



TOTAL DOSE RADIATION TEST REPORT

Part Type : BUK456-200A

Package : TO-220AB

N-Channel Power MOSFET

Philips Semiconductors

Report Reference : ESA_QCA990902T_C

Issue : 01

Date : July 1st 1999

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

European Space Agency Contract Report

The work described in this report was done under ESA contract.
Responsibility for the contents resides in the author or organization that prepared it

ESTEC Technical Officer: R. Harboe Sorensen

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|--------------------------|-------------|------------|--------|---------------------------|
| Hirex reference : | HRX/99.4561 | Issue : 01 | Date : | July 1 st 1999 |
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| Approved by : | F.X GUERRE | | Date : | |

TOTAL DOSE RADIATION TEST REPORT
on
Philips Semiconductors BUK456-200A N-Channel Power Mosfet.

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| HIREX Engineering | Total Dose Test Report | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors |

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 | |
| Siemens | BUZ100S | ESA_QCA990906T_C | ESA_QCA990906S_C |
| Siemens | BUZ100SL | ESA_QCA990907T_C | ESA_QCA990907S_C |
| Siemens | 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 |
| Siemens | SPP1N60S5 | ESA_QCA9909012T_C | ESA_QCA9909012S_C |
| Philips | BUK7508-55 | ESA_QCA9909013T_C | ESA_QCA9909013S_C |
| Harris | HUF75639P3 | ESA_QCA9909014T_C | ESA_QCA9909014S_C |

| | | | |
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2 Introduction

A total dose radiation evaluation test of the Philips Semiconductors BUK456-200A 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_QCA990902S_C

3 Applicable and Reference Documents

3.1 Applicable Documents

- ESA/SCC Basic specification N° 22900 issue 4
- Philips Semiconductors 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 BUK456-200A device were tested (2 groups of 5 + 1 control sample). The samples were serialized before the radiation test as indicated in the following table.

| Serial Number | Allocation |
|---------------|------------|
| 1 | Control |
| 2 | Bias 1 |
| 3 | Bias 1 |
| 4 | Bias 1 |
| 5 | Bias 1 |
| 6 | Bias 1 |
| 7 | Bias 2 |
| 8 | Bias 2 |
| 9 | Bias 2 |
| 10 | Bias 2 |
| 11 | Bias 2 |

Identification of the BUK456-200A is given below:

| | | | |
|-----------------------|-------------------------------------|----------------------|-------------|
| Part Number: | BUK456-200A | Mask Set: | NA |
| Top Marking: | BUL456-200A PH-m9616 Philippines | Chip Marking: | NA |
| Diffusion Lot: | NA | Wafer #: | NA |
| Date Code: | 9616 | Project: | Not Defined |

| | | | |
|--------------------------|-------------------------------|----------------|----------------------------------|
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| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors |

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 V_{GS} 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.

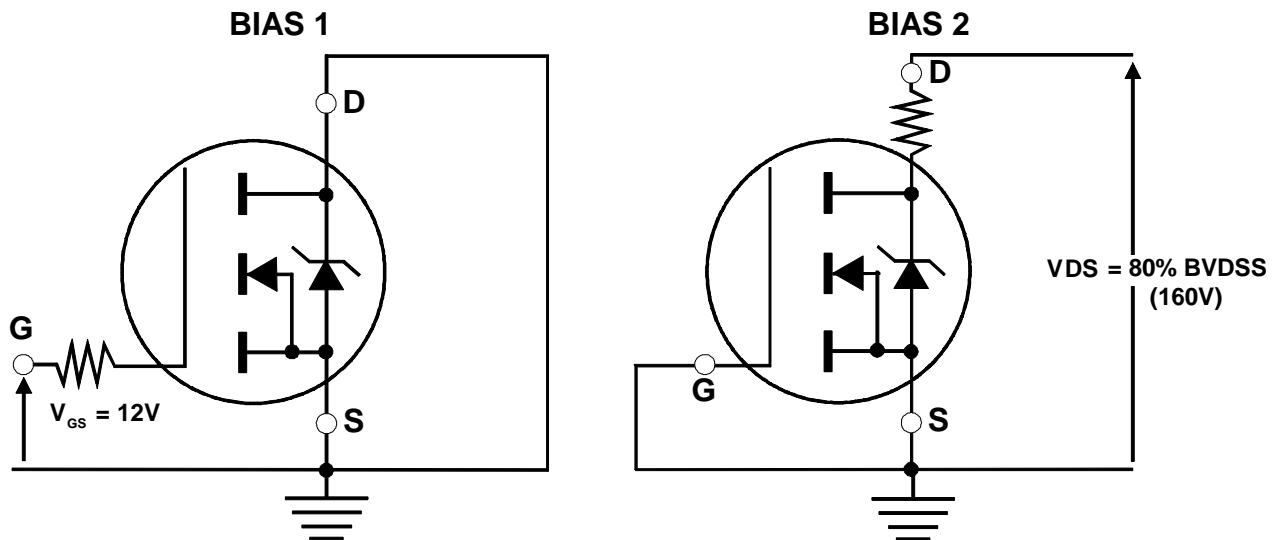


Figure 1 : Bias Conditions during Irradiation Exposures and Annealing

| | | | |
|--------------------------|-------------------------------|----------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors |

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.

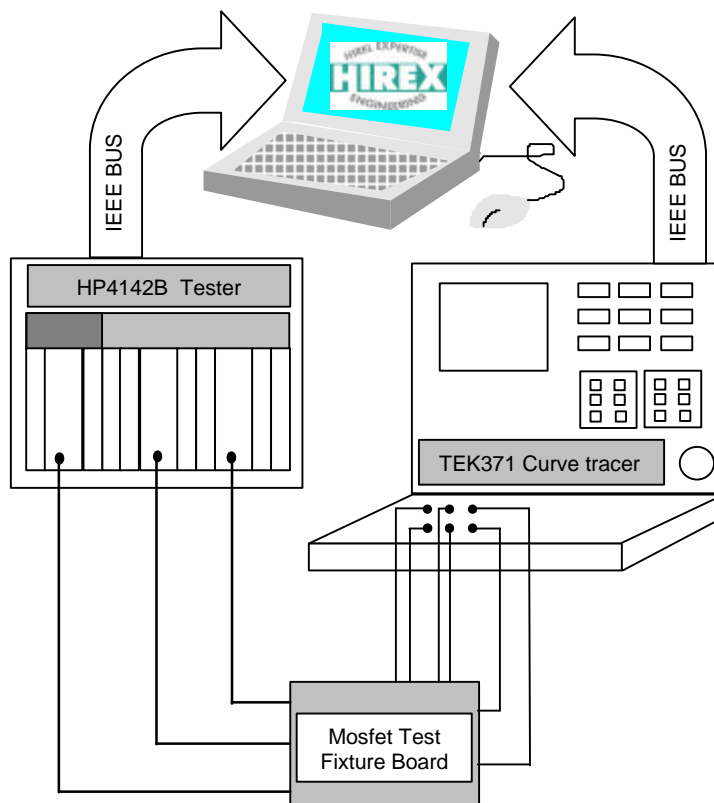
Two instruments were used to cover low power and high power measurements respectively. HP4142B was used for breakdown voltage, gate and drain leakage currents, and threshold voltage measurements.

Tektronix TEK371 high power curve tracer was used for $R_{DS(ON)}$ 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. GPIB 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



| | | | |
|--------------------------|-------------------------------|----------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | Réf. : HRX/99.4561 Issue : 01 |
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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=1mA | 2.1 | 4 | V |
| +IGSS | Positive Gate Source leakage current | VGS=+30V, VDS=0V | | 100 | nA |
| -IGSS | Negative Gate Source leakage current | VGS=-30V, VDS=0V | | 100 | nA |
| IDSS | Drain current | VGS=0V, VDS=200V | | 10 | μA |
| RDSON | Static drain to source on-state resistance | VGS=10V, ID=10A | | 0.16 | Ohm |

Table 1 : Measured electrical parameters

| | | | |
|--------------------------|-------------------------------|----------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors |

6 Test Summary

A Total Ionizing Dose assessment was carried out by Hirex Engineering under ESA contract on the Philips Semiconductors BUK456-200A 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 (\geq Krad) - Bias 1:

Parametric Tolerance Level (\geq Krad) - Bias 2:

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

Main conclusion:

Two pieces (#2 and #3) exhibit high gate and drain to source leakage currents and consequently very low breakdown voltage, during annealing steps under Bias 1 conditions. Breakdown voltage is out of specification limit at 13.95 Krad(Si) under Bias 2 conditions, and a recovery is observed after 168 hours annealing step.

Threshold voltage is out of specification at 29.85 Krad(Si) under Bias 1 conditions, but a recovery is observed after 168 hours annealing step.

Threshold voltage is out of specification at 19.65 Krad(Si) under Bias 2 conditions, but a recovery is also observed after 168 hours annealing step.

| | | | | |
|--------------------------|-------------------------------|----------------|------------------------|----------------------------------|
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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

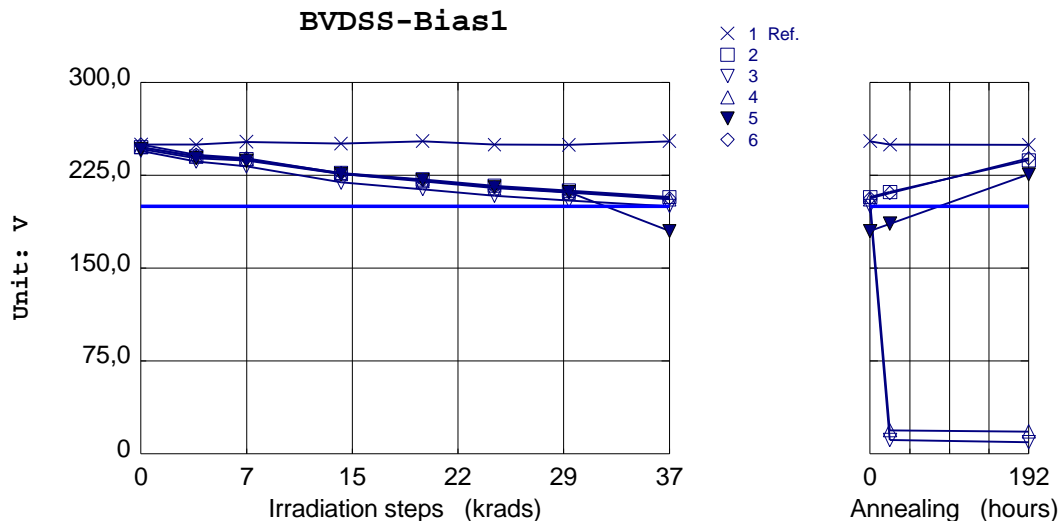
Unit= V

Spec limit min: 200

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 2,498E +02 | 2,497E +02 | 2,520E +02 | 2,505E +02 | 2,524E +02 | 2,497E +02 | 2,495E +02 |
| 2 | 2,476E +02 | 2,401E +02 | 2,380E +02 | 2,268E +02 | 2,216E +02 | 2,165E +02 | 2,126E +02 |
| 3 | 2,448E +02 | 2,361E +02 | 2,321E +02 | 2,191E +02 | 2,136E +02 | 2,083E +02 | 2,045E +02 |
| 4 | 2,479E +02 | 2,401E +02 | 2,378E +02 | 2,259E +02 | 2,201E +02 | 2,147E +02 | 2,109E +02 |
| 5 | 2,460E +02 | 2,387E +02 | 2,366E +02 | 2,258E +02 | 2,209E +02 | 2,153E +02 | 2,113E +02 |
| 6 | 2,498E +02 | 2,416E +02 | 2,387E +02 | 2,267E +02 | 2,210E +02 | 2,153E +02 | 2,114E +02 |
| Statistics | | | | | | | |
| Min | 2,448E +02 | 2,361E +02 | 2,321E +02 | 2,191E +02 | 2,136E +02 | 2,083E +02 | 2,045E +02 |
| Max | 2,498E +02 | 2,416E +02 | 2,387E +02 | 2,268E +02 | 2,216E +02 | 2,165E +02 | 2,126E +02 |
| Mean | 2,472E +02 | 2,393E +02 | 2,366E +02 | 2,249E +02 | 2,194E +02 | 2,140E +02 | 2,101E +02 |
| Sigma | 1,919E +00 | 2,056E +00 | 2,657E +00 | 3,265E +00 | 3,302E +00 | 3,255E +00 | 3,221E +00 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 2,525E +02 | 2,497E +02 | 2,495E +02 |
| 2 | 2,074E +02 | 2,115E +02 | 2,370E +02 |
| 3 | 2,000E +02 | 1,120E +01 | 9,430E +00 |
| 4 | 2,055E +02 | 1,895E +01 | 1,809E +01 |
| 5 | 1,799E +02 | 1,858E +02 | 2,257E +02 |
| 6 | 2,063E +02 | 2,106E +02 | 2,386E +02 |
| Statistics | | | |
| Min | 1,799E +02 | 1,120E +01 | 9,430E +00 |
| Max | 2,074E +02 | 2,114E +02 | 2,386E +02 |
| Mean | 1,998E +02 | 1,276E +02 | 1,458E +02 |
| Sigma | 1,149E +01 | 1,033E +02 | 1,206E +02 |



| | | | | |
|--------------------------|-------------------------------|----------------|------------------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors | |

Parameter: Drain to source breakdown voltage: BVDSS-Bias2 VGS=0V, ID=0.25mA

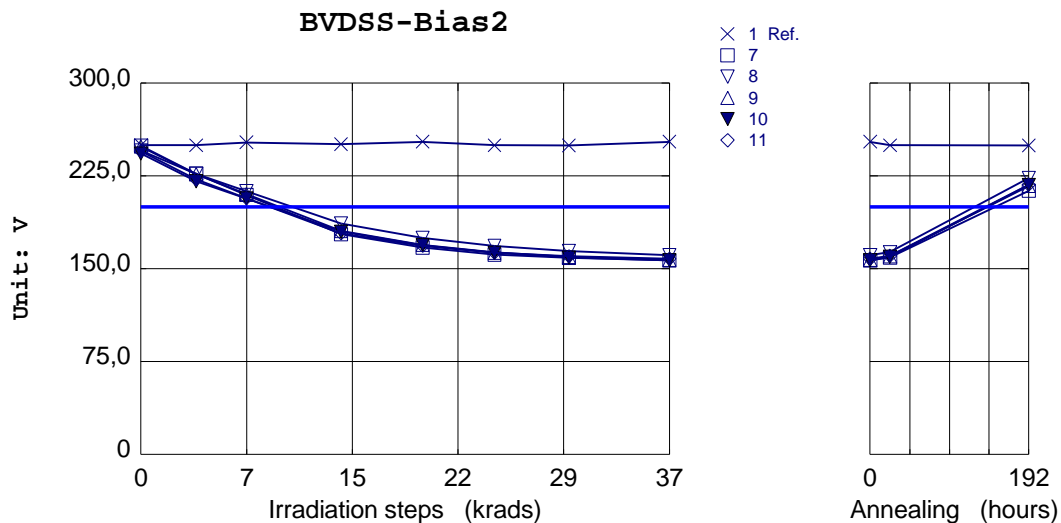
Unit= V

Spec limit min: 200

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 2,498E +02 | 2,497E +02 | 2,520E +02 | 2,505E +02 | 2,524E +02 | 2,497E +02 | 2,495E +02 |
| 7 | 2,493E +02 | 2,267E +02 | 2,096E +02 | 1,777E +02 | 1,671E +02 | 1,613E +02 | 1,586E +02 |
| 8 | 2,454E +02 | 2,266E +02 | 2,125E +02 | 1,864E +02 | 1,749E +02 | 1,683E +02 | 1,643E +02 |
| 9 | 2,486E +02 | 2,262E +02 | 2,102E +02 | 1,804E +02 | 1,691E +02 | 1,630E +02 | 1,596E +02 |
| 10 | 2,429E +02 | 2,205E +02 | 2,065E +02 | 1,798E +02 | 1,689E +02 | 1,628E +02 | 1,590E +02 |
| 11 | 2,448E +02 | 2,221E +02 | 2,068E +02 | 1,786E +02 | 1,685E +02 | 1,629E +02 | 1,600E +02 |
| Statistics | | | | | | | |
| Min | 2,429E +02 | 2,205E +02 | 2,065E +02 | 1,777E +02 | 1,671E +02 | 1,613E +02 | 1,586E +02 |
| Max | 2,493E +02 | 2,267E +02 | 2,125E +02 | 1,864E +02 | 1,749E +02 | 1,683E +02 | 1,643E +02 |
| Mean | 2,462E +02 | 2,244E +02 | 2,091E +02 | 1,806E +02 | 1,697E +02 | 1,637E +02 | 1,603E +02 |
| Sigma | 2,683E +00 | 2,908E +00 | 2,496E +00 | 3,406E +00 | 3,014E +00 | 2,688E +00 | 2,291E +00 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 2,525E +02 | 2,497E +02 | 2,495E +02 |
| 7 | 1,566E +02 | 1,590E +02 | 2,129E +02 |
| 8 | 1,609E +02 | 1,633E +02 | 2,232E +02 |
| 9 | 1,572E +02 | 1,599E +02 | 2,168E +02 |
| 10 | 1,567E +02 | 1,596E +02 | 2,175E +02 |
| 11 | 1,580E +02 | 1,605E +02 | 2,178E +02 |
| Statistics | | | |
| Min | 1,566E +02 | 1,590E +02 | 2,129E +02 |
| Max | 1,609E +02 | 1,633E +02 | 2,232E +02 |
| Mean | 1,579E +02 | 1,604E +02 | 2,176E +02 |
| Sigma | 1,788E +00 | 1,676E +00 | 3,705E +00 |



| | | | | |
|-------------------|------------------------|----------------|------------------------|--------------------|
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Parameter: Gate to source threshold voltage: VGSTH-Bias1 VDS>=VGS, ID=1mA

Unit= V

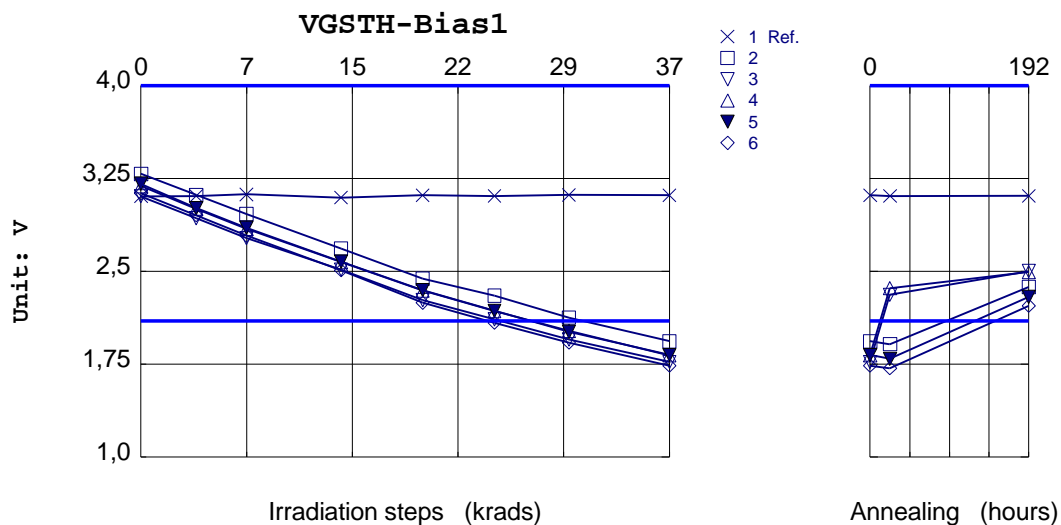
Spec limit max: 4

Spec limit min: 2.1

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 3,106E +00 | 3,107E +00 | 3,121E +00 | 3,095E +00 | 3,115E +00 | 3,108E +00 | 3,117E +00 |
| 2 | 3,287E +00 | 3,117E +00 | 2,962E +00 | 2,684E +00 | 2,440E +00 | 2,303E +00 | 2,126E +00 |
| 3 | 3,104E +00 | 2,928E +00 | 2,768E +00 | 2,512E +00 | 2,267E +00 | 2,112E +00 | 1,949E +00 |
| 4 | 3,188E +00 | 3,005E +00 | 2,843E +00 | 2,574E +00 | 2,344E +00 | 2,179E +00 | 2,019E +00 |
| 5 | 3,207E +00 | 3,010E +00 | 2,851E +00 | 2,577E +00 | 2,348E +00 | 2,181E +00 | 2,011E +00 |
| 6 | 3,130E +00 | 2,954E +00 | 2,789E +00 | 2,508E +00 | 2,246E +00 | 2,084E +00 | 1,923E +00 |
| Statistics | | | | | | | |
| Min | 3,104E +00 | 2,928E +00 | 2,768E +00 | 2,508E +00 | 2,246E +00 | 2,084E +00 | 1,923E +00 |
| Max | 3,287E +00 | 3,117E +00 | 2,962E +00 | 2,684E +00 | 2,440E +00 | 2,303E +00 | 2,126E +00 |
| Mean | 3,183E +00 | 3,003E +00 | 2,843E +00 | 2,571E +00 | 2,329E +00 | 2,172E +00 | 2,006E +00 |
| Sigma | 7,138E -02 | 7,269E -02 | 7,558E -02 | 7,098E -02 | 7,684E -02 | 8,444E -02 | 7,847E -02 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 3,114E +00 | 3,107E +00 | 3,109E +00 |
| 2 | 1,935E +00 | 1,911E +00 | 2,373E +00 |
| 3 | 1,768E +00 | 2,310E +00 | 2,502E +00 |
| 4 | 1,820E +00 | 2,364E +00 | 2,494E +00 |
| 5 | 1,824E +00 | 1,793E +00 | 2,293E +00 |
| 6 | 1,739E +00 | 1,718E +00 | 2,223E +00 |
| Statistics | | | |
| Min | 1,739E +00 | 1,718E +00 | 2,223E +00 |
| Max | 1,935E +00 | 2,364E +00 | 2,502E +00 |
| Mean | 1,817E +00 | 2,019E +00 | 2,377E +00 |
| Sigma | 7,484E -02 | 2,987E -01 | 1,225E -01 |



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| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors | |

Parameter: Gate to source threshold voltage: VGSTH-Bias2 **VDS>=VGS, ID=1mA**

Unit= V

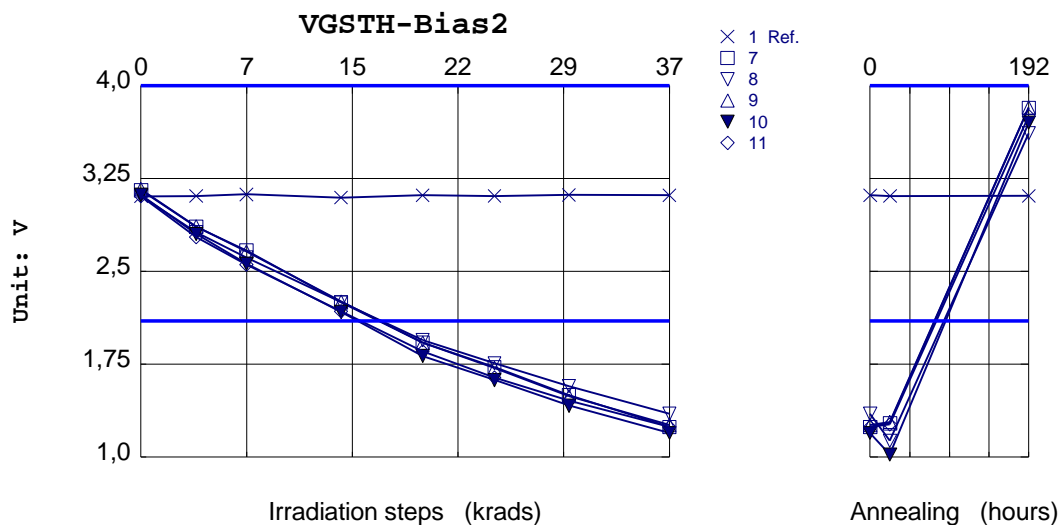
Spec limit max: 4

Spec limit min: 2.1

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 3,106E +00 | 3,107E +00 | 3,121E +00 | 3,095E +00 | 3,115E +00 | 3,108E +00 | 3,117E +00 |
| 7 | 3,154E +00 | 2,859E +00 | 2,668E +00 | 2,248E +00 | 1,922E +00 | 1,726E +00 | 1,501E +00 |
| 8 | 3,110E +00 | 2,815E +00 | 2,612E +00 | 2,250E +00 | 1,944E +00 | 1,758E +00 | 1,572E +00 |
| 9 | 3,164E +00 | 2,862E +00 | 2,659E +00 | 2,256E +00 | 1,922E +00 | 1,720E +00 | 1,492E +00 |
| 10 | 3,117E +00 | 2,802E +00 | 2,561E +00 | 2,172E +00 | 1,815E +00 | 1,622E +00 | 1,415E +00 |
| 11 | 3,106E +00 | 2,776E +00 | 2,553E +00 | 2,177E +00 | 1,853E +00 | 1,642E +00 | 1,454E +00 |
| Statistics | | | | | | | |
| Min | 3,106E +00 | 2,776E +00 | 2,553E +00 | 2,172E +00 | 1,815E +00 | 1,622E +00 | 1,415E +00 |
| Max | 3,164E +00 | 2,862E +00 | 2,668E +00 | 2,256E +00 | 1,944E +00 | 1,758E +00 | 1,572E +00 |
| Mean | 3,130E +00 | 2,823E +00 | 2,611E +00 | 2,221E +00 | 1,891E +00 | 1,693E +00 | 1,487E +00 |
| Sigma | 2,654E -02 | 3,711E -02 | 5,332E -02 | 4,217E -02 | 5,482E -02 | 5,845E -02 | 5,866E -02 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 3,114E +00 | 3,107E +00 | 3,109E +00 |
| 7 | 1,243E +00 | 1,273E +00 | 3,819E +00 |
| 8 | 1,349E +00 | 1,132E +00 | 3,614E +00 |
| 9 | 1,258E +00 | 1,283E +00 | 3,824E +00 |
| 10 | 1,194E +00 | 1,021E +00 | 3,700E +00 |
| 11 | 1,242E +00 | 1,263E +00 | 3,755E +00 |
| Statistics | | | |
| Min | 1,194E +00 | 1,021E +00 | 3,614E +00 |
| Max | 1,349E +00 | 1,283E +00 | 3,824E +00 |
| Mean | 1,257E +00 | 1,194E +00 | 3,742E +00 |
| Sigma | 5,682E -02 | 1,150E -01 | 8,792E -02 |



| | | | | |
|--------------------------|-------------------------------|----------------|------------------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors | |

Parameter: Positive Gate source leakage current: +IGSS-Bias1 VGS=+30V, VDS=0V

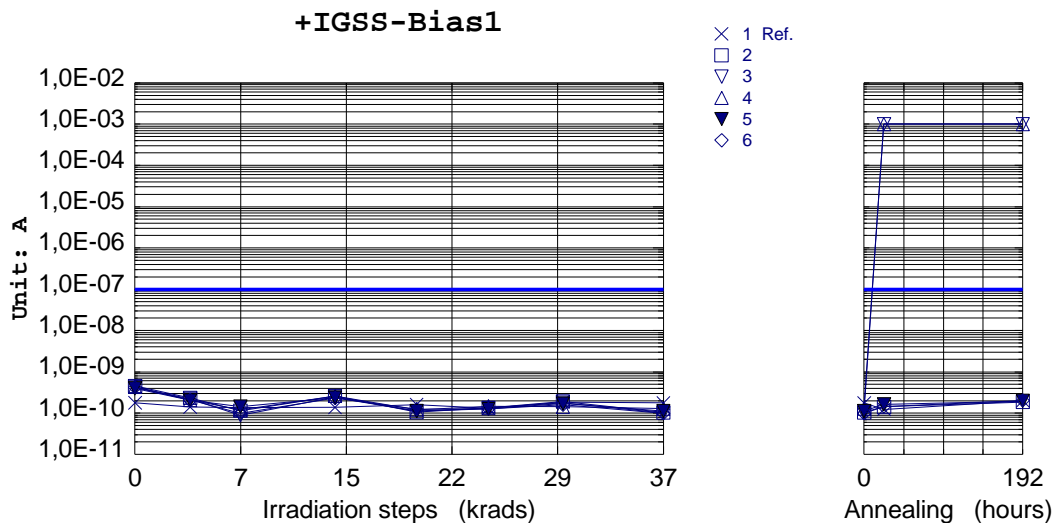
Unit= A

Spec limit max: 100E-9

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 1,782E -10 | 1,401E -10 | 1,353E -10 | 1,373E -10 | 1,596E -10 | 1,316E -10 | 1,868E -10 |
| 2 | 4,576E -10 | 2,352E -10 | 1,152E -10 | 2,600E -10 | 1,058E -10 | 1,340E -10 | 1,914E -10 |
| 3 | 4,247E -10 | 2,205E -10 | 8,892E -11 | 2,480E -10 | 1,121E -10 | 1,337E -10 | 1,776E -10 |
| 4 | 4,365E -10 | 2,094E -10 | 1,213E -10 | 2,593E -10 | 1,202E -10 | 1,472E -10 | 1,419E -10 |
| 5 | 3,961E -10 | 2,047E -10 | 1,432E -10 | 2,370E -10 | 1,118E -10 | 1,259E -10 | 1,697E -10 |
| 6 | 4,196E -10 | 2,096E -10 | 9,904E -11 | 2,320E -10 | 1,241E -10 | 1,274E -10 | 1,589E -10 |
| Statistics | | | | | | | |
| Min | 3,961E -10 | 2,047E -10 | 8,892E -11 | 2,320E -10 | 1,058E -10 | 1,259E -10 | 1,419E -10 |
| Max | 4,576E -10 | 2,352E -10 | 1,432E -10 | 2,600E -10 | 1,241E -10 | 1,472E -10 | 1,914E -10 |
| Mean | 4,269E -10 | 2,159E -10 | 1,135E -10 | 2,472E -10 | 1,148E -10 | 1,337E -10 | 1,679E -10 |
| Sigma | 2,258E -11 | 1,228E -11 | 2,098E -11 | 1,273E -11 | 7,300E -12 | 8,421E -12 | 1,872E -11 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 1,753E -10 | 1,233E -10 | 1,985E -10 |
| 2 | 1,043E -10 | 1,415E -10 | 1,853E -10 |
| 3 | 1,000E -10 | 1,000E -03 | 1,000E -03 |
| 4 | 1,280E -10 | 1,000E -03 | 1,000E -03 |
| 5 | 1,121E -10 | 1,633E -10 | 1,965E -10 |
| 6 | 9,906E -11 | 1,453E -10 | 2,022E -10 |
| Statistics | | | |
| Min | 9,906E -11 | 1,415E -10 | 1,853E -10 |
| Max | 1,280E -10 | 1,000E -03 | 1,000E -03 |
| Mean | 1,087E -10 | 4,000E -04 | 4,000E -04 |
| Sigma | 1,196E -11 | 5,478E -04 | 5,477E -04 |



| | | | | |
|--------------------------|-------------------------------|----------------|------------------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors | |

Parameter: Positive Gate source leakage current: +IGSS-Bias2 VGS=+30V, VDS=0V

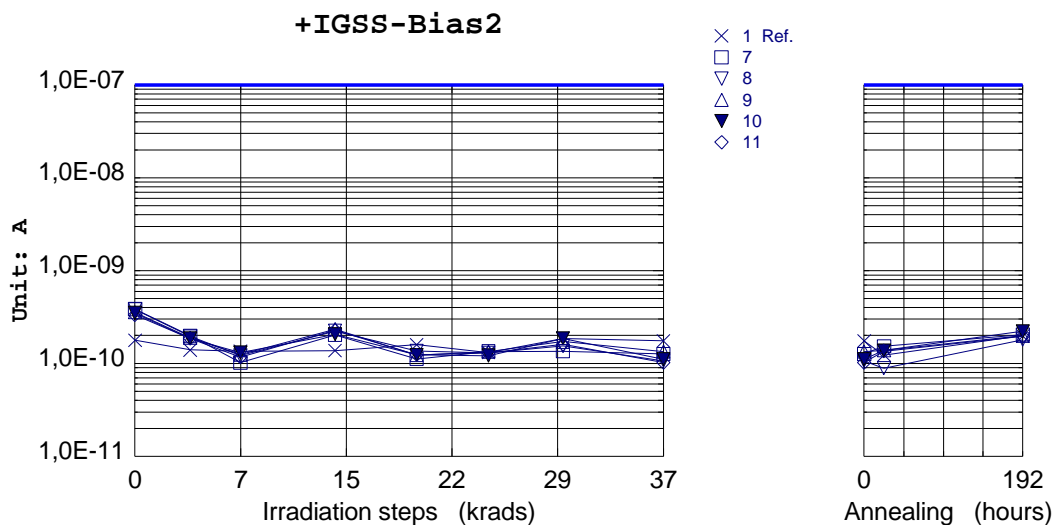
Unit= A

Spec limit max: 100E-9

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 1,782E -10 | 1,401E -10 | 1,353E -10 | 1,373E -10 | 1,596E -10 | 1,316E -10 | 1,868E -10 |
| 7 | 3,859E -10 | 1,984E -10 | 1,025E -10 | 2,032E -10 | 1,122E -10 | 1,349E -10 | 1,352E -10 |
| 8 | 3,819E -10 | 1,956E -10 | 1,219E -10 | 2,247E -10 | 1,365E -10 | 1,300E -10 | 1,542E -10 |
| 9 | 3,565E -10 | 1,888E -10 | 1,247E -10 | 2,344E -10 | 1,235E -10 | 1,344E -10 | 1,724E -10 |
| 10 | 3,497E -10 | 1,864E -10 | 1,315E -10 | 2,066E -10 | 1,240E -10 | 1,215E -10 | 1,859E -10 |
| 11 | 3,336E -10 | 1,859E -10 | 1,172E -10 | 2,286E -10 | 1,240E -10 | 1,299E -10 | 1,609E -10 |
| Statistics | | | | | | | |
| Min | 3,336E -10 | 1,859E -10 | 1,025E -10 | 2,032E -10 | 1,122E -10 | 1,215E -10 | 1,352E -10 |
| Max | 3,859E -10 | 1,984E -10 | 1,315E -10 | 2,344E -10 | 1,365E -10 | 1,349E -10 | 1,859E -10 |
| Mean | 3,615E -10 | 1,910E -10 | 1,196E -10 | 2,195E -10 | 1,240E -10 | 1,302E -10 | 1,617E -10 |
| Sigma | 2,209E -11 | 5,642E -12 | 1,082E -11 | 1,383E -11 | 8,613E -12 | 5,365E -12 | 1,908E -11 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 1,753E -10 | 1,233E -10 | 1,985E -10 |
| 7 | 1,266E -10 | 1,538E -10 | 2,046E -10 |
| 8 | 1,073E -10 | 8,888E -11 | 1,813E -10 |
| 9 | 1,345E -10 | 1,385E -10 | 1,993E -10 |
| 10 | 1,111E -10 | 1,382E -10 | 2,218E -10 |
| 11 | 1,027E -10 | 1,359E -10 | 1,963E -10 |
| Statistics | | | |
| Min | 1,027E -10 | 8,888E -11 | 1,813E -10 |
| Max | 1,345E -10 | 1,538E -10 | 2,218E -10 |
| Mean | 1,164E -10 | 1,311E -10 | 2,007E -10 |
| Sigma | 1,351E -11 | 2,463E -11 | 1,467E -11 |



| | | | | |
|-------------------|------------------------|----------------|------------------------|--------------------|
| HIREX Engineering | Total Dose Test Report | | | Réf. : HRX/99.4561 |
| | | | | Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors | |

Parameter: Negative Gate source leakage current: -IGSS-Bias1 VGS=-30V, VDS=0V

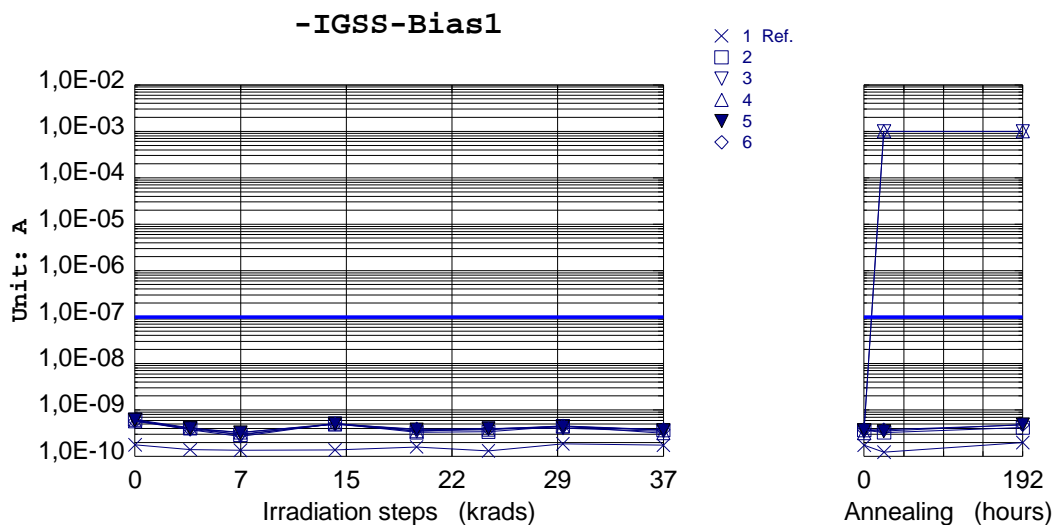
Unit= A

Spec limit max: 100E-9

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 1,782E -10 | 1,401E -10 | 1,353E -10 | 1,373E -10 | 1,596E -10 | 1,316E -10 | 1,868E -10 |
| 2 | 6,185E -10 | 4,132E -10 | 2,902E -10 | 5,058E -10 | 3,278E -10 | 3,408E -10 | 4,463E -10 |
| 3 | 6,006E -10 | 3,761E -10 | 2,691E -10 | 5,124E -10 | 3,459E -10 | 4,011E -10 | 4,034E -10 |
| 4 | 5,749E -10 | 4,043E -10 | 3,280E -10 | 4,887E -10 | 3,536E -10 | 3,766E -10 | 4,445E -10 |
| 5 | 6,074E -10 | 4,020E -10 | 3,232E -10 | 5,047E -10 | 3,772E -10 | 3,952E -10 | 4,364E -10 |
| 6 | 5,771E -10 | 3,853E -10 | 3,016E -10 | 4,960E -10 | 3,900E -10 | 3,889E -10 | 4,523E -10 |
| Statistics | | | | | | | |
| Min | 5,749E -10 | 3,761E -10 | 2,691E -10 | 4,887E -10 | 3,278E -10 | 3,408E -10 | 4,034E -10 |
| Max | 6,185E -10 | 4,132E -10 | 3,280E -10 | 5,124E -10 | 3,900E -10 | 4,011E -10 | 4,523E -10 |
| Mean | 5,957E -10 | 3,962E -10 | 3,024E -10 | 5,015E -10 | 3,589E -10 | 3,805E -10 | 4,366E -10 |
| Sigma | 1,909E -11 | 1,506E -11 | 2,422E -11 | 9,238E -12 | 2,485E -11 | 2,399E -11 | 1,941E -11 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 1,753E -10 | 1,233E -10 | 1,985E -10 |
| 2 | 3,648E -10 | 3,268E -10 | 4,166E -10 |
| 3 | 3,473E -10 | 1,000E -03 | 1,000E -03 |
| 4 | 3,149E -10 | 1,000E -03 | 1,000E -03 |
| 5 | 3,665E -10 | 3,498E -10 | 4,815E -10 |
| 6 | 3,793E -10 | 3,764E -10 | 4,790E -10 |
| Statistics | | | |
| Min | 3,149E -10 | 3,268E -10 | 4,166E -10 |
| Max | 3,793E -10 | 1,000E -03 | 1,000E -03 |
| Mean | 3,546E -10 | 4,000E -04 | 4,000E -04 |
| Sigma | 2,491E -11 | 5,478E -04 | 5,477E -04 |



| | | | | |
|--------------------------|-------------------------------|----------------|------------------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors | |

Parameter: Negative Gate source leakage current: -IGSS-Bias2 VGS=-30V, VDS=0V

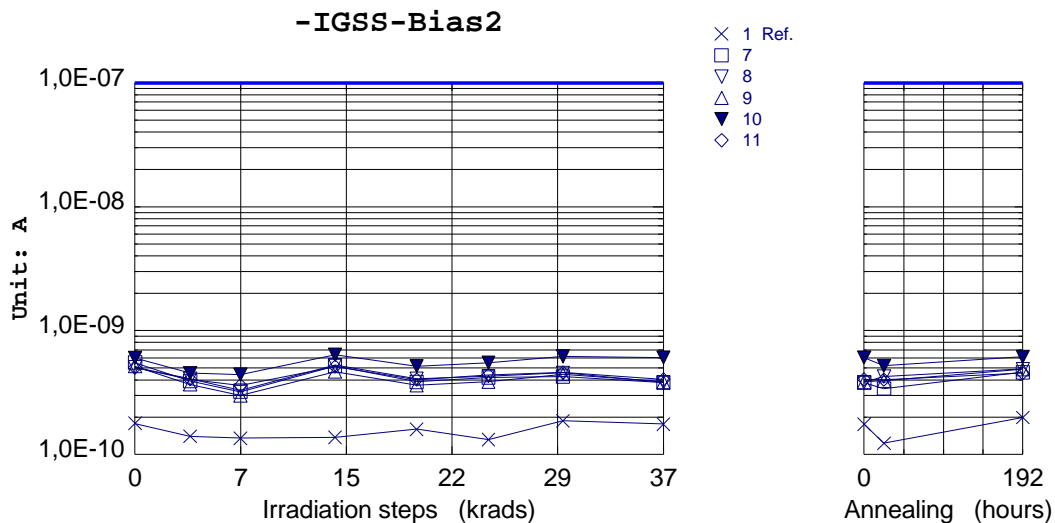
Unit= A

Spec limit max: 100E-9

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 1,782E -10 | 1,401E -10 | 1,353E -10 | 1,373E -10 | 1,596E -10 | 1,316E -10 | 1,868E -10 |
| 7 | 5,517E -10 | 3,911E -10 | 3,193E -10 | 5,166E -10 | 3,851E -10 | 4,179E -10 | 4,257E -10 |
| 8 | 5,050E -10 | 4,088E -10 | 3,286E -10 | 5,260E -10 | 4,082E -10 | 4,289E -10 | 4,551E -10 |
| 9 | 5,147E -10 | 3,678E -10 | 2,989E -10 | 4,656E -10 | 3,619E -10 | 3,860E -10 | 4,428E -10 |
| 10 | 6,015E -10 | 4,529E -10 | 4,418E -10 | 6,366E -10 | 5,144E -10 | 5,510E -10 | 6,197E -10 |
| 11 | 5,025E -10 | 4,042E -10 | 3,600E -10 | 5,115E -10 | 4,008E -10 | 4,379E -10 | 4,572E -10 |
| Statistics | | | | | | | |
| Min | 5,025E -10 | 3,678E -10 | 2,989E -10 | 4,656E -10 | 3,619E -10 | 3,860E -10 | 4,257E -10 |
| Max | 6,015E -10 | 4,529E -10 | 4,418E -10 | 6,366E -10 | 5,144E -10 | 5,510E -10 | 6,197E -10 |
| Mean | 5,351E -10 | 4,050E -10 | 3,497E -10 | 5,313E -10 | 4,141E -10 | 4,443E -10 | 4,801E -10 |
| Sigma | 4,204E -11 | 3,117E -11 | 5,600E -11 | 6,331E -11 | 5,882E -11 | 6,276E -11 | 7,906E -11 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 1,753E -10 | 1,233E -10 | 1,985E -10 |
| 7 | 3,790E -10 | 3,397E -10 | 4,602E -10 |
| 8 | 3,823E -10 | 4,249E -10 | 4,891E -10 |
| 9 | 3,851E -10 | 3,923E -10 | 4,869E -10 |
| 10 | 6,046E -10 | 5,196E -10 | 6,152E -10 |
| 11 | 4,027E -10 | 4,015E -10 | 4,543E -10 |
| Statistics | | | |
| Min | 3,790E -10 | 3,397E -10 | 4,543E -10 |
| Max | 6,046E -10 | 5,196E -10 | 6,152E -10 |
| Mean | 4,307E -10 | 4,156E -10 | 5,011E -10 |
| Sigma | 9,764E -11 | 6,596E -11 | 6,565E -11 |



| | | | | |
|--------------------------|-------------------------------|----------------|------------------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors | |

Parameter: Drain current: IDSS-Bias1 VGS=0V, VDS=200V

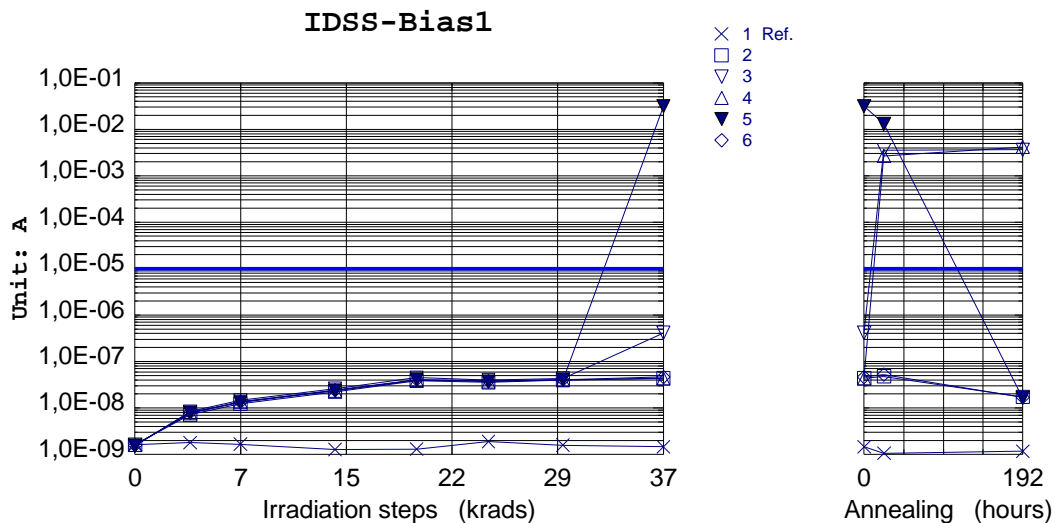
Unit= A

Spec limit max: 10E-6

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 1,629E -09 | 1,802E -09 | 1,654E -09 | 1,273E -09 | 1,301E -09 | 1,895E -09 | 1,582E -09 |
| 2 | 1,612E -09 | 7,177E -09 | 1,226E -08 | 2,230E -08 | 3,822E -08 | 3,585E -08 | 3,987E -08 |
| 3 | 1,509E -09 | 8,378E -09 | 1,463E -08 | 2,616E -08 | 4,477E -08 | 4,014E -08 | 4,334E -08 |
| 4 | 1,602E -09 | 7,634E -09 | 1,375E -08 | 2,369E -08 | 4,007E -08 | 3,755E -08 | 4,008E -08 |
| 5 | 1,558E -09 | 7,923E -09 | 1,316E -08 | 2,363E -08 | 4,022E -08 | 3,706E -08 | 4,018E -08 |
| 6 | 1,573E -09 | 7,986E -09 | 1,348E -08 | 2,413E -08 | 4,076E -08 | 3,785E -08 | 4,076E -08 |
| Statistics | | | | | | | |
| Min | 1,509E -09 | 7,177E -09 | 1,226E -08 | 2,230E -08 | 3,822E -08 | 3,585E -08 | 3,987E -08 |
| Max | 1,612E -09 | 8,378E -09 | 1,463E -08 | 2,616E -08 | 4,477E -08 | 4,014E -08 | 4,334E -08 |
| Mean | 1,571E -09 | 7,820E -09 | 1,346E -08 | 2,398E -08 | 4,081E -08 | 3,769E -08 | 4,084E -08 |
| Sigma | 4,107E -11 | 4,466E -10 | 8,657E -10 | 1,397E -09 | 2,412E -09 | 1,570E -09 | 1,433E -09 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 1,469E -09 | 1,061E -09 | 1,174E -09 |
| 2 | 4,401E -08 | 4,814E -08 | 1,731E -08 |
| 3 | 4,154E -07 | 3,564E -03 | 3,628E -03 |
| 4 | 4,303E -08 | 2,676E -03 | 4,159E -03 |
| 5 | 3,158E -02 | 1,314E -02 | 1,644E -08 |
| 6 | 4,624E -08 | 5,202E -08 | 1,709E -08 |
| Statistics | | | |
| Min | 4,303E -08 | 4,814E -08 | 1,644E -08 |
| Max | 3,158E -02 | 1,314E -02 | 4,159E -03 |
| Mean | 6,315E -03 | 3,876E -03 | 1,557E -03 |
| Sigma | 1,412E -02 | 5,417E -03 | 2,141E -03 |



| | | | | |
|--------------------------|-------------------------------|----------------|------------------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors | |

Parameter: Drain current: IDSS-Bias2 VGS=0V, VDS=200V

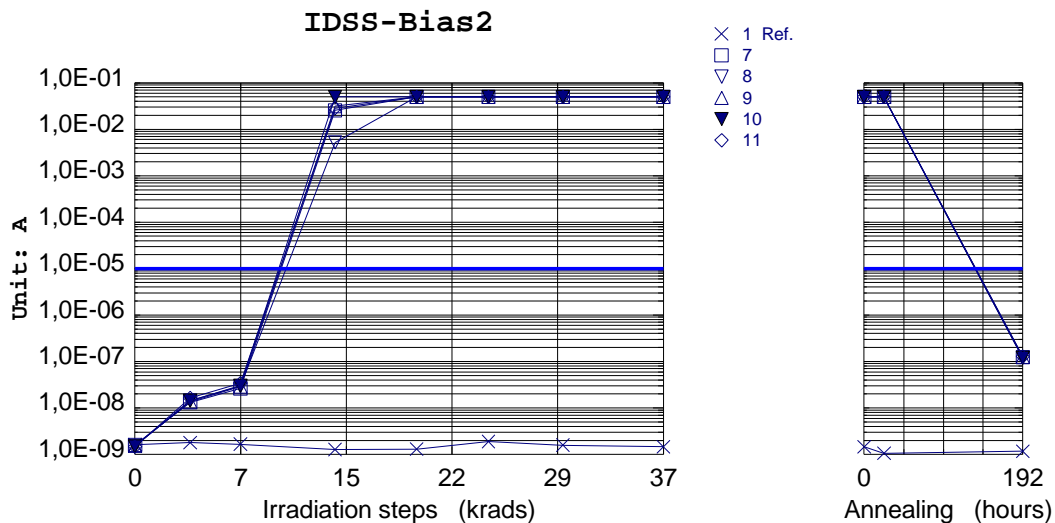
Unit= A

Spec limit max: 10E-6

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 1,629E -09 | 1,802E -09 | 1,654E -09 | 1,273E -09 | 1,301E -09 | 1,895E -09 | 1,582E -09 |
| 7 | 1,604E -09 | 1,332E -08 | 2,635E -08 | 2,568E -02 | 5,000E -02 | 5,002E -02 | 5,000E -02 |
| 8 | 1,496E -09 | 1,443E -08 | 2,933E -08 | 5,208E -03 | 5,000E -02 | 5,002E -02 | 5,000E -02 |
| 9 | 1,526E -09 | 1,360E -08 | 2,895E -08 | 3,146E -02 | 5,001E -02 | 5,002E -02 | 4,999E -02 |
| 10 | 1,489E -09 | 1,426E -08 | 3,034E -08 | 5,000E -02 | 5,002E -02 | 5,001E -02 | 5,001E -02 |
| 11 | 1,474E -09 | 1,636E -08 | 3,405E -08 | 2,860E -02 | 5,002E -02 | 5,002E -02 | 5,002E -02 |
| Statistics | | | | | | | |
| Min | 1,474E -09 | 1,332E -08 | 2,635E -08 | 5,208E -03 | 5,000E -02 | 5,001E -02 | 4,999E -02 |
| Max | 1,604E -09 | 1,636E -08 | 3,405E -08 | 5,000E -02 | 5,002E -02 | 5,002E -02 | 5,002E -02 |
| Mean | 1,518E -09 | 1,439E -08 | 2,981E -08 | 2,819E -02 | 5,001E -02 | 5,002E -02 | 5,000E -02 |
| Sigma | 5,173E -11 | 1,190E -09 | 2,793E -09 | 1,598E -02 | 9,362E -06 | 6,420E -06 | 9,339E -06 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 1,469E -09 | 1,061E -09 | 1,174E -09 |
| 7 | 5,000E -02 | 5,002E -02 | 1,236E -07 |
| 8 | 5,000E -02 | 5,001E -02 | 1,192E -07 |
| 9 | 4,999E -02 | 5,002E -02 | 1,279E -07 |
| 10 | 5,000E -02 | 5,003E -02 | 1,195E -07 |
| 11 | 5,002E -02 | 5,003E -02 | 1,280E -07 |
| Statistics | | | |
| Min | 4,999E -02 | 5,001E -02 | 1,192E -07 |
| Max | 5,002E -02 | 5,003E -02 | 1,280E -07 |
| Mean | 5,000E -02 | 5,002E -02 | 1,237E -07 |
| Sigma | 7,798E -06 | 7,483E -06 | 4,287E -09 |



| | | | | |
|--------------------------|-------------------------------|----------------|------------------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors | |

Parameter: Static drain to source on-state resistance: RDSON-Bias1

VGS=10V, ID=10A

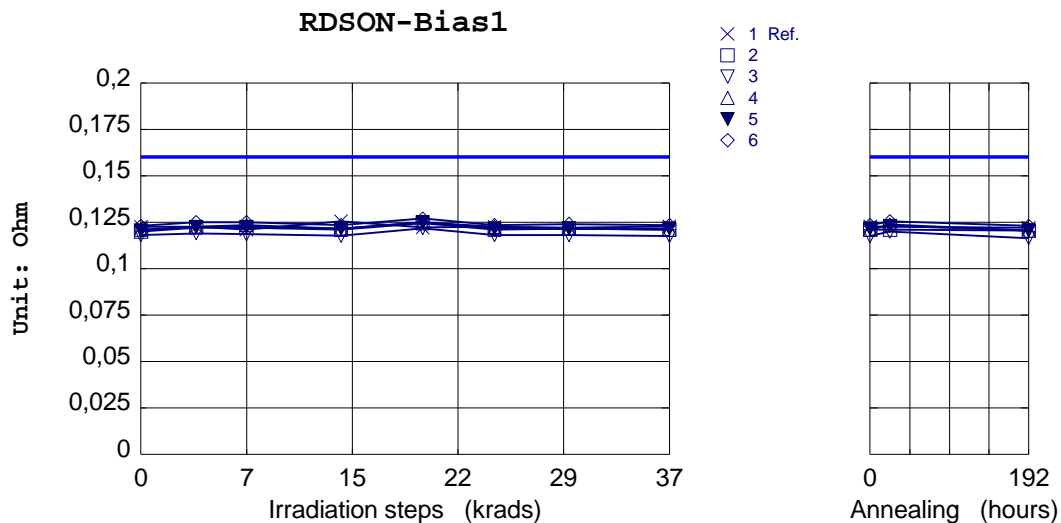
Unit= Ohm

Spec limit max: 0.16

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 1,225E -01 | 1,225E -01 | 1,210E -01 | 1,255E -01 | 1,222E -01 | 1,225E -01 | 1,220E -01 |
| 2 | 1,200E -01 | 1,220E -01 | 1,220E -01 | 1,210E -01 | 1,245E -01 | 1,210E -01 | 1,215E -01 |
| 3 | 1,180E -01 | 1,190E -01 | 1,185E -01 | 1,177E -01 | 1,217E -01 | 1,180E -01 | 1,180E -01 |
| 4 | 1,210E -01 | 1,225E -01 | 1,235E -01 | 1,215E -01 | 1,250E -01 | 1,225E -01 | 1,215E -01 |
| 5 | 1,205E -01 | 1,225E -01 | 1,225E -01 | 1,215E -01 | 1,250E -01 | 1,215E -01 | 1,215E -01 |
| 6 | 1,230E -01 | 1,250E -01 | 1,250E -01 | 1,235E -01 | 1,270E -01 | 1,235E -01 | 1,240E -01 |
| Statistics | | | | | | | |
| Min | 1,180E -01 | 1,190E -01 | 1,185E -01 | 1,177E -01 | 1,217E -01 | 1,180E -01 | 1,180E -01 |
| Max | 1,230E -01 | 1,250E -01 | 1,250E -01 | 1,235E -01 | 1,270E -01 | 1,235E -01 | 1,240E -01 |
| Mean | 1,205E -01 | 1,222E -01 | 1,223E -01 | 1,210E -01 | 1,246E -01 | 1,213E -01 | 1,213E -01 |
| Sigma | 1,803E -03 | 2,139E -03 | 2,414E -03 | 2,085E -03 | 1,887E -03 | 2,080E -03 | 2,139E -03 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 1,227E -01 | 1,225E -01 | 1,220E -01 |
| 2 | 1,210E -01 | 1,210E -01 | 1,205E -01 |
| 3 | 1,175E -01 | 1,200E -01 | 1,165E -01 |
| 4 | 1,210E -01 | 1,237E -01 | 1,205E -01 |
| 5 | 1,215E -01 | 1,230E -01 | 1,205E -01 |
| 6 | 1,235E -01 | 1,255E -01 | 1,230E -01 |
| Statistics | | | |
| Min | 1,175E -01 | 1,200E -01 | 1,165E -01 |
| Max | 1,235E -01 | 1,255E -01 | 1,230E -01 |
| Mean | 1,209E -01 | 1,226E -01 | 1,202E -01 |
| Sigma | 2,162E -03 | 2,191E -03 | 2,335E -03 |



| | | | | |
|--------------------------|-------------------------------|----------------|------------------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors | |

Parameter: Static drain to source on-state resistance: RDSON-Bias2

VGS=10V, ID=10A

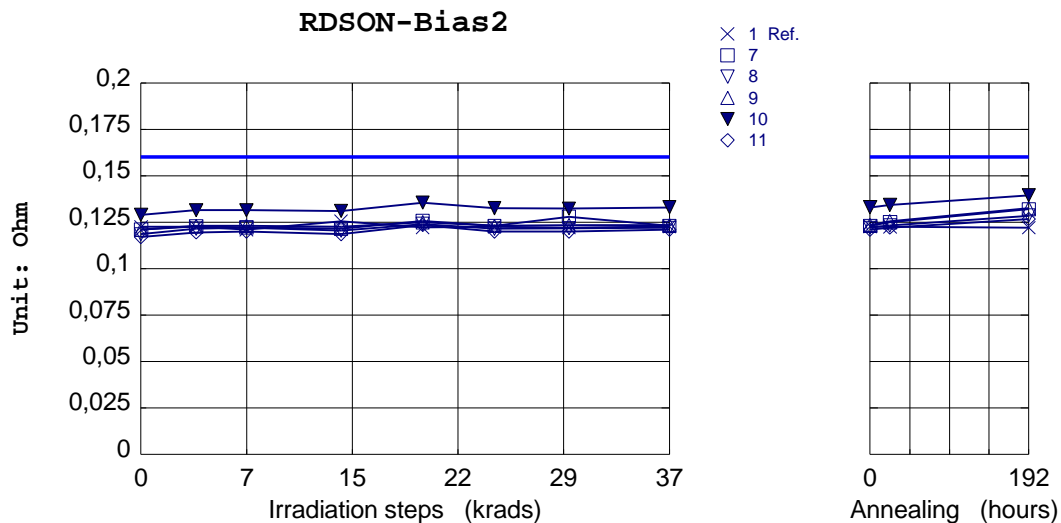
Unit= Ohm

Spec limit max: 0.16

Spec limits are represented in bold lines on the graphic.

| Test Step | Initial | 3,85 krad | 7,35 krad | 13,95 krad | 19,65 krad | 24,65 krad | 29,85 krad |
|------------|------------|------------|------------|------------|------------|------------|------------|
| Serial # | | | | | | | |
| 1 Ref. | 1,225E -01 | 1,225E -01 | 1,210E -01 | 1,255E -01 | 1,222E -01 | 1,225E -01 | 1,220E -01 |
| 7 | 1,210E -01 | 1,227E -01 | 1,222E -01 | 1,215E -01 | 1,258E -01 | 1,230E -01 | 1,280E -01 |
| 8 | 1,185E -01 | 1,215E -01 | 1,220E -01 | 1,205E -01 | 1,240E -01 | 1,215E -01 | 1,217E -01 |
| 9 | 1,210E -01 | 1,230E -01 | 1,230E -01 | 1,225E -01 | 1,250E -01 | 1,230E -01 | 1,235E -01 |
| 10 | 1,290E -01 | 1,315E -01 | 1,315E -01 | 1,310E -01 | 1,355E -01 | 1,325E -01 | 1,323E -01 |
| 11 | 1,170E -01 | 1,195E -01 | 1,200E -01 | 1,185E -01 | 1,235E -01 | 1,200E -01 | 1,200E -01 |
| Statistics | | | | | | | |
| Min | 1,170E -01 | 1,195E -01 | 1,200E -01 | 1,185E -01 | 1,235E -01 | 1,200E -01 | 1,200E -01 |
| Max | 1,290E -01 | 1,315E -01 | 1,315E -01 | 1,310E -01 | 1,355E -01 | 1,325E -01 | 1,323E -01 |
| Mean | 1,213E -01 | 1,236E -01 | 1,237E -01 | 1,228E -01 | 1,268E -01 | 1,240E -01 | 1,251E -01 |
| Sigma | 4,631E -03 | 4,602E -03 | 4,473E -03 | 4,817E -03 | 4,969E -03 | 4,912E -03 | 4,989E -03 |

| Test Step | 36,85 krad | 24 hours | 192 hours |
|------------|------------|------------|------------|
| Serial # | | | |
| 1 Ref. | 1,227E -01 | 1,225E -01 | 1,220E -01 |
| 7 | 1,230E -01 | 1,250E -01 | 1,320E -01 |
| 8 | 1,220E -01 | 1,232E -01 | 1,285E -01 |
| 9 | 1,235E -01 | 1,255E -01 | 1,325E -01 |
| 10 | 1,330E -01 | 1,343E -01 | 1,395E -01 |
| 11 | 1,210E -01 | 1,220E -01 | 1,268E -01 |
| Statistics | | | |
| Min | 1,210E -01 | 1,220E -01 | 1,268E -01 |
| Max | 1,330E -01 | 1,343E -01 | 1,395E -01 |
| Mean | 1,245E -01 | 1,260E -01 | 1,319E -01 |
| Sigma | 4,848E -03 | 4,827E -03 | 4,903E -03 |



| | | | |
|--------------------------|-------------------------------|----------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors |

8 Conclusion

A total dose radiation verification test has been performed on BUK456-200A N-Channel Power Mosfet from Philips Semiconductors up to 36.85 Krad(Si) accumulated dose.

This device has shown a significant susceptibility to radiation induced effects.

Two pieces (#2 and #3) exhibit high gate and drain to source leakage currents and consequently very low breakdown voltage, during annealing steps under Bias 1 conditions.

These gate leakage currents are very high (up to the compliance value of 1mA), for Bias 1 conditions.

Breakdown voltage is out of specification limit at 13.95 Krad(Si) under Bias 2 conditions, and a recovery is observed after 168 hours annealing step.

Threshold voltage is out of specification at 29.85 Krad(Si) under Bias 1 conditions, but a recovery is observed after 168 hours annealing step.

Threshold voltage is out of specification at 19.65 Krad(Si) under Bias 2 conditions, but a recovery is also observed after 168 hours annealing step.

IDSS, under Bias 2 conditions, increases dramatically up to the compliance value of 50mA at a dose level of 13.95 Krad(Si) and subsequent steps, but recovers after 168 hours annealing step.

| | | | |
|--------------------------|-------------------------------|----------------|----------------------------------|
| HIREX Engineering | Total Dose Test Report | | Réf. : HRX/99.4561 Issue : 01 |
| Part Type : | BUK456-200A | Manufacturer : | Philips Semiconductors |

ANNEX 1 : BUK456-200A DATA SHEET

PowerMOS transistor

BUK456-200A/B

GENERAL DESCRIPTION

N-channel enhancement mode field-effect power transistor in a plastic envelope.
The device is intended for use in Switched Mode Power Supplies (SMPS), motor control, welding, DC/DC and AC/DC converters, and in general purpose switching applications.

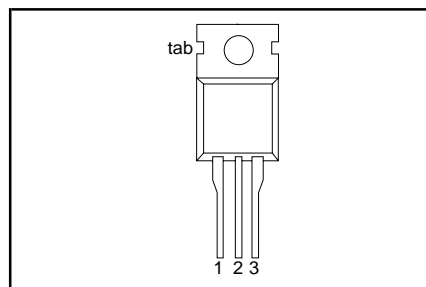
QUICK REFERENCE DATA

| SYMBOL | PARAMETER | MAX. | MAX. | UNIT |
|--------------|----------------------------------|--------------|--------------|------|
| | BUK456 | -200A | -200B | |
| V_{DS} | Drain-source voltage | 200 | 200 | V |
| I_D | Drain current (DC) | 19 | 17 | A |
| P_{tot} | Total power dissipation | 150 | 150 | W |
| T_j | Junction temperature | 175 | 175 | °C |
| $R_{DS(ON)}$ | Drain-source on-state resistance | 0.16 | 0.2 | Ω |

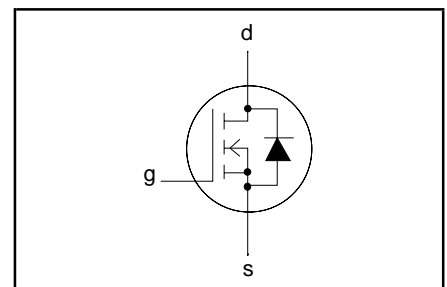
PINNING - TO220AB

| PIN | DESCRIPTION |
|-----|-------------|
| 1 | gate |
| 2 | drain |
| 3 | source |
| tab | drain |

PIN CONFIGURATION



SYMBOL



LIMITING VALUES

Limiting values in accordance with the Absolute Maximum System (IEC 134)

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|--------------|----------------------------------|--------------------------------------|------|--------------------|------|
| V_{DS} | Drain-source voltage | - | - | 200 | V |
| V_{DGR} | Drain-gate voltage | $R_{GS} = 20\text{ k}\Omega$ | - | 200 | V |
| $\pm V_{GS}$ | Gate-source voltage | - | - | 30 | V |
| I_D | Drain current (DC) | $T_{mb} = 25\text{ }^\circ\text{C}$ | - | -200A 19 | A |
| I_D | Drain current (DC) | $T_{mb} = 100\text{ }^\circ\text{C}$ | - | 13 | A |
| I_{DM} | Drain current (pulse peak value) | $T_{mb} = 25\text{ }^\circ\text{C}$ | - | 76 | A |
| P_{tot} | Total power dissipation | $T_{mb} = 25\text{ }^\circ\text{C}$ | - | 150 | W |
| T_{stg} | Storage temperature | - | - 55 | 175 | °C |
| T_j | Junction Temperature | - | - | 175 | °C |

THERMAL RESISTANCES

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|----------------|--|------------|------|------|------|------|
| $R_{th\ j-mb}$ | Thermal resistance junction to mounting base | | - | - | 1.0 | K/W |
| $R_{th\ j-a}$ | Thermal resistance junction to ambient | | - | 60 | - | K/W |

PowerMOS transistor

BUK456-200A/B

STATIC CHARACTERISTICST_{mb} = 25 °C unless otherwise specified

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|----------------------|----------------------------------|---|------|------|------|------|
| V _{(BR)DSS} | Drain-source breakdown voltage | V _{GS} = 0 V; I _D = 0.25 mA | 200 | - | - | V |
| V _{GS(TO)} | Gate threshold voltage | V _{DS} = V _{GS} ; I _D = 1 mA | 2.1 | 3.0 | 4.0 | V |
| I _{DSS} | Zero gate voltage drain current | V _{DS} = 200 V; V _{GS} = 0 V; T _J = 25 °C | - | 1 | 10 | μA |
| I _{DSS} | Zero gate voltage drain current | V _{DS} = 200 V; V _{GS} = 0 V; T _J = 125 °C | - | 0.1 | 1.0 | mA |
| I _{GSS} | Gate source leakage current | V _{GS} = ±30 V; V _{DS} = 0 V | - | 10 | 100 | nA |
| R _{DS(ON)} | Drain-source on-state resistance | V _{GS} = 10 V; I _D = 10 A | - | 0.15 | 0.16 | Ω |
| | | BUK456-200A BUK456-200B | - | 0.18 | 0.20 | Ω |

DYNAMIC CHARACTERISTICST_{mb} = 25 °C unless otherwise specified

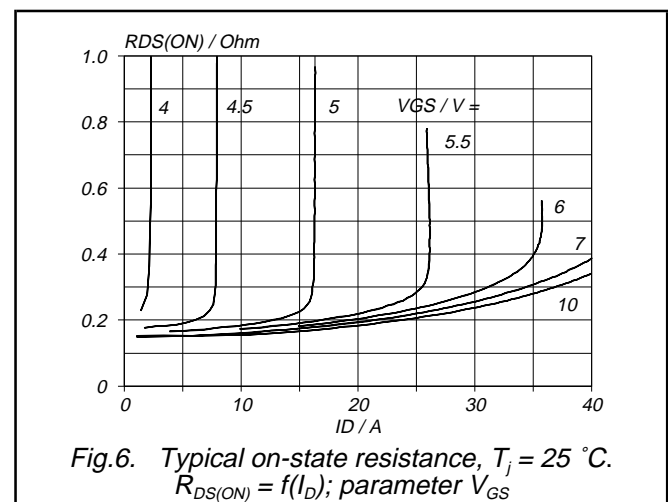
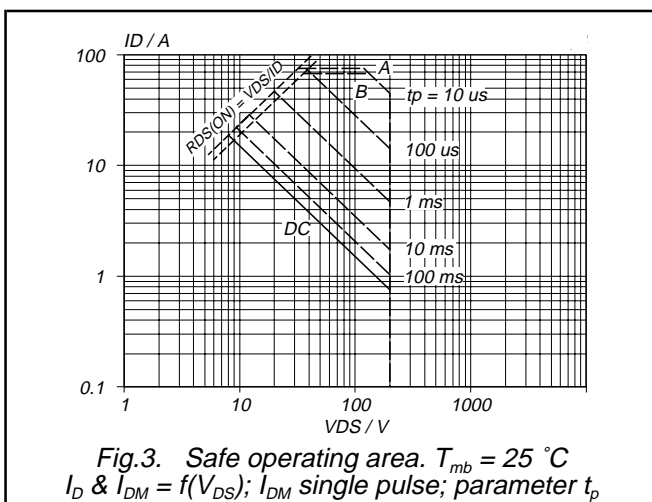
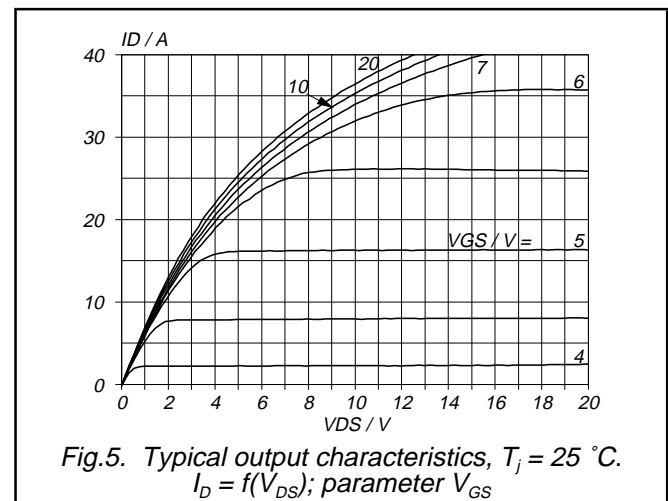
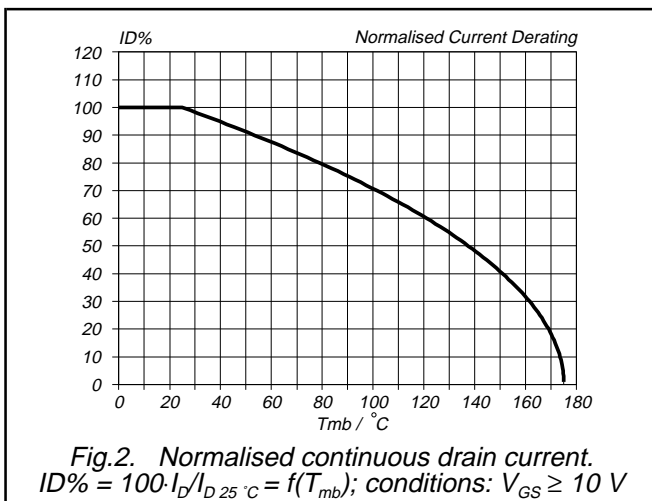
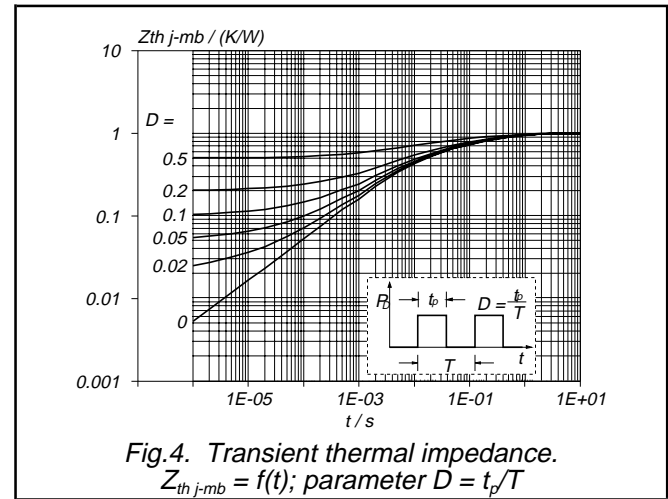
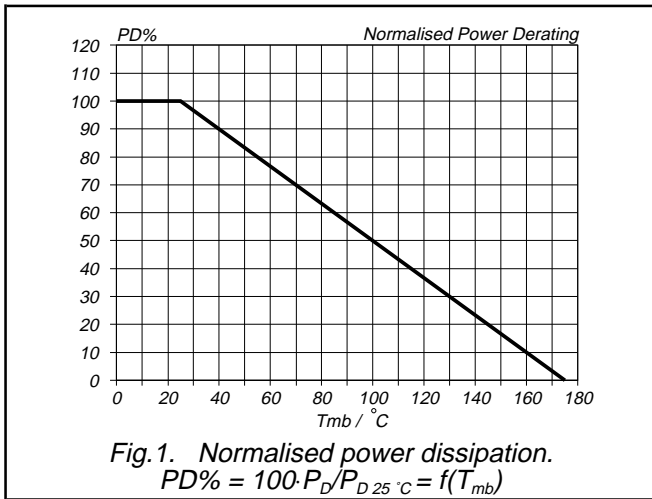
| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|--------------------|----------------------------|--|------|------|------|------|
| g _{fs} | Forward transconductance | V _{DS} = 25 V; I _D = 10 A | 8.5 | 16 | - | S |
| C _{iss} | Input capacitance | V _{GS} = 0 V; V _{DS} = 25 V; f = 1 MHz | - | 1500 | 2000 | pF |
| C _{oss} | Output capacitance | | - | 300 | 400 | pF |
| C _{rss} | Feedback capacitance | | - | 60 | 100 | pF |
| t _{d on} | Turn-on delay time | V _{DD} = 30 V; I _D = 3 A; V _{GS} = 10 V; R _{gen} = 50 Ω; R _{GS} = 50 Ω | - | 20 | 30 | ns |
| t _r | Turn-on rise time | | - | 40 | 60 | ns |
| t _{d off} | Turn-off delay time | | - | 145 | 185 | ns |
| t _f | Turn-off fall time | | - | 50 | 70 | ns |
| L _d | Internal drain inductance | Measured from contact screw on tab to centre of die | - | 3.5 | - | nH |
| L _d | Internal drain inductance | Measured from drain lead 6 mm from package to centre of die | - | 4.5 | - | nH |
| L _s | Internal source inductance | Measured from source lead 6 mm from package to source bond pad | - | 7.5 | - | nH |

REVERSE DIODE LIMITING VALUES AND CHARACTERISTICST_{mb} = 25 °C unless otherwise specified

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|------------------|----------------------------------|---|------|------|------|------|
| I _{DR} | Continuous reverse drain current | - | - | - | 19 | A |
| I _{DRM} | Pulsed reverse drain current | - | - | - | 76 | A |
| V _{SD} | Diode forward voltage | I _F = 19 A; V _{GS} = 0 V | - | 1.0 | 1.7 | V |
| t _{rr} | Reverse recovery time | I _F = 19 A; -di _F /dt = 100 A/μs; | - | 180 | - | ns |
| Q _{rr} | Reverse recovery charge | V _{GS} = 0 V; V _R = 30 V | - | 2.5 | - | μC |

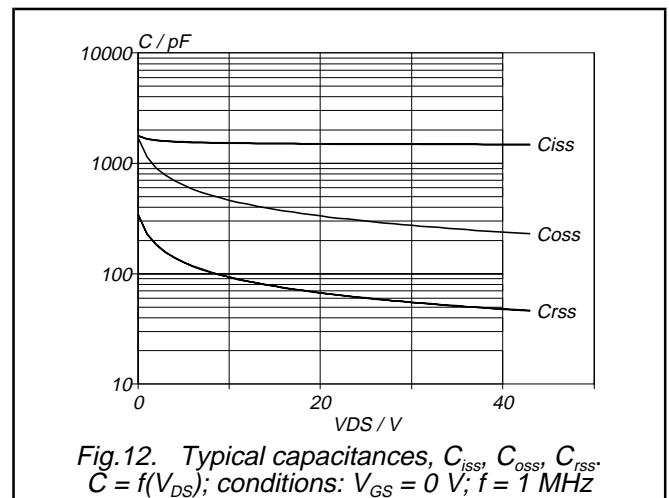
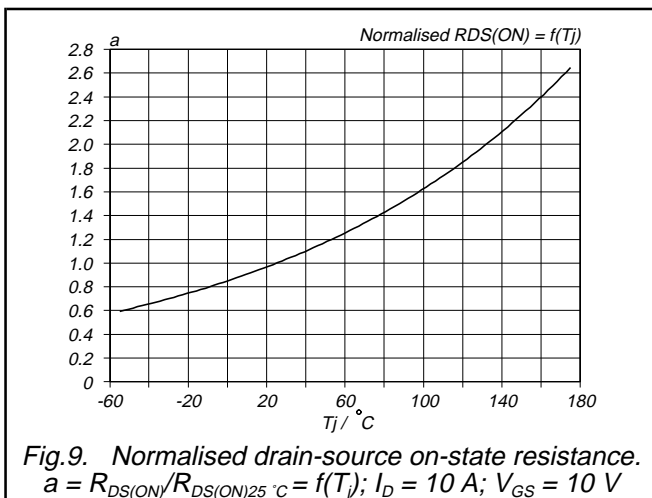
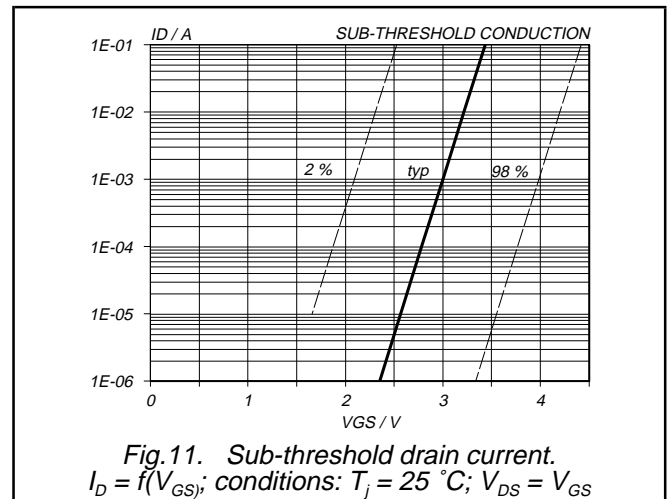
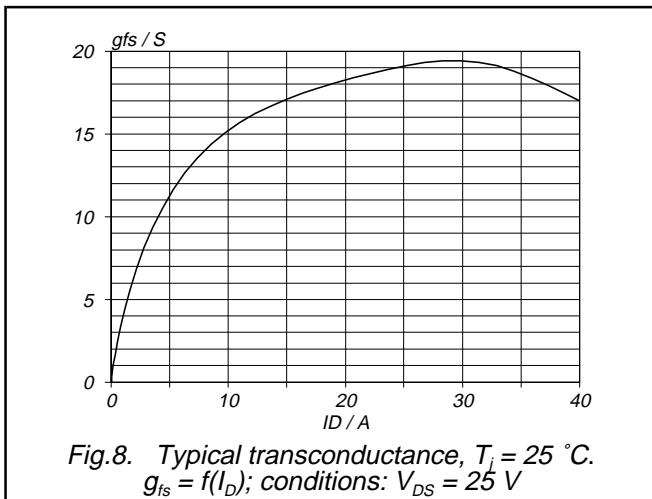
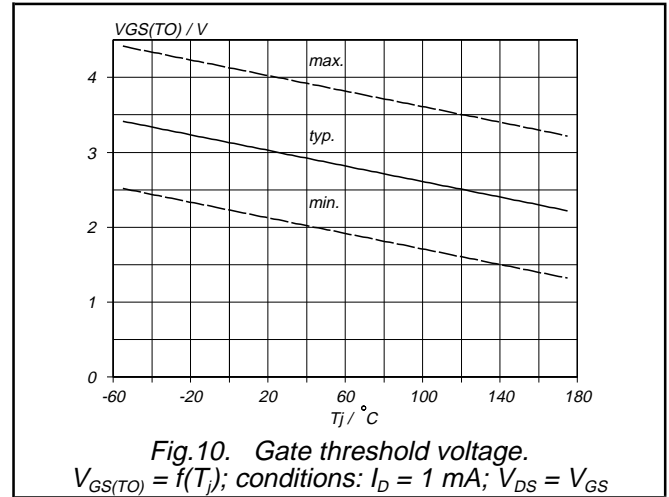
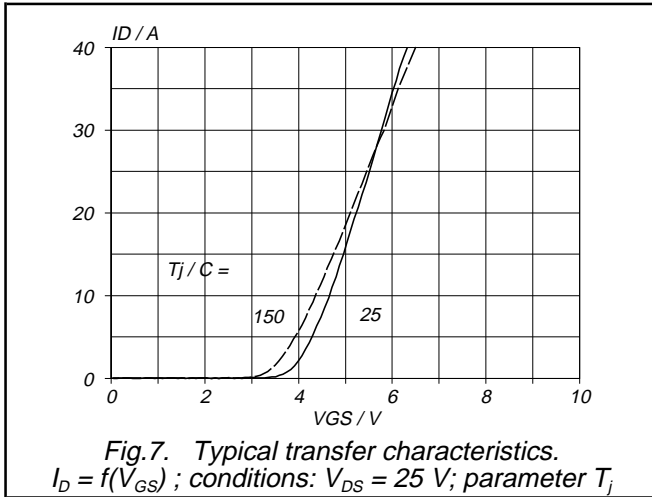
PowerMOS transistor

BUK456-200A/B



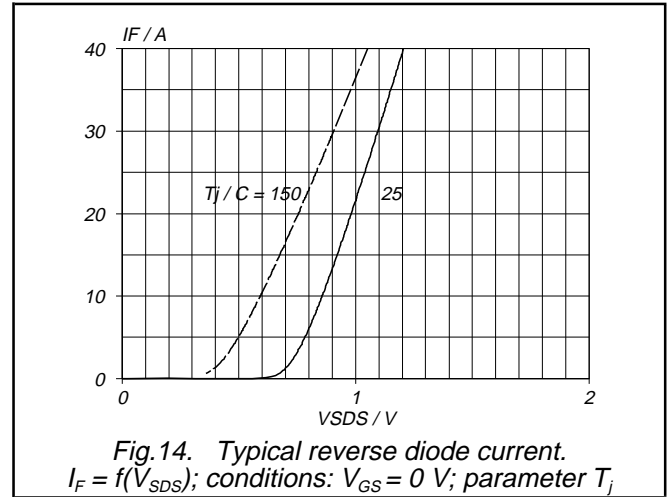
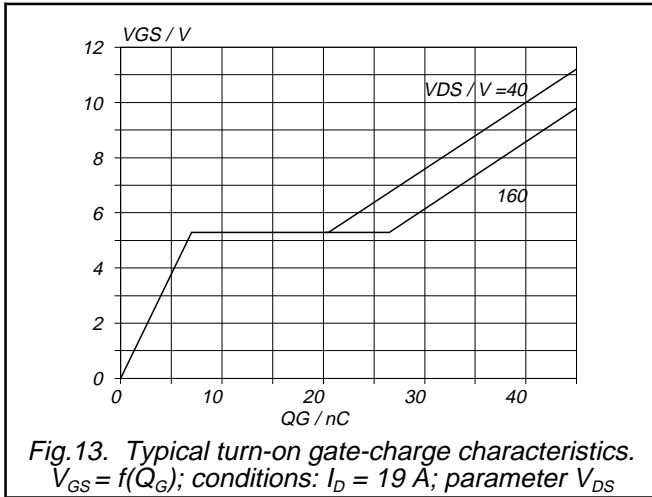
PowerMOS transistor

BUK456-200A/B

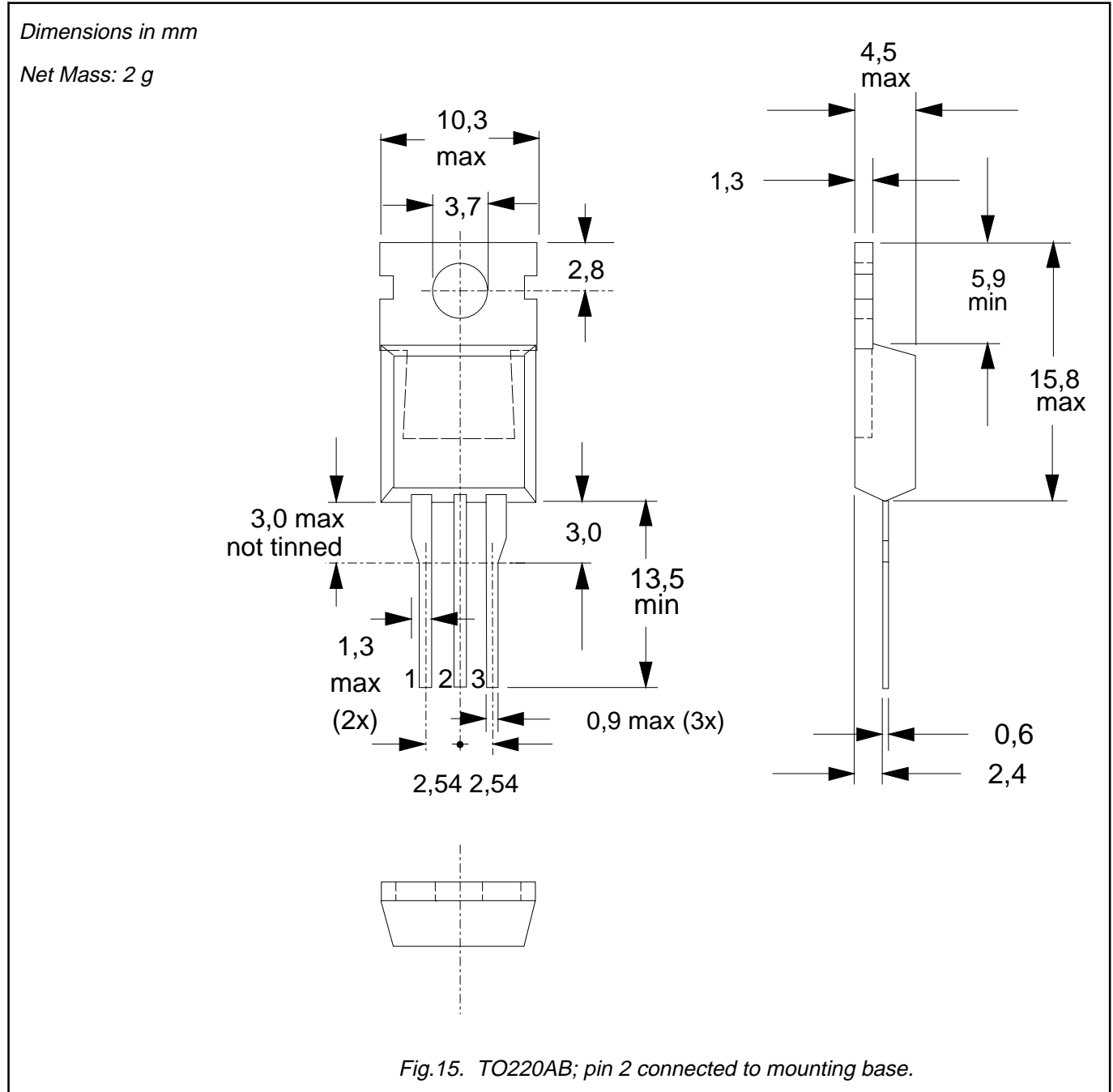


PowerMOS transistor

BUK456-200A/B



MECHANICAL DATA



Notes

1. Observe the general handling precautions for electrostatic-discharge sensitive devices (ESDs) to prevent damage to MOS gate oxide.
2. Refer to mounting instructions for TO220 envelopes.
3. Epoxy meets UL94 V0 at 1/8".

PowerMOS transistor

BUK456-200A/B

DEFINITIONS

| | |
|--|---|
| Data sheet status | |
| Objective specification | This data sheet contains target or goal specifications for product development. |
| Preliminary specification | This data sheet contains preliminary data; supplementary data may be published later. |
| Product specification | This data sheet contains final product specifications. |
| Limiting values | |
| Limiting values are given in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of this specification is not implied. Exposure to limiting values for extended periods may affect device reliability. | |
| Application information | |
| Where application information is given, it is advisory and does not form part of the specification. | |
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