

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

Part Description	POWER MOSFET, N-CHANNEL, RADIATION HARDENED
Part Number and Type	JAXA R 2SK4152 JAXA R 2SK4153 JAXA R 2SK4154 JAXA R 2SK4155 JAXA R 2SK4156 JAXA R 2SK4157 JAXA R 2SK4158 JAXA R 2SK4159 JAXA R 2SK4160 JAXA R 2SK4217 JAXA R 2SK4218 JAXA R 2SK4219
Applicable Specification	JAXA-QTS-2030 JAXA-QTS-2030/102

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 Feb. 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 3.3 Recommended Surface Mounting Method (for SMD Packages) · Paragraph 3.3.1 Recommended Mounting Board · Paragraph 3.3.2 Recommended Reflow Conditions · Table A. Recommended Reflow Temperature Profile · Figure A. Recommended Reflow Temperature Profile · Paragraph 3.3.3 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-2030/102	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

1.3 Reference Document

MIL-PRF-19500N	PERFORMANCE SPECIFICATION SEMICONDUCTOR DEVICES, GENERAL SPECIFICATION FOR
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2. SUMMARY OF PRODUCT

2.1 Externals and Dimensions

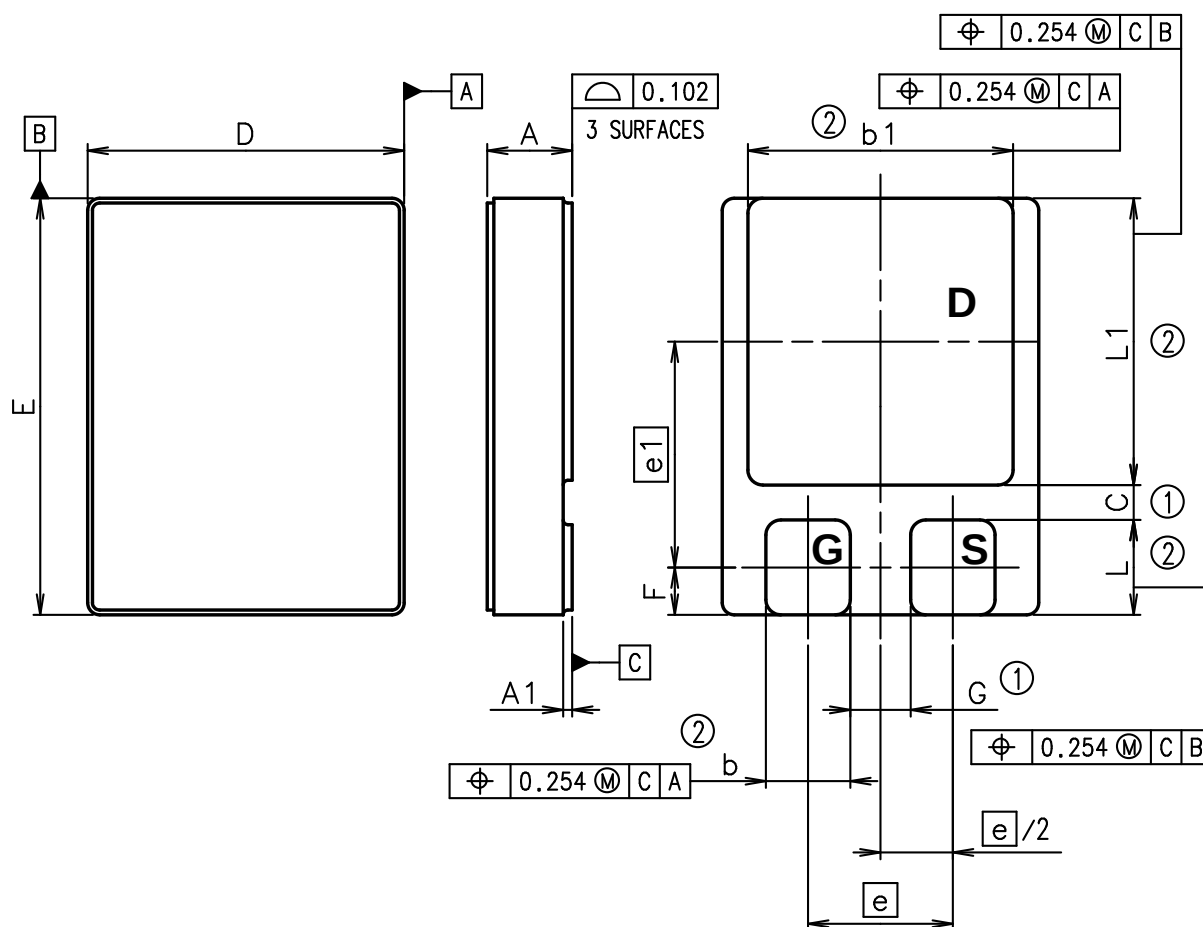
The case outline and dimensions of the device are shown in Figures 1a, 1b and 1c. The marking of the device is illustrated in Figures 5a, 5b and 5c.

2.2 Net Weight

SMD-2 package type (JAXA R 2SK4152, 2SK4155, 2SK4158, 2SK4217) : 3.3g (typ.)
SMD-1 package type (JAXA R 2SK4153, 2SK4156, 2SK4159, 2SK4218) : 2.6g (typ.)
SMD-0.5 package type (JAXA R 2SK4154, 2SK4157, 2SK4160, 2SK4219): 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, and 1c. The internal structure and the cross-section of the device are drawn in Figures 2 through 4.



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

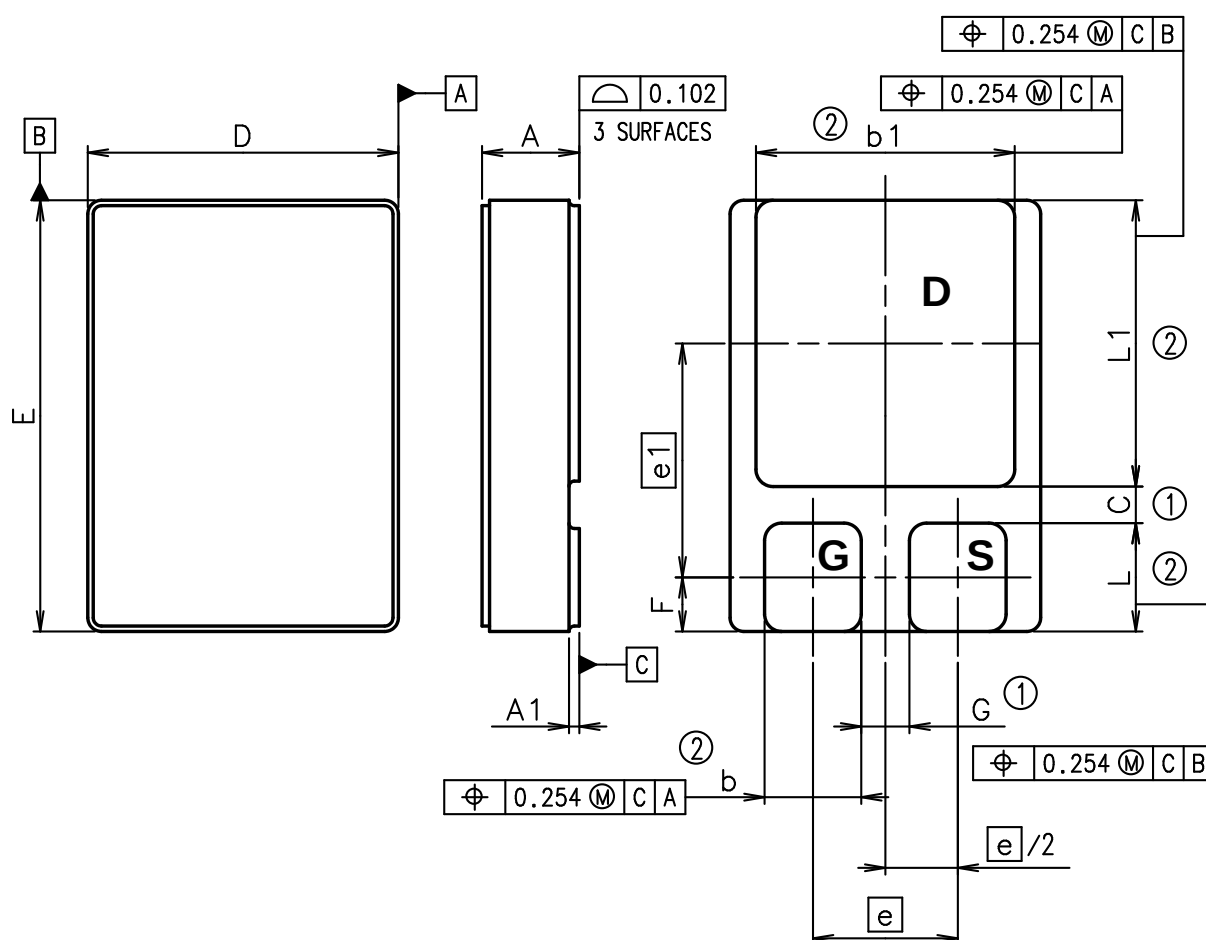
Symbol	Dimension (mm)		
	Min	Typ	Max
$[e]/2$	—	3.05	—
$[e]$	—	6.10	—
$[e1]$	—	9.50	—
F	—	1.99	—
G	1.27	—	—
L	3.87	3.99	4.11
L1	11.94	12.065	12.19

Notes: ① Dimension includes metallization flash.

② Dimension does not include metallization flash.

Note: All terminals are isolated from the case.

**Figure 1a. Outline and Dimensions of SMD-2
(JAXA R 2SK4152, 4155, 4158, 4217)**



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

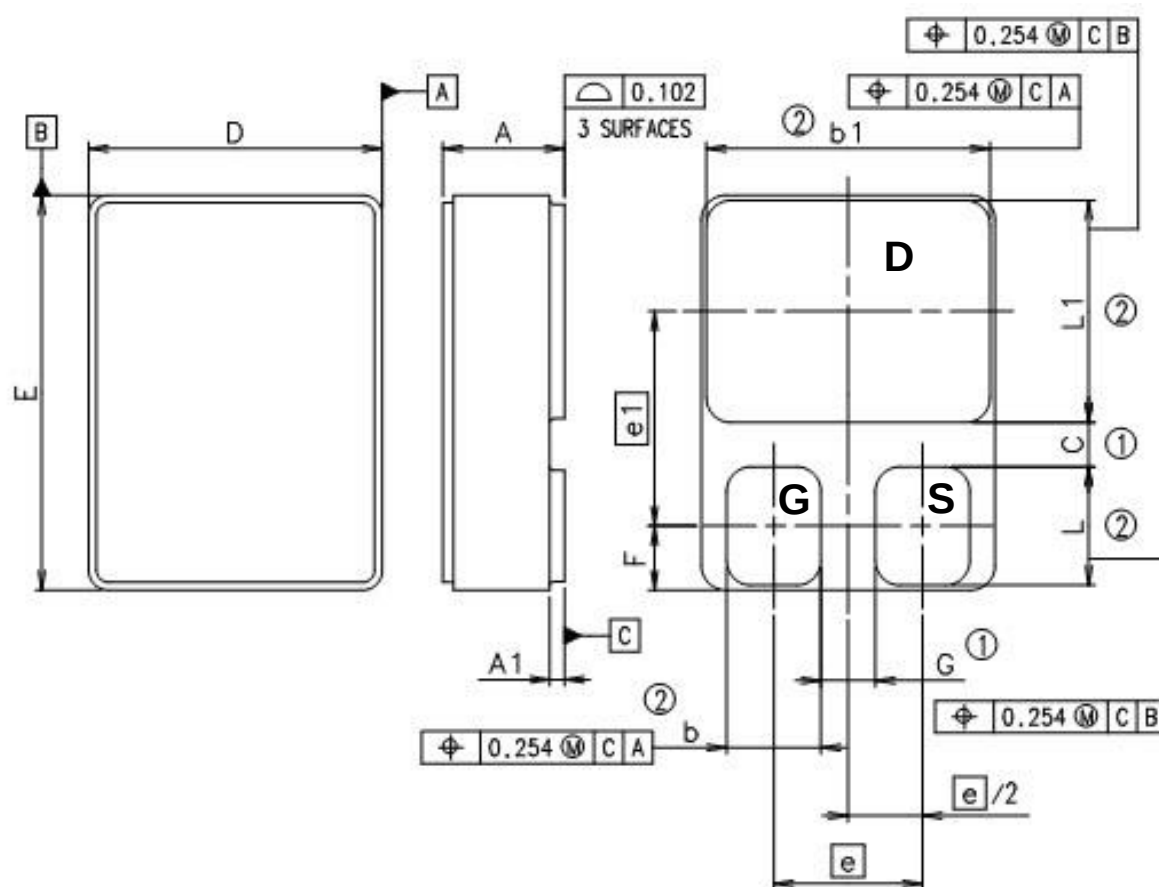
Symbol	Dimension (mm)		
	Min	Typ	Max
$e/2$	—	2.67	—
e	—	5.33	—
$e1$	—	8.61	—
F	—	1.99	—
G	0.89	—	—
L	3.87	3.99	4.11
L1	10.42	10.54	10.66

Notes: ① Dimension includes metallization flash.

② Dimension does not include metallization flash.

Note: All terminals are isolated from the case.

**Figure 1b. Outline and Dimensions of SMD-1
(JAXA R 2SK4153, 4156, 4159, 4218)**



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

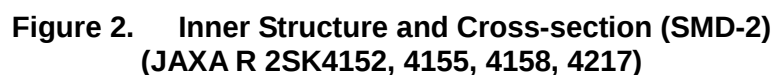
Symbol	Dimension (mm)		
	Min	Typ	Max
$\boxed{e}/2$	—	1.905	—
$\boxed{e}$	—	3.81	—
$\boxed{e1}$	—	5.52	—
F	—	1.65	—
G	0.762	—	—
L	2.93	3.05	3.17
L1	5.59	5.715	5.84

Notes: ① Dimension includes metallization flash.

② Dimension does not include metallization flash.

Note: All terminals are isolated from the case.

**Figure 1c. Outline and Dimensions of SMD-0.5
(JAXA R 2SK4154, 4157, 4160, 4219)**



**Figure 2. Inner Structure and Cross-section (SMD-2)
(JAXA R 2SK4152, 4155, 4158, 4217)**

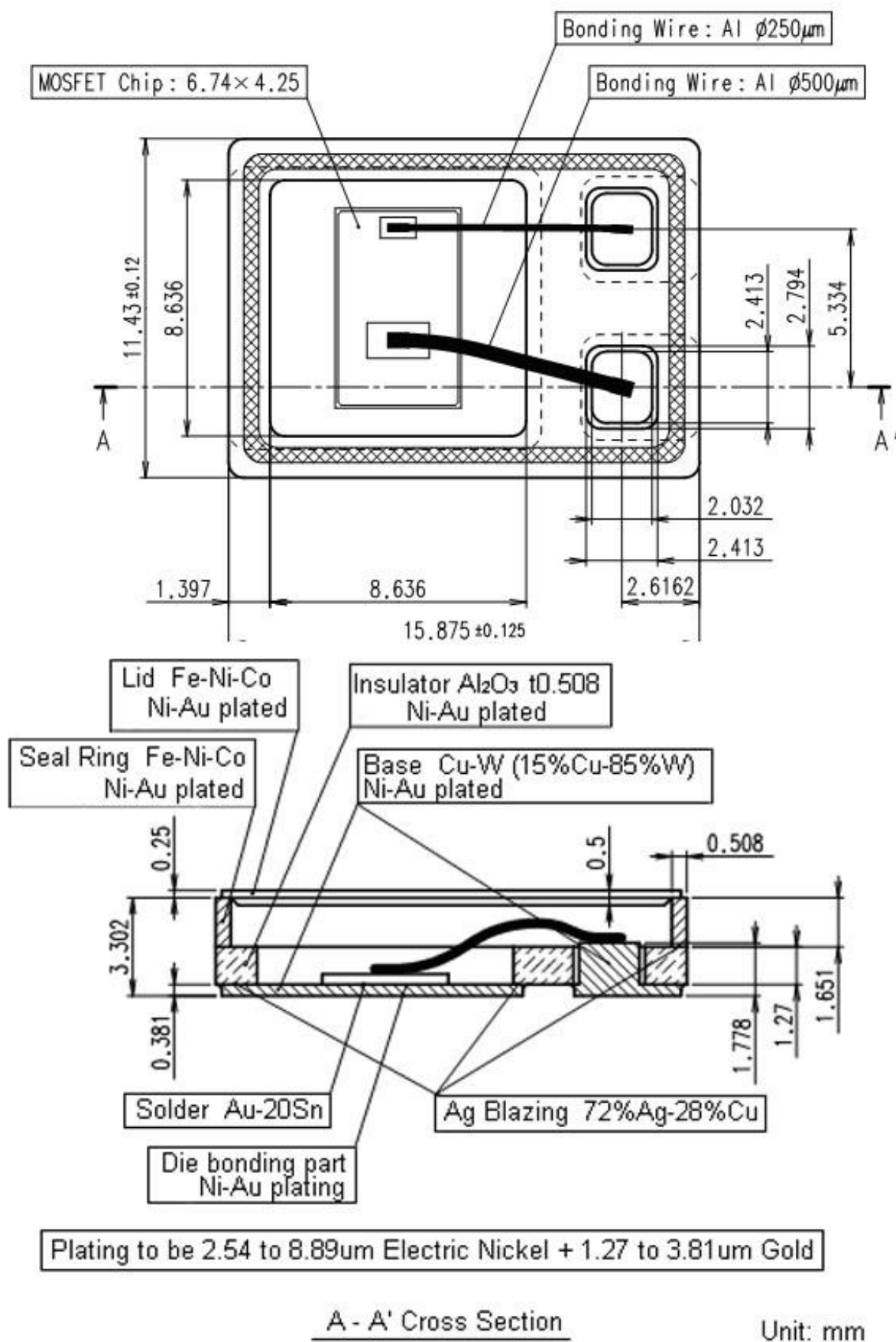
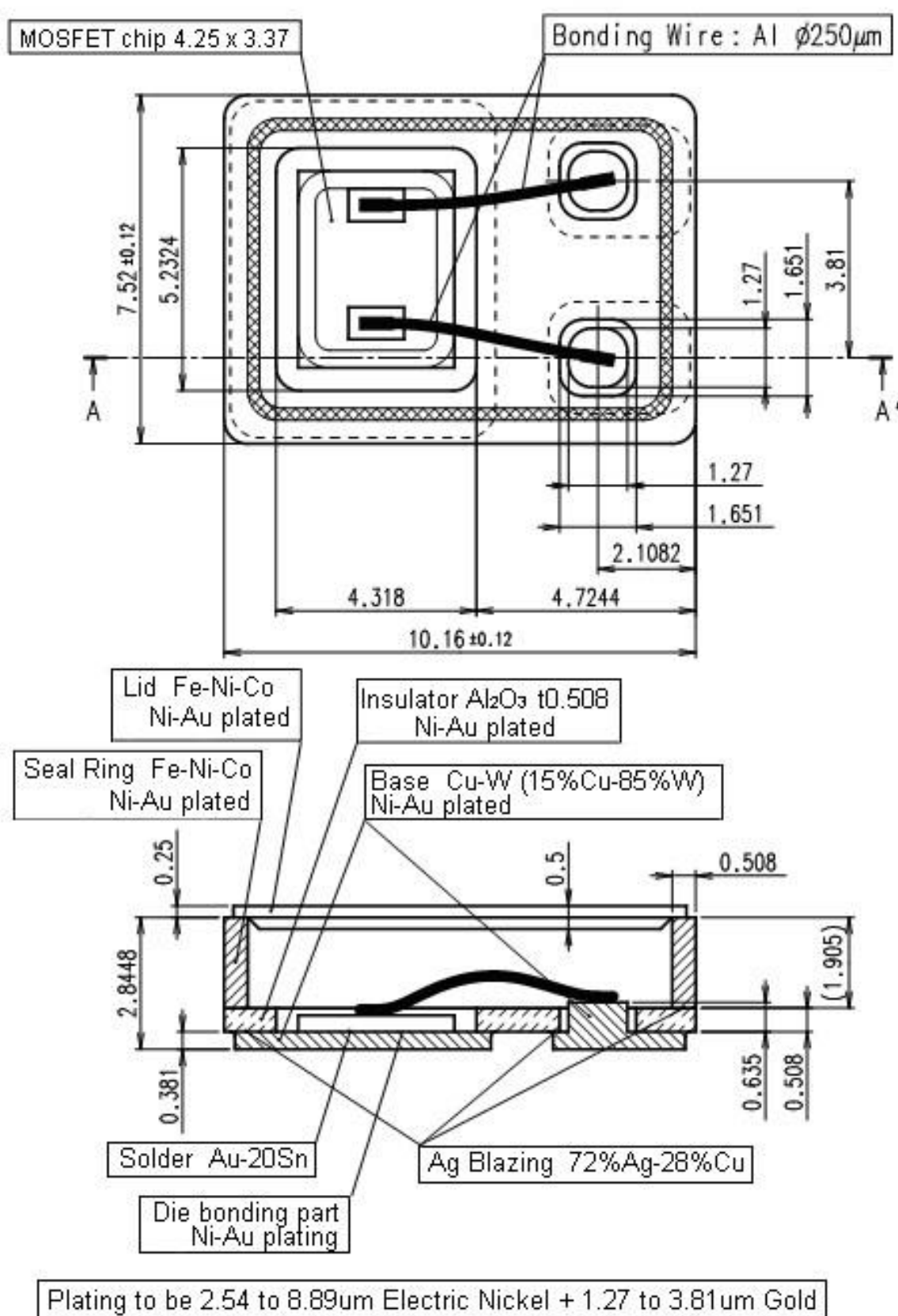


Figure 3. Inner Structure and Cross-section (SMD-1)
(JAXA R 2SK4153, 4156, 4159, 4218)



A - A' Cross Section

Unit: mm

Figure 4. Inner Structure and Cross-section (SMD-0.5)
(JAXA R 2SK4154, 4157, 4160, 4219)

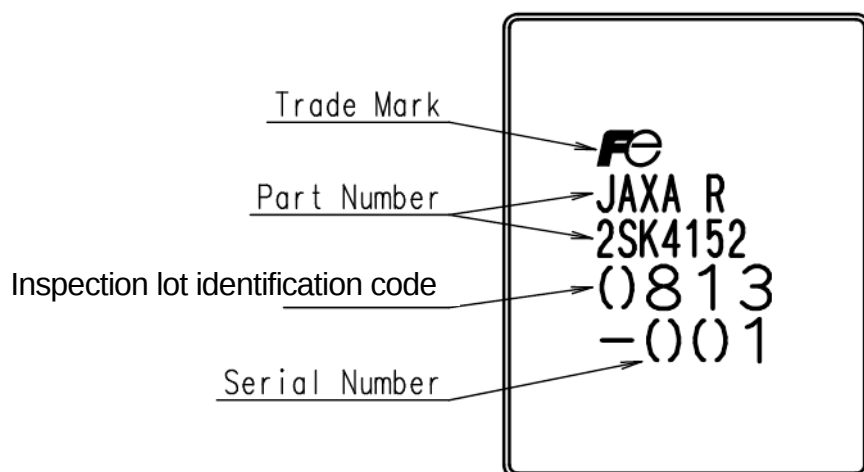


Figure 5a. Marking (SMD-2)
(JAXA R 2SK4152, 2SK4155, 2SK4158, 2SK4217)

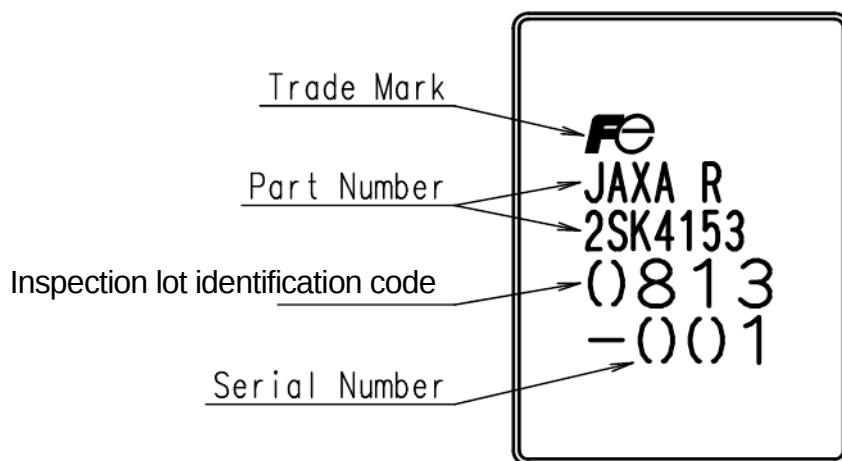


Figure 5b. Marking (SMD-1)
(JAXA R 2SK4153, 2SK4156, 2SK4159, 2SK4218)

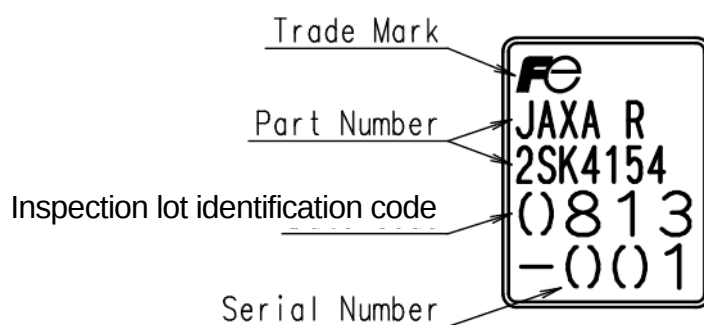


Figure 5c. Marking (SMD-0.5)
(JAXA R 2SK4154, 2SK4157, 2SK4160, 2SK4219)

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)	T _{ch} ⁽¹⁾ (°C)	T _{stg} (°C)	R _{th(ch-c)} (°C/W)
JAXA R 2SK4152	130	42	168	±20	250	150	-55 to 150	0.5
JAXA R 2SK4153	130	39	156		150			0.83
JAXA R 2SK4154	130	15	60		70			1.67
JAXA R 2SK4155	200	42	168		250			0.5
JAXA R 2SK4156	200	32	128		150			0.83
JAXA R 2SK4157	200	14	56		70			1.67
JAXA R 2SK4158	250	42	168		250			0.5
JAXA R 2SK4159	250	26	104		150			0.83
JAXA R 2SK4160	250	12	48		70			1.67
JAXA R 2SK4217	100	42	168		250			0.5
JAXA R 2SK4218	100	42	168		150			0.83
JAXA R 2SK4219	100	15	60		70			1.67

Note⁽¹⁾ Channel temperature T_{ch} is given by the following equation:

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

where T_c: Case temperature (°C)

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

P_D: Power dissipation (W)

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 Recommended Surface Mounting Method (for SMD Packages)

3.3.1 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.

3.3.2 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

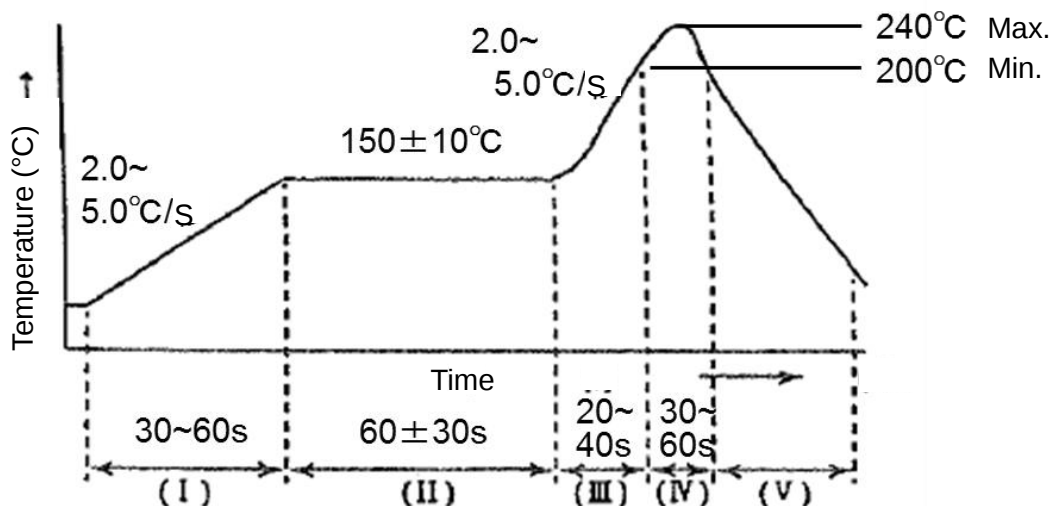


Figure A. Recommended Reflow Temperature Profile

3.3.3 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	Evaluation result Defect /sample size
	Test item	Method		2SJ1A04(-100V, SMD2)	
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)	1051	Sample size	22p	---
		---	Condition	$-55^{+0}_{-5}^{\circ}\text{C} \leftrightarrow 25^{+10}_{-5}^{\circ}\text{C} \leftrightarrow 150^{+5}_{-0}^{\circ}\text{C}$ 30 cycles	
3-1	Visual Inspection	1051	Sample size	22p	0/22
		1021	Condition	---	
		---	---	---	
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 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	
3-3	Hermetic Seal (1) Fine Leak (2) Gross Leak	1071	Condition	Condition H max 1×10 ⁻³ Pa·cm ³ /s	0/22
		1071	Limits	Condition C	0/22
3-4	Ultrasonic test	---	Condition	No cracks between chip-solder-frame.	0/22
3-5	Internal visual and Mechanical inspection	2075 2071	Condition	---	0/22
3-6	Bond strength	2037	Sample size	22p	0/22
		---	Condition Limits	Condition D 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

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°C unless otherwise specified)

Part No.	V _{(BR)DSS} (V)		I _{DSS} (μA)		I _{GSS} (nA)		V _{GS(th)} (V)		R _{DS(on)} ⁽¹⁾ (mΩ)		gfs ⁽¹⁾ (S)	
	I _D =1mA V _{GS} =0V		V _{DS} =80% of rated V _{DS} V _{GS} =0V		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	
	Min.	Typ.	Max.	Typ.	Max.	Typ.	Min.-Max.	Typ.	Max.	Typ.	Min.	Typ.
JAXA R 2SK4152	130	143	10	60n	±100	+9 -12	2.5-4.5	3.5	17	15	8	12
JAXA R 2SK4153	130	143		40n		+8 -8			39	34	8	12
JAXA R 2SK4154	130	143		30n		+1 -1			89	78	4	6
JAXA R 2SK4155	200	220		130n		+7 -15			26	23	8	12
JAXA R 2SK4156	200	220		70n		+5 -10			62	54	8	12
JAXA R 2SK4157	200	220		40n		+5 -2			148	129	4	6
JAXA R 2SK4158	250	275		140n		+8 -16			38	33	8	12
JAXA R 2SK4159	250	275		120n		+15 -10			91	80	8	12
JAXA R 2SK4160	250	275		50n		+6 -1			223	195	4	6
JAXA R 2SK4217	100	110		40n		+9 -12			13	11	8	12
JAXA R 2SK4218	100	110		30n		+8 -8			28	24	8	12
JAXA R 2SK4219	100	110		25n		+1 -1			64	56	4	6

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

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

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	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ	Max	Typ
JAXA R 2SK4152	60	40	70	47	220	147	65	43	30	20	190	127	65	45
JAXA R 2SK4153	30	20	30	20	100	67	40	27	20	13	100	67	30	20
JAXA R 2SK4154	13	9	10	7	50	33	30	20	20	13	65	43	15	10
JAXA R 2SK4155	60	40	70	47	220	147	65	43	30	20	190	127	35	23
JAXA R 2SK4156	30	20	30	20	100	67	40	27	20	13	100	67	20	13
JAXA R 2SK4157	13	9	10	7	50	33	30	20	20	13	65	43	15	10
JAXA R 2SK4158	60	40	70	47	220	147	65	43	30	20	190	127	30	20
JAXA R 2SK4159	30	20	30	20	100	67	40	27	20	13	100	67	15	10
JAXA R 2SK4160	13	9	10	7	50	33	30	20	20	13	65	43	10	7
JAXA R 2SK4217	60	40	70	47	220	147	65	43	30	20	190	127	65	50
JAXA R 2SK4218	30	20	30	20	100	67	40	27	20	13	100	67	30	20
JAXA R 2SK4219	13	9	10	7	50	33	30	20	20	13	65	43	15	10

Table 3c. Electrical Characteristics (T_A=+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 2SK4152	8000	5200	1300	900	80	50
JAXA R 2SK4153	3300	2100	550	420	30	20
JAXA R 2SK4154	1500	1000	300	200	20	11
JAXA R 2SK4155	8000	5250	900	580	65	40
JAXA R 2SK4156	3300	2200	350	280	30	15
JAXA R 2SK4157	1500	1000	200	130	20	10
JAXA R 2SK4158	8000	5300	750	500	65	40
JAXA R 2SK4159	3300	2200	350	240	20	15
JAXA R 2SK4160	1500	1000	150	110	10	8
JAXA R 2SK4152	8000	5200	1500	1000	90	55
JAXA R 2SK4153	3300	2100	650	460	30	20
JAXA R 2SK4154	1500	1000	350	220	20	11

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.
2SK4152	1.6	1.2	520	11.0
2SK4153			540	9.0
2SK4154			390	5.0
2SK4155			690	13.5
2SK4156			800	12.0
2SK4157			620	6.0
2SK4158			1000	19.0
2SK4159			900	12.0
2SK4160			640	6.5
2SK4217			450	7.0
2SK4218			500	6.5
2SK4219			350	3.5

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	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 -Y ₂ -Z ₁ each orientation, 5 times		
	Constant Acceleration	98100 m/s ² (10000G) X ₁ -Y ₁ -Y ₂ -Z ₁ each orientation, 1 time		
Electrostatic Discharge (ESD)		JAXA R 2SK4152 JAXA R 2SK4155 JAXA R 2SK4158 JAXA R 2SK4217	JAXA R 2SK4153 JAXA R 2SK4156 JAXA R 2SK4159 JAXA R 2SK4218	JAXA R 2SK4154 JAXA R 2SK4157 JAXA R 2SK4160 JAXA R 2SK4219
		C=100pF, R=1.5kΩ V _{GS} =±2750V V _{GS} =±1000V V _{GS} =±500V		

5. CHARACTERISTIC CURVES IN VARIOUS OPERATING CONDITIONS

The characteristic curves are shown in Figures 6 through 41:

Figs. 6 - 8 : Characteristic Curves of JAXA R 2SK4152

Figs. 9 - 11 : Characteristic Curves of JAXA R 2SK4153

Figs. 12-14 : Characteristic Curves of JAXA R 2SK4154

Figs. 15-17 : Characteristic Curves of JAXA R 2SK4155

Figs. 18-20 : Characteristic Curves of JAXA R 2SK4156

Figs. 21-23 : Characteristic Curves of JAXA R 2SK4157

Figs. 24-26 : Characteristic Curves of JAXA R 2SK4158

Figs. 27-29 : Characteristic Curves of JAXA R 2SK4159

Figs. 30-32 : Characteristic Curves of JAXA R 2SK4160

Figs. 33-35 : Characteristic Curves of JAXA R 2SK4217

Figs. 36-38 : Characteristic Curves of JAXA R 2SK4218

Figs. 39-41 : Characteristic Curves of JAXA R 2SK4219

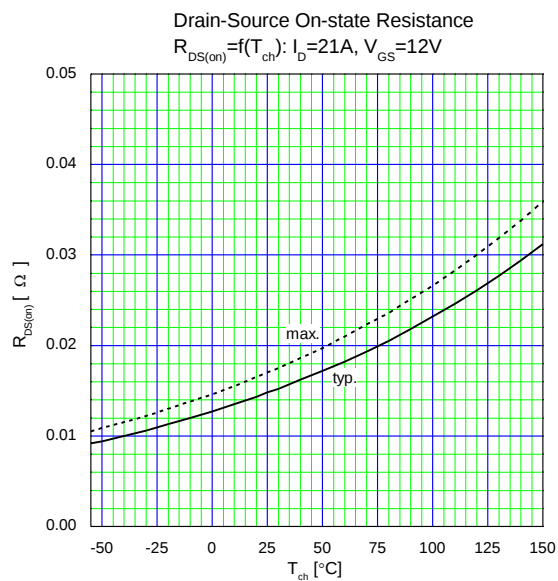
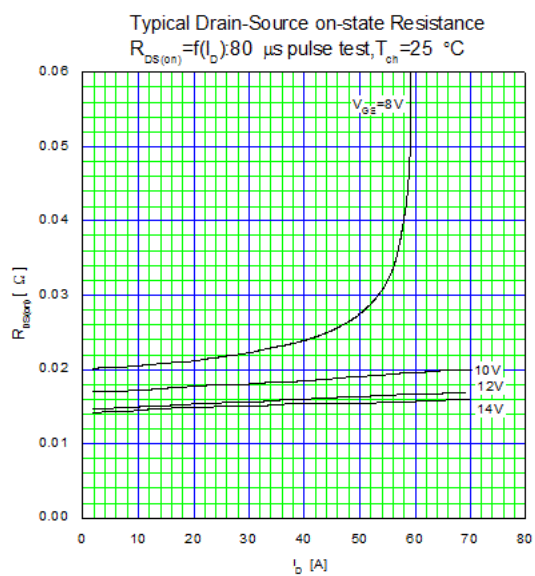
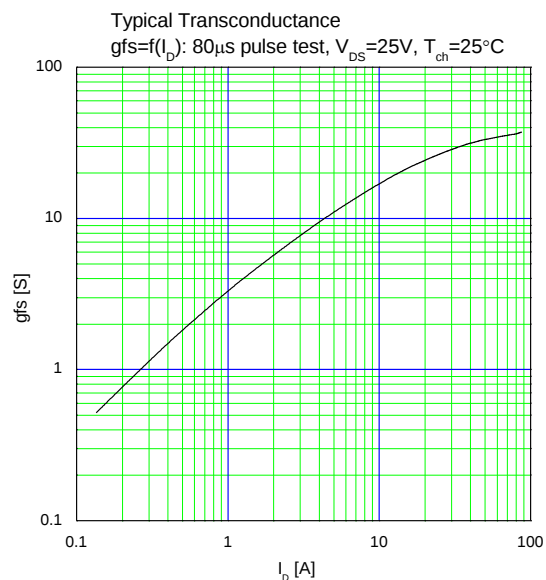
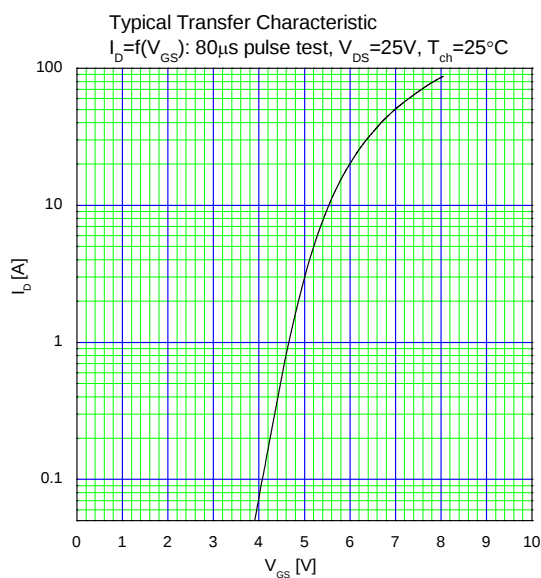
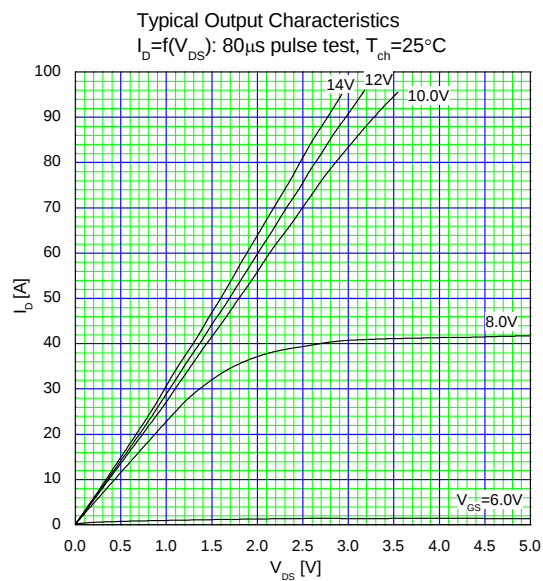
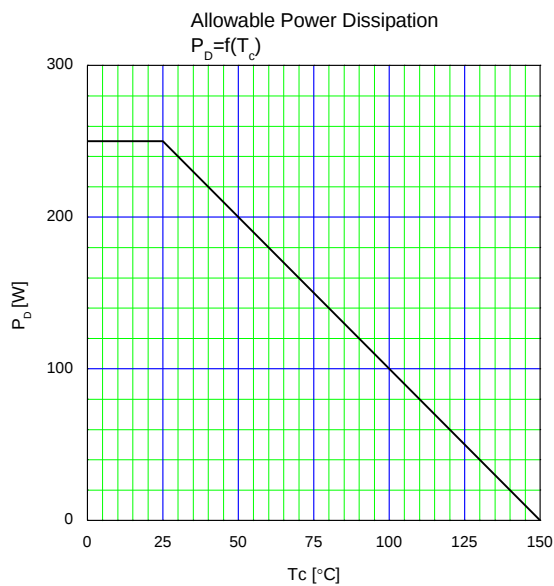


Figure 6. Characteristic Curves of JAXA R 2SK4152 (1/3)

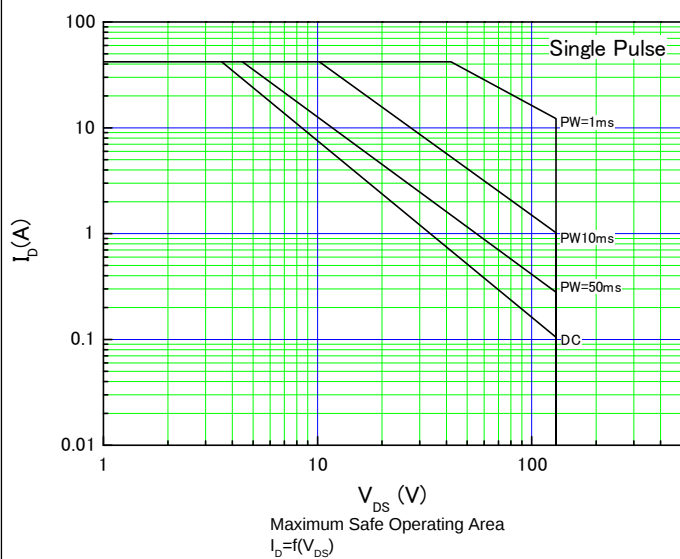
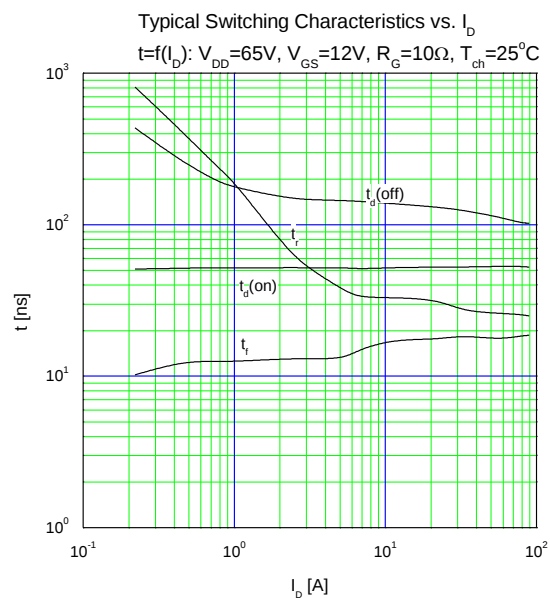
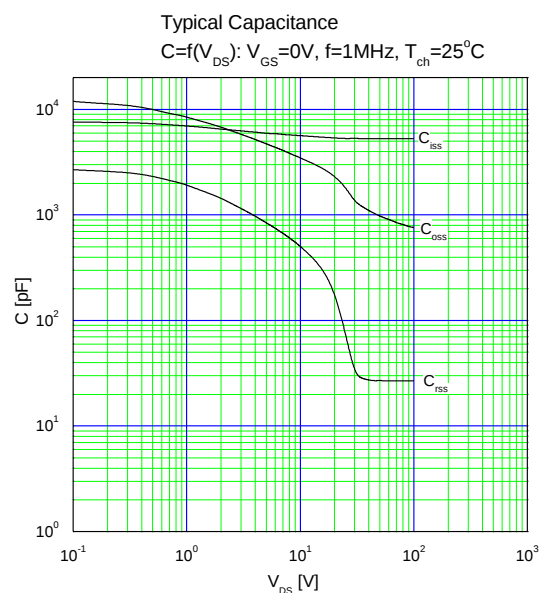
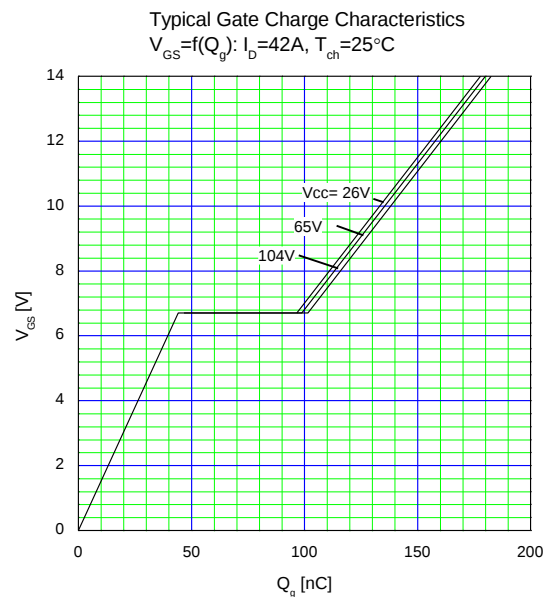
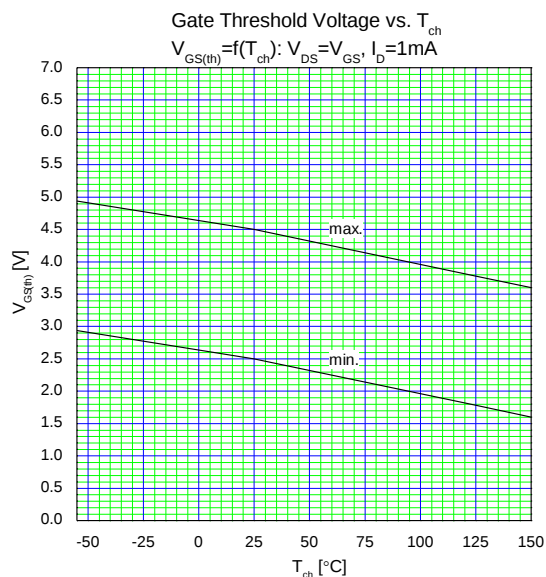


Figure 7. Characteristic Curves of JAXA R 2SK4152 (2/3)

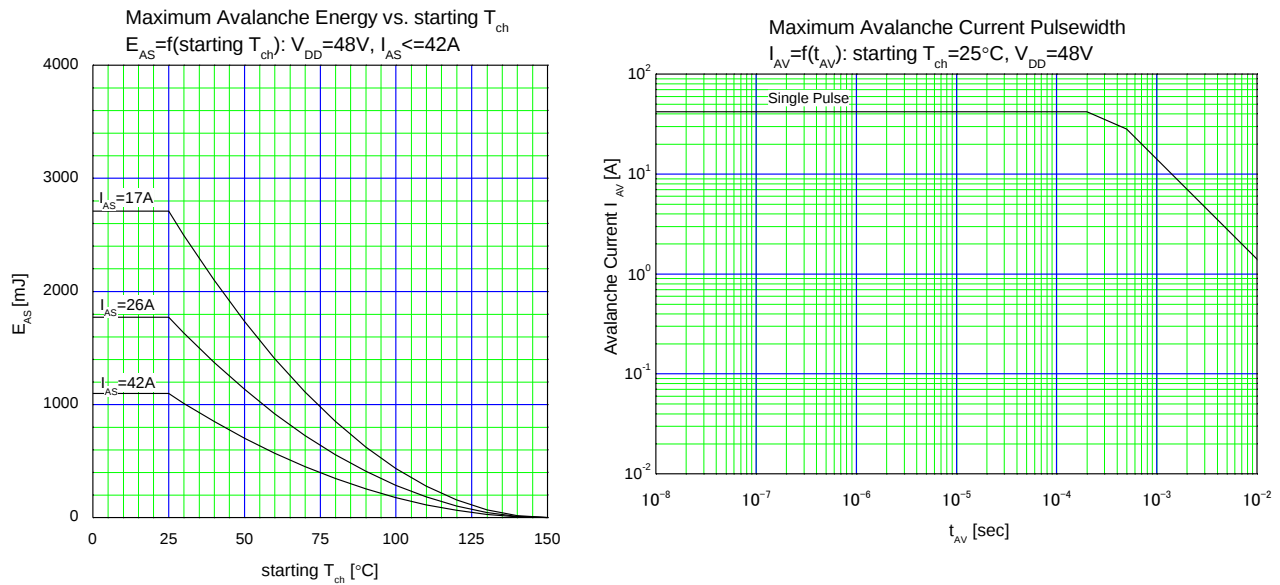


Figure 8. Characteristic Curves of JAXA R 2SK4152 (3/3)

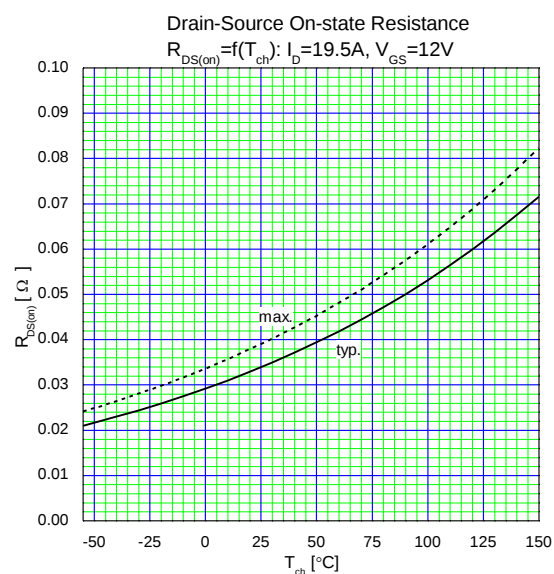
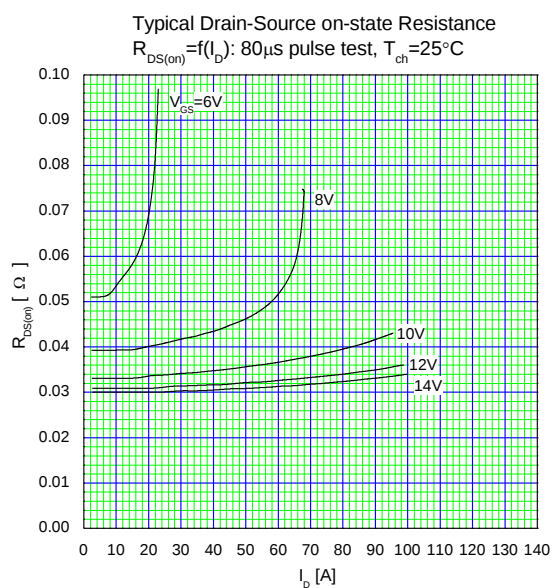
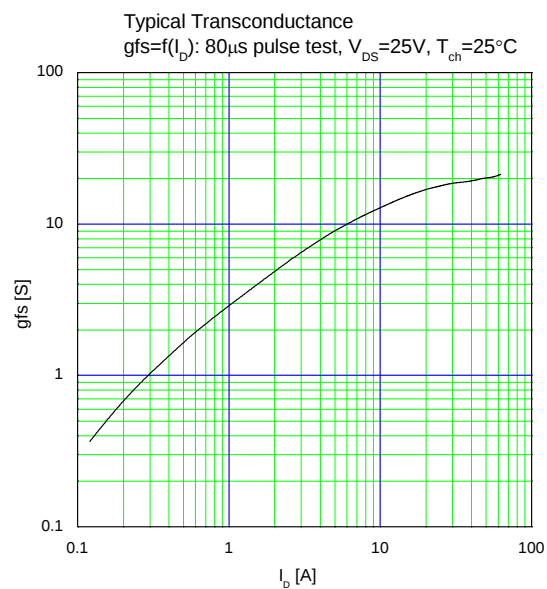
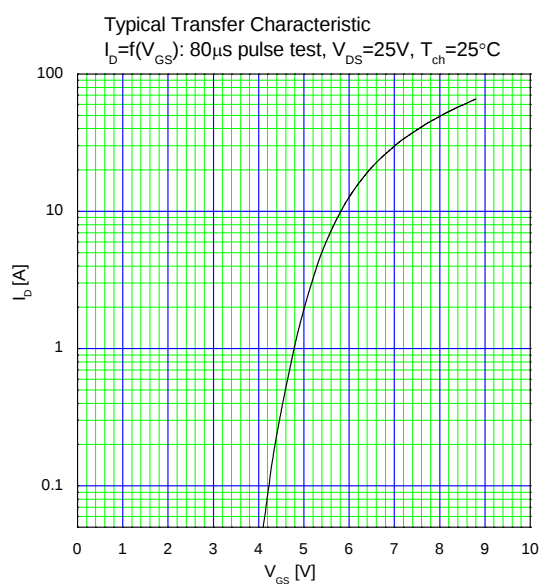
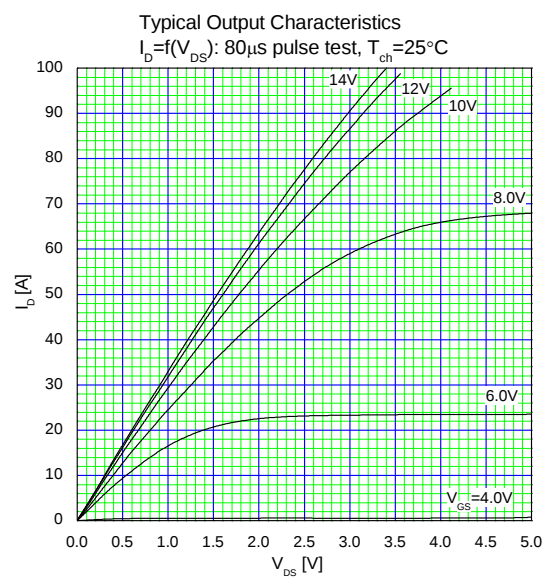
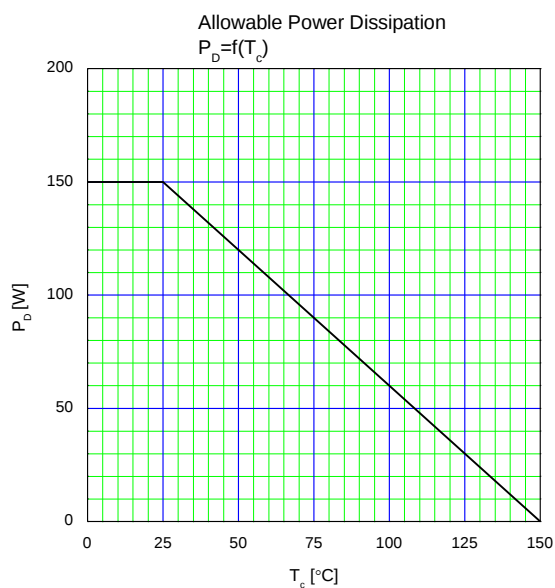


Figure 9. Characteristic Curves of JAXA R 2SK4153 (1/3)

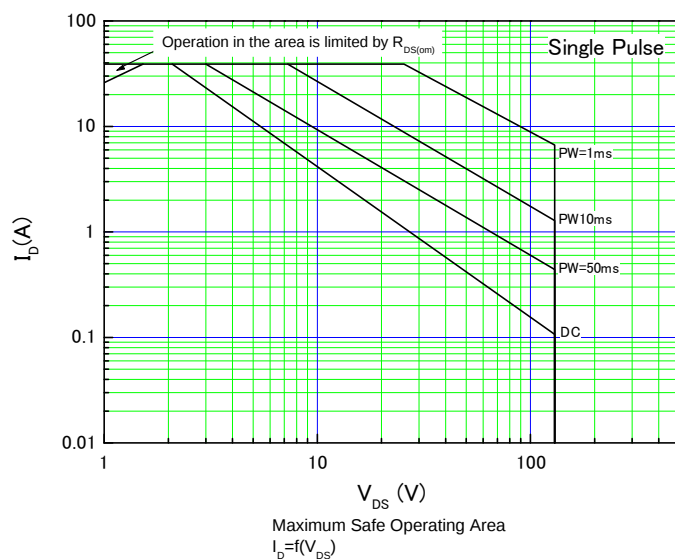
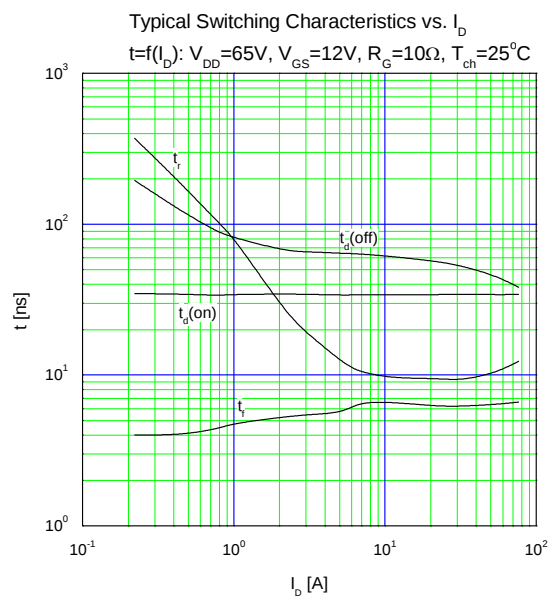
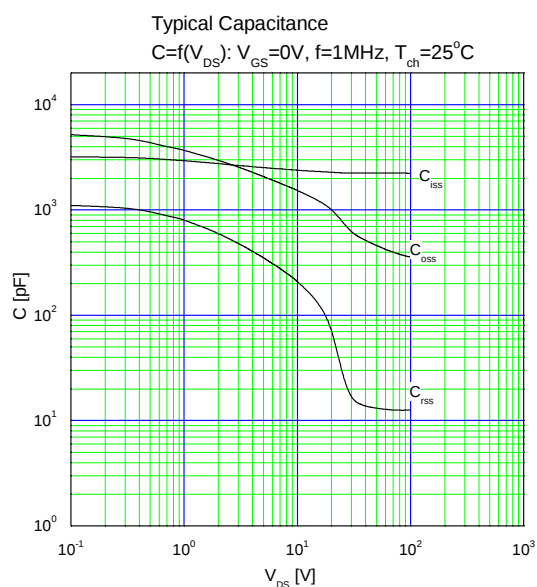
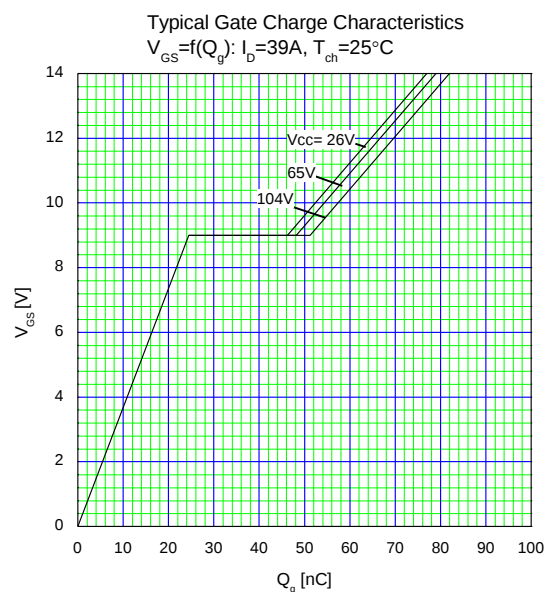
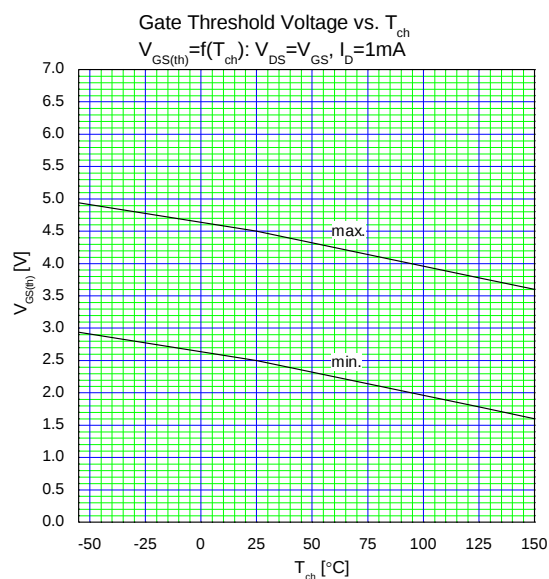


Figure 10. Characteristic Curves of JAXA R 2SK4153 (2/3)

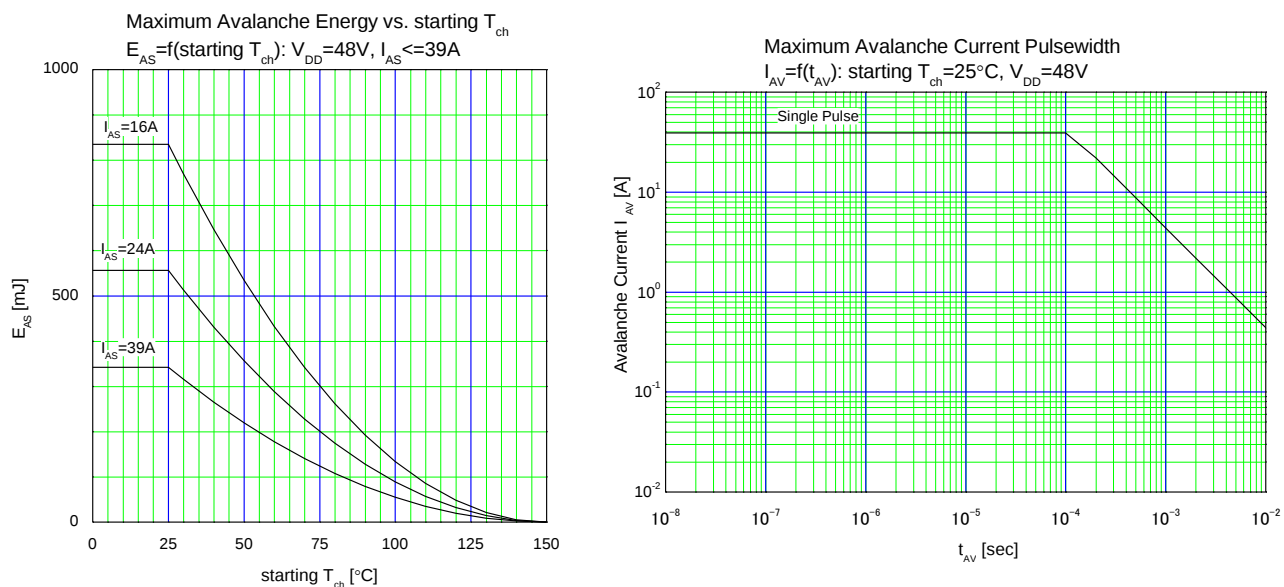


Figure 11. Characteristic Curves of JAXA R 2SK4153 (3/3)

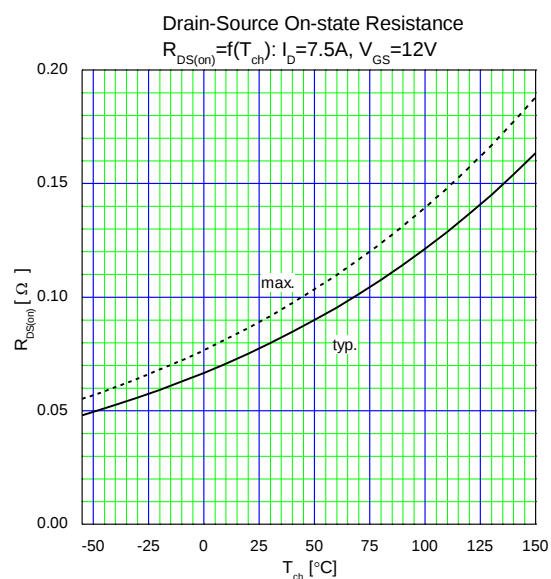
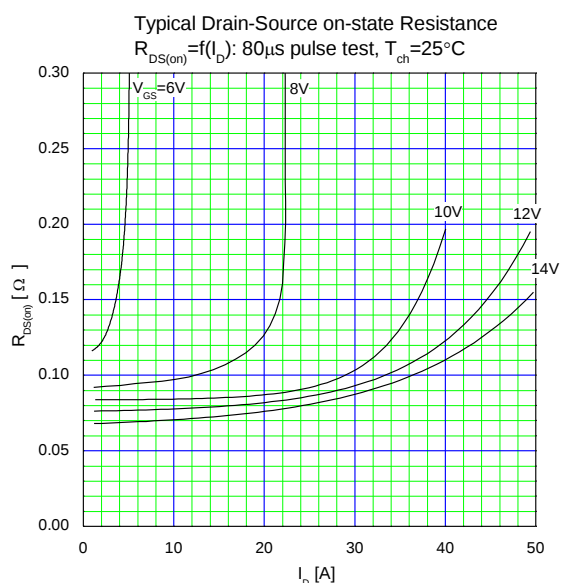
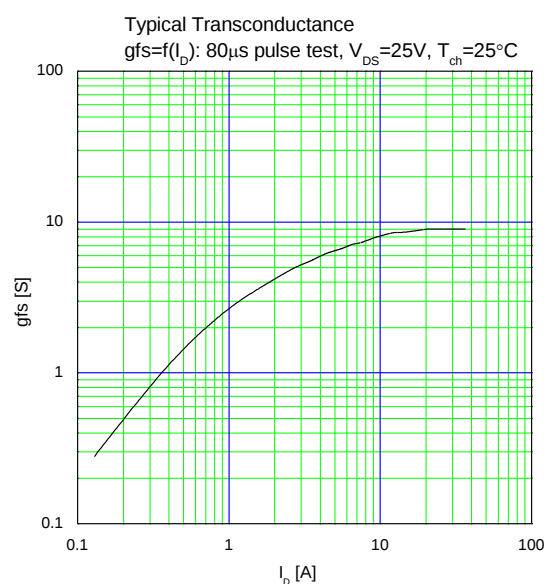
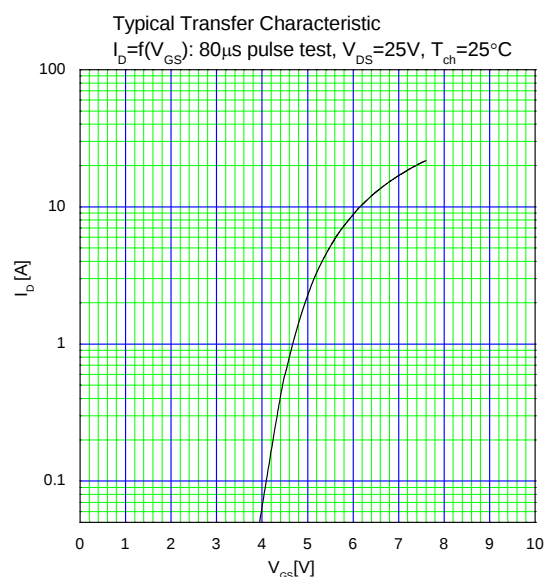
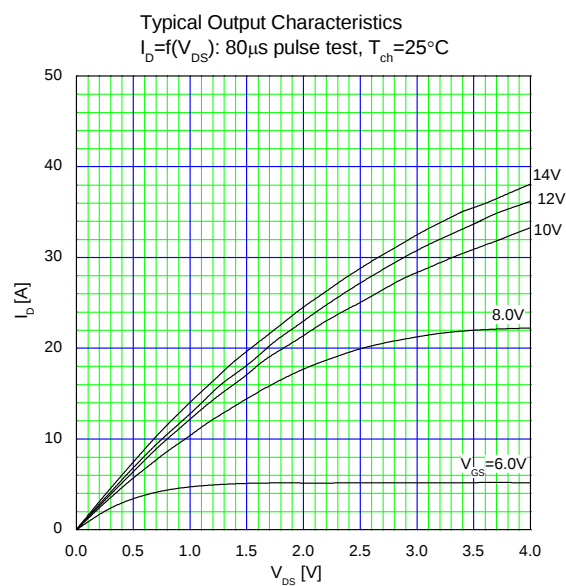
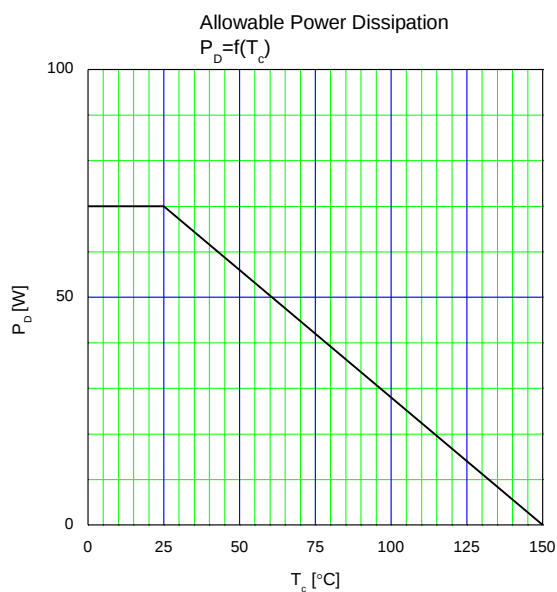


Figure 12. Characteristic Curves of JAXA R 2SK4154 (1/3)

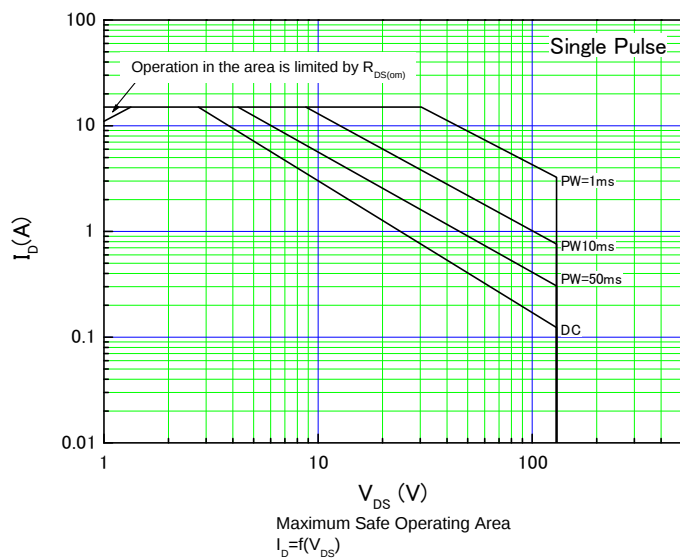
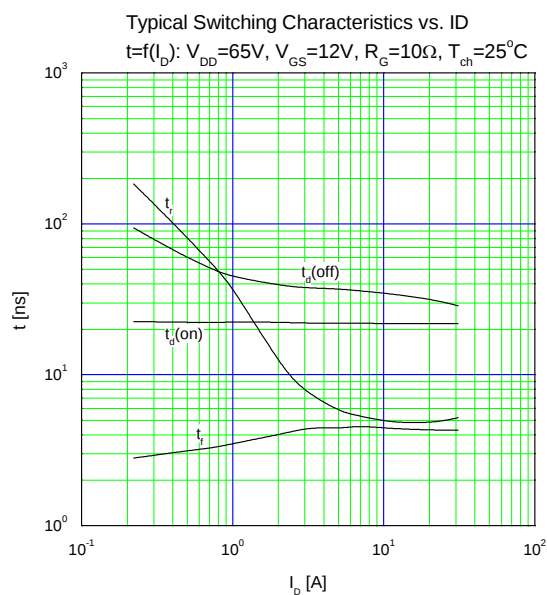
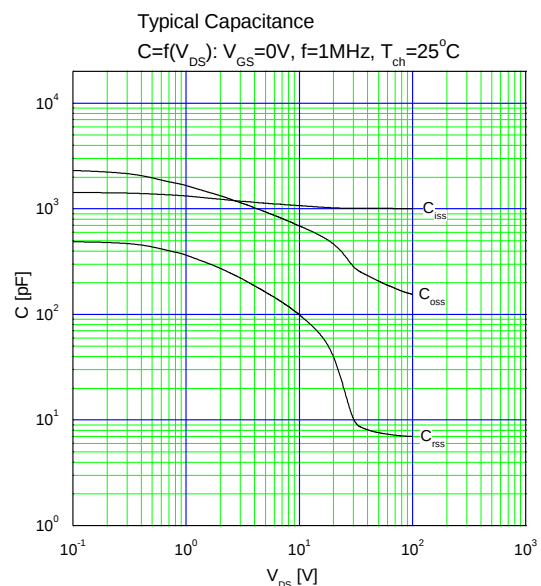
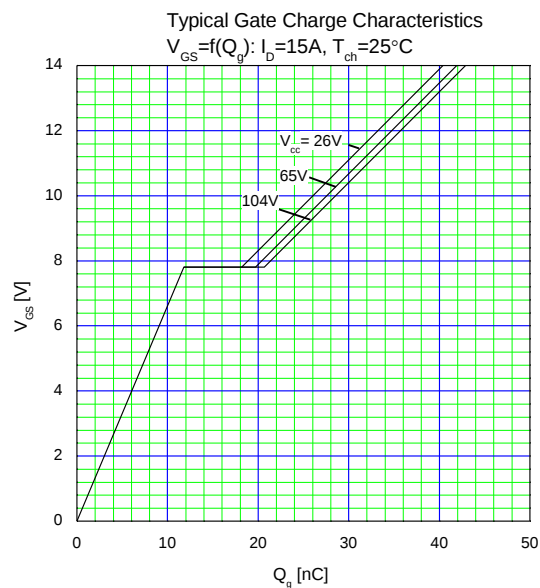
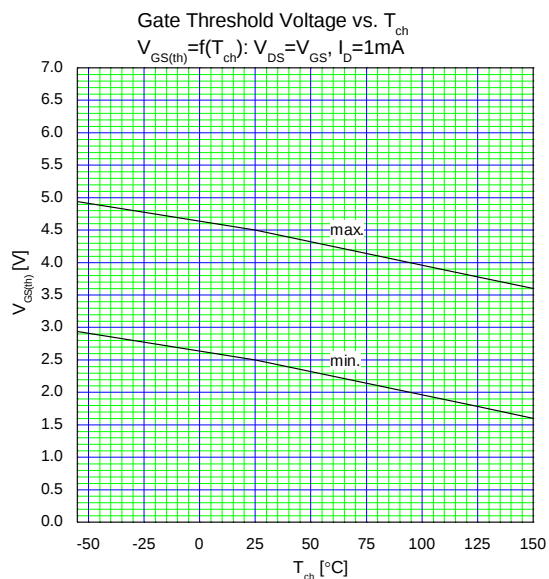


Figure 13. Characteristic Curves of JAXA R 2SK4154 (2/3)

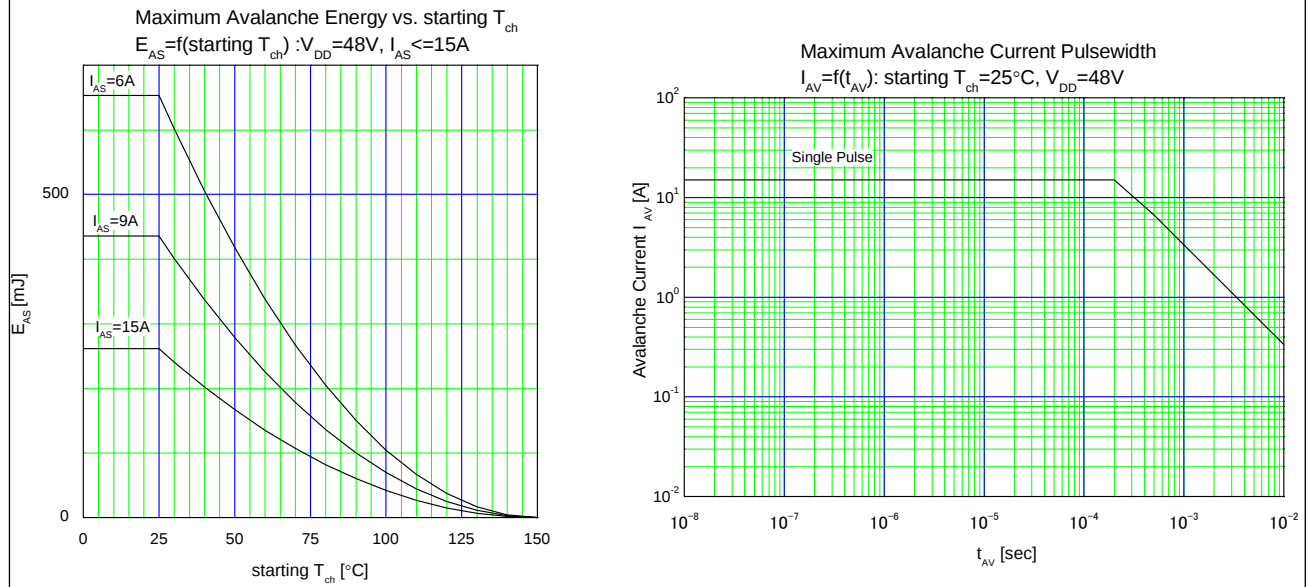


Figure 14. Characteristic Curves of JAXA R 2SK4154 (3/3)

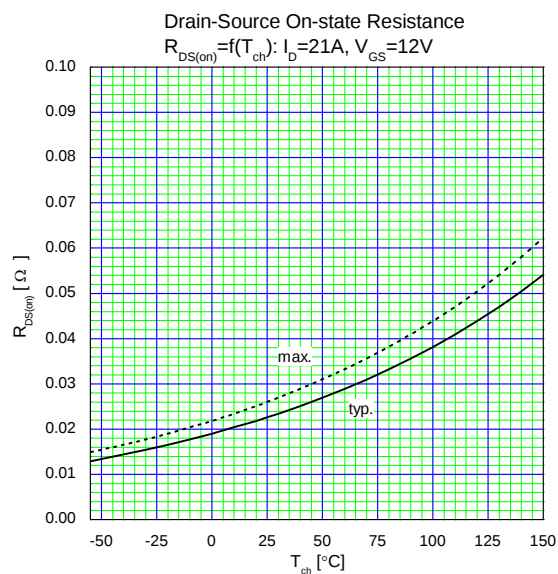
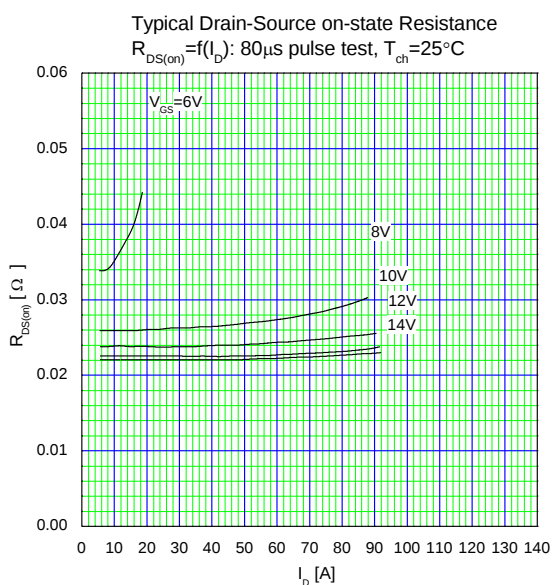
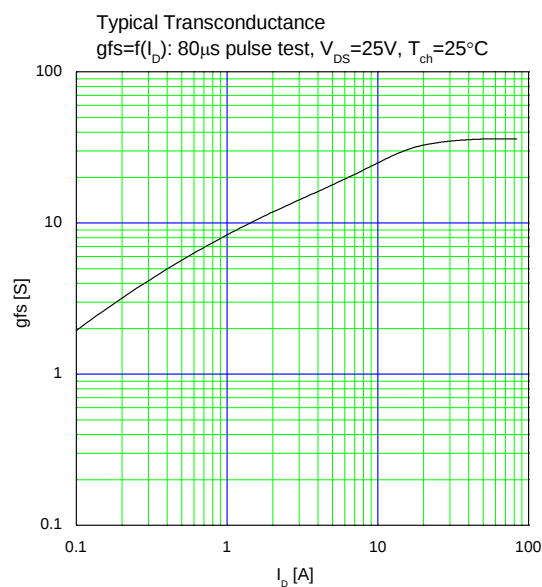
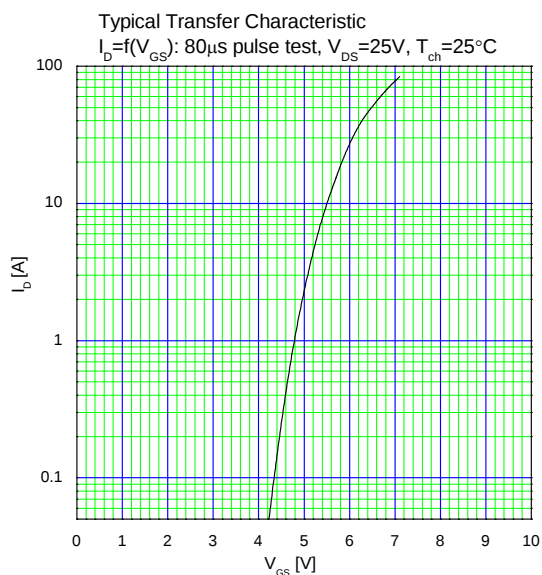
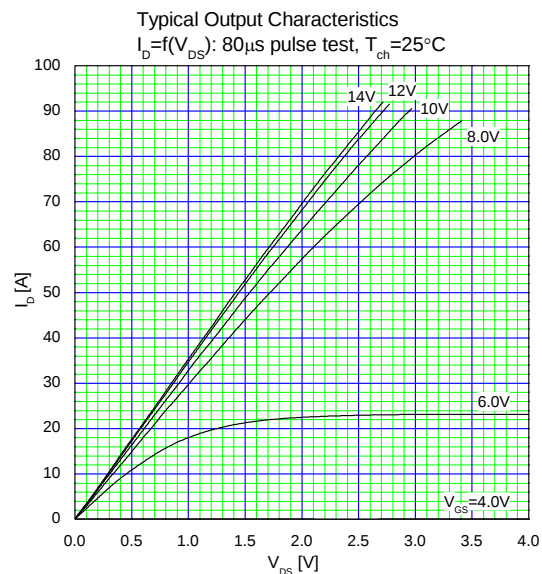
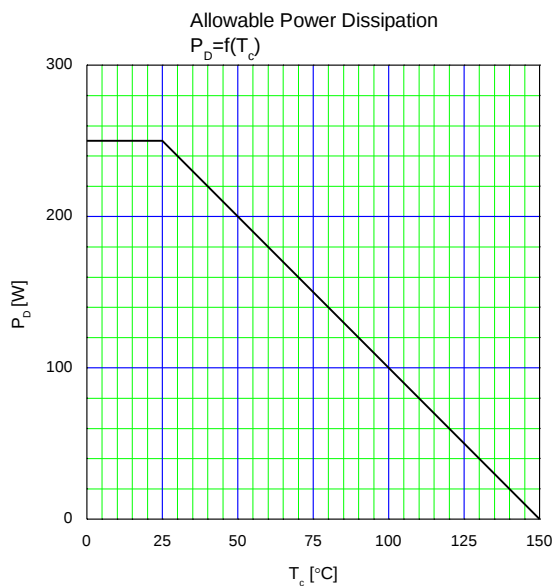


Figure 15. Characteristic Curves of JAXA R 2SK4155 (1/3)

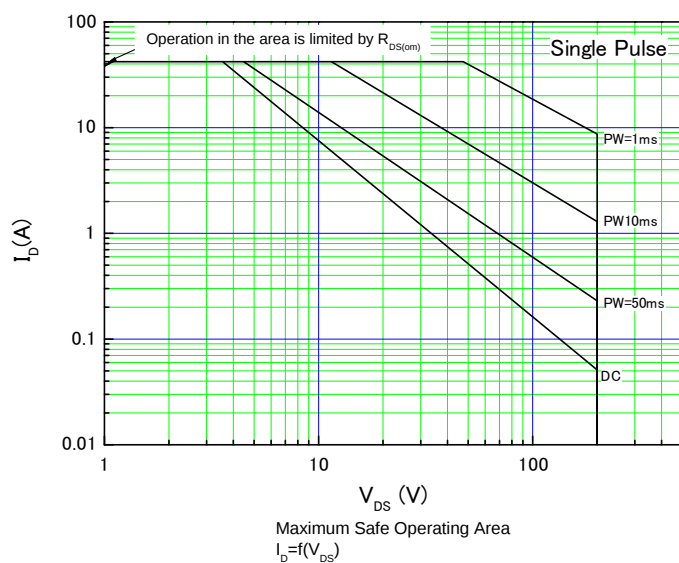
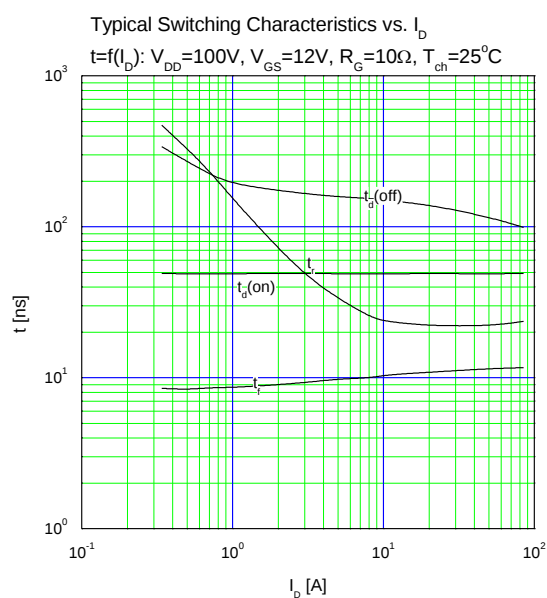
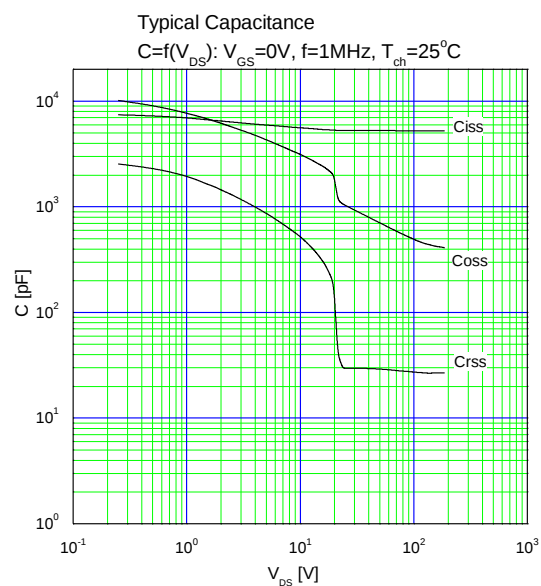
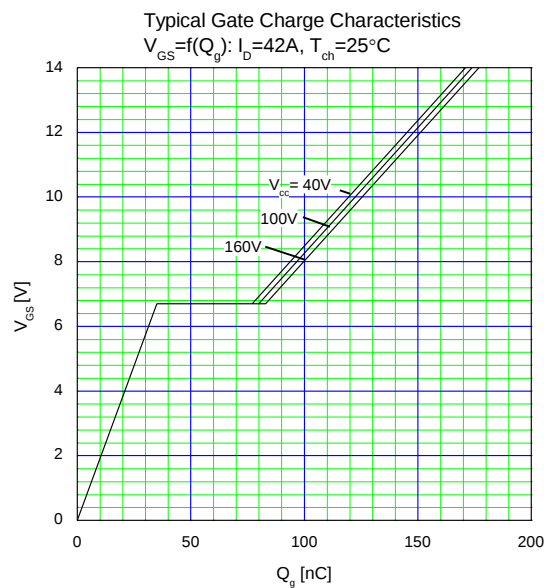
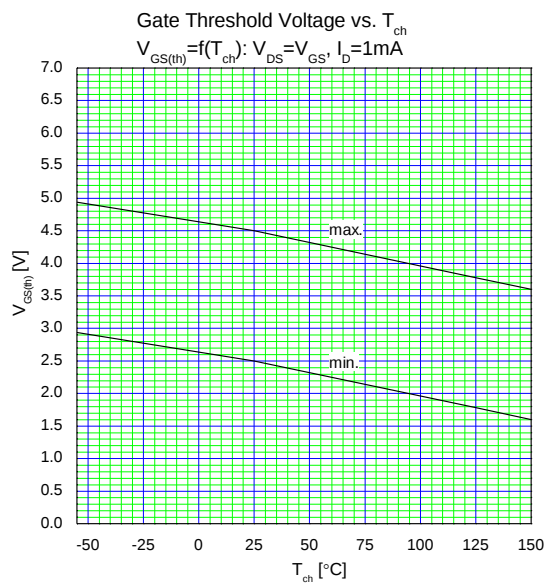


Figure 16. Characteristic Curves of JAXA R 2SK4155 (2/3)

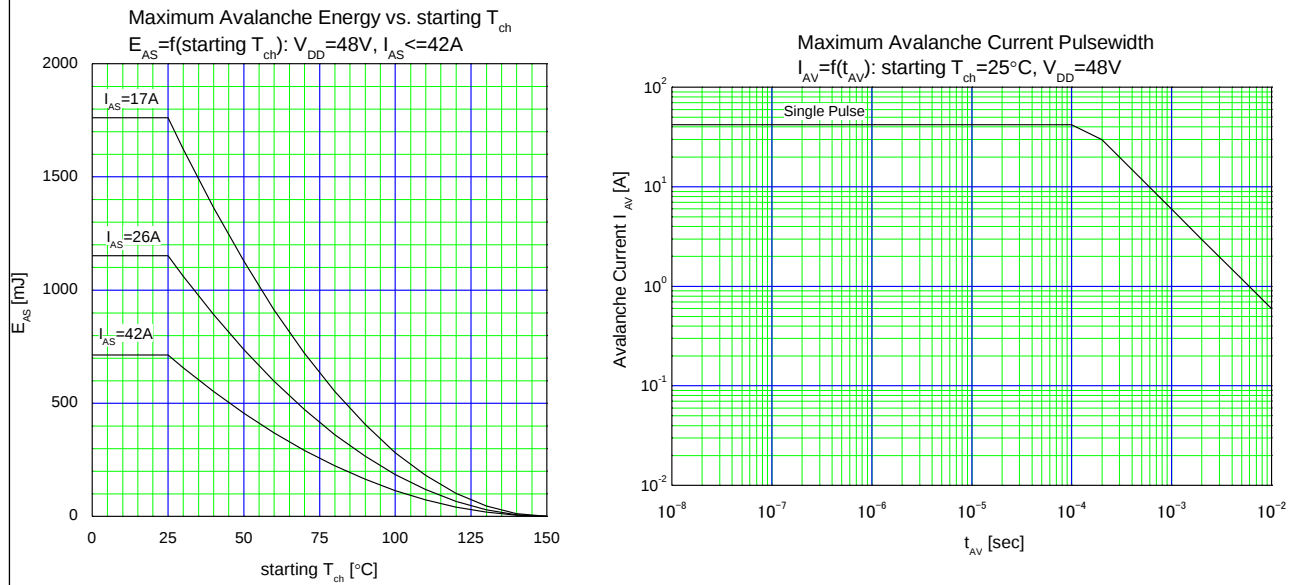


Figure 17. Characteristic Curves of JAXA R 2SK4155 (3/3)

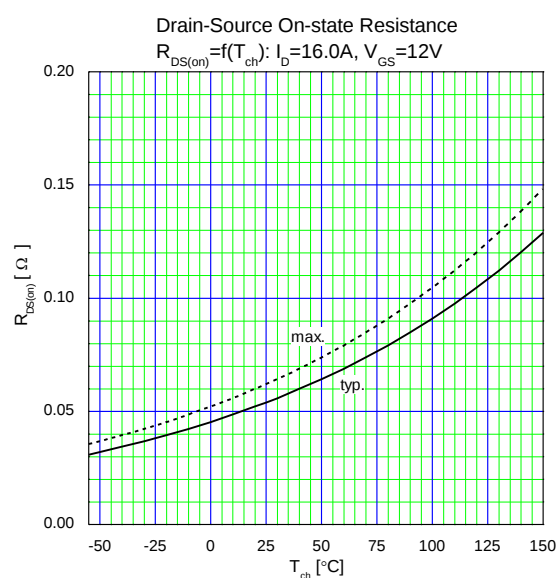
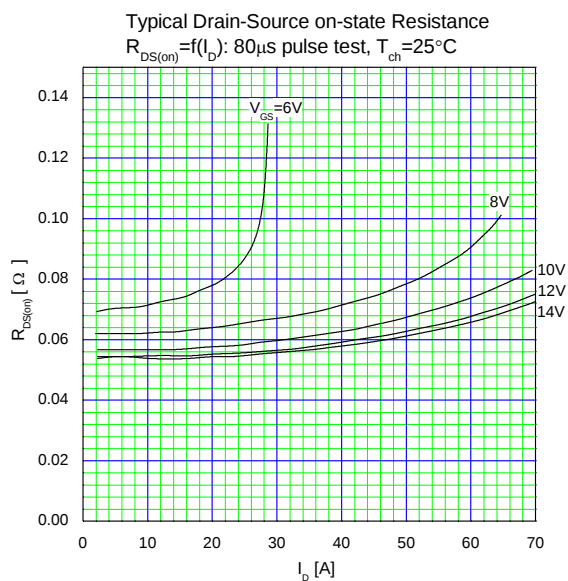
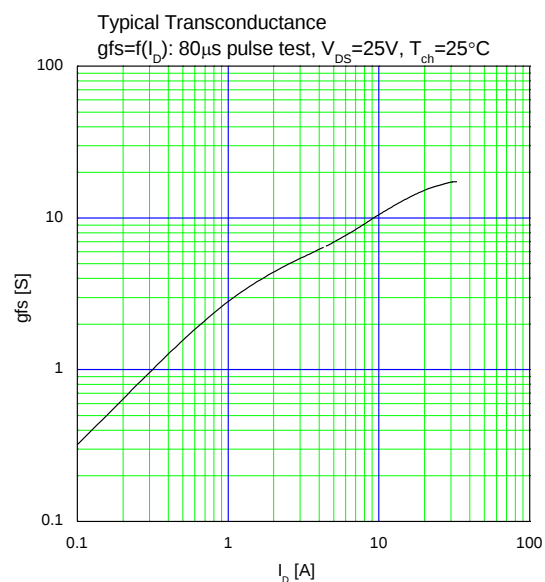
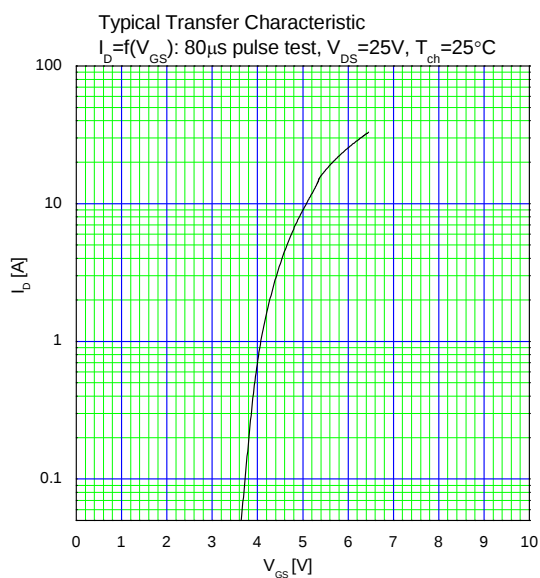
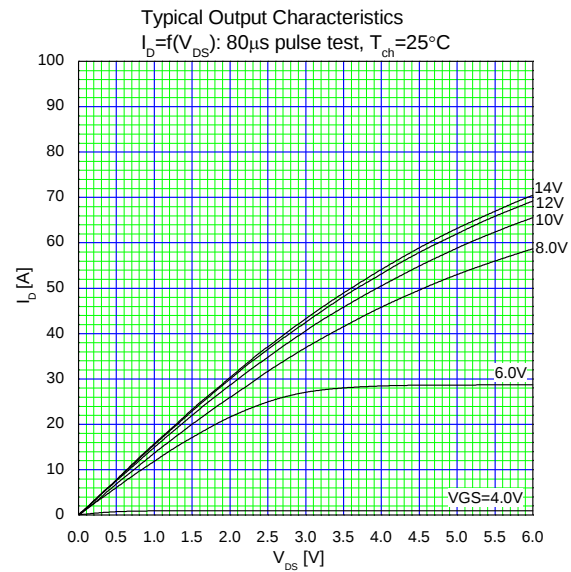
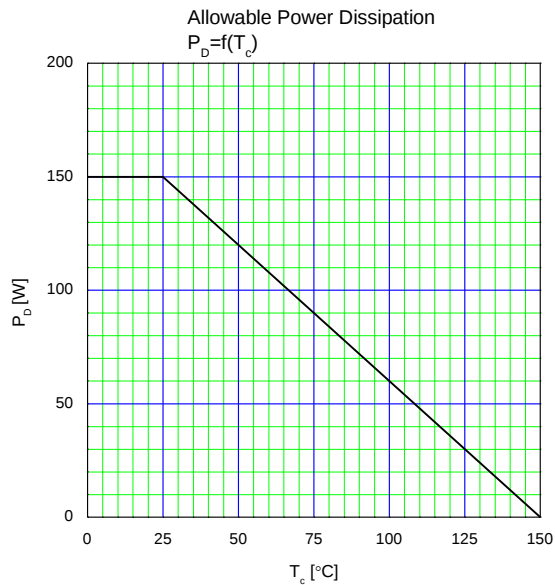


Figure 18. Characteristic Curves of JAXA R 2SK4156 (1/3)

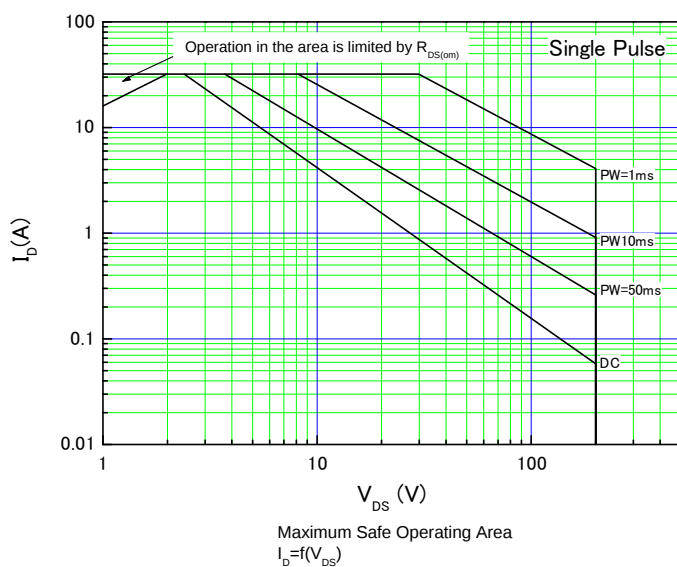
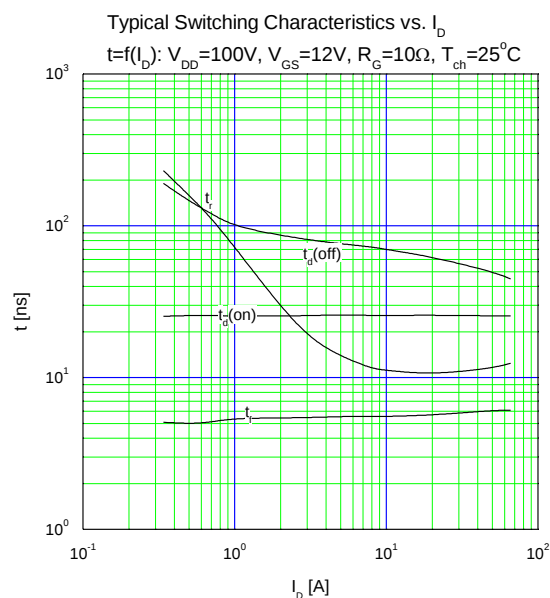
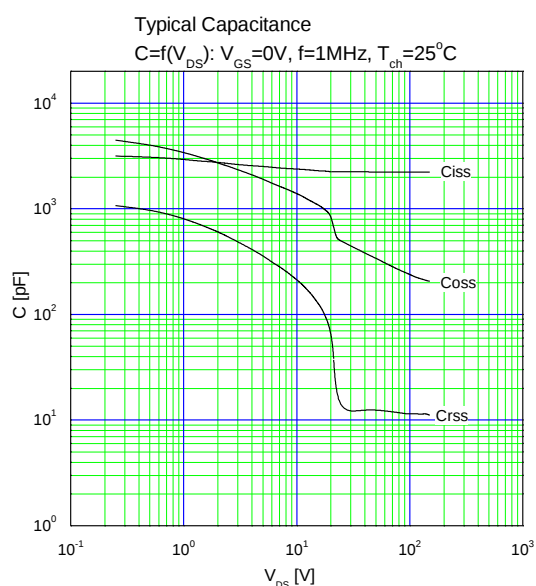
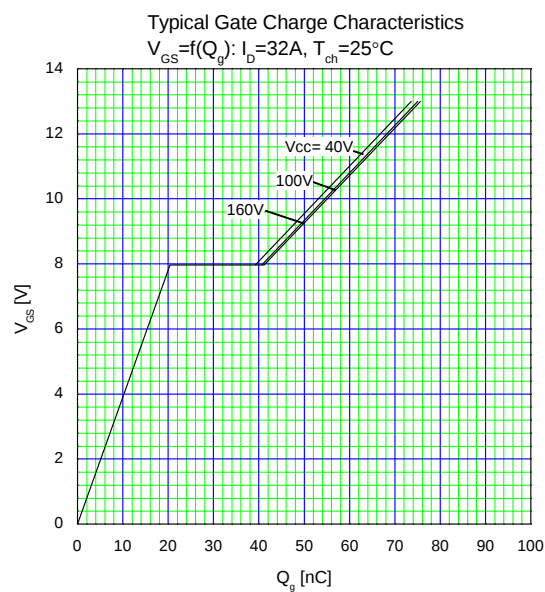
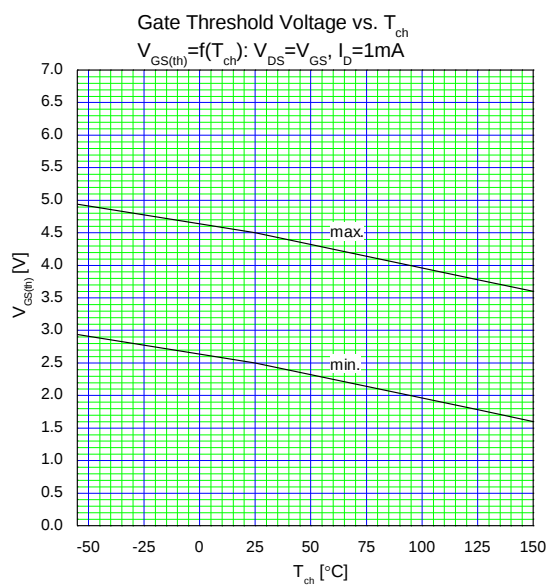


Figure 19. Characteristic Curves of JAXA R 2SK4156 (2/3)

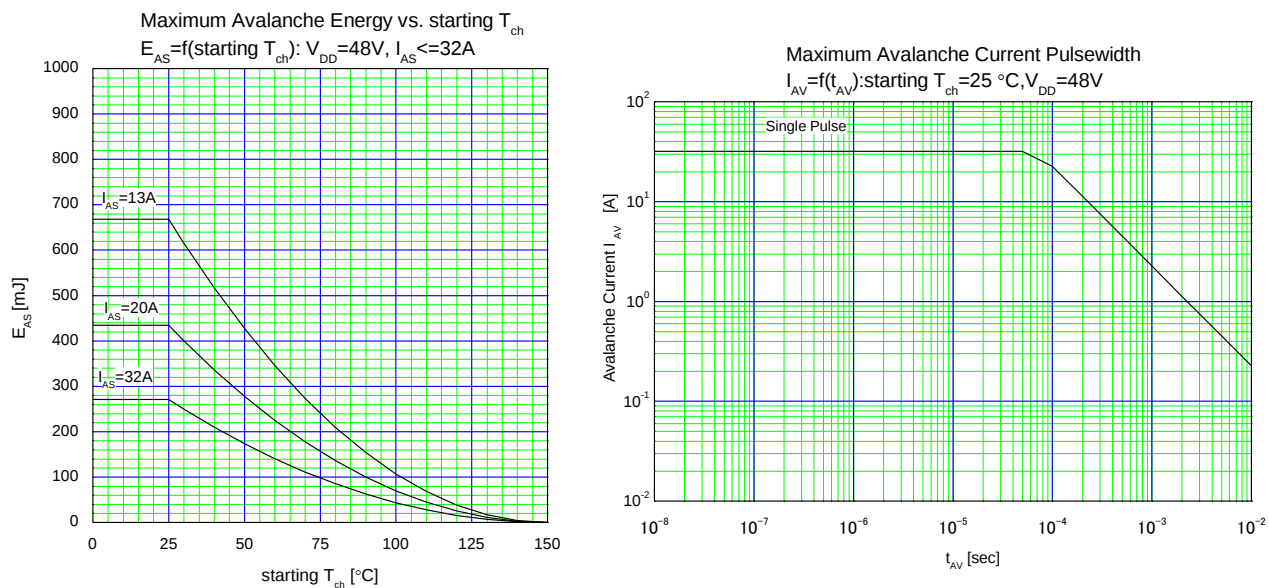


Figure 20. Characteristic Curves of JAXA R 2SK4156 (3/3)

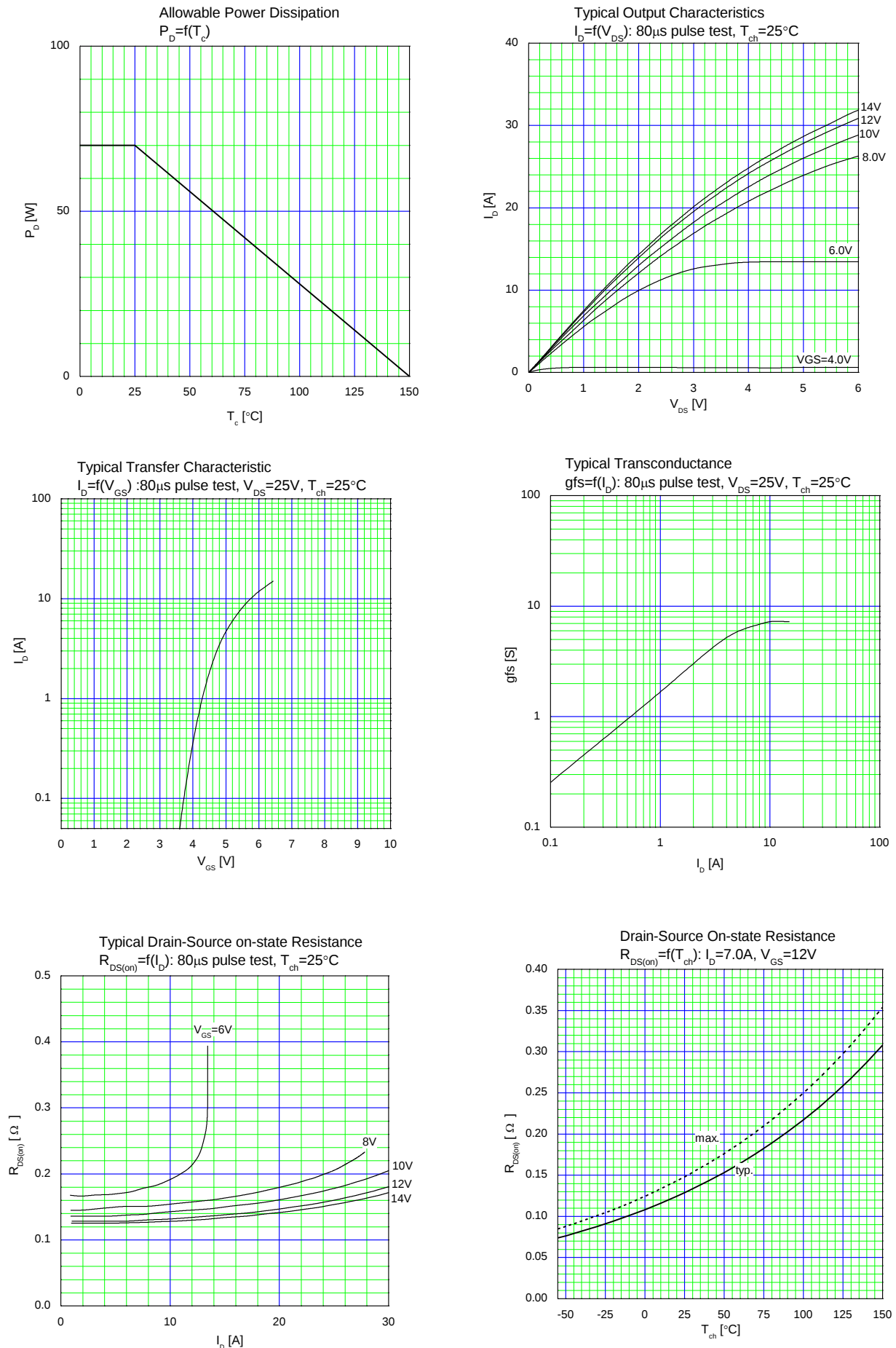


Figure 21. Characteristic Curves of JAXA R 2SK4157 (1/3)

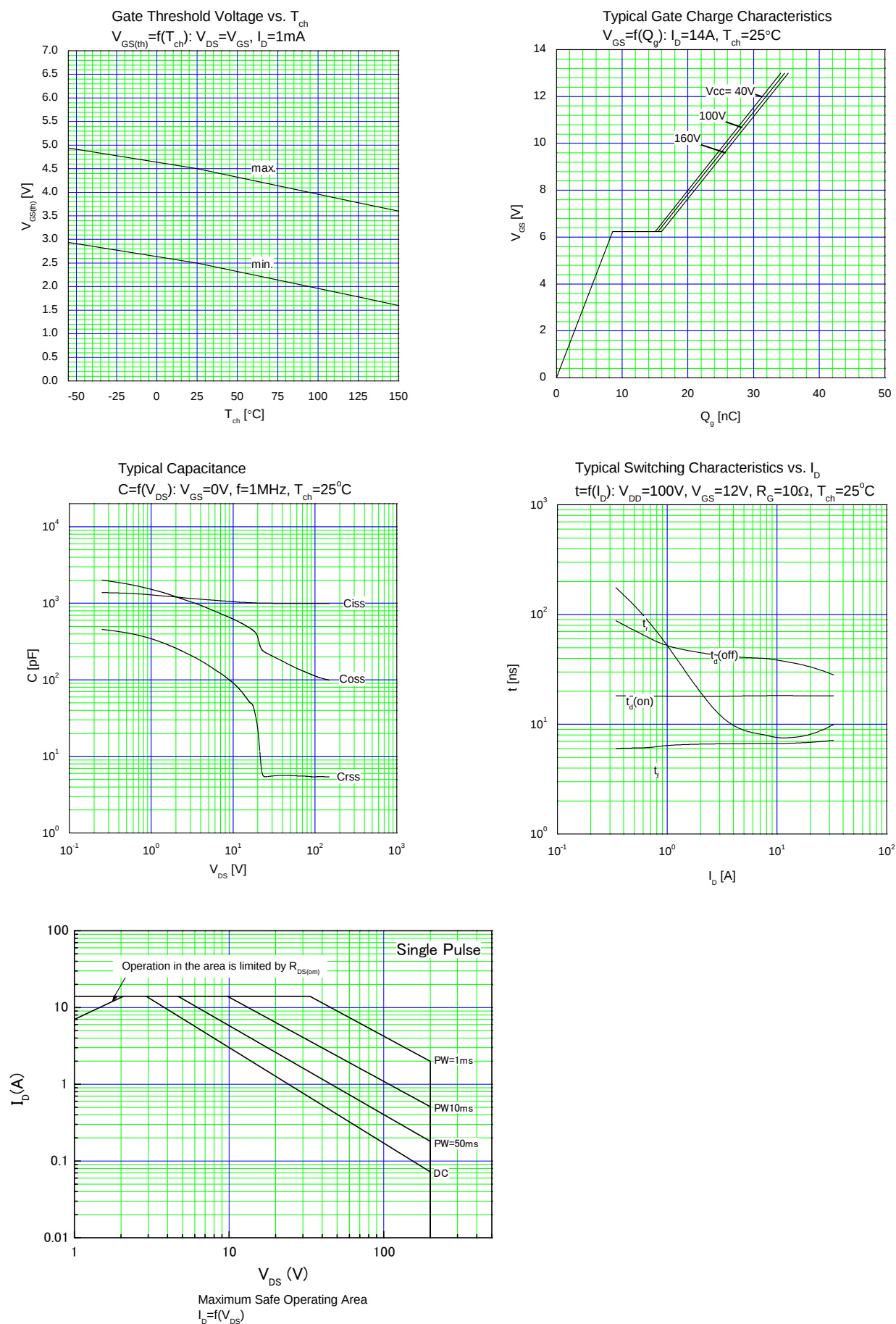


Figure 22. Characteristic Curves of JAXA R 2SK4157 (2/3)

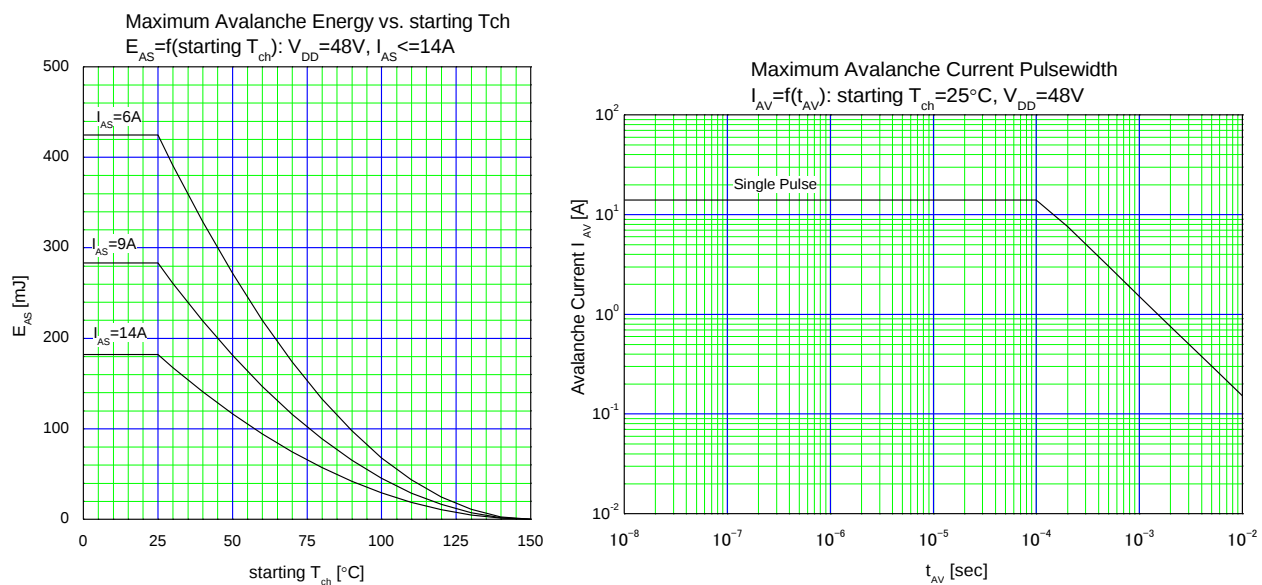


Figure 23. Characteristic Curves of JAXA R 2SK4157 (3/3)

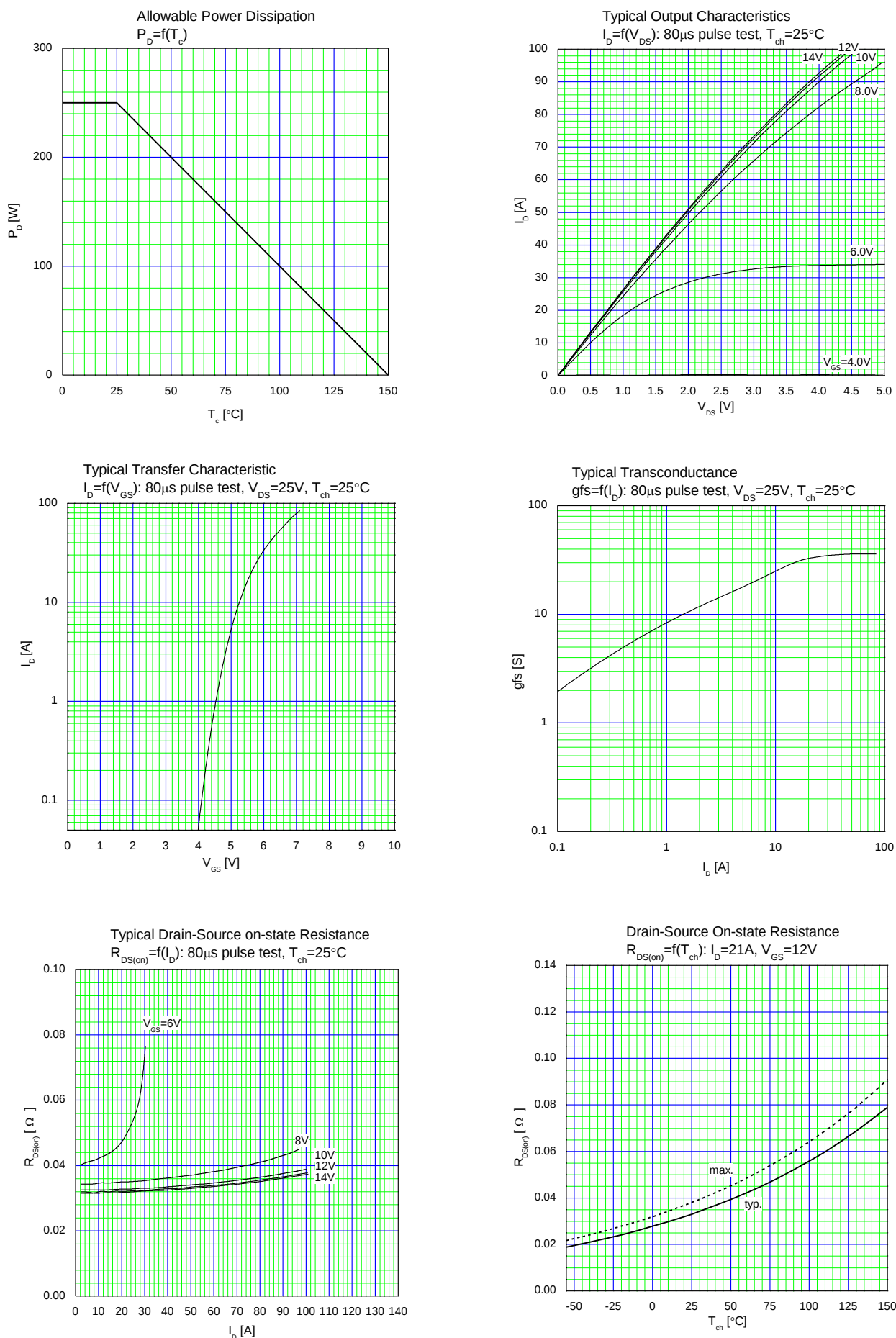


Figure 24. Characteristic Curves of JAXA R 2SK4158 (1/3)

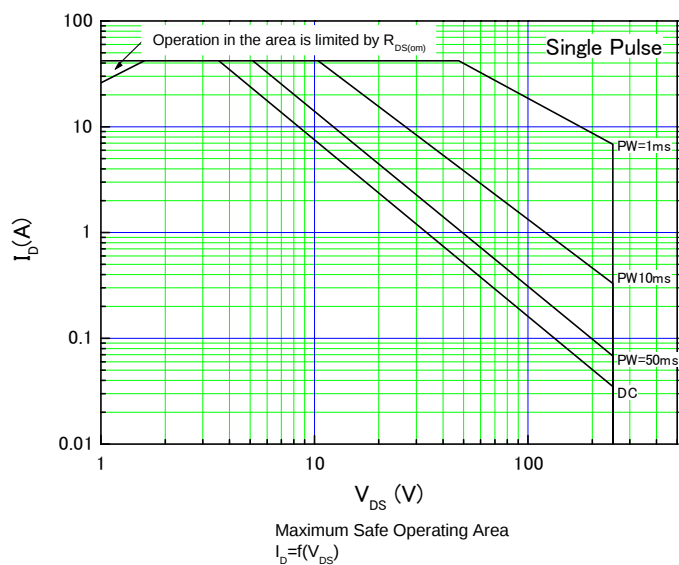
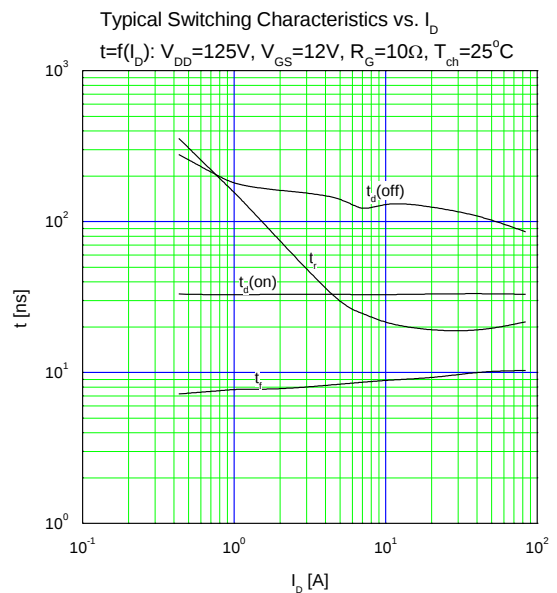
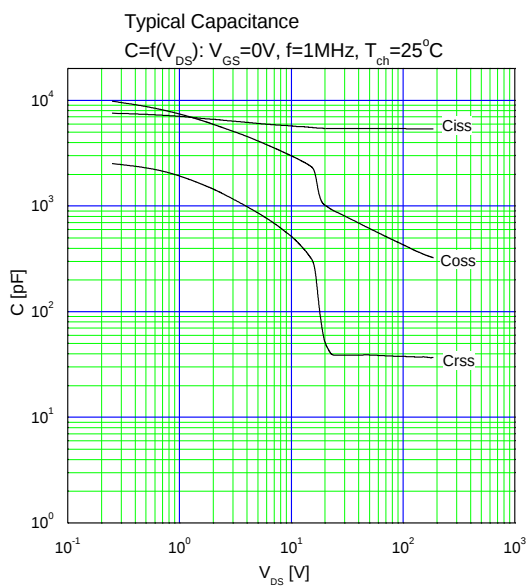
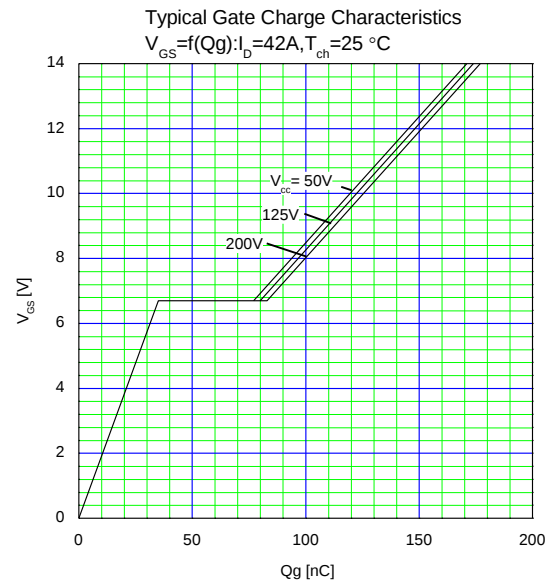
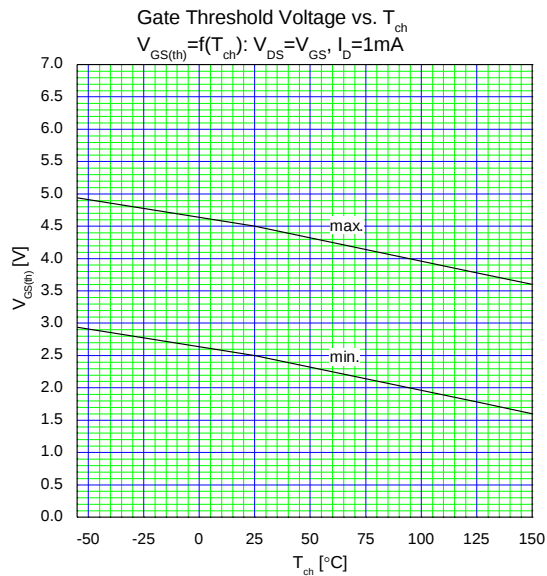


Figure 25. Characteristic Curves of JAXA R 2SK4158 (2/3)

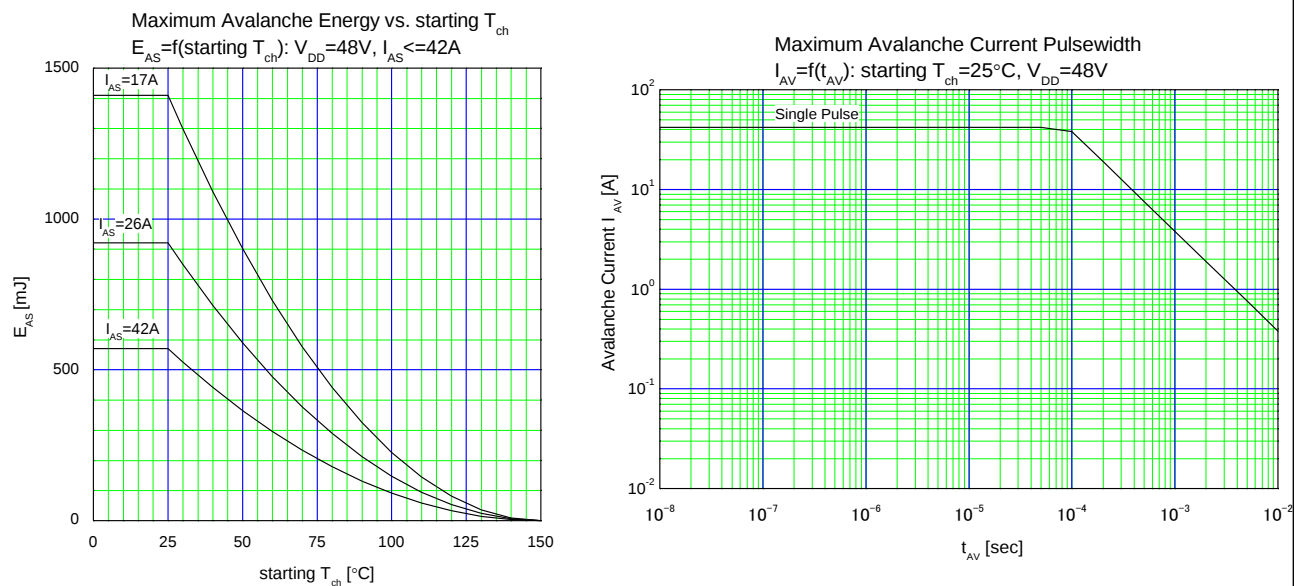


Figure 26. Characteristic Curves of JAXA R 2SK4158 (3/3)

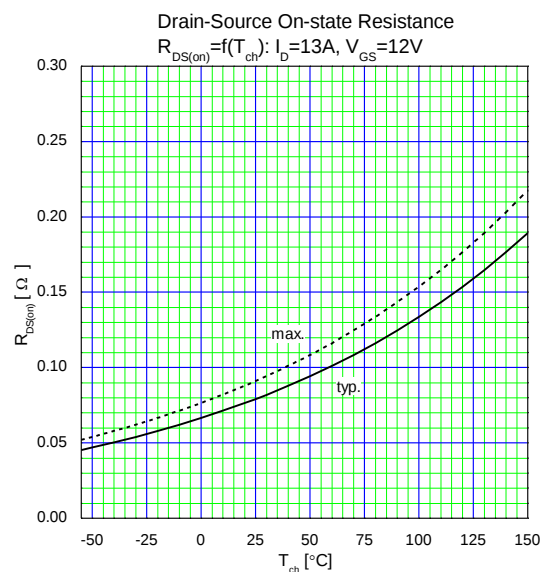
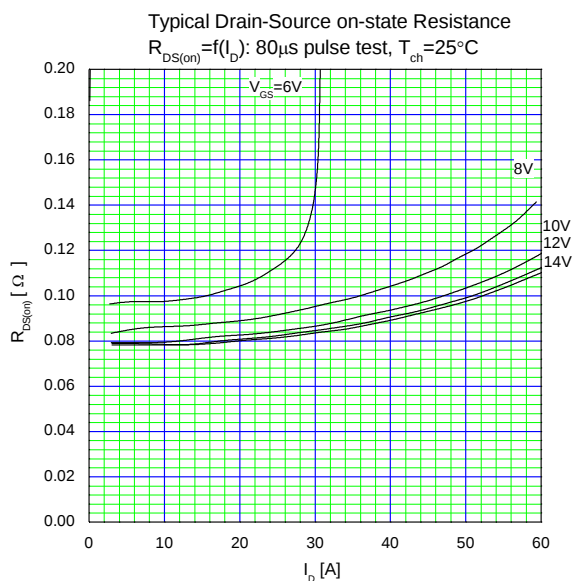
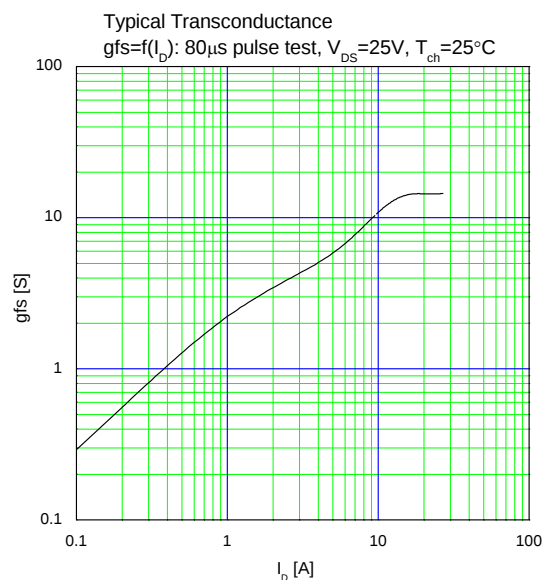
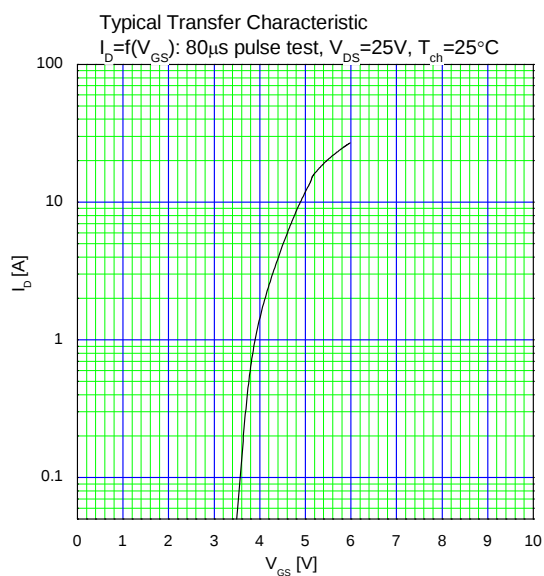
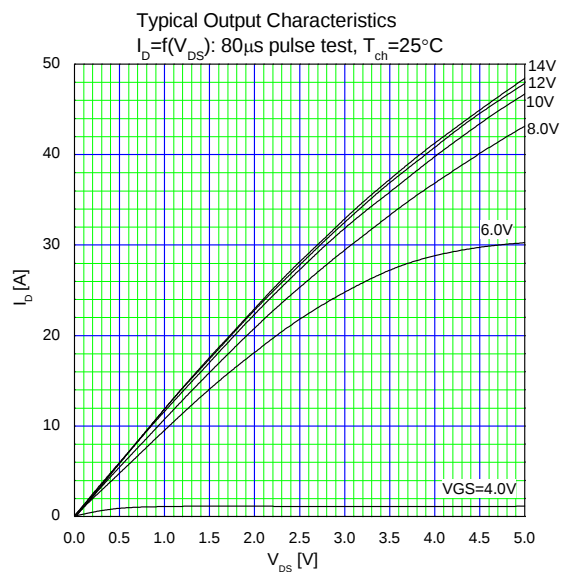
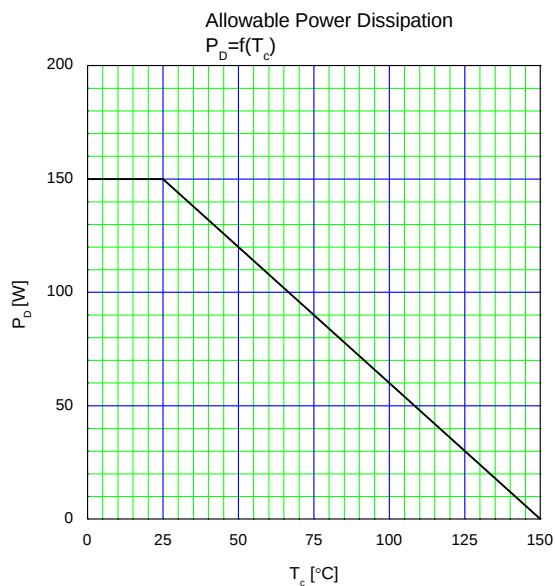


Figure 27. Characteristic Curves of JAXA R 2SK4159 (1/3)

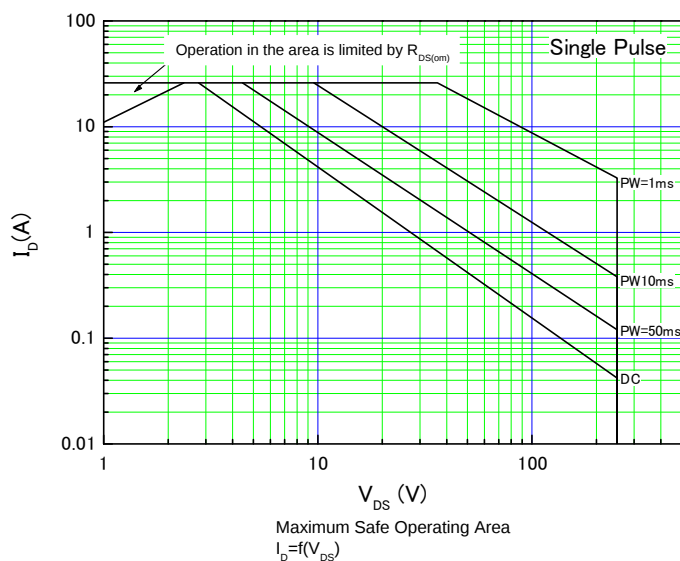
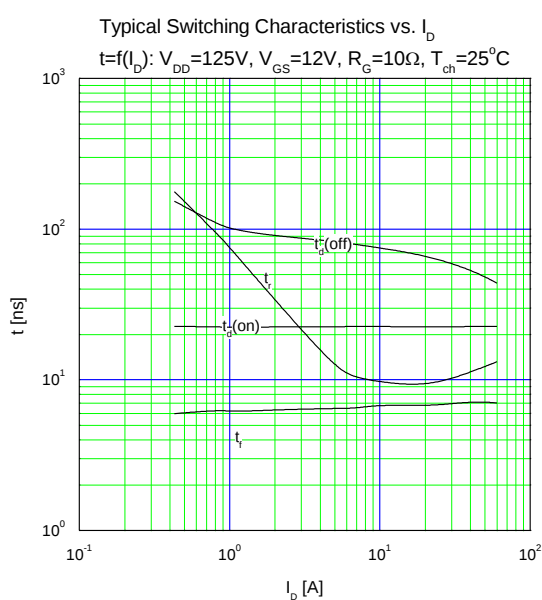
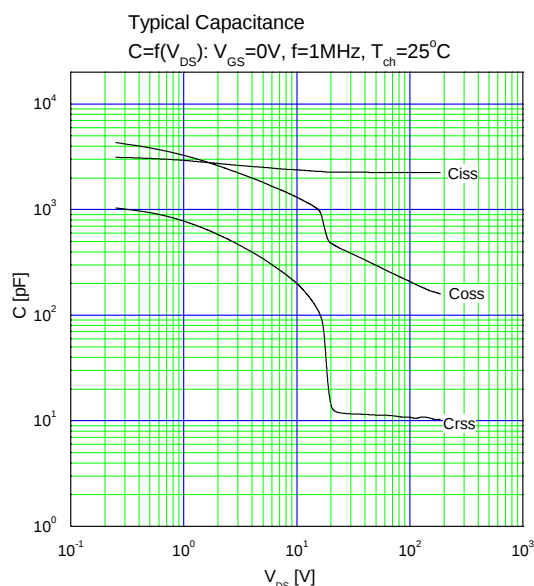
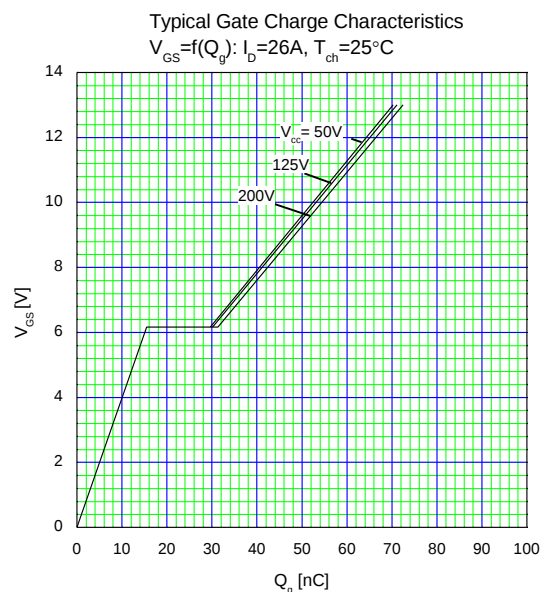
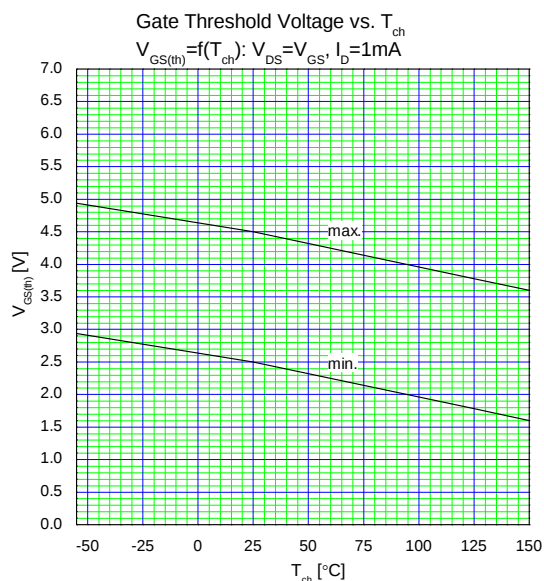


Figure 28. Characteristic Curves of JAXA R 2SK4159 (2/3)

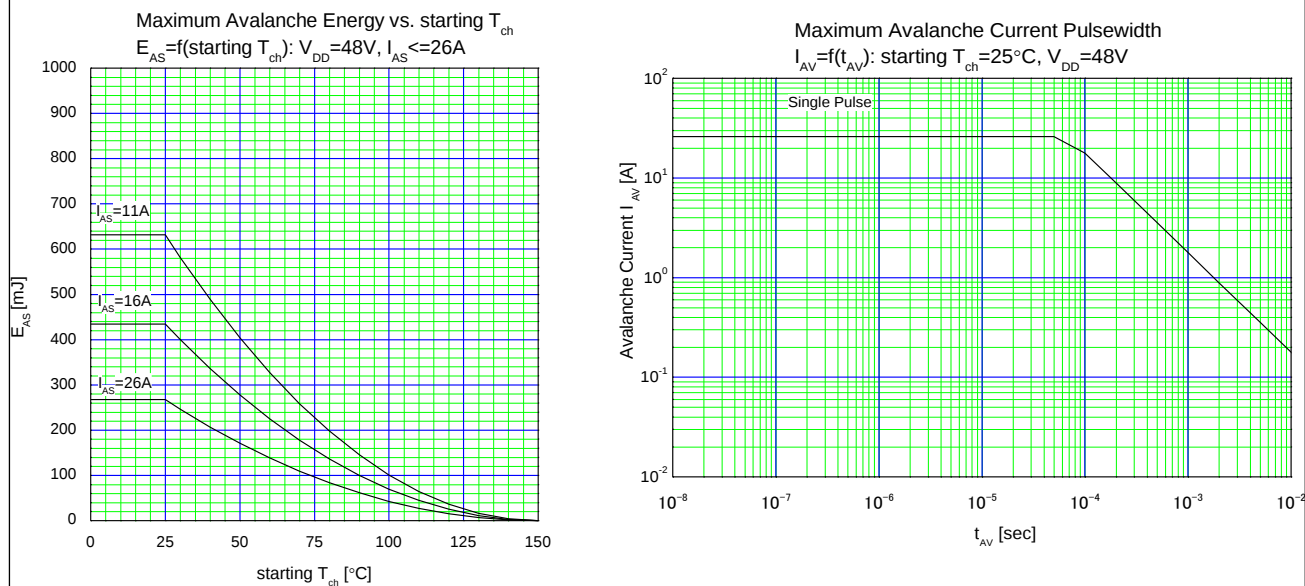


Figure 29. Characteristic Curves of JAXA R 2SK4159 (3/3)

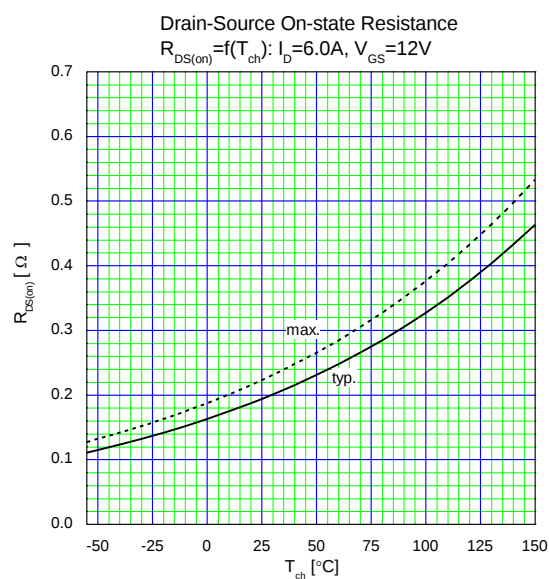
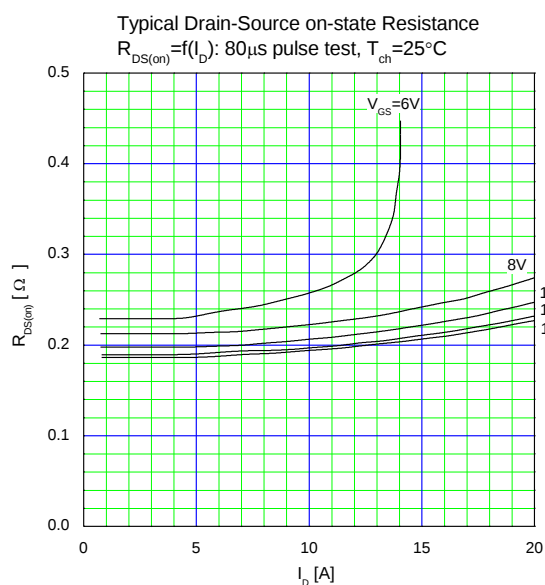
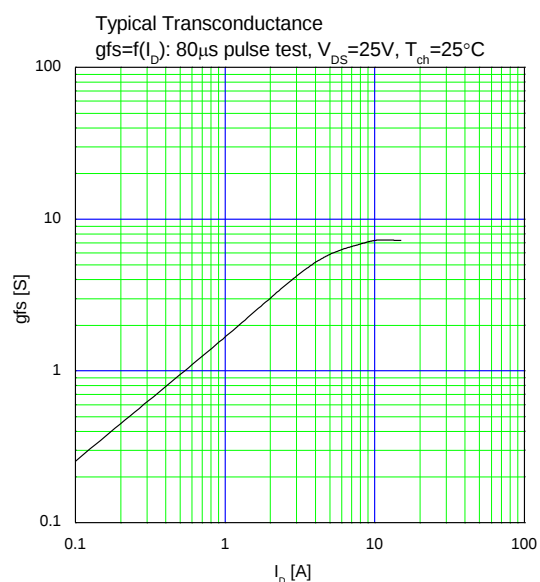
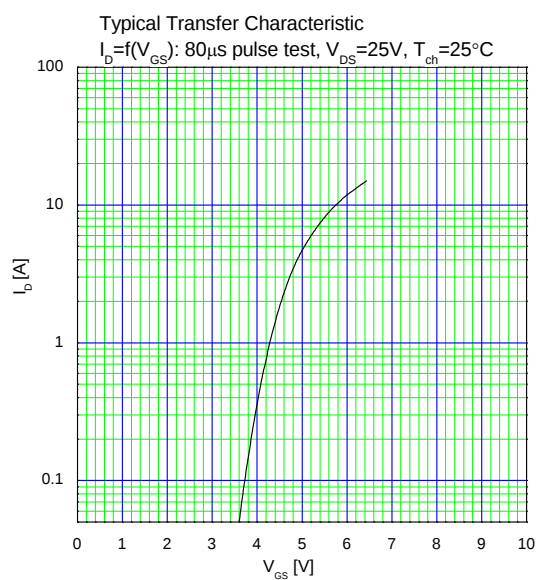
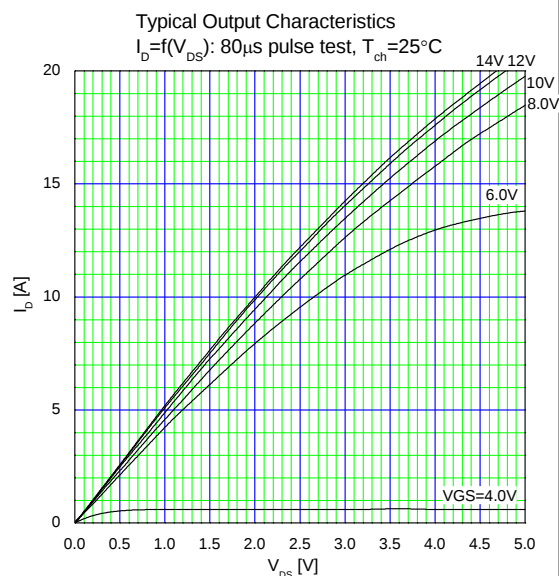
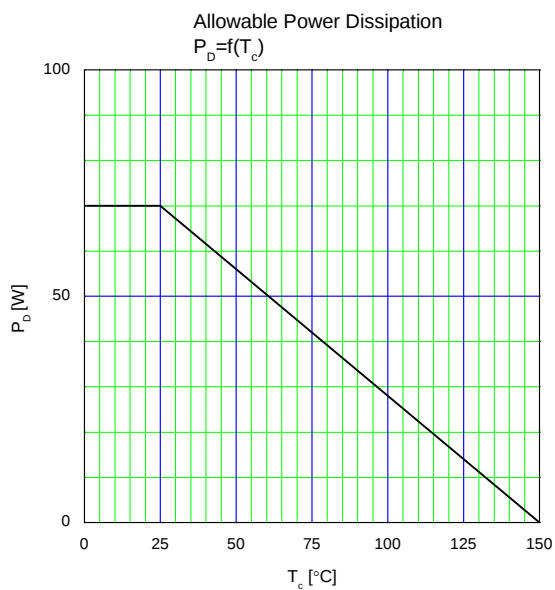


Figure 30. Characteristic Curves of JAXA R 2SK4160 (1/3)

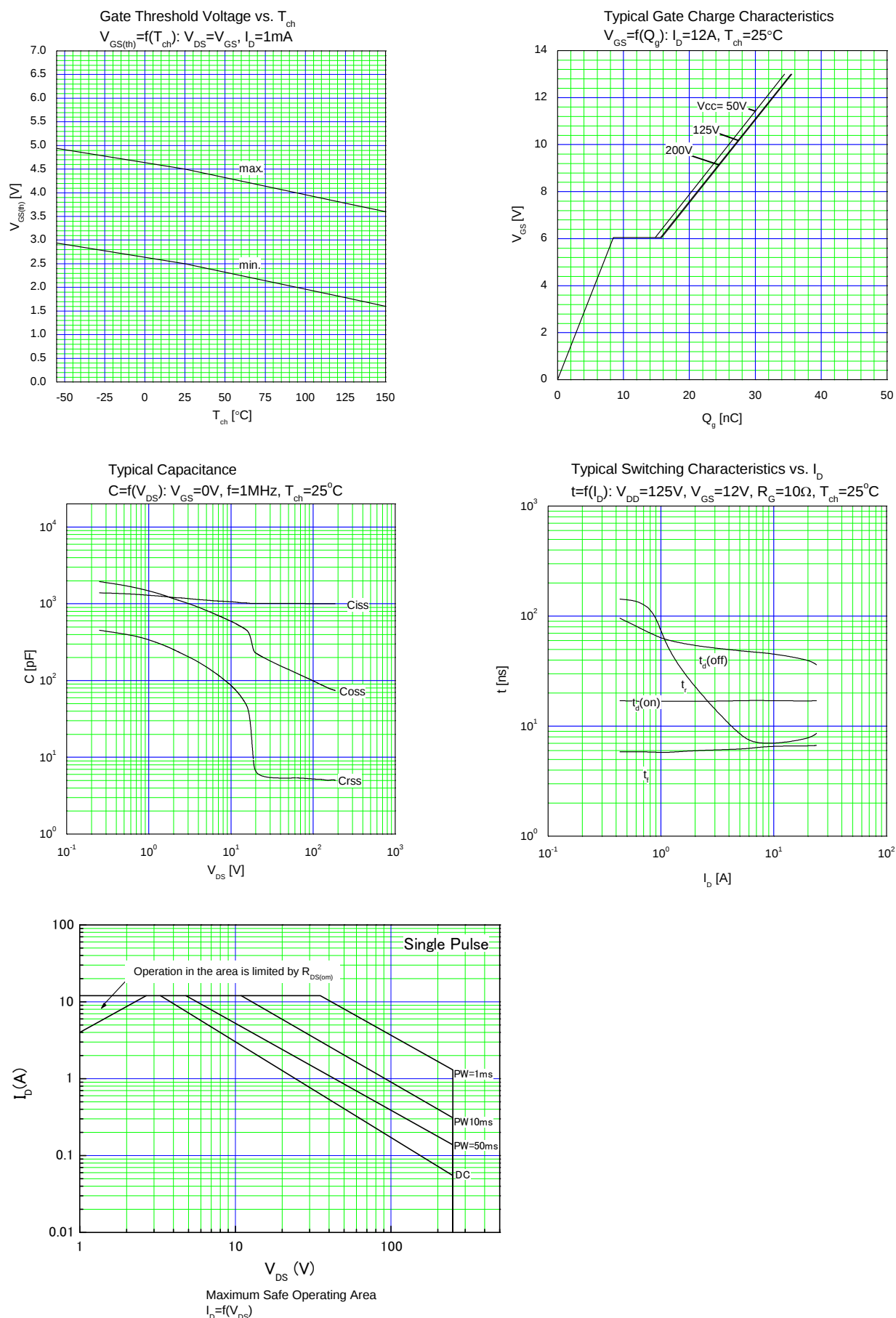


Figure 31. Characteristic Curves of JAXA R 2SK4160 (2/3)

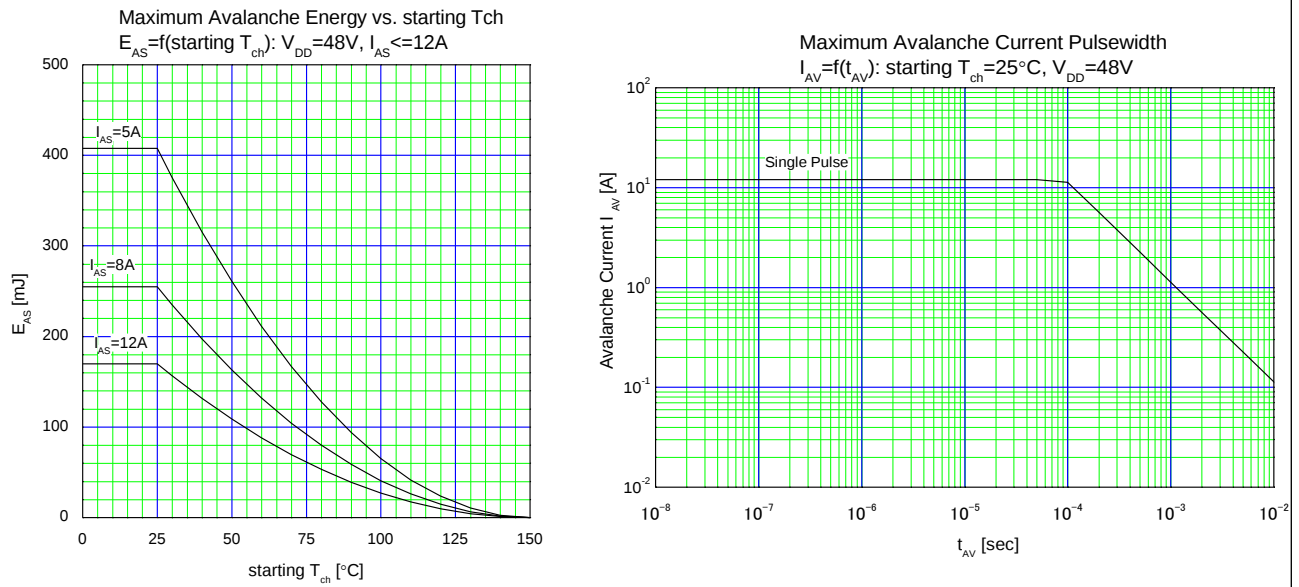


Figure 32. Characteristic Curves of JAXA R 2SK4160 (3/3)

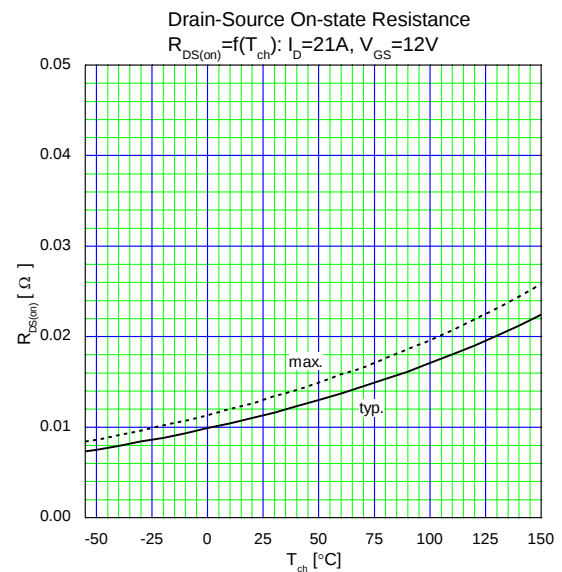
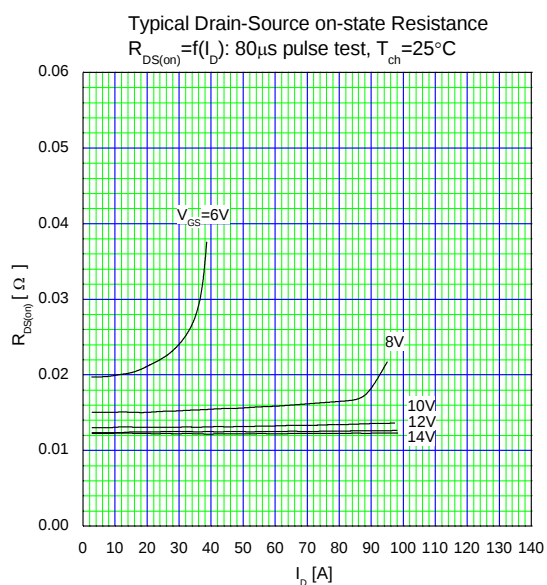
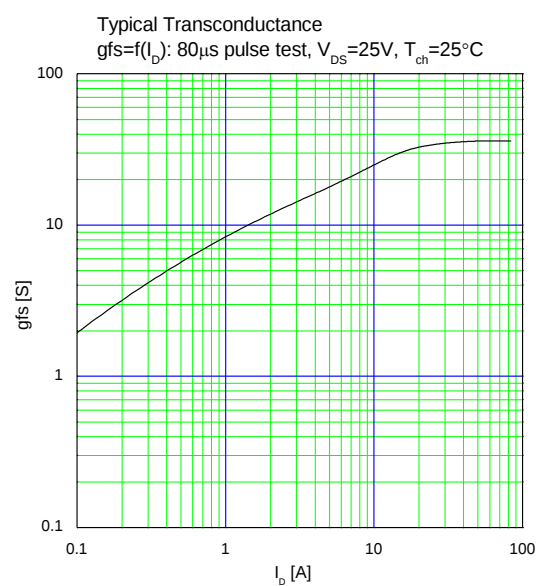
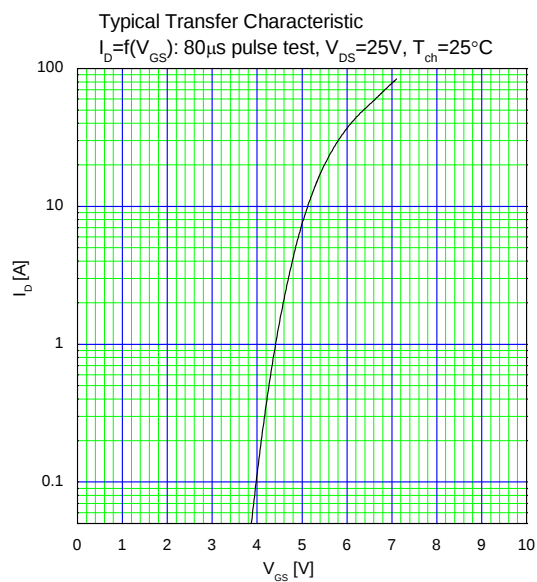
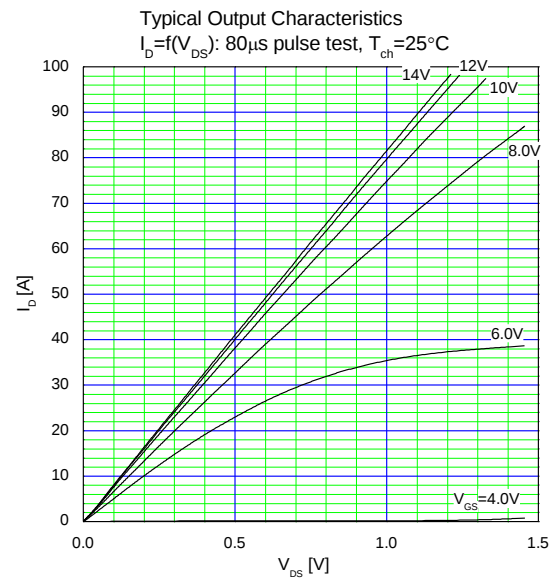
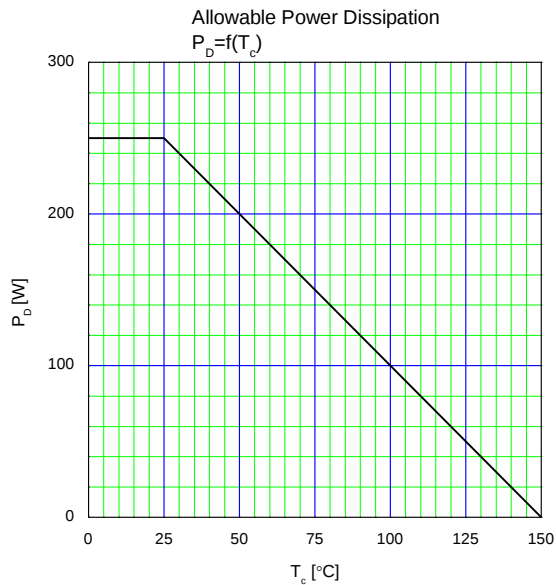


Figure 33. Characteristic Curves of JAXA R 2SK4217 (1/3)

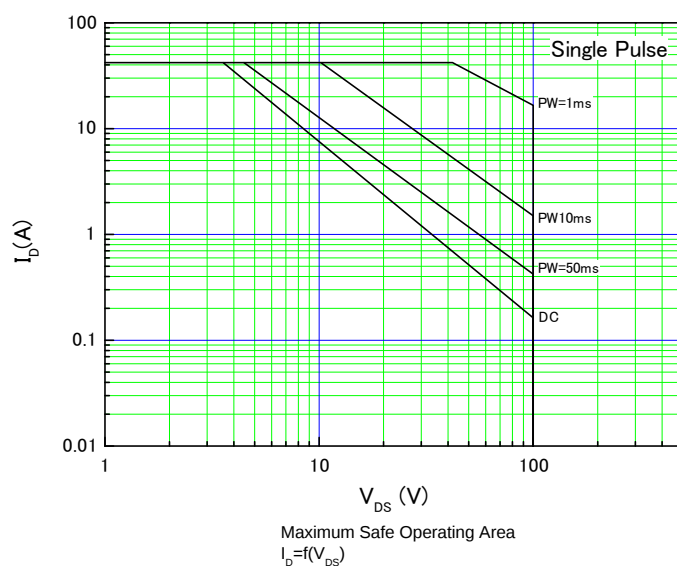
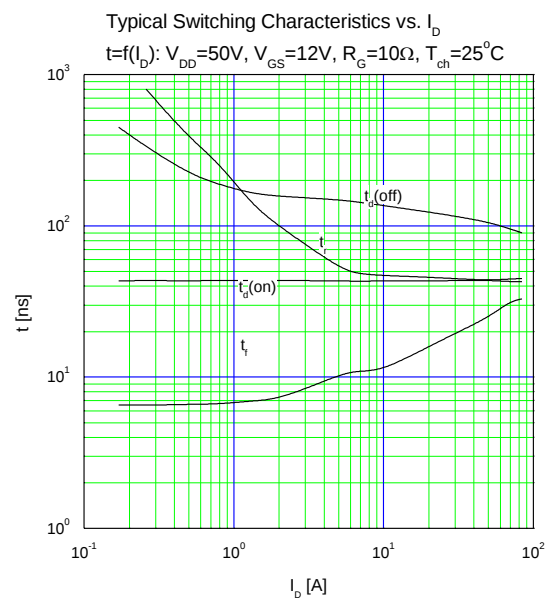
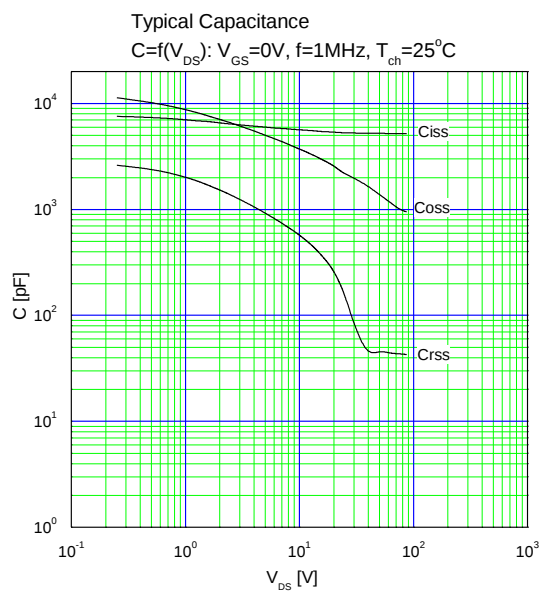
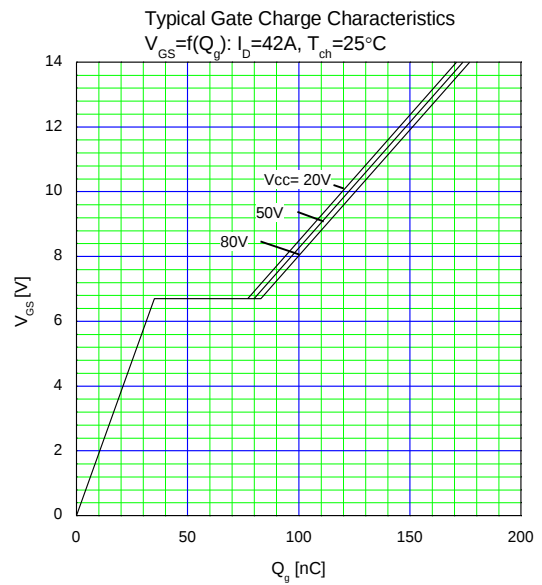
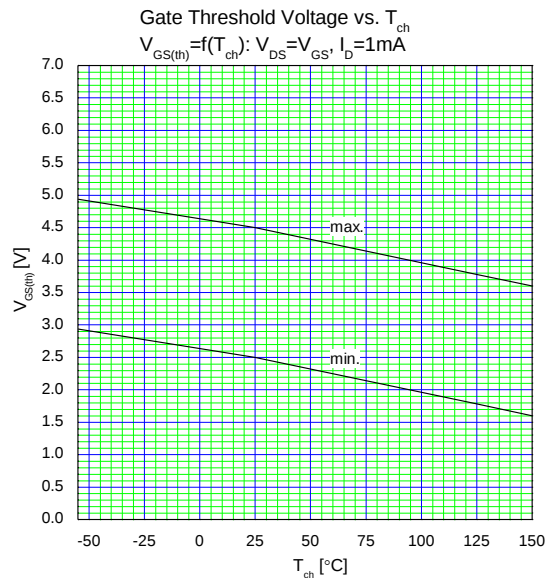


Figure 34. Characteristic Curves of JAXA R 2SK4217 (2/3)

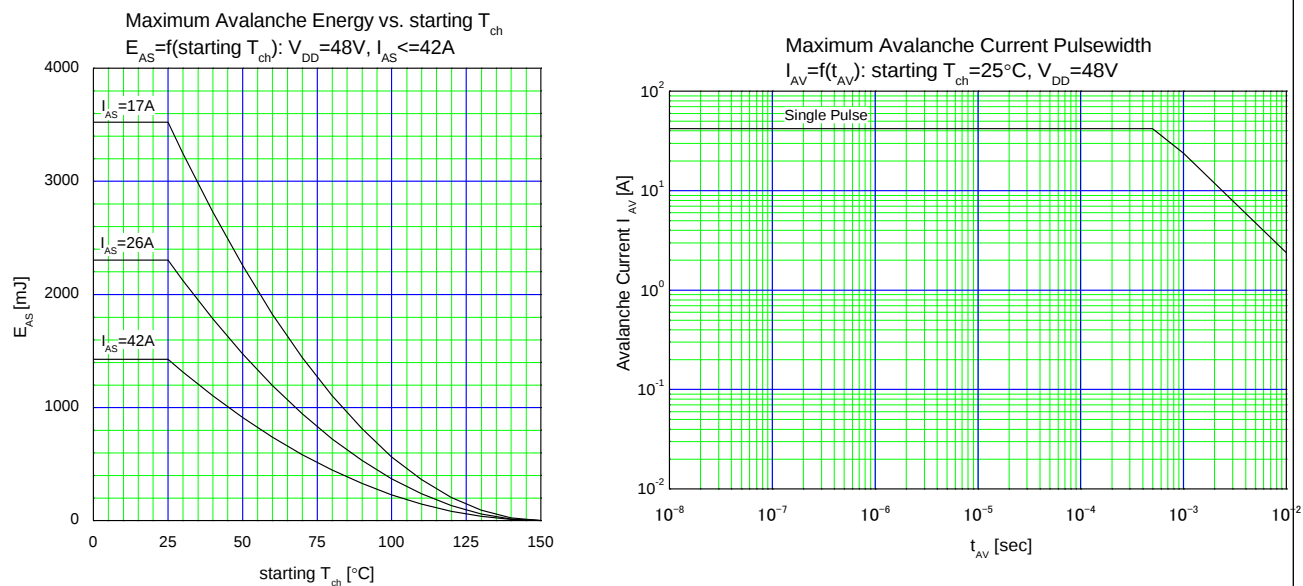


Figure 35. Characteristic Curves of JAXA R 2SK4217 (3/3)

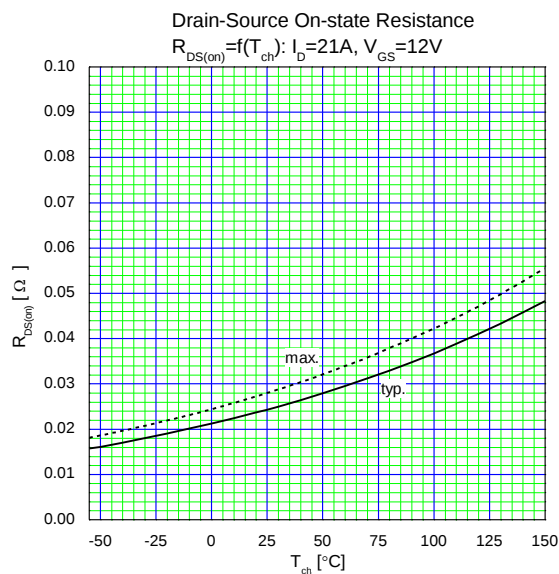
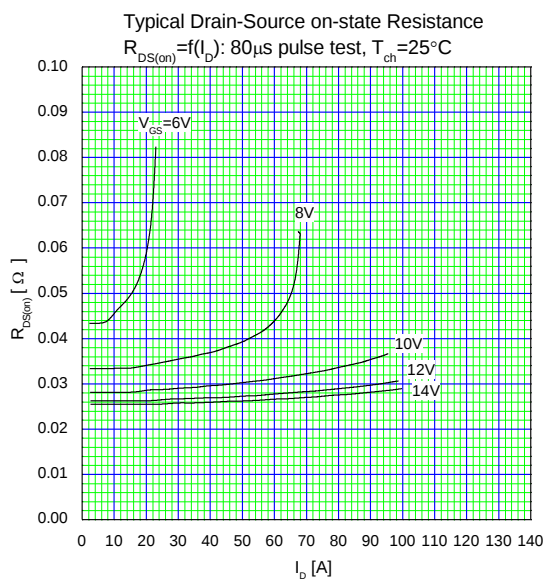
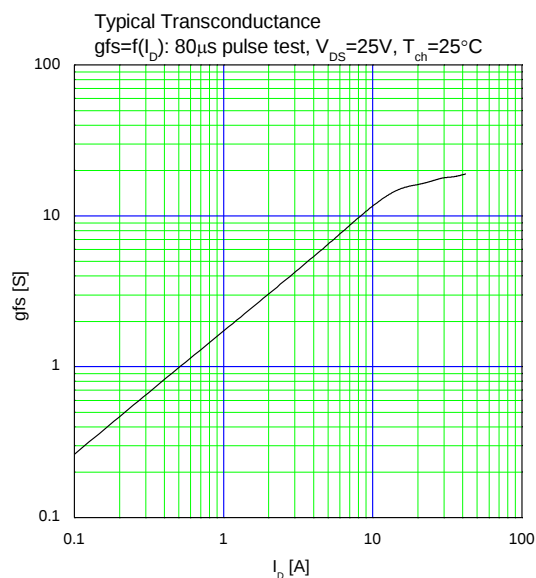
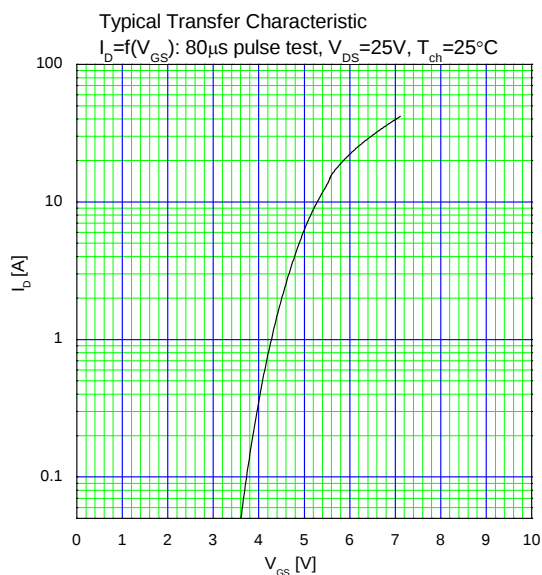
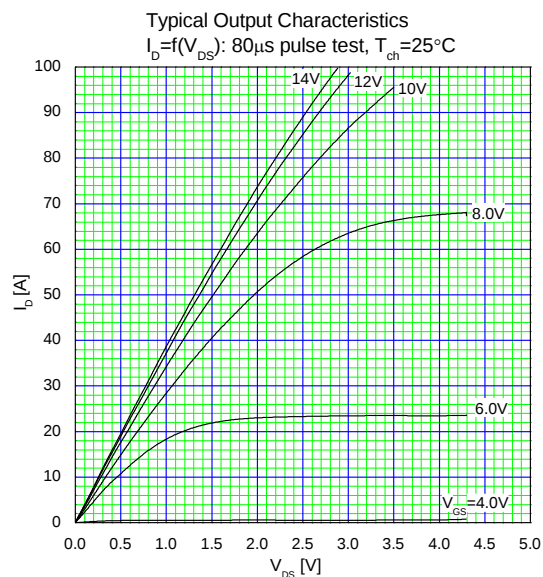
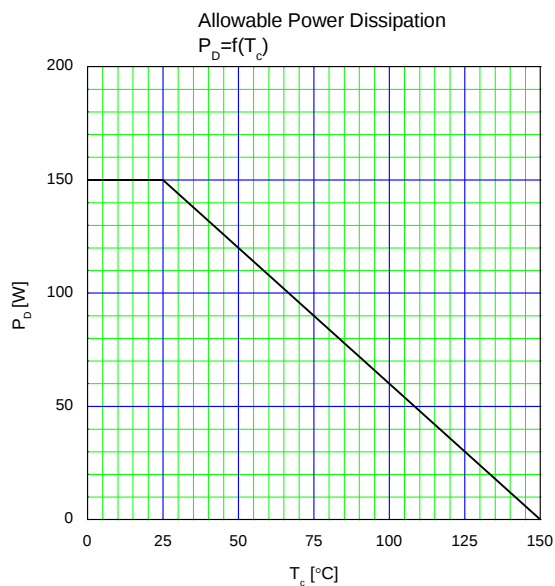


Figure 36. Characteristic Curves of JAXA R 2SK4218 (1/3)

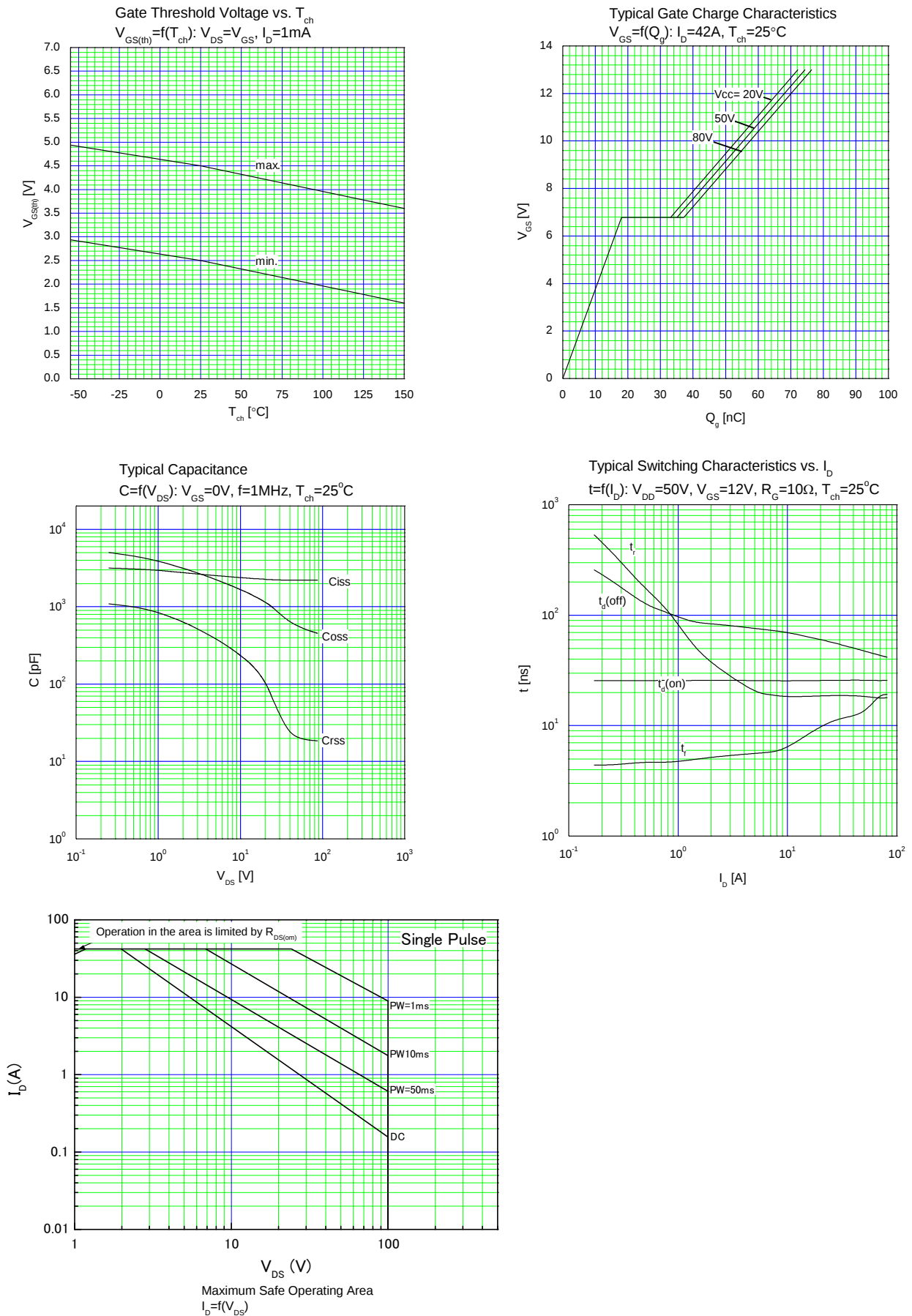


Figure 37. Characteristic Curves of JAXA R 2SK4218 (2/3)

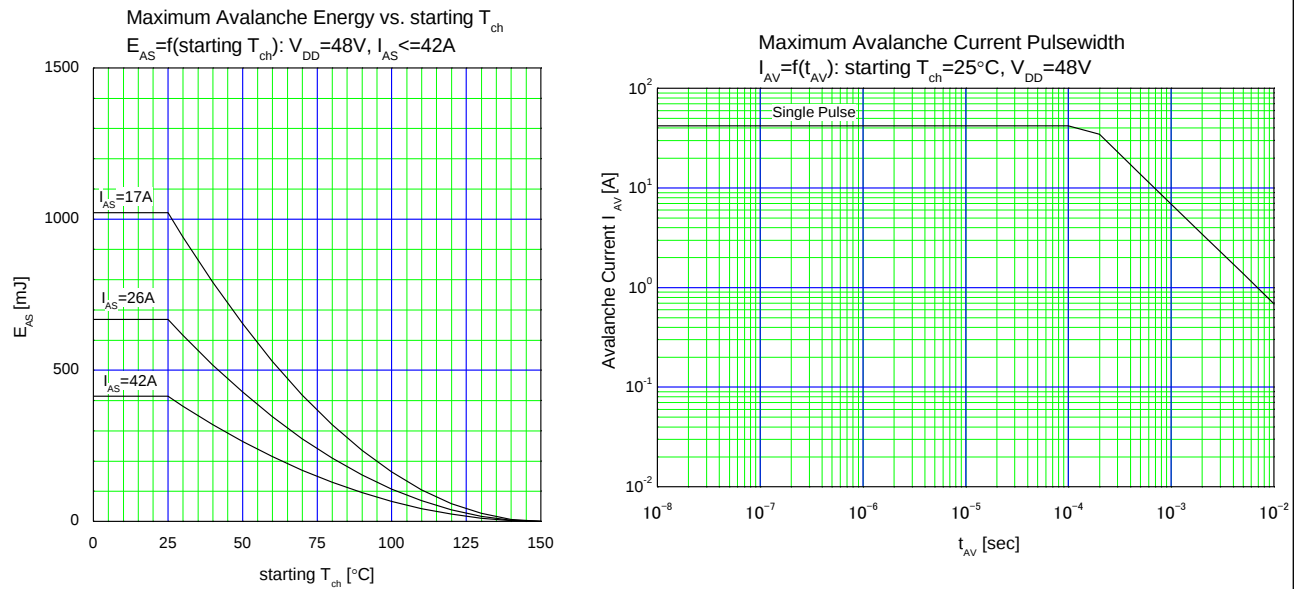


Figure 38. Characteristic Curves of JAXA R 2SK4218 (3/3)

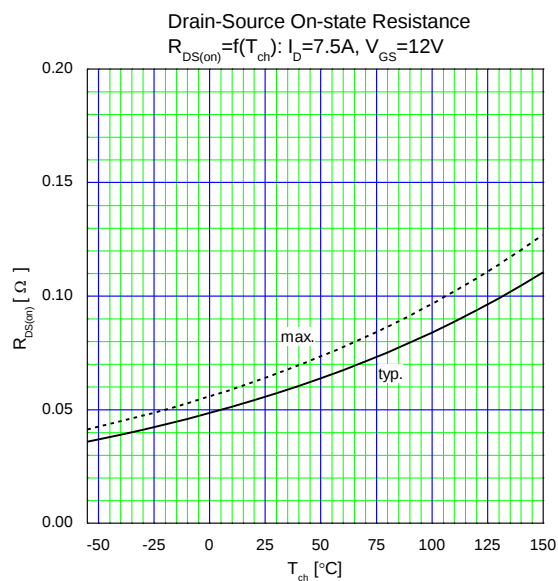
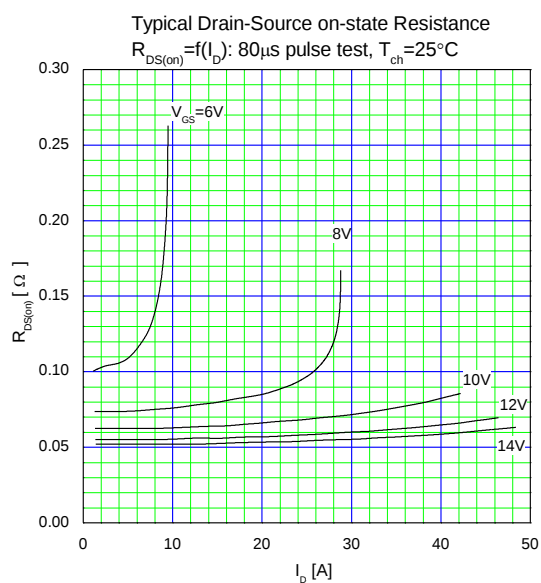
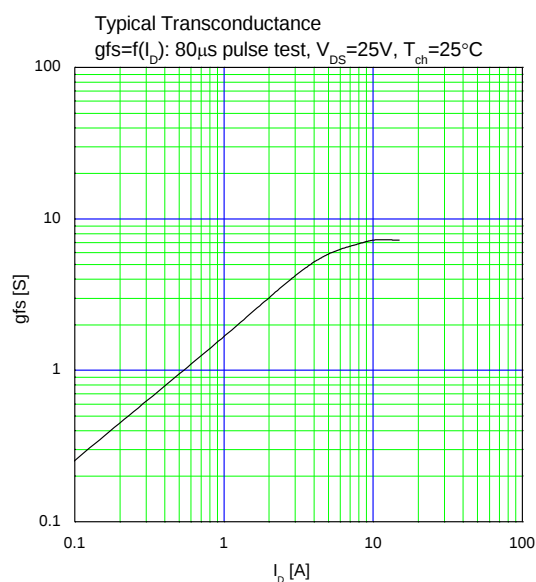
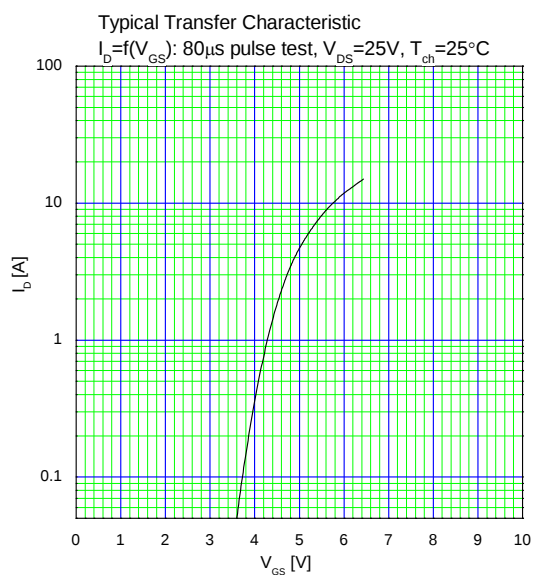
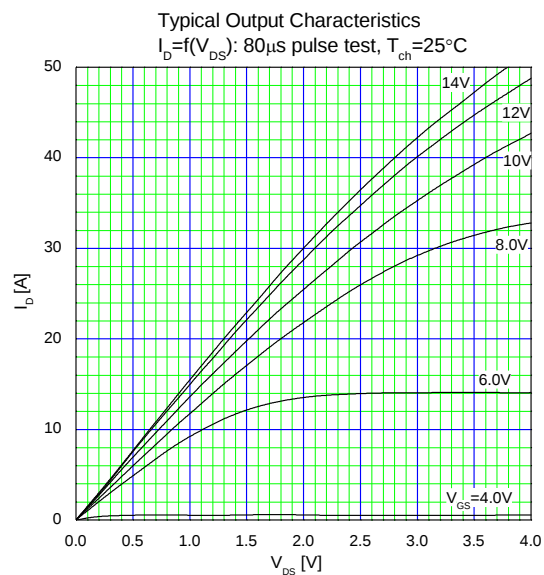
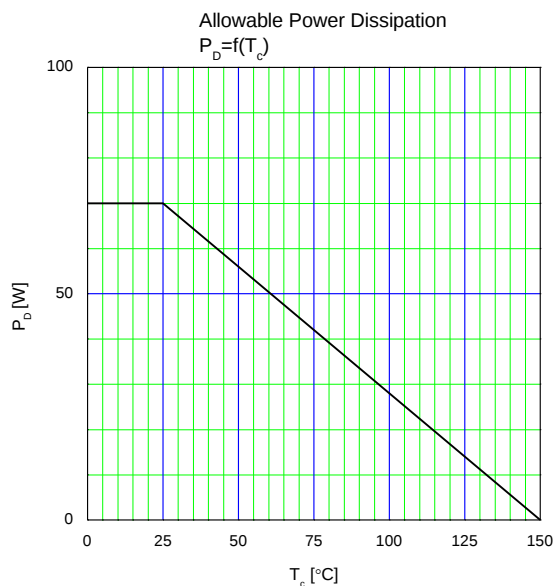


Figure 39. Characteristic Curves of JAXA R 2SK4219 (1/3)

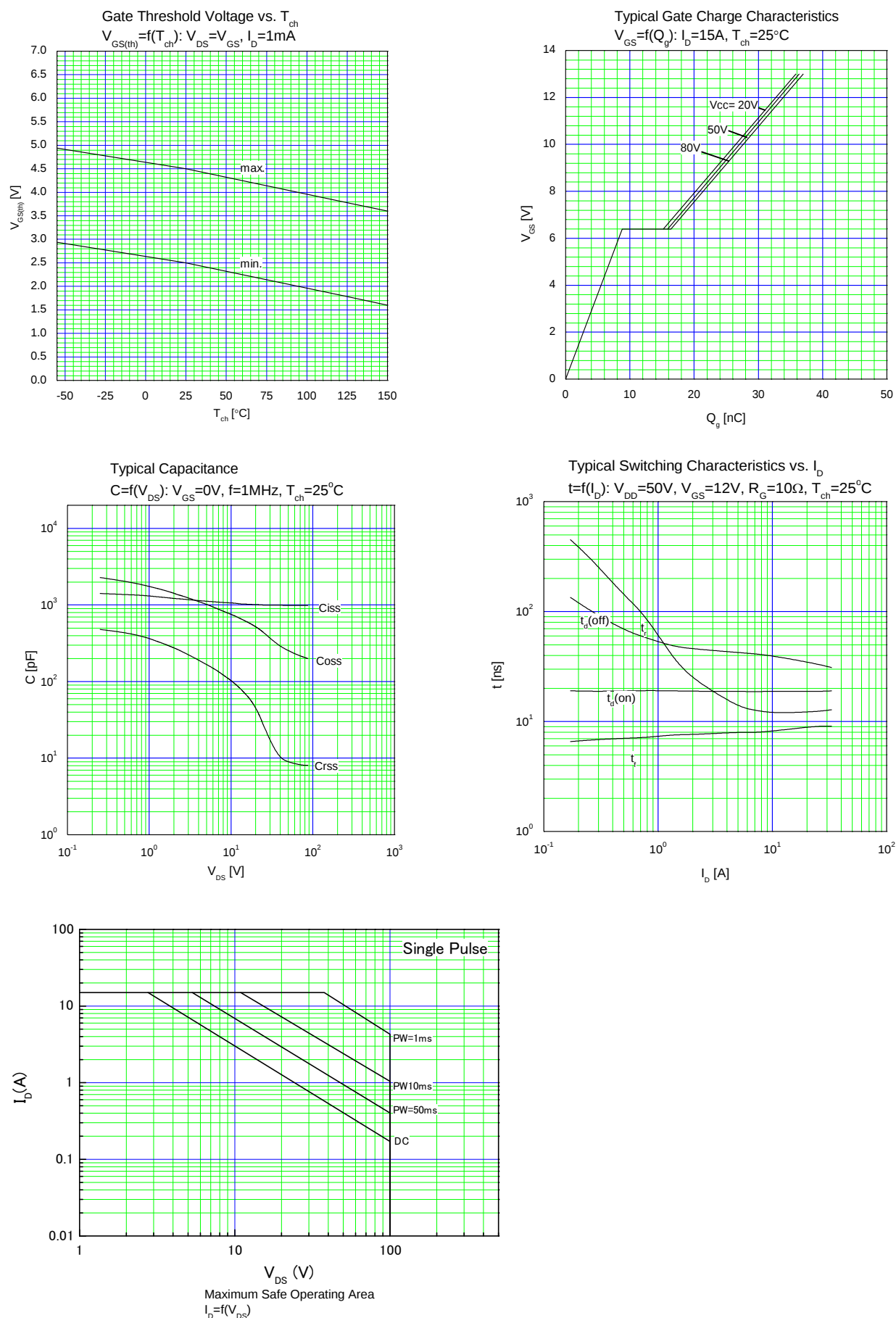


Figure 40. Characteristic Curves of JAXA R 2SK4219 (2/3)

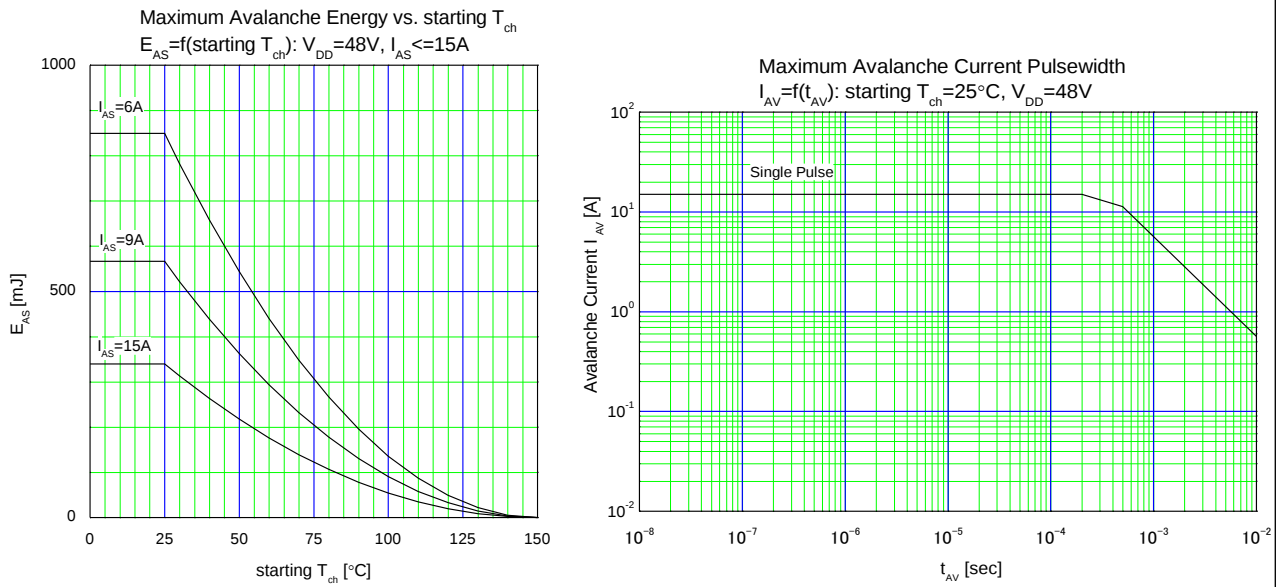


Figure 41. Characteristic Curves of JAXA R 2SK4219 (3/3)

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	0/66 pieces JAXA R 2SK4152 /22pcs JAXA R 2SK4153 /22pcs JAXA R 2SK4154 /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	0/66 pieces JAXA R 2SK4152 /22pcs JAXA R 2SK4153 /22pcs JAXA R 2SK4154 /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	0/66 pieces JAXA R 2SK4152 /22pcs JAXA R 2SK4153 /22pcs JAXA R 2SK4154 /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	0/135 pieces JAXA R 2SK4158 /45pcs JAXA R 2SK4159 /45pcs JAXA R 2SK4160 /45pcs

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 2SK4152, JAXA R 2SK4155 JAXA R 2SK4158, JAXA R 2SK4217	$V_{GS}=\pm 2750V$	Class 2
	JAXA R 2SK4153, JAXA R 2SK4156 JAXA R 2SK4159, JAXA R 2SK4218	$V_{GS}=\pm 1000V$	Class 1
	JAXA R 2SK4154, JAXA R 2SK4157 JAXA R 2SK4160, JAXA R 2SK4219	$V_{GS}=\pm 500V$	Class 1

6.6 Radiation Hardness

Table 10a. Radiation Hardness Test Results

Total Dose Irradiation (TID)	Test Conditions
	Source: Co ⁶⁰ gamma-ray Dose: 1000 Gy(1000Gy/hr), 3000 Gy(3000Gy/hr), 6000 Gy(3000Gy/hr)
	Bias Conditions (During and after irradiation) (a) $V_{DS}=0V$, $V_{GS}=20V$ (b) $V_{DS}=0V$, $V_{GS}=-20V$ (c) $V_{DS}=200V$, $V_{GS}=0V$
	Representative Sample: JAXA R 2SK4158
	Test Results
	For each bias condition: 0/4 pieces (1×10^3 Gy, JAXA R 2SK4158) BV _{DSS} TID dependence: Fig. 42, $V_{GS(th)}$ TID dependence : Fig. 43

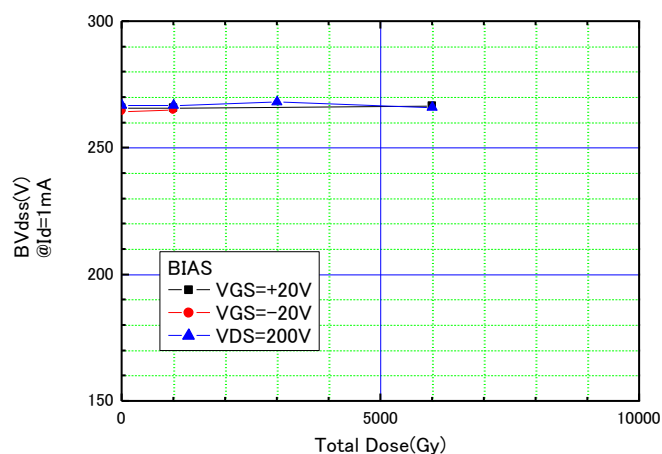


Figure 42. Total Dose Dependence of BV_{DSS} (JAXA R 2SK4158)

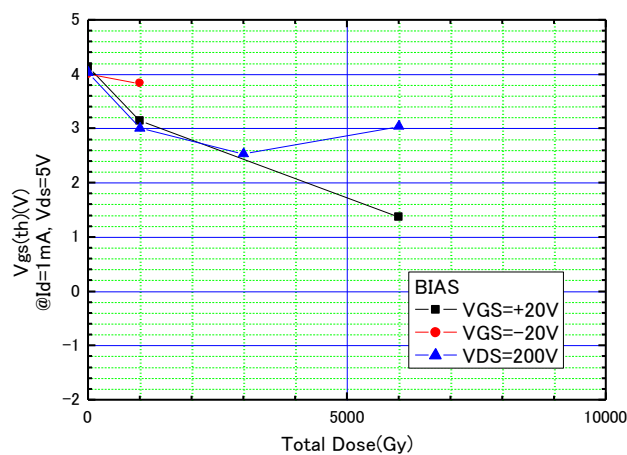


Figure 43. Total Dose Dependence of V_{GS(th)} (JAXA R 2SK4158)

Table 10b. Radiation Hardness Test Results

Part Number JAXA R	100V Class			130V Class			200V Class			250V Class		
	2SK 4217	2SK 4218	2SK 4219	2SK 4152	2SK 4153	2SK 4154	2SK 4155	2SK 4156	2SK 4157	2SK 4158	2SK 4159	2SK 4160
Single Event Tolerance (SEB/SEGR) Single Event Burnout/ Single Event Gate Rupture	Test Conditions											
	LET 37.9MeV/(mg/cm ²)(¹)			LET 38.4MeV/(mg/cm ²)(¹)			LET 39.3MeV/(mg/cm ²)(¹)			LET 40.1MeV/(mg/cm ²)(¹)		
	Ion: ⁸⁹ Y, Energy: 928 MeV Range: 102μm, T _A =25+/-5°C Fluence: 3E5+/- 5% ions/cm ² Irradiation angle: Perpendicular to die surface Limits: I _{GSS} ≤10μA and it shall not be destroyed.											
	Test Results											
	V _{DS} =100V and V _{GS} =-7.5V 0/3 pieces V _{DS} = 20V and V _{GS} =-20V 0/1 piece (SEE-SOA: Fig. 44)			V _{DS} =130V and V _{GS} =-7.5V 0/3 pieces (SEE-SOA: Fig. 45)			V _{DS} =200V and V _{GS} =-7.5V 0/3 pieces V _{DS} =30V and V _{GS} =-20V 0/1 piece (SEE-SOA: Fig. 46)			V _{DS} =250V and V _{GS} =-7.5V 0/3 pieces V _{DS} =30V and V _{GS} =-20V 0/1 piece (SEE-SOA: Fig. 47)		

Note⁽¹⁾: Average LET in the device.

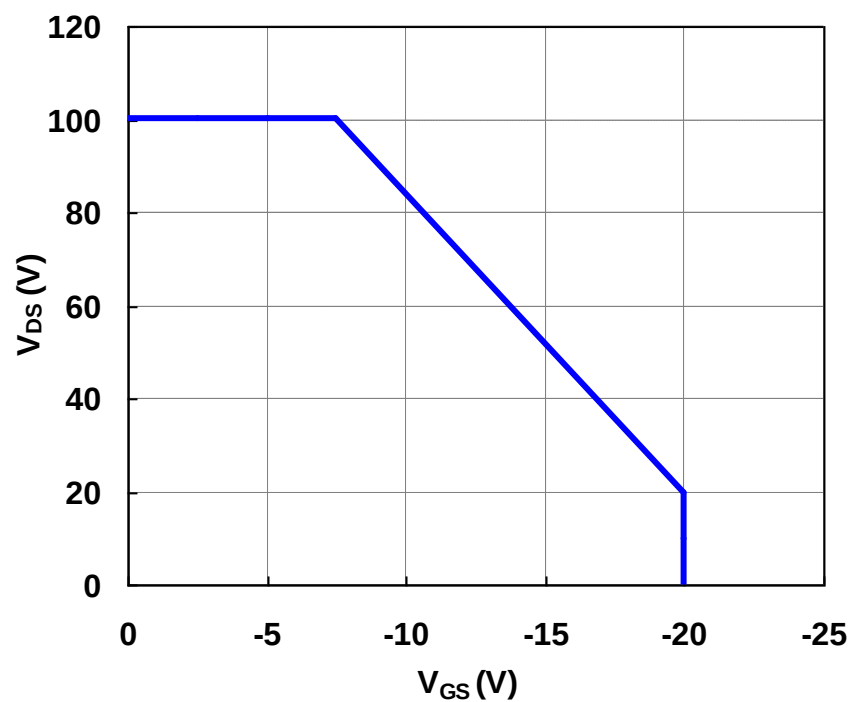


Figure 44. SEE-SOA (JAXA R 2SK4217, 2SK4218, 2SK4219)

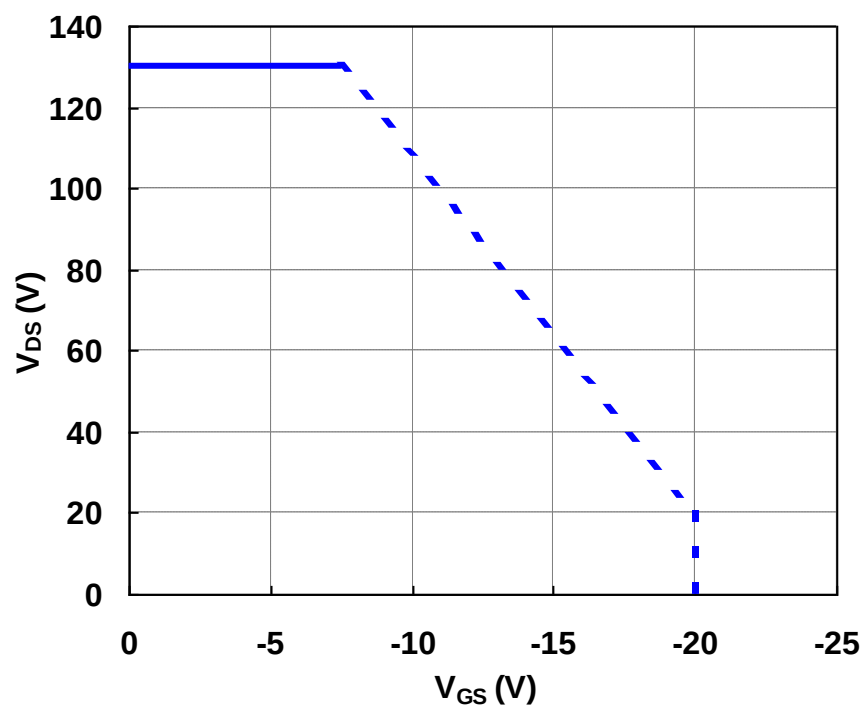


Figure 45. SEE-SOA (JAXA R 2SK4152, 2SK4153, 2SK4154)

Note: The dotted line in this figure is estimated from the results of radiation hardness test in the 100V-class devices.

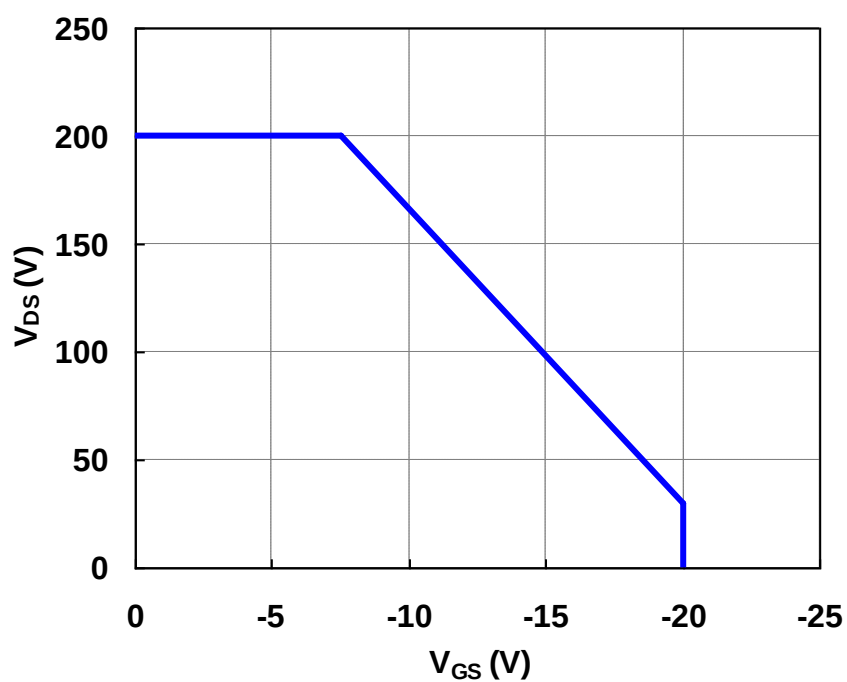


Figure 46. SEE-SOA (JAXA R 2SK4155, 2SK4156, 2SK4157)

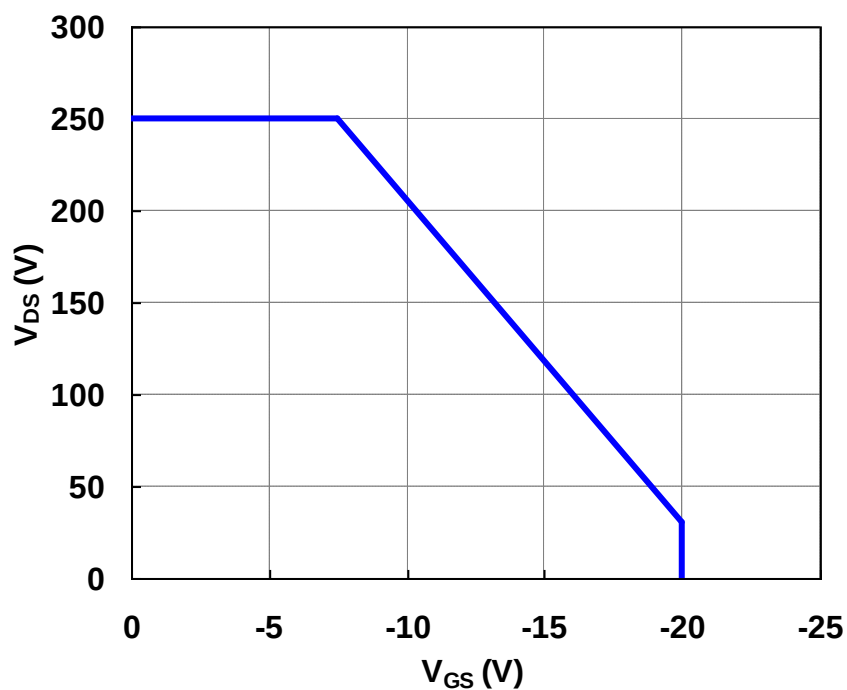


Figure 47. SEE-SOA (JAXA R 2SK4158, 2SK4159, 2SK4160)

7. RELIABILITY

7.1 Accelerated Test Results

The accelerated test results are 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 2SK4152/15 pcs JAXA R 2SK4153/15 pcs JAXA R 2SK4154/15 pcs JAXA R 2SK4155/15 pcs JAXA R 2SK4156/15 pcs JAXA R 2SK4157/15 pcs JAXA R 2SK4158/15 pcs JAXA R 2SK4159/15 pcs JAXA R 2SK4160/15 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 2SK4152, K4153, K4154: $V_{DS}=104\text{V}$ 2SK4155, K4156, K4157: $V_{DS}=160\text{V}$ 2SK4158, K4159, K4160: $V_{DS}=200\text{V}$	0/135 pieces (JAXA R 2SK4152/15 pcs JAXA R 2SK4153/15 pcs JAXA R 2SK4154/15 pcs JAXA R 2SK4155/15 pcs JAXA R 2SK4156/15 pcs JAXA R 2SK4157/15 pcs JAXA R 2SK4158/15 pcs JAXA R 2SK4159/15 pcs JAXA R 2SK4160/15 pcs)
Thermal shock (Temperature Cycling)	-55 to 150°C , 500cycles	0/135 pieces (JAXA R 2SK4158/45 pcs JAXA R 2SK4159/45 pcs JAXA R 2SK4160/45 pcs)
Intermittent operating life test (Power Cycling)	$\Delta T_c=70\text{deg}$, 6000cycles	0/72 pieces (JAXA R 2SK4152/8 pcs JAXA R 2SK4153/8 pcs JAXA R 2SK4154/8 pcs JAXA R 2SK4155/8 pcs JAXA R 2SK4156/8 pcs JAXA R 2SK4157/8 pcs JAXA R 2SK4158/8 pcs JAXA R 2SK4159/8 pcs JAXA R 2SK4160/8 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 reflow soldering of terminals for SMD package should be performed at 200°C or more for 30 to 60sec of pre-heat temperature and at 240°C or below for 10sec of peak temperature in accordance with JERG-0-043.
- (2) In handling the product, ground human body, work area and measuring instruments.

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