TOTAL DOSE RADIATION TEST REPORT

Part Type : SP200V

Package : TO-3

N-Channel Power MOSFET

SGS-THOMSON

Report Reference : ESA_QCA9909011T_C

Issue : 01

Date : July 1st 1999

ESA Contract No 13413/98/NL/MV dated 25/01/99

ESTEC Technical Officer: R. Harboe Sorensen

Hirex reference :	HRX/99.4570	Issue : 01	Date :	July 1st 1999
Written by :	J.F. PASCAL		Date :	
Approved by :	F.X GUERRE		Date :	

TOTAL DOSE RADIATION TEST REPORT
on
SGS-Thomson SP200V N-Channel Power Mosfet.

TABLE OF CONTENTS

1 Abstract

Under ESA/ESTEC contract n° 13413/98/NL/MV covering "Radiation Evaluation of Power MOSFET Devices from Different European Manufacturers", a large number of commercial Power MOSFET device types were radiation assessed. Results from these assessments, primarily focused on the radiation sensitivity of the MOSFETs to Total Ionizing Dose (TID) and Single Event Effects (SEE), are reported in individual TID and SEE reports. Below summary table list manufacturer and evaluated types, and give references to the various reports issued.

Manufacturer	Type	TID Report	SEE Report
Philips	PHP50N06T	ESA_QCA990901T_C	ESA_QCA990901S_C
Philips	BUK456-200A	ESA_QCA990902T_C	ESA_QCA990902S_C
Motorola	MTP50N06VL	ESA_QCA990903T_C	
Motorola	MTW32N20E	ESA_QCA990904T_C	
Motorola	MTP50N06V	ESA_QCA990905T_C	
SGS-Thomson	BUZ100S	ESA_QCA990906T_C	ESA_QCA990906S_C
SGS-Thomson	BUZ100SL	ESA_QCA990907T_C	ESA_QCA990907S_C
SGS-Thomson	BUZ341	ESA_QCA990908T_C	ESA_QCA990908S_C
SGS-Thomson	SP60	ESA_QCA990909T_C	ESA_QCA990909S_C
SGS-Thomson	SP100V	ESA_QCA9909010T_C	ESA_QCA9909010S_C
SGS-Thomson	SP200V	ESA_QCA9909011T_C	ESA_QCA9909011S_C
SGS-Thomson	SPP1N60S5	ESA_QCA9909012T_C	ESA_QCA9909012S_C
Philips	BUK7508-55	ESA_QCA9909013T_C	ESA_QCA9909013S_C
Harris	HUF75639P3	ESA_QCA9909014T_C	ESA_QCA9909014S_C

2 Introduction

A total dose radiation evaluation test of the SGS-THOMSON SP200V N-Channel Power Mosfet has been performed with an accumulated dose of about 37 Krad(Si) at a dose rate of 75 rad(Si)/hour, in response to European Space Agency contract reference : 13413/98/NL/MV.

The purpose of this test was to evaluate total dose withstanding of this component, to investigate its suitability for being used in space applications. This test was conducted on commercial samples provided by ESTEC.
Test has been performed in accordance with Hirex proposal HRX/98.3475 issue 01.

A complete set of electrical measurements together with graphical representation of measured parameters with respect to total dose received, are provided for all samples.

SEE results for this device type can be found in SEE radiation test report: ESA_QCA9909011S_C

3 Applicable and Reference Documents

3.1 Applicable Documents

- ESA/SCC Basic specification N° 22900 issue 4
- SGS-Thomson datasheet (See Annex)
- Hirex Engineering proposal: HRX/98.3475 issue 01.

3.2 Reference Documents

- MIL-STD-883: test methods and procedures for microcircuits

4 Test Samples

11 samples of the SP200V device, provided in TO-3 package , were tested (2 groups of 5 + 1 control sample). Samples were already serialized when received at Hirex. For the purpose of this evaluation, sample identification was reallocated in order to be consistent with the other types under evaluation, and considering parts used for heavy ions test. The correspondence is provided in the following table.

Old identification	New identification	Allocation
1	1	Control
2	2	Bias 1
3	3	Bias 1
4	4	Bias 1
5	5	Bias 1
7	6	Bias 1
8	7	Bias 2
9	8	Bias 2
10	9	Bias 2
11	10	Bias 2
12	11	Bias 2

Identification of the SP200V is given below:

Part Number:	SP200V	**Mask Set:**	NA
Top Marking:	SP200V 9820	**Chip Marking:**	NA
Diffusion Lot:	NA	**Wafer #:**	NA
Date Code:	9820	**Project:**	Not defined

5 Experimental Conditions

5.1 Radiation Source Dose Rate and Annealing

The dose exposures were performed at CERT-ONERA. In this irradiation facility, a Cobalt 60 source is used with the possibility to vary the dose rate by simply adjusting the distance to the source.
The irradiation conditions used for this test are provided in the following table:

Irradiation Steps	Dose rate	Annealing steps	Temperature
krads	krads/h	hours	°C
0			
3.85	0,075		25
7.35	0,075		25
13.95	0,075		25
19.65	0,075		25
24.65	0,075		25
29.85	0,075		25
36.85	0,075	0	25
		24	25
		192	100

5.2 Bias during Dose Exposures and Measurements conditions

5.2.1 Bias conditions

During exposures dedicated test boards were used mounted on a special board-holder made for irradiation. The test board allowed to bias the devices in accordance with the electrical circuit provided in Figure 1. Two bias conditions were used so called Bias 1 and Bias 2.
Bias 1 corresponds to a gate stress of VGSS equals 12 Volts. Bias 2 corresponds to drain to source stress equals 80% of BVDSS.
During annealing steps the same stress conditions were applied at room and 100°C temperatures respectively.

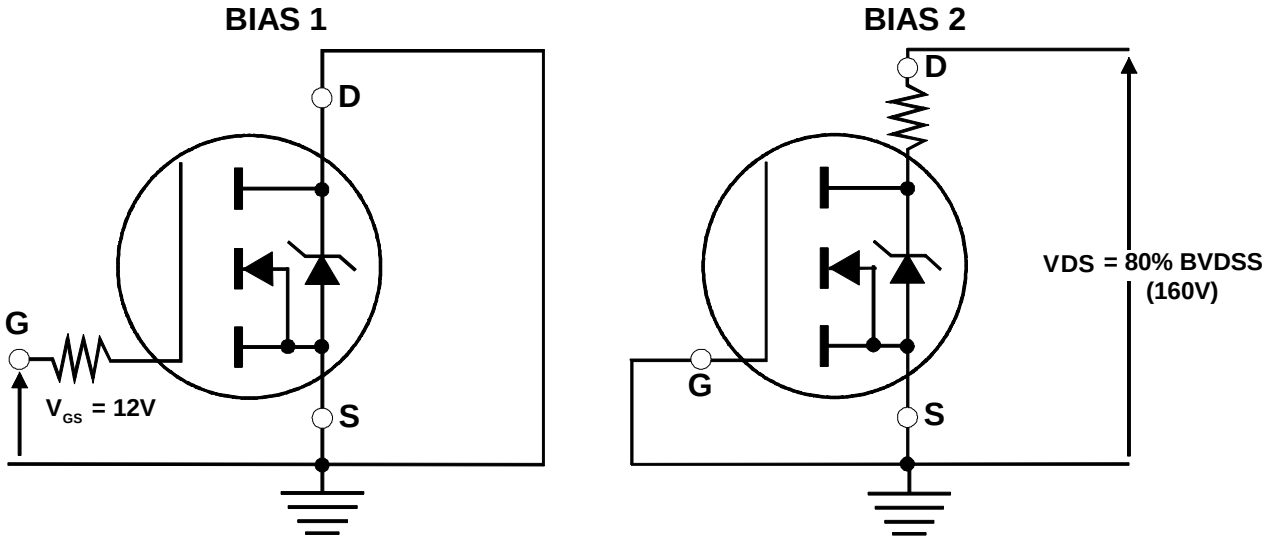


Figure 1 : Bias Conditions during Irradiation Exposures and Annealing

5.2.2 Electrical Measurements

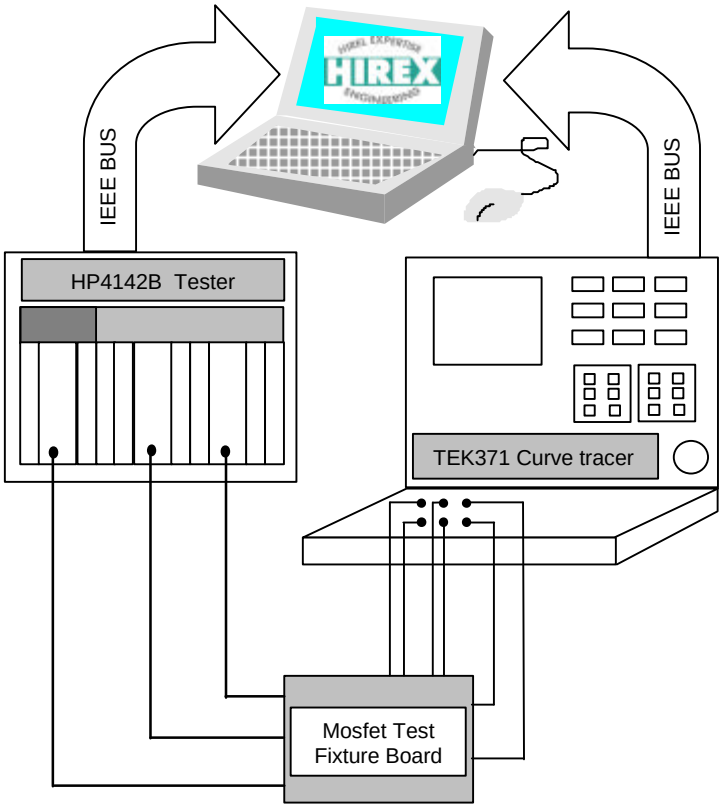
Mosfet transistor test program principle is provided in Figure 2. Due to the great number of samples to be measured (test campaign was conducted on 14 part types at the same time) and the time interval constraints required for performing measurements after each exposure and annealing step, It was decided to automate low power and high power measurements.

Two instruments were used to cover low power and high power measurements respectively.
HP4142B was used for breakdown voltage, gate and drain leakage currents, and threshold voltage measurements.
Tektronix TEK371 high power curve tracer was used for R_{DSON} measurements.

A dedicated test fixture was designed to ensure proper switching of instruments. In addition a faraday cup was used to ensure optimum conditions for low level measurements.

Test program has been written in Visual Basic on a PC computer. HPIB commands were sent to each instrument via IEEE bus, in order to measure a given parameter with specified conditions.
Results were automatically loaded in an Excel worksheet and compared in real time to specification limits. This allowed for real time data analysis in particular when failures were recorded.

Figure 2 : Mosfet transistor test program principle



Electrical parameters test conditions and limits used for performing this test are given in the following table.

Symbol	Test Parameter	Test Conditions	Min limit	Max limit	Unit
BVDSS	Drain to Source breakdown voltage	VGS=0V, ID=0.25mA	200		V
VGSTH	Gate to Source threshold voltage	VDS>=VGS, ID=0.25mA	2	4	V
+IGSS	Positive Gate Source leakage current	VGS=+20V, VDS=0V		100	nA
-IGSS	Negative Gate Source leakage current	VGS=-20V, VDS=0V		100E-9	nA
IDSS	Drain current	VGS=0V, VDS=200V		1	µA
RDSON	Static drain to source on-state resistance	VGS=10V, ID=5A		0.4	Ohm

Table 1 : Measured electrical parameters

6 Test Summary

A Total Ionizing Dose assessment was carried out by Hirex Engineering under ESA contract on the SGS-Thomson SP200V N-Channel Power Mosfet.
2 groups of 5 samples each plus one control sample were used during testing. The first group was exposed to radiation using Bias 1 conditions corresponding to a gate stress of the devices. The second group of 5 samples was exposed to radiation using Bias 2 conditions corresponding to drain to source stress of the devices, equals 80% of BVDSS (160 Volts).

Based on the analysis of the results, the tolerances of this component and main conclusion are provided below.

Parametric Tolerance Level (>=Krad) - Bias 1:	3.85
Parametric Tolerance Level (>=Krad) - Bias 2:	3.85

Parametric tolerance level represents the last cumulative exposure at which no samples failed any test

Main conclusion:

Breakdown voltage is marginal at 3.85 Krad(Si) and out of specification limit at 7.35 Krad(Si) under Bias 1 conditions, and did not recover for subsequent steps.
Under Bias 2 conditions, Breakdown voltage is out of specification limit at 13.95 Krad(Si) and no further recovery is observed.
IDSS, under Bias 2 conditions, increases significantly for most samples at a dose as low as 3.85 Krad(Si) and up to the compliance value of 50mA without further recovery.
IDSS, under Bias 1 conditions, increases dramatically up to the compliance value of 50mA at a dose level of 13.95 Krad(Si) and subsequent steps, without recovery.

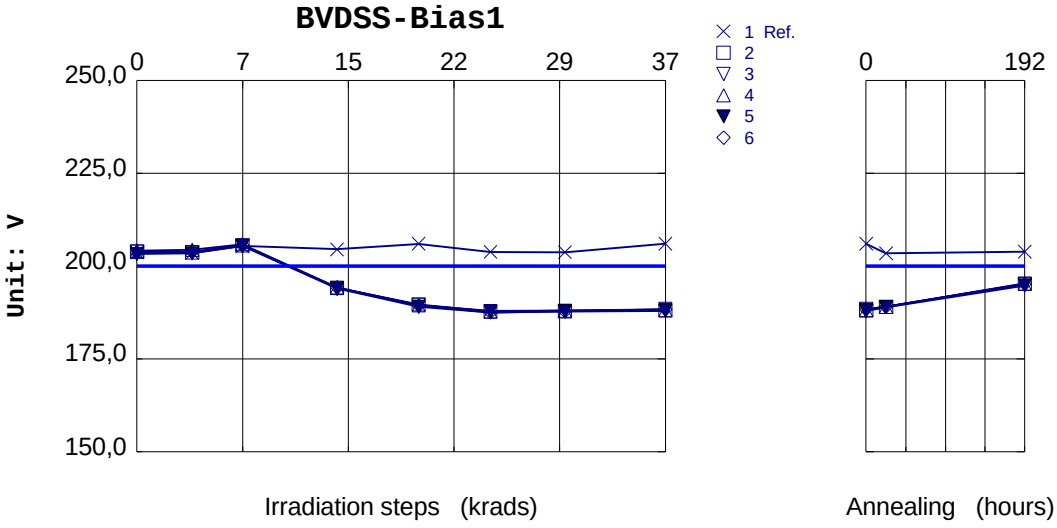
7 Test Results

Test results including tables and graphics are provided in this section for each measured parameter. To allow easy reading of data, each parameter is plotted twice, one for the first bias condition: Bias 1 and one for the second condition: Bias 2.

Parameter: Drain to source breakdown voltage: BVDSS-Bias1 **VGS=0V, ID=0.25mA**
Unit= V
Spec limit min: 200
Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	2,037E +02	2,035E +02	2,054E +02	2,045E +02	2,060E +02	2,038E +02	2,037E +02
2	2,039E +02	2,037E +02	2,056E +02	1,941E +02	1,897E +02	1,877E +02	1,879E +02
3	2,039E +02	2,037E +02	2,055E +02	1,940E +02	1,894E +02	1,879E +02	1,880E +02
4	2,041E +02	2,044E +02	2,059E +02	1,943E +02	1,894E +02	1,878E +02	1,880E +02
5	2,032E +02	2,034E +02	2,054E +02	1,939E +02	1,891E +02	1,875E +02	1,877E +02
6	2,036E +02	2,038E +02	2,057E +02	1,942E +02	1,894E +02	1,875E +02	1,878E +02
Statistics							
Min	2,032E +02	2,034E +02	2,054E +02	1,939E +02	1,891E +02	1,875E +02	1,877E +02
Max	2,041E +02	2,044E +02	2,059E +02	1,943E +02	1,897E +02	1,879E +02	1,880E +02
Mean	2,037E +02	2,038E +02	2,056E +02	1,941E +02	1,894E +02	1,877E +02	1,879E +02
Sigma	3,413E -01	3,599E -01	1,647E -01	1,404E -01	2,290E -01	1,514E -01	1,139E -01

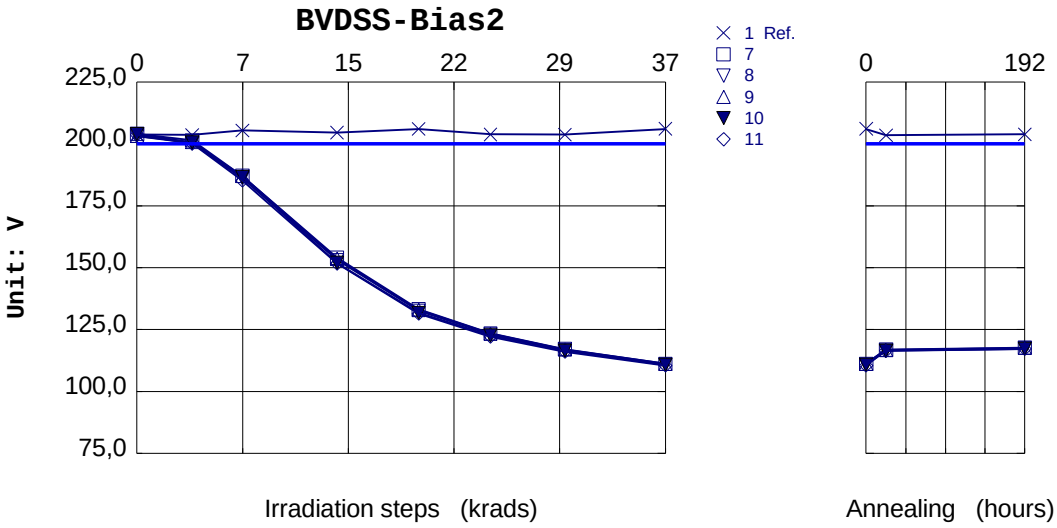
Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	2,060E +02	2,035E +02	2,038E +02
2	1,881E +02	1,891E +02	1,953E +02
3	1,884E +02	1,891E +02	1,951E +02
4	1,882E +02	1,890E +02	1,952E +02
5	1,879E +02	1,889E +02	1,947E +02
6	1,884E +02	1,890E +02	1,951E +02
Statistics			
Min	1,879E +02	1,889E +02	1,947E +02
Max	1,884E +02	1,891E +02	1,953E +02
Mean	1,882E +02	1,890E +02	1,951E +02
Sigma	1,935E -01	6,656E -02	2,143E -01



Parameter: Drain to source breakdown voltage: BVDSS-Bias2 **VGS=0V, ID=0.25mA**
Unit= V
Spec limit min: 200
Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	2,037E +02	2,035E +02	2,054E +02	2,045E +02	2,060E +02	2,038E +02	2,037E +02
7	2,040E +02	2,014E +02	1,870E +02	1,540E +02	1,332E +02	1,234E +02	1,171E +02
8	2,030E +02	2,002E +02	1,861E +02	1,531E +02	1,325E +02	1,231E +02	1,167E +02
9	2,031E +02	2,007E +02	1,870E +02	1,536E +02	1,329E +02	1,233E +02	1,170E +02
10	2,039E +02	2,006E +02	1,866E +02	1,519E +02	1,318E +02	1,226E +02	1,165E +02
11	2,036E +02	2,001E +02	1,852E +02	1,516E +02	1,314E +02	1,222E +02	1,160E +02
Statistics							
Min	2,030E +02	2,001E +02	1,852E +02	1,516E +02	1,314E +02	1,222E +02	1,160E +02
Max	2,040E +02	2,014E +02	1,870E +02	1,540E +02	1,332E +02	1,234E +02	1,171E +02
Mean	2,035E +02	2,006E +02	1,864E +02	1,528E +02	1,324E +02	1,229E +02	1,167E +02
Sigma	4,425E -01	5,287E -01	7,716E -01	1,041E +00	7,562E -01	5,296E -01	4,298E -01

Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	2,060E +02	2,035E +02	2,038E +02
7	1,112E +02	1,169E +02	1,177E +02
8	1,110E +02	1,166E +02	1,174E +02
9	1,112E +02	1,168E +02	1,176E +02
10	1,108E +02	1,164E +02	1,172E +02
11	1,105E +02	1,164E +02	1,172E +02
Statistics			
Min	1,105E +02	1,164E +02	1,172E +02
Max	1,112E +02	1,169E +02	1,177E +02
Mean	1,109E +02	1,166E +02	1,174E +02
Sigma	3,076E -01	2,092E -01	2,155E -01

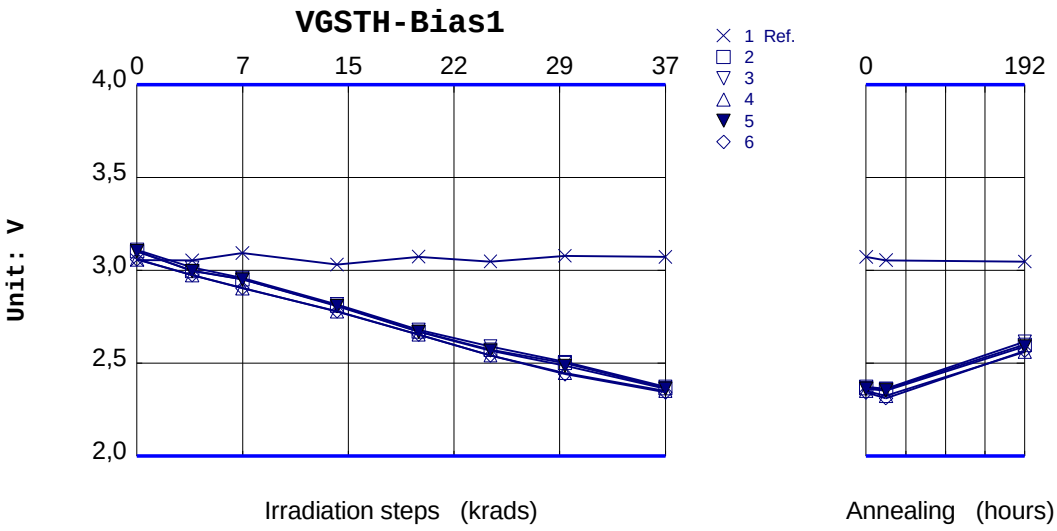


Parameter: Gate to source threshold voltage: VGSTH-Bias1 **VDS>=VGS, ID=0.25mA**

Unit= V
Spec limit max: 4
Spec limit min: 2
Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	3,055E +00	3,053E +00	3,093E +00	3,030E +00	3,073E +00	3,048E +00	3,078E +00
2	3,102E +00	2,997E +00	2,951E +00	2,810E +00	2,670E +00	2,573E +00	2,500E +00
3	3,110E +00	3,015E +00	2,959E +00	2,817E +00	2,680E +00	2,589E +00	2,507E +00
4	3,060E +00	2,973E +00	2,904E +00	2,778E +00	2,655E +00	2,542E +00	2,448E +00
5	3,103E +00	2,996E +00	2,951E +00	2,807E +00	2,669E +00	2,567E +00	2,486E +00
6	3,058E +00	2,973E +00	2,903E +00	2,779E +00	2,654E +00	2,541E +00	2,440E +00
Statistics							
Min	3,058E +00	2,973E +00	2,903E +00	2,778E +00	2,654E +00	2,541E +00	2,440E +00
Max	3,110E +00	3,015E +00	2,959E +00	2,817E +00	2,680E +00	2,589E +00	2,507E +00
Mean	3,086E +00	2,991E +00	2,934E +00	2,798E +00	2,665E +00	2,563E +00	2,476E +00
Sigma	2,565E -02	1,776E -02	2,767E -02	1,847E -02	1,113E -02	2,071E -02	3,033E -02

Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	3,072E +00	3,054E +00	3,047E +00
2	2,366E +00	2,358E +00	2,599E +00
3	2,373E +00	2,363E +00	2,615E +00
4	2,351E +00	2,324E +00	2,561E +00
5	2,363E +00	2,353E +00	2,590E +00
6	2,342E +00	2,311E +00	2,566E +00
Statistics			
Min	2,342E +00	2,311E +00	2,561E +00
Max	2,373E +00	2,363E +00	2,615E +00
Mean	2,359E +00	2,342E +00	2,586E +00
Sigma	1,227E -02	2,323E -02	2,267E -02

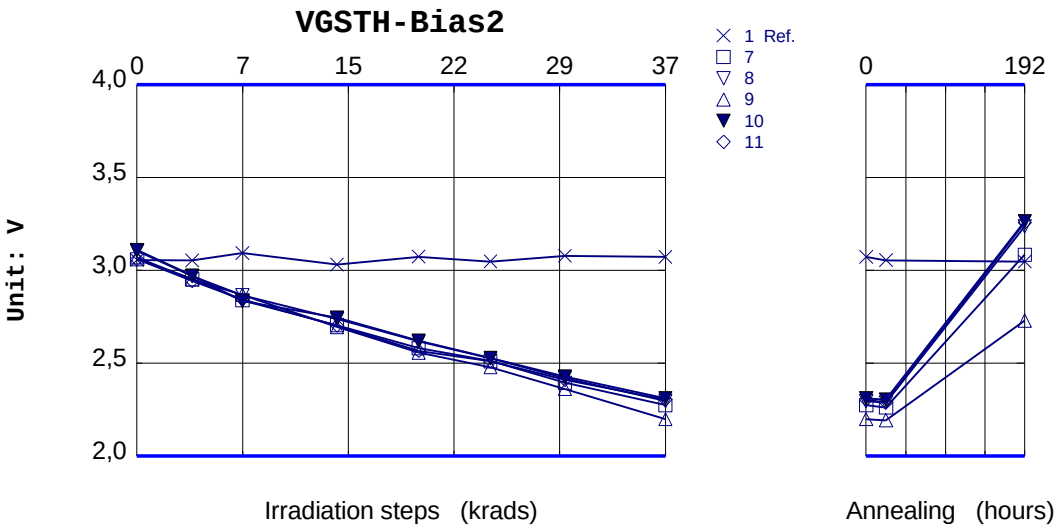


Parameter: Gate to source threshold voltage: VGSTH-Bias2 **VDS>=VGS,ID=0.25mA**

Unit= V
Spec limit max: 4
Spec limit min: 2
Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	3,055E +00	3,053E +00	3,093E +00	3,030E +00	3,073E +00	3,048E +00	3,078E +00
7	3,060E +00	2,952E +00	2,838E +00	2,704E +00	2,580E +00	2,511E +00	2,394E +00
8	3,105E +00	2,969E +00	2,866E +00	2,738E +00	2,617E +00	2,526E +00	2,421E +00
9	3,070E +00	2,952E +00	2,868E +00	2,695E +00	2,557E +00	2,478E +00	2,360E +00
10	3,110E +00	2,971E +00	2,834E +00	2,745E +00	2,621E +00	2,528E +00	2,428E +00
11	3,059E +00	2,943E +00	2,843E +00	2,702E +00	2,566E +00	2,510E +00	2,411E +00
Statistics							
Min	3,059E +00	2,943E +00	2,834E +00	2,695E +00	2,557E +00	2,478E +00	2,360E +00
Max	3,110E +00	2,971E +00	2,868E +00	2,745E +00	2,621E +00	2,528E +00	2,428E +00
Mean	3,081E +00	2,957E +00	2,850E +00	2,717E +00	2,588E +00	2,511E +00	2,403E +00
Sigma	2,485E -02	1,214E -02	1,599E -02	2,275E -02	2,929E -02	1,983E -02	2,694E -02

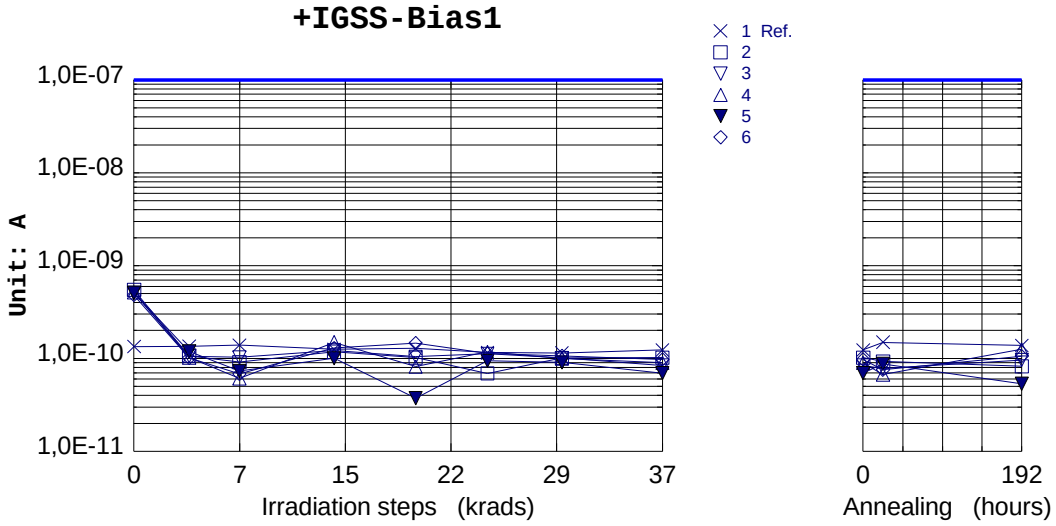
Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	3,072E +00	3,054E +00	3,047E +00
7	2,274E +00	2,261E +00	3,084E +00
8	2,296E +00	2,288E +00	3,236E +00
9	2,199E +00	2,193E +00	2,729E +00
10	2,311E +00	2,304E +00	3,263E +00
11	2,303E +00	2,288E +00	3,257E +00
Statistics			
Min	2,199E +00	2,193E +00	2,729E +00
Max	2,311E +00	2,304E +00	3,263E +00
Mean	2,276E +00	2,267E +00	3,114E +00
Sigma	4,555E -02	4,408E -02	2,273E -01



Parameter: Positive Gate source leakage current: +IGSS-Bias1 **VGS=+20V, VDS=0V**
Unit= A
Spec limit max: 100E-9
Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	1,344E -10	1,353E -10	1,391E -10	1,259E -10	1,286E -10	1,157E -10	1,146E -10
2	5,468E -10	1,073E -10	9,146E -11	1,184E -10	1,023E -10	6,916E -11	1,016E -10
3	5,113E -10	1,060E -10	1,029E -10	1,220E -10	1,047E -10	1,123E -10	1,016E -10
4	5,162E -10	1,022E -10	6,108E -11	1,497E -10	8,204E -11	1,173E -10	9,972E -11
5	5,108E -10	1,190E -10	7,330E -11	1,007E -10	3,736E -11	9,440E -11	9,084E -11
6	4,830E -10	1,016E -10	6,812E -11	1,296E -10	1,469E -10	1,132E -10	1,071E -10
Statistics							
Min	4,830E -10	1,016E -10	6,108E -11	1,007E -10	3,736E -11	6,916E -11	9,084E -11
Max	5,468E -10	1,190E -10	1,029E -10	1,497E -10	1,469E -10	1,173E -10	1,071E -10
Mean	5,136E -10	1,072E -10	7,937E -11	1,241E -10	9,466E -11	1,013E -10	1,002E -10
Sigma	2,266E -11	7,031E -12	1,730E -11	1,779E -11	3,977E -11	1,999E -11	5,901E -12

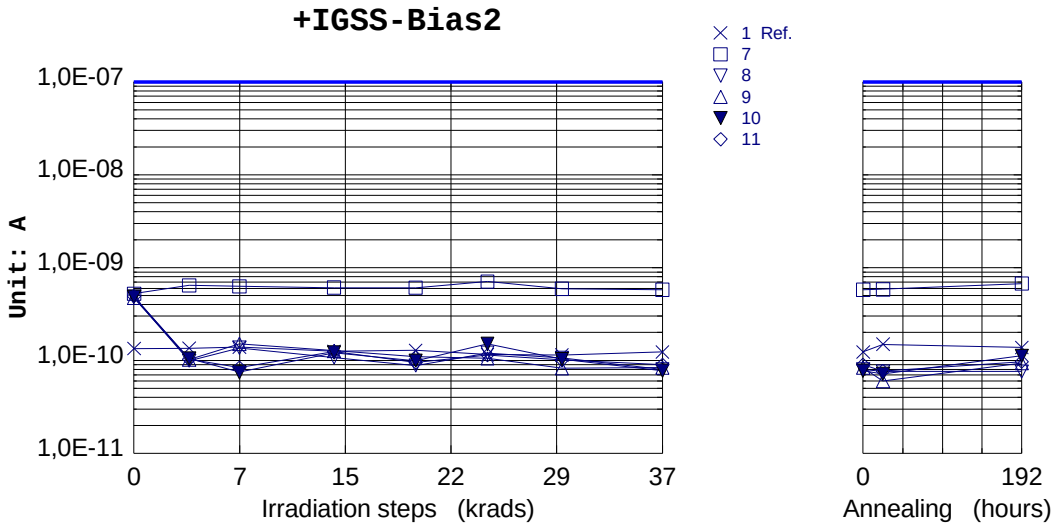
Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	1,236E -10	1,495E -10	1,380E -10
2	1,022E -10	9,284E -11	8,262E -11
3	8,398E -11	7,858E -11	9,632E -11
4	9,008E -11	6,730E -11	1,256E -10
5	6,966E -11	8,764E -11	5,360E -11
6	9,772E -11	7,566E -11	1,061E -10
Statistics			
Min	6,966E -11	6,730E -11	5,360E -11
Max	1,022E -10	9,284E -11	1,256E -10
Mean	8,874E -11	8,040E -11	9,286E -11
Sigma	1,276E -11	1,006E -11	2,696E -11



Parameter: Positive Gate source leakage current: +IGSS-Bias2 **VGS=+20V, VDS=0V**
Unit= A
Spec limit max: 100E-9
Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	1,344E -10	1,353E -10	1,391E -10	1,259E -10	1,286E -10	1,157E -10	1,146E -10
7	5,231E -10	6,429E -10	6,286E -10	6,085E -10	6,065E -10	7,098E -10	5,921E -10
8	4,836E -10	9,922E -11	1,367E -10	1,077E -10	8,836E -11	1,207E -10	1,069E -10
9	4,723E -10	1,025E -10	1,510E -10	1,274E -10	1,101E -10	1,054E -10	8,272E -11
10	4,859E -10	1,049E -10	7,488E -11	1,216E -10	9,928E -11	1,509E -10	1,034E -10
11	4,921E -10	1,031E -10	8,360E -11	1,247E -10	9,518E -11	1,144E -10	1,013E -10
Statistics							
Min	4,723E -10	9,922E -11	7,488E -11	1,077E -10	8,836E -11	1,054E -10	8,272E -11
Max	5,231E -10	6,429E -10	6,286E -10	6,085E -10	6,065E -10	7,098E -10	5,921E -10
Mean	4,914E -10	2,105E -10	2,150E -10	2,180E -10	1,999E -10	2,402E -10	1,973E -10
Sigma	1,914E -11	2,417E -10	2,335E -10	2,184E -10	2,275E -10	2,630E -10	2,209E -10

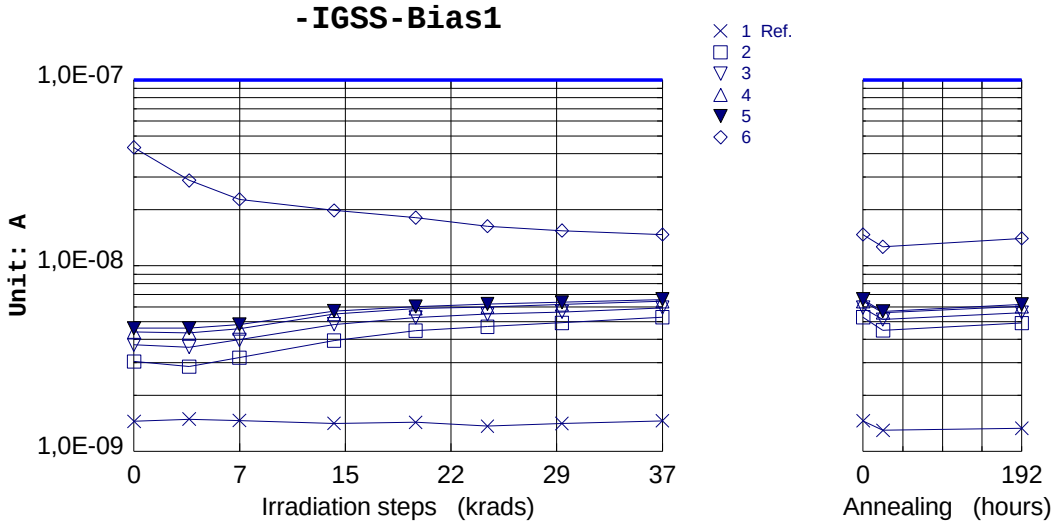
Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	1,236E -10	1,495E -10	1,380E -10
7	5,775E -10	5,837E -10	6,720E -10
8	8,022E -11	7,594E -11	7,606E -11
9	8,410E -11	6,018E -11	9,396E -11
10	7,760E -11	7,172E -11	1,122E -10
11	8,992E -11	7,700E -11	9,742E -11
Statistics			
Min	7,760E -11	6,018E -11	7,606E -11
Max	5,775E -10	5,837E -10	6,720E -10
Mean	1,819E -10	1,737E -10	2,103E -10
Sigma	2,212E -10	2,293E -10	2,584E -10



Parameter: Negative Gate source leakage current: -IGSS-Bias1 **VGS=-20V, VDS=0V**
Unit= A
Spec limit max: 100E-9
Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	1,451E -09	1,492E -09	1,468E -09	1,413E -09	1,436E -09	1,368E -09	1,412E -09
2	3,049E -09	2,862E -09	3,200E -09	3,954E -09	4,466E -09	4,691E -09	4,920E -09
3	3,752E -09	3,643E -09	3,987E -09	4,827E -09	5,254E -09	5,478E -09	5,637E -09
4	4,386E -09	4,344E -09	4,578E -09	5,487E -09	5,880E -09	5,993E -09	6,168E -09
5	4,610E -09	4,606E -09	4,818E -09	5,694E -09	6,022E -09	6,220E -09	6,361E -09
6	4,330E -08	2,875E -08	2,274E -08	1,984E -08	1,813E -08	1,631E -08	1,545E -08
Statistics							
Min	3,049E -09	2,862E -09	3,200E -09	3,954E -09	4,466E -09	4,691E -09	4,920E -09
Max	4,330E -08	2,875E -08	2,274E -08	1,984E -08	1,813E -08	1,631E -08	1,545E -08
Mean	1,182E -08	8,841E -09	7,864E -09	7,960E -09	7,950E -09	7,738E -09	7,707E -09
Sigma	1,761E -08	1,115E -08	8,337E -09	6,675E -09	5,724E -09	4,827E -09	4,363E -09

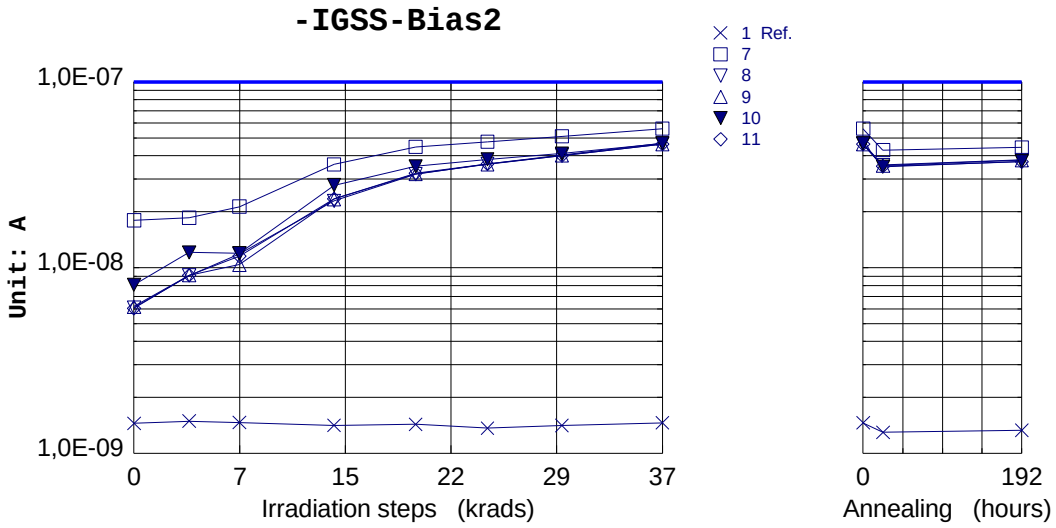
Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	1,462E -09	1,299E -09	1,331E -09
2	5,277E -09	4,486E -09	4,913E -09
3	5,934E -09	5,131E -09	5,586E -09
4	6,426E -09	5,589E -09	6,037E -09
5	6,583E -09	5,672E -09	6,188E -09
6	1,470E -08	1,262E -08	1,402E -08
Statistics			
Min	5,277E -09	4,486E -09	4,913E -09
Max	1,470E -08	1,262E -08	1,402E -08
Mean	7,784E -09	6,699E -09	7,348E -09
Sigma	3,900E -09	3,342E -09	3,760E -09



Parameter: Negative Gate source leakage current: -IGSS-Bias2 **VGS=-20V, VDS=0V**
Unit= A
Spec limit max: 100E-9
Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	1,451E -09	1,492E -09	1,468E -09	1,413E -09	1,436E -09	1,368E -09	1,412E -09
7	1,798E -08	1,858E -08	2,130E -08	3,593E -08	4,467E -08	4,761E -08	5,092E -08
8	6,090E -09	9,076E -09	1,187E -08	2,286E -08	3,187E -08	3,624E -08	4,043E -08
9	6,164E -09	9,113E -09	1,037E -08	2,339E -08	3,192E -08	3,598E -08	4,022E -08
10	8,081E -09	1,207E -08	1,195E -08	2,779E -08	3,516E -08	3,825E -08	4,123E -08
11	6,038E -09	9,092E -09	1,152E -08	2,345E -08	3,221E -08	3,617E -08	4,005E -08
Statistics							
Min	6,038E -09	9,076E -09	1,037E -08	2,286E -08	3,187E -08	3,598E -08	4,005E -08
Max	1,798E -08	1,858E -08	2,130E -08	3,593E -08	4,467E -08	4,761E -08	5,092E -08
Mean	8,870E -09	1,159E -08	1,340E -08	2,669E -08	3,516E -08	3,885E -08	4,257E -08
Sigma	5,163E -09	4,117E -09	4,458E -09	5,534E -09	5,490E -09	4,984E -09	4,689E -09

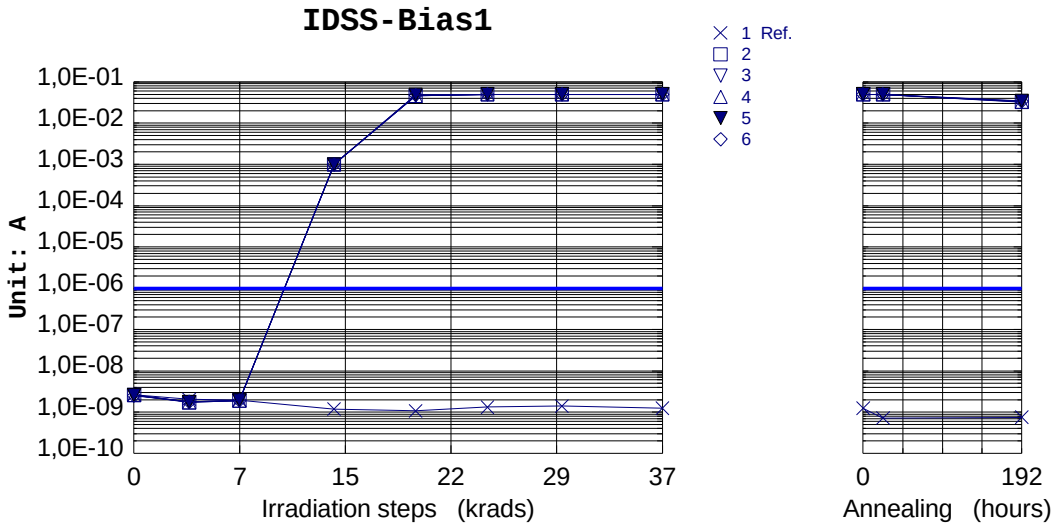
Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	1,462E -09	1,299E -09	1,331E -09
7	5,600E -08	4,288E -08	4,428E -08
8	4,663E -08	3,567E -08	3,797E -08
9	4,629E -08	3,542E -08	3,784E -08
10	4,659E -08	3,491E -08	3,735E -08
11	4,623E -08	3,520E -08	3,715E -08
Statistics			
Min	4,623E -08	3,491E -08	3,715E -08
Max	5,600E -08	4,288E -08	4,428E -08
Mean	4,835E -08	3,682E -08	3,892E -08
Sigma	4,281E -09	3,401E -09	3,019E -09



Parameter: Drain current: IDSS-Bias1 VGS=0V, VDS=200V
Unit= A
Spec limit max: 1E-6
Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	2,652E -09	2,054E -09	1,968E -09	1,187E -09	1,073E -09	1,325E -09	1,402E -09
2	2,634E -09	1,745E -09	1,891E -09	9,989E -04	4,600E -02	4,993E -02	4,992E -02
3	2,565E -09	1,758E -09	1,933E -09	1,001E -03	4,582E -02	4,993E -02	4,992E -02
4	2,575E -09	1,713E -09	1,907E -09	9,983E -04	4,621E -02	4,992E -02	4,992E -02
5	2,571E -09	1,762E -09	1,925E -09	9,999E -04	4,882E -02	4,992E -02	4,992E -02
6	2,487E -09	1,775E -09	1,925E -09	1,001E -03	4,793E -02	4,992E -02	4,992E -02
Statistics							
Min	2,487E -09	1,713E -09	1,891E -09	9,983E -04	4,582E -02	4,992E -02	4,992E -02
Max	2,634E -09	1,775E -09	1,933E -09	1,001E -03	4,882E -02	4,993E -02	4,992E -02
Mean	2,566E -09	1,751E -09	1,916E -09	9,997E -04	4,695E -02	4,993E -02	4,992E -02
Sigma	5,241E -11	2,380E -11	1,711E -11	1,045E -06	1,342E -03	2,682E -06	1,789E -06

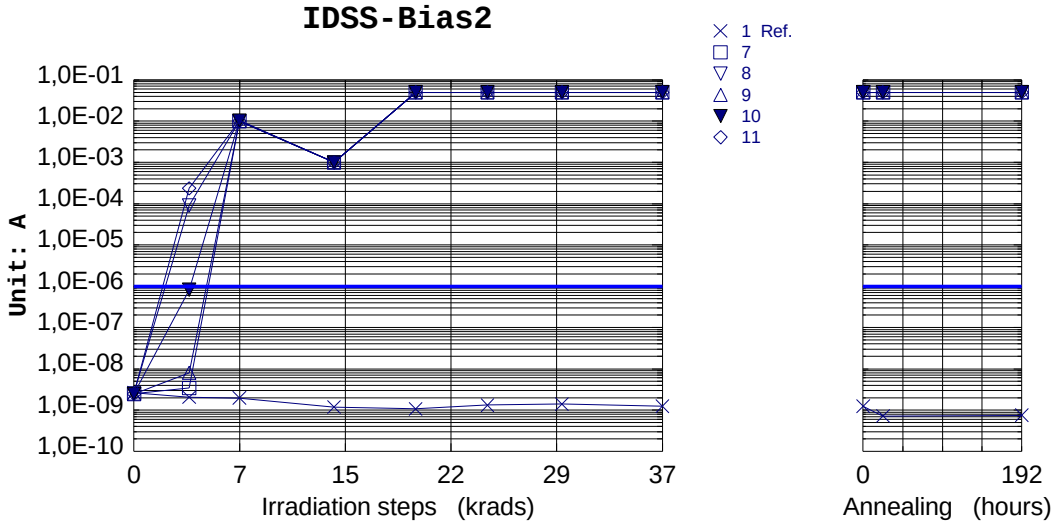
Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	1,240E -09	7,206E -10	7,494E -10
2	4,993E -02	4,993E -02	3,216E -02
3	4,993E -02	4,992E -02	3,347E -02
4	4,993E -02	4,992E -02	3,301E -02
5	4,993E -02	4,993E -02	3,473E -02
6	4,993E -02	4,993E -02	3,388E -02
Statistics			
Min	4,993E -02	4,992E -02	3,216E -02
Max	4,993E -02	4,993E -02	3,473E -02
Mean	4,993E -02	4,993E -02	3,345E -02
Sigma	3,032E -06	3,846E -06	9,580E -04



Parameter: Drain current: IDSS-Bias2 VGS=0V, VDS=200V
Unit= A
Spec limit max: 1E-6
Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	2,652E -09	2,054E -09	1,968E -09	1,187E -09	1,073E -09	1,325E -09	1,402E -09
7	2,508E -09	3,443E -09	9,983E -03	9,984E -04	4,999E -02	4,999E -02	4,998E -02
8	2,512E -09	9,022E -05	1,001E -02	9,996E -04	4,999E -02	4,999E -02	4,998E -02
9	2,447E -09	8,000E -09	1,008E -02	9,983E -04	4,999E -02	4,999E -02	4,999E -02
10	2,464E -09	8,190E -07	1,040E -02	9,996E -04	4,999E -02	4,999E -02	4,999E -02
11	2,457E -09	2,350E -04	1,000E -02	9,999E -04	4,999E -02	4,999E -02	4,998E -02
Statistics							
Min	2,447E -09	3,443E -09	9,983E -03	9,983E -04	4,999E -02	4,999E -02	4,998E -02
Max	2,512E -09	2,350E -04	1,040E -02	9,999E -04	4,999E -02	4,999E -02	4,999E -02
Mean	2,478E -09	6,522E -05	1,009E -02	9,992E -04	4,999E -02	4,999E -02	4,999E -02
Sigma	2,992E -11	1,026E -04	1,745E -04	7,367E -07	8,930E -07	8,946E -07	3,577E -06

Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	1,240E -09	7,206E -10	7,494E -10
7	4,999E -02	4,999E -02	4,999E -02
8	4,999E -02	4,999E -02	4,999E -02
9	4,999E -02	4,999E -02	4,998E -02
10	4,999E -02	4,999E -02	4,999E -02
11	4,999E -02	5,000E -02	4,998E -02
Statistics			
Min	4,999E -02	4,999E -02	4,998E -02
Max	4,999E -02	5,000E -02	4,999E -02
Mean	4,999E -02	4,999E -02	4,999E -02
Sigma	2,449E -06	2,608E -06	2,000E -06



Parameter: Static drain to source on-state resistance: RDSON-Bias1 **VGS=10V, ID=5A**

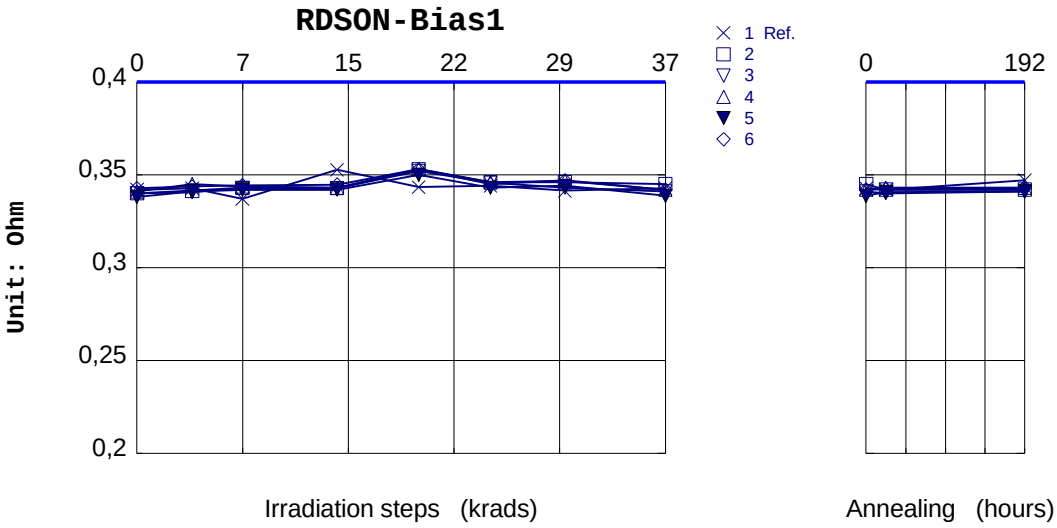
Unit= Ohm

Spec limit max: 0.4

Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	3,420E -01	3,427E -01	3,370E -01	3,527E -01	3,434E -01	3,440E -01	3,414E -01
2	3,400E -01	3,414E -01	3,430E -01	3,427E -01	3,530E -01	3,460E -01	3,460E -01
3	3,400E -01	3,407E -01	3,427E -01	3,427E -01	3,520E -01	3,457E -01	3,430E -01
4	3,410E -01	3,450E -01	3,437E -01	3,430E -01	3,530E -01	3,460E -01	3,467E -01
5	3,380E -01	3,410E -01	3,420E -01	3,420E -01	3,500E -01	3,430E -01	3,440E -01
6	3,427E -01	3,437E -01	3,444E -01	3,447E -01	3,530E -01	3,450E -01	3,470E -01
Statistics							
Min	3,380E -01	3,407E -01	3,420E -01	3,420E -01	3,500E -01	3,430E -01	3,430E -01
Max	3,427E -01	3,450E -01	3,444E -01	3,447E -01	3,530E -01	3,460E -01	3,470E -01
Mean	3,403E -01	3,423E -01	3,432E -01	3,430E -01	3,522E -01	3,451E -01	3,453E -01
Sigma	1,706E -03	1,897E -03	9,160E -04	1,002E -03	1,304E -03	1,263E -03	1,753E -03

Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	3,427E -01	3,420E -01	3,470E -01
2	3,450E -01	3,420E -01	3,420E -01
3	3,410E -01	3,400E -01	3,410E -01
4	3,420E -01	3,430E -01	3,430E -01
5	3,387E -01	3,407E -01	3,410E -01
6	3,420E -01	3,424E -01	3,427E -01
Statistics			
Min	3,387E -01	3,400E -01	3,410E -01
Max	3,450E -01	3,430E -01	3,430E -01
Mean	3,417E -01	3,416E -01	3,419E -01
Sigma	2,274E -03	1,236E -03	9,287E -04



Parameter: Static drain to source on-state resistance: RDSON-Bias2 **VGS=10V, ID=5A**

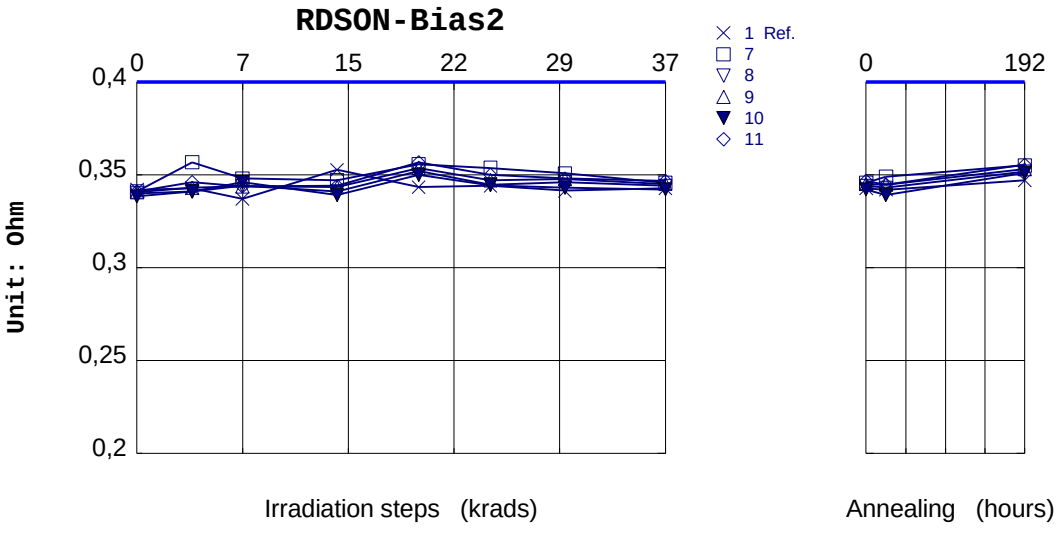
Unit= Ohm

Spec limit max: 0.4

Spec limits are represented in bold lines on the graphic.

Test Step	Initial	3,85 krads	7,35 krads	13,95 krads	19,65 krads	24,65 krads	29,85 krads
Serial #							
1 Ref.	3,420E -01	3,427E -01	3,370E -01	3,527E -01	3,434E -01	3,440E -01	3,414E -01
7	3,410E -01	3,567E -01	3,480E -01	3,470E -01	3,557E -01	3,537E -01	3,507E -01
8	3,400E -01	3,410E -01	3,440E -01	3,410E -01	3,520E -01	3,447E -01	3,460E -01
9	3,407E -01	3,430E -01	3,437E -01	3,434E -01	3,537E -01	3,470E -01	3,477E -01
10	3,384E -01	3,410E -01	3,460E -01	3,390E -01	3,500E -01	3,444E -01	3,430E -01
11	3,410E -01	3,460E -01	3,437E -01	3,440E -01	3,567E -01	3,500E -01	3,480E -01
Statistics							
Min	3,384E -01	3,410E -01	3,437E -01	3,390E -01	3,500E -01	3,444E -01	3,430E -01
Max	3,410E -01	3,567E -01	3,480E -01	3,470E -01	3,567E -01	3,537E -01	3,507E -01
Mean	3,402E -01	3,455E -01	3,451E -01	3,429E -01	3,536E -01	3,480E -01	3,471E -01
Sigma	1,114E -03	6,571E -03	1,899E -03	3,044E -03	2,724E -03	3,926E -03	2,835E -03

Test Step	36,85 krads	24 hours	192 hours
Serial #			
1 Ref.	3,427E -01	3,420E -01	3,470E -01
7	3,457E -01	3,490E -01	3,550E -01
8	3,440E -01	3,430E -01	3,517E -01
9	3,450E -01	3,447E -01	3,530E -01
10	3,421E -01	3,390E -01	3,510E -01
11	3,467E -01	3,447E -01	3,554E -01
Statistics			
Min	3,421E -01	3,390E -01	3,510E -01
Max	3,467E -01	3,490E -01	3,554E -01
Mean	3,447E -01	3,441E -01	3,532E -01
Sigma	1,751E -03	3,603E -03	1,955E -03



8 Conclusion

A total dose radiation verification test has been performed on SP200V N-Channel Power Mosfet from Philips Semiconductors up to 36.85 Krad(Si) accumulated dose.

Breakdown voltage is marginal at 3.85 Krad(Si) and out of specification limit at 7.35 Krad(Si) under Bias 1 conditions, and did not recover for subsequent steps.
Under Bias 2 conditions, Breakdown voltage is out of specification limit at 13.95 Krad(Si) and no further recovery is observed.

IDSS, under Bias 2 conditions, increases significantly for most samples at a dose as low as 3.85 Krad(Si) and up to the compliance value of 50mA without further recovery.

IDSS, under Bias 1 conditions, increases dramatically up to the compliance value of 50mA at a dose level of 13.95 Krad(Si) and subsequent steps, without recovery.

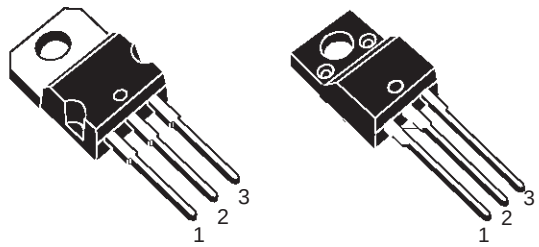
ANNEX 1 : SP200V DATA SHEET

IRF630
IRF630FP

N - CHANNEL 200V - 0.35Ω - 9A - TO-220/FP
MESH OVERLAY™ MOSFET

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
IRF630	200 V	< 0.40 Ω	9 A
IRF630FP	200 V	< 0.40 Ω	9 A

- TYPICAL $R_{DS(on)}$ = 0.35 Ω
- EXTREMELY HIGH dV/dt CAPABILITY
- VERY LOW INTRINSIC CAPACITANCES
- GATE CHARGE MINIMIZED



TO-220 **TO-220FP**

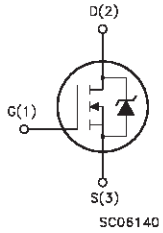
DESCRIPTION

This power MOSFET is designed using he company's consolidated strip layout-based MESH OVERLAY™ process. This technology matches and improves the performances compared with standard parts from various sources.

APPLICATIONS

- HIGH CURRENT SWITCHING
- UNINTERRUPTIBLE POWER SUPPLY (UPS)
- DC/DC COVERTERS FOR TELECOM, INDUSTRIAL, AND LIGHTING EQUIPMENT.

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value		Unit
		IRF630	IRF630FP	
V_{DS}	Drain-source Voltage (V_{GS} = 0)	200		V
V_{DGR}	Drain- gate Voltage (R_{GS} = 20 kΩ)	200		V
V_{GS}	Gate-source Voltage	± 20		V
I_D	Drain Current (continuous) at T_c = 25 °C	9	9(**)	A
I_D	Drain Current (continuous) at T_c = 100 °C	5.7	5.7(**)	A
I_{DM}(•)	Drain Current (pulsed)	36	36	A
P_{tot}	Total Dissipation at T_c = 25 °C	75	25	W
	Derating Factor	0.6	0.20	W/°C
dv/dt(1)	Peak Diode Recovery voltage slope	5	5	V/ns
V_{ISO}	Insulation Withstand Voltage (DC)	—	2000	V
T_{stg}	Storage Temperature	-65 to 150		°C
T_j	Max. Operating Junction Temperature	150		°C

(•) Pulse width limited by safe operating area (1) $I_{SD} \leq 9A$, $di/dt \leq 300$ A/µs, $V_{DD} \leq V_{(BR)DSS}$, $Tj \leq T_{JMAX}$

First Digit of the Datecode Being Z or K Identifies Silicon Characterized in this Datasheet

(**) Limited only by Maximum Temperature Allowed

THERMAL DATA

			TO-220	TO-220FP	
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	1.67	4.17	°C/W
$R_{thj\text{-}amb}$	Thermal Resistance Junction-ambient	Max	62.5		°C/W
$R_{thc\text{-}sink}$	Thermal Resistance Case-sink	Typ	0.5		°C/W
T_l	Maximum Lead Temperature For Soldering Purpose		300		°C

AVALANCHE CHARACTERISTICS

Symbol	Parameter	Max Value	Unit
I_{AR}	Avalanche Current, Repetitive or Not-Repetitive (pulse width limited by T_j max)	9	A
E_{AS}	Single Pulse Avalanche Energy (starting T_j = 25 °C, $I_D = I_{AR}$, V_{DD} = 50 V)	160	mJ

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source Breakdown Voltage	I_D = 250 µA V_{GS} = 0	200			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating T_c = 125 °C			1 50	µA µA
I_{GSS}	Gate-body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 100	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 250 µA	2	3	4	V
$R_{DS(on)}$	Static Drain-source On Resistance	V_{GS} = 10V I_D = 5 A		0.35	0.40	Ω
$I_{D(on)}$	On State Drain Current	V_{DS} > $I_{D(on)}$ x $R_{DS(on)max}$ V_{GS} = 10 V	10			A

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs} (*)	Forward Transconductance	V_{DS} > $I_{D(on)}$ x $R_{DS(on)max}$ I_D = 5 A	3	4		S
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0		540 90 35	700 120 50	pF pF pF

ELECTRICAL CHARACTERISTICS (continued)

SWITCHING ON

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r	Turn-on Time Rise Time	V_{DD} = 100 V I_D = 4.5 A R_G = 4.7 Ω V_{GS} = 10 V (see test circuit, figure 3)		10 15	14 20	ns ns
Q_g Q_{gs} Q_{gd}	Total Gate Charge Gate-Source Charge Gate-Drain Charge	V_{DD} = 160 V I_D = 9 A V_{GS} = 10 V		31 7.5 9	45	nC nC nC

SWITCHING OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{r(Voff)}$ t_f t_c	Off-voltage Rise Time Fall Time Cross-over Time	V_{DD} = 160 V I_D = 9 A R_G = 4.7 Ω V_{GS} = 10 V (see test circuit, figure 5)		12 12 25	17 17 35	ns ns ns

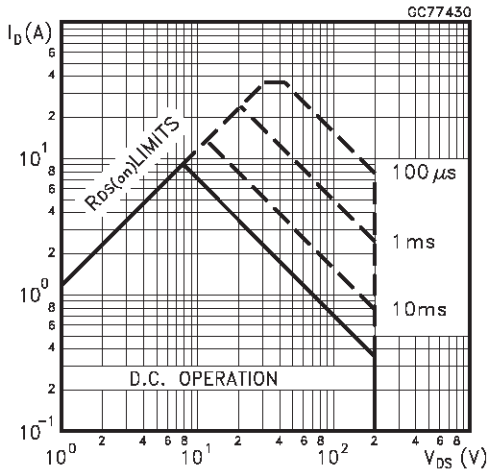
SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-drain Current Source-drain Current (pulsed)				9 36	A A
V_{SD} (*)	Forward On Voltage	I_{SD} = 9 A V_{GS} = 0			1.5	V
t_{rr} Q_{rr} I_{RRM}	Reverse Recovery Time Reverse Recovery Charge Reverse Recovery Current	I_{SD} = 9 A di/dt = 100 A/µs V_{DD} = 50 V T_j = 150 °C (see test circuit, figure 5)		170 0.95 11		ns µC A

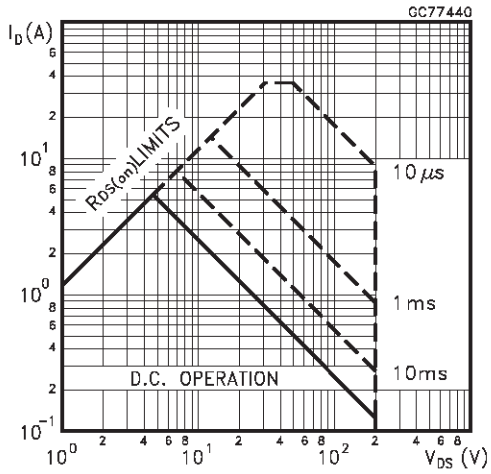
(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

(•) Pulse width limited by safe operating area

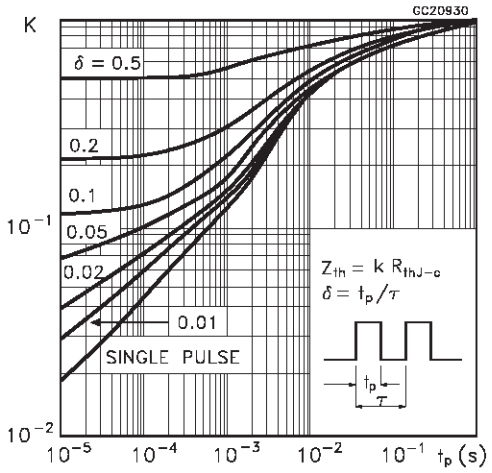
Safe Operating Area for TO-220



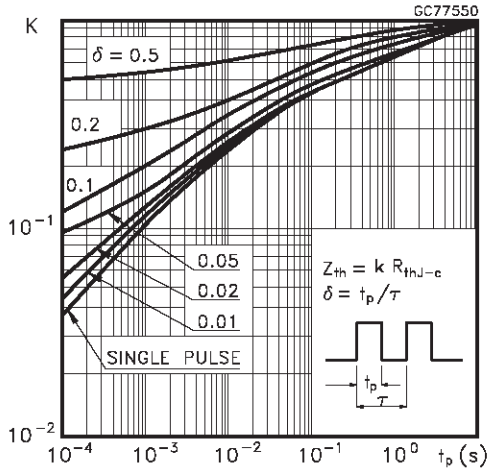
Safe Operating Area for TO-220FP



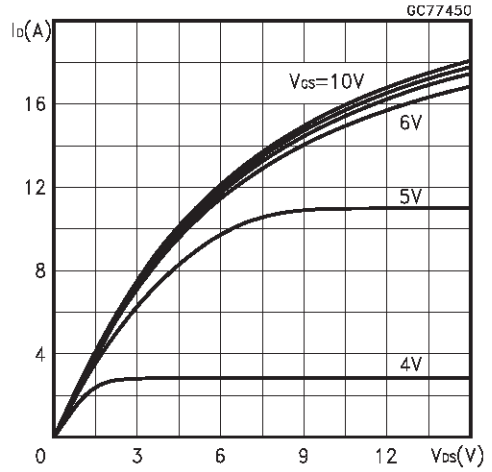
Thermal Impedance for TO-220



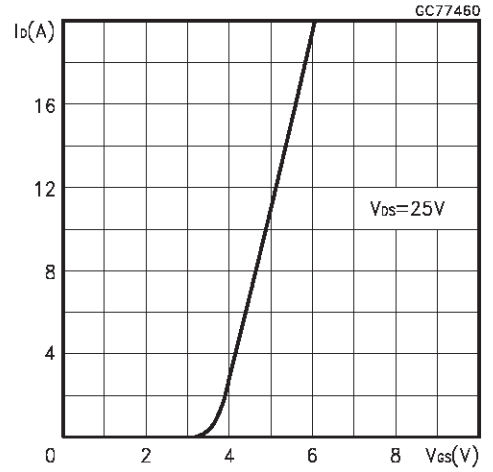
Thermal Impedance for TO-220FP



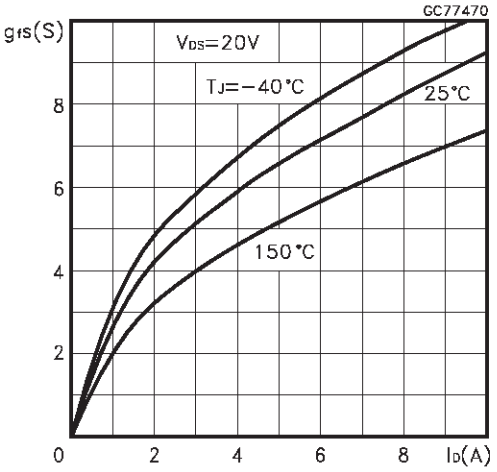
Output Characteristics



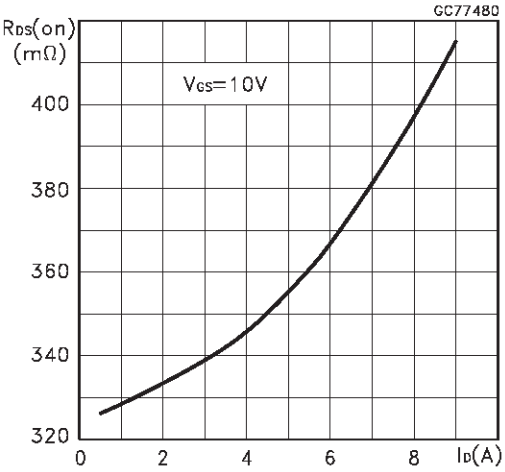
Transfer Characteristics



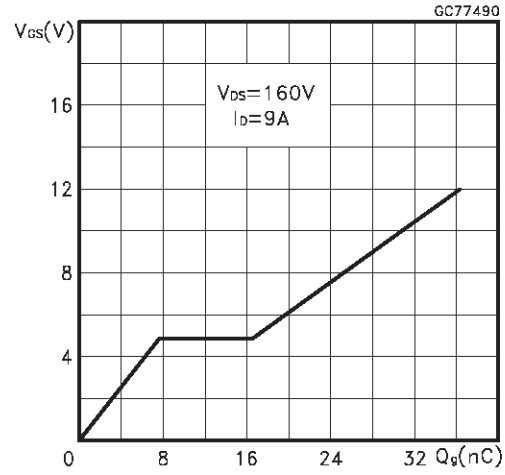
Transconductance



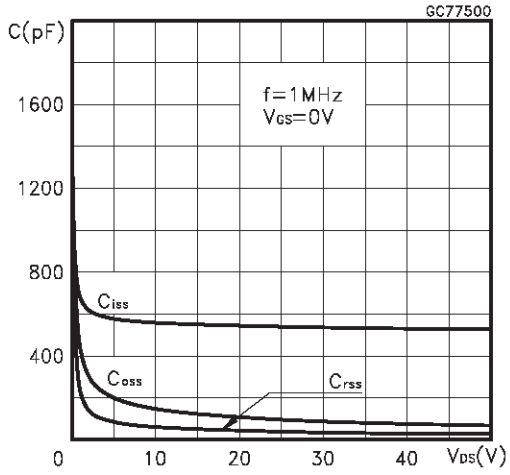
Static Drain-source On Resistance



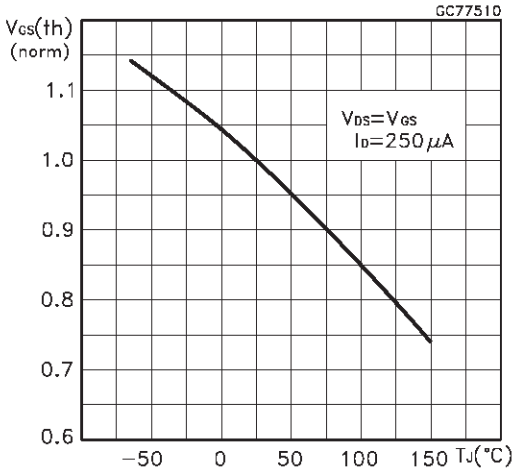
Gate Charge vs Gate-source Voltage



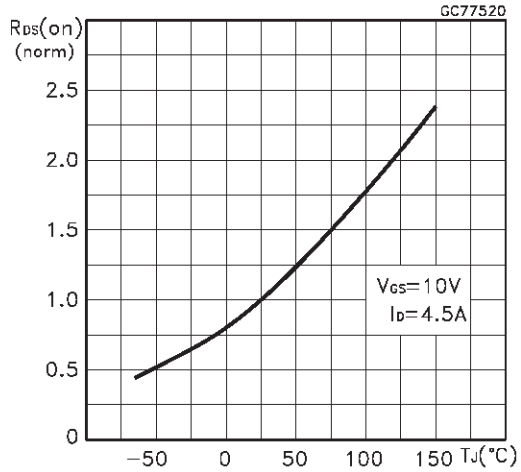
Capacitance Variations



Normalized Gate Threshold Voltage vs Temperature



Normalized On Resistance vs Temperature



Source-drain Diode Forward Characteristics

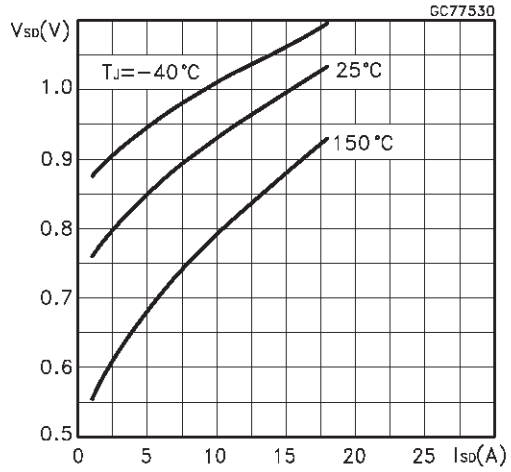


Fig. 1: Unclamped Inductive Load Test Circuit

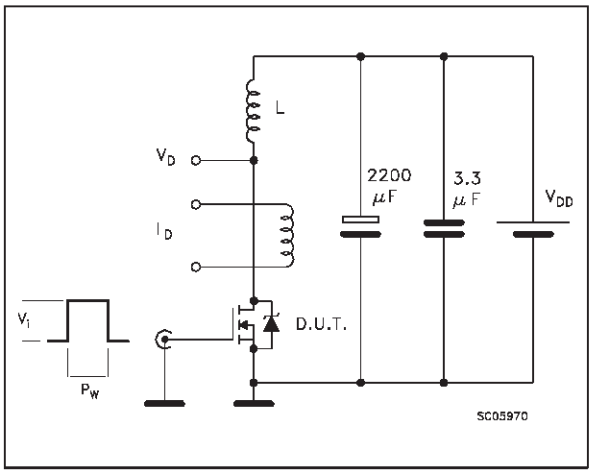


Fig. 2: Unclamped Inductive Waveform

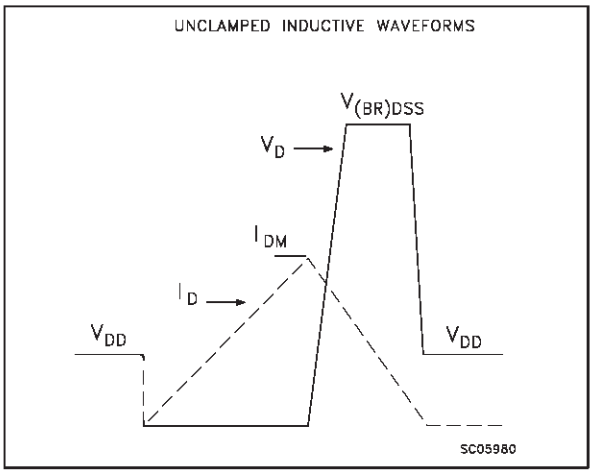


Fig. 3: Switching Times Test Circuits For Resistive Load

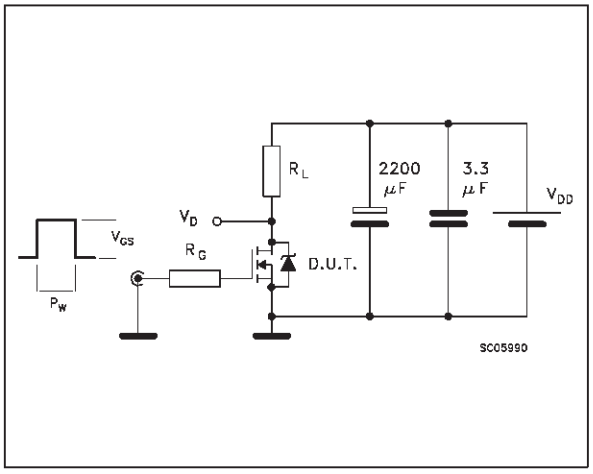


Fig. 4: Gate Charge test Circuit

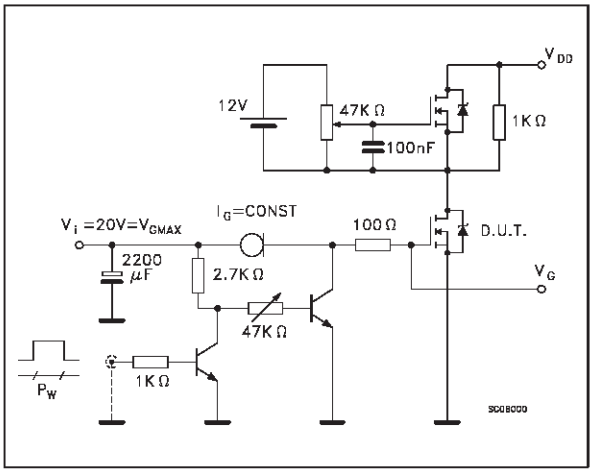
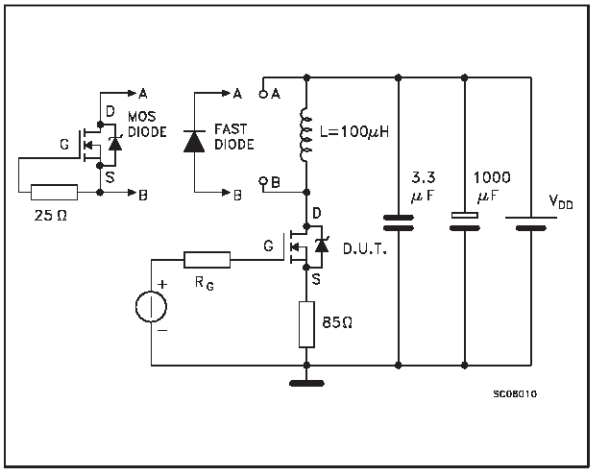
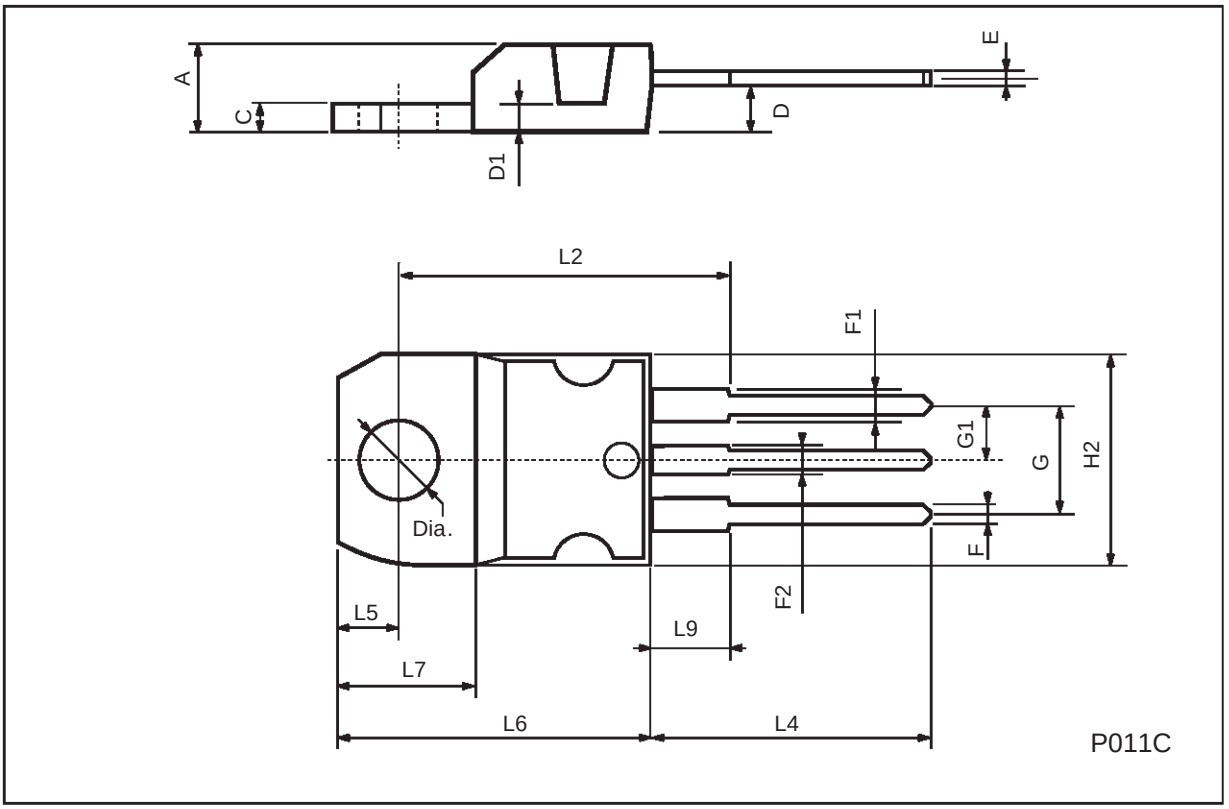


Fig. 5: Test Circuit For Inductive Load Switching And Diode Recovery Times



TO-220 MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
C	1.23		1.32	0.048		0.051
D	2.40		2.72	0.094		0.107
D1		1.27			0.050	
E	0.49		0.70	0.019		0.027
F	0.61		0.88	0.024		0.034
F1	1.14		1.70	0.044		0.067
F2	1.14		1.70	0.044		0.067
G	4.95		5.15	0.194		0.203
G1	2.4		2.7	0.094		0.106
H2	10.0		10.40	0.393		0.409
L2		16.4			0.645	
L4	13.0		14.0	0.511		0.551
L5	2.65		2.95	0.104		0.116
L6	15.25		15.75	0.600		0.620
L7	6.2		6.6	0.244		0.260
L9	3.5		3.93	0.137		0.154
DIA.	3.75		3.85	0.147		0.151



TO-220FP MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.4		4.6	0.173		0.181
B	2.5		2.7	0.098		0.106
D	2.5		2.75	0.098		0.108
E	0.45		0.7	0.017		0.027
F	0.75		1	0.030		0.039
F1	1.15		1.7	0.045		0.067
F2	1.15		1.7	0.045		0.067
G	4.95		5.2	0.195		0.204
G1	2.4		2.7	0.094		0.106
H	10		10.4	0.393		0.409
L2		16			0.630	
L3	28.6		30.6	1.126		1.204
L4	9.8		10.6	0.385		0.417
L6	15.9		16.4	0.626		0.645
L7	9		9.3	0.354		0.366
Ø	3		3.2	0.118		0.126