	0
500	-3.323	-3.339	-3.308	0.010	0
600	-3.316	-3.332	-3.299	0.010	0
800	-3.313	-3.330	-3.300	0.010	0

Slew Rate vs

Total Dose (Amplifier-A Only)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	2794.2	2727.3	2912.6	77.4	0
34	2292.7	2006.7	3030.3	416.9	0
57.1	2514.1	1428.6	3000.0	541.4	0
115.6	2501.1	1880.9	3333.3	634.2	0
300	2621.0	2069.0	3278.7	544.8	0
400	2622.4	2020.2	3352.0	534.7	0
500	2421.5	1892.7	3157.9	551.9	0
600	2615.9	2150.5	3352.0	489.8	0
800	2580.9	2158.3	3278.7	444.7	0

Gain Bandwidth

vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	98.20	95.00	101.25	2.41	0
34	96.25	93.75	98.75	1.77	0
57.1	96.18	93.75	98.75	1.92	0
115.6	95.47	92.50	98.75	1.57	0
300	96.88	95.00	100.00	1.88	0
400	97.03	95.00	100.00	1.82	0
500	97.50	95.00	100.00	1.94	0
600	97.11	95.00	100.00	2.08	0
800	97.33	95.00	101.25	2.36	0

Dose Rate: 115.10 Rads(Si)/sec.

V_S = +/-15V, V_{CM} = 0V, R_L = 1kΩ unless specified otherwise.

Note 1: Number of devices that were outside MDS sub group 1 limits.