

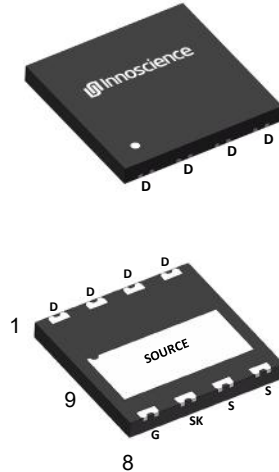
INN650D190A

1. General description

650V GaN-on-Silicon Enhancement-mode Power Transistor in Dual Flat No-lead package (DFN) with 8 mm × 8 mm size

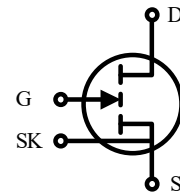
2. Features

- Enhancement mode transistor-Normally off power switch
- Ultra high switching frequency
- No reverse-recovery charge
- Low gate charge, low output charge
- Qualified for industrial applications according to JEDEC Standards
- ESD safeguard
- RoHS, Pb-free, REACH-compliant



3. Applications

- DCM/BCM PFC
- AHB/LLC/QR Flyback/ACF DCDC converter
- LED driver
- Fast battery charger
- Notebook/AIO adaptor
- Desktop PC/ATX/TV/power tool power supply



4. Key performance parameters

Table 1 Key performance parameters at $T_j = 25\text{ }^\circ\text{C}$

Parameter	Value	Unit
$V_{DS,max}$	650	V
$R_{DS(on),max}$ @ $V_{GS} = 6\text{ V}$	190	m Ω
$Q_{G,typ}$ @ $V_{DS} = 400\text{ V}$	2.8	nC
$I_{D,pulse}$	20.5	A
Q_{OSS} @ $V_{DS} = 400\text{ V}$	24.5	nC
Q_{rr} @ $V_{DS} = 400\text{ V}$	0	nC

5. Pin information

Table 2 Pin information

Gate	Drain	Kelvin Source	Source
8	1,2,3,4	7	5,6,9

Table 3 Ordering information

Type/Ordering Code	Package	Product Code
INN650D190A	DFN 8X8	65D190A

Table of contents

1. General description	1
2. Features	1
3. Applications.....	1
4. Key performance parameters.....	1
5. Pin information	1
6. Maximum ratings.....	3
7. Thermal characteristics.....	4
8. Electric characteristics	5
9. Electric characteristics diagrams	7
10.Package outlines	13
11.Reel information.....	14
12.Recommended PCB footprint	15
13.Revision history	16

6. Maximum ratings

at $T_j = 25\text{ °C}$ unless otherwise specified

Exceeding the maximum ratings may destroy the device. For further information, contact Innoscience sales office

Table 4 Maximum ratings

Parameter	Symbol	Values	Unit	Note/Test Condition
Drain source voltage	$V_{DS,max}$	650	V	$V_{GS} = 0\text{ V}$, $T_j = -55\text{ °C}$ to 150 °C
Drain source voltage transient ¹	$V_{DS,transient}$	800	V	$V_{GS} = 0\text{ V}$
Drain source voltage, pulsed ²	$V_{DS,pulse}$	750	V	$T_j = 25\text{ °C}$; total time < 10 h
				$T_j = 125\text{ °C}$; total time < 1 h
Continuous current, drain source	I_D	11.5	A	$T_c = 25\text{ °C}$
Pulsed current, drain source ³	$I_{D,pulse}$	20.5	A	$T_c = 25\text{ °C}$; $V_{GS} = 6\text{ V}$; $t_{PULSE} = 10\text{ }\mu\text{s}$
Pulsed current, drain source ³	$I_{D,pulse}$	11.5	A	$T_c = 125\text{ °C}$; $V_{GS} = 6\text{ V}$; $t_{PULSE} = 10\text{ }\mu\text{s}$
Gate source voltage, continuous ⁴	V_{GS}	-1.4 to +7	V	$T_j = -55\text{ °C}$ to 150 °C
Gate source voltage, pulsed	$V_{GS,pulse}$	-20 to +10	V	$T_j = -55\text{ °C}$ to 150 °C ; $t_{PULSE} = 50\text{ ns}$, $f = 100\text{ kHz}$; open drain
Power dissipation	P_{tot}	84	W	$T_c = 25\text{ °C}$
Operating temperature	T_j	-55 to +150	°C	
Storage temperature	T_{stg}	-55 to +150	°C	

1 $V_{DS,transient}$ is intended for non-repetitive events, $t_{PULSE} < 200\text{ }\mu\text{s}$

2 $V_{DS,pulse}$ is intended for repetitive pulse, $t_{PULSE} < 100\text{ ns}$

3 Limit was extracted from characterization test, not measured during production

4 The minimum V_{GS} is clamped by ESD protection circuit, as shown in Figure 10

7. Thermal characteristics

Table 5 Thermal characteristics

Parameter	Symbol	Values	Unit	Note/Test Condition
Thermal resistance, junction-ambient	R_{thJA}	33.6	°C/W	
Thermal resistance, junction-top	R_{thJC_top}	17.4	°C/W	
Thermal resistance, junction-bottom	R_{thJC_bot}	1	°C/W	
Maximum reflow soldering temperature	T_{sold}	260	°C	MSL3

8. Electric characteristics

at $T_j = 25\text{ °C}$, unless specified otherwise

Table 6 Static characteristics

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Gate threshold voltage	$V_{GS(th)}$	1.2	1.7	2.5	V	$I_D = 12.2\text{ mA}; V_{DS} = V_{GS}; T_j = 25\text{ °C}$
		-	1.7	-		$I_D = 12.2\text{ mA}; V_{DS} = V_{GS}; T_j = 150\text{ °C}$
Drain-source leakage current	I_{DSS}	-	0.45	20	μA	$V_{DS} = 650\text{ V}; V_{GS} = 0\text{ V}; T_j = 25\text{ °C}$
		-	6	-		$V_{DS} = 650\text{ V}; V_{GS} = 0\text{ V}; T_j = 150\text{ °C}$
Gate-source leakage current	I_{GSS}	-	60	-	μA	$V_{GS} = 6\text{ V}; V_{DS} = 0\text{ V}$
Drain-source on-state resistance	$R_{DS(on)}$	-	138	190	m Ω	$V_{GS} = 6\text{ V}; I_D = 3.9\text{ A}; T_j = 25\text{ °C}$
		-	300	-		$V_{GS} = 6\text{ V}; I_D = 3.9\text{ A}; T_j = 150\text{ °C}$
Gate resistance	R_G	-	5	-	Ω	$f = 5\text{ MHz}; \text{open drain}$

Table 7 Dynamic characteristics

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}	-	96	-	pF	$V_{GS} = 0\text{ V}; V_{DS} = 400\text{ V}; f = 100\text{ kHz}$
Output capacitance	C_{oss}	-	30	-	pF	$V_{GS} = 0\text{ V}; V_{DS} = 400\text{ V}; f = 100\text{ kHz}$
Reverse transfer Capacitance	C_{rss}	-	0.5	-	pF	$V_{GS} = 0\text{ V}; V_{DS} = 400\text{ V}; f = 100\text{ kHz}$
Effective output capacitance, energy related ¹	$C_{o(er)}$	-	43	-	pF	$V_{GS} = 0\text{ V}; V_{DS} = 0\text{ to }400\text{ V}$
Effective output capacitance, time related ²	$C_{o(tr)}$	-	60	-	pF	$V_{GS} = 0\text{ V}; V_{DS} = 0\text{ to }400\text{ V}$
Output charge	Q_{oss}	-	24.5	-	nC	$V_{GS} = 0\text{ V}; V_{DS} = 0\text{ to }400\text{ V}$
Turn-on delay time	$t_{d(on)}$	-	1.4	-	nS	$V_{DS} = 400\text{ V}; I_D = 8\text{ A}; L = 318\text{ }\mu\text{H};$ $V_{GS} = 6\text{ V}; R_{on} = 10\text{ }\Omega; R_{off} = 2\text{ }\Omega;$ See Figure 22
Turn-off delay time	$t_{d(off)}$	-	1.7	-	nS	
Rise time	t_r	-	4.0	-	nS	
Fall time	t_f	-	4.0	-	nS	
Output Capacitance Stored Energy	E_{oss}	-	3.5	-	μJ	$V_{GS} = 0\text{ V}; V_{DS} = 400\text{ V}; f = 100\text{ kHz}$

- $C_{o(er)}$ is the fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 400 V
- $C_{o(tr)}$ is the fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 400 V

Table 8 Gate charge characteristics

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Gate charge	Q_G	-	2.8	-	nC	$V_{GS} = 0$ to 6 V; $V_{DS} = 400$ V; $I_D = 3.9$ A
Gate-source charge	Q_{GS}	-	0.25	-	nC	
Gate-drain charge	Q_{GD}	-	1.1	-	nC	
Gate Plateau Voltage	V_{Plat}	-	2.2	-	V	$V_{DS} = 400$ V; $I_D = 3.9$ A

Table 9 Reverse conduction characteristics

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Source-Drain reverse voltage	V_{SD}	-	2.6	-	V	$V_{GS} = 0$ V; $I_S = 3.9$ A
Pulsed current, reverse	$I_{S,pulse}$	-	-	20.5	A	$V_{GS} = 6$ V; $t_{PULSE} = 10$ μ s
Reverse recovery charge	Q_{rr}	-	0	-	nC	$I_S = 3.9$ A; $V_{DS} = 400$ V
Reverse recovery time	t_{rr}	-	0	-	ns	
Peak reverse recovery current	I_{rrm}	-	0	-	A	

9. Electric characteristics diagrams

at $T_j = 25\text{ }^\circ\text{C}$, unless specified otherwise

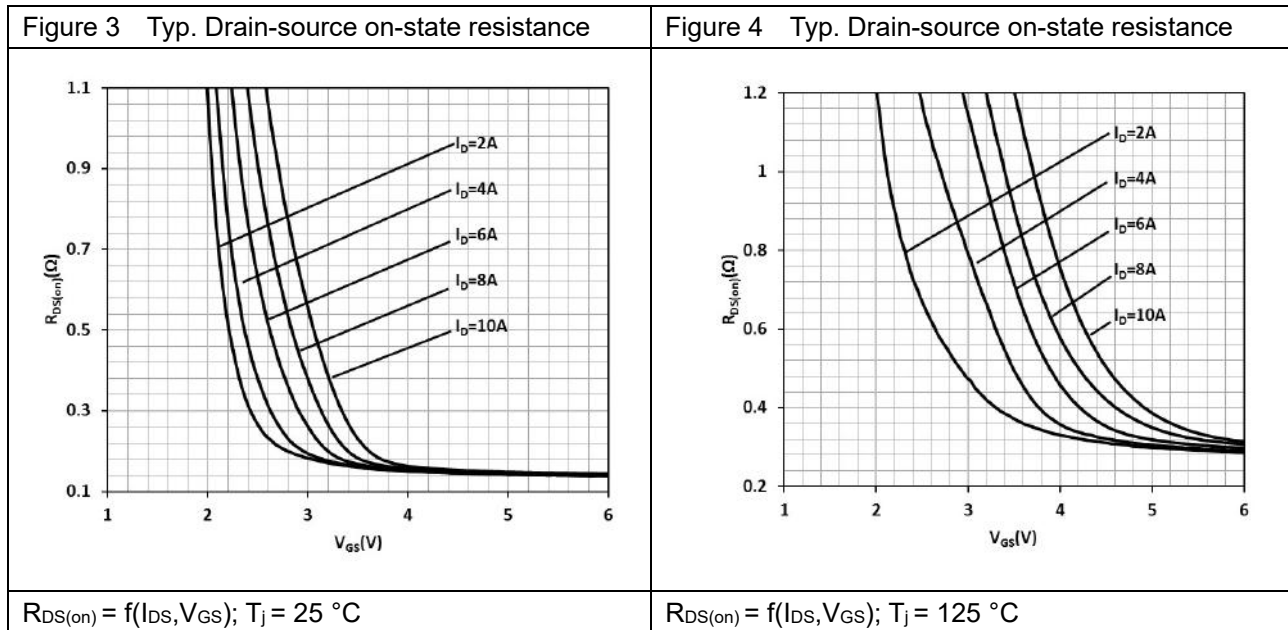
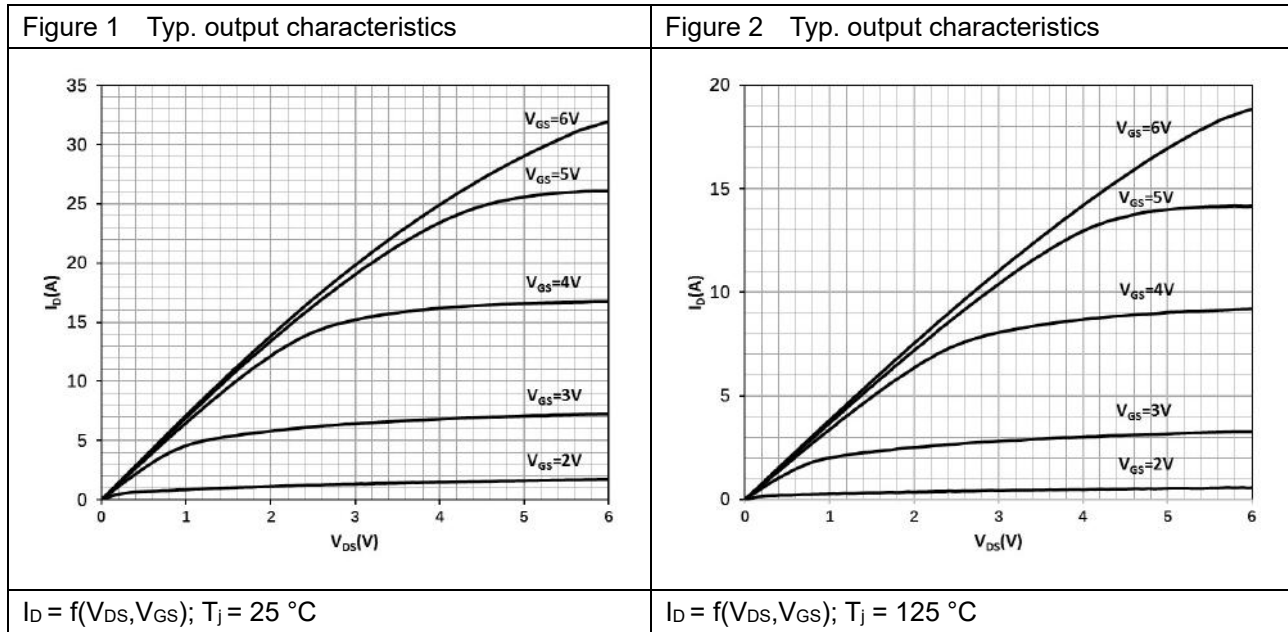
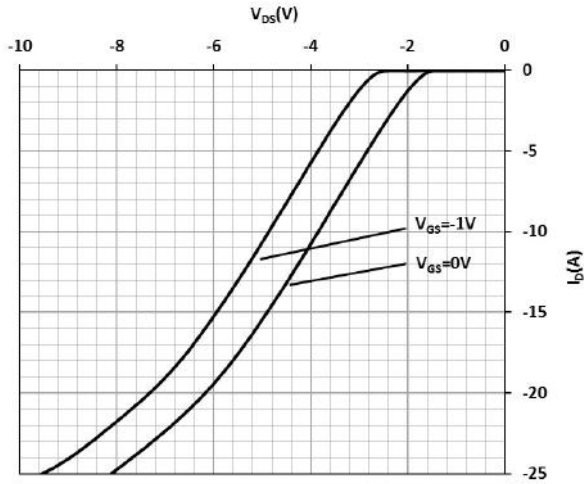
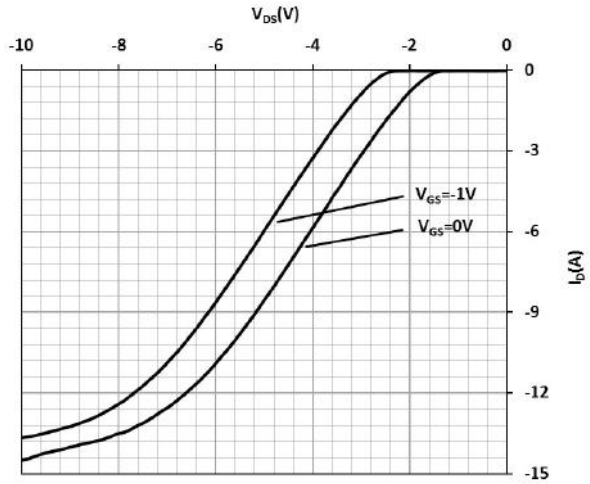


Figure 5 Typ. channel reverse characteristics



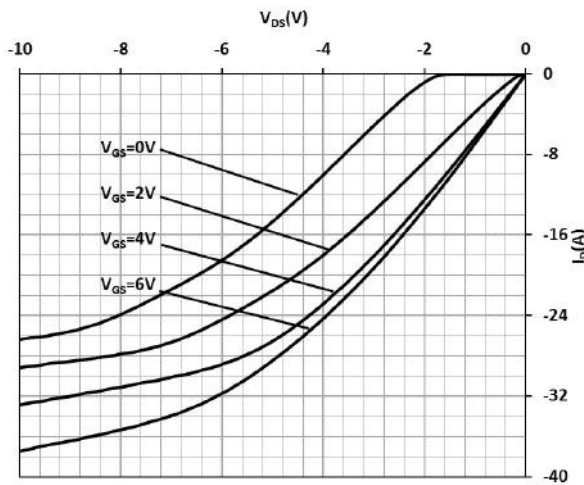
$I_D = f(V_{DS}, V_{GS}); T_j = 25\text{ }^\circ\text{C}$

Figure 6 Typ. channel reverse characteristics



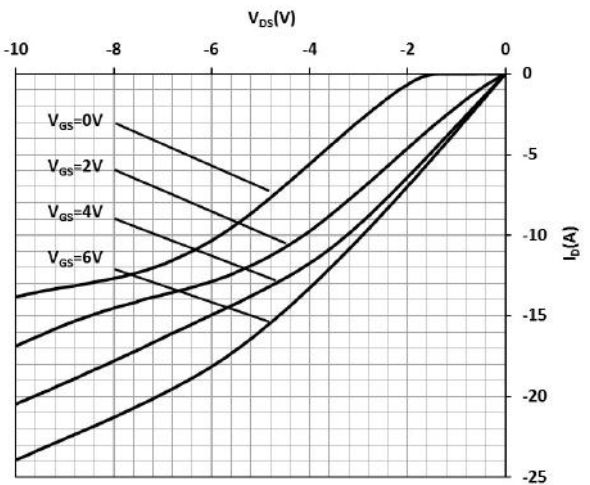
$I_D = f(V_{DS}, V_{GS}); T_j = 125\text{ }^\circ\text{C}$

Figure 7 Typ. channel reverse characteristics



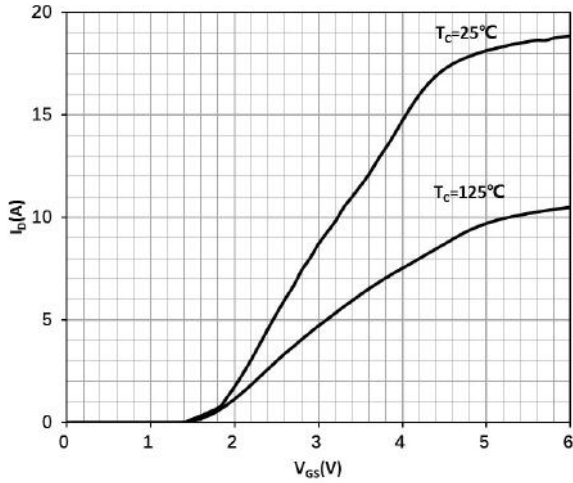
$I_D = f(V_{DS}, V_{GS}); T_j = 25\text{ }^\circ\text{C}$

Figure 8 Typ. channel reverse characteristics



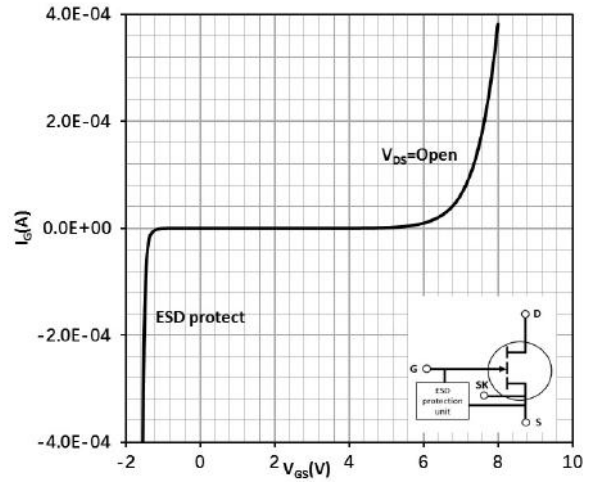
$I_D = f(V_{DS}, V_{GS}); T_j = 125\text{ }^\circ\text{C}$

Figure 9 Typ. transfer characteristics



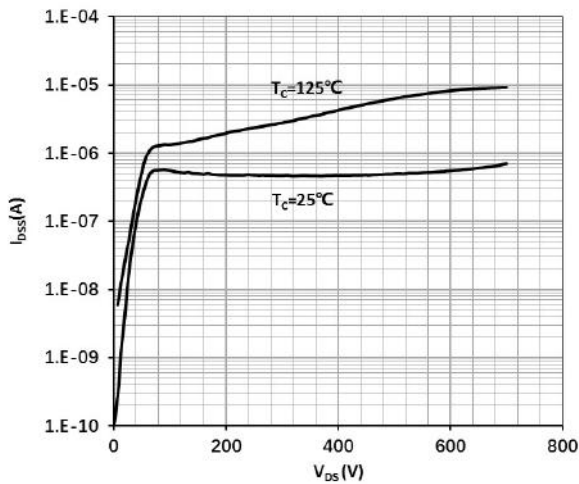
$I_D = f(V_{GS}); V_{DS} = 3\text{ V}$

Figure 10 Typ. Gate-to-Source leakage



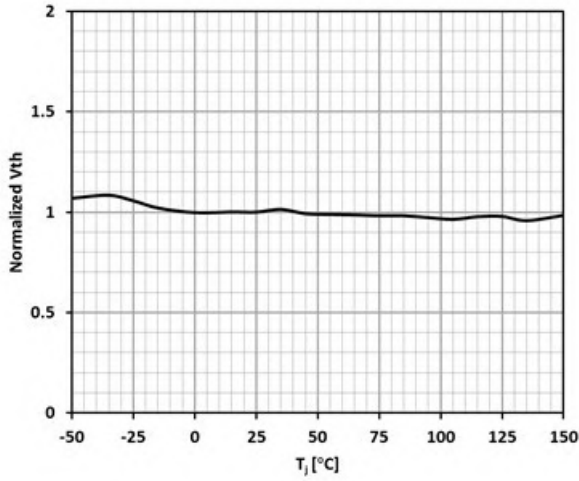
$I_G = f(V_{GS}); I_G$ reverse turn on by ESD unit

Figure 11 Drain-source leakage characteristics



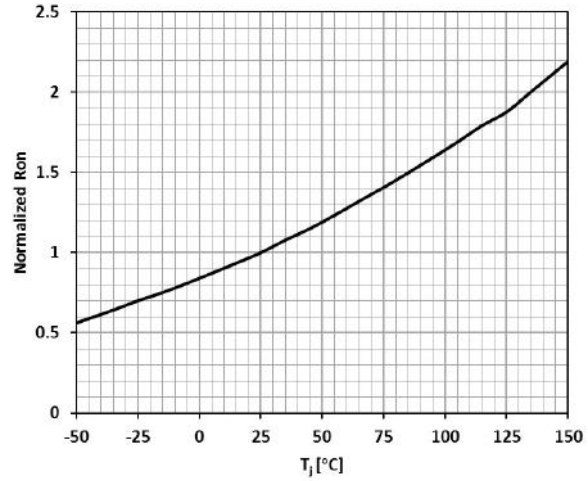
$I_{DSS} = f(V_{DS}); V_{GS} = 0\text{ V}$

Figure 12 Gate threshold voltage



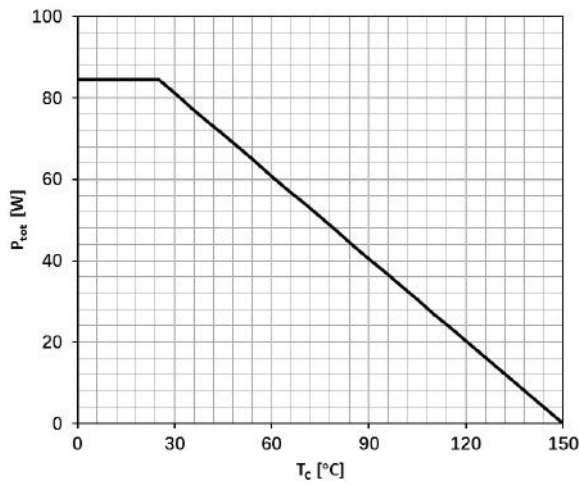
$V_{TH} = f(T_j); V_{GS} = V_{DS}; I_D = 12.2 \text{ mA}$

Figure 13 Drain-source on-state resistance



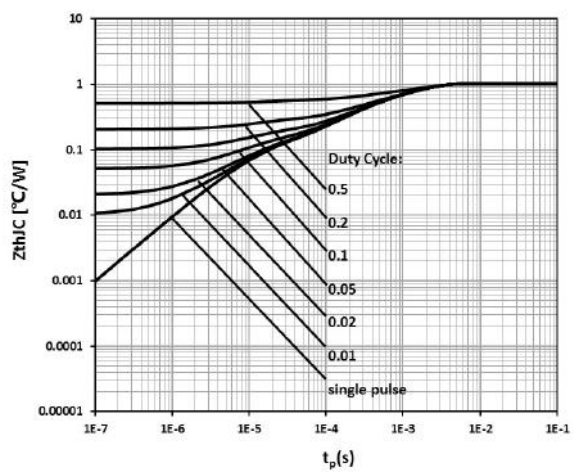
$R_{DS(on)} = f(T_j); I_D = 3.9 \text{ A}; V_{GS} = 6 \text{ V}$

Figure 14 Power dissipation



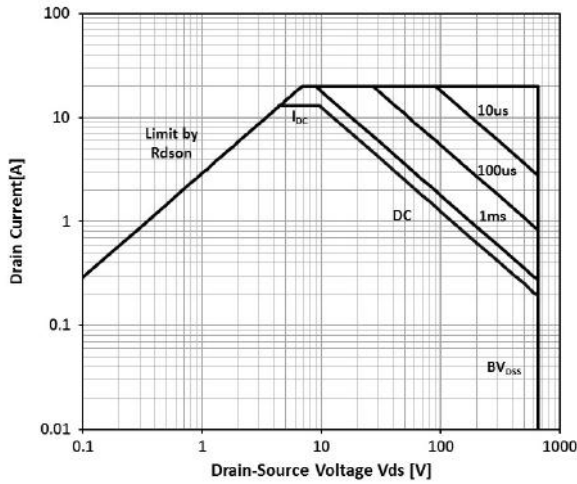
$P_{tot} = f(T_c)$

Figure 15 Max.transient thermal impedance



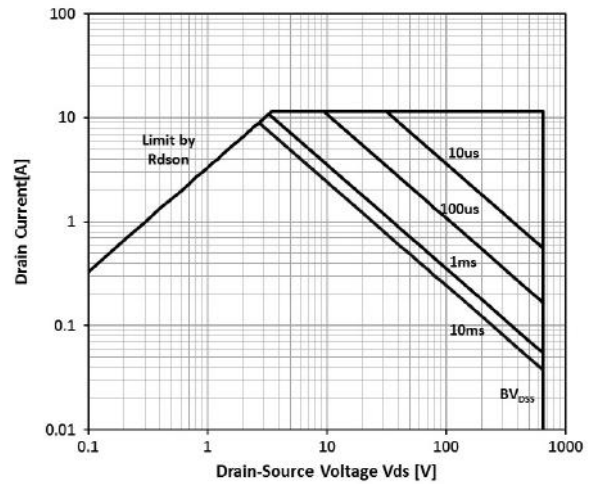
$Z_{thJC} = f(t_p, D)$

Figure 16 Safe operating area



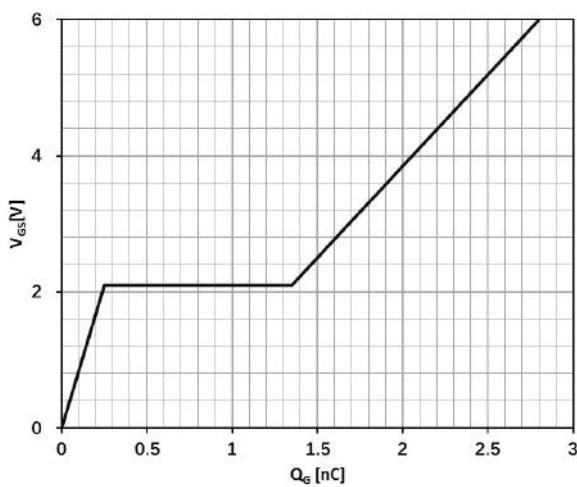
$I_D = f(V_{DS}); T_C = 25\text{ °C}$

Figure 17 Safe operating area



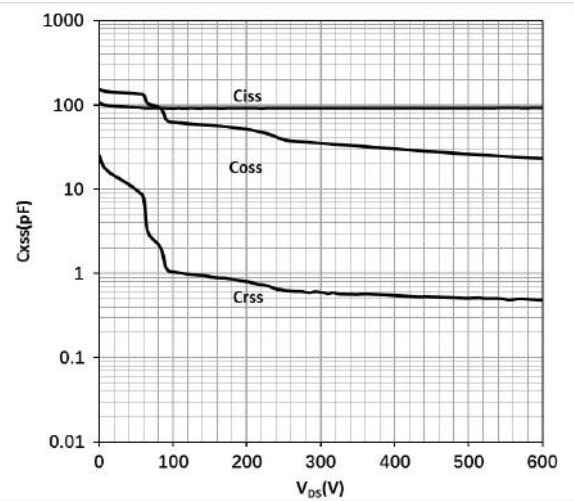
$I_D = f(V_{DS}); T_C = 125\text{ °C}$

Figure 18 Typ. gate charge



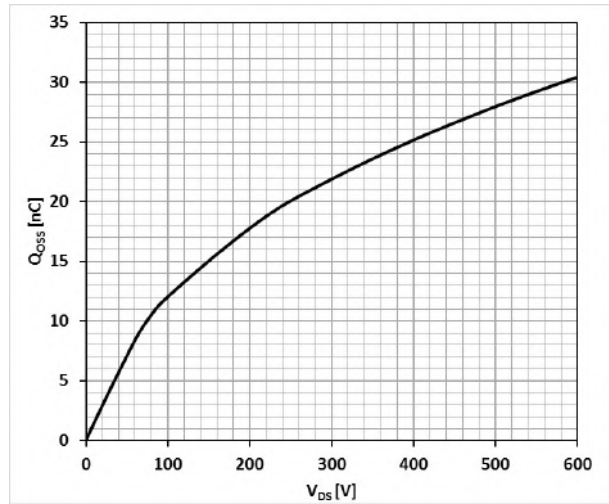
$V_{GS} = f(Q_G); V_{DCLINK} = 400\text{ V}; I_D = 5\text{ A}$

Figure 19 Typ. capacitances



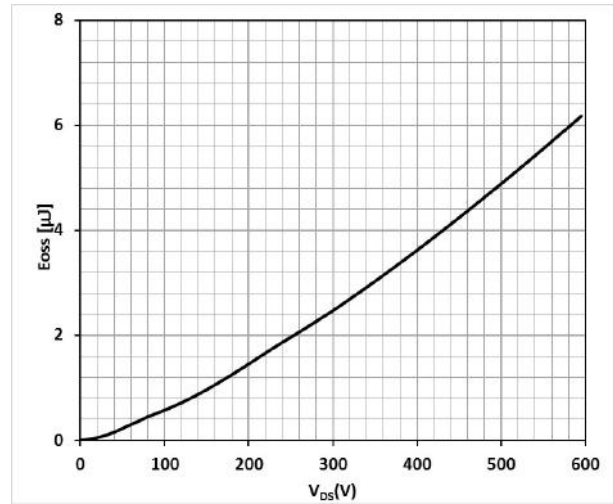
$C_{XSS} = f(V_{DS}); \text{Freq.} = 100\text{ kHz}$

Figure 20 Typ. output charge



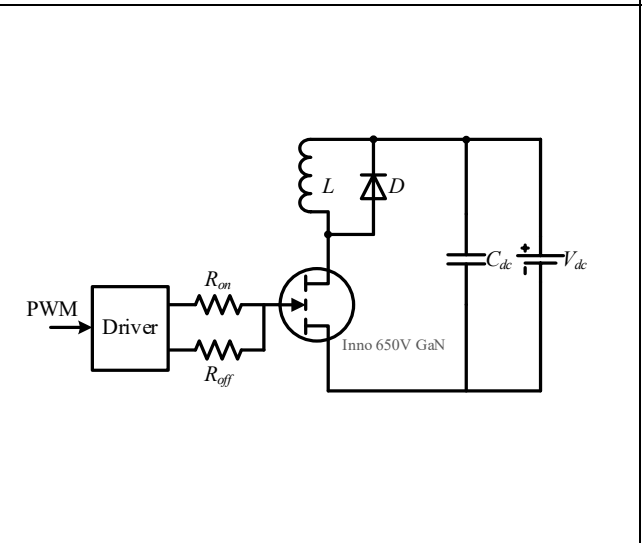
$Q_{oss} = f(V_{DS}); \text{Freq.} = 100 \text{ kHz}$

Figure 21 Typ. Coss stored Energy



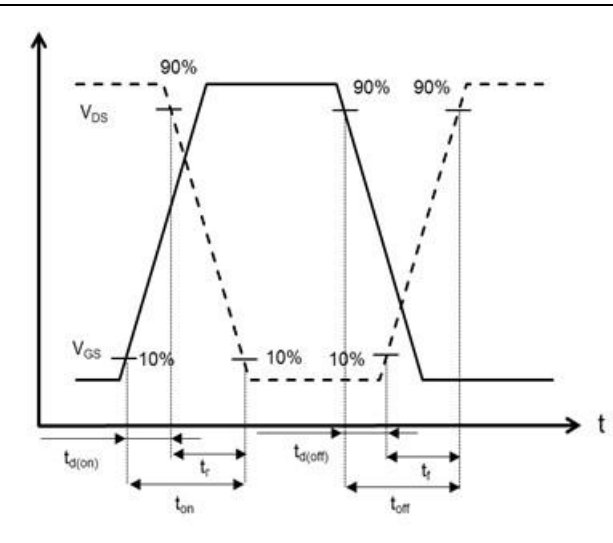
$E_{oss} = f(V_{DS}); \text{Freq.} = 100 \text{ kHz}$

Figure 22 Typ. Switching times with inductive load

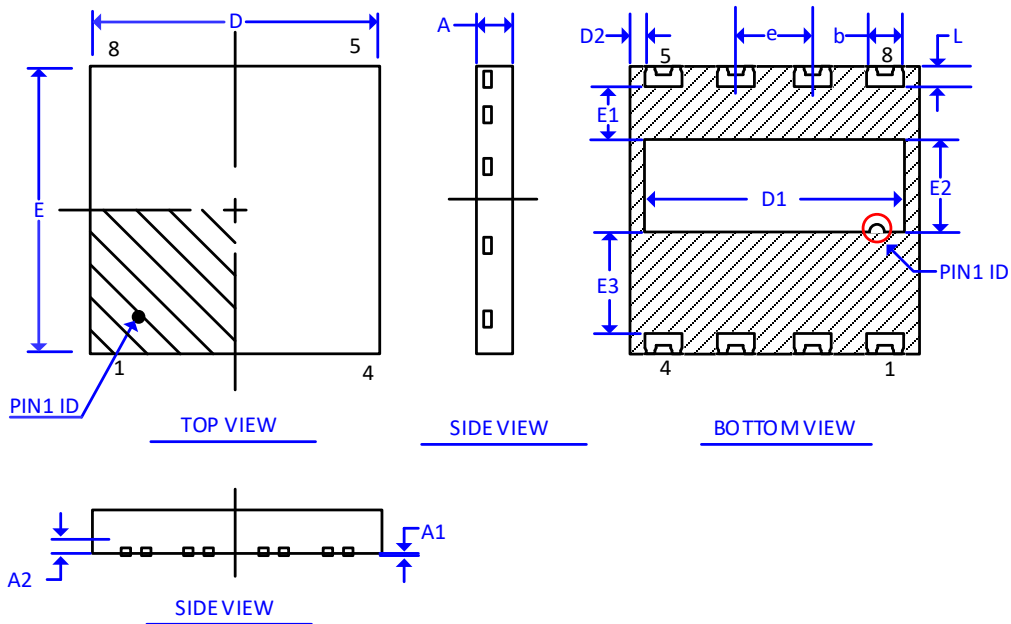


$V_{DS} = 400 \text{ V}, I_D = 8 \text{ A}, L = 318 \mu\text{H}, V_{GS} = 6 \text{ V},$
 $R_{on} = 10 \Omega, R_{off} = 2 \Omega$

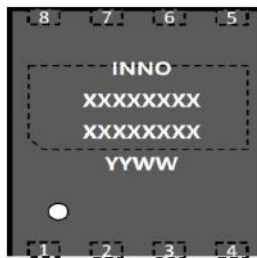
Figure 23 Typ. Switching times waveform



10. Package outlines



SYMBOL	DIMENSION			SYMBOL	DIMENSION		
	MIN	NOM	MAX		MIN	NOM	MAX
A	0.80	0.90	1.00	E	8.00 B.S.C		
A1	0.00	0.02	0.05	E1	0.90	1.00	1.10
A2	---	0.203 ref	---	E2	3.10	3.20	3.30
b	0.92	1.00	1.05	E3	2.70	2.80	2.90
D	8.00 B.S.C			e	2.00 B.S.C		
D1	6.84	6.94	7.04	L	0.40	0.50	0.60
D2	0.40	0.50	0.60				

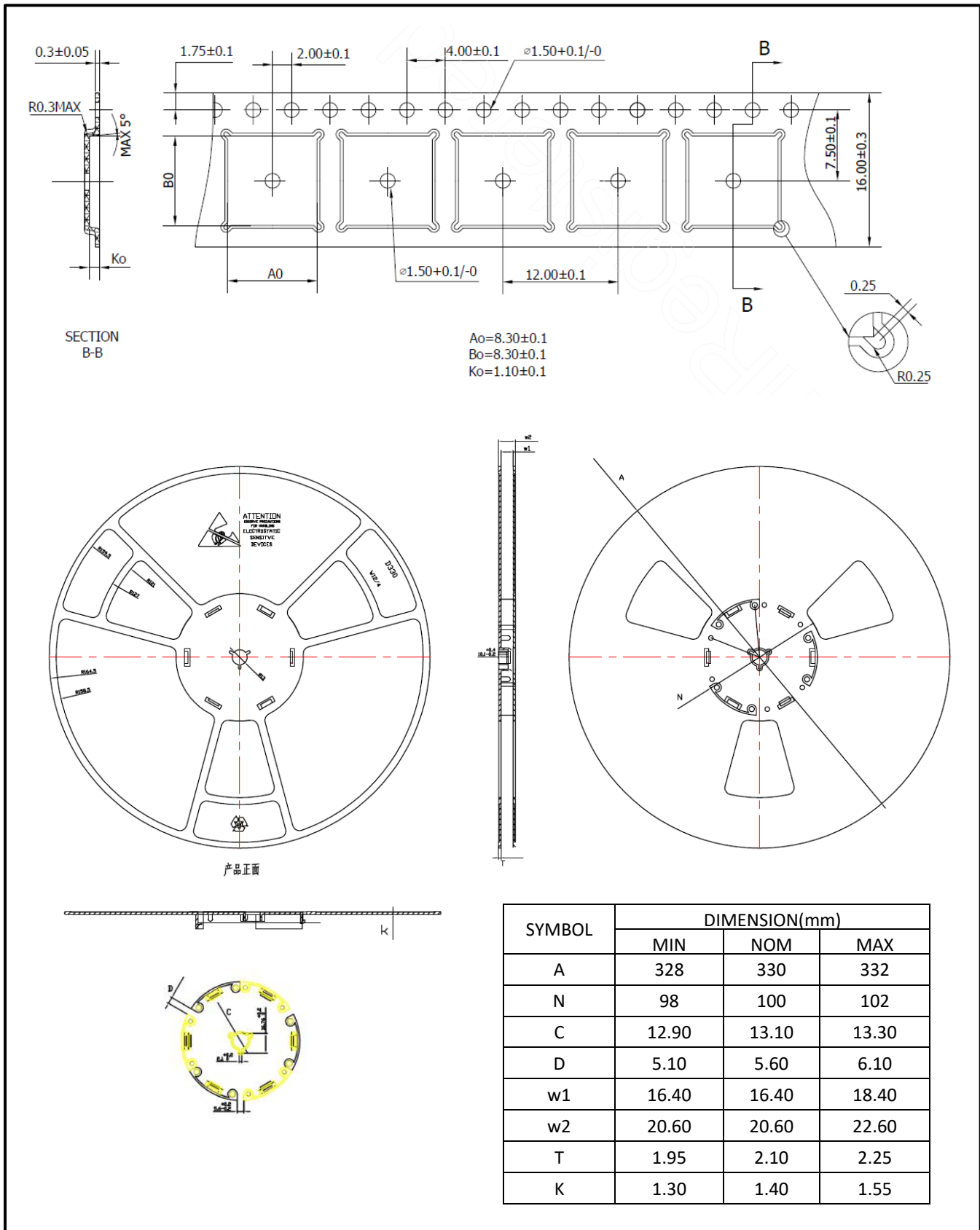


Row	Description	Example
Row1	Company name	INNO
Row2	Product code (In short)	XXXXXXXXXX
Row3	ASSY lot No.	XXXXXXXXXX
Row4	Date code	YYWW

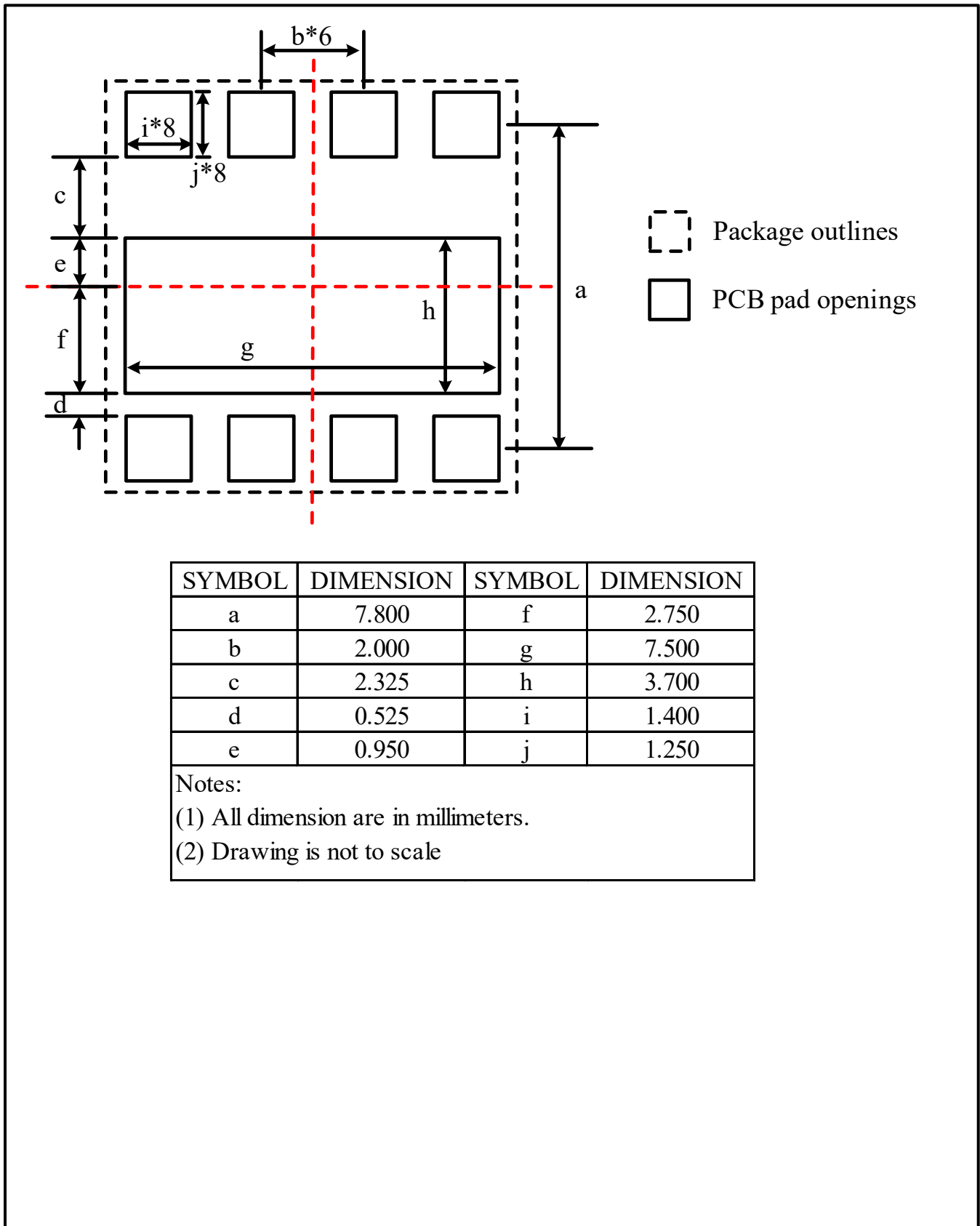
Notes:

- (1) Dimension and tolerance conform to ASME Y14.5-2009.
- (2) All dimension are in millimeters.
- (3) Lead coplanarity shall be 0.1 millimeters max.
- (4) Complies with JEDEC MO-229.
- (5) Drawing is not to scale.
- (6) Dimensions do not include mold protrusion.
- (7) Package outline exclusive of metal burr dimensions.

11. Reel information



12. Recommended PCB footprint



SYMBOL	DIMENSION	SYMBOL	DIMENSION
a	7.800	f	2.750
b	2.000	g	7.500
c	2.325	h	3.700
d	0.525	i	1.400
e	0.950	j	1.250

Notes:

- (1) All dimension are in millimeters.
- (2) Drawing is not to scale

13. Revision history

Major changes since the last revision

Revision	Date	Description of changes
1.0	2022-04-22	1.0 version release

Important Notice

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