

COMMON PARTS/MATERIALS, SPACE USE,
APPLICATION DATA SHEET FOR

Part Description	POWER MOSFET, N-CHANNEL, RADIATION HARDENED
Part Number and Type	JAXA R 2SK4185 JAXA R 2SK4186 JAXA R 2SK4187 JAXA R 2SK4188 JAXA R 2SK4189 JAXA R 2SK4190
Applicable Specification	JAXA-QTS-2030 JAXA-QTS-2030/103

March 2020

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 15, 2022.

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Revision Log			
Rev.	Date	Description	
-----	29 February 2008	Original	
A	12 Nov. 2012	▪ Table 4: Reviewed the number of significant figures in the test conditions of Vibration, Shock, and Constant acceleration test. ▪ Table 6: Reviewed the number of significant figures in the test conditions of shock test. ▪ Table 7: Reviewed the number of significant figures in the test conditions of Constant acceleration test. ▪ Added the maximum safe operating area of DC to figures.	
B	18 March 2020	▪ Cover: Changed the corporate name. ▪ Added the following Paragraphs, tables and figure. · Paragraph 3.5 Recommended Surface Mounting Method (for SMD Packages) · Paragraph 3.5.1 Recommended Mounting Board · Paragraph 3.5.2 Recommended Reflow Conditions · Table A. Recommended Reflow Temperature Profile · Figure A. Recommended Reflow Temperature Profile · Paragraph 3.5.3 Thermal Stress Evaluation Test for Cargo Flight On-Board Devices · Table B. Results of Environmental Tests after Thermal Stresses ▪ Paragraph 10 Others: Changed the contact information.	

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**COMMON PARTS/MATERIALS,
SPACE USE,
APPLICATION DATA SHEET FOR**

1. GENERAL

1.1 Scope

This Application Data Sheet provides additional detailed information necessary for designing or selecting products not contained in JAXA QTS. Relevant information not covered in this document shall also be considered. Users are responsible for all aspects pertaining to selection and use of the product(s) specified in this document.

1.2 Applicable Documents

The latest versions of the following documents are applicable to the device mentioned in this data sheet.

JAXA-QTS-2030	Semiconductor Device, High Reliability, Space Use, General Specification for
JAXA-QTS-2030/103	POWER MOSFET, N-CHANNEL, RADIATION HARDENED, HIGH RELIABILITY, SPACE USE, DETAIL SPECIFICATION FOR
MIL-STD-750	TEST METHOD STANDARD, TEST METHODS FOR SEMICONDUCTOR DEVICES
JERG-0-043	STANDARD FOR SURFACE MOUNT SOLDERING PROCESS

2. SUMMARY OF PRODUCT

2.1 Externals and Dimensions

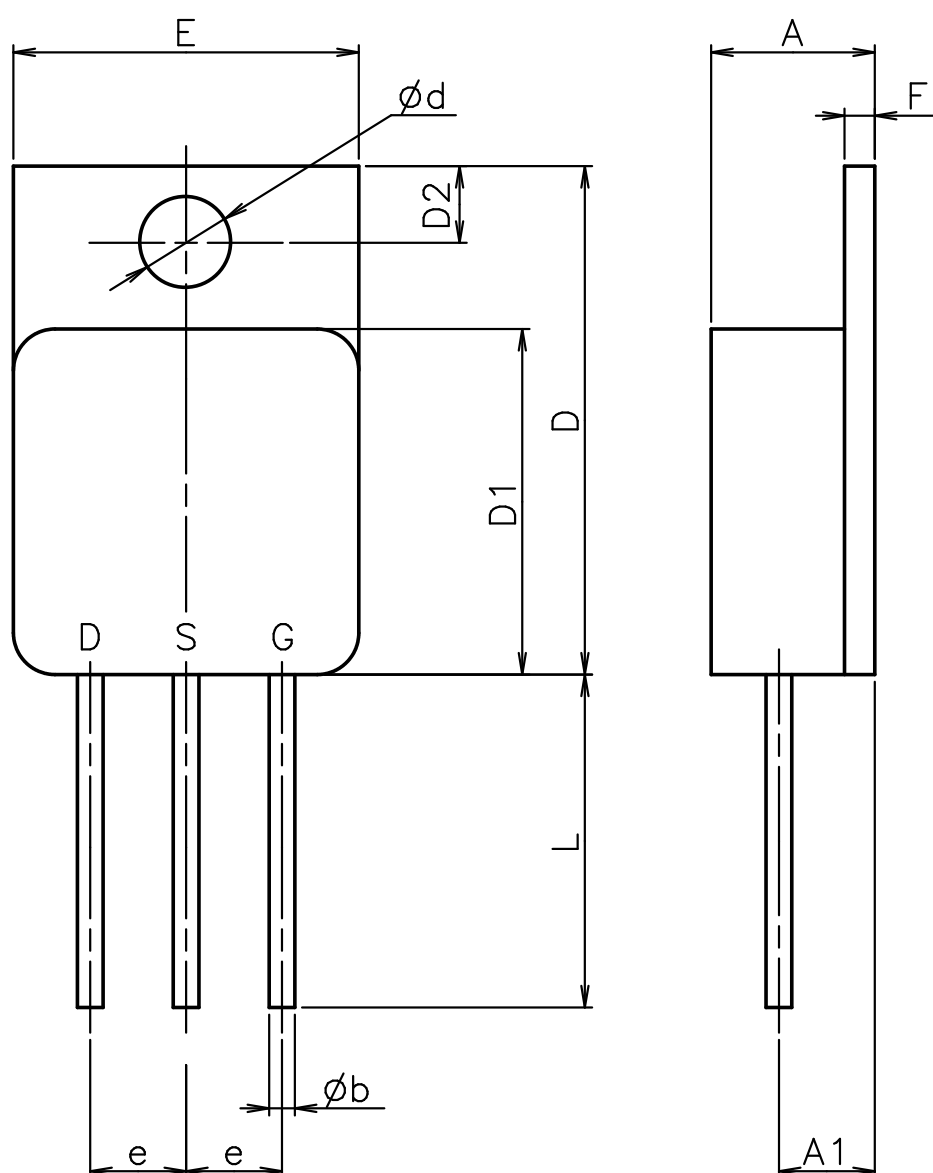
The case outline and dimensions of the device are shown in Figures 1a, 1b, 1c and 1d. The marking of the device is illustrated in Figures 8a, 8b, 8c and 8d.

2.2 Net Weight

TO-254 package type (JAXA R 2SK4185, 2SK4186, 2SK4187)	: 9.3g. (typ.)
SMD-2 package type (JAXA R 2SK4188)	: 3.3g (typ.)
SMD-1 package type (JAXA R 2SK4189)	: 2.6g (typ.)
SMD-0.5 package type (JAXA R 2SK4190)	: 1.0g (typ.)

2.3 Devices Structure

The device consists of one N-channel enhancement MOSFET chip with planar structure and a seam-welded hermetic seal package as shown in Figures 1a, 1b, 1c and 1d. The internal structure and the cross-section of the device are drawn in Figures 2 through 7.

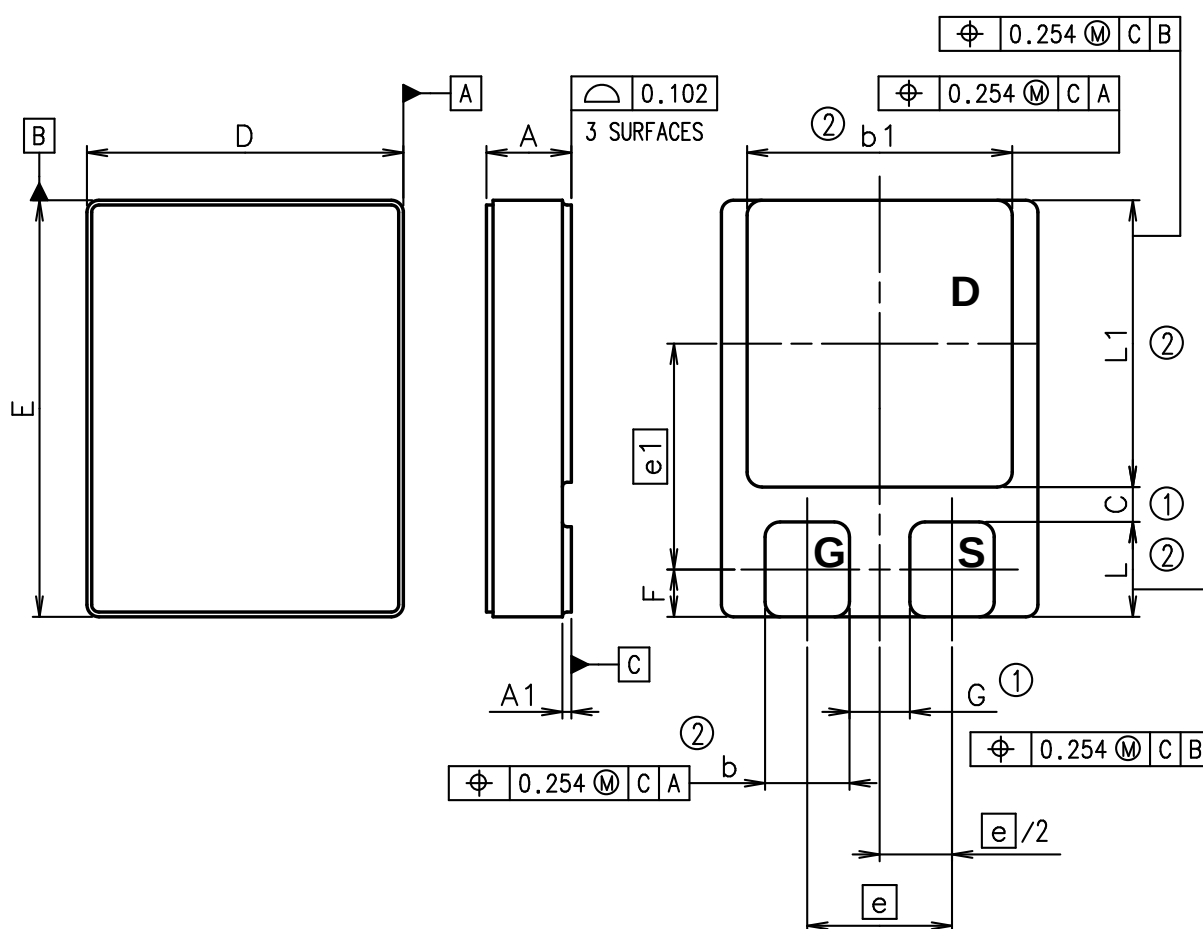


Symbol	Dimension (mm)	
	Min	Max
A	6.35	6.65
A1	3.61	4.01
ϕb	0.90	1.14
D	20.07	20.31
D1	13.59	13.85
D2	2.93	3.17

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 1a. Outline and Dimensions of TO-254
(JAXA R 2SK4185, 4186, 4187)**



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

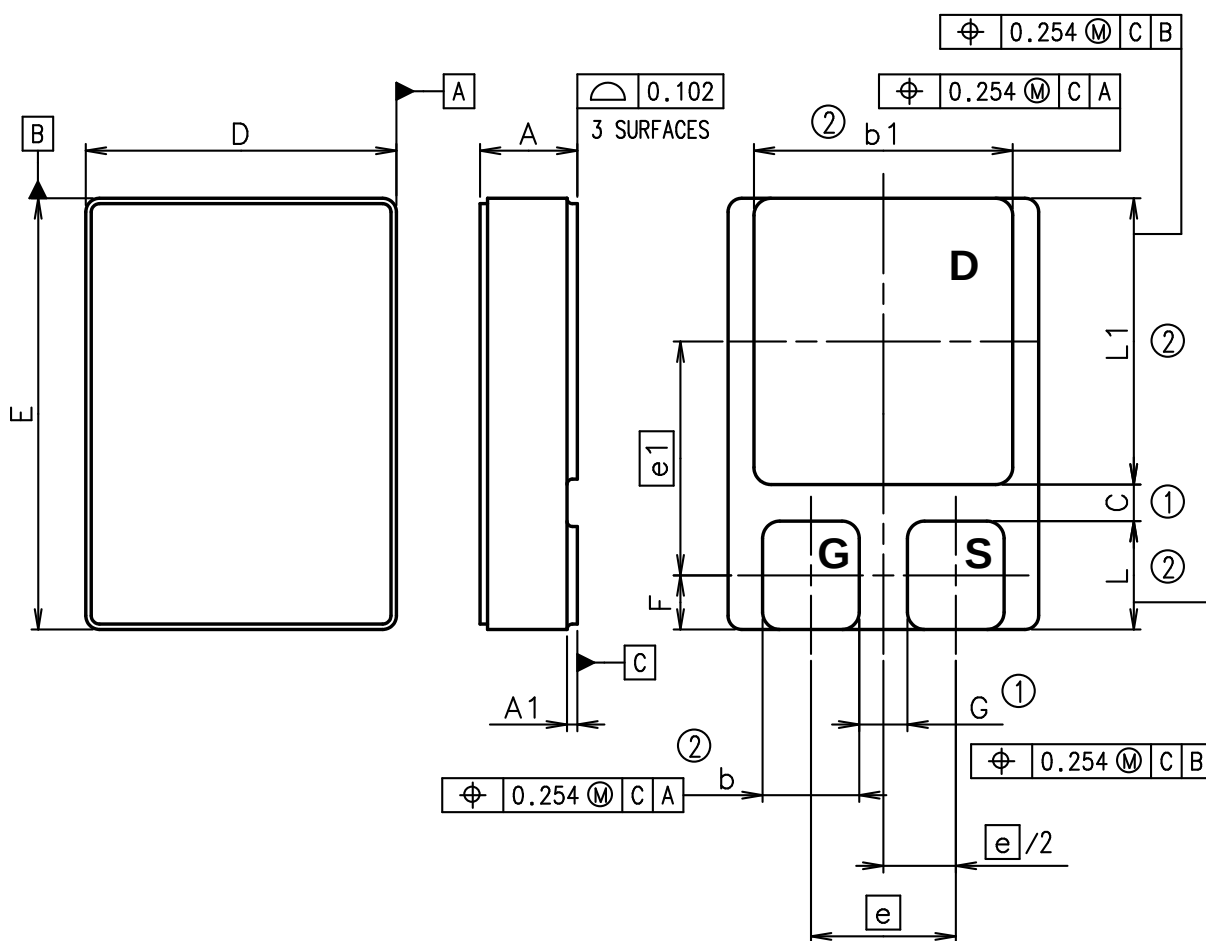
Symbol	Dimension (mm)		
	Min	Typ	Max
$e/2$	—	3.05	—
e	—	6.10	—
$e1$	—	9.50	—
F	—	1.99	—
G	1.27	—	—
L	3.87	3.99	4.11
L1	11.94	12.065	12.19

Notes: ① Dimension includes metallization flash.

② Dimension does not include metallization flash.

Note: All terminals are isolated from the case.

**Figure 1b. Outline and Dimensions of SMD-2
(JAXA R 2SK4188)**



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

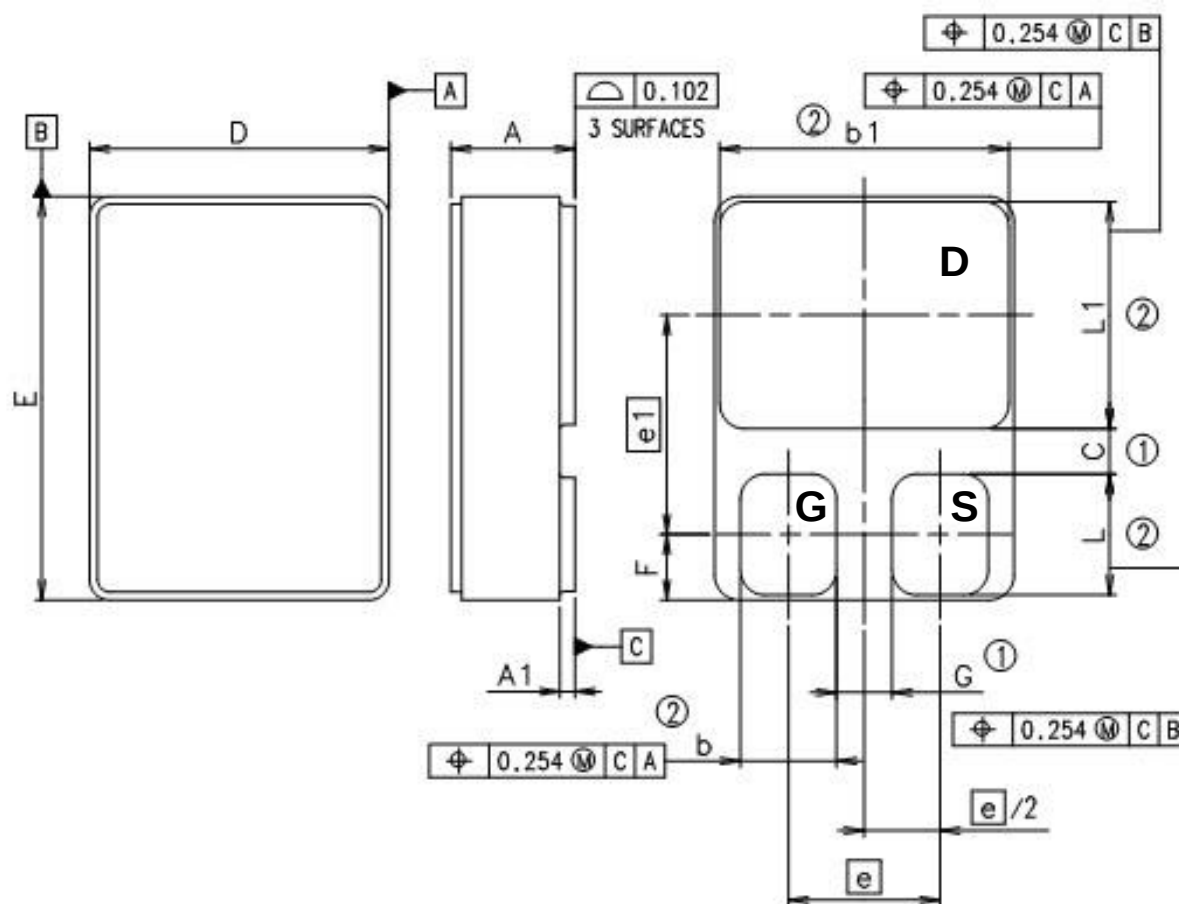
Symbol	Dimension (mm)		
	Min	Typ	Max
$e/2$	—	2.67	—
e	—	5.33	—
$e1$	—	8.61	—
F	—	1.99	—
G	0.89	—	—
L	3.87	3.99	4.11
L1	10.42	10.54	10.66

Notes: ① Dimension includes metallization flash.

② Dimension does not include metallization flash.

Note: All terminals are isolated from the case.

**Figure 1c. Outline and Dimensions of SMD-1
(JAXA R 2SK4189)**



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 1d. Outline and Dimensions of SMD-0.5
(JAXA R 2SK4190)**

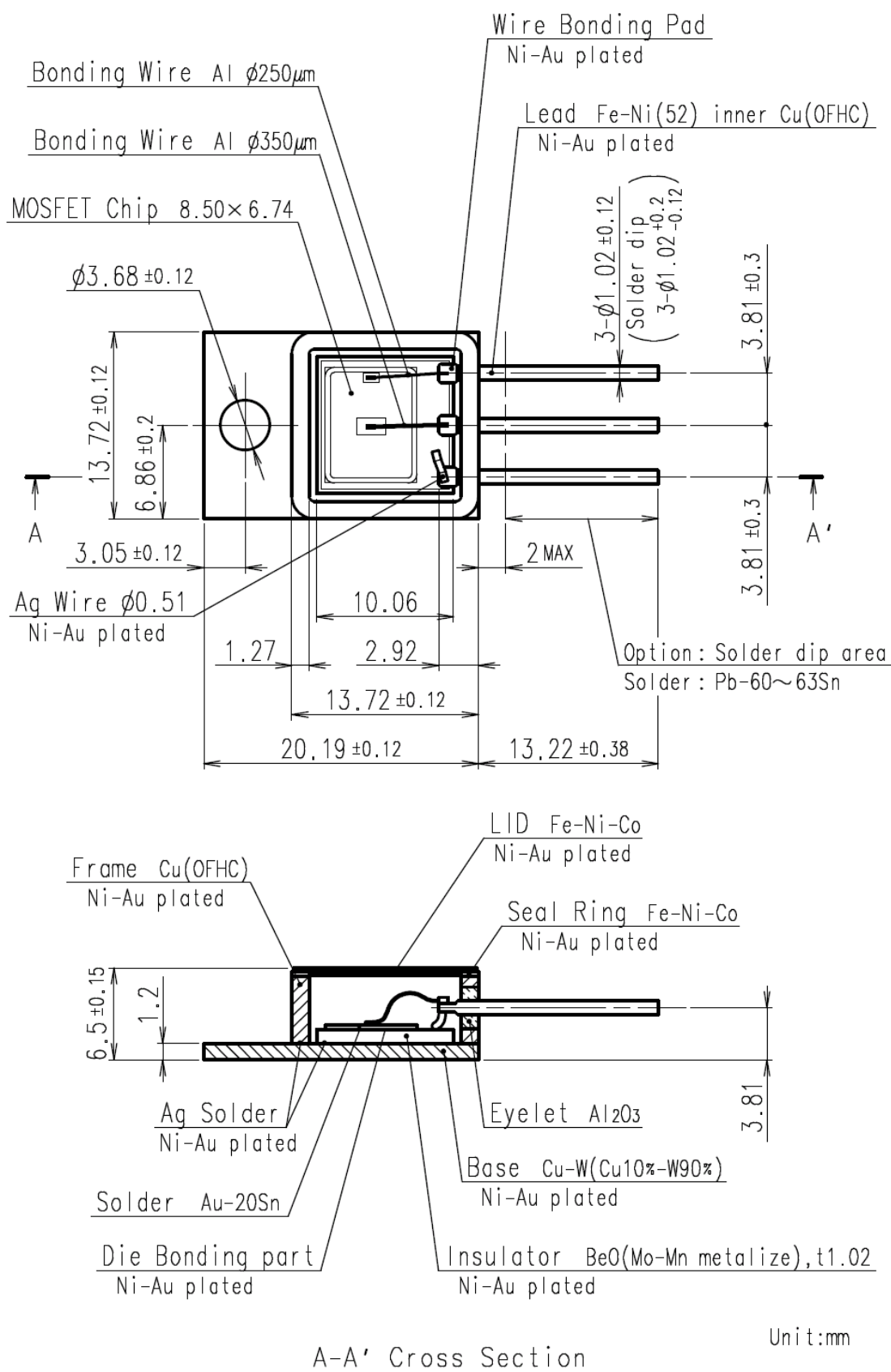


Figure 2. Inner Structure and Cross-section of TO-254 (JAXA R 2SK4185)

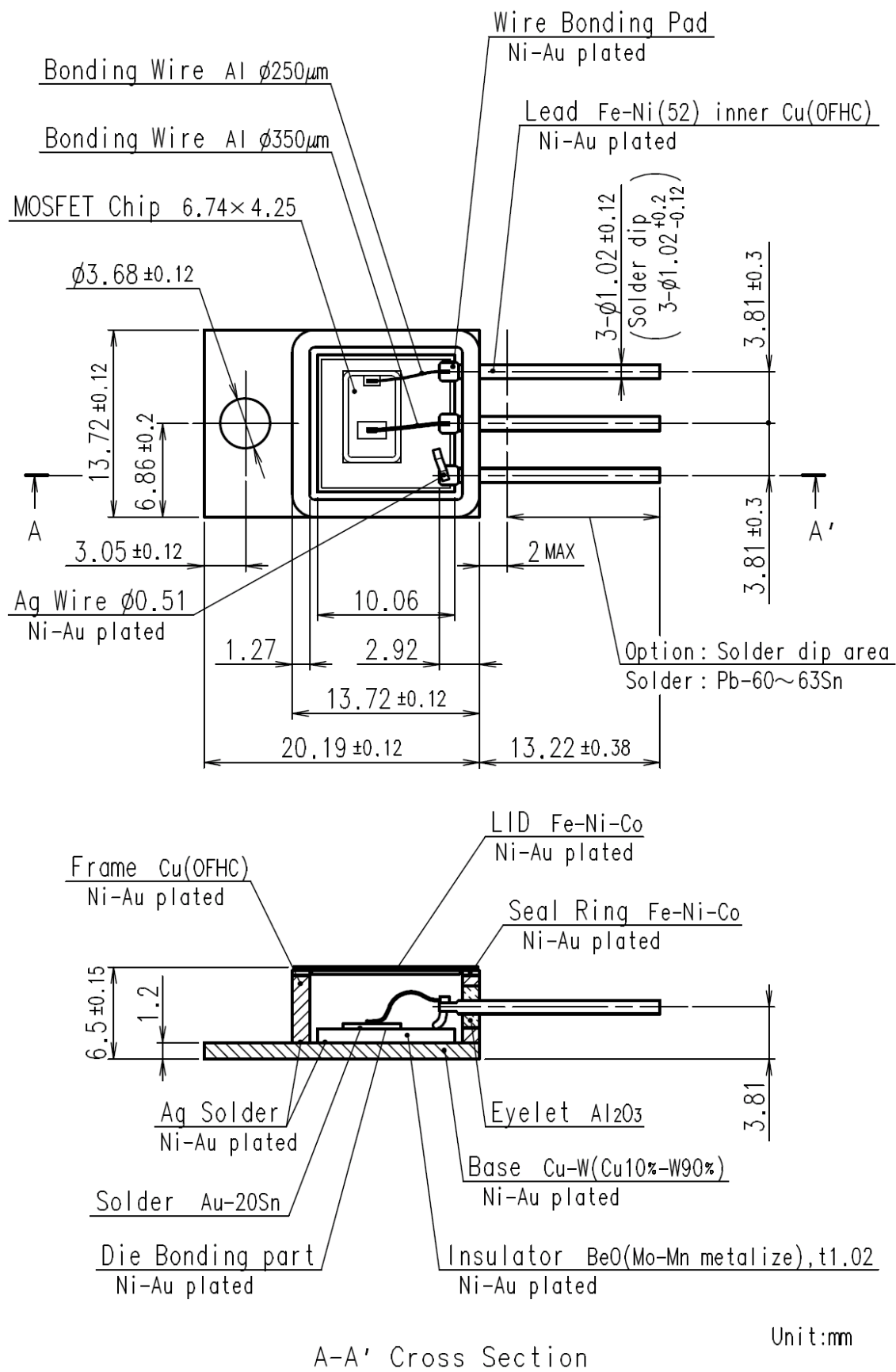
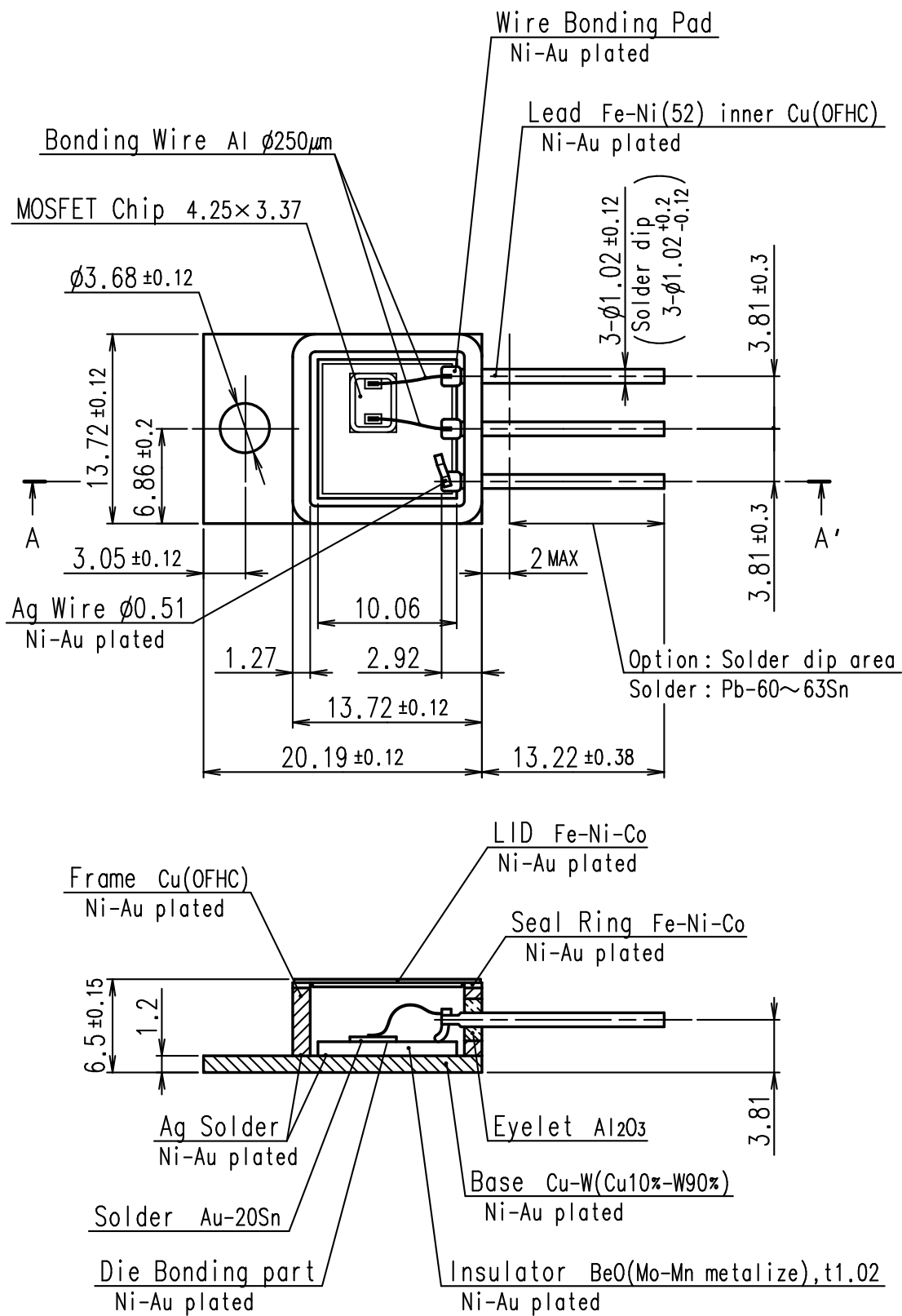


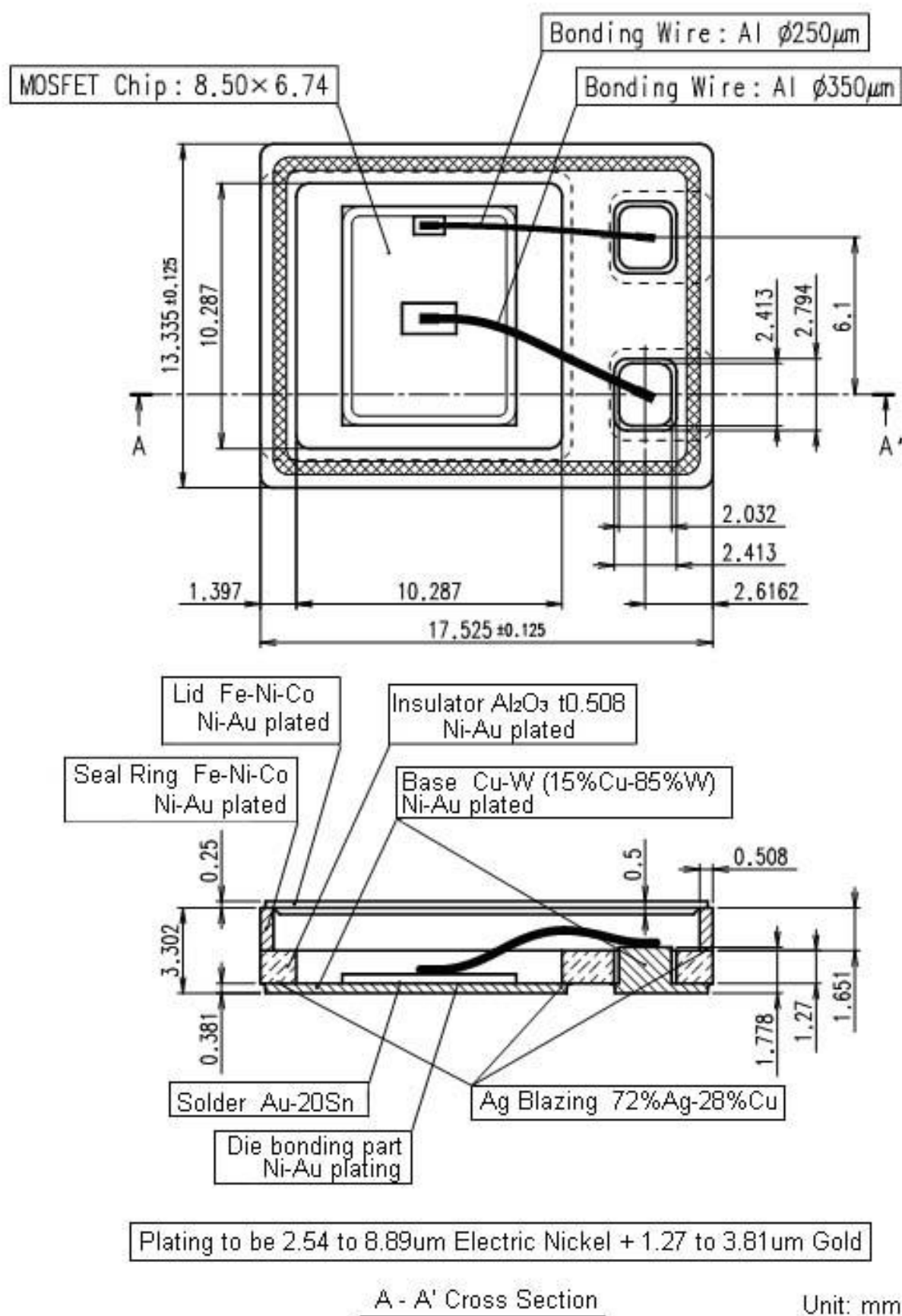
Figure 3. Inner Structure and Cross-section of TO-254 (JAXA R 2SK4186)



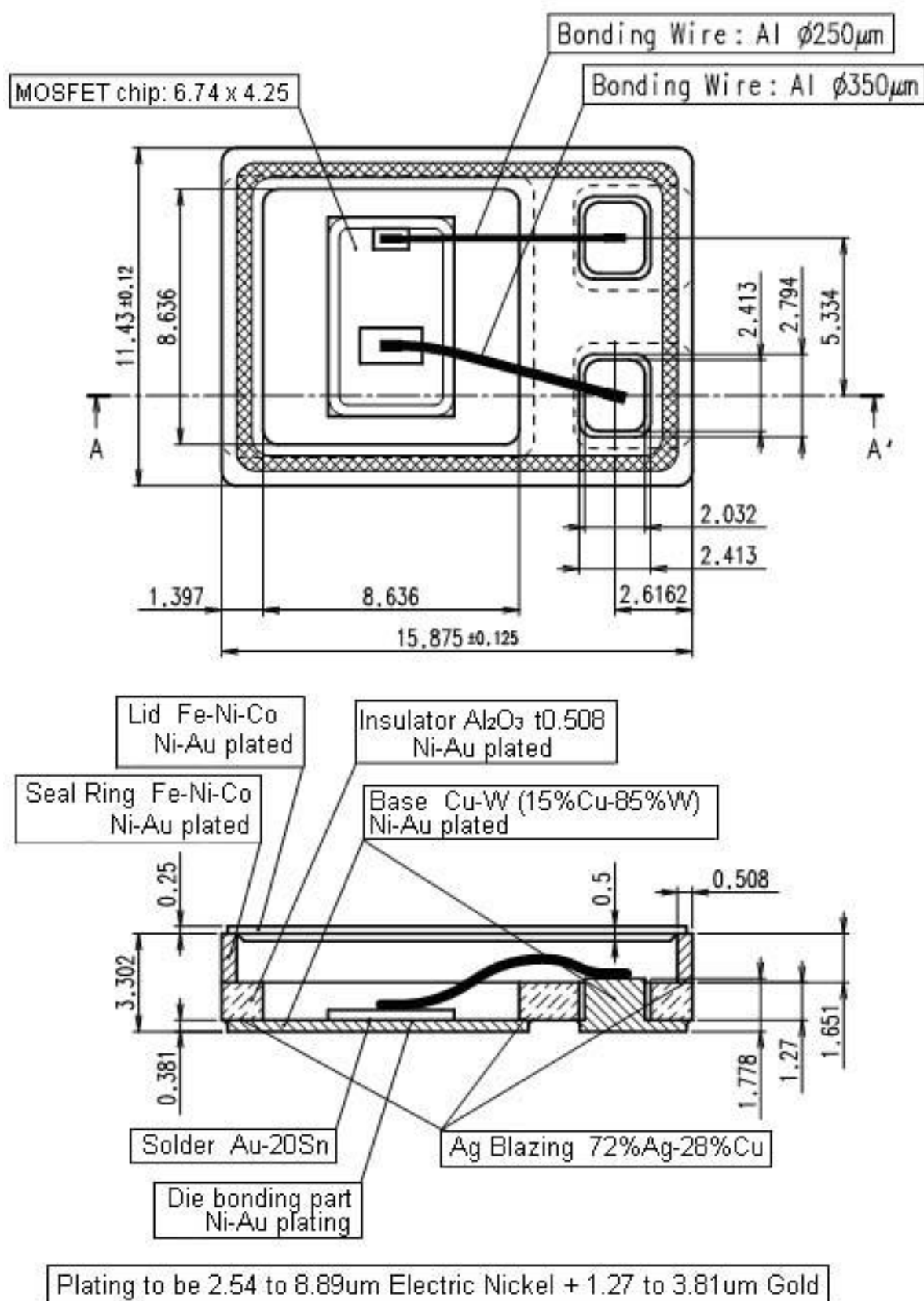
Unit:mm

A-A' Cross Section

**Figure 4. Inner Structure and Cross-section of TO-254
(JAXA R 2SK4187)**



**Figure 5. Inner Structure and Cross-section of SMD-2
(JAXA R 2SK4188)**



A - A' Cross Section

Unit: mm

Figure 6. Inner Structure and Cross-section of SMD-1 (JAXA R 2SK4189)

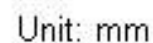
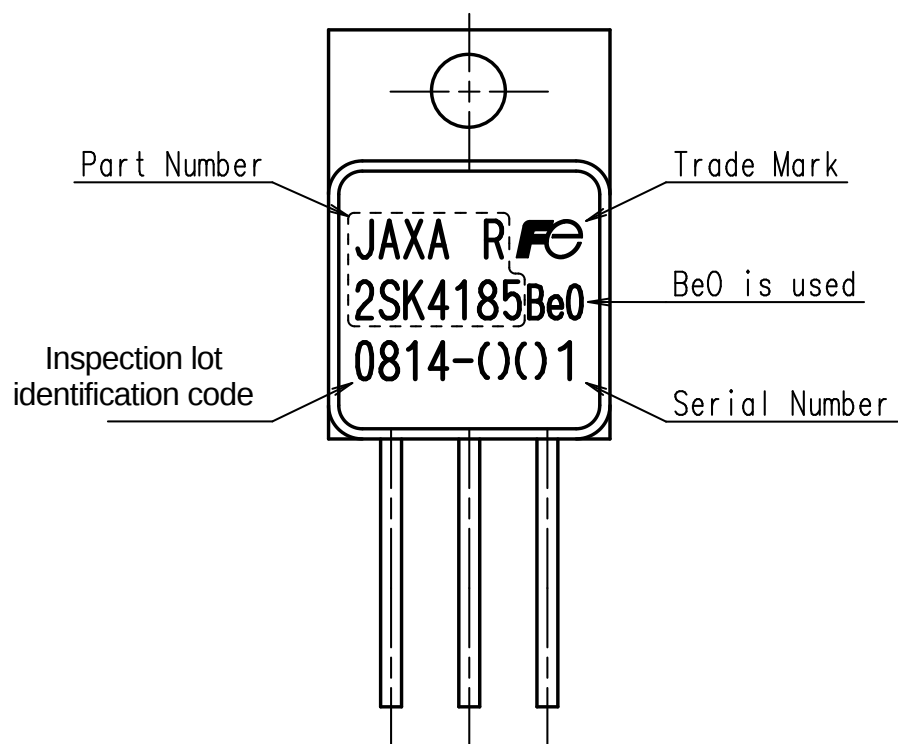
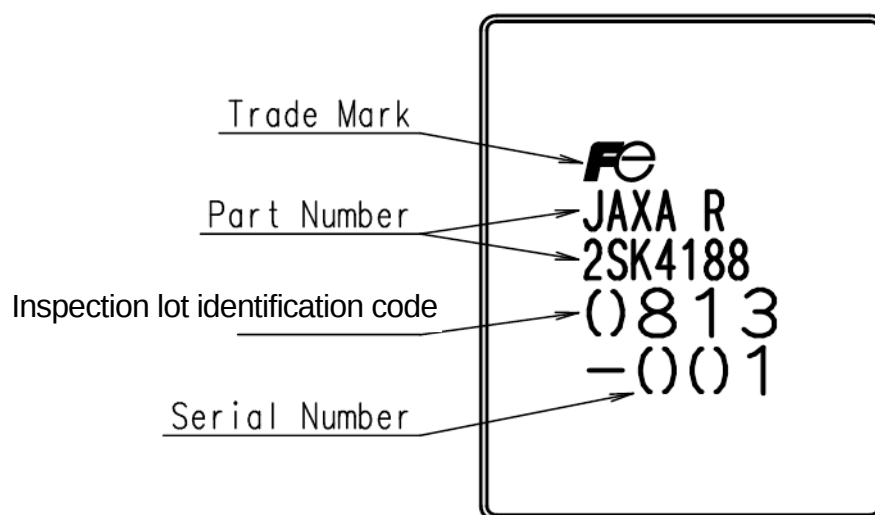


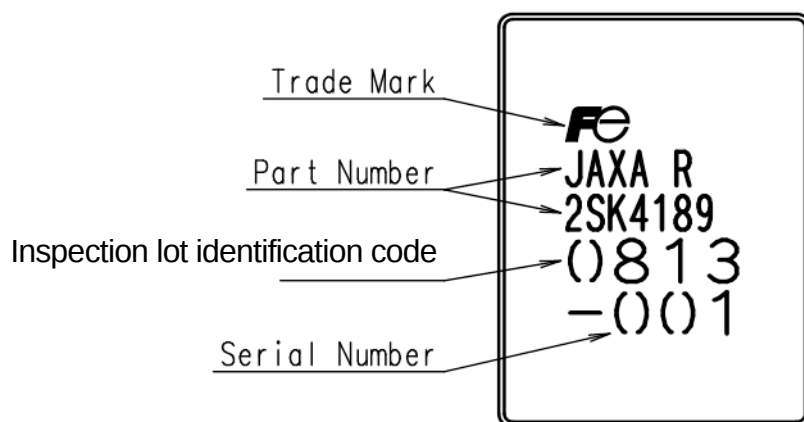
Figure 7. Inner Structure and Cross-section of SMD-0.5 (JAXA R 2SK4190)



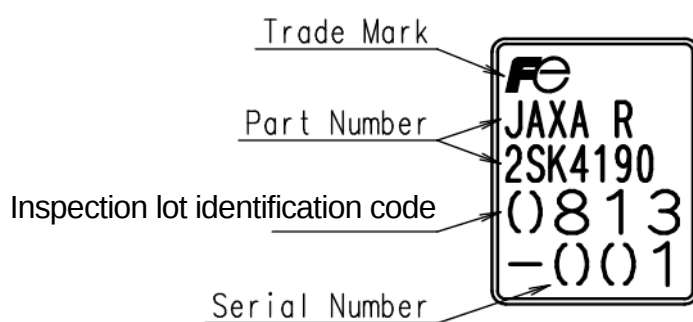
**Figure 8a. Marking of TO-254
(JAXA R 2SK4185, 4186, 4187)**



**Figure 8b. Marking of SMD-2
(JAXA R 2SK4188)**



**Figure 8c. Marking of SMD-1
(JAXA R 2SK4189)**



**Figure 8d. Marking of SMD-0.5
(JAXA R 2SK4190)**

3. USAGE

The circuit must be designed to have sufficient margins for the absolute maximum ratings as shown in Table 1. It is desirable that the device is operated under the recommended operating conditions as shown in Table 2.

3.1 Absolute Maximum Ratings

Table 1. Absolute Maximum Ratings

Part No.	V _{DS} (V)	I _D (A)	I _{D(pulse)} (A)	V _{GS} (V)	P _D T _C =25°C (W)	P _D T _A =25°C (W)	T _{ch} ⁽¹⁾ (°C)	T _{stg} (°C)	R _{th(ch-c)} (°C/W)	R _{th(ch-a)} (°C/W)
JAXA R 2SK4185	500	23	92	±20	250	2.6	150	-55 to 150	0.5	48.0
JAXA R 2SK4186		10	40		125	2.58			1.0	48.5
JAXA R 2SK4187		4.5	18		60	2.55			2.0	49.0
JAXA R 2SK4188		23	92		250	---			0.5	---
JAXA R 2SK4189		10	40		150	---			0.83	---
JAXA R 2SK4190		4.5	18		70	---			1.67	---

Note⁽¹⁾ 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)

3.2 Recommended Operating Conditions

Table 2. Recommended Operating Conditions

Items	Recommended Values
V _{DS} (DC)	75% of rated
I _D (DC)	70% of rated
V _{GS}	-7.5 to +15V
T _{ch}	-55 to 125°C

3.3 Torque (for TO-254 package)

The recommended torque when mounting the device on a heat sink shall be shown in the following table. Excess torque applied to the mounting screw will cause damage to the device, and smaller torque will depress the heat dissipation and may cause to destroy by thermal runaway.

Package	Screw	Tightening torques
TO-254	M3	40-60Ncm

Note: Flatness of heat sink: $< \pm 30\mu\text{m}$
 Roughness: $< 10\mu\text{m}$
 Plane off the edges: $C < 1.0\text{mm}$

3.4 Lead Bending (for TO-254 package)

- The bending shall be performed at the point of 2.0 mm as a minimum apart from the lead egress.
- The minimum inside radius when the lead is bent shall be 1.5mm.
- The egress of the lead shall be held securely when bending to avoid adding stress on the ceramic.

3.5 Recommended Surface Mounting Method (for SMD Packages)

3.5.1 Recommended Mounting Board

Unintentional cracks may occur on the solder joints and ceramic due to the heat stress on the parts, substrate, or solder materials during and after the device is mounted. Therefore, the mounting boards shall be either CIC, metal core boards, or the boards with thermal expansion coefficient similar to that of ceramics, and post-mount evaluation is recommended.

3.5.2 Recommended Reflow Conditions

The reflow soldering of terminals shall be performed in accordance with JERG-0-043 Standards for Surface Mount Soldering Process.

Recommended reflow temperature profile shall be shown in table A and figure A.

Table A. Recommended Reflow Temperature Profile

	Zone	Temperature / Time
I	Ramp to pre-heat	2.0 to 5.0°C/sec. for 30 to 60 sec.
II	Pre-heat	150±10°C for 60±30 sec.
III	Ramp to peak	2.0 to 5.0°C/sec. for 20 to 40 sec.
IV	Reflow	200°C or higher for 30 to 60 sec. with peak temperature of 240°C max.
V	Cooling	Cool continuously

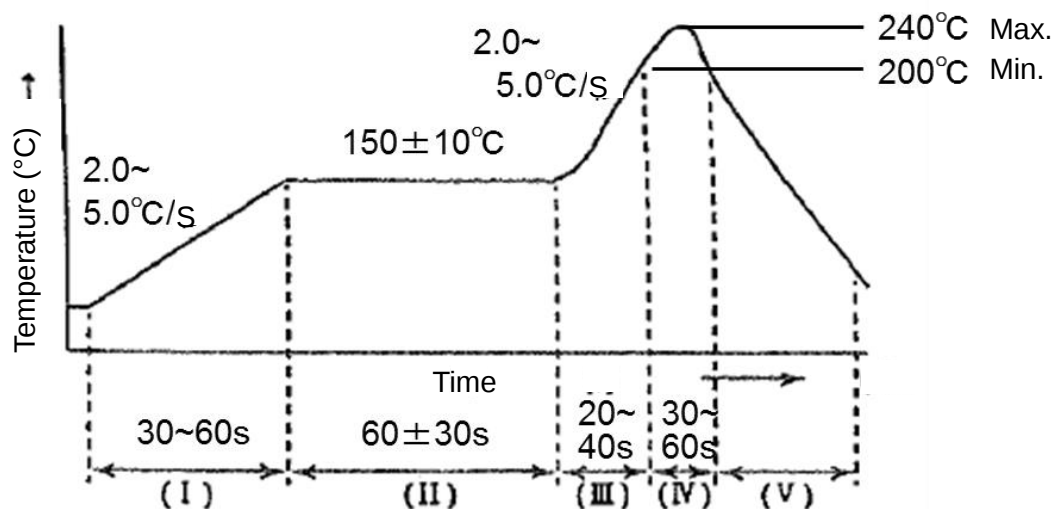


Figure A. Recommended Reflow Temperature Profile

3.5.3 Thermal Stress Evaluation Test for Cargo Flight On-Board Devices

The evaluation test was performed simulating that space-use stand-alone power devices without being mounted on PWB etc. were subjected to thermal stress of reflow soldering process to assure static characteristics, hermeticity, and bond strength of the devices.

Note: As environmental tests after 6 times of above thermal processes, temperature cycling tests were performed on the assumption that the device was on board the cargo flight. The results of the evaluation tests were shown in Table B.

Table B. Results of Environmental Tests after Thermal Stresses

Order	MIL-STD-750		JAXA R	Typical evaluation sample 2SJ1A04(-100V, SMD2)	Evaluation result Defect /sample size
	Test item	Method			
1	Reflow soldering (Assuming Au plating is removed and reflow is re-performed.)		Sample size	22p	---
		---	Condition	Reflow temperature profile: see table A and figure A	
				6 times	
2	Temperature Cycling (Air to Air) (Assuming on-board flight environmental stress)		Sample size	22p	---
		1051	Condition	-55 ⁺⁰ ₋₅ °C↔25 ⁺¹⁰ ₋₅ °C↔150 ⁺⁵ ₋₀ °C	
				30 cycles	
3-1	Visual Inspection		Sample size	22p	0/22
		1051	Condition	---	
		1021			
3-2	Static characteristics (T_A=25°C)		Sample size	22p	0/22
	-2a Breakdown Voltage Drain to Source V _{DSS}	3407	Condition	Bias condition C, I _D =-1mA, V _{GS} =0V	
			Limits	min -100V DC	
	-2b Gate to Source Leakage Current I _{GSS}	3411	Condition	Bias condition C, V _{GS} =±20V, V _{DS} =0V	
			Limits	max ±100nA DC	
	-2c Drain Current I _{DSS}	3413	Condition	Bias condition C, V _{DS} =-80V, V _{GS} =0V	
			Limits	max -10μA DC	
	-2d Gate to Source Voltage (Threshold) V _{GS(th)}	3404	Condition	Bias condition C, V _{GS} =V _{DS} , I _D =-1mA	
			Limits	-2.5 ~ - 4.5V DC	
	-2e Static Drain to Source On-State Resistance R _{DS(on)}	3421	Condition	Pulse test ⁽¹⁾ , V _{GS} =-12V, I _D =-21A	
			Limits	max 38mΩ	
	-2f Forward Transconductance g _{fs}	3475	Condition	Pulse test ⁽¹⁾ , V _{DS} = -25V, I _D =-21A	
			Limits	min 8S	
	-2g Forward Voltage V _{SD}	---	Condition	Pulse test ⁽¹⁾ , V _{GS} =0V, I _D =-42A	
			Limits	max -2.0V DC	
3-3	Hermetic Seal (1) Fine Leak (2) Gross Leak	1071	Condition	Condition H	0/22
			Limits	max 1×10 ⁻³ Pa·cm ³ /s	
		1071	Condition	Condition C	
3-4	Ultrasonic test	---	Condition	No cracks between chip-solder-frame.	0/22
3-5	Internal visual and Mechanical inspection	2075	Condition		0/22
		2071		---	
3-6	Bond strength		Sample size	22p	0/22
		2037	Condition	Condition D	
			Limits	G-Wire >90gf S-Wire >300gf	

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

4. CHARACTERISTICS IN NORMAL CONDITIONS

4.1 Electrical Characteristics

The electrical characteristics are shown in Tables 3a, 3b, 3c and 3d.

4.2 Mechanical and Thermal Characteristics

The mechanical and thermal characteristics (environmental resistance) assured in detail specification are shown in Table 4.

Table 3a. Electrical Characteristics ($T_A=+25^{\circ}\text{C}$ unless otherwise specified)

Part No.	$V_{(BR)DSS}$ (V)		I_{DSS} (μA)		I_{GSS} (nA)		$V_{GS(th)}$ (V)		$R_{DS(on)}^{(1)}$ (Ω)		$gfs^{(1)}$ (S)	
	$I_D=1\text{mA}$ $V_{GS}=0\text{V}$		$V_{DS}=80\%$ of rated V_{DS} $V_{GS}=0\text{V}$		$V_{GS}=\pm 20\text{V}$ $V_{DS}=0\text{V}$		$I_D=1\text{mA}$ $V_{DS}=V_{GS}$		$I_D=50\%$ of rated I_D $V_{GS}=12\text{V}$		$I_D=50\%$ of rated I_D $V_{DS}=25\text{V}$	
	Min.	Typ.	Max.	Typ.	Max.	Typ.	Min.-Max.	Typ.	Max.	Typ.	Min.	Typ.
JAXA R 2SK4185	500	550	25	280n	± 100	+5 -3	2.5-4.5	3.5	0.18	0.16	7	10.5
JAXA R 2SK4186				35n		+1 -5			0.48	0.42	4	6
JAXA R 2SK4187				30n		+1 -1			1.15	1.00	2.5	3.75
JAXA R 2SK4188				280n		+5 -3			0.18	0.16	7	10.5
JAXA R 2SK4189				35n		+1 -5			0.48	0.42	4	6
JAXA R 2SK4190				30n		+1 -1			1.15	1.00	2.5	3.75

Note⁽¹⁾ Pulse test: Pulse width $\leq 1\text{ms}$, Duty cycle $\leq 2\%$ **Table 3b. Electrical Characteristics ($T_A=+25^{\circ}\text{C}$ unless otherwise specified)**

Part No.	Electrical Characteristics						At $T_a = 25^\circ\text{C}$ unless otherwise specified							
	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 , $V_{GS}=12\text{V}$						$V_{DD}=50\%$ of rated V_{DS} , I_D = rated I_D , $V_{GS}=12\text{V}$, $R_G=10\Omega$							
	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ
JAXA R 2SK4185	85	56	85	56	300	200	85	55	30	20	190	130	30	20
JAXA R 2SK4186	35	23	35	23	120	80	60	40	15	10	90	60	15	10
JAXA R 2SK4187	14	9	14	9	48	32	55	35	10	8	70	45	10	8
JAXA R 2SK4188	85	56	85	56	300	200	85	55	30	20	190	130	30	20
JAXA R 2SK4189	35	23	35	23	120	80	60	40	15	10	90	60	15	10
JAXA R 2SK4190	14	9	14	9	48	32	55	35	10	8	70	45	10	8

Table 3c. Electrical Characteristics (T_A=+25°C unless otherwise specified)

Electrical Characteristics (TA = 25°C unless otherwise specified)						
Part No.	C _{iss} (pF)		C _{oss} (pF)		C _{rss} (pF)	
	V _{DS} =75V, V _{GS} =0V f=1MHz					
	Max	Typ	Max	Typ	Max	Typ
JAXA R 2SK4185	7800	5200	780	520	30	20
JAXA R 2SK4186	3450	2300	360	240	15	10
JAXA R 2SK4187	1500	1000	165	110	9	6
JAXA R 2SK4188	7800	5200	780	520	30	20
JAXA R 2SK4189	3450	2300	360	240	15	10
JAXA R 2SK4190	1500	1000	165	110	9	6

Table 3d. Electrical Characteristics (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.	Typ.
2SK4185	1.6	1.2	950	23
2SK4186			900	19
2SK4187			800	11
2SK4188			950	23
2SK4189			900	19
2SK4190			800	11

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

Table 4. Mechanical and Thermal Characteristics

Test Items		Limits and Conditions		
Temperature	Temperature Cycling	-55 to 150°C, 500cycles		
	Thermal Shock	0 to 100°C, 25cycles		
	Resistance to Soldering heat	TO-254: 250°C, 10s SMD: 240°C, 10s		
Moisture Resistance		80 to 98%, 25 to 65°C, 10cycles		
Salt Atmosphere		35°C, 24hr, Rate of salt deposit=10 to 50g/m ² /24hr		
Mechanical Environment	Vibration	196m/s ² (20G), 100 to 2000Hz, 4minutes X-Y-Z each orientation, 4 times		
	Shock	14700m/s ² (1500G), 0.5ms X ₁ -Y ₁ -Z ₁ each orientation, 5 times		
	Constant Acceleration	98100 m/s ² (10000G) X ₁ -Y ₁ -Z ₁ each orientation, 1 time		
	Terminal Strength	TO-254: 1.5kgf, Z ₁ orientation, 30s		
Electrostatic Discharge (ESD)		JAXA R 2SK4185 JAXA R 2SK4188	JAXA R 2SK4186 JAXA R 2SK4189	JAXA R 2SK4187 JAXA R 2SK4190
		C=100pF, R=1.5kΩ		
		V _{GS} =±2750V	V _{GS} =±1000V	V _{GS} =±500V

5. CHARACTERISTIC CURVES IN VARIOUS OPERATING CONDITIONS

Characteristic curves are shown in Figures 9 through 26:

Figs. 9 - 11 : Characteristic Curves of JAXA R 2SK4185

Figs. 12-14 : Characteristic Curves of JAXA R 2SK4186

Figs. 15-17 : Characteristic Curves of JAXA R 2SK4187

Figs. 18-20 : Characteristic Curves of JAXA R 2SK4188

Figs. 21-23 : Characteristic Curves of JAXA R 2SK4189

Figs. 24-26 : Characteristic Curves of JAXA R 2SK4190

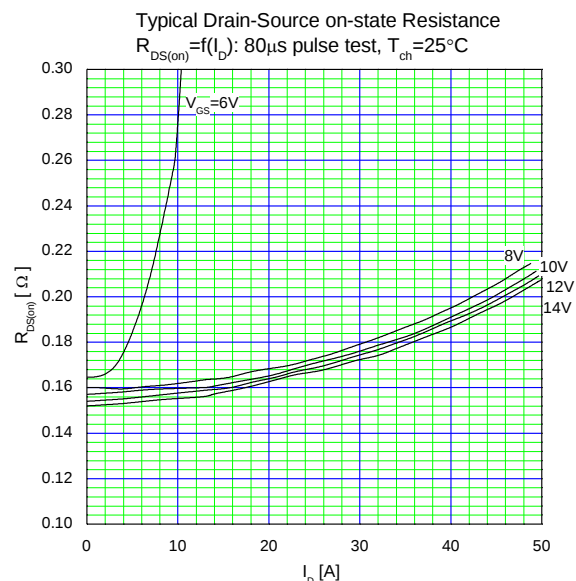
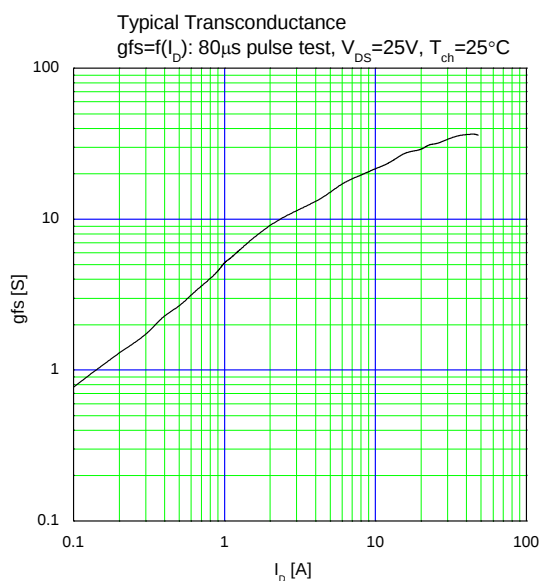
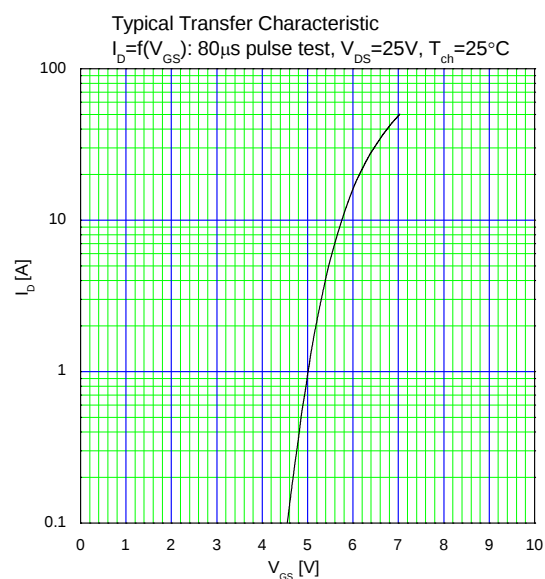
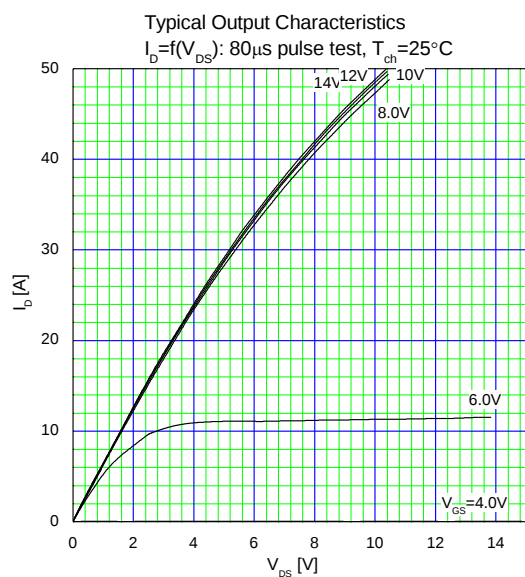
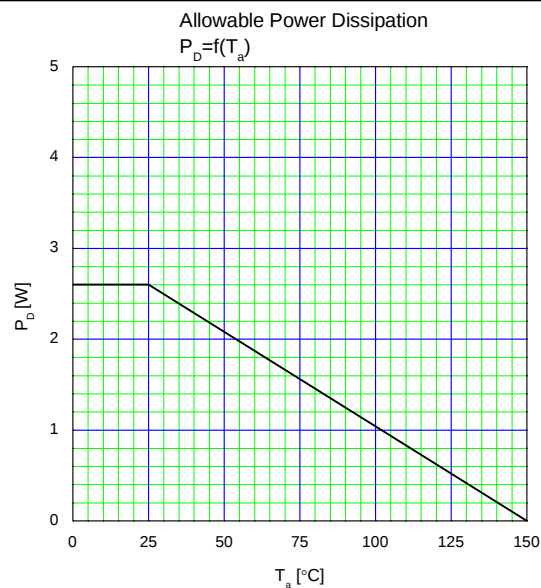
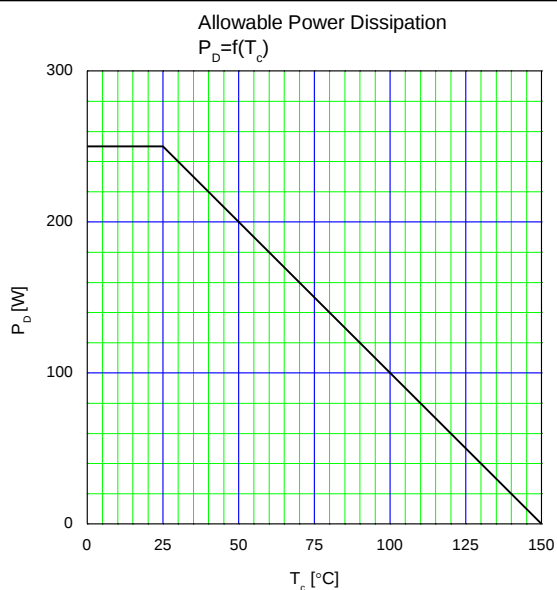


Figure 9. Characteristic Curves of JAXA R 2SK4185 (1/3)

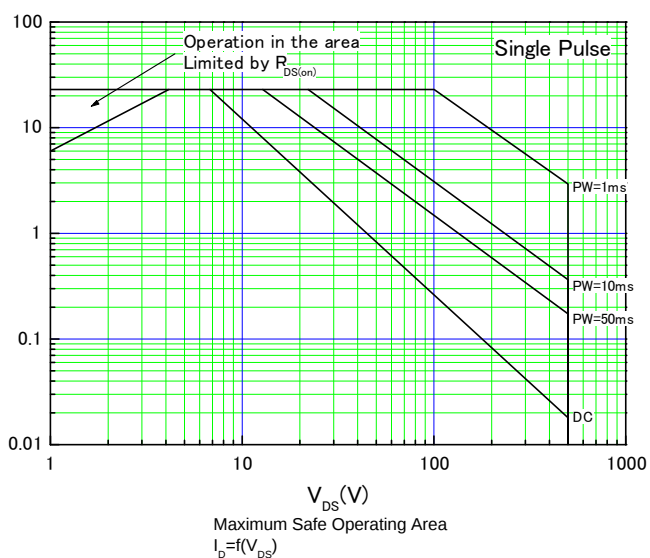
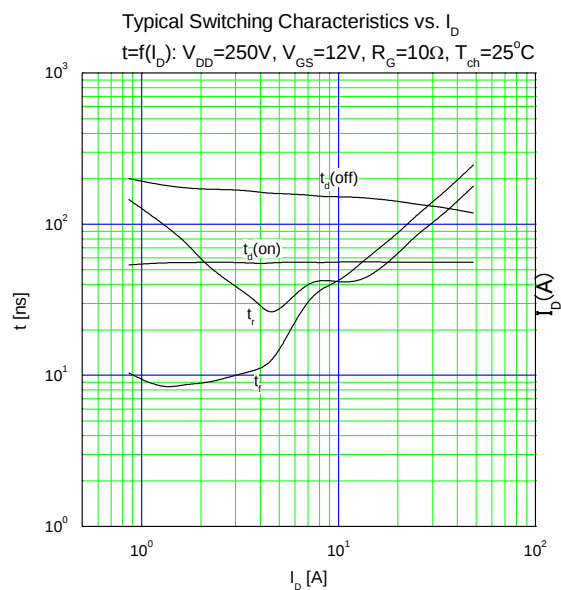
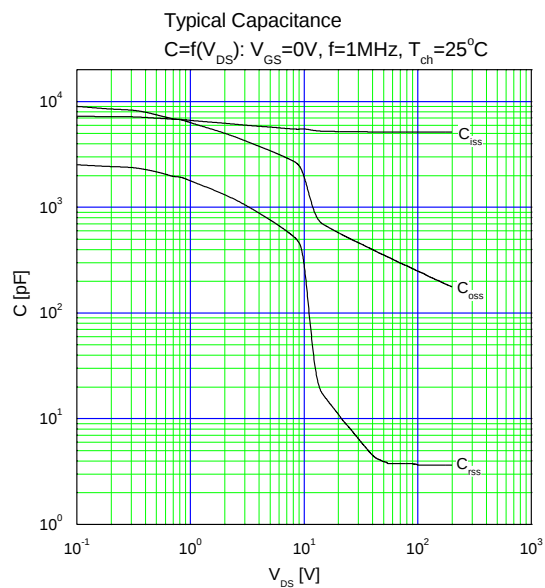
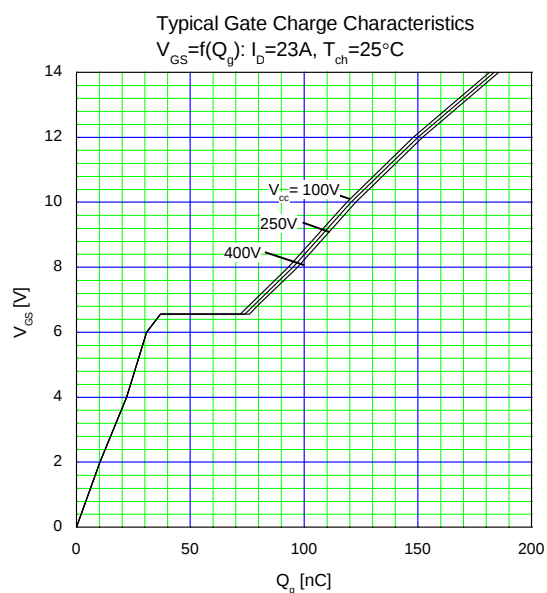
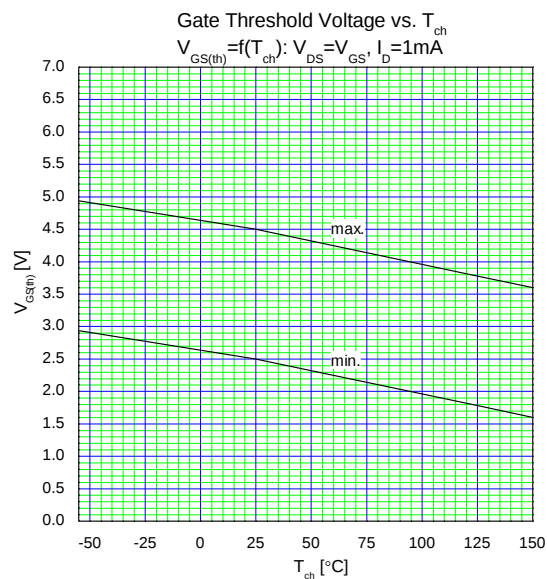
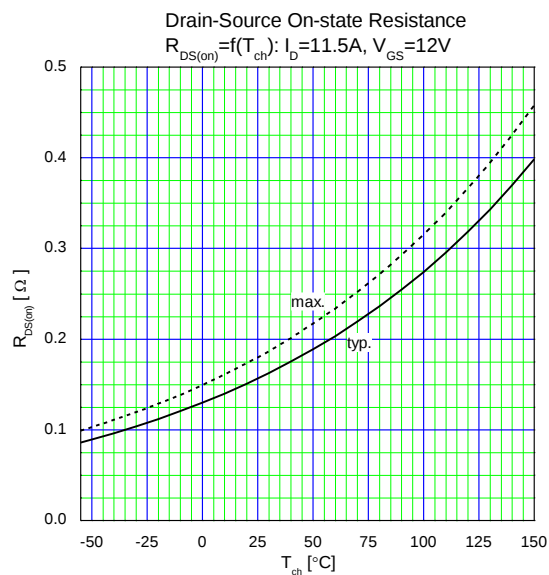


Figure 10. Characteristic Curves of JAXA R 2SK4185 (2/3)

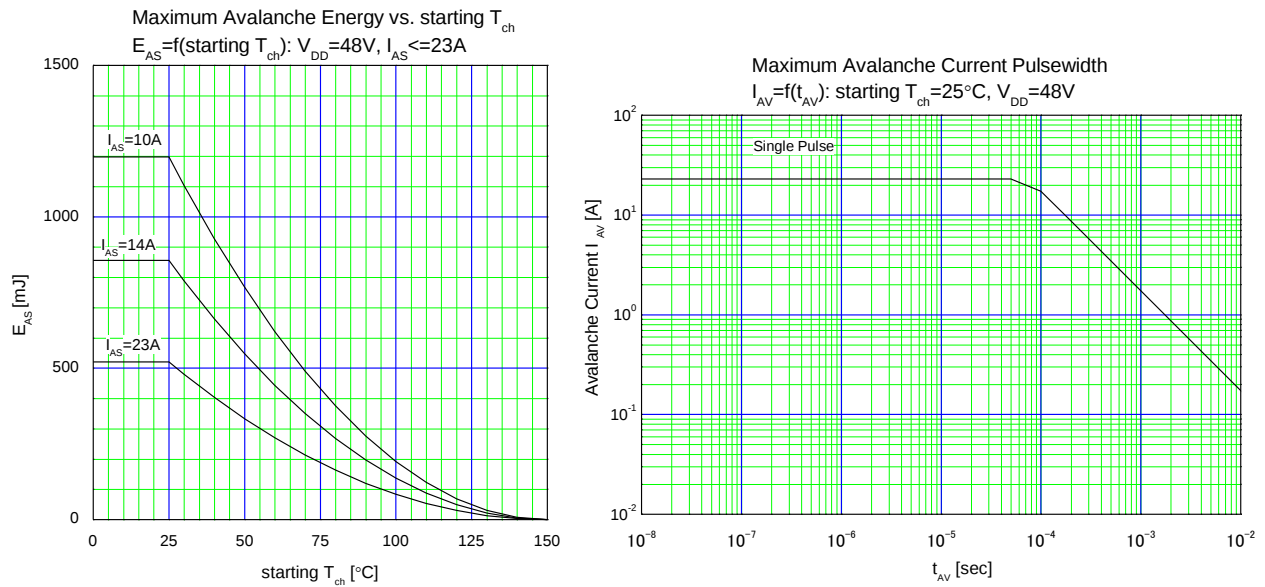


Figure 11. Characteristic Curves of JAXA R 2SK4185 (3/3)

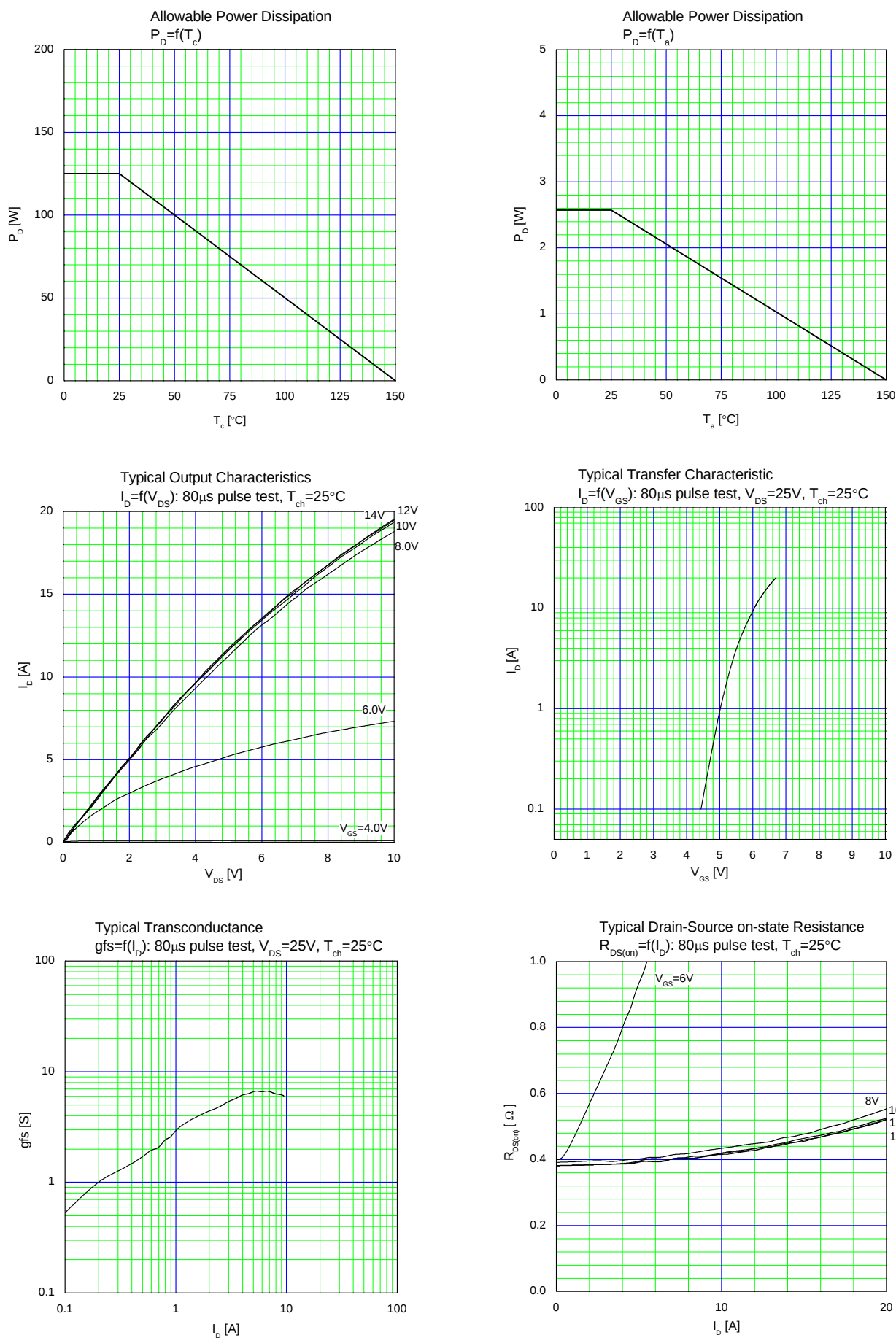


Figure 12. Characteristic Curves of JAXA R 2SK4186 (1/3)

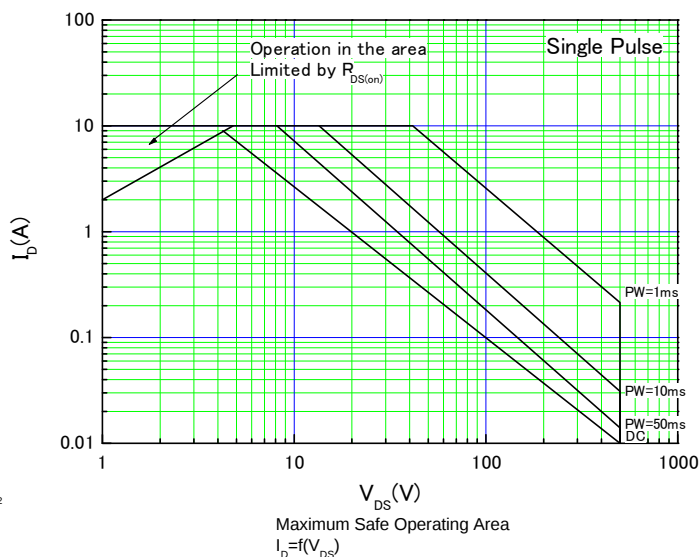
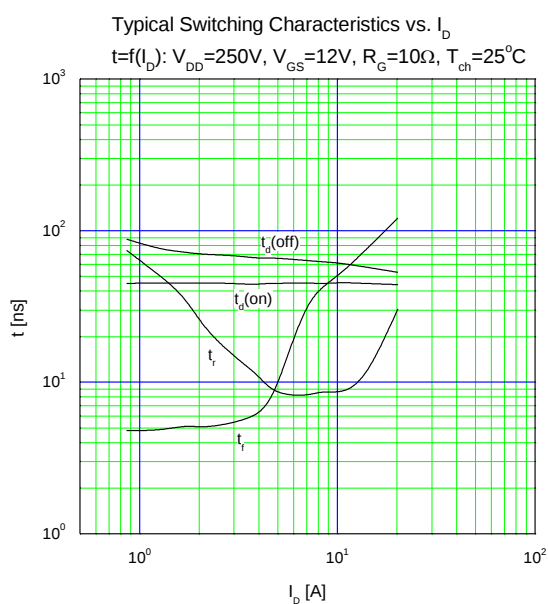
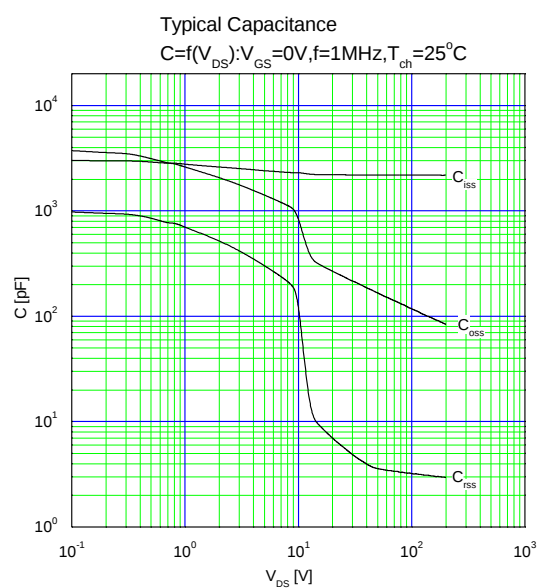
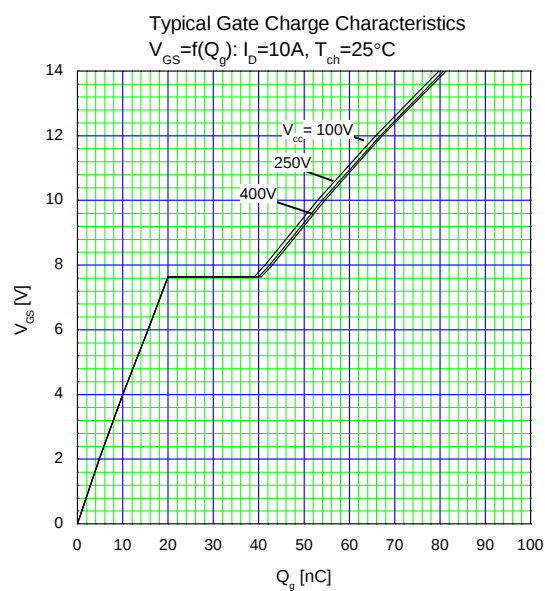
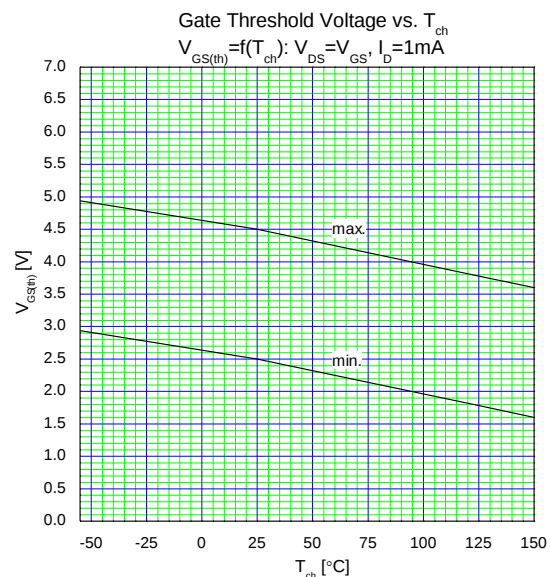
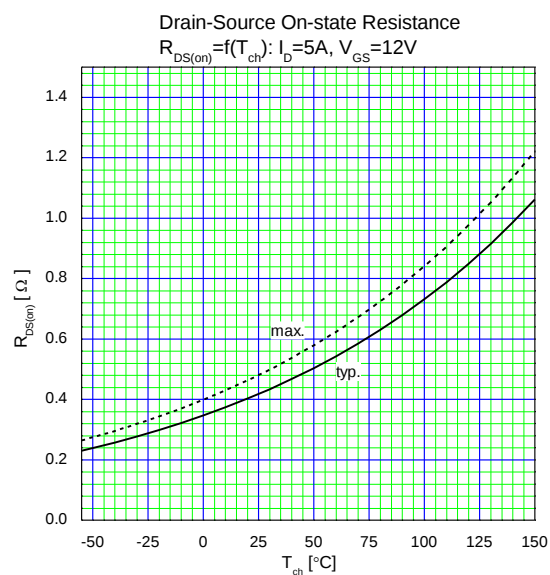


Figure 13. Characteristic Curves of JAXA R 2SK4186 (2/3)

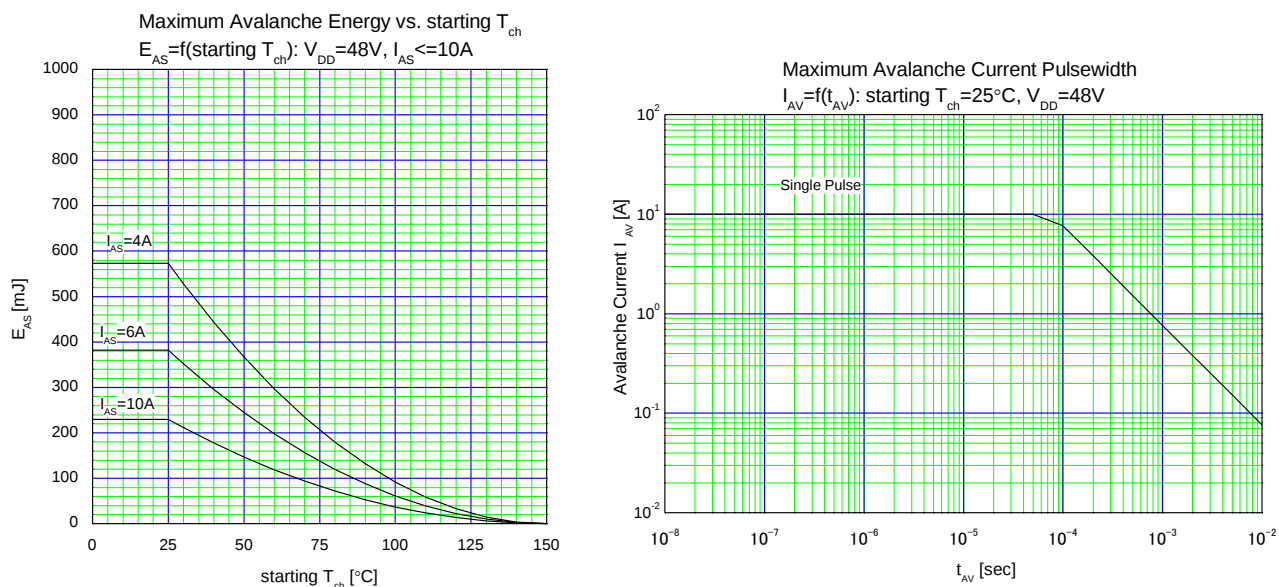


Figure 14. Characteristic Curves of JAXA R 2SK4186 (3/3)

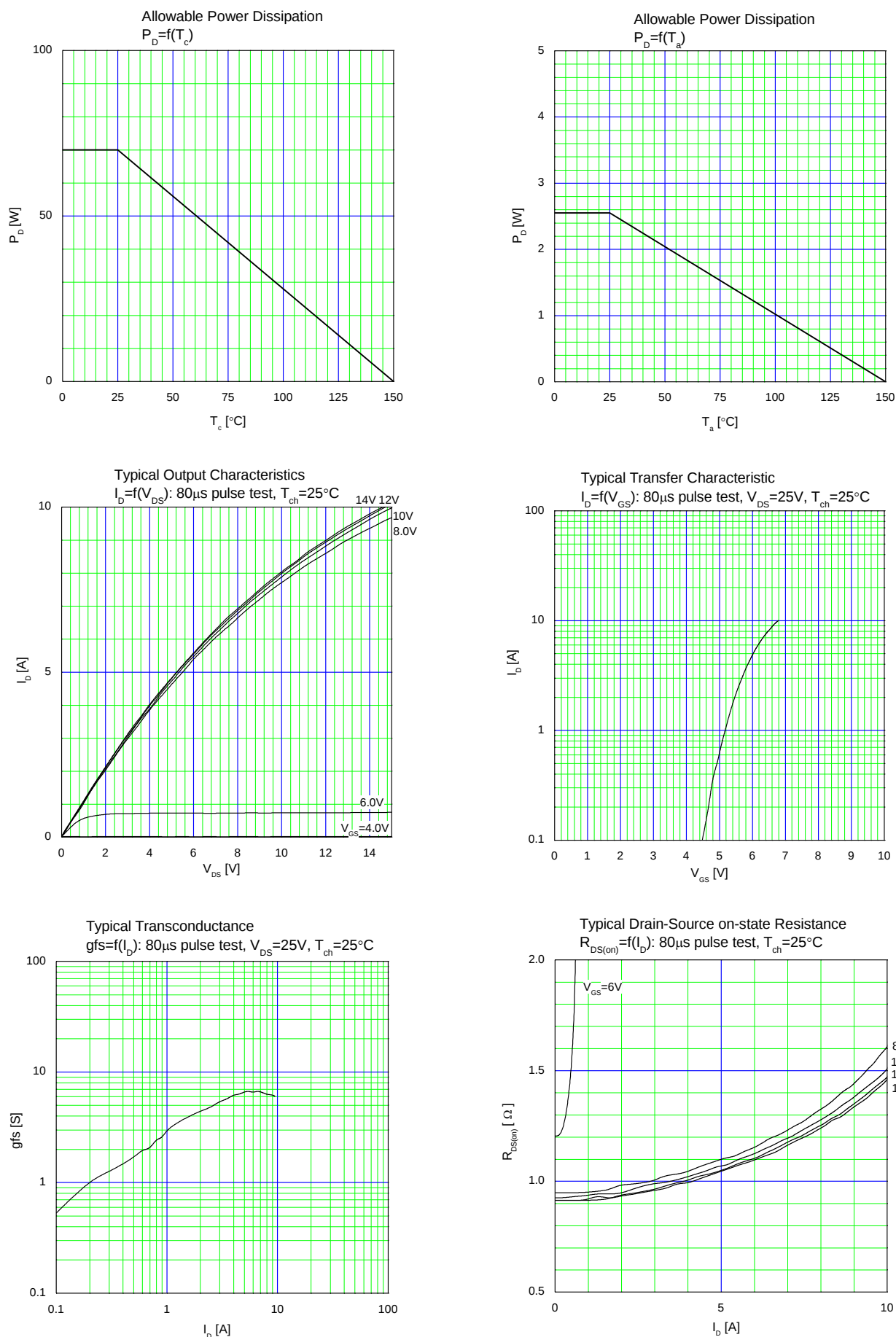


Figure 15. Characteristic Curves of JAXA R 2SK4187 (1/3)

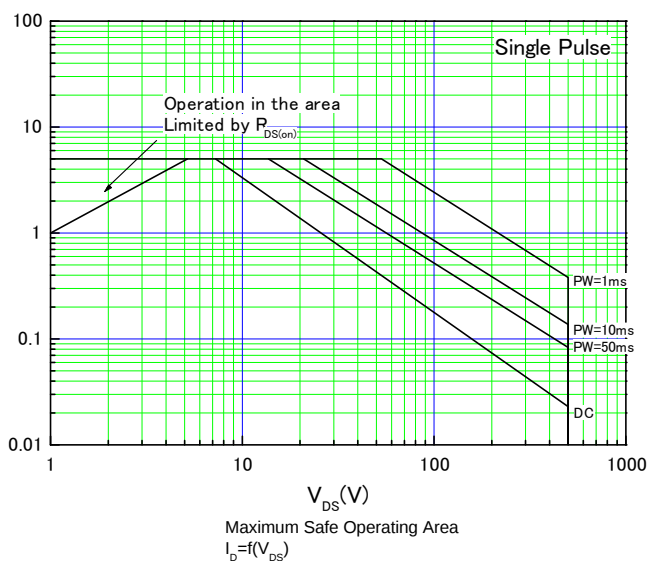
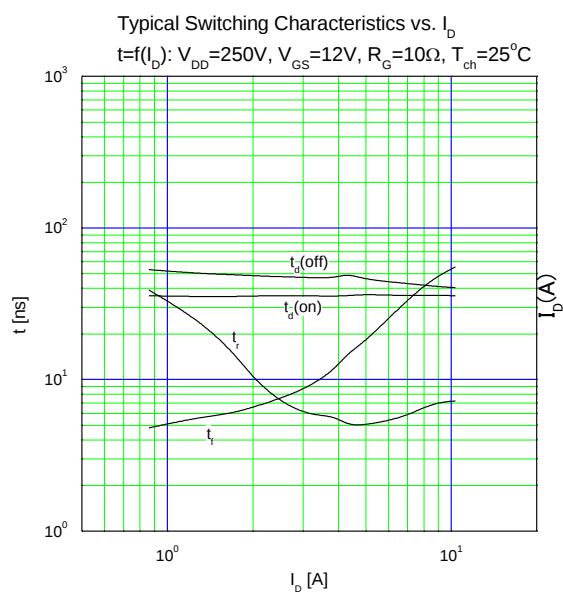
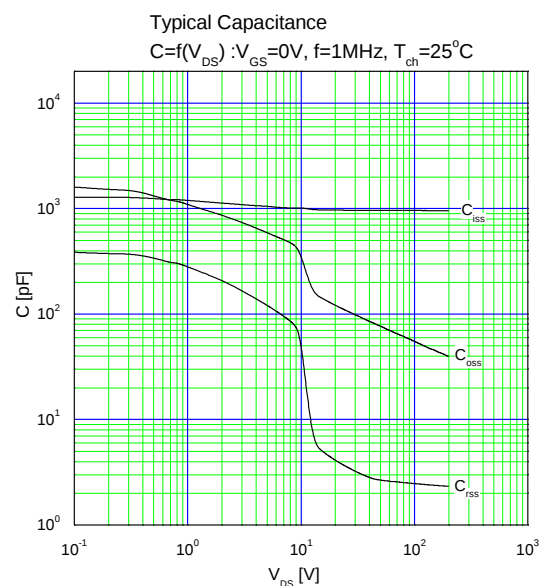
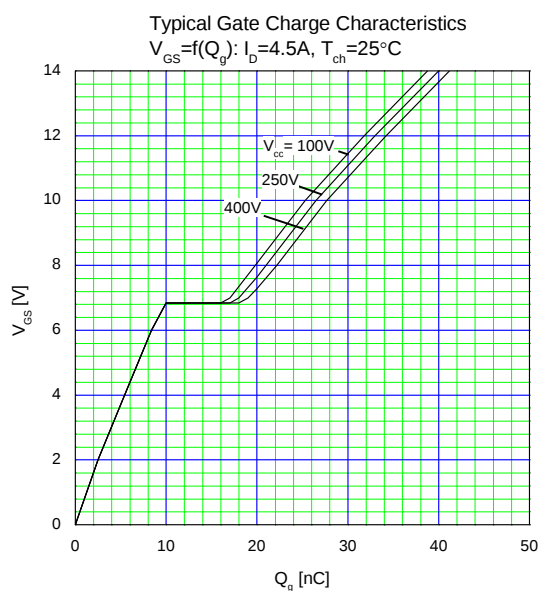
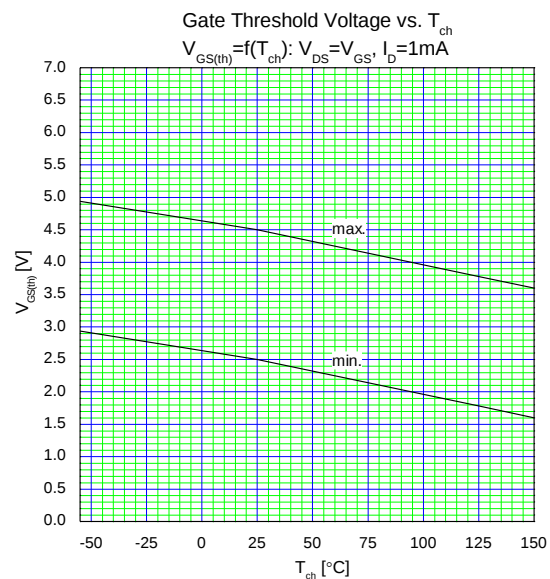
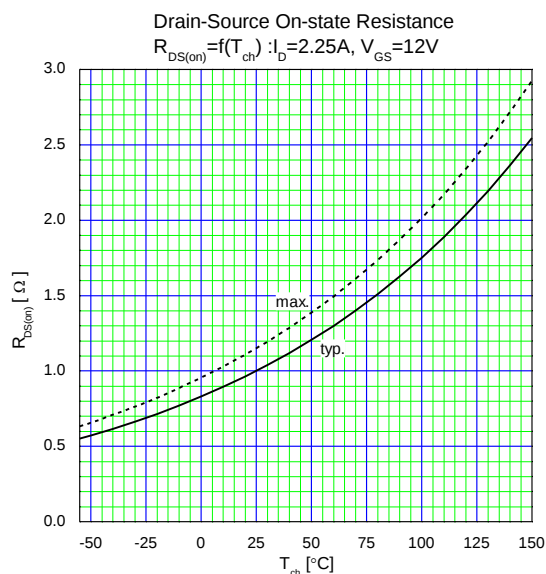


Figure 16. Characteristic Curves of JAXA R 2SK4187 (2/3)

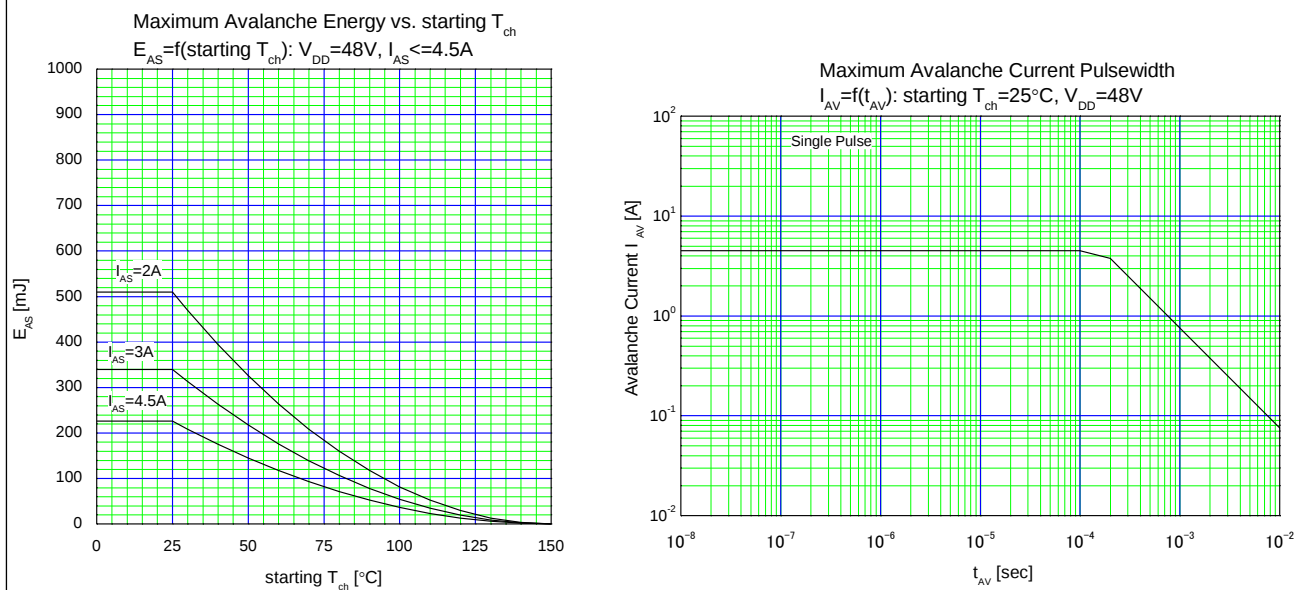


Figure 17. Characteristic Curves of JAXA R 2SK4187 (3/3)

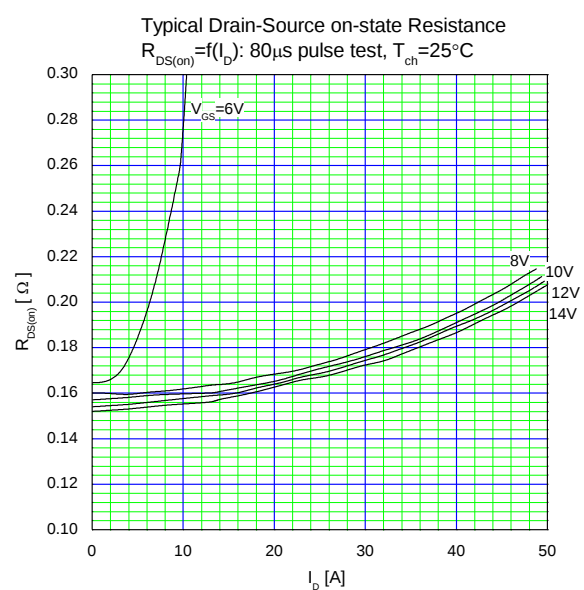
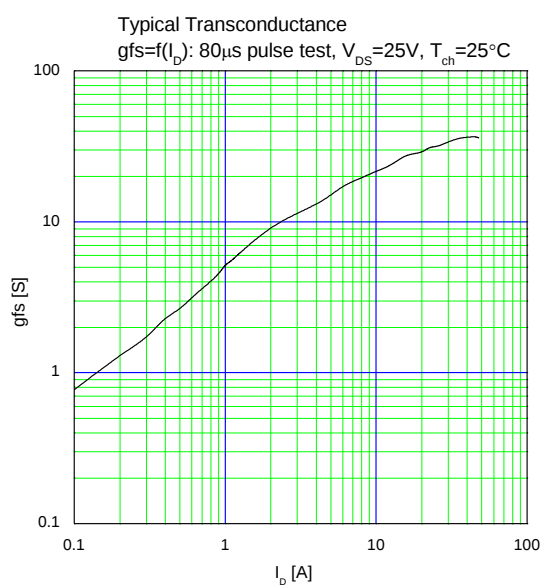
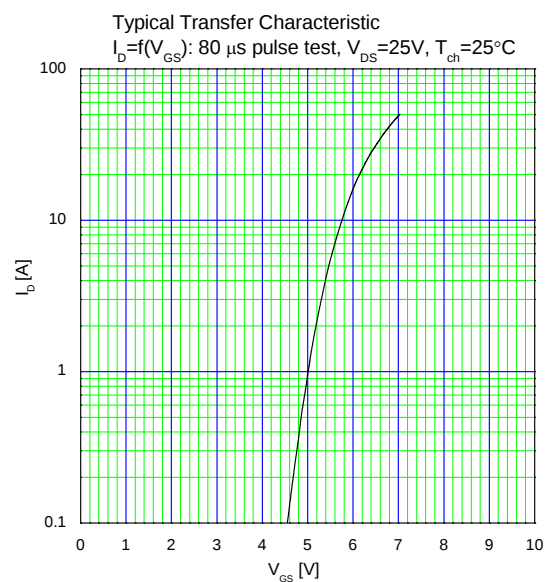
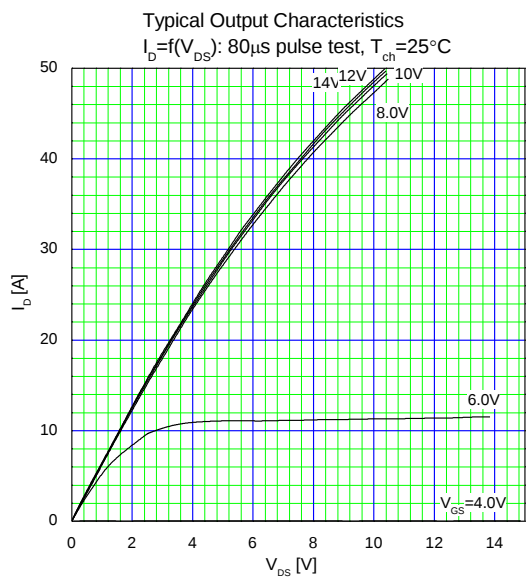
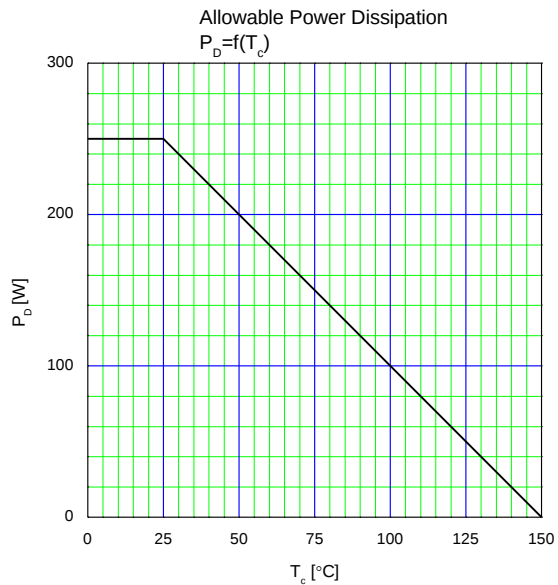


Figure 18. Characteristic Curves of JAXA R 2SK4188 (1/3)

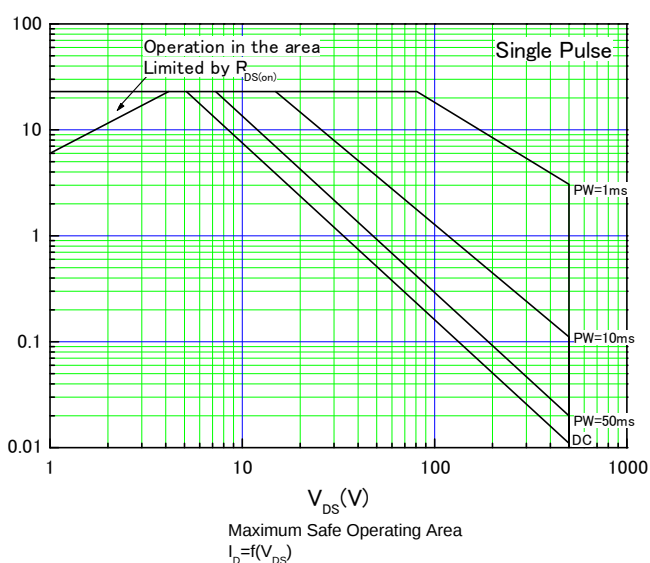
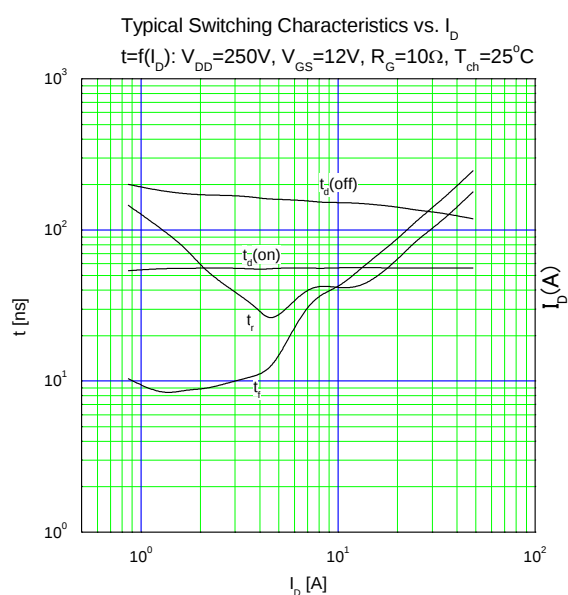
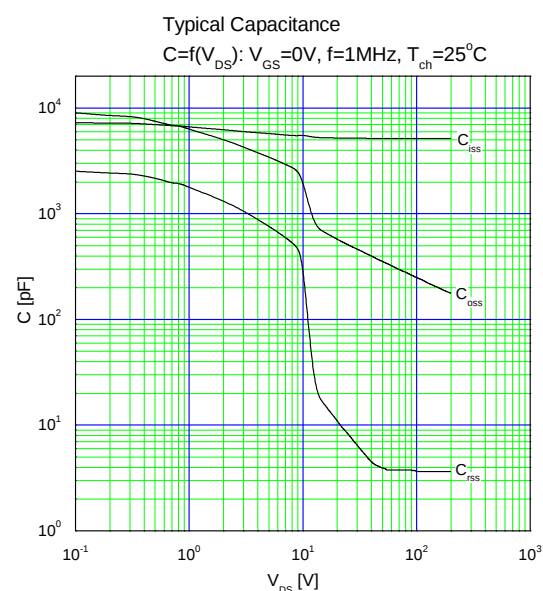
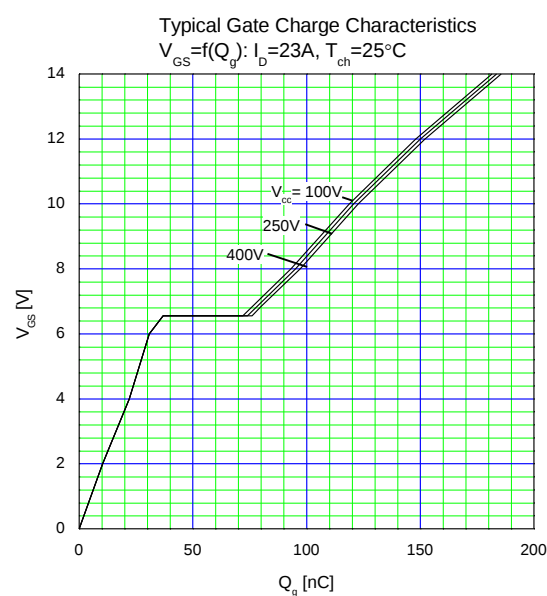
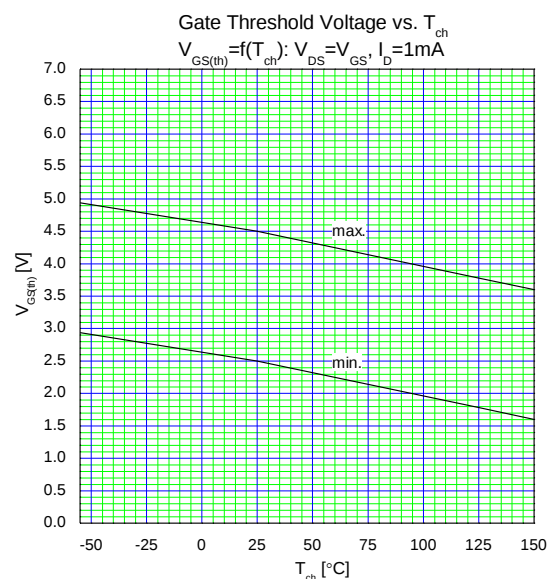
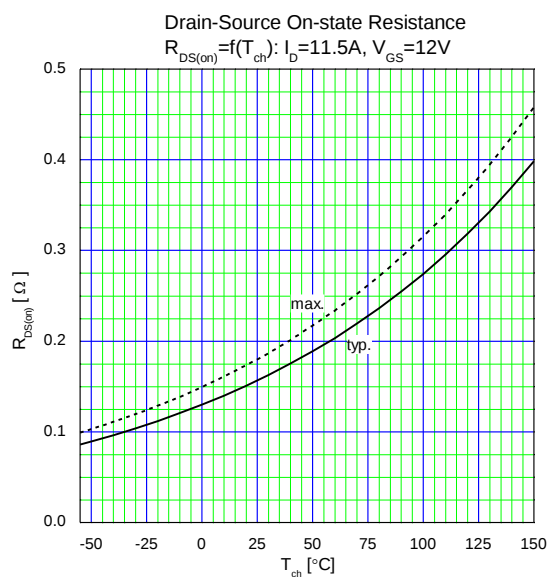


Figure 19. Characteristic Curves of JAXA R 2SK4188 (2/3)

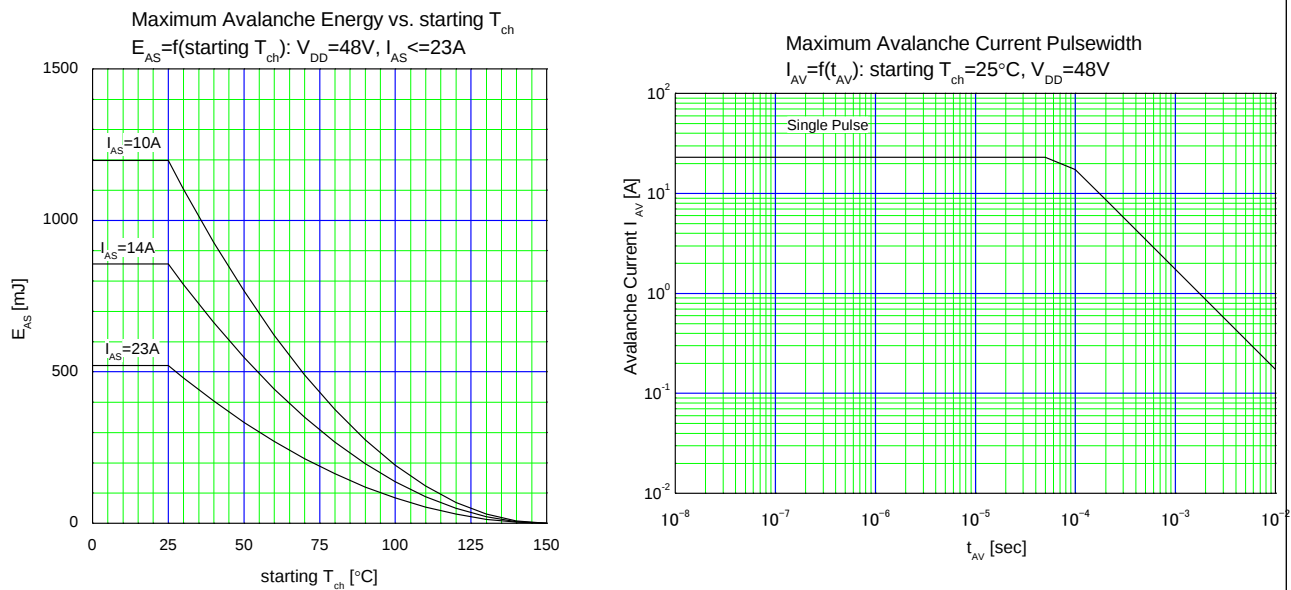


Figure 20. Characteristic Curves of JAXA R 2SK4188 (3/3)

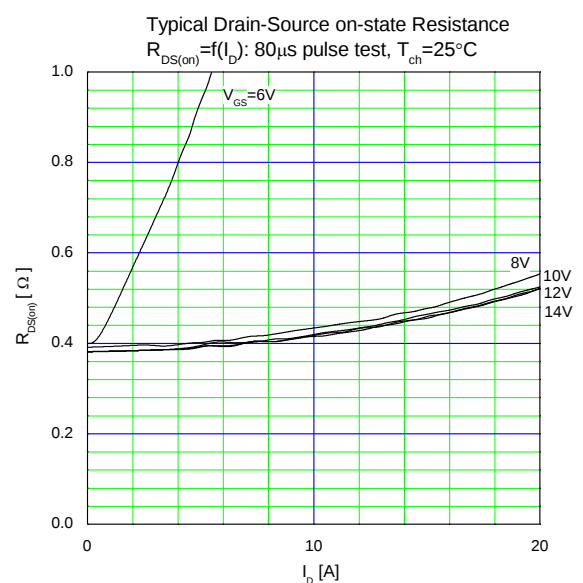
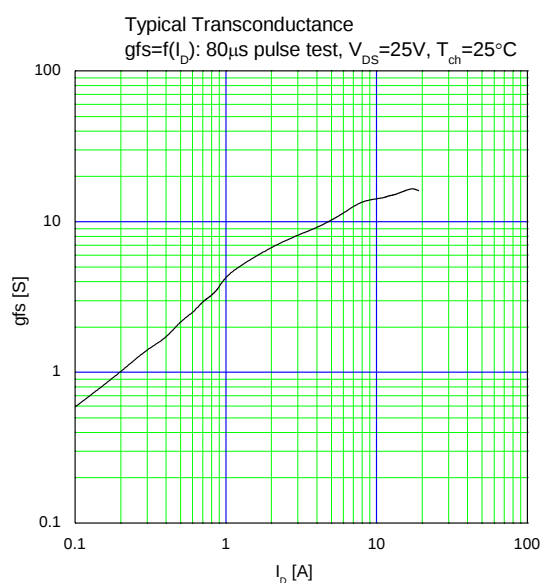
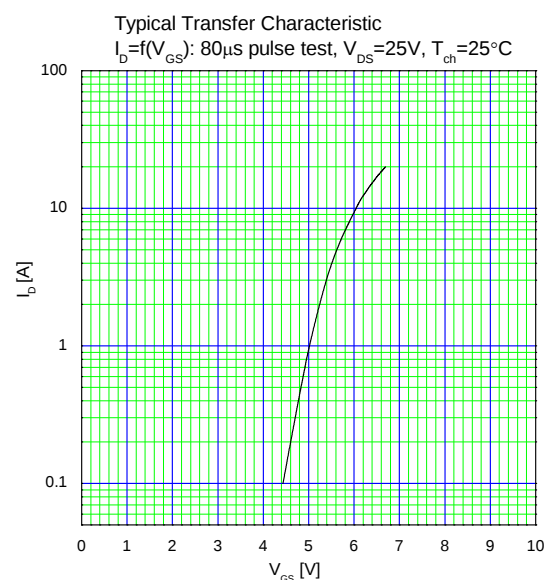
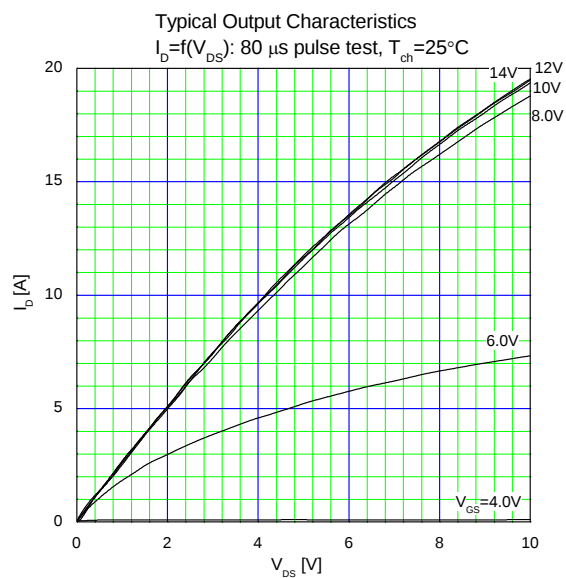
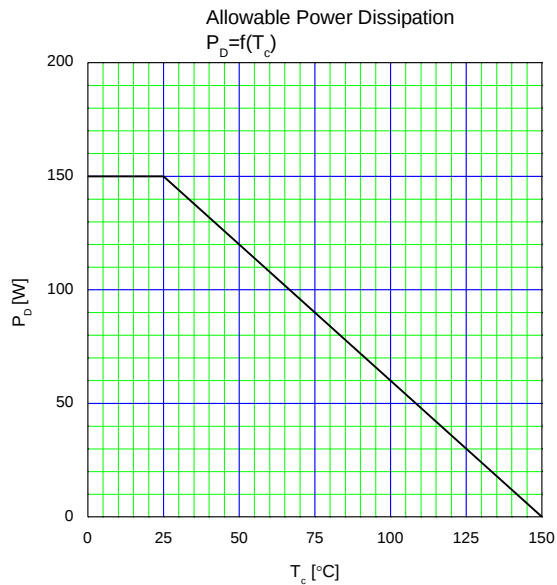


Figure 21. Characteristic Curves of JAXA R 2SK4189 (1/3)

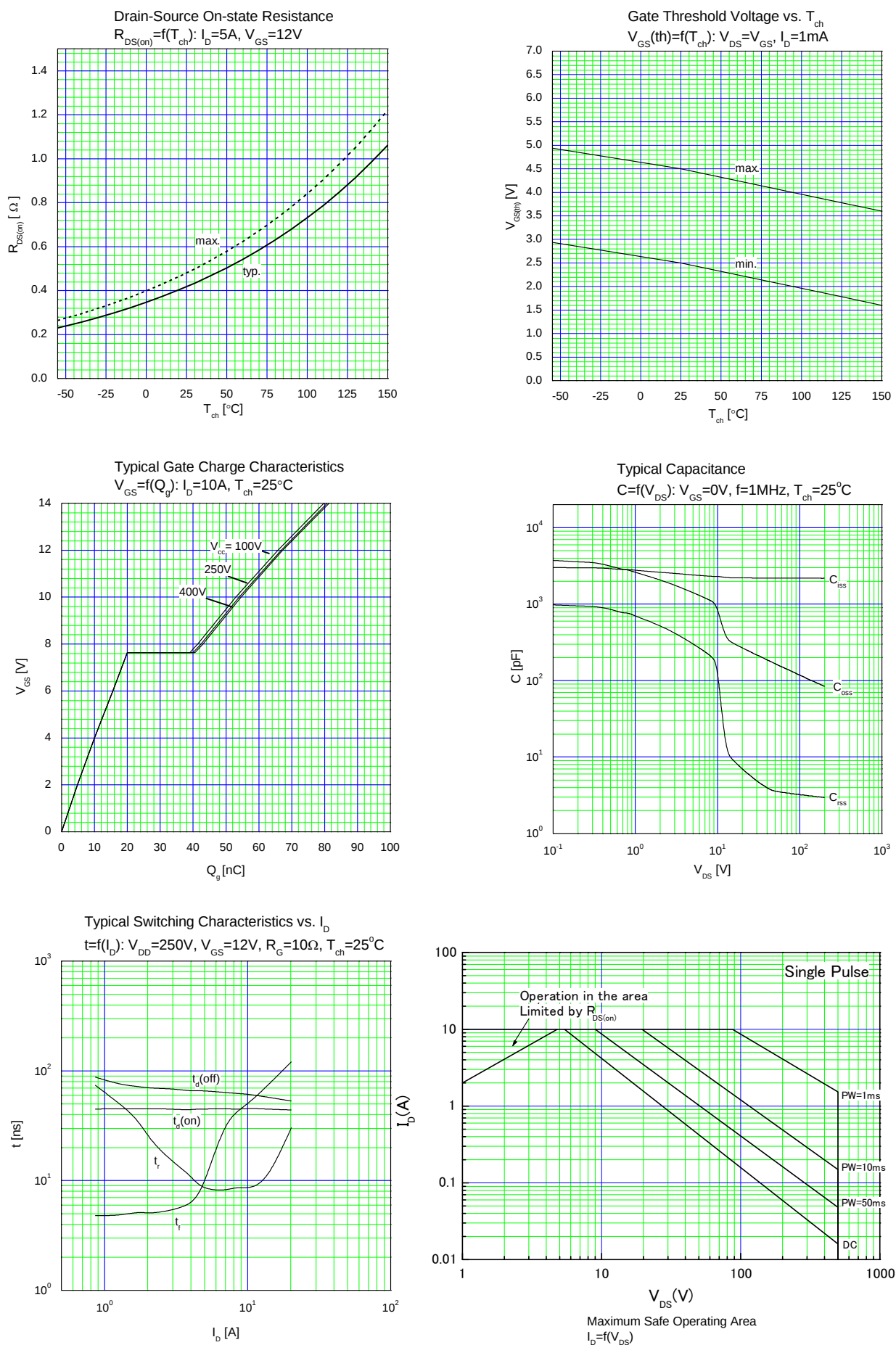


Figure 22. Characteristic Curves of JAXA R 2SK4189 (2/3)

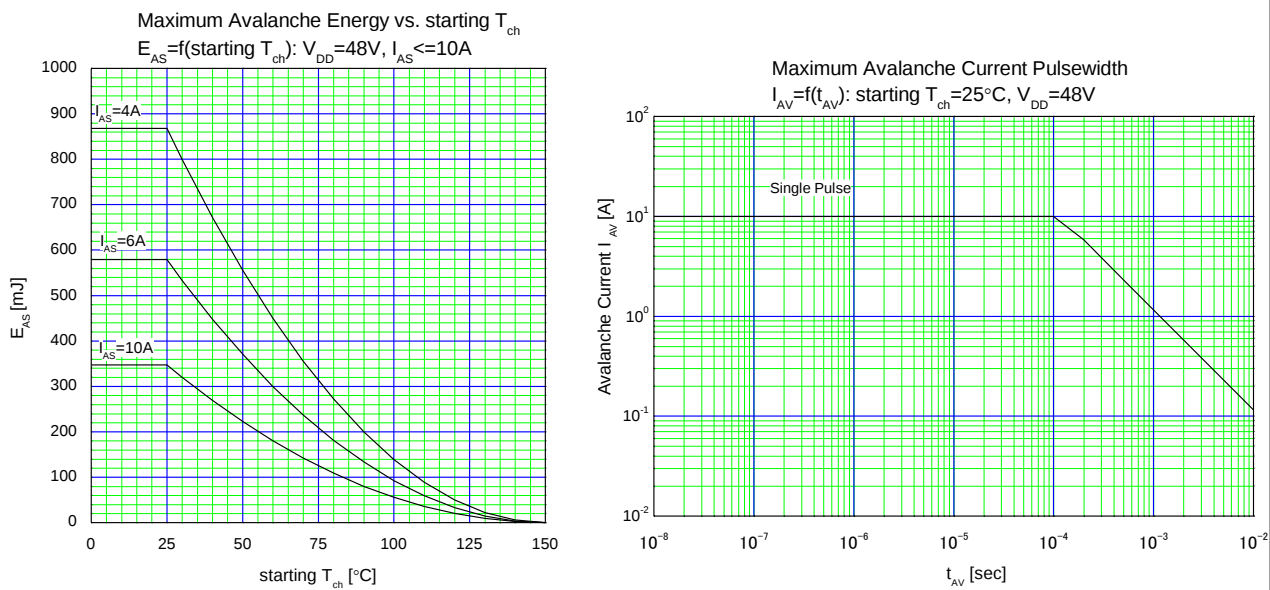


Figure 23. Characteristic Curves of JAXA R 2SK4189 (3/3)

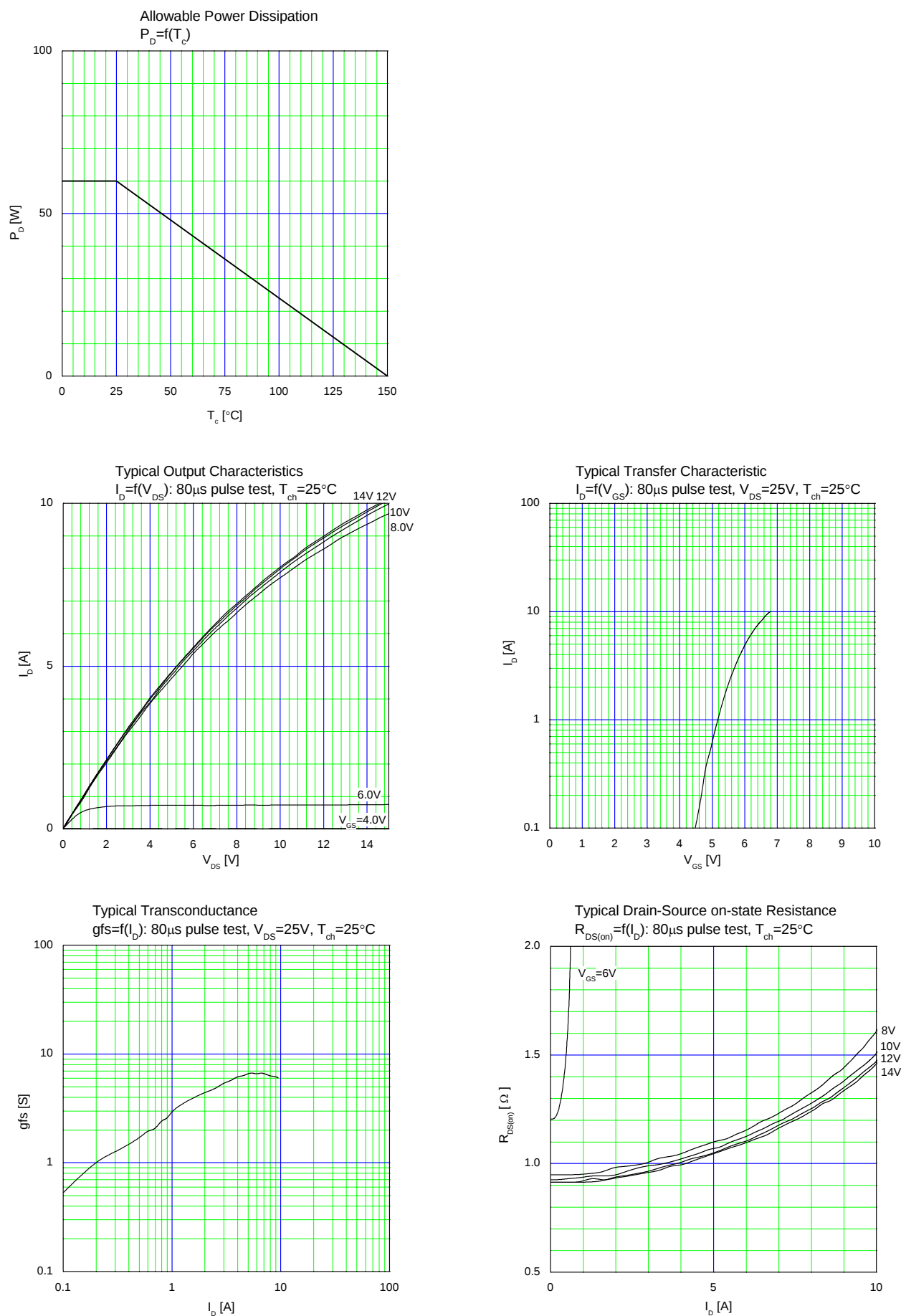


Figure 24. Characteristic Curves of JAXA R 2SK4190 (1/3)

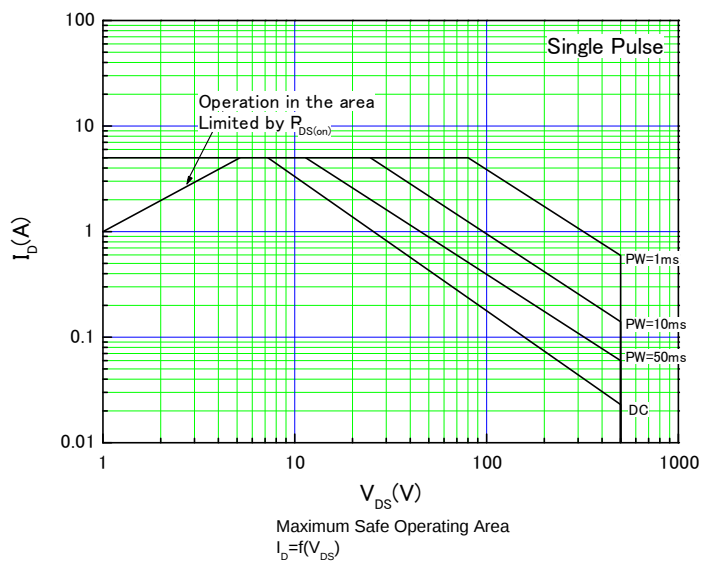
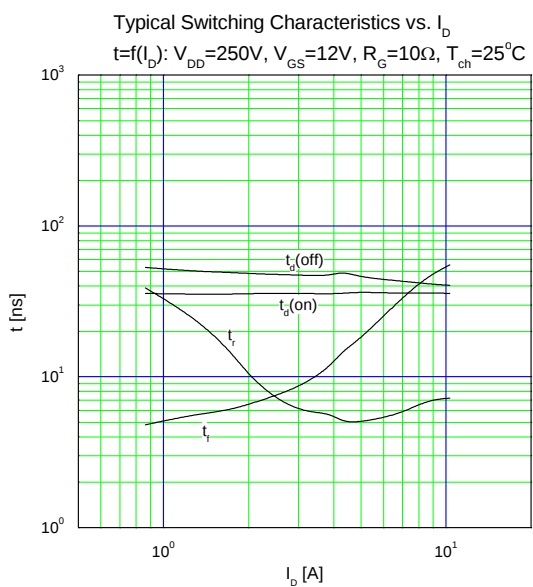
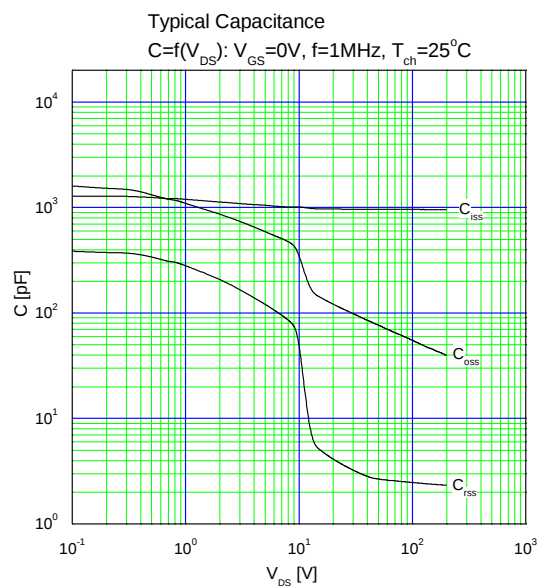
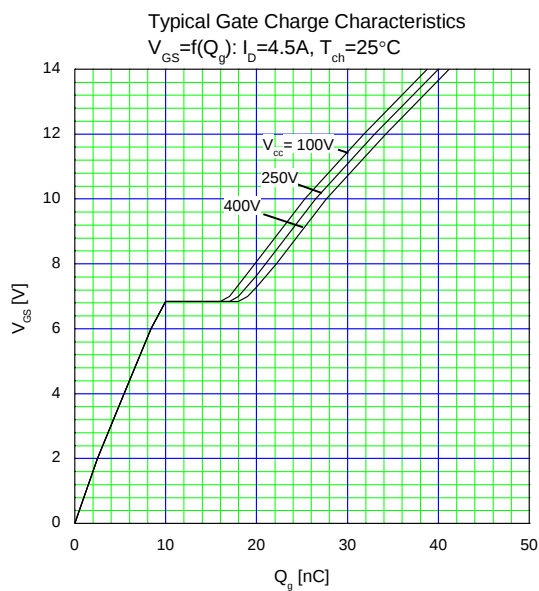
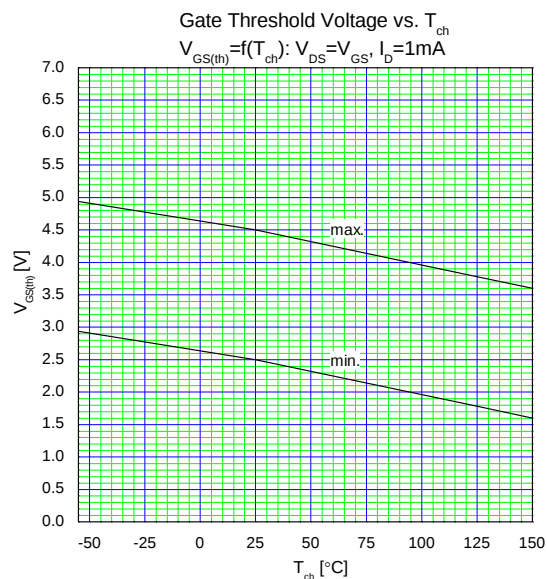
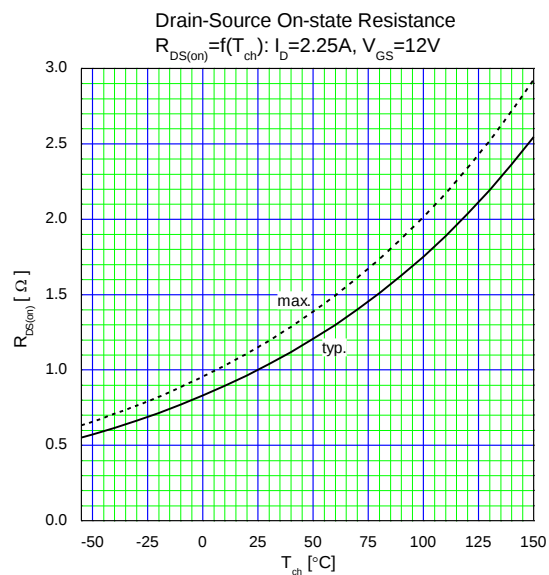


Figure 25. Characteristic Curves of JAXA R 2SK4190 (2/3)

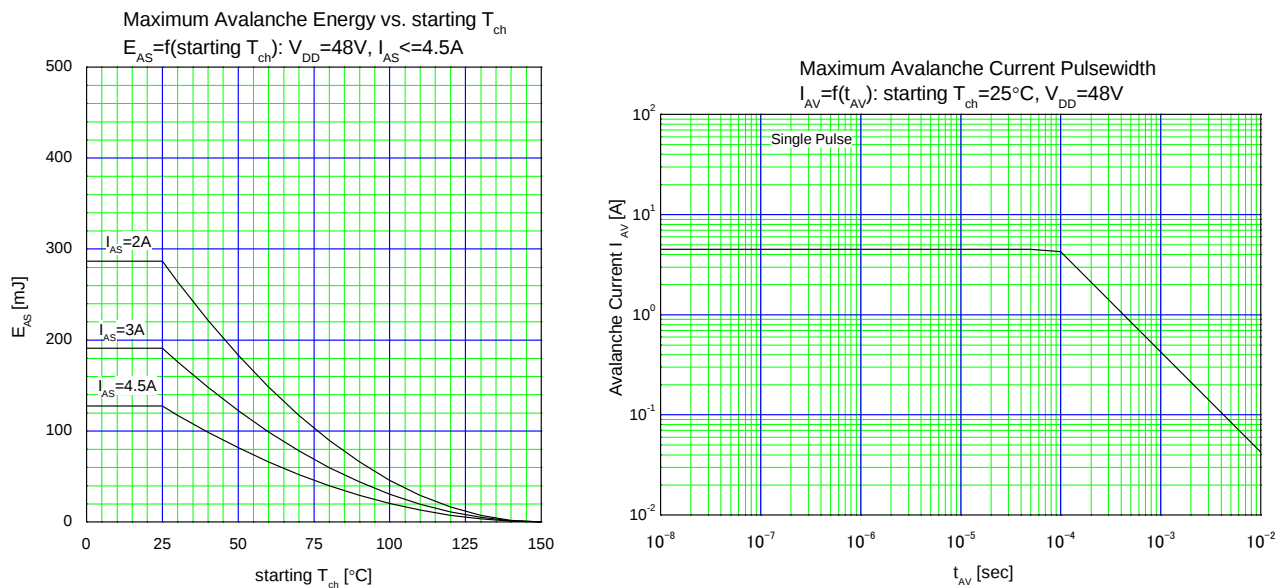


Figure 26. Characteristic Curves of JAXA R 2SK4190 (3/3)

6. ENVIRONMENTAL LIMITS

The environmental test results are shown in Tables 5 through 10.

6.1 Mechanical Vibration

Table 5. Mechanical Vibration Test Result

Test Items	Test Conditions	Failure/Samples
Vibration, Variable Frequency	20G (peak) or Maximum vibration amplitude 1.52mm, whichever is smaller, 100 to 2000Hz, Total sweep time: 4 minutes X, Y, Z each orientation: 4 times	0/22 pieces (TO-254) JAXA R 2SK4185 /22pcs 0/66 pieces (SMD) JAXA R 2SK4152 ⁽¹⁾ /22pcs JAXA R 2SK4153 ⁽¹⁾ /22pcs JAXA R 2SK4154 ⁽¹⁾ /22pcs

6.2 Mechanical Shock

Table 6. Mechanical Shock Test Result

Test Items	Test Conditions	Failure/Samples
Shock	1500G (14700m/s ²): Pulse width 0.5msec X ₁ , Y ₁ , Y ₂ , Z ₁ each orientation : 5 times	0/22 pieces (TO-254) JAXA R 2SK4185 /22pcs 0/66 pieces (SMD) JAXA R 2SK4152 ⁽¹⁾ /22pcs JAXA R 2SK4153 ⁽¹⁾ /22pcs JAXA R 2SK4154 ⁽¹⁾ /22pcs

6.3 Constant Acceleration

Table 7. Constant Acceleration Test Result

Test Items	Test Conditions	Failure/Samples
Constant Acceleration	10000G (98100m/s ²): 1 minute X ₁ , Y ₁ , Y ₂ , Z ₁ each orientation	0/22 pieces (TO-254) JAXA R 2SK4185 /22pcs 0/66 pieces (SMD) JAXA R 2SK4152 ⁽¹⁾ /22pcs JAXA R 2SK4153 ⁽¹⁾ /22pcs JAXA R 2SK4154 ⁽¹⁾ /22pcs

6.4 Thermal Shock

Table 8. Thermal Shock Test Result

Test Items	Test Conditions	Failure/Samples
Thermal Shock	-55°C to 25°C to 150°C (30min) (5min) (30min.) 500cycles	0/45 pieces (TO-254) JAXA R 2SK4185 /45pcs 0/135 pieces (SMD) JAXA R 2SK4158 ⁽¹⁾ /45pcs JAXA R 2SK4159 ⁽¹⁾ /45pcs JAXA R 2SK4160 ⁽¹⁾ /45pcs

Note⁽¹⁾ This test is substituted with the device having same die size and same package passed in this test.

See the detail specification, JAXA-QTS-2030/102.

6.5 Electrostatic Discharge Sensitivity Classification

Table 9. Electrostatic Discharge Sensitivity Classification

Test Items	Test Conditions MIL-STD-750 method 1020		Test result
Electrostatic Discharge	JAXA R 2SK4185 JAXA R 2SK4188	$V_{GS}=\pm 2750V$	Class 2
	JAXA R 2SK4186 JAXA R 2SK4189	$V_{GS}=\pm 1000V$	Class 1
	JAXA R 2SK4187 JAXA R 2SK4190	$V_{GS}=\pm 500V$	Class 1

6.6 Radiation Hardness

Table 10a. Radiation Hardness Test Results

Total Dose Irradiation (TID)	Test Conditions
	Source: Co ⁶⁰ gamma-ray 1 x 10 ³ Gy (42Gy/hr)
	Bias Conditions (During and after irradiation) (a) V _{DS} =0V, V _{GS} =20 V (b) V _{DS} =0V, V _{GS} =-20 V (c) V _{DS} =400V, V _{GS} =0V
	Representative Sample: JAXA R 2SK4189
	Test Results
	For each bias condition: 0/4 pieces (1x10 ³ Gy, JAXA R 2SK4189) BV _{DSS} TID dependence: Fig. 27, V _{GS(th)} TID dependence : Fig. 28

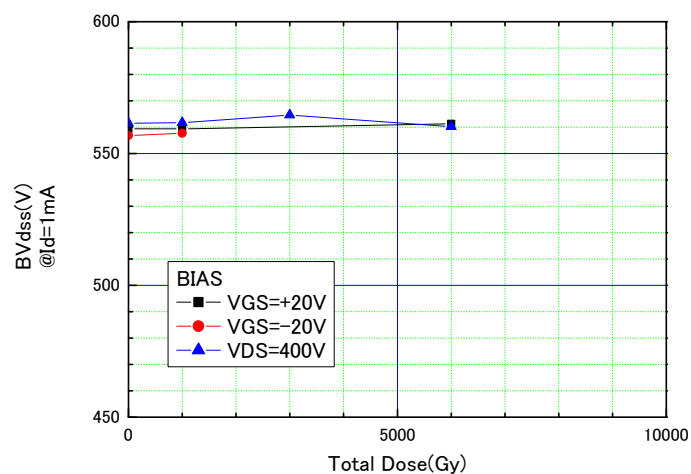
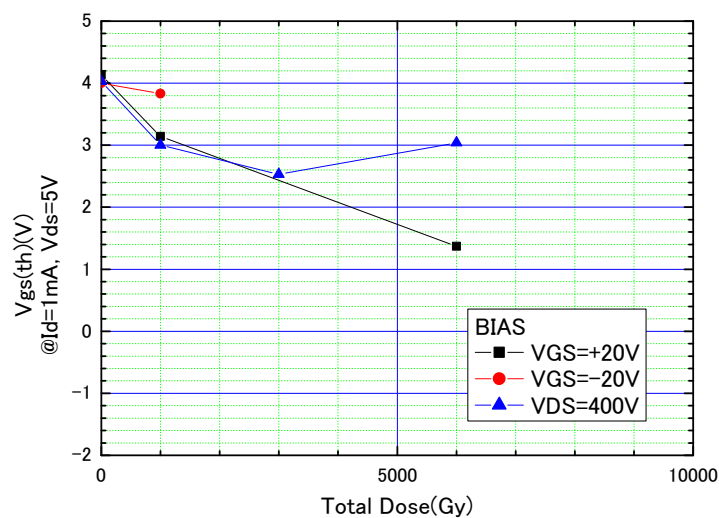
**Figure 27. Total Dose Dependence of BV_{DSS} (JAXA R 2SK4189)****Figure 28. Total Dose Dependence of V_{GS(th)} (JAXA R 2SK4189)**

Table 10b. Radiation Hardness Test Results

Part Number JAXA R	500V Class					
	2SK4185	2SK4186	2SK4187	2SK4188	2SK4189	2SK4190
Single Event Tolerance (SEB/SEGR) Single Event Burnout/ Single Event Gate Rupture	Test Conditions					
	Ion: ^{89}Y , Energy: 928 MeV LET: 40.5 MeV (mg/cm ²) ⁽¹⁾ Range: 102 μm , $T_A=25\pm 5^\circ\text{C}$ Fluence: $3\text{E}5\pm 5\%$ ions/cm ² Irradiation angle: Perpendicular to die surface Limits: $I_{\text{GSS}}\leq 10\mu\text{A}$ and it shall not be destroyed.					
	Test Results					
	$V_{\text{DS}}=500\text{V}$ and $V_{\text{GS}}=-7.5\text{V}$ 0/3 pieces (SEE-SOA: Fig. 29)					

Note⁽¹⁾: Average LET in the device.

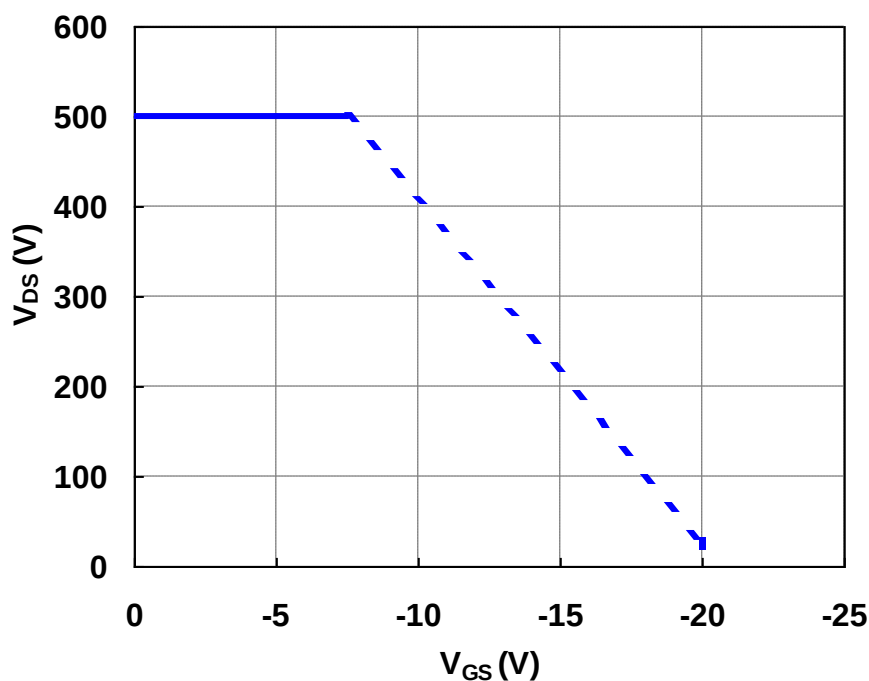


Figure 29. SEE-SOA (For All Part Number)

Note: The dotted line in this figure is estimated from the results of the radiation hardness test by Xe ion.
(Average LET = 67 MeV/(mg/cm²), Range: 90 μm)

7. RELIABILITY

7.1 Accelerated Test Results

The accelerated test results shall be shown in Table 11.

Table 11. Accelerated Test Results

Test Items	Test Conditions	Failure/Samples
Steady-state operating life test (High Temperature, voltage applied for gate to source)	Method 1042 of MIL-STD-750, Condition A $T_A=150^{\circ}\text{C}$, 1000hr $V_{GS}=16\text{V}$	0/135 pieces (JAXA R 2SK4185 /45 pcs JAXA R 2SK4188 /45 pcs JAXA R 2SK4190 /45 pcs)
Steady-state operating life test (High Temperature, voltage applied for drain to source)	Method 1042 of MIL-STD-750, Condition B $T_A=150^{\circ}\text{C}$, 1000hr $V_{DS}=400\text{V}$	0/90 pieces (JAXA R 2SK4185 /45 pcs JAXA R 2SK4190 /45 pcs)
Thermal shock test (Temperature Cycling)	-55 to 150°C , 500cycles	0/45 pieces JAXA R 2SK4185 /45 pcs
Intermittent operating life test (Power Cycling)	$\Delta T_C=70\text{deg}$, 6000cycles	0/88 pieces (JAXA R 2SK4185 /22 pcs JAXA R 2SK4188 /22 pcs JAXA R 2SK4189 /22 pcs JAXA R 2SK4190 /22 pcs)

7.2 Possible Failure Mode

Table 12. Possible Failure Mode

Failure mode	Rate (%)
Short	70
Increase of Leakage Current	20
Increase of Thermal Impedance	3
Degradation of $V_{GS(th)}$	3
Open	3
Others	1

8. STORAGE

- (1) The devices are necessary to be stored under the appropriate temperature and humidity ranges. The recommended ambient temperature range is 10 to 30°C. The recommended relative humidity range is 40 to 60%.
- (2) The devices shall be stored in an environment free of corrosive gases and minimum dusts.
- (3) Countermeasures such as conductive bags and aluminum films shall be utilized to avoid the electrostatic discharge occurring between gate and source, and gate and drain terminals.

9. NOTES

The following precautions shall be taken when handling this device.

- (1) The soldering of leads for TO-254 packages shall be performed at the temperature of 250°C or below and at the point of 1mm as a minimum apart from the lead egress within a time frame of 5 seconds. The solder pot and the soldering iron shall be properly grounded.
- (2) The reflow soldering of terminals for SMD package shall be performed at 200°C or more for 30 to 60 seconds of pre-heat temperature and at 240°C or below for 10 seconds of peak temperature in accordance with JERG-0-043.
- (3) In handling the product, ground human body, work area and measuring instruments.
- (4) BERYLLIA WARNING (for TO-254 package): The products using TO-254 package contain beryllium oxide (BeO). 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.

10. OTHERS

The contact information on this data sheet is as follows:

Supplier: Fuji Electric Co., Ltd.

Address: Gate City Ohsaki, East Tower

11-2, Osaki 1-chome, Shinagawa-ku, Tokyo 141-0032, Japan

Phone: +81-3-5435-7151