# Cancelled

Title: POWER MOSFET, N-CHANNEL, RADIATION HARDENED, HIGH RELIABILITY, SPACE USE, DETAIL SPECIFICATION FOR (JAXA R 2SK4152, 2SK4153, 2SK4154, 2SK4155, 2SK4156, 2SK4157, 2SK4158, 2SK4159, 2SK4160, 2SK4217, 2SK4218, 2SK4219)

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# POWER MOSFET, N-CHANNEL, RADIATION HARDENED, HIGH RELIABILITY, SPACE USE, DETAIL SPECIFICATION FOR

JAXA R
2SK4152, 2SK4153, 2SK4154
2SK4155, 2SK4156, 2SK4157
2SK4158, 2SK4159, 2SK4160
2SK4217, 2SK4218, 2SK4219

Prepared and Established by Fuji Electric Co.,Ltd.
Issued by Japan Aerospace Exploration Agency

This document is the English version of JAXA QTS/ADS which was originally written and authorized in Japanese and carefully translated into English for international users. If any question arises as to the context or detailed description, it is strongly recommended to verify against the latest official Japanese version.

The release date of the English version of this specification: March 14, 2022.

Revision Log

| Rev. | Date | Description |
|---|---|---|
| ---- | 29 Feb. 2008 | Original |
| A | 12 Nov. 2012 | ▪ Table 1b: Corrected an error for the condition of Dynamic characteristics Corrected ID of 2SK4159 in Group A-4 of Dynamic characteristics from "27A" to "26A".<br>▪ Table 2b: Changed "Thermal resistance ($R_{th(ch-c)}(\Delta V_{SD})$)" to "Thermal impedance ($Z_{th\ (ch-c)}(\Delta V_{SD})$)" in compliance with the terms in MIL-STD-750.<br>▪ Table 2b: Added a test condition (Minimum On time: 30 seconds) of Intermittent Operation Life test.<br>▪ Table 3: Changed "Thermal resistance ($R_{th(ch-c)}(\Delta V_{SD})$)" to "Thermal impedance ($Zth_{(ch-c)}(\Delta VSD)$)" in compliance with the terms in MIL-STD-750.<br>▪ Table 3: Added a test condition (Minimum On time: 30 seconds) of Intermittent Operation Life test.<br>▪ Table 3: Added "($^{5}$) If the inspection lot is the one used in the Group B test, this test may be exempted" in compliance with General specification.<br>▪ Table 4a: Reviewed the number of significant figures in the test conditions of D-2a, D-2b and D-2c.<br>▪ Table 6 Exemption of Quality Conformance Inspection: Deleted test items, for which the quality conformance inspection is not performed.<br>▪ Added the maximum safe operating area of DC to figures.<br>▪ Others: Corrected errors to ensure consistency. |
| B | 18 March 2020 | ▪ Cover: Changed the corporate name.<br>▪ Paragraph 3.2.1: Added marking for inspection lot identification code and serial number.<br>▪ Modified the wording in each paragraph in the document.<br>▪ Table 7a Qualification inspection (A-3b): Corrected test condition error of gfs from "$V_{GS}$=25V" to "$V_{DS}$=25V".<br>▪ Table 2a Group B inspection (B-3g), Table 2b Group B inspection (B-6g), and Table 8a Qualification test, Group B inspection (B-3g) and Table 8b Qualification test, Group B inspection (B-6g): Corrected test condition error of Bond strength from "condition A" to "condition D". |
| | | |

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# POWER MOSFET, N-CHANNEL, RADIATION HARDENED, HIGH RELIABILITY, SPACE USE, DETAIL SPECIFICATION FOR

JAXA R
2SK4152, 2SK4153, 2SK4154
2SK4155, 2SK4156, 2SK4157
2SK4158, 2SK4159, 2SK4160
2SK4217, 2SK4218, 2SK4219

## 1 GENERAL

This specification establishes the detailed requirements for space use, high reliability, N channel power MOSFET (100, 130, 200 and 250V for SMD types) used for electronic equipment installed on spacecrafts. The products specified in this specification are as follows.

### 1.1 Part Number

The part numbers for the products covered by this specification are as follows:

JAXA(1) R(2) 2SK4152
JAXA(1) R(2) 2SK4153
JAXA(1) R(2) 2SK4154
JAXA(1) R(2) 2SK4155
JAXA(1) R(2) 2SK4156
JAXA(1) R(2) 2SK4157
JAXA(1) R(2) 2SK4158
JAXA(1) R(2) 2SK4159
JAXA(1) R(2) 2SK4160
JAXA(1) R(2) 2SK4217
JAXA(1) R(2) 2SK4218
JAXA(1) R(2) 2SK4219

Notes (1) "JAXA" indicates the common parts for space applications.
(2) "R" indicates the radiation hardness assurance designator.

1.2 Absolute Maximum Ratings

The absolute maximum ratings of the products specified in this specification are as follows. Unless otherwise specified, $T_A$ is +25°C.

| Part No. | $V_{DS}$ (V) | $I_D$ (A) | $I_{D(pulse)}$ (A) | $V_{GS}$ (V) | $P_D$ $T_C$=25°C (W) | $T_{ch}$(1) (°C) | $T_{stg}$ (°C) | $R_{th(ch-c)}$ (°C/W) | SOA |
|---|---|---|---|---|---|---|---|---|---|
| JAXA R 2SK4152 | 130 | 42 | 168 | ±20 | 250 Fig. 5 | 150 | -55 to 150 | 0.5 | Fig. 6 |
| JAXA R 2SK4153 | 130 | 39 | 156 | | 150 Fig. 7 | | | 0.83 | Fig. 8 |
| JAXA R 2SK4154 | 130 | 15 | 60 | | 70 Fig. 9 | | | 1.67 | Fig. 10 |
| JAXA R 2SK4155 | 200 | 42 | 168 | | 250 Fig. 11 | | | 0.5 | Fig. 12 |
| JAXA R 2SK4156 | 200 | 32 | 128 | | 150 Fig. 13 | | | 0.83 | Fig. 14 |
| JAXA R 2SK4157 | 200 | 14 | 56 | | 70 Fig. 15 | | | 1.67 | Fig. 16 |
| JAXA R 2SK4158 | 250 | 42 | 168 | | 250 Fig. 17 | | | 0.5 | Fig. 18 |
| JAXA R 2SK4159 | 250 | 26 | 104 | | 150 Fig. 19 | | | 0.83 | Fig. 20 |
| JAXA R 2SK4160 | 250 | 12 | 48 | | 70 Fig. 21 | | | 1.67 | Fig. 22 |
| JAXA R 2SK4217 | 100 | 42 | 168 | | 250 Fig. 23 | | | 0.5 | Fig. 24 |
| JAXA R 2SK4218 | 100 | 42 | 168 | | 150 Fig. 25 | | | 0.83 | Fig. 26 |
| JAXA R 2SK4219 | 100 | 15 | 60 | | 70 Fig. 27 | | | 1.67 | Fig. 28 |

Note(1) The channel temperature $T_{ch}$ is given by the following equations:

$$T_{ch}=T_C + R_{th(ch-c)} \times P_D$$

Where, $T_C$: Case temperature (°C)

$R_{th(ch-c)}$: Thermal resistance between channel and case (°C/W)

$P_D$: Power dissipation (W)

1.3 Primary Electrical Characteristics

The primary electrical characteristics of the products specified in this specification are as follows. Unless otherwise specified, $T_A$ is +25°C.

**Electrical Characteristics (1/3)**

| Part No. | $V_{(BR)DSS}$ (V) | $I_{DSS}$ (μA) | $I_{GSS}$ (nA) | $V_{GS(th)}$ (V) | $R_{DS(on)}$(1) (mΩ) | gfs(1) (S) | $E_{AS}$ (mJ) |
|---|---|---|---|---|---|---|---|
| | $I_D$=1mA<br>$V_{GS}$=0V | $V_{DS}$=80% of rated $V_{DS}$<br>$V_{GS}$=0V | $V_{GS}$=±20V<br>$V_{DS}$=0V | $I_D$=1mA<br>$V_{DS}$=$V_{GS}$ | $I_D$=50% of rated $I_D$<br>$V_{GS}$=12V | $I_D$=50% of rated $I_D$<br>$V_{DS}$=25V | Rated $I_D$<br>$V_{DD}$=48V,<br>$V_{GS}$=12V |
| | Min | Max | Max | Min-Max | Max | Min | Max |
| JAXA R 2SK4152 | 130 | 10 | ±100 | 2.5-4.5 | 17 | 8 | 1097 |
| JAXA R 2SK4153 | 130 | | | | 39 | 8 | 343 |
| JAXA R 2SK4154 | 130 | | | | 89 | 4 | 261 |
| JAXA R 2SK4155 | 200 | | | | 26 | 8 | 713 |
| JAXA R 2SK4156 | 200 | | | | 62 | 8 | 271 |
| JAXA R 2SK4157 | 200 | | | | 148 | 4 | 182 |
| JAXA R 2SK4158 | 250 | | | | 38 | 8 | 570 |
| JAXA R 2SK4159 | 250 | | | | 91 | 8 | 267 |
| JAXA R 2SK4160 | 250 | | | | 223 | 4 | 170 |
| JAXA R 2SK4217 | 100 | | | | 13 | 8 | 1426 |
| JAXA R 2SK4218 | 100 | | | | 28 | 8 | 414 |
| JAXA R 2SK4219 | 100 | | | | 64 | 4 | 340 |

Note(1) Pulse test: Pulse width ≤ 1ms, Duty cycle ≤ 2%

## Electrical Characteristics (2/3)

| Part No. | $Q_{GS}$ (nC) | $Q_{GD}$ (nC) | $Q_G$ (nC) | $t_{d(on)}$ (ns) | $t_r$ (ns) | $t_{d(off)}$ (ns) | $t_f$ (ns) |
|---|---|---|---|---|---|---|---|
| | $V_{DS}$=50% of rated $V_{DS}$, $I_D$= rated $I_D$, $V_{GS}$=12V | | | $V_{DD}$=50% of rated $V_{DS}$, $I_D$= rated $I_D$, $V_{GS}$=12V, $R_G$=10Ω | | | |
| | Max | Max | Max | Max | Max | Max | Max |
| JAXA R 2SK4152 | 60 | 70 | 220 | 65 | 30 | 190 | 65 |
| JAXA R 2SK4153 | 30 | 30 | 100 | 40 | 20 | 100 | 30 |
| JAXA R 2SK4154 | 13 | 10 | 50 | 30 | 20 | 65 | 15 |
| JAXA R 2SK4155 | 60 | 70 | 220 | 65 | 30 | 190 | 35 |
| JAXA R 2SK4156 | 30 | 30 | 100 | 40 | 20 | 100 | 20 |
| JAXA R 2SK4157 | 13 | 10 | 50 | 30 | 20 | 65 | 15 |
| JAXA R 2SK4158 | 60 | 70 | 220 | 65 | 30 | 190 | 30 |
| JAXA R 2SK4159 | 30 | 30 | 100 | 40 | 20 | 100 | 15 |
| JAXA R 2SK4160 | 13 | 10 | 50 | 30 | 20 | 65 | 10 |
| JAXA R 2SK4217 | 60 | 70 | 220 | 65 | 30 | 190 | 65 |
| JAXA R 2SK4218 | 30 | 30 | 100 | 40 | 20 | 100 | 30 |
| JAXA R 2SK4219 | 13 | 10 | 50 | 30 | 20 | 65 | 15 |

## Electrical Characteristics (3/3)

## (Body Diode Characteristics)

| Part No. | $V_{SD}$(1) (V) | $t_{rr}$ (ns) | $Q_{rr}$ (μC) |
|---|---|---|---|
| | $I_F$= rated $I_D$ $V_{GS}$=0V | $I_F$= rated $I_D$, $V_{GS}$=0V, -di/dt=100A/μs, $T_{ch}$=25°C | |
| | Max | Typ | Typ |
| JAXA R 2SK4152 | 1.6 | 520 | 11.0 |
| JAXA R 2SK4153 | | 540 | 9.0 |
| JAXA R 2SK4154 | | 390 | 5.0 |
| JAXA R 2SK4155 | | 690 | 13.5 |
| JAXA R 2SK4156 | | 800 | 12.0 |
| JAXA R 2SK4157 | | 620 | 6.0 |
| JAXA R 2SK4158 | | 1000 | 19.0 |
| JAXA R 2SK4159 | | 900 | 12.0 |
| JAXA R 2SK4160 | | 640 | 6.5 |
| JAXA R 2SK4217 | | 450 | 7.0 |
| JAXA R 2SK4218 | | 500 | 6.5 |
| JAXA R 2SK4219 | | 350 | 3.5 |

Note(1) Pulse test: Pulse width ≤ 1ms, Duty cycle ≤ 2%

1.4 Radiation Hardness

The radiation hardness of the products specified in this specification is as follows.

| Symbol | Radiation hardness assurance level |
|---|---|
| R | 1000 Gy(Si) {$1\times10^5$ rad(Si)}<br>(Dose Rate 36Gy(Si)/ h to 360Gy(Si)/ h) |

2 APPLICABLE DOCUMENTS

The latest issues of documents listed below at the time of contract award or application form a part of this specification the extent specified herein.

| | |
|---|---|
| JAXA-QTS-2030 | Semiconductor Devices, High Reliability, Space Use, General Specification for |
| MIL-STD-750 | Test Method Standard, Test Methods for Semiconductor Devices |
| MIL-PRF-19500N | Performance Specification<br>Semiconductor Devices, General Specification for |

# 3 REQUIREMENTS

## 3.1 Design and Construction

The design and construction of the products shall meet the requirements specified in this paragraph and paragraph 3.3 of JAXA-QTS-2030.

### 3.1.1 Package Configuration and Terminal Connection

The package configuration and terminal connection shall meet the requirements specified in Figures 1a, 1b and 1c.

### 3.1.2 Terminal Materials and Finish

The material of terminals shall be Cu-W alloy. The terminals shall be finished with gold plating.

The purity of gold shall be a minimum of 99.7%. The thickness of the plating shall be a minimum of 1.27μm. This finish shall be plated with nickel as an underplating of a thickness between 1.27μm and 7.62μm.

### 3.1.3 Electrical Characteristics

The electrical characteristics shall meet the requirements specified in Tables 1a and 1b.

## 3.2 Marking

Marking shall be in accordance with the paragraph 3.4 of JAXA-QTS-2030, and Figures 2a, 2b and 2c.

### 3.2.1 Marking for Inspection Lot Identification Code and Serial Number

The marking for inspection lot identification code and serial number shall be as follows.

Example:

19 01 001

a) b) c)

Inspection lot identification code — Serial number

a) The last two digit number indicating the year the inspection started
b) The two digit number indicating the week of sealing for the first inspection sublot (production lot) of each inspection lot. The week number is counted from the first week of January of the year.
c) Unique three-digit number from 001 to 999 consecutively assigned for each product within the inspection lot

3.3 Certification

The requirements for the products to be certified shall be in accordance with paragraph 3.1 of JAXA-QTS-2030.

## 4 QUALITY ASSURANCE PROVISIONS

4.1 General Requirements

The general requirements shall be in accordance with paragraph 4.1 of JAXA-QTS-2030.

4.2 Incoming Materials Control

The incoming materials control shall be in accordance with paragraph 4.2 of JAXA-QTS-2030.

4.3 Manufacturing Process Control

The manufacturing process control shall be in accordance with paragraph 4.3 of JAXA-QTS-2030.

4.4 In-process Inspection

The in-process inspection shall be in accordance with paragraph 4.5 of JAXA-QTS-2030.

4.5 Screening

The screening shall be in accordance with paragraph 4.7 of JAXA-QTS-2030. The electrical characteristics to be measured, test conditions and delta limits shall be as follows.

4.5.1 Electrical Characteristics to be Measured

The following parameters shall be measured during the interim and final electrical characteristics tests for screening.

(1) Interim electrical characteristic tests $T_A$=+25°C

| Measuring item | $V_{(BR)DSS}$ (V) | $I_{DSS}$ (μA) | $I_{GSS}$ (nA) | $V_{GS(th)}$ (V) | $R_{DS(on)}$(1) (mΩ) | gfs(1) (S) | $V_{SD}$(1) (V) |
|---|---|---|---|---|---|---|---|
| MIL-STD-750 Test Method No. | 3407 | 3413 | 3411 | 3404 | 3421 | 3475 | --- |
| Test conditions | Bias Condition C $I_D$=1mA $V_{GS}$=0V | Bias Condition C $V_{DS}$=80% of rated $V_{DS}$ $V_{GS}$=0V | Bias Condition C $V_{GS}$=±20V $V_{DS}$=0V | $I_D$=1mA $V_{DS}$=$V_{GS}$ | $I_D$=50% of rated $I_D$ $V_{GS}$=12V | $I_D$=50% of rated $I_D$ $V_{DS}$=25V | $I_F$= rated $I_D$ $V_{GS}$=0V |
| | Min | Max | Max | Min-Max | Max | Min | Max |
| JAXA R 2SK4152 | 130 | 10 | ±100 | 2.5-4.5 | 17 | 8 | 1.6 |
| JAXA R 2SK4153 | 130 | | | | 39 | 8 | |
| JAXA R 2SK4154 | 130 | | | | 89 | 4 | |
| JAXA R 2SK4155 | 200 | | | | 26 | 8 | |
| JAXA R 2SK4156 | 200 | | | | 62 | 8 | |
| JAXA R 2SK4157 | 200 | | | | 148 | 4 | |
| JAXA R 2SK4158 | 250 | | | | 38 | 8 | |
| JAXA R 2SK4159 | 250 | | | | 91 | 8 | |
| JAXA R 2SK4160 | 250 | | | | 223 | 4 | |
| JAXA R 2SK4217 | 100 | | | | 13 | 8 | |
| JAXA R 2SK4218 | 100 | | | | 28 | 8 | |
| JAXA R 2SK4219 | 100 | | | | 64 | 4 | |

Note(1) Pulse test: Pulse width ≤ 1ms, Duty cycle ≤ 2%

(2) Final electrical characteristics test: As specified in the subgroups 1, 2 and 3 of Tables 1a and 1b.

4.5.2 Test Conditions

The conditions of gate stress test, avalanche energy test, temperature cycling test, reverse bias burn-in test and burn-in test for screening test shall be as follows.
(Gate stress test is performed as part of In-process inspection.)

Gate stress test: $V_{GS}$=35V, t=1ms, $T_A$=25°C

Single pulse avalanche energy ($E_{AS}$) test: $I_{D(pulse)}$ = rated $I_D$, $V_{DD}$=48V, $V_{GS}$=12V, single pulse

Initial $T_C = +25^{-5}_{+10}$ °C

$$L(mH) = \left[\frac{2E_{AS}}{(I_D)^2}\right]\left[\frac{BV_{DSS} - V_{DD}}{BV_{DSS}}\right] \quad \text{▪▪ Equation (1)}$$

Temperature cycling test: Condition G, 20 cycles

Reverse bias burn-in test (GS): $T_A$=150°C, $V_{GS}$=16V
$V_{DS}$=0V, 48hr

Burn-in test (DS): $T_A$=150°C, $V_{DS}$=80% of rated $V_{DS}$
$V_{GS}$=0V, 240hr

4.5.3 Delta Limits

The delta limits for reverse bias burn-in test and burn-in test shall be as follows.

$\Delta I_{GSS} \leq |20nA|$
$\Delta I_{DSS} \leq |10\mu A|$
$\Delta R_{DS(on)} \leq |20\%|$
$\Delta V_{GS(th)} \leq |20\%|$

4.6 Qualification Test and Quality Conformance Inspection

The qualification test and the quality conformance inspection shall be in accordance with paragraphs 4.6 and 4.8 of JAXA-QTS-2030. External dimensions, electrical characteristics, test conditions and limits shall be as specified in Figure 1, and Tables 1, 2, 3 and 4.
Group C inspection and Group D inspection may be exempted when the qualification test or quality conformance inspection for the Groups C and D inspections was performed and the device passed the test within a year. Detailed requirements are specified in Table 6.
Group E inspection may be exempted in spite of chip size, when the semiconductor devices manufactured from the die of the same wafer lot have passed the Group E inspection in the qualification test or the quality conformance inspection.

4.6.1 Electrostatic Discharge Sensitivity Test

Electrostatic discharge sensitivity test in the qualification test shall be performed with the following lead combination:

Gate and Source

4.6.2 Radiation Hardness Test

Radiation test (TID: Total Dose Irradiation) level, electrical characteristics, test conditions and limits in the qualification tests and the quality conformance inspections shall be as specified in Table 5. The bias shall be maintained during the irradiation and post-irradiation electrical characteristics test. The post-irradiation electrical characteristics test shall be performed within 24 hours after the completion of irradiation.

4.7 Change of Tests and Inspections

No change has been made to any test or inspection specified in appendixes A, B or C of JAXA-QTS -2030.

4.8 Shipment after Long-term Storage

Shipment of the products stored at the manufacturer's site for 24 months or longer shall be in accordance with paragraph 4.9.1 of JAXA-QTS-2030.

5 PREPARATION FOR DELIVERY

Preparation for delivery shall be in accordance with paragraph 5 of JAXA-QTS-2030.

6 NOTES

6.1 Terms and Definitions

The terms and definitions used herein shall be in accordance with paragraph 1.2 of JAXA-QTS-2030 and as follows.

(1) SEB (Single Event Burnout);

Burnout of the device caused by the incidence of a proton or a heavy ion, when the device is applied to an off-state voltage between drain and source.

(2) SEGR (Single Event Gate Rupture);

Breakdown of MOSFET Gate Oxide film caused by the incidence of a proton or a heavy ion, when the device is applied to a gate bias voltage between gate and source.

6.2 Notes for Purchasers

The precautions to be taken by the purchaser shall be in accordance with paragraph 6.2 of JAXA-QTS-2030 and as follows.

6.2.1 Handling Instructions

The products specified in this specification contain thin oxide films and can be damaged due to electrostatic discharge (ESD). ESD protection measures shall be implemented to avoid ESD between the gate and source and between the gate and drain during transportation and other handling environments.

6.3 Coordination with MIL-PRF-19500N

The comparison of qualification test items between MIL-PRF-19500N and JAXA-QTS-2030/102 is shown in Tables 7 through 11.

## Table 1a. Group A Inspection ([1])

| Gr.No | Sub | MIL-STD-750 Test Item | Method | JAXA R | 100V Class 2SK 4217 | 100V Class 2SK 4218 | 100V Class 2SK 4219 | 130V Class 2SK 4152 | 130V Class 2SK 4153 | 130V Class 2SK 4154 | 200V Class 2SK 4155 | 200V Class 2SK 4156 | 200V Class 2SK 4157 | 250V Class 2SK 4158 | 250V Class 2SK 4159 | 250V Class 2SK 4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A -1** | | **Static Characteristics ($T_A$=25°C)** | | Sample Size | LTPD 3 | | | | | | | | | | | |
| **-1a** | | Breakdown Voltage Drain to Source $V_{DSS}$ | 3407 | Conditions | Bias Condition C $I_D$=1mA , $V_{GS}$=0V | | | | | | | | | | | |
| | | | | Limits | min 100V DC | | | min 130V DC | | | min 200V DC | | | min 250V DC | | |
| **-1b** | | Gate-to-Source Leakage Current $I_{GSS}$ | 3411 | Conditions | Bias Condition C $V_{GS}$=±20V , $V_{DS}$=0V | | | | | | | | | | | |
| | | | | Limits | max ±100nA DC | | | | | | | | | | | |
| **-1c** | | Drain Current $I_{DSS}$ | 3413 | Conditions | Bias Condition C $V_{DS}$=80V , $V_{GS}$=0V | | | Bias Condition C $V_{DS}$=104V , $V_{GS}$=0V | | | Bias Condition C $V_{DS}$=160V , $V_{GS}$=0V | | | Bias Condition C $V_{DS}$=200V , $V_{GS}$=0V | | |
| | | | | Limits | max 10μA DC | | | | | | | | | | | |
| **-1d** | | Gate to Source Voltage (Threshold) $V_{GS(th)}$ | 3404 | Conditions | Bias Condition C $V_{GS}$=$V_{DS}$ , $I_D$=1mA | | | | | | | | | | | |
| | | | | Limits | 2.5 - 4.5V DC | | | | | | | | | | | |
| **-1e** | | Static Drain to Source On-State Resistance $R_{DS(on)}$ | 3421 | Conditions | Pulse Test([2]) , $V_{GS}$=12V | | | | | | | | | | | |
| | | | | | $I_D$ | | | $I_D$ | | | $I_D$ | | | $I_D$ | | |
| | | | | | 21A | 21A | 7.5A | 21A | 19.5A | 7.5A | 21A | 16A | 7A | 21A | 13A | 6A |
| | | | | Limits | max [mΩ] | | | max [mΩ] | | | max [mΩ] | | | max [mΩ] | | |
| | | | | | 13 | 28 | 64 | 17 | 39 | 89 | 26 | 62 | 148 | 38 | 91 | 223 |
| **-1f** | | Forward Transconductance gfs | 3475 | Conditions | Pulse Test([2]) , $V_{DS}$=25V | | | | | | | | | | | |
| | | | | | $I_D$ | | | $I_D$ | | | $I_D$ | | | $I_D$ | | |
| | | | | | 21A | 21A | 7.5A | 21A | 19.5A | 7.5A | 21A | 16A | 7A | 21A | 13A | 6A |
| | | | | Limits | min | | | min | | | min | | | min | | |
| | | | | | 8S | 8S | 4S | 8S | 8S | 4S | 8S | 8S | 4S | 8S | 8S | 4S |
| **-1g** | | Forward Voltage $V_{SD}$ | --- | Conditions | Pulse Test([2]) , $V_{GS}$=0V | | | | | | | | | | | |
| | | | | | $I_F$ | | | $I_F$ | | | $I_F$ | | | $I_F$ | | |
| | | | | | 42A | 42A | 15A | 42A | 39A | 15A | 42A | 32A | 14A | 42A | 26A | 12A |
| | | | | Limits | max 1.6V | | | | | | | | | | | |
| **A -2** | | **Static Characteristics ($T_A$=125°C)** | | Sample Size | LTPD 5 | | | | | | | | | | | |
| **-2a** | | Gate-to-Source Leakage Current $I_{GSS}$ (125°C) | 3411 | Conditions | Bias Condition C $V_{GS}$=±20V , $V_{DS}$=0V | | | | | | | | | | | |
| | | | | Limits | max ±100nA DC | | | | | | | | | | | |
| **-2b** | | Drain Current $I_{DSS}$ (125°C) | 3413 | Conditions | Bias Condition C $V_{DS}$=80V , $V_{GS}$=0V | | | Bias Condition C $V_{DS}$=104V , $V_{GS}$=0V | | | Bias Condition C $V_{DS}$=160V , $V_{GS}$=0V | | | Bias Condition C $V_{DS}$=200V , $V_{GS}$=0V | | |
| | | | | Limits | max 25μA DC | | | | | | | | | | | |
| **-2c** | | Gate to Source Voltage (Threshold) $V_{GS(th)}$ (125°C) | 3404 | Conditions | Bias Condition C $V_{GS}$=$V_{DS}$ , $I_D$=1mA | | | | | | | | | | | |
| | | | | Limits | min 1.5V DC | | | | | | | | | | | |
| **-2d** | | Static Drain to Source On-State Resistance $R_{DS(on)}$ (125°C) | 3421 | Conditions | Pulse Test([2]) , $V_{GS}$=12V | | | | | | | | | | | |
| | | | | | $I_D$ | | | $I_D$ | | | $I_D$ | | | $I_D$ | | |
| | | | | | 21A | 21A | 7.5A | 21A | 19.5A | 7.5A | 21A | 16A | 7A | 21A | 13A | 6A |
| | | | | Limits | max [mΩ] | | | max [mΩ] | | | max [mΩ] | | | max [mΩ] | | |
| | | | | | 23 | 49 | 110 | 31 | 71 | 162 | 52 | 125 | 297 | 76 | 183 | 448 |

Notes([1]) The same sample may be used for all subgroups.

([2]) Pulse test: Pulse width ≤ 1ms, Duty cycle ≤ 2%

## Table 1b. Group A Inspection ([1])

| Gr.No | Sub | Test Item | MIL-STD-750 Method | JAXA R | 100V Class 2SK 4217 | 100V Class 2SK 4218 | 100V Class 2SK 4219 | 130V Class 2SK 4152 | 130V Class 2SK 4153 | 130V Class 2SK 4154 | 200V Class 2SK 4155 | 200V Class 2SK 4156 | 200V Class 2SK 4157 | 250V Class 2SK 4158 | 250V Class 2SK 4159 | 250V Class 2SK 4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A -3** | | **Static Characteristics ($T_A$=-55°C)** | | Sample Size | LTPD 5 | | | | | | | | | | | |
| | **-3a** | Gate to Source Voltage (Threshold) $V_{GS(th)}$ (-55°C) | 3404 | Conditions | Bias Condition C $V_{GS}$=$V_{DS}$ , $I_D$=1mA | | | | | | | | | | | |
| | | | | Limits | max 5.0V DC | | | | | | | | | | | |
| | **-3b** | Forward Transconductance gfs (-55°C) | 3475 | Conditions | Pulse Test([2]) , $V_{DS}$=25V | | | | | | | | | | | |
| | | | | | $I_D$ | | | $I_D$ | | | $I_D$ | | | $I_D$ | | |
| | | | | | 21A | 21A | 7.5A | 21A | 19.5A | 7.5A | 21A | 16A | 7A | 21A | 13A | 6A |
| | | | | Limits | min | | | min | | | min | | | min | | |
| | | | | | 8.5S | 8.5S | 4.5S | 8.5S | 8.5S | 4.5S | 8.5S | 8.5S | 4.5S | 8.5S | 8.5S | 4.5S |
| **A -4** | | **Dynamic Characteristics ($T_A$=25°C)** | | Sample Size | LTPD 3 | | | | | | | | | | | |
| | | Switching Time Test | 3472 | Conditions | $V_{DD}$=50V | | | $V_{DD}$=65V | | | $V_{DD}$=100V | | | $V_{DD}$=125V | | |
| | | (1) Turn-on delay time: | | | $V_{GS}$=12V , $R_g$=10Ω | | | $V_{GS}$=12V , $R_g$=10Ω | | | $V_{GS}$=12V , $R_g$=10Ω | | | $V_{GS}$=12V , $R_g$=10Ω | | |
| | | $t_{d(on)}$ | | | $I_D$ | | | $I_D$ | | | $I_D$ | | | $I_D$ | | |
| | | Rise time: $t_r$ | | | 42A | 42A | 15A | 42A | 39A | 15A | 42A | 32A | 14A | 42A | 26A | 12A |
| | | (2) Turn-off delay time: | | Limits | max | | | max | | | max | | | max | | |
| | | $t_{d(off)}$ | | $t_{d(on)}$ | 65ns | 40ns | 30ns | 65ns | 40ns | 30ns | 65ns | 40ns | 30ns | 65ns | 40ns | 30ns |
| | | Fall time: $t_f$ | | $t_r$ | 30ns | 20ns | 20ns | 30ns | 20ns | 20ns | 30ns | 20ns | 20ns | 30ns | 20ns | 20ns |
| | | | | $t_{d(off)}$ | 190ns | 100ns | 65ns | 190ns | 100ns | 65ns | 190ns | 100ns | 65ns | 190ns | 100ns | 65ns |
| | | | | $t_f$ | 65ns | 30ns | 15ns | 65ns | 30ns | 15ns | 35ns | 20ns | 15ns | 30ns | 15ns | 10ns |
| **A -6a** | | **Safe Operating Area Test([3])** | | Sample Size | LTPD 5 | | | | | | | | | | | |
| | | | 3474 | Conditions | --- | | | | | | | | | | | |
| | **-6b** | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| **A -7** | | **Other Characteristics ($T_A$=25°C)([4])** | | Sample Size | LTPD 10 | | | | | | | | | | | |
| | **-7a** | Gate Charge | 3471 | Conditions | $V_{GS}$=12V | | | $V_{GS}$=12V | | | $V_{GS}$=12V | | | $V_{GS}$=12V | | |
| | | (1) Gate Charge: $Q_g$ | | | $V_{DS}$=50V | | | $V_{DS}$=65V | | | $V_{DS}$=100V | | | $V_{DS}$=125V | | |
| | | (2) Gate to Drain Charge: $Q_{gd}$ | | | $I_D$ | | | $I_D$ | | | $I_D$ | | | $I_D$ | | |
| | | | | | 42A | 42A | 15A | 42A | 39A | 15A | 42A | 32A | 14A | 42A | 26A | 12A |
| | | (3) Gate to Source Charge: $Q_{gs}$ | | Limits | max | | | max | | | max | | | max | | |
| | | | | $Q_g$ | 220nC | 100nC | 50nC | 220nC | 100nC | 50nC | 220nC | 100nC | 50nC | 220nC | 100nC | 50nC |
| | | | | $Q_{gd}$ | 70nC | 30nC | 10nC | 70nC | 30nC | 10nC | 70nC | 30nC | 10nC | 70nC | 30nC | 10nC |
| | | | | $Q_{gs}$ | 60nC | 30nC | 13nC | 60nC | 30nC | 13nC | 60nC | 30nC | 13nC | 60nC | 30nC | 13nC |
| | **-7b** | **Reverse Recovery Characteristics** | 3473 | Conditions | $I_F$= $I_D$ | | | $I_F$= $I_D$ | | | $I_F$= $I_D$ | | | $I_F$= $I_D$ | | |
| | | | | | 42A | 42A | 15A | 42A | 39A | 15A | 42A | 32A | 14A | 42A | 26A | 12A |
| | | (1) $t_{rr}$ | | | $V_{GS}$=0V | | | | | | | | | | | |
| | | (2) $Q_{rr}$ | | | -di/dt=100A/μs | | | | | | | | | | | |
| | | | | Limits | max | | | max | | | max | | | max | | |
| | | | | $t_{rr}$ | 765ns | 750ns | 525ns | 765ns | 750ns | 525ns | 1050ns | 1200ns | 950ns | 1500ns | 1350ns | 950ns |
| | | | | $Q_{rr}$ | 10.5μC | 10.0μC | 5.5μC | 13.0μC | 12.0μC | 6.5μC | 20.0μC | 18.0μC | 9.0μC | 29.0μC | 18.0μC | 10.0μC |

Notes ([1]) The same sample may be used for all subgroups.

([2]) Pulse test: Pulse width ≤ 1ms, Duty cycle ≤ 2%

([3]) The samples used for subgroups A-1, A-2, and A-3 tests shall be used.

([4]) The samples used for subgroups A-6 tests shall be used.

## Table 2a. Group B Inspection

| Gr.No | MIL-STD-750 | | | 100V Class | | | 130V Class | | | 200V Class | | | 250V Class | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub | Test Item | Method | JAXA R | 2SK 4217 | 2SK 4218 | 2SK 4219 | 2SK 4152 | 2SK 4153 | 2SK 4154 | 2SK 4155 | 2SK 4156 | 2SK 4157 | 2SK 4158 | 2SK 4159 | 2SK 4160 |
| **B -1** | **External Dimensions**(1) | | Sample Size | Level I (2) 3p<br>Level II (2) 3p | | | | | | | | | | | |
| | | 2066 | Conditions | See Fig. 1a, 1b, 1c | | | | | | | | | | | |
| **B -2** | **Resistance to Solvents**(3) (4) | | Sample Size | Level I 3p<br>Level II 3p | | | | | | | | | | | |
| | | 1022 | Conditions | Solvent a, b, c | | | | | | | | | | | |
| **B -3b** | **Temperature Cycling (Air to Air)** | | Sample Size | Level I 6p<br>Level II 6p | | | | | | | | | | | |
| | | 1051 | Conditions | $-55^{+0}_{-5}$°C↔$25^{+10}_{-5}$°C↔$150^{+5}_{-0}$°C<br>100 cycles | | | | | | | | | | | |
| **-3c** | **Surge Test**<br>(1) Gate Shock | 4066 | Conditions | $V_{GS}$=35V | | | | | | | | | | | |
| | (2) Avalanche | 3470 | Conditions | $V_{DS}$=48V, L= See paragraph 4.5.2, Equation (1), $R_g$=10Ω | | | | | | | | | | | |
| | | | | $I_{D(pulse)}$ | | | | | | | | | | | |
| | | | | 42A | 42A | 15A | 42A | 39A | 15A | 42A | 32A | 14A | 42A | 26A | 12A |
| **-3d** | **Hermetic Seal**<br>(1) Fine | 1071 | Conditions | Condition H | | | | | | | | | | | |
| | | | Limits | max<br>$1\times10^{-3}$Pa-cm$^3$/s | | | | | | | | | | | |
| | (2) Gross | 1071 | Conditions | Condition C | | | | | | | | | | | |
| **-3e** | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| **-3f** | **Decap-Internal**<br>**Visual and mechanical** inspection | 2075<br>2071 | Conditions | --- | | | | | | | | | | | |
| **-3g** | **Bond Strength** | 2037 | Conditions | Condition D | | | | | | | | | | | |
| | | | Limits | Gate Wire<br>>90gf | | | | | | | | | | | |
| | | | | Source Wire | | | | | | | | | | | |
| | | | | >300gf | >300gf | >90gf | >300gf | >300gf | >90gf | >300gf | >300gf | >90gf | >300gf | >300gf | >90gf |
| **-3h** | **SEM**(1) | 2077 | Conditions | --- | | | | | | | | | | | |
| **-3i** | **Die Shear** | | Sample Size | Level I 3p<br>Level II 3p | | | | | | | | | | | |
| | | 2017 | Conditions | --- | | | | | | | | | | | |
| | | | Limits | min<br>2.5kgf | | | | | | | | | | | |
| **B -4** | **Solderability**(3) (4) | | Sample Size | Level I 6 terminals(5)<br>Level II 6 terminals(5) | | | | | | | | | | | |
| | | 2026 | Conditions | --- | | | | | | | | | | | |

Notes(1) The test may be performed using the samples prior to inspection lot formation.

(2) Level I and Level II shall be applicable to the qualification test and the quality conformance inspection, respectively. (See paragraphs C.3.2 and C.3.3 of JAXA-QTS-2030)

(3) Electrical reject products from the same inspection lot may be used.

(4) When Electrical reject products are used, the samples shall be exposed to the same thermal environments as the experience in all thermal tests required in the screening test.

(5) This test shall be performed for each 3 terminals from 2 devices.

## Table 2b. Group B Inspection

| Gr.No | MIL-STD-750 | | | 100V Class | | | 130V Class | | | 200V Class | | | 250V Class | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub | Test Item | Method | JAXA R | 2SK 4217 | 2SK 4218 | 2SK 4219 | 2SK 4152 | 2SK 4153 | 2SK 4154 | 2SK 4155 | 2SK 4156 | 2SK 4157 | 2SK 4158 | 2SK 4159 | 2SK 4160 |
| **B -5a** | **Intermittent Operation Life** | | Sample Size | Level I LTPD 10<br>Level II 12p | | | | | | | | | | | |
| | | 1042 | Conditions | Condition D, 2000 cycles([1])<br>Minimum On time: 30 seconds | | | | | | | | | | | |
| **-5b** | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| **B -6c** | **Accelerated Steady-state Gate Stress (High Temp. GS)** | | Sample Size | Level I LTPD 10<br>Level II 12p | | | | | | | | | | | |
| | | 1042 | Conditions | $V_{GS}$=20V, $T_A$ =150°C, 48hr<br>or $V_{GS}$=20V, $T_A$ =175°C, 24hr | | | | | | | | | | | |
| **-6d** | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| **-6e** | **Accelerated Steady-state Reverse Bias (DS)** | 1042 | Conditions | $V_{DS}$=100V | | | $V_{DS}$=130V | | | $V_{DS}$=200V | | | $V_{DS}$=250V | | |
| | | | | $T_A$ =150°C, 240hr<br>or $T_A$ =175°C, 120hr | | | | | | | | | | | |
| **-6f** | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| **-6g** | **Bond Strength** | | Sample Size | 20 wires | | | | | | | | | | | |
| | | 2037 | Conditions | Condition D | | | | | | | | | | | |
| | | | Limits | Gate Wire<br>>90gf | | | | | | | | | | | |
| | | | | Source Wire | | | | | | | | | | | |
| | | | | >300gf | >300gf | >90gf | >300gf | >300gf | >90gf | >300gf | >300gf | >90gf | >300gf | >300gf | >90gf |
| **B -7** | **Thermal impedance** $Z_{th(ch-c)}(\Delta V_{SD})$ | | Sample Size | Level I LTPD 10<br>Level II 8p | | | | | | | | | | | |
| | | 3161 | Conditions | $T_A$=25°C | | | | | | | | | | | |
| | | | Limits | max (°C/W) | | | max (°C/W) | | | max (°C/W) | | | max (°C /W) | | |
| | | | | 0.5 | 0.83 | 1.67 | 0.5 | 0.83 | 1.67 | 0.5 | 0.83 | 1.67 | 0.5 | 0.83 | 1.67 |

Note([1]) If the samples are also used for “Intermittent operating life test” of C1-1 in the Group C inspection, the test shall be performed up to 6000 cycles.

## Table 3. Group C Inspection

| Gr.No | MIL-STD-750 | | | 100V Class | | | 130V Class | | | 200V Class | | | 250V Class | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub | Test Item | Method | JAXA R | 2SK 4217 | 2SK 4218 | 2SK 4219 | 2SK 4152 | 2SK 4153 | 2SK 4154 | 2SK 4155 | 2SK 4156 | 2SK 4157 | 2SK 4158 | 2SK 4159 | 2SK 4160 |
| **C 1-1a** | **Intermittent Operation Life** | | Sample Size | Level I LTPD 10<br>Level II LTPD 10 | | | | | | | | | | | |
| | | 1042 | Conditions | Condition D, 6000 cycles ([1])<br>Minimum On time: 30 seconds | | | | | | | | | | | |
| **1-1b** | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| **C 1-2a** | **Steady-state Bias Life test (high temp. GS applied)** ([2]) | | Sample Size | Level I LTPD 5<br>Level II NA | | | | | | | | | | | |
| | | 1042 | Conditions | $V_{GS}$=16V<br>$T_A$=150°C, 1000hr | | | | | | | | | | | |
| **1-2b** | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| **1-2c** | **Steady-state Bias Life test (high temp. DS applied)** ([2]) | 1042 | Conditions | $V_{DS}$=80V | | | $V_{DS}$=104V | | | $V_{DS}$=160V | | | $V_{DS}$=200V | | |
| | | | | $T_A$=150°C, 1000hr | | | | | | | | | | | |
| **1-2d** | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| **C -2a** | **Temperature Cycling** | | Sample Size | Level I 12p<br>Level II NA | | | | | | | | | | | |
| | | 1051 | Conditions | $-55^{+0}_{-5}$°C↔$25^{+10}_{-5}$°C↔$150^{+5}_{-0}$°C<br>100 cycles | | | | | | | | | | | |
| **-2b** | **Hermetic Seal** (1) Fine | 1071 | Conditions | Condition H | | | | | | | | | | | |
| | | | Limits | max<br>$1\times10^{-3}$Pa-cm$^3$/s | | | | | | | | | | | |
| | (2) Gross | 1071 | Conditions | Condition C | | | | | | | | | | | |
| **-2c** | **End-Point Electrical Measurements** ([3]) | | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| **C -3** | **Thermal Impedance** ([4]) ([5])<br>$Z_{th(ch-c)}(\Delta V_{SD})$ | | Sample Size | Level I LTPD 10<br>Level II 8p | | | | | | | | | | | |
| | | 3161 | Conditions | $T_A$=25°C | | | | | | | | | | | |
| | | | Limits | max (°C/W) | | | max (°C/W) | | | max (°C/W) | | | max (°C /W) | | |
| | | | | 0.5 | 0.83 | 1.67 | 0.5 | 0.83 | 1.67 | 0.5 | 0.83 | 1.67 | 0.5 | 0.83 | 1.67 |
| **C -4a** | **Safe Operating Area Test**([6]) | | Sample Size | Level I LTPD 10<br>Level II LTPD 10 | | | | | | | | | | | |
| | | 3474 | Conditions | --- | | | | | | | | | | | |
| **-4b** | **End-Point Electrical Measurements** ([6]) | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| **C -6a** | **Electric Discharge Sensitivity Classification** | | Sample Size | Level I 3p<br>Level II NA | | | | | | | | | | | |
| | | 1020 | Conditions | $V_{GS}$ | | | | | | | | | | | |
| | | | | ±2750V | ±1000V | ±500V | ±2750V | ±1000V | ±500V | ±2750V | ±1000V | ±500V | ±2750V | ±1000V | ±500V |
| | | | | $V_{DS}$=0V | | | | | | | | | | | |
| **-6b** | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |

Notes([1]) For the quality conformance inspection, the cycles may be reduced to 2000 cycles as a minimum.
([2]) The legibility of the marking shall not apply.
([3]) This test may be conducted prior to the hermetic seal.
([4]) Thermal impedance curve shall be obtained during the qualification test.
([5]) If the inspection lot is the one used in the Group B inspection, this test may be exempted.
([6]) This test may be exempted if performed in the Group A inspection.

## Table 4a. Group D Inspection

| Gr.No | Sub | MIL-STD-750 Test Item | Method | JAXA R | 100V Class 2SK 4217 | 100V Class 2SK 4218 | 100V Class 2SK 4219 | 130V Class 2SK 4152 | 130V Class 2SK 4153 | 130V Class 2SK 4154 | 200V Class 2SK 4155 | 200V Class 2SK 4156 | 200V Class 2SK 4157 | 250V Class 2SK 4158 | 250V Class 2SK 4159 | 250V Class 2SK 4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D | -1a | **Thermal Shock (Glass Strain)** | | Sample Size | Level I LTPD 15<br>Level II LTPD 15 | | | | | | | | | | | |
| | | | 1056 | Conditions | Condition B, 15 cycles | | | | | | | | | | | |
| | -1b | **Temperature Cycling** | 1051 | Conditions | $-55^{+0}_{-5}$°C↔$25^{+10}_{-5}$°C↔$150^{+5}_{-0}$°C<br>45 cycles | | | | | | | | | | | |
| | -1d | **Moisture Resistance** | 1021 | Conditions | (MIL-STD-202, Method 106) | | | | | | | | | | | |
| | -1e | **Hermetic Seal**<br>(1) Fine | 1071 | Conditions | Condition H | | | | | | | | | | | |
| | | | | Limits | max<br>$1\times10^{-3}$Pa-cm$^3$/s | | | | | | | | | | | |
| | | (2) Gross | 1071 | Conditions | Condition C | | | | | | | | | | | |
| | -1f | **Visual Inspection** | 1051<br>1021 | Conditions | --- | | | | | | | | | | | |
| | -1g | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| D | -2a | **Shock**(1) | | Sample Size | Level I LTPD 15<br>Level II LTPD 15 | | | | | | | | | | | |
| | | | 2016 | Conditions | No Operating, 14700m/s$^2$ (1500G)<br>5 blows in each orientation, $X_1$, $Y_1$, $Y_2$ and $Z_1$ | | | | | | | | | | | |
| | -2b | **Vibration, Variable Frequency**(1) | 2056 | Conditions | 100 to 2000 Hz, 4min<br>196 m/s$^2$ (20G)<br>4 blows in each orientation X,Y,Z | | | | | | | | | | | |
| | -2c | **Constant Acceleration**(1) | 2006 | Conditions | 98100m/s$^2$ (10000G)<br>$X_1$, $Y_1$, $Y_2$ and $Z_1$ orientation | | | | | | | | | | | |
| | -2d | **Hermetic Seal**(1)<br>(1) Fine | 1071 | Conditions | Condition H | | | | | | | | | | | |
| | | | | Limits | max<br>$1\times10^{-3}$Pa-cm$^3$/s | | | | | | | | | | | |
| | | (2) Gross | 1071 | Conditions | Condition C | | | | | | | | | | | |
| | -2e | **End-Point Electrical Measurements**(1) | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |
| D | -3a | **Salt Atmosphere**(2) | | Sample Size | Level I LTPD 15<br>Level II LTPD 15 | | | | | | | | | | | |
| | | | 1041 | Conditions | 35°C, 24hr<br>Rate of salt deposit=10 to 50g/m$^2$/24hr | | | | | | | | | | | |

Notes(1) Samples used for subgroup 1 may be used.

(2) Electrical reject products from the same inspection lot may be used.

## Table 4b. Group D Inspection

| Gr.No | MIL-STD-750 | | | 100V Class | | | 130V Class | | | 200V Class | | | 250V Class | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub | Test Item | Method | JAXA R | 2SK 4217 | 2SK 4218 | 2SK 4219 | 2SK 4152 | 2SK 4153 | 2SK 4154 | 2SK 4155 | 2SK 4156 | 2SK 4157 | 2SK 4158 | 2SK 4159 | 2SK 4160 |
| **D -4** | **Barometric Pressure (reduced)** | | Sample Size | | | | | | | | | | Level I 3p<br>Level II NA | | |
| | | 1001 | Conditions | Not applicable for devices with rated voltage ≤ 200V. | | | | | | | | | 8mmHg<br>60sec (minimum)<br>$V_{DS}$=250V, $V_{GS}$=0V | | |
| **D -5** | **Internal Water Vapor** (1) | | Sample Size | Level I 3p<br>Level II 3p | | | | | | | | | | | |
| | | 1018 | Conditions | --- | | | | | | | | | | | |
| **D -6a** | **Resistance to Soldering Heat** | | Sample Size | Level I 3p<br>Level II NA | | | | | | | | | | | |
| | | 2031 | Conditions | 240°C, 10s | | | | | | | | | | | |
| **-6b** | **Visual Inspection** | --- | Conditions | --- | | | | | | | | | | | |
| **-6c** | **Hermetic Seal**<br>(1) Fine | 1071 | Conditions | Condition H | | | | | | | | | | | |
| | | | Limits | max<br>$1\times10^{-3}$Pa-cm$^3$/s | | | | | | | | | | | |
| | (2) Gross | 1071 | Conditions | Condition C | | | | | | | | | | | |
| **-6d** | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-1 | | | | | | | | | | | |

Note(1) Electrical reject products from the same inspection lot may be used.

## Table 5. Group E Inspection

| Gr.No | Sub | Test Item | MIL-STD-750 Method | JAXA R | 100V Class 2SK 4217 | 2SK 4218 | 2SK 4219 | 130V Class 2SK 4152 | 2SK 4153 | 2SK 4154 | 200V Class 2SK 4155 | 2SK 4156 | 2SK 4157 | 250V Class 2SK 4158 | 2SK 4159 | 2SK 4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E | -1a | **Total Dose Irradiation (TID)** | | Sample Size | Level I 4 p([1])<br>Level II 4 p([1]) | | | | | | | | | | | |
| | | | 1019 | Conditions | Total Dose<br>$1\times10^3$Gy(Si)<br>Dose Rate<br>36Gy(Si)/h to 360Gy(Si)/h<br><br>Bias Condition<br>(during irradiation, after irradiation)<br>(a) $V_{DS}$=0V , $V_{GS}$=20V<br>(b) $V_{DS}$=0V , $V_{GS}$=-20V<br>(c) $V_{DS}$=80V, $V_{GS}$=0V | | | (c) $V_{DS}$=104V, $V_{GS}$=0V | | | (c) $V_{DS}$=160V, $V_{GS}$=0V | | | (c) $V_{DS}$=200V, $V_{GS}$=0V | | |
| | -1b | **End-Point Electrical Measurements** | | | Within 24hr after irradiation | | | | | | | | | | | |
| | (1) | Breakdown Voltage Drain to Source $V_{DSS}$ | 3407 | Conditions | Bias Condition C<br>$I_D$=1mA , $V_{GS}$=0V | | | | | | | | | | | |
| | | | | Limits | min 100V DC | | | min 130V DC | | | min 200V DC | | | min 250V DC | | |
| | (2) | Gate-to-Source Leakage Current $I_{GSS}$ | 3411 | Conditions | Bias Condition C<br>$V_{GS}$=±20V , $V_{DS}$=0V | | | | | | | | | | | |
| | | | | Limits | max<br>±100nA DC | | | | | | | | | | | |
| | (3) | Drain Current $I_{DSS}$ | 3413 | Conditions | Bias Condition C<br>$V_{DS}$=80V , $V_{GS}$=0V | | | Bias Condition C<br>$V_{DS}$=104V , $V_{GS}$=0V | | | Bias Condition C<br>$V_{DS}$=160V , $V_{GS}$=0V | | | Bias Condition C<br>$V_{DS}$=200V , $V_{GS}$=0V | | |
| | | | | Limits | max<br>10μA DC | | | | | | | | | | | |
| | (4) | Gate to Source Voltage (Threshold) $V_{GS(th)}$ | 3404 | Conditions | Bias Condition C<br>$V_{GS}$=$V_{DS}$ , $I_D$=1mA | | | | | | | | | | | |
| | | | | Limits | min 1.5V DC<br>$\Delta V_{GS(th)}$ max 2.0V | | | | | | | | | | | | |
| | (5) | Static Drain to Source On-State Resistance $R_{DS(on)}$ | 3421 | Conditions | Pulse Test([2]) , $V_{GS}$=12V | | | | | | | | | | | |
| | | | | | $I_D$ | | | $I_D$ | | | $I_D$ | | | $I_D$ | | |
| | | | | | 21A | 21A | 7.5A | 21A | 19.5A | 7.5A | 21A | 16A | 7A | 21A | 13A | 6A |
| | | | | Limits | max (mΩ) | | | max (mΩ) | | | max (mΩ) | | | max (mΩ) | | |
| | | | | | 13 | 28 | 64 | 17 | 39 | 89 | 26 | 62 | 148 | 38 | 91 | 223 |

Notes([1]) This test shall be performed for each single wafer lot. When an inspection lot consists of multiple inspection sublots, one inspection sublot may be performed this test.

([2]) Pulse test: Pulse width ≤ 1ms, Duty cycle ≤ 2%

## Table 6. Exemption of Quality Conformance Inspection

When the qualification test or the quality conformance inspection for products specified as following Table was initiated within a year from the completion date of the screening test for the inspection lot, and the device passed the test or inspection, the corresponding tests may be exempted.

| Gr.No | | | 100V Class | | | 130V Class | | | 200V Class | | | 250V Class | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sub | JAXA R | 2SK 4217 | 2SK 4218 | 2SK 4219 | 2SK 4152 | 2SK 4153 | 2SK 4154 | 2SK 4155 | 2SK 4156 | 2SK 4157 | 2SK 4158 | 2SK 4159 | 2SK 4160 |
| | | JAXA-QTS-2030 Appendix C | Die Size 1/1 | 1/2 | 1/4 | Die Size 1/1 | 1/2 | 1/4 | Die Size 1/1 | 1/2 | 1/4 | Die Size 1/1 | 1/2 | 1/4 |
| | | Test Item | Package Type SMD2 | SMD1 | SMD0.5 | Package Type SMD2 | SMD1 | SMD0.5 | Package Type SMD2 | SMD1 | SMD0.5 | Package Type SMD2 | SMD1 | SMD0.5 |
| | **1-1a** | Intermittent Operation Life | These tests may be exempted when the following two conditions are satisfied.<br>• When the devices having the same die size or larger die size passed.<br>• When the devices passed using the value of $V_{DS}$ defined in paragraph 1.2 or larger value of the $V_{DS}$. | | | | | | | | | | | |
| | **1-1b** | End-Point Electrical Measurements | | | | | | | | | | | | |
| | **-3** | Thermal Impedance | This test may be exempted when the device passed the subgroup B-7 of Group B inspection. | | | | | | | | | | | |
| | **-4a** | Safe Operating Area Test | This test may be exempted when the device passed the subgroup A-6 of Group A inspection. | | | | | | | | | | | |
| | **-4b** | End-Point Electrical Measurements | | | | | | | | | | | | |
| **D** | **-1a** | Thermal Shock (Glass Strain) | • This test for the device having SMD-1 and SMD-0.5 Package may be exempted when the device having SMD-2 Package passed this test.<br>• This test for the device having SMD-0.5 Package may be exempted when the device having SMD-1 Package passed this test. | | | | | | | | | | | |
| | **-1b** | Thermal Shock (Temperature Cycling) | | | | | | | | | | | | |
| | **-1d** | Moisture Resistance | | | | | | | | | | | | |
| | **-1e** | Hermetic Seal | | | | | | | | | | | | |
| | **-1f** | Visual Inspection | | | | | | | | | | | | |
| | **-1g** | End-Point Electrical Measurements | | | | | | | | | | | | |
| | **-2a** | Shock | | | | | | | | | | | | |
| | **-2b** | Vibration, Variable Frequency | | | | | | | | | | | | |
| | **-2c** | Constant Acceleration | | | | | | | | | | | | |
| | **-2d** | Hermetic Seal | | | | | | | | | | | | |
| | **-2e** | End-Point Electrical Measurements | | | | | | | | | | | | |
| | **-3a** | Salt Atmosphere | This test may be exempted when any one of the products passed the test. | | | | | | | | | | | |
| | **-5** | Internal Water Vapor | | | | | | | | | | | | |

## Table 7a. Qualification Test : Group A Inspection

| MIL-PRF-19500N Gr.No Sub | 2030C Gr.No. (1) | MIL-STD-750 Test Item | Method | JAXA R | 130V Class 2SK4152 | 130V Class 2SK4153 | 130V Class 2SK4154 | 200V Class 2SK4155 | 200V Class 2SK4156 | 200V Class 2SK4157 | 250V Class 2SK4158 | 250V Class 2SK4159 | 250V Class 2SK4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A -2** | A-1 | **Static Characteristics ($T_A$=25°C)** | | Sample Size | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs |
| **-2a** | A-1a | Breakdown Voltage Drain to Source $V_{DSS}$ | 3407 | Conditions | Bias Condition C $I_D$=1mA , $V_{GS}$=0V | | | | | | | | |
| | | | | Limits | min 130V DC | | | min 200V DC | | | min 250V DC | | |
| **-2b** | A-1b | Gate Current $I_{GSS}$ | 3411 | Conditions | Bias Condition C $V_{GS}$=±20V , $V_{DS}$=0V | | | | | | | | |
| | | | | Limits | max ±100nA DC | | | | | | | | |
| **-2c** | A-1c | Drain Current $I_{DSS}$ | 3413 | Conditions | Bias Condition C $V_{DS}$=104V , $V_{GS}$=0V | | | Bias Condition C $V_{DS}$=160V , $V_{GS}$=0V | | | Bias Condition C $V_{DS}$=200V , $V_{GS}$=0V | | |
| | | | | Limits | max 10μA DC | | | | | | | | |
| **-2d** | A-1d | Gate to Source Voltage (Threshold) $V_{GS(th)}$ | 3404 | Conditions | Bias Condition C $V_{GS}$=$V_{DS}$ , $I_D$=1mA | | | | | | | | |
| | | | | Limits | 2.5 - 4.5V DC | | | | | | | | |
| **-2e** | A-1e | Static Drain to Source On-State Resistance $R_{DS(on)}$ | 3421 | Conditions | Pulse Test(2) , $V_{GS}$=12V | | | | | | | | |
| | | | | | $I_D$ 21A | $I_D$ 19.5A | $I_D$ 7.5A | $I_D$ 21A | $I_D$ 16A | $I_D$ 7A | $I_D$ 21A | $I_D$ 13A | $I_D$ 6A |
| | | | | Limits | max 17mΩ | max 39mΩ | max 89mΩ | max 26mΩ | max 62mΩ | max 148mΩ | max 38mΩ | max 91mΩ | max 223mΩ |
| **-2f** | A-1f | Forward Transconductance gfs | 3475 | Conditions | Pulse Test(2) , $V_{DS}$=25V | | | | | | | | |
| | | | | | $I_D$ 21A | $I_D$ 19.5A | $I_D$ 7.5A | $I_D$ 21A | $I_D$ 16A | $I_D$ 7A | $I_D$ 21A | $I_D$ 13A | $I_D$ 6A |
| | | | | Limits | min 8S | min 8S | min 4S | min 8S | min 8S | min 4S | min 8S | min 8S | min 4S |
| **-2g** | A-1g | Forward Voltage $V_{SD}$ | --- | Conditions | Pulse Test(2) , $V_{GS}$=0V | | | | | | | | |
| | | | | | $I_D$ 42A | $I_D$ 39A | $I_D$ 15A | $I_D$ 42A | $I_D$ 32A | $I_D$ 14A | $I_D$ 42A | $I_D$ 26A | $I_D$ 12A |
| | | | | Limits | max 1.6VDC | | | max 1.6VDC | | | max 1.6VDC | | |
| **A -3** | A-2<br>A-3 | **Static Characteristics ($T_A$=-55, 125°C)** | | Sample Size | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs |
| **-3a** | A-3a | Gate to Source Voltage (Threshold) $V_{GS(th)}$ (-55°C) | 3404 | Conditions | Bias Condition C $V_{GS}$=$V_{DS}$ , $I_D$=1mA | | | | | | | | |
| | | | | Limits | max 5.0V DC | | | | | | | | |
| **-3b** | A-3b | Forward Transconductance gfs (-55°C) | 3475 | Conditions | Pulse Test(2) , $V_{DS}$=25V | | | | | | | | |
| | | | | | $I_D$ 21A | $I_D$ 19.5A | $I_D$ 7.5A | $I_D$ 21A | $I_D$ 16A | $I_D$ 7A | $I_D$ 21A | $I_D$ 13A | $I_D$ 6A |
| | | | | Limits | min 8.5S | min 8.5S | min 4.5S | min 8.5S | min 8.5S | min 4.5S | min 8.5S | min 8.5S | min 4.5S |
| **-3c** | A-2a | Gate Current $I_{GSS}$ (125°C) | 3411 | Conditions | Bias Condition C $V_{GS}$=±20V , $V_{DS}$=0V | | | | | | | | |
| | | | | Limits | max ±100nA DC | | | | | | | | |
| **-3d** | A-2b | Drain Current $I_{DSS}$ (125°C) | 3413 | Conditions | Bias Condition C $V_{DS}$=104V , $V_{GS}$=0V | | | Bias Condition C $V_{DS}$=160V , $V_{GS}$=0V | | | Bias Condition C $V_{DS}$=200V , $V_{GS}$=0V | | |
| | | | | Limits | max 25μA DC | | | | | | | | |
| **-3e** | A-2c | Gate to Source Voltage (Threshold) $V_{GS(th)}$ (125°C) | 3404 | Conditions | Bias Condition C $V_{GS}$=$V_{DS}$ , $I_D$=1mA | | | | | | | | |
| | | | | Limits | min 1.5V DC | | | | | | | | |
| **-3f** | A-2d | Static Drain to Source On-State Resistance $R_{DS(on)}$ (125°C) | 3421 | Conditions | Pulse Test(2) , $V_{GS}$=12V | | | | | | | | |
| | | | | | $I_D$ 21A | $I_D$ 19.5A | $I_D$ 7.5A | $I_D$ 21A | $I_D$ 16A | $I_D$ 7A | $I_D$ 21A | $I_D$ 13A | $I_D$ 6A |
| | | | | Limits | max 31mΩ | max 71mΩ | max 162mΩ | max 52mΩ | max 125mΩ | max 297mΩ | max 76mΩ | max 183mΩ | max 448mΩ |

Notes(1) The symbols refer to the test method number in JAXA-QTS-2030C.

(2) Pulse width ≤ 1ms, Duty cycle ≤ 2%

## Table 7b. Qualification Test : Group A Inspection

| MIL-PRF-19500N Gr.No / Sub | 2030C Gr.No. | MIL-STD-750 Test Item | Method | JAXA R | 130V Class 2SK4152 | 130V Class 2SK4153 | 130V Class 2SK4154 | 200V Class 2SK4155 | 200V Class 2SK4156 | 200V Class 2SK4157 | 250V Class 2SK4158 | 250V Class 2SK4159 | 250V Class 2SK4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A -4** | A-4 | **Dynamic Characteristics ($T_A$=25°C)** | | Sample Size | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs | 116pcs |
| | | Switching Time Test | 3472 | Conditions | $V_{DD}$=65V | | | $V_{DD}$=100V | | | $V_{DD}$=125V | | |
| | | (1) Turn-on | | | $V_{GS}$=12V , $R_g$=10Ω | | | $V_{GS}$=12V , $R_g$=10Ω | | | $V_{GS}$=12V , $R_g$=10Ω | | |
| | | $t_{d(on)}$ | | | $I_D$ | | | $I_D$ | | | $I_D$ | | |
| | | Rise time: $t_r$ | | | 42A | 39A | 15A | 42A | 32A | 14A | 42A | 26A | 12A |
| | | (2) Turn-off | | Limits | max | | | max | | | max | | |
| | | $t_{d(off)}$ | | $t_{d(on)}$ | 65ns | 40ns | 30ns | 65ns | 40ns | 30ns | 65ns | 40ns | 30ns |
| | | Fall time: $t_f$ | | $t_r$ | 30ns | 20ns | 20ns | 30ns | 20ns | 20ns | 30ns | 20ns | 20ns |
| | | | | $t_{d(off)}$ | 190ns | 100ns | 65ns | 190ns | 100ns | 65ns | 190ns | 100ns | 65ns |
| | | | | $t_f$ | 65ns | 30ns | 15ns | 35ns | 20ns | 15ns | 30ns | 15ns | 10ns |
| **A -5a** | A-6a | **Safe Operating Area test** | | Sample Size | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs |
| | | | 3474 | Conditions | --- | | | --- | | | --- | | |
| **-5b** | A-6b | **End-Point Electrical Measurements** | --- | | Same as Gr.A-2 | | | | | | | | |
| **A -7** | **A-7** | **Dynamic Characteristics ($T_A$=25°C)** | | Sample Size | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs |
| **-7a** | A-7a | Gate Charge | 3471 | Conditions | $V_{GS}$=12V | | | $V_{GS}$=12V | | | $V_{GS}$=12V | | |
| | | (1) $Q_g$ | | | $V_{DS}$=65V | | | $V_{DS}$=100V | | | $V_{DS}$=125V | | |
| | | (2) $Q_{gd}$ | | | $I_D$ | | | $I_D$ | | | $I_D$ | | |
| | | (3) $Q_{gs}$ | | | 42A | 39A | 15A | 42A | 32A | 14A | 42A | 26A | 12A |
| | | | | Limits | max | | | max | | | max | | |
| | | | | $Q_g$ | 220nC | 100nC | 50nC | 220nC | 100nC | 50nC | 220nC | 100nC | 50nC |
| | | | | $Q_{gd}$ | 70nC | 30nC | 10nC | 70nC | 30nC | 10nC | 70nC | 30nC | 10nC |
| | | | | $Q_{gs}$ | 60nC | 30nC | 13nC | 60nC | 30nC | 13nC | 60nC | 30nC | 13nC |
| **-7b** | A-7b | Reverse Recovery Characteristics | 3473 | Conditions | $I_F$= $I_D$ | | | $I_F$= $I_D$ | | | $I_F$= $I_D$ | | |
| | | | | | 42A | 39A | 15A | 42A | 32A | 14A | 42A | 26A | 12A |
| | | (1) $t_{rr}$ | | | $V_{GS}$=0V | | | | | | | | |
| | | (2) $Q_{rr}$ | | | -di/dt=100A/μs | | | | | | | | |
| | | | | Limits | max | | | max | | | max | | |
| | | | | $t_{rr}$ | 765ns | 750ns | 525ns | 1050ns | 1200ns | 950ns | 1500ns | 1350ns | 950ns |
| | | | | $Q_{rr}$ | 13.0μC | 12.0μC | 6.5μC | 20.0μC | 18.0μC | 9.0μC | 29.0μC | 18.0μC | 10.0μC |

## Table 8a. Qualification Test : Group B Inspection

| MIL-PRF-19500N Gr.No / Sub | 2030C Gr.No. | MIL-STD-750 Test Item | Method | JAXA R | 130V Class 2SK4152 | 130V Class 2SK4153 | 130V Class 2SK4154 | 200V Class 2SK4155 | 200V Class 2SK4156 | 200V Class 2SK4157 | 250V Class 2SK4158 | 250V Class 2SK4159 | 250V Class 2SK4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **B -1** | B-1 | **External Dimensions** (1) | | Sample Size | --- | --- | --- | 22pcs | 22pcs | 22pcs | --- | --- | --- |
| | | | 2066 | Conditions | Omitted (Tested in 200V class because of the same package.) | | | --- | | | Omitted (Tested in 200V class because of the same package.) | | |
| **B -2a** | B-4 | **Solderability** (1) (2) | | Sample Size | 15pcs | 15pcs | 15pcs | --- | --- | --- | --- | --- | --- |
| | | | 2026 | Conditions | --- | | | Omitted (Tested in 130V class because of the same package.) | | | Omitted (Tested in 130V class because of the same package.) | | |
| **-2b** | B-2 | **Resistance to Solvents**(1) (2) | 1022 | Conditions | --- | | | Omitted (Tested in 130V class because of the same package.) | | | Omitted (Tested in 130V class because of the same package.) | | |
| **B -3b** | B-3b | **Temperature Cycling (Air to Air)** | | Sample Size | --- | --- | --- | 22pcs | 22pcs | 22pcs | --- | --- | --- |
| | | | 1051 | Conditions | Omitted (Tested in 200V class because of the same package.) | | | $-55^{+0}_{-5}$°C↔$25^{+10}_{-5}$°C↔ $150^{+5}_{-0}$°C 100 cycles | | | Omitted (Tested in 200V class because of the same package.) | | |
| **-3c** | B-3c | **Surge Test** (1) Gate Shock | 4066 | Conditions | Omitted (Tested in 200V class because of the same package.) | | | $V_{GS}$=35V | | | Omitted (Tested in 200V class because of the same package.) | | |
| | | (2) Avalanche | 4066 | Conditions | Omitted (Tested in 200V class because of the same package.) | | | $V_{DS}$=100V<br>$I_{D(pulse)}$<br>42A / 32A / 14A<br>L=100μH, $R_g$=10Ω | | | Omitted (Tested in 200V class because of the same package.) | | |
| **-3d** | B-3d | **Hermetic Seal** (1) Fine | 1071 | Conditions | Omitted (Tested in 200V class because of the same package.) | | | Condition H | | | Omitted (Tested in 200V class because of the same package.) | | |
| | | | | Limits | max $1\times10^{-3}$Pa-cm³/s | | | | | | | | |
| | | (2) Gross | 1071 | Conditions | Omitted (Tested in 200V class because of the same package.) | | | Condition C | | | Omitted (Tested in 200V class because of the same package.) | | |
| **-3e** | B-3e | **End-Point Electrical Measurements** | --- | Conditions | Omitted (Tested in 200V class because of the same package.) | | | Same as Gr.A-2 | | | Omitted (Tested in 200V class because of the same package.) | | |
| **-3f** | B-3f | **Decap-Internal** Visual and mechanical inspection | 2075<br>2071 | Conditions | Omitted (Tested in 200V class because of the same package.) | | | --- | | | Omitted (Tested in 200V class because of the same package.) | | |
| **-3g** | B-3g | **Bond Strength** | 2037 | Conditions | Omitted (Tested in 200V class because of the same package.) | | | Condition D | | | Omitted (Tested in 200V class because of the same package.) | | |
| | | | | Limits | Gate Wire >90gf | | | | | | | | |
| | | | | | Source Wire | | | | | | | | |
| | | | | | >300gf | >300gf | >90gf | >300gf | >300gf | >90gf | >300gf | >300gf | >90gf |
| **-3h** | B-3h | **SEM** | 2077 | Conditions | After bond strength test | | | | | | | | |
| **-3i** | B-3i | **Die Shear** | 2017 | Conditions | Omitted (Tested in 200V class because of the same package.) | | | --- | | | Omitted (Tested in 200V class because of the same package.) | | |
| | | | | Limits | min 2.5kgf | | | | | | | | |

Notes (1) Electrical reject products from the same inspection lot may be used.

(2) When electrical reject products are used, the samples shall be exposed to the same thermal environments as the experience in all thermal tests required in the screening test.

## Table 8b. Qualification Test : Group B Inspection

| MIL-PRF-19500N Gr.No / Sub | 2030C Gr.No. | MIL-STD-750 Test Item | Method | JAXA R | 130V Class 2SK4152 | 130V Class 2SK4153 | 130V Class 2SK4154 | 200V Class 2SK4155 | 200V Class 2SK4156 | 200V Class 2SK4157 | 250V Class 2SK4158 | 250V Class 2SK4159 | 250V Class 2SK4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **B -4a** | B-5a | **Intermittent Operation Life** | | Sample Size | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs |
| | | | 1042 | Conditions | Condition D, 2000 cycles<br>Refer to the result of Gr.C-6. | | | | | | | | |
| **-4b** | B-5b | **End-Point Electrical Measurements** | --- | Conditions | Refer to the result of Gr.C-6. | | | | | | | | |
| **B -5a** | B-6c | **Steady-state Gate Stress** | | Sample Size | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs |
| | | **(High temp. GS)** | 1042 | Conditions | $V_{GS}$=20V<br>$T_A$=150°C , 48hr | | | | | | | | |
| **-5b** | B-6d | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-2 | | | | | | | | |
| **-5c** | B-6e | **Accelerated Steady-state Reverse Bias (High temp. DS)** | 1042 | Conditions | $V_{DS}$=130V | | | $V_{DS}$=200V<br>$T_A$ =150°C, 240hr | | | $V_{DS}$=250V | | |
| **-5d** | B-6f | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-2 | | | | | | | | |
| **-5e** | B-6g | **Bond Strength** | 2037 | Conditions | Condition D | | | | | | | | |
| | | | | Limits | Gate Wire >90gf<br>Source Wire | | | | | | | | |
| | | | | | >300gf | >300gf | >90gf | >300gf | >300gf | >90gf | >300gf | >300gf | >90gf |
| **B -6** | B-7 | **Thermal Impedance** | | Sample Size | 22pcs | 22pcs | 22pcs | 22pcs | 22pcs | 22pcs | 22pcs | 22pcs | 22pcs |
| | | $Z_{th(ch-c)}(\Delta V_{SD})$ | 3161 | Conditions | $T_A$=25°C | | | | | | | | |
| | | | | Limits | max | | | max | | | max | | |
| | | | | | 0.5°C/W | 0.83°C/W | 1.67°C/W | 0.5°C/W | 0.83°C/W | 1.67°C/W | 0.5°C/W | 0.83°C/W | 1.67°C/W |

## Table 9a. Qualification Test : Group C Inspection

| MIL-PRF-19500N Gr.No / Sub | 2030C Gr.No. | MIL-STD-750 Test Item | Method | JAXA R | 130V Class 2SK4152 | 130V Class 2SK4153 | 130V Class 2SK4154 | 200V Class 2SK4155 | 200V Class 2SK4156 | 200V Class 2SK4157 | 250V Class 2SK4158 | 250V Class 2SK4159 | 250V Class 2SK4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **C -1** | B-1 | **External Dimensions**(1) | | Sample Size | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | 2066 | Conditions | Performed in Gr.B-1 test. | | | | | | | | |
| **C -2a** | D-1a | **Thermal Shock (Glass Strain)** | | Sample Size | --- | --- | --- | --- | --- | --- | 22pcs | 22pcs | 22pcs |
| | | | 1056 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | Condition B, 25 cycles | | |
| **-2b** | D-1b | **Temperature Cycling** | 1051 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | $-55^{+0}_{-5}$°C↔$25^{+10}_{-5}$°C↔ $150^{+5}_{-0}$°C 45 cycles | | |
| **-2d** | D-1d | **Moisture Resistance** | 1021 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | (MIL-STD-202 Method 106) | | |
| **-2e** | D-1e | **Hermetic Seal** (1) Fine | 1071 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | Condition H | | |
| | | | | Limits | | | | | | | max $1\times10^{-3}$Pa-cm$^3$/s | | |
| | | (2) Gross | 1071 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | Condition C | | |
| **-2f** | D-1g | **End-Point Electrical Measurements** | --- | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | Same as Gr.A-2 | | |
| **C -3a** | D-2a | **Shock** | | Sample Size | 22pcs | 22pcs | 22pcs | --- | --- | --- | --- | --- | --- |
| | | | 2016 | Conditions | No Operating, 14710m/s$^2$ (1500G) $X_1$, $Y_1$, $Y_2$, $Z_1$ orientation 5 blows | | | Omitted (Tested in 130V class because of the same package.) | | | Omitted (Tested in 130V class because of the same package.) | | |
| **-3b** | D-2b | **Vibration, Variable Frequency** | 2056 | Conditions | 100 to 2000 Hz 196.1 m/s$^2$ (20G) | | | Omitted (Tested in 130V class because of the same package.) | | | Omitted (Tested in 130V class because of the same package.) | | |
| **-3c** | D-2c | **Constant Acceleration** | 2006 | Conditions | 98066.5m/s$^2$ (10000G) $X_1$, $Y_1$, $Y_2$, $Z_1$ orientation | | | Omitted (Tested in 130V class because of the same package.) | | | Omitted (Tested in 130V class because of the same package.) | | |
| **-3d** | D-2f | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-2 | | | Omitted (Tested in 130V class because of the same package.) | | | Omitted (Tested in 130V class because of the same package.) | | |

Note(1) Electrical reject products from the same inspection lot may be used.

## Table 9b. Qualification Test : Group C Inspection

| MIL-PRF-19500N Gr.No / Sub | 2030C Gr.No. | MIL-STD-750 Test Item | Method | JAXA R | 130V Class 2SK4152 | 130V Class 2SK4153 | 130V Class 2SK4154 | 200V Class 2SK4155 | 200V Class 2SK4156 | 200V Class 2SK4157 | 250V Class 2SK4158 | 250V Class 2SK4159 | 250V Class 2SK4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **C -4** | D-3a | **Salt Atmosphere** ([1]) | | Sample Size | 15pcs | 15pcs | 15pcs | --- | --- | --- | --- | --- | --- |
| | | | 1041 | Conditions | 35°C, 24hr Rate of salt deposit = 10 to 50g/m$^2$/24hr | | | Omitted (Tested in 130V class because of the same package.) | | | Omitted (Tested in 130V class because of the same package.) | | |
| **C -5** | C-3 | **Thermal Impedance** $Z_{th(ch-c)}(\Delta V_{SD})$ | | Sample Size | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs |
| | | | 3161 | Conditions | Performed in Gr.B-6 test. | | | | | | | | |
| **C -6a** | C1-1a | **Intermittent Operation Life** | | Sample Size | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs | 8pcs |
| | | | 1042 | Conditions | Condition D, 6000 cycles | | | | | | | | |
| **-6b** | C1-1b | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-2 | | | | | | | | |
| **C -7** | D-5 | **Internal Water Vapor** | | Sample Size | --- | --- | --- | --- | --- | --- | 3pcs | 3pcs | 3pcs |
| | | | 1018 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | --- | | |

Note ([1]) Electrical reject products from the same inspection lot may be used.

## Table 10. Qualification Test : Group D Inspection

| MIL-PRF-19500N Gr.No | Sub | 2030C Gr.No. | MIL-STD-750 Test Item | Method | JAXA R | 130V Class 2SK4152 | 130V Class 2SK4153 | 130V Class 2SK4154 | 200V Class 2SK4155 | 200V Class 2SK4156 | 200V Class 2SK4157 | 250V Class 2SK4158 | 250V Class 2SK4159 | 250V Class 2SK4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **D -2** | | E-1a | **Total Dose Irradiation** | | Sample Size | --- | --- | --- | --- | --- | --- | 4/4/4pcs | --- | --- |
| | | | **(TID)** | 1019 | Conditions | Tested in 2SK4158. | | | Tested in 2SK4158. | | | Total Dose $1\times10^3$Gy(Si)<br>Dose Rate $1\times10^3$Gy(Si)/h<br>Bias Condition<br>(during irradiation, after irradiation)<br>(a)$V_{DS}$=0V , $V_{GS}$=20V<br>(b)$V_{DS}$=0V , $V_{GS}$=-20V<br>(c)$V_{DS}$=200V , $V_{GS}$=0V | | |
| | **-2a** | **E-1b** | **End-Point Electrical Measurements** | --- | | | | | | | | Within 24hr after irradiation | | |
| | (1) | | Breakdown Voltage Drain to Source $V_{DSS}$ | 3407 | Conditions | Tested in 2SK4158. | | | Tested in 2SK4158. | | | Bias Condition C<br>$I_D$=1mA , $V_{GS}$=0V | | |
| | | | | | Limits | | | | | | | min 250V DC | --- | --- |
| | (2) | | Gate Current $I_{GSS}$ | 3411 | Conditions | Tested in 2SK4158. | | | Tested in 2SK4158. | | | Bias Condition C<br>$V_{GS}$=±20V , $V_{DS}$=0V | | |
| | | | | | Limits | | | | | | | max ±100nA DC | --- | --- |
| | (3) | | Drain Current $I_{DSS}$ | 3413 | Conditions | Tested in 2SK4158. | | | Tested in 2SK4158. | | | Bias Condition C<br>$V_{DS}$=200V , $V_{GS}$=0V | | |
| | | | | | Limits | | | | | | | max 10μA DC | --- | --- |
| | (4) | | Gate to Source Voltage (Threshold) $V_{GS(th)}$ | 3404 | Conditions | Tested in 2SK4158. | | | Tested in 2SK4158. | | | Bias Condition C<br>$V_{GS}$=$V_{DS}$ , $I_D$=1mA | | |
| | | | | | Limits | | | | | | | min 1.5V DC<br>$\Delta V_{GS(th)}$ max 2.0V | --- | --- |
| | (5) | | Static Drain to Source On-State Resistance $R_{DS(on)}$ | 3421 | Conditions | Tested in 2SK4158. | | | Tested in 2SK4158. | | | Pulse Test([1]) , $V_{GS}$=12V<br>$I_D$=42A | --- | --- |
| | | | | | Limits | | | | | | | max 38mΩ | --- | --- |

Note([1]) Pulse width ≤ 1ms, Duty cycle ≤ 2%

## Table 11a. Qualification Test : Group E Inspection

| MIL-PRF-19500N Gr.No / Sub | 2030C Gr.No. | MIL-STD-750 Test Item | Method | JAXA R | 130V Class 2SK4152 | 130V Class 2SK4153 | 130V Class 2SK4154 | 200V Class 2SK4155 | 200V Class 2SK4156 | 200V Class 2SK4157 | 250V Class 2SK4158 | 250V Class 2SK4159 | 250V Class 2SK4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **E -1a** | C-2a | **Temperature Cycling** | | Sample Size | --- | --- | --- | --- | --- | --- | 45pcs | 45pcs | 45pcs |
| | | | 1051 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | $-55^{+0}_{-5}$°C↔$25^{+10}_{-5}$°C↔ $150^{+5}_{-0}$°C 500 cycles | | |
| **-1b** | C-2b | **Hermetic Seal** (1) Fine | 1071 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | Condition H | | |
| | | | | Limits | | | | | | | max $1\times10^{-3}$Pa-cm$^3$/s | | |
| | | (2) Gross | 1071 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | Condition C | | |
| **-1c** | C-2c | **End-Point Electrical Measurements**(1) | --- | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | Same as Gr.A-2 | | |
| **E -2a** | C1-2a | **Steady-state Bias Life test (High Temperature GS Applied)**(2) | | Sample Size | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs | 15pcs |
| | | | 1042 | Conditions | $V_{GS}$=16V $T_A$=150°C , 1000hr | | | | | | | | |
| **-2b** | C1-2b | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-2 | | | | | | | | |
| **-2c** | C1-2c | **Steady-state Bias Life test (High Temperature DS Applied)**(2) | 1042 | Conditions | $V_{DS}$=104V | | | $V_{DS}$=160V | | | $V_{DS}$=200V | | |
| | | | | | $T_A$=150°C , 1000hr | | | | | | | | |
| **-2d** | C1-2d | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-2 | | | | | | | | |
| **E -4** | C-3 | **Thermal Impedance**(3) | | Sample Size | 3pcs | 3pcs | 3pcs | 3pcs | 3pcs | 3pcs | 3pcs | 3pcs | 3pcs |
| | | | 3161 | Conditions | $T_A$=25°C | | | | | | | | |
| | | | | Limits | max 0.5°C/W | | | max 0.83°C/W | | | max 1.67°C/W | | |
| **E -5** | D-4 | **Barometric Pressure** | | Sample Size | --- | --- | --- | --- | --- | --- | 3pcs | 3pcs | 3pcs |
| | | | 1001 | Conditions | Not applied for the devices with rated voltage ≤ 200V (4) | | | Not applied for the devices with rated voltage ≤ 200V (4) | | | 8mmHg 60sec (minimum) $V_{DS}$=250V, $V_{GS}$=0V | | |
| **E -6a** | C-6a | **Electric Discharge Sensitivity Classification** | | Sample Size | 3pcs | 3pcs | 3pcs | 3pcs | 3pcs | 3pcs | 3pcs | 3pcs | 3pcs |
| | | | 1020 | Conditions | $V_{GS}$ | | | $V_{GS}$ | | | $V_{GS}$ | | |
| | | | | | ±2750V | ±1000V | ±500V | ±2750V | ±1000V | ±500V | ±2750V | ±1000V | ±500V |
| | | | | | $V_{DS}$=0V | | | | | | | | |
| **-6b** | C-6b | **End-Point Electrical Measurements** | --- | Conditions | Same as Gr.A-2 | | | | | | | | |

Notes (1) This test may be conducted prior to the hermetic seal.

(2) The legibility of the marking shall not apply.

(3) Thermal impedance curve shall be obtained during the qualification test.

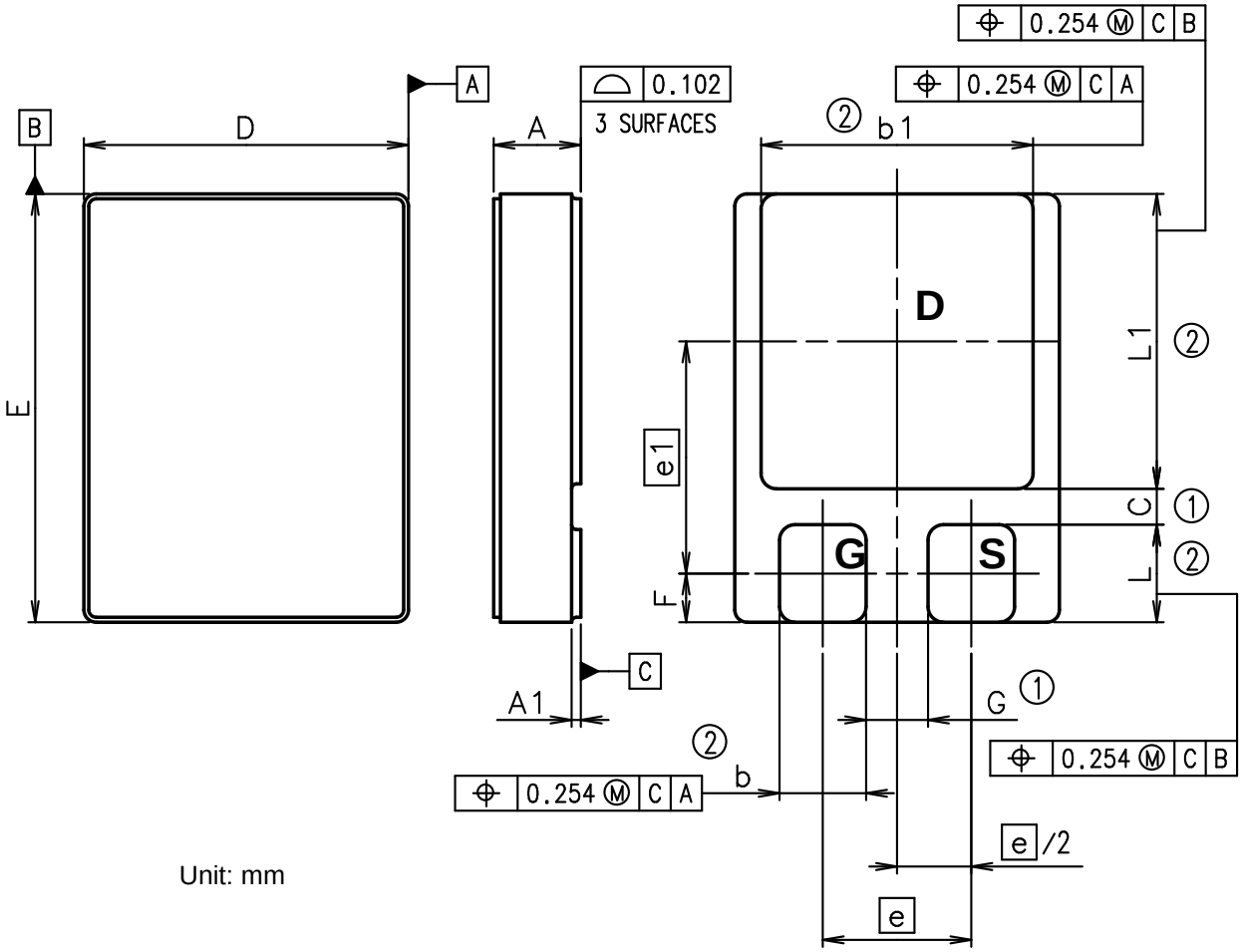
(4) See Table C-4 in JAXA-QTS-2030C Appendix C.

## Table 11b. Qualification Test : Group E Inspection

| MIL-PRF-19500N Gr.No / Sub | 2030C Gr.No. | MIL-STD-750 Test Item | Method | JAXA R | 130V Class 2SK4152 | 130V Class 2SK4153 | 130V Class 2SK4154 | 200V Class 2SK4155 | 200V Class 2SK4156 | 200V Class 2SK4157 | 250V Class 2SK4158 | 250V Class 2SK4159 | 250V Class 2SK4160 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **E -7a** | D-6a | **Resistance to Soldering Heat** | | Sample Size | --- | --- | --- | --- | --- | --- | 3pcs | 3pcs | 3pcs |
| | | | 2031 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | 240°C, 10s | | |
| **-7b** | D-6c | **Hermetic Seal** (1) Fine | 1071 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | Condition H | | |
| | | | | Limits | | | | | | | max $1\times10^{-3}$Pa-cm$^3$/s | | |
| | | (2) Gross | 1071 | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | Condition C | | |
| **-7c** | D-6d | **End-Point Electrical Measurements**(1) | --- | Conditions | Omitted (Tested in 250V class because of the same package.) | | | Omitted (Tested in 250V class because of the same package.) | | | Same as Gr.A-2 | | |
| **E -8** | E-2, 3 | **Radiation Hardness (SEB/SEGR test)** | | Sample Size | 3pcs | | | 3pcs | | | 3pcs | | |
| | | | 1080 | Conditions | Ion: $^{89}$Y Energy: 928MeV | | | | | | | | |
| | | | | | LET: 38.4MeV/(mg/cm$^2$) (2) | | | LET: 39.3MeV/(mg/cm$^2$) (2) | | | LET: 40.1MeV/(mg/cm$^2$) (2) | | |
| | | | | | Range (Si): 102µm $T_A$ =25+/-5°C Fluence: 3E5+/-5% ions/cm$^2$ | | | | | | | | |
| | | | | | $V_{DS}$=130V and $V_{GS}$=-7.5V | | | $V_{DS}$=200V and $V_{GS}$=-7.5V | | | $V_{DS}$=250V and $V_{GS}$=-7.5V | | |
| | | | | Limits | $I_{GSS}$≤10µA and shall not be destroyed | | | | | | | | |

Notes(1) This test may be conducted prior to the hermetic seal.

(2) Average LET in the device.



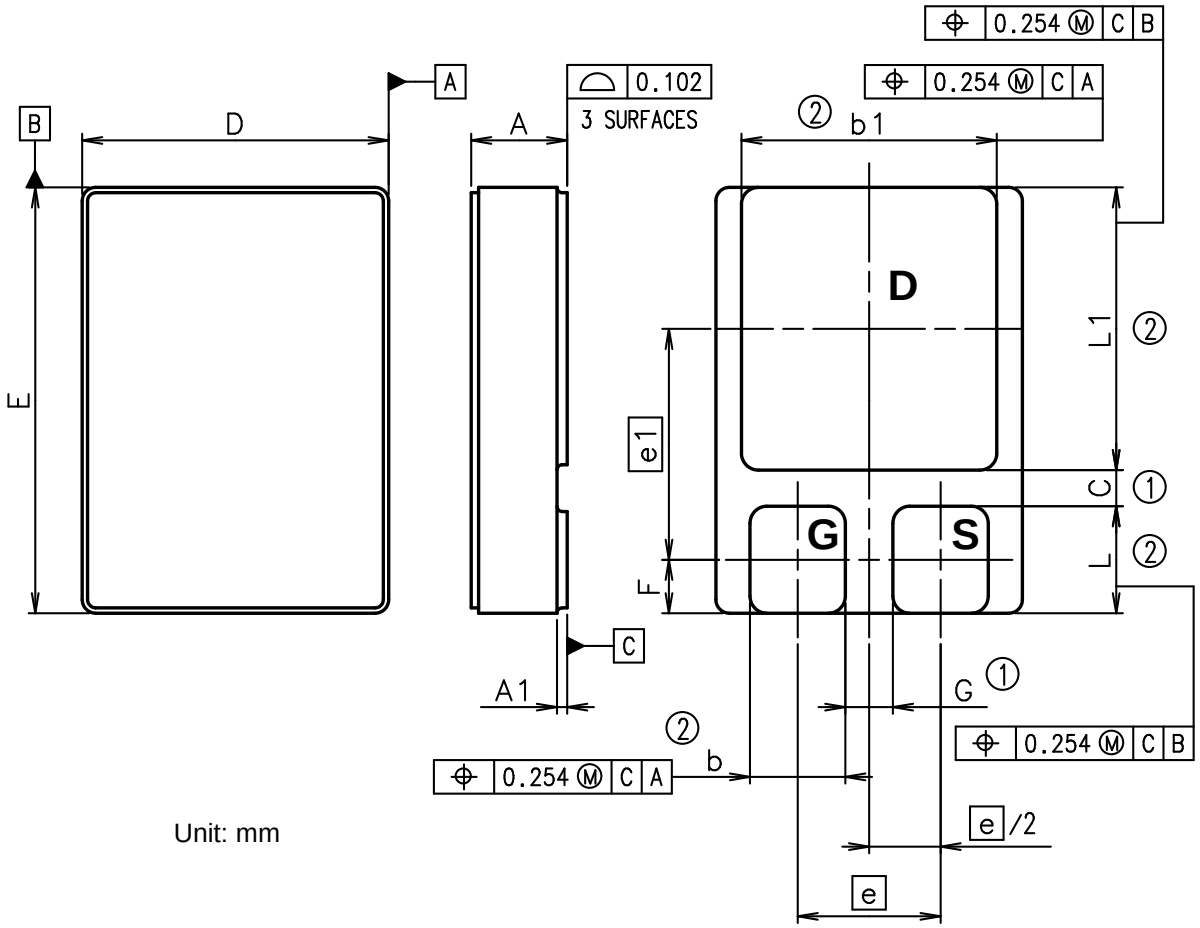

| Symbol | Dimension (mm) | | |
|---|---|---|---|
| | Min | Typ | Max |
| A | ——— | ——— | 3.58 |
| A1 | 0.254 | 0.381 | 0.508 |
| b | 3.43 | 3.555 | 3.68 |
| b1 | 11.05 | 11.175 | 11.30 |
| C | 0.89 | ——— | ——— |
| D | 13.21 | 13.335 | 13.46 |
| E | 17.40 | 17.525 | 17.65 |

| Symbol | Dimension (mm) | | |
|---|---|---|---|
| | Min | Typ | Max |
| e/2 | ——— | 3.05 | ——— |
| e | ——— | 6.10 | ——— |
| e1 | ——— | 9.50 | ——— |
| F | ——— | 1.99 | ——— |
| G | 1.27 | ——— | ——— |
| L | 3.87 | 3.99 | 4.11 |
| L1 | 11.94 | 12.065 | 12.19 |

Notes: ① Dimension includes metallization flash.
② Dimension does not include metallization flash.

Note: All terminals are isolated from the case.

**Figure 1a. Package Configuration and Terminal Connection of SMD-2 type package (JAXA R 2SK4152, 2SK4155, 2SK4158, 2SK4217)**



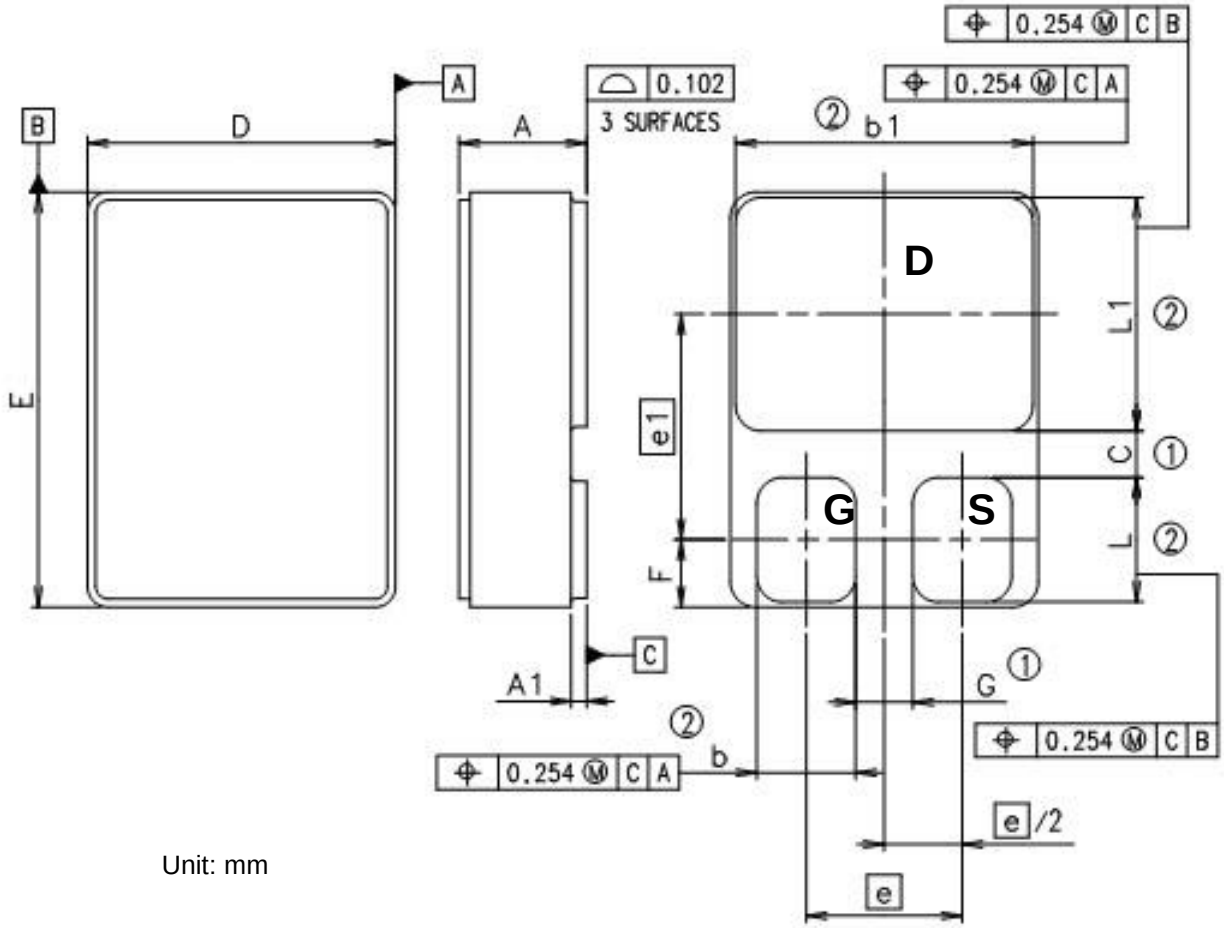

| Symbol | Dimension (mm) | | |
|---|---|---|---|
| | Min | Typ | Max |
| A | ——— | ——— | 3.58 |
| A1 | 0.254 | 0.381 | 0.508 |
| b | 3.43 | 3.555 | 3.68 |
| b1 | 9.40 | 9.525 | 9.65 |
| C | 0.76 | ——— | ——— |
| D | 11.31 | 11.43 | 11.55 |
| E | 15.75 | 15.875 | 16.00 |

| Symbol | Dimension (mm) | | |
|---|---|---|---|
| | Min | Typ | Max |
| e/2 | ——— | 2.67 | ——— |
| e | ——— | 5.33 | ——— |
| e1 | ——— | 8.61 | ——— |
| F | ——— | 1.99 | ——— |
| G | 0.89 | ——— | ——— |
| L | 3.87 | 3.99 | 4.11 |
| L1 | 10.42 | 10.54 | 10.66 |

Notes: ① Dimension includes metallization flash.
② Dimension does not include metallization flash.

Note: All terminals are isolated from the case.

**Figure 1b. Package Configuration and Terminal Connection of SMD-1 type package (JAXA R 2SK4153, 2SK4156, 2SK4159, 2SK4218)**




Unit: mm

| Symbol | Dimension (mm) | | |
|---|---|---|---|
| | Min | Typ | Max |
| A | —— | —— | 3.12 |
| A1 | 0.254 | 0.381 | 0.508 |
| b | 2.29 | 2.415 | 2.54 |
| b1 | 7.14 | 7.265 | 7.39 |
| C | 0.76 | —— | —— |
| D | 7.40 | 7.52 | 7.64 |
| E | 10.04 | 10.16 | 10.28 |

| Symbol | Dimension (mm) | | |
|---|---|---|---|
| | Min | Typ | Max |
| e/2 | —— | 1.905 | —— |
| e | —— | 3.81 | —— |
| e1 | —— | 5.52 | —— |
| F | —— | 1.65 | —— |
| G | 0.762 | —— | —— |
| L | 2.93 | 3.05 | 3.17 |
| L1 | 5.59 | 5.715 | 5.84 |

Notes: ① Dimension includes metallization flash.
② Dimension does not include metallization flash.

Note: All terminals are isolated from the case.

**Figure 1c. Package Configuration and Terminal Connection of SMD-0.5 type package (JAXA R 2SK4154, 2SK4157, 2SK4160, 2SK4219)**

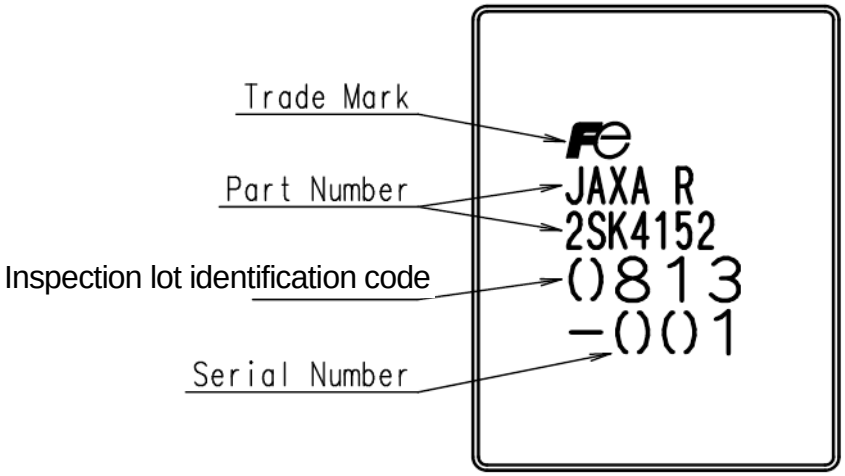



**Fig. 2a Marking (SMD-2)**

**(JAXA R 2SK4152, 2SK4155, 2SK4158, 2SK4217)**

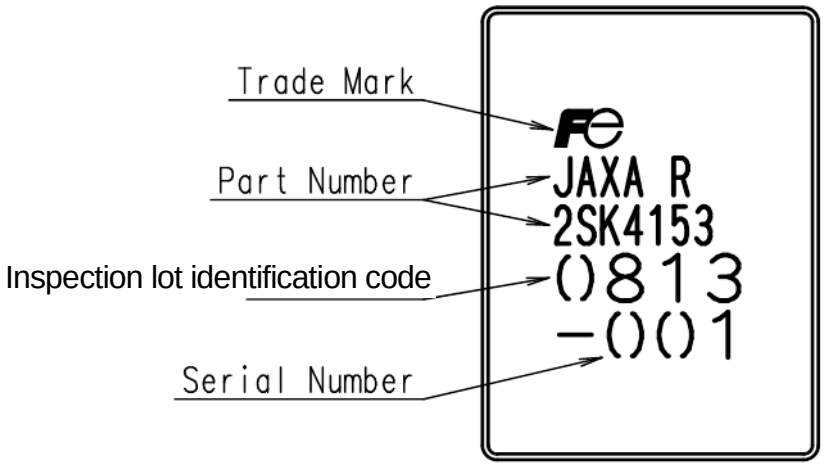



**Fig. 2b Marking (SMD-1)**

**(JAXA R 2SK4153, 2SK4156, 2SK4159, 2SK4218)**

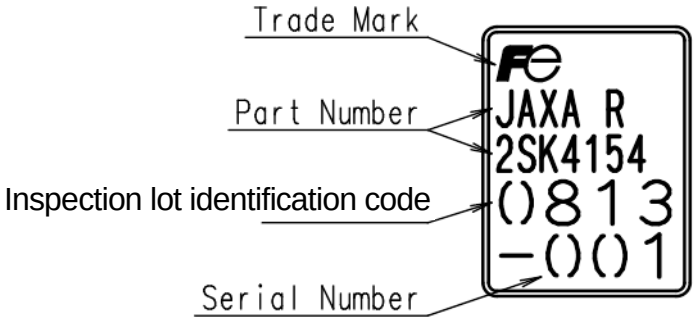



**Figure 2c. Marking (SMD-0.5)**

**(JAXA R 2SK4154, 2SK4157, 2SK4160, 2SK4219)**

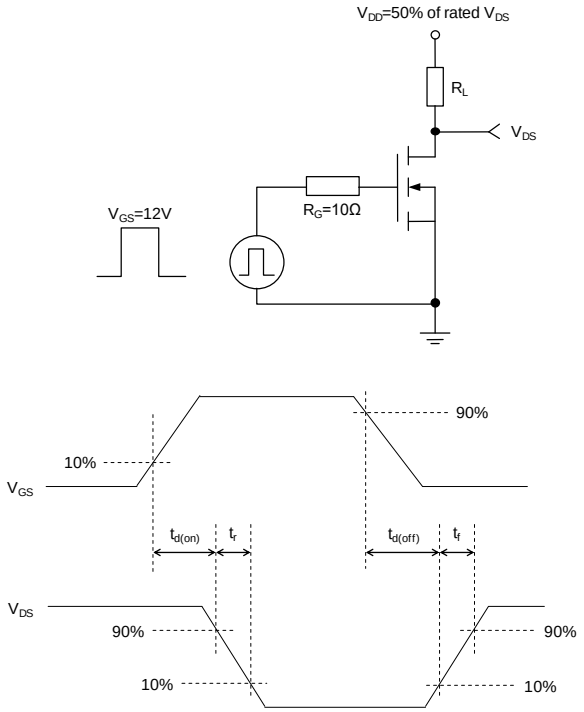



**Figure 3. Switching time test circuit and waveforms**

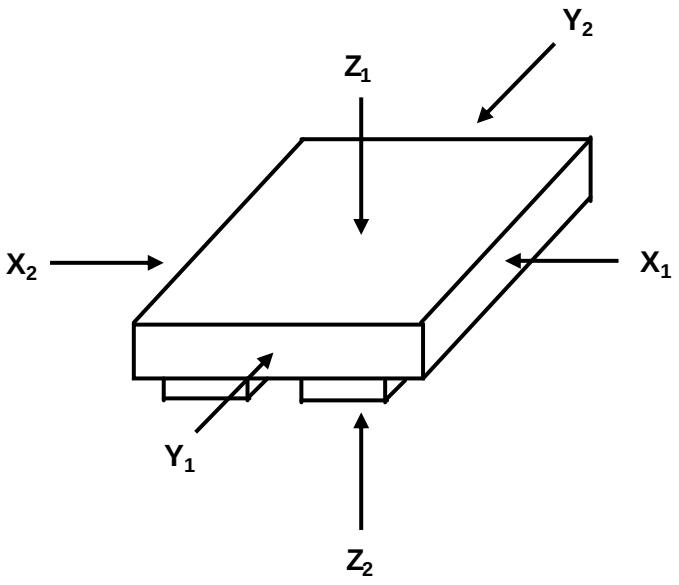



**Figure 4. Orientation**

## JAXA R 2SK4152

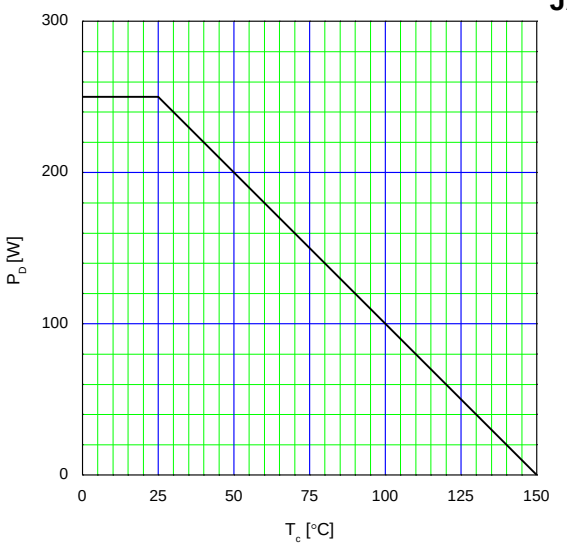



**Fig. 5** Allowable Power Dissipation $P_D=f(T_c)$

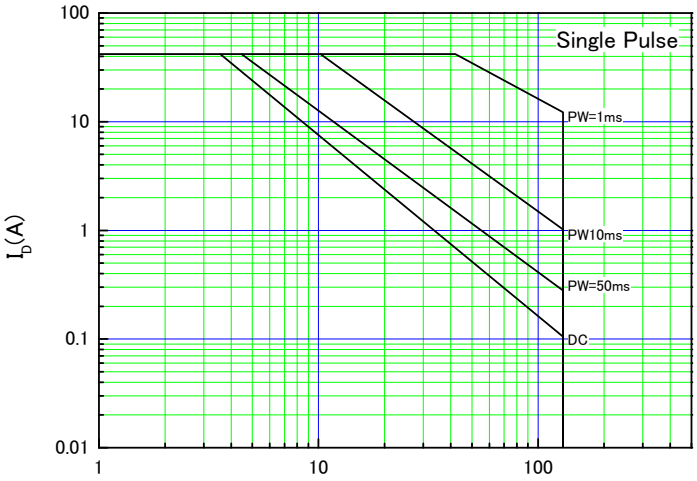



**Fig. 6** Maximum Safe Operating Area $I_D= f(V_{DS})$

## JAXA R 2SK4153

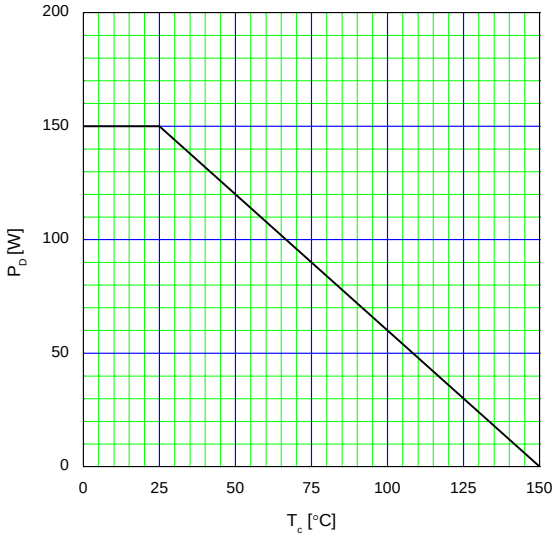



**Fig. 7** Allowable Power Dissipation $P_D=f(T_c)$

Maximum Safe Operating Area
$I_D=f(V_{DS})$

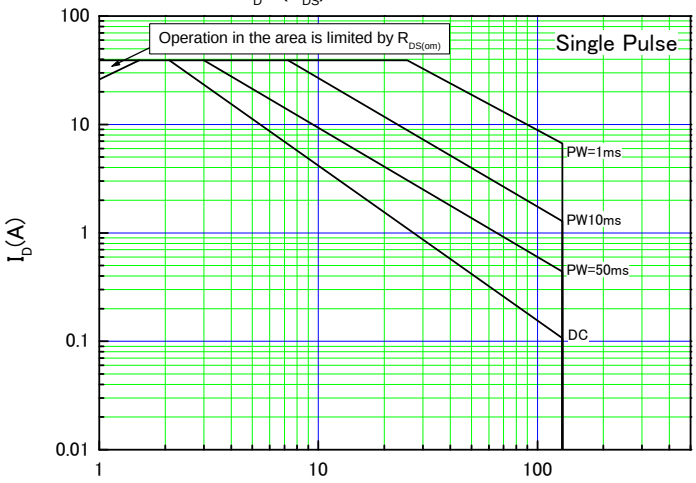



**Fig. 8** Maximum Safe Operating Area $I_D= f(V_{DS})$

## JAXA R 2SK4154

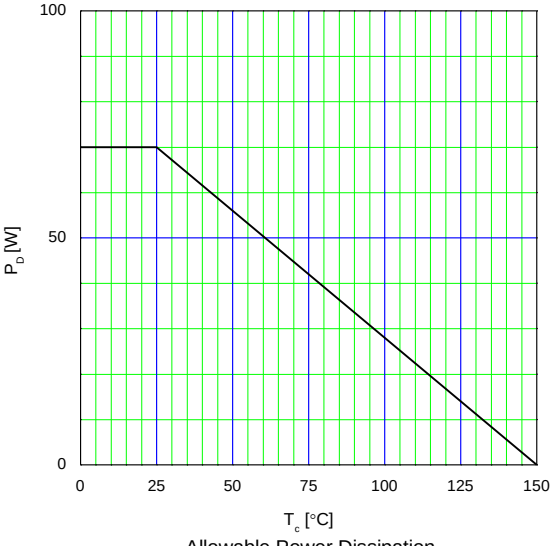



**Fig. 9** Allowable Power Dissipation $P_D=f(T_c)$

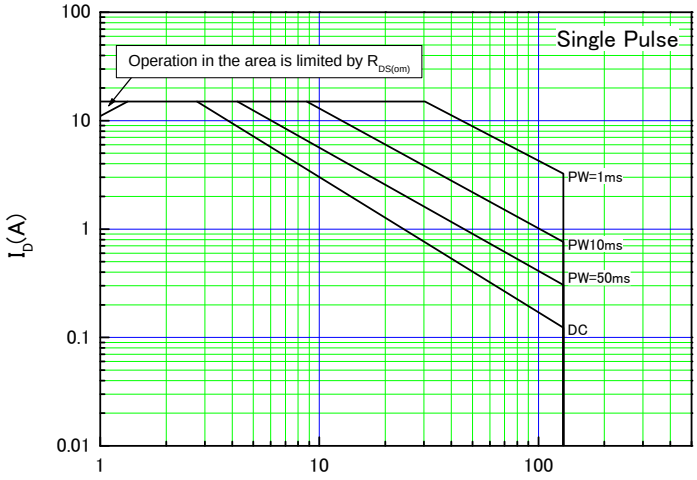



**Fig. 10** Maximum Safe Operating Area $I_D= f(V_{DS})$

## JAXA R 2SK4155

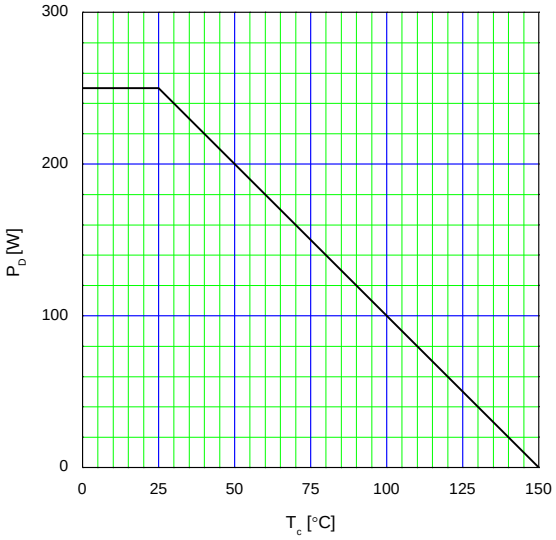



**Fig. 11** Allowable Power Dissipation $P_D=f(T_c)$

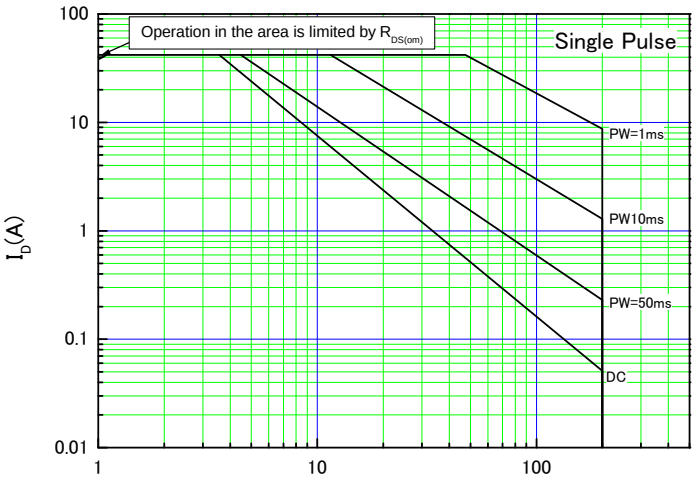



**Fig. 12** Maximum Safe Operating Area $I_D= f(V_{DS})$

## JAXA R 2SK4156

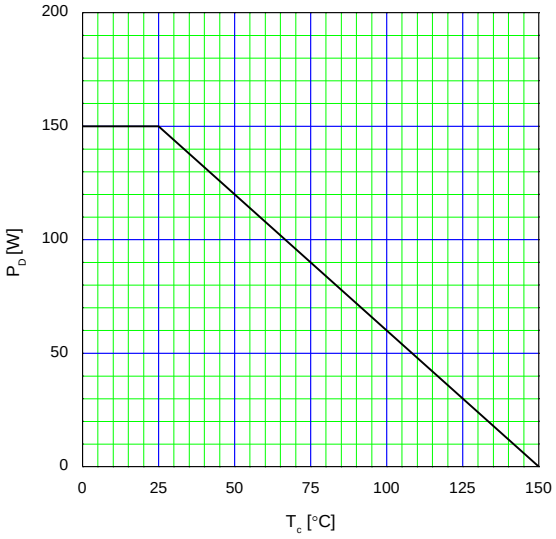



**Fig. 13** Allowable Power Dissipation $P_D=f(T_c)$

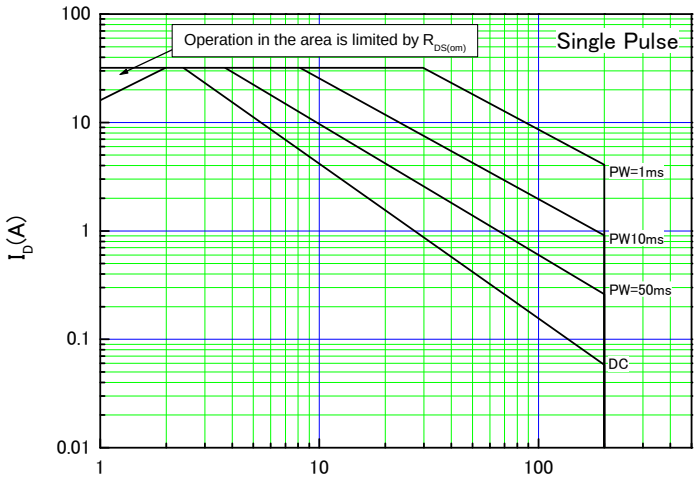



**Fig. 14** Maximum Safe Operating Area $I_D= f(V_{DS})$

## JAXA R 2SK4157

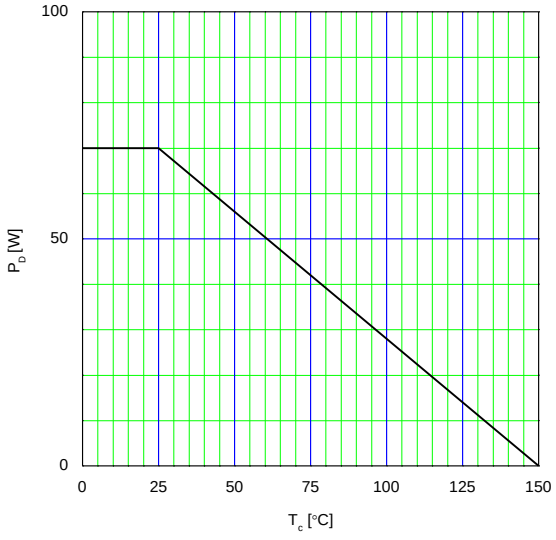



**Fig. 15** Allowable Power Dissipation $P_D=f(T_c)$

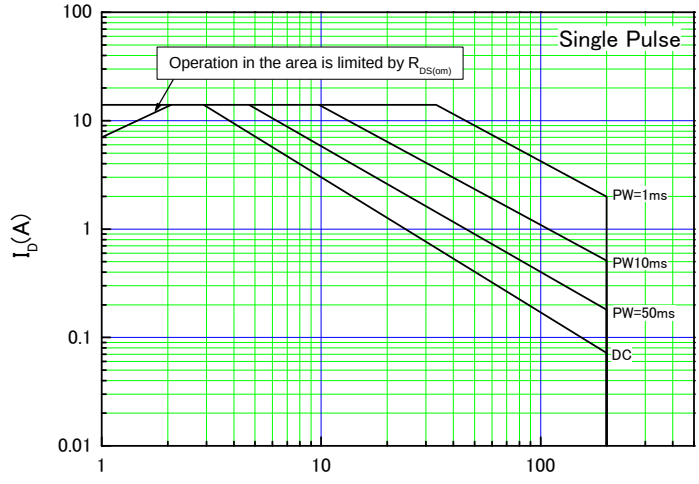



**Fig. 16** Maximum Safe Operating Area $I_D= f(V_{DS})$

## JAXA R 2SK4158

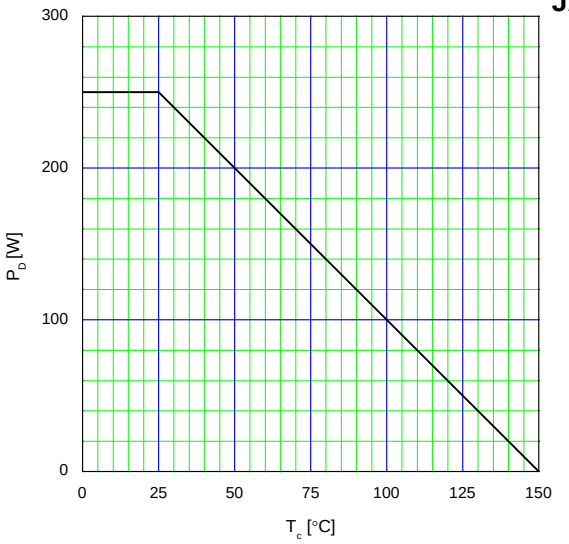



**Fig. 17** Allowable Power Dissipation $P_D=f(T_c)$

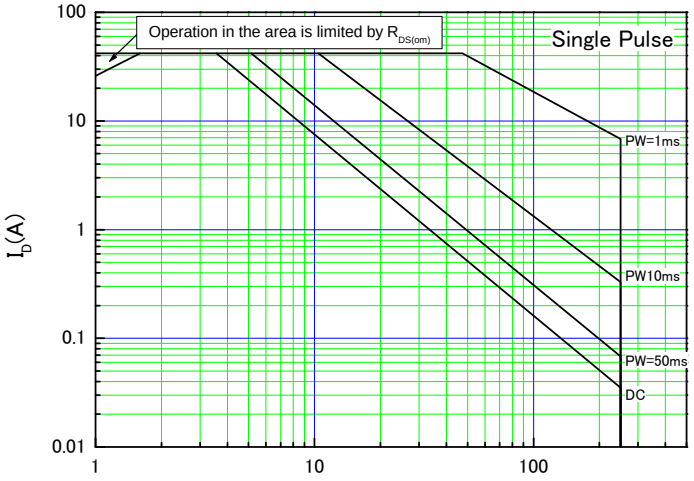



**Fig. 18** Maximum Safe Operating Area $I_D= f(V_{DS})$

## JAXA R 2SK4159

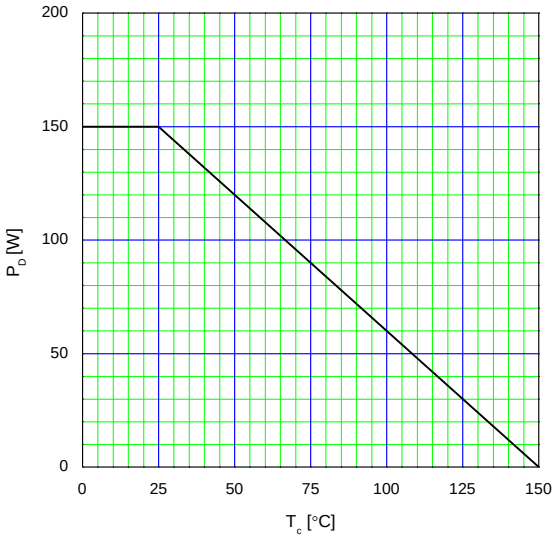



**Fig. 19** Allowable Power Dissipation $P_D=f(T_c)$

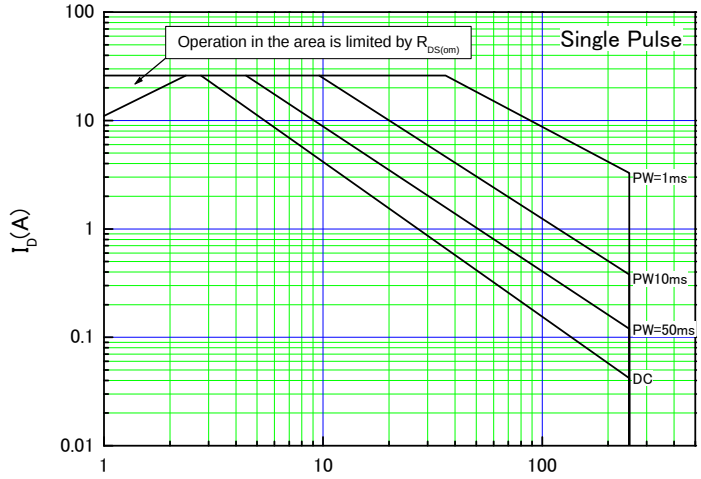



**Fig. 20** Maximum Safe Operating Area $I_D= f(V_{DS})$

## JAXA R 2SK4160

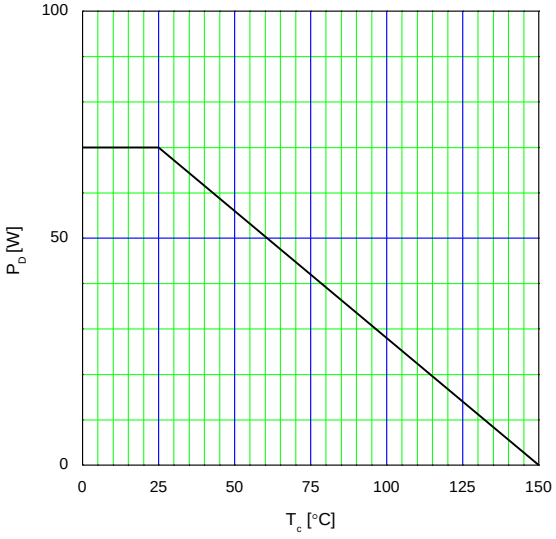



**Fig. 21** Allowable Power Dissipation $P_D=f(T_c)$

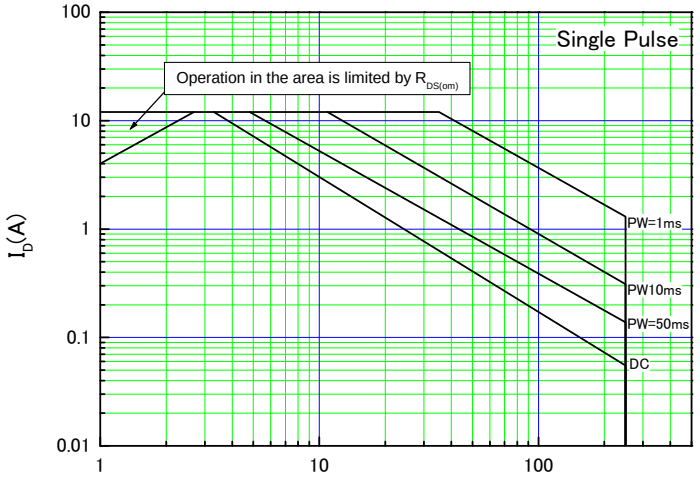



**Fig. 22** Maximum Safe Operating Area $I_D= f(V_{DS})$

## JAXA R 2SK4217

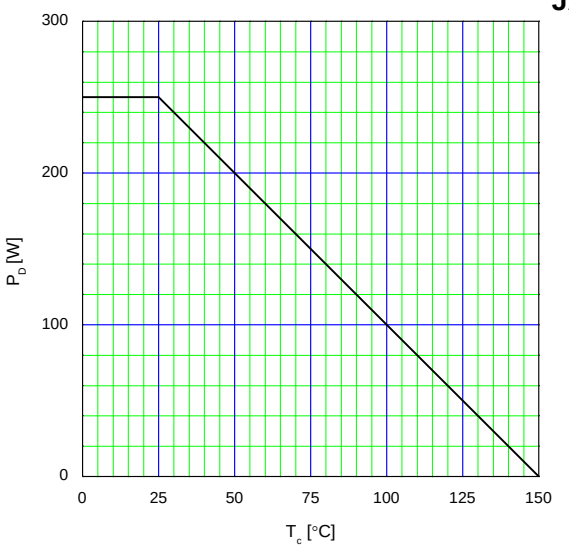



**Fig. 23** Allowable Power Dissipation $P_D=f(T_c)$

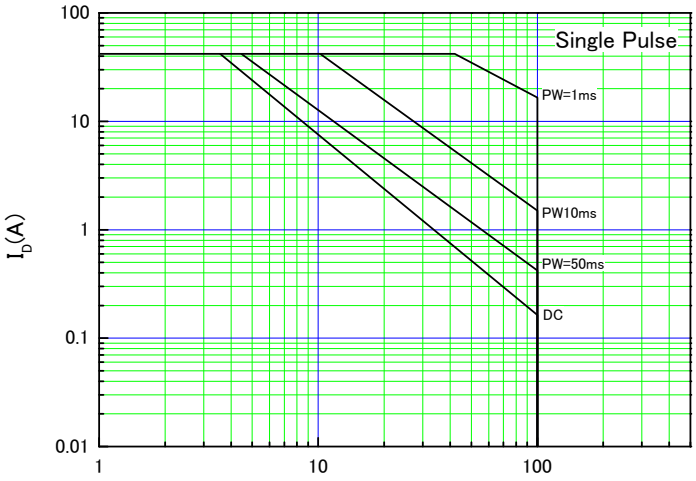



**Fig. 24** Maximum Safe Operating Area $I_D= f(V_{DS})$

## JAXA R 2SK4218

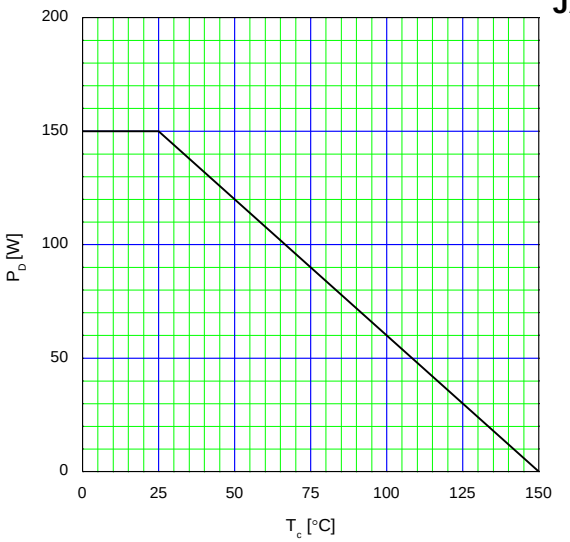



**Fig. 25** Allowable Power Dissipation $P_D=f(T_c)$

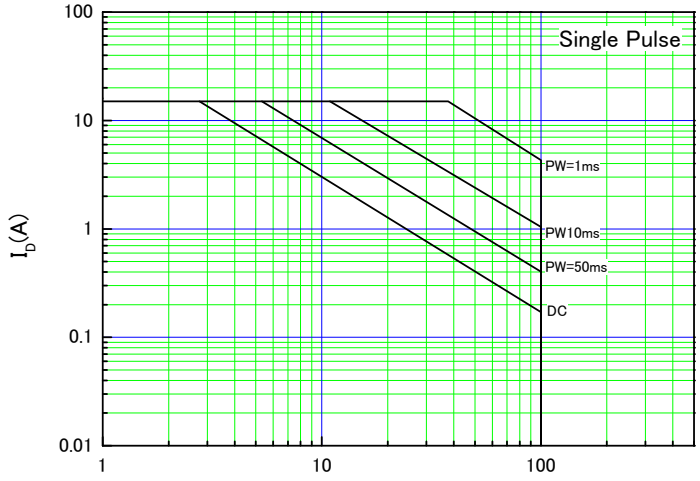



**Fig. 26** Maximum Safe Operating Area $I_D= f(V_{DS})$

## JAXA R 2SK4219

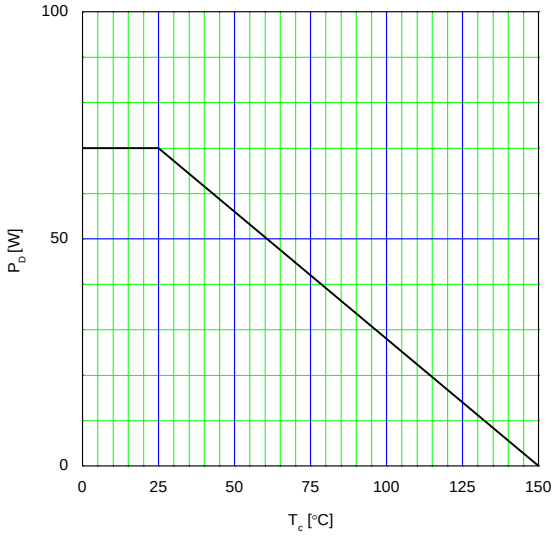



**Fig. 27** Allowable Power Dissipation $P_D=f(T_c)$

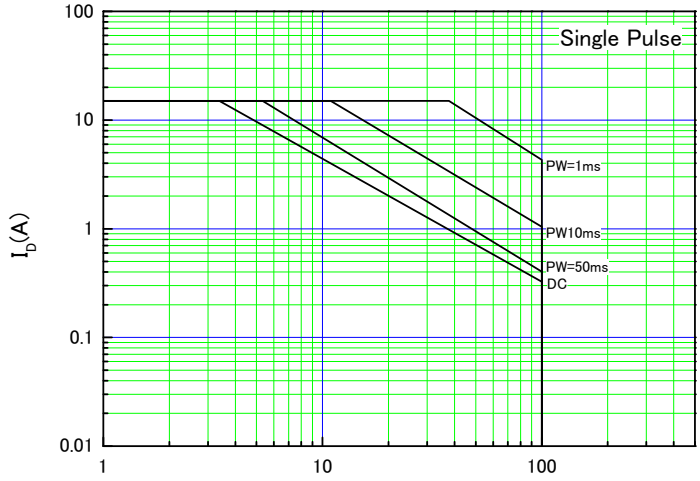



**Fig. 28** Maximum Safe Operating Area $I_D= f(V_{DS})$