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JAXA-QTS-2030/101D

29 July 2022

Superseding

JAXA-QTS-2030/101C

Cancelled

29 July 2022

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

JAXA R
2SK4048
2SK4051
2SK4054

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.

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Revision Log

| Rev. | Date | Description |
|------|---------------------|--|
| ---- | 20 Dec. 2006 | Original |
| A | 29 Feb. 2008 | <p>Added the family type part number</p> <ul style="list-style-type: none"> ▪ Added Part No.: 2SK4214, 2SK4215 and 2SK4216 (V_{DS} 130V Class) <p>Revised to reflect the changes made to JAXA-QTS-2030C.</p> <ul style="list-style-type: none"> ▪ Revised screening test in compliance with JAXA-QTS-2030C. ▪ Revised qualification test and quality conformance inspection in compliance with JAXA-QTS-2030C. |
| B | 12 Nov. 2012 | <ul style="list-style-type: none"> ▪ 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. ▪ Table 2b: Added a test condition (Minimum On time: 30 seconds) of Intermittent Operation Life test. ▪ Table 3: 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. ▪ Table 3: Added a test condition (Minimum On time: 30 seconds) of Intermittent Operation Life test. ▪ 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. ▪ Table 4a: Reviewed the number of significant figures in the test conditions of D-2a, D-2b and D-2c. ▪ Table 6 Exemption of Quality Conformance Inspection: Deleted test items, for which the quality conformance inspection is not performed. ▪ Added the maximum safe operating area of DC to figures. ▪ Others: Corrected errors to ensure consistency. |
| C | 18 March 2020 | <ul style="list-style-type: none"> ▪ Cover: Changed the corporate name. ▪ Paragraph 3.2.1: Added marking for inspection lot identification code and serial number. ▪ Modified the wording in each paragraph in the document. ▪ Paragraph 6.1: Added Terms and definitions. ▪ Table 1b Group A inspection (A-3b): Corrected test condition error of gfs from "$V_{GS}=25V$" to "$V_{DS}=25V$". ▪ Table 2a Group B inspection (B-3g) and Table 2b Group B inspection (B-6g): Corrected test condition error of Bond strength from "condition A" to "condition D". |
| D | 29 July 2022 | <ul style="list-style-type: none"> ▪ Deleted the certification-terminated product types (2SK4049, 2SK4050, 2SK4052, 2SK4053, 2SK4055, 2SK4056, 2SK4214, 2SK4215, 2SK4216). |
| | | |

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

JAXA R
2SK4048, 2SK4051, 2SK4054,

1 GENERAL

This specification establishes the detailed requirements for space use, high reliability, N channel power MOSFET (100, 200 and 250V for TO-254 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⁾ 2SK4048

JAXA⁽¹⁾ R⁽²⁾ 2SK4051

JAXA⁽¹⁾ R⁽²⁾ 2SK4054

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 $T_C=25^\circ C$ (W) | | P_D $T_A=25^\circ C$ (W) | | $T_{ch}^{(1)}$ (°C) | T_{stg} (°C) | $R_{th(ch-c)}$ (°C/W) | $R_{th(ch-a)}$ (°C/W) | SOA |
|-------------------|-----------------|--------------|-----------------------|-----------------|----------------------------------|--------|----------------------------------|--------|------------------------|-------------------|--------------------------|--------------------------|--------|
| | | | | | | | | | | | | | |
| JAXA R 2SK4048 | 100 | 42 | 168 | ±20 | 250 | Fig.5 | 2.6 | Fig.6 | 150 | -55 to 150 | 0.5 | 48.0 | Fig.7 |
| JAXA R 2SK4051 | 200 | 42 | 168 | | 250 | Fig.14 | 2.6 | Fig.15 | | | 0.5 | 48.0 | Fig.16 |
| JAXA R 2SK4054 | 250 | 42 | 168 | | 250 | Fig.23 | 2.6 | Fig.24 | | | 0.5 | 48.0 | Fig.25 |

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

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

$$T_{ch}=T_A + R_{th(ch-a)} \times P_D$$

Where T_C : Case temperature (°C)

T_A : Ambient temperature (°C)

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

$R_{th(ch-a)}$: Thermal resistance between channel and ambient (°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) |
|-------------------|--------------------------|---|---------------------------------|------------------------------|--|--|---|
| | $I_D=1mA$ $V_{GS}=0V$ | $V_{DS}=80\%$ of rated V_{DS} $V_{GS}=0V$ | $V_{GS}=\pm 20V$ $V_{DS}=0V$ | $I_D=1mA$ $V_{DS}=V_{GS}$ | $I_D=50\%$ of rated I_D $V_{GS}=12V$ | $I_D=50\%$ of rated I_D $V_{DS}=25V$ | Rated I_D $V_{DD}=48V$, $V_{GS}=12V$ |
| | Min | Max | Max | Min-Max | Max | Min | Max |
| JAXA R 2SK4048 | 100 | 10 | ±100 | 2.5-4.5 | 18 | 8 | 1091 |
| JAXA R 2SK4051 | 200 | | | | 33 | 8 | 545 |
| JAXA R 2SK4054 | 250 | | | | 45 | 8 | 436 |

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 2SK4048 | 60 | 70 | 220 | 65 | 30 | 190 | 65 |
| JAXA R 2SK4051 | 60 | 70 | 220 | 65 | 30 | 190 | 35 |
| JAXA R 2SK4054 | 60 | 70 | 220 | 65 | 30 | 190 | 30 |

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 2SK4048 | 1.6 | 450 | 7.0 |
| JAXA R 2SK4051 | | 690 | 13.5 |
| JAXA R 2SK4054 | | 1000 | 19.0 |

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) {1×10 ⁵ rad(Si)} |
| | (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 |

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 Lead Connection

The package configuration and lead connection shall meet the requirements specified in Figure 1.

3.1.2 Lead Materials and Finish

The leads shall be made of Fe-Ni (Ni-Au plating) covered OCF (Oxygen-Free Copper) and plated with Au as specified in the paragraph 3.3.7 c) 2) 2.3) or with Pb-Sn solder dipping as specified in paragraph 3.3.7 c) 2) 2.1) of JAXA-QTS-2030.

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 Figure 2.

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 Serial number
identification code

- 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 subplot (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 the paragraph 4.1 of JAXA-QTS-2030.

4.2 Incoming Materials Control

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

4.3 Manufacturing Process Control

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

4.4 In-process Inspection

The in-process inspection shall be in accordance with the 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

$T_A=+25^{\circ}\text{C}$

| Measuring item | $V_{(BR)DSS}$ (V) | I_{DSS} (μA) | I_{GSS} (nA) | $V_{GS(th)}$ (V) | $R_{DS(on)}^{(1)}$ (m Ω) | gfs ⁽¹⁾ (S) | $V_{SD}^{(1)}$ (V) |
|--------------------------------|--|---|---|-------------------------------------|--|--|---|
| MIL-STD-750 Test Method No. | 3407 | 3413 | 3411 | 3404 | 3421 | 3475 | --- |
| Test conditions | Bias Condition C $I_D=1\text{mA}$ $V_{GS}=0\text{V}$ | Bias Condition C $V_{DS}=80\%$ of rated V_{DS} $V_{GS}=0\text{V}$ | Bias Condition C $V_{GS}=\pm 20\text{V}$ $V_{DS}=0\text{V}$ | $I_D=1\text{mA}$ $V_{DS}=V_{GS}$ | $I_D=50\%$ of rated I_D $V_{GS}=12\text{V}$ | $I_D=50\%$ of rated I_D $V_{DS}=25\text{V}$ | $I_F=\text{rated } I_D$ $V_{GS}=0\text{V}$ |
| | Min | Max | Max | Min-Max | Max | Min | Max |
| JAXA R 2SK4048 | 100 | 10 | ± 100 | 2.5-4.5 | 18 | 8 | 1.6 |
| JAXA R 2SK4051 | 200 | | | | 33 | 8 | |
| JAXA R 2SK4054 | 250 | | | | 45 | 8 | |

Note⁽¹⁾ Pulse test: Pulse width $\leq 1\text{ms}$, Duty cycle $\leq 2\%$

(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: $V_{GS}=35V, t=1ms, T_A=25^{\circ}C$

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

Initial $T_C = +25_{+10}^{-5} \text{ }^{\circ}C$

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

Temperature cycling test: Condition G, 20 cycles

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

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

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 were 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 Section 5 of JAXA-QTS-2030.

6 NOTES

6.1 Terms and Definitions

The terms and definitions 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.

6.2.2 Beryllia Warning

The products of TO-254 package contain beryllium. Disintegration or chemical processing of the products that may produce dusts or fumes shall be prohibited. Disposition of the products shall be performed in accordance with applicable regulations.

Table 1a. Group A Inspection (1)

| Gr.No | MIL-STD-750 | | | 100V Clas | 200V Class | 250V Class |
|-------------|---|--------|----------------|--|--|--|
| Sub | Test Item | Method | JAXA R | 2SK 4048 | 2SK 4051 | 2SK 4054 |
| 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 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} =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 21A | I _D 21A | I _D 21A |
| | | | Limits | max [mΩ] 18 | max [mΩ] 33 | max [mΩ] 45 |
| -1f | Forward Transconductance g _{fs} | 3475 | Conditions | Pulse Test ⁽²⁾ , V _{DS} =25V | | |
| | | | | I _D 21A | I _D 21A | I _D 21A |
| | | | Limits | min 8S | min 8S | min 8S |
| -1g | Forward Voltage V _{SD} | --- | Conditions | Pulse Test ⁽²⁾ , V _{GS} =0V | | |
| | | | | I _D 42A | I _D 42A | I _D 42A |
| | | | Limits | max 1.6V DC | | |
| 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} =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 21A | I _D 21A | I _D 21A |
| | | | Limits | max [mΩ] 31 | max [mΩ] 66 | max [mΩ] 90 |

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 | MIL-STD-750 | | | 100V Class | 200V Class | 250V Class |
|--------------|---|--------|---------------------|--|---|---|
| Sub | Test Item | Method | JAXA R | 2SK 4048 | 2SK 4051 | 2SK 4054 |
| 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 g _{fs} (-55°C) | 3475 | Conditions | Pulse Test (2), V _{DS} =25V | | |
| | | | Limits | I _D 21A min 8.5S | I _D 21A min 8.5S | I _D 21A min 8.5S |
| A -4 | Dynamic Characteristics (T_A=25°C) | | Sample Size | LTPD 3 | | |
| | Switching Time Test (1) Turn-on delay time: t _{d(on)} Rise time: t _r (2) Turn-off delay time: t _{d(off)} Fall time: t _f | 3472 | Conditions | V _{DD} =50V V _{GS} =12V, R _g =10Ω I _D 42A | V _{DD} =100V V _{GS} =12V, R _g =10Ω I _D 42A | V _{DD} =125V V _{GS} =12V, R _g =10Ω I _D 42A |
| | | | Limits | max | max | max |
| | | | t _{d(on)} | 65ns | 65ns | 65ns |
| | | | t _r | 30ns | 30ns | 30ns |
| | | | t _{d(off)} | 190ns | 190ns | 190ns |
| | | | t _f | 65ns | 35ns | 30ns |
| A -6a | Safe Operating Area Test(3) | | Sample Size | LTPD 5 | | |
| | | 3474 | Conditions | --- | | |
| -6b | End-Point Electrical Measurements | --- | | Same as Gr.A-1 | | |
| A -7 | Other Characteristics (T_A=25°C) (4) | | Sample Size | LTPD 10 | | |
| -7a | Gate Charge (1) Gate Charge: Q _g (2) Gate to Drain Charge: Q _{gd} (3) Gate to Source Charge: Q _{gs} | 3471 | Conditions | V _{GS} =12V V _{DS} =50V I _D 42A | V _{GS} =12V V _{DS} =100V I _D 42A | V _{GS} =12V V _{DS} =125V I _D 42A |
| | | | Limits | max | max | max |
| | | | Q _g | 220nC | 220nC | 220nC |
| | | | Q _{gd} | 70nC | 70nC | 70nC |
| | | | Q _{gs} | 60nC | 60nC | 60nC |
| -7b | Reverse Recovery Characteristics (1) t _{rr} (2) Q _{rr} | 3473 | Conditions | I _F = I _D 42A | I _F = I _D 42A V _{GS} =0V -di/dt=100A/μs | I _F = I _D 42A |
| | | | Limits | max | max | max |
| | | | t _{rr} | 765ns | 1050ns | 1500ns |
| | | | Q _{rr} | 10.5μC | 20.0μC | 29.0μC |

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 | | JAXA R | 100V Class | 200V Class | 250V Class |
|-------|-------------|--|---------------|---|--|--|
| | Sub | Test Item | | Method | 2SK 4048 | 2SK 4051 |
| B-1 | | External Dimensions ⁽¹⁾ | Sample Size | Level I ⁽²⁾ 3p Level II ⁽²⁾ 3p | | |
| | | | 2066 | Conditions | See Fig. 1 | |
| B-2 | | Resistance to Solvents ⁽³⁾ ⁽⁴⁾ | Sample Size | Level I 3p Level II 3p | | |
| | | | 1022 | Conditions | Solvent a, b, c | |
| B-3b | | Temperature Cycling (Air to Air) | Sample Size | Level I 6p Level II 6p | | |
| | | | 1051 | Conditions | -55 ⁺⁰ ₋₅ °C ↔ 25 ⁺¹⁰ ₋₅ °C ↔ 150 ⁺⁵ ₋₀ °C 100 cycles | |
| -3c | | Surge Test (1) Gate Shock | 4066 | Conditions | V _{GS} =35V | |
| | | | (2) Avalanche | 3470 | Conditions | V _{DS} =48V, L= See paragraph 4.5.2, Equation (1) |
| -3d | | Hermetic Seal (1) Fine | 1071 | Conditions | Condition H | |
| | | | | Limits | max 1×10 ⁻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 Visual and mechanical inspection | 2075 2071 | Conditions | --- | |
| -3g | | Bond Strength | 2037 | Conditions | Condition D | |
| | | | | Limits | Gate Wire >90gf Source Wire >300gf >300gf >300gf | |
| -3h | | SEM ⁽¹⁾ | 2077 | Conditions | --- | |
| -3i | | Die Shear | Sample Size | Level I 3p Level II 3p | | |
| | | | 2017 | Conditions | --- | |
| | | | Limits | min 2.5kgf | | |
| B-4 | | Solderability ⁽³⁾ ⁽⁴⁾ | Sample Size | Level I 6 leads ⁽⁵⁾ Level II 6 leads ⁽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 certified samples experience in all thermal tests required as part of the screening test.

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

Table 2b. Group B Inspection

| Gr.No | MIL-STD-750 | | | 100V Class | 200V Class | 250V Class | |
|--------------|-------------|---|-------------|------------|---|--|-----------------------|
| | Sub | Test Item | Method | JAXA R | 2SK 4048 | 2SK 4051 | 2SK 4054 |
| B -5a | | Intermittent Operation Life | Sample Size | | Level I LTPD 10 Level II 12p | | |
| | | | 1042 | Conditions | Condition D, 2000 cycles ⁽¹⁾ Minimum On time: 30 seconds | | |
| -5b | | End-Point Electrical Measurements | --- | | Same as Gr.A-1 | | |
| B -6c | | Accelerated Steady-state Gate Bias (High Temp. GS) | Sample Size | | Level I LTPD 10 Level II 12p | | |
| | | | 1042 | Conditions | V _{GS} =20V, T _A =150°C, 48hr or V _{GS} =20V, T _A =175°C, 24hr | | |
| -6d | | End-Point Electrical Measurements | --- | | Same as Gr.A-1 | | |
| -6e | | Accelerated Steady-state Reverse Bias (High Temp. DS) | 1042 | Conditions | V _{DS} =100V | V _{DS} =200V T _A =150°C, 240hr or T _A =175°C, 120hr | V _{DS} =250V |
| -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 >90gf Source Wire >300gf | | |
| B -7 | | Thermal Impedance Z _{th(ch-c)} (ΔV _{SD}) | Sample Size | | Level I LTPD 10 Level II 8p | | |
| | | | 3161 | Conditions | T _A =25°C | | |
| | | | | Limits | max (°C/W) 0.5 | max (°C/W) 0.5 | max (°C/W) 0.5 |

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 | | JAXA R | 100V Class | 200V Class | 250V Class |
|--------|-------------|---|----------------|-------------------------------------|--|-----------------------|
| | Sub | Test Item | | Method | 2SK 4048 | 2SK 4051 |
| C 1-1a | | Intermittent Operation Life | Sample Size | Level I LTPD 10 Level II LTPD 10 | | |
| | | | 1042 | Conditions | Condition D, 6000 cycles (1) 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 temperature GS applied) (2) | Sample Size | Level I LTPD 5 Level II NA | | |
| | | | 1042 | Conditions | V _{GS} =16V 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 temperature DS applied) (2) | 1042 | Conditions | V _{DS} =80V V _{DS} =160V T _A =150°C, 1000hr | V _{DS} =200V |
| 1-2d | | End-Point Electrical Measurements | --- | Conditions Same as Gr.A-1 | | |
| C -2a | | Temperature Cycling | Sample Size | Level I 12p Level II NA | | |
| | | | 1051 | Conditions | -55 ⁺⁰ ₋₅ °C ↔ 25 ⁺¹⁰ ₋₅ °C ↔ 150 ⁺⁵ ₋₀ °C 100 cycles | |
| -2b | (1) Fine | Hermetic Seal | 1071 | Conditions | Condition H | |
| | | | | Limits | max 1×10 ⁻³ Pa·cm ³ /s | |
| | (2) Gross | Hermetic Seal | 1071 | Conditions | Condition C | |
| -2c | | End-Point Electrical Measurements (3) | --- | Conditions Same as Gr.A-1 | | |
| C -3 | | Thermal Impedance (4) (5) Z _{th(ch-o)} (ΔV _{SD}) | Sample Size | Level I LTPD 10 Level II 8p | | |
| | | | 3161 | Conditions | T _A =25°C | |
| | | | Limits | max (°C/W) 0.5 | max (°C/W) 0.5 | max (°C/W) 0.5 |
| C -4a | | Safe Operating Area Test(6) | Sample Size | Level I LTPD 10 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 Level II NA | | |
| | | | 1020 | Conditions | V _{GS} ±2750V ±2750V ±2750V 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 | MIL-STD-750 | | | 100V Class | 200V Class | 250V Class |
|--------------|--|--|-------------|----------------|---|-------------|
| | Sub | Test Item | Method | JAXA R | 2SK 4048 | 2SK 4051 |
| D -1a | Thermal Shock (Glass Strain) | | Sample Size | | Level I LTPD 15 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 45 cycles | |
| | -1c | Terminal Strength | 2036 | Conditions | Condition A 1.5kg, 30s | |
| | -1d | Moisture Resistance | 1021 | Conditions | (MIL-STD-202, Method 106) | |
| | -1e | Hermetic Seal (1) Fine | 1071 | Conditions | Condition H | |
| | | | | Limits | max 1×10 ⁻³ Pa·cm ³ /s | |
| | | (2) Gross | 1071 | Conditions | Condition C | |
| -1f | Visual Inspection | 1051 1021 | Conditions | --- | | |
| 1g | End-Point Electrical Measurements | --- | Conditions | Same as Gr.A-1 | | |
| D -2a | Shock⁽¹⁾ | | Sample Size | | Level I LTPD 15 Level II LTPD 15 | |
| | | | 2016 | Conditions | No Operating, 14700m/s ² (1500G) 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 196 m/s ² (20G) 4 blows in each orientation X,Y,Z | |
| | -2c | Constant Acceleration⁽¹⁾ | 2006 | Conditions | 98100.5m/s ² (10000G) X ₁ , Y ₁ , Y ₂ and Z ₁ orientation | |
| | -2d | Hermetic Seal⁽¹⁾ (1) Fine | 1071 | Conditions | Condition H | |
| | | | | Limits | max 1×10 ⁻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 Level II LTPD 15 | |
| | | | 1041 | Conditions | 35°C, 24hr 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 | 200V Class | 250V Class | |
|--------------|-------------|--|-------------|------------|---|-------------|--|
| | Sub | Test Item | Method | JAXA R | 2SK 4048 | 2SK 4051 | 2SK 4054 |
| D -4 | | Barometric Pressure (reduced) | Sample Size | | Level I 3p | | |
| | | | 1001 | Conditions | | Level II NA | |
| | | | | | Not applicable for devices with rated voltage ≤ 200V. | | 8mmHg 60sec (minimum) V _{DS} =250V, V _{GS} =0V |
| D -5 | | Internal Water Vapor (1) | Sample Size | | Level I 3p | | |
| | | | 1018 | Conditions | | Level II 3p | |
| | | | | | --- | | |
| D -6a | | Resistance to Soldering Heat | Sample Size | | Level I 3p | | |
| | | | 2031 | Conditions | | Level II NA | |
| | | | | | 250°C, 10s | | |
| -6b | | Visual Inspection | --- | Conditions | --- | | |
| -6c | | Hermetic Seal (1) Fine | Conditions | | Condition H | | |
| | | | Limits | | max 1×10 ⁻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 | MIL-STD-750 | | | 100V Class | 200V Class | 250V Class |
|--------------|---|--------|-------------|---|--|--|
| Sub | Test Item | Method | JAXA R | 2SK 4048 | 2SK 4051 | 2SK 4054 |
| E -1a | Total Dose Irradiation (TID) | 1019 | Sample Size | Level I 4p ⁽¹⁾ Level II 4p ⁽¹⁾ | | |
| | | | Conditions | Total Dose 1×10 ³ Gy(Si) Dose Rate 36Gy(Si)/h to 360Gy(Si)/h Bias Condition (during irradiation, after irradiation) (a) V _{DS} =0V, V _{GS} =20V (b) V _{DS} =0V, V _{GS} =-20V (c) V _{DS} =80V, 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 I _D =1mA, V _{GS} =0V | | |
| | | | Limits | min 100V DC | min 200V DC | min 250V DC |
| (2) | Gate-to-Source Leakage Current I _{GSS} | 3411 | Conditions | Bias Condition C V _{GS} =±20V, V _{DS} =0V | | |
| | | | Limits | max ±100nA DC | | |
| (3) | Drain Current I _{DSS} | 3413 | Conditions | Bias Condition C V _{DS} =80V, 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 | | |
| (4) | Gate to Source Voltage (Threshold) V _{GS(th)} | 3404 | Conditions | Bias Condition C V _{GS} =V _{DS} , I _D =1mA | | |
| | | | Limits | min 1.5V DC ΔV _{GS(th)} max 2.0V | | |
| (5) | Static Drain to Source On-State Resistance R _{DS(on)} | 3421 | Conditions | Pulse Test ⁽²⁾ , V _{GS} =12V | | |
| | | | Limits | I _D 21A max [mΩ] 18 | I _D 21A max [mΩ] 33 | I _D 21A max [mΩ] 45 |

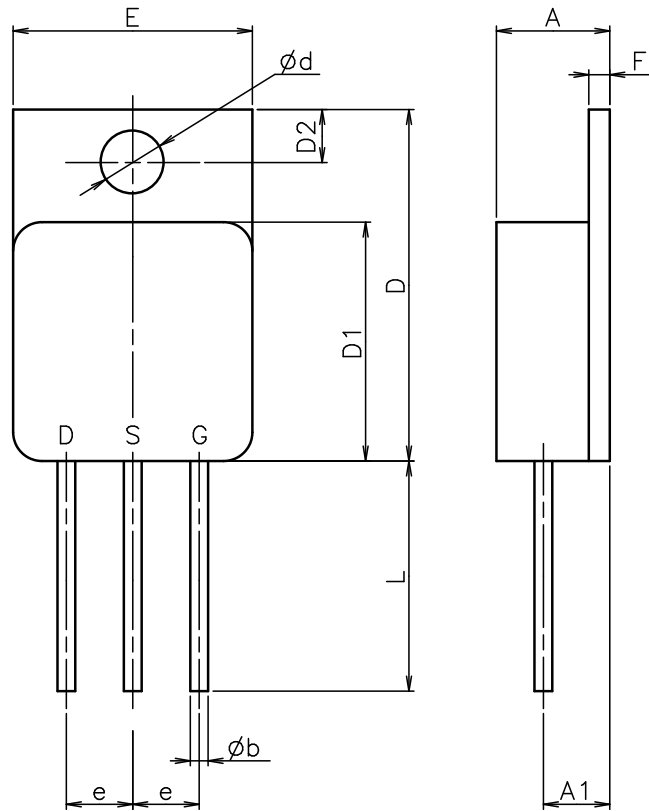
Notes ⁽¹⁾ This test shall be performed for each single wafer lot. When an inspection lot consists of multiple inspection sublots, one inspection subplot may be performed this test.

⁽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 | 200V Class | 250V Class |
|----------|--|--|-----------------|-----------------|
| Sub | JAXA R | 2SK 4048 | 2SK 4051 | 2SK 4054 |
| | JAXA-QTS-2030 Appendix C Test Item | Die Size 1/1 | Die Size 1/1 | Die Size 1/1 |
| C | 1-1a Intermittent Operation Life | These tests may be exempted when the following two conditions are satisfied. • When the devices having the same die size or larger die size passed the test. • When the devices passed the test 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 in the subgroup B-7 of Group B inspection. | | |
| | -4a Safe Operating Area Test | This test may be exempted when the device passed in the subgroup A-6 of Group A inspection. | | |
| | -4b End-Point Electrical Measurements | | | |
| D | -1a Thermal Shock (Glass Strain) | This test may be exempted when any one of the products passed the test. | | |
| | -1b Thermal Shock (Temperature Cycling) | | | |
| | -1c Terminal Strength | | | |
| | -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 | | | |
| | -5 Internal Water Vapor | | | |



| Symbol | Dimension (mm) | |
|----------|----------------|-------|
| | Min | Max |
| A | 6.35 | 6.65 |
| A1 | 3.61 | 4.01 |
| ϕb | 0.90 | 1.14 |
| D | 20.07 | 20.31 |
| D1 | 13.59 | 13.85 |
| D2 | 2.93 | 3.17 |

| Symbol | Dimension (mm) | |
|----------|----------------|-------|
| | Min | Max |
| ϕd | 3.56 | 3.80 |
| E | 13.60 | 13.84 |
| e | 3.51 | 4.11 |
| F | 1.10 | 1.30 |
| L | 12.84 | 13.60 |

Note: All leads are isolated from the case.

Figure 1. Package Configuration and Lead Connection of TO-254 type package

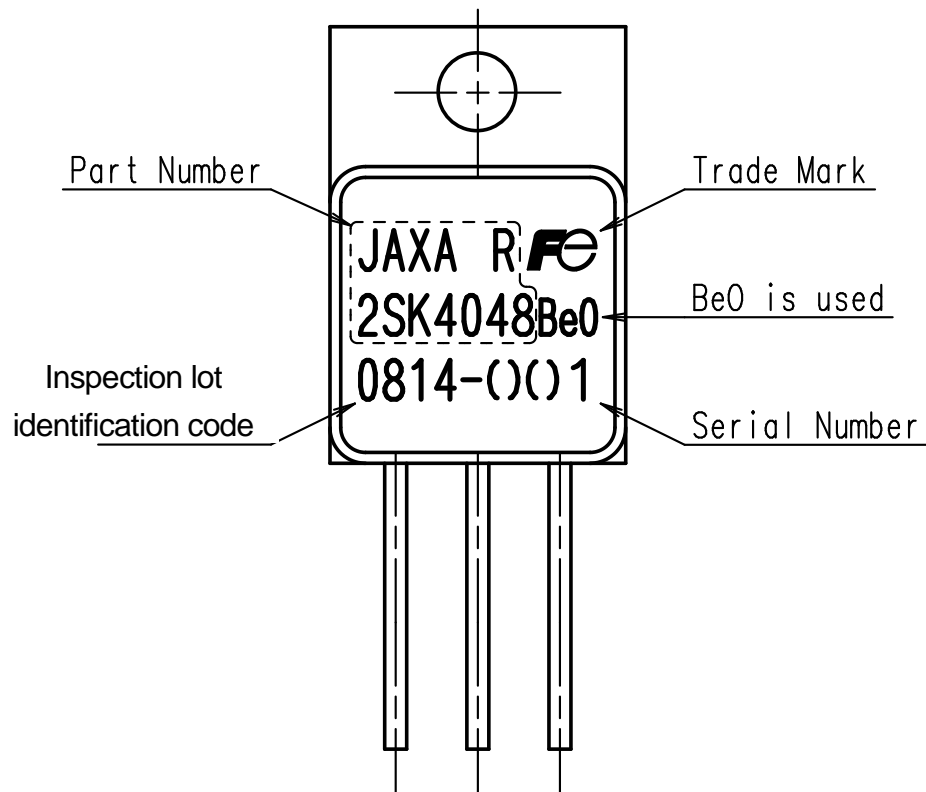


Figure 2. Marking

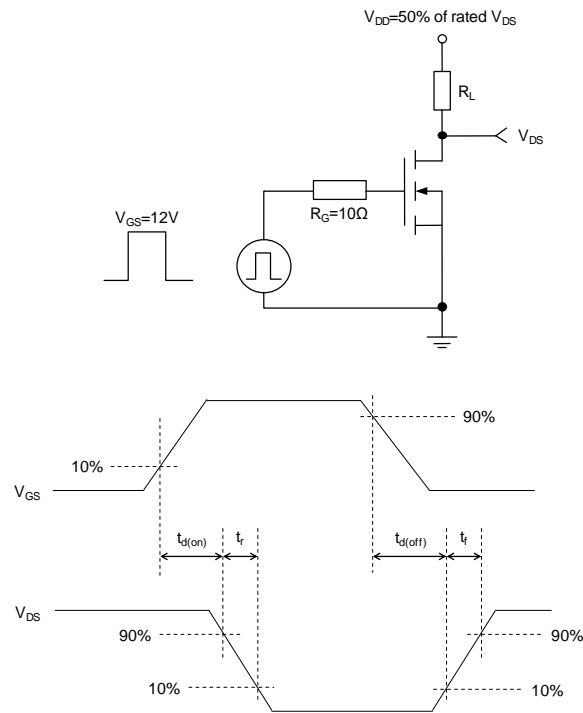


Figure 3. Switching time test circuit and waveforms

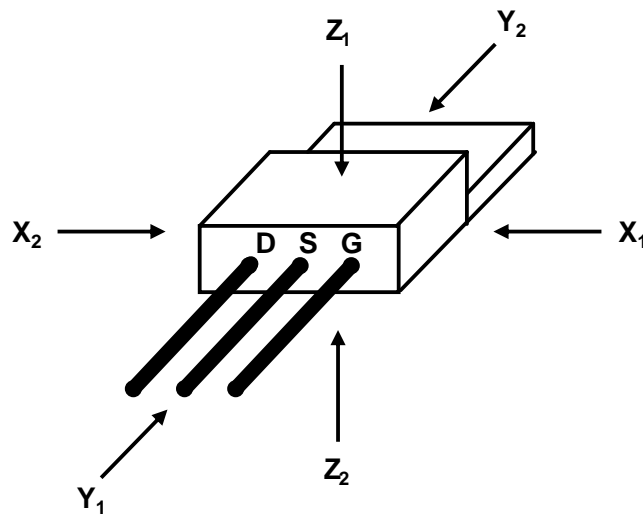


Figure 4. Orientation

JAXA R 2SK4048

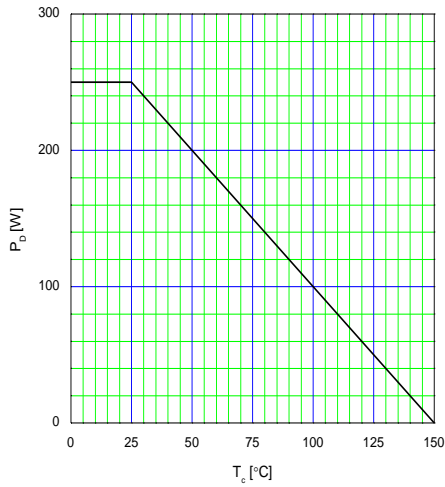


Fig. 5 Allowable Power Dissipation
 $P_D=f(T_j)$

JAXA R 2SK4048

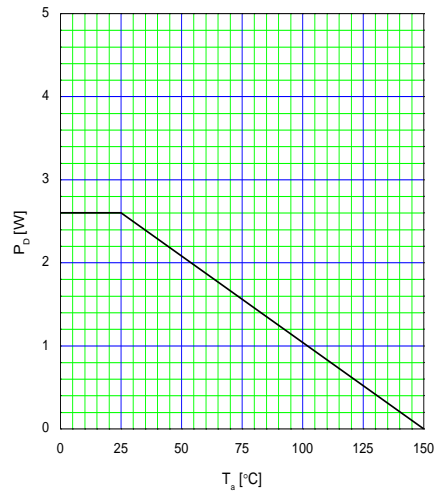


Fig. 6 Allowable Power Dissipation
 $P_D=f(T_j)$

JAXA R 2SK4048

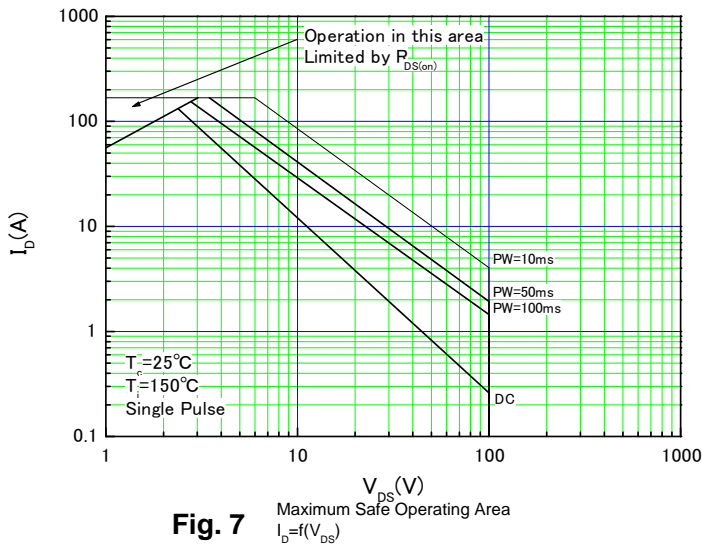


Fig. 7 Maximum Safe Operating Area
 $I_D=f(V_{DS})$

JAXA R 2SK4051

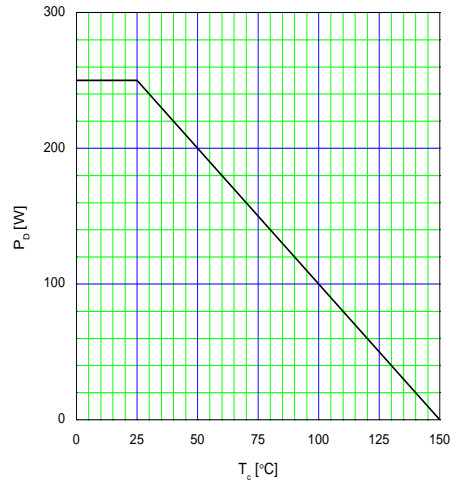


Fig. 14 Allowable Power Dissipation
 $P_D=f(T_j)$

JAXA R 2SK4051

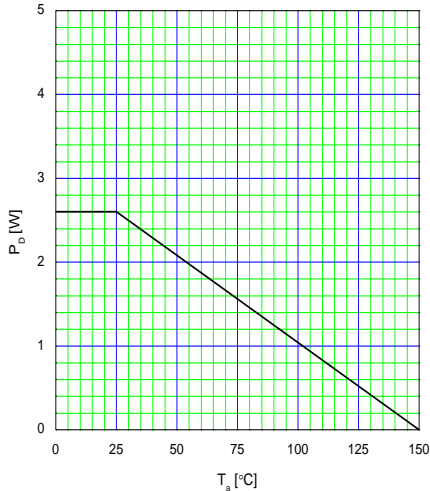


Fig. 15 Allowable Power Dissipation
 $P_D=f(T_j)$

JAXA R 2SK4051

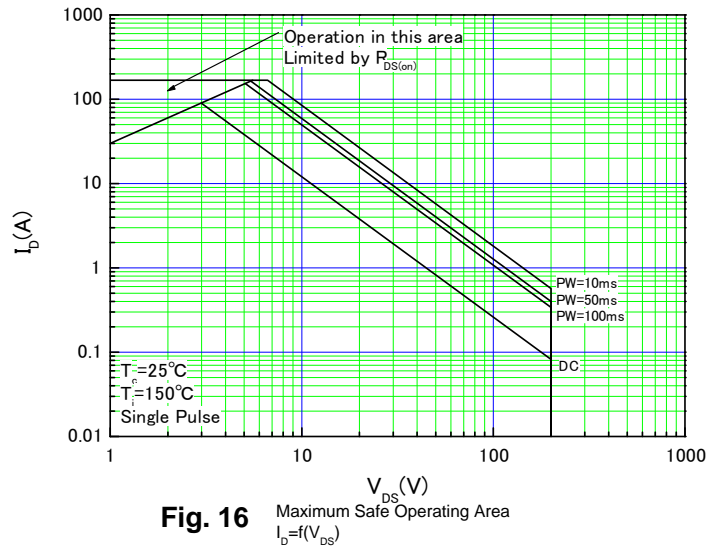


Fig. 16 Maximum Safe Operating Area
 $I_D=f(V_{DS})$

JAXA R 2SK4054

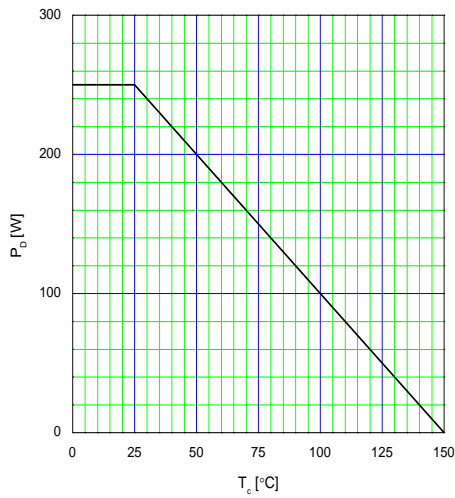


Fig. 23 Allowable Power Dissipation
 $P_d=f(T_c)$

JAXA R 2SK4054

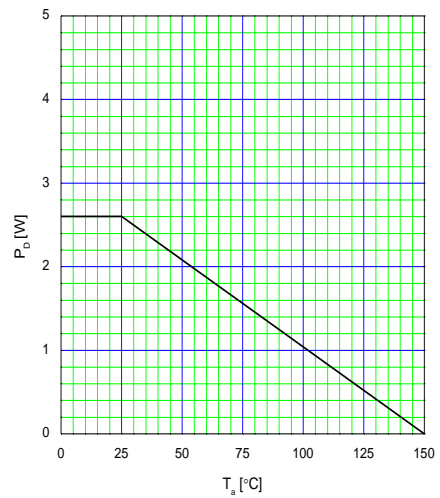


Fig. 24 Allowable Power Dissipation
 $P_d=f(T_a)$

JAXA R 2SK4054

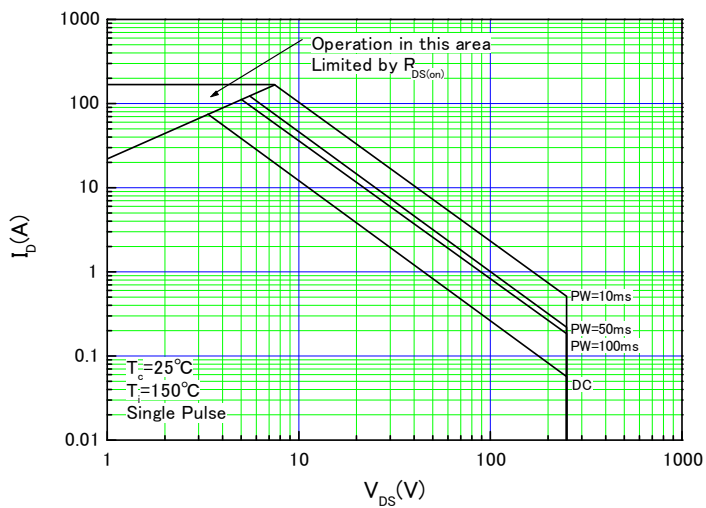


Fig. 25 Maximum Safe Operating Area
 $I_D=f(V_{DS})$