650V GaN Power Transistor (FET)

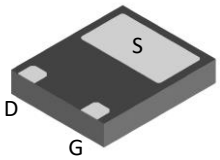
Features

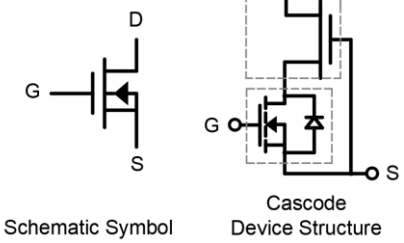
- Easy to use, compatible with standard gate drivers
- Excellent Q_G x $R_{DS(on)}$ figure of merit (FOM)
- Low Q_{RR}, no free-wheeling diode required
- Low switching loss
- RoHS compliant and Halogen-free

Product Summary		
V_{DSS}	650	V
$R_{DS(on),\ typ}$	240	mΩ
$Q_{G,\ typ}$	21.5	nC
$Q_{RR,\ typ}$	39	nC

Applications

- High efficiency power supplies
- High efficiency USB PD adapters
- Other consumer electronics





Schematic Symbol　　Cascode Device Structure

Packaging

Part Number	Package	Packaging	Base QTY
HMN9N65Q	DFN 5 x 6	Tape and Reel	2500

Maximum ratings, at T_C=25 °C, unless otherwise specified

Symbol	Parameter		Limit Value	Unit
I_D	Continuous drain current @T_C=25°C		8	A
	Continuous drain current @T_C=100°C		5	A
I_{DM}	Pulsed drain current @T_C=25°C (pulse width: 10us)		31	A
	Pulsed drain current @T_C=150°C (pulse width: 10us)		23	A
V_{DSS}	Drain to source voltage (T_J = -55°C to 150°C)		650	V
V_{TDSS}	Transient drain to source voltage [a]		800	V
V_{GSS}	Gate to source voltage		±20	V
P_D	Maximum power dissipation @T_C=25°C		29	W
T_C	Operating temperature	Case	-55 to 150	°C
T_J		Junction	-55 to 150	°C
T_S	Storage temperature		-55 to 150	°C
T_{CSOLD}	Soldering peak temperature		260	°C

Thermal Resistance

Symbol	Parameter	Typical	Unit
$R_{\Theta JC}$	Junction-to-case	4.3	°C/W
$R_{\Theta JA}$	Junction-to-ambient [b]	50	°C/W

Notes:

a. Off-state spike duty cycle < 0.01, spike duration < 2us

b. Device on one layer epoxy PCB for drain connection (vertical and without air stream cooling, with 6cm^2 copper area and 70μm thickness)

Electrical Parameters, at T_J=25 °C, unless otherwise specified

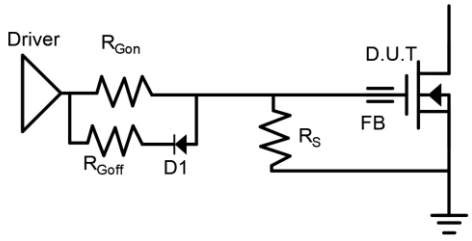
Symbol	Min	Typ	Max	Unit	Test Conditions
Forward Characteristics					
$V_{DSS-MAX}$	650	-	-	V	V_{GS}=0V
$V_{GS(th)}$	1.2	1.6	2.0	V	V_{DS}=V_{GS}, I_D=500μA
$R_{DS(on)}$ [c]	190	240	312	mΩ	V_{GS}=8V, I_D=4A, T_J=25°C
	-	500	-		V_{GS}=8V, I_D=4A, T_J=150°C
I_{DSS}	-	8	20	μA	V_{DS}=700V, V_{GS}=0V, T_J=25°C
	-	50	-	μA	V_{DS}=700V, V_{GS}=0V, T_J=150°C
I_{GSS}	-	-	150	nA	V_{GS}=20V
	-	-	-150	nA	V_{GS}=-20V
C_{ISS}	-	500	-	pF	V_{GS}=0V, V_{DS}=650V, f=1MHz
C_{OSS}	-	18	-	pF	
C_{RSS}	-	2	-	pF	
$C_{O(er)}$	-	25	-	pF	V_{GS}=0V, V_{DS}=0 - 650V
$C_{O(tr)}$	-	45	-	pF	
Q_G	-	21.5	-	nC	V_{DS}=400V, V_{GS}=0 - 12V, I_D=5.5A
Q_{GS}	-	3	-		
Q_{GD}	-	3.5	-		
$t_{D(on)}$	-	20	-	ns	V_{DS}=400V, V_{GS}=0 - 12V, I_D=3A, R_G=30Ω
t_R	-	7	-		
$t_{D(off)}$	-	80	-		
t_F	-	6	-		
Reverse Characteristics					
V_{SD}	-	1.2	-	V	V_{GS}=0V, I_S=2A, T_J=25°C
	-	1.7	-		V_{GS}=0V, I_S=5A, T_J=25°C
	-	2	-		V_{GS}=0V, I_S=5A, T_J=150°C
t_{RR}	-	12	-	ns	I_S=3A, V_{GS}=0V, d_i/d_t=1000A/us, V_{DD}=400V
Q_{RR}	-	39	-	nC	

Notes:

c. Dynamic on-resistance; see Figure 17 and 18 for test circuit and configurations

Circuit Implementation

Mostly used in flyback, forward and push-pull converters



Recommended Single Ended Drive Circuit

Recommended gate drive: (0 V, 12 V) with R_{Gon} = 300 - 500 Ω, R_{Goff} =10 Ω

Gate Ferrite Bead (FB)	Gate Resistance (R_{Gon})	Gate Resistance (R_{Goff})	Gate Source Resistance (R_S)	Gate Diode (D1)
300 - 600 Ω@100 MHz	300 - 500 Ω	10 Ω	10 kΩ	1N4148

Typical Characteristics, at T_C=25 °C, unless otherwise specified

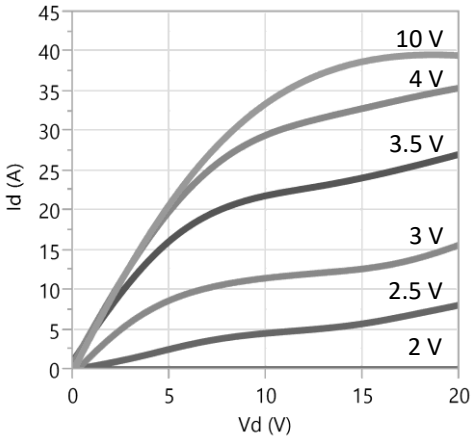


Figure 1. Typical Output Characteristics T_J=25°C

Parameter: V_{GS}

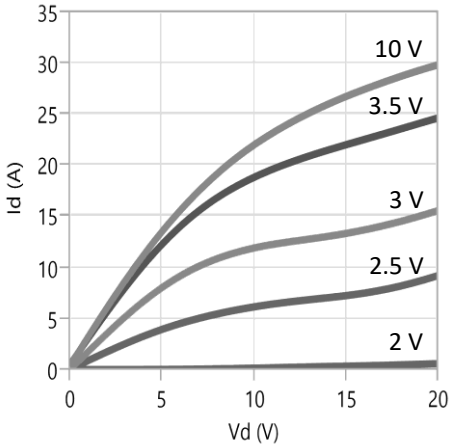


Figure 2. Typical Output Characteristics T_J=150°C

Parameter: V_{GS}

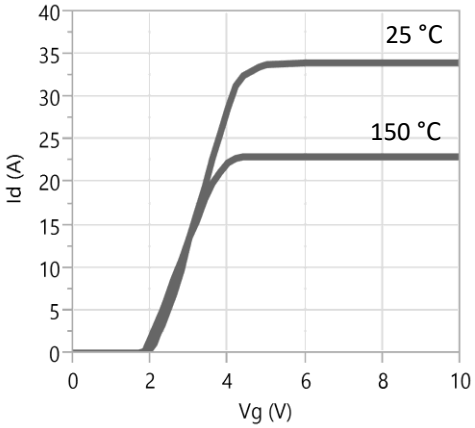


Figure 3. Typical Transfer Characteristics

V_{DS}=10V, Parameter: T_J

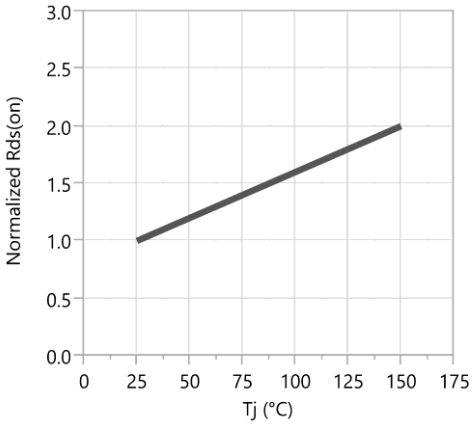


Figure 4. Normalized On-resistance

I_D=4A, V_{GS}=8V

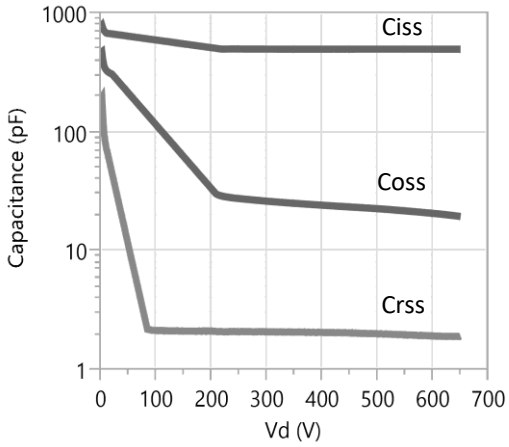


Figure 5. Typical Capacitance

V_{GS}=0V, f=1MHZ

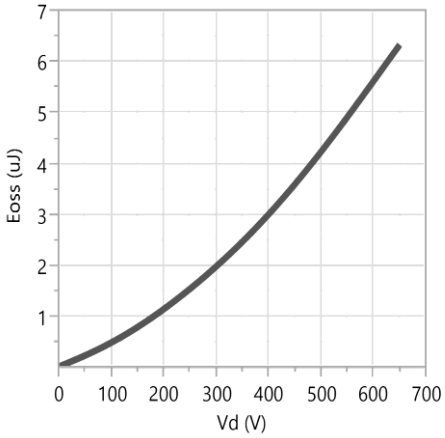


Figure 6. Typical Coss Stored Energy

Typical Characteristics, at T_C=25 °C, unless otherwise specified

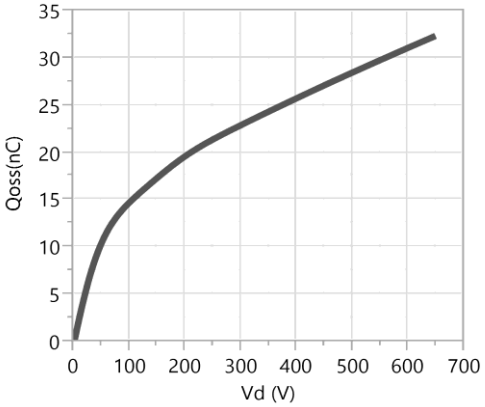


Figure 7. Typical Qoss

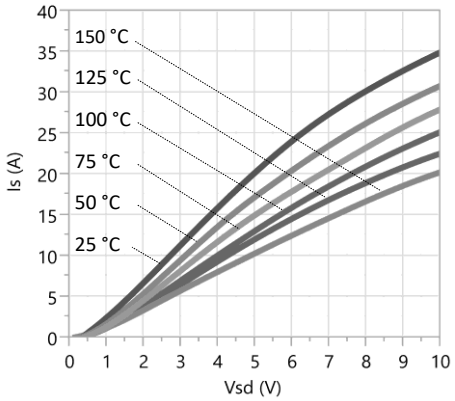


Figure 8. Forward Characteristic of Rev. Diode

Is=f(V_{sd}), Parameter T_J

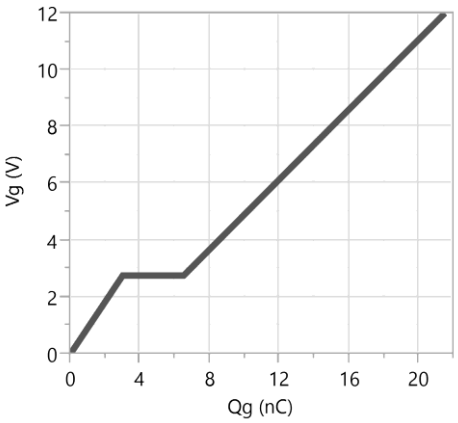


Figure 9. Typical Gate Charge

I_{DS}=5.5A, V_{DS}=400V

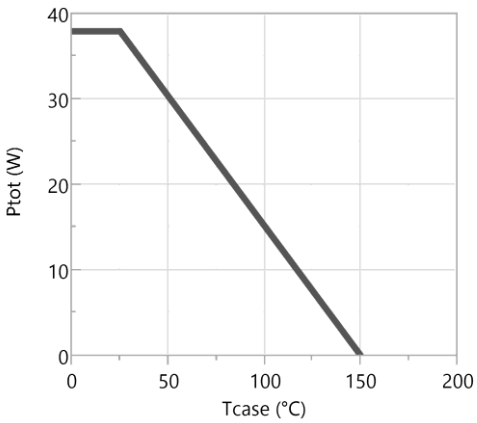


Figure 10. Power Dissipation

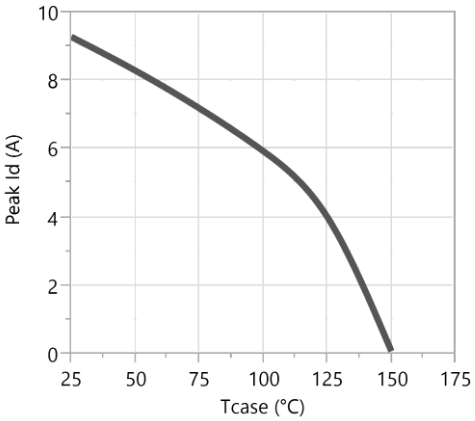


Figure 11. Current Derating

Typical Characteristics, at T_C=25 °C, unless otherwise specified

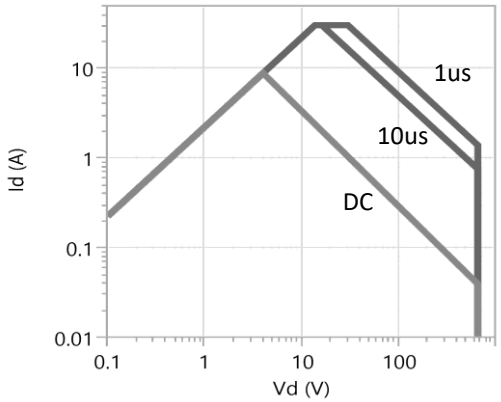


Figure 12. Safe Operating Area T_C=25°C

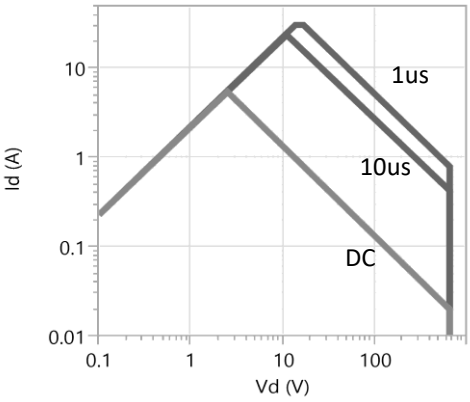


Figure 13. Safe Operating Area T_C=80°C

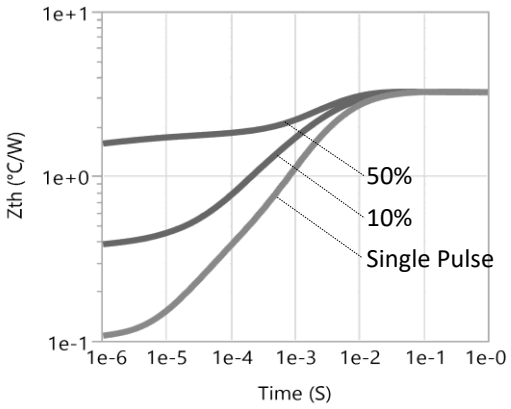


Figure 14. Transient Thermal Resistance

Test Circuits and Waveforms

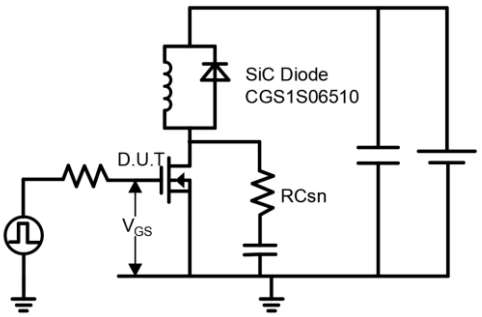


Figure 15. Switching Time Test Circuit

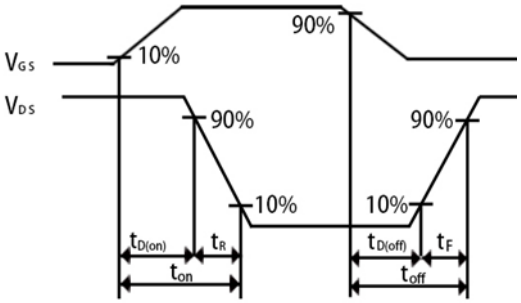


Figure 16. Switching Time Waveform

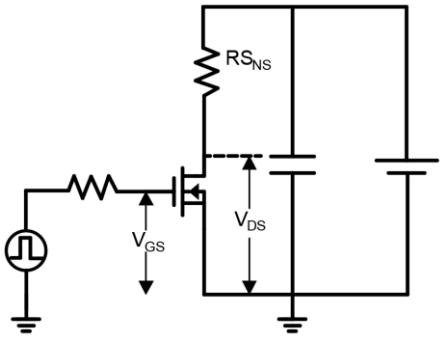


Figure 17. Dynamic $R_{DS(on)}$ Test Circuit

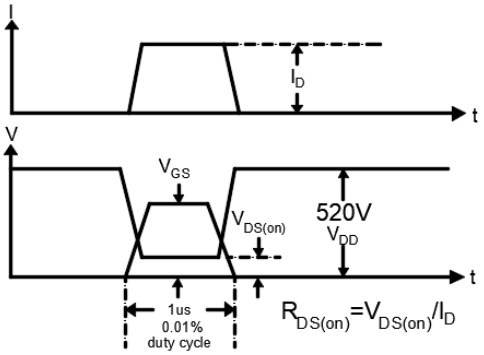


Figure 18. Dynamic $R_{DS(on)}$ Waveform

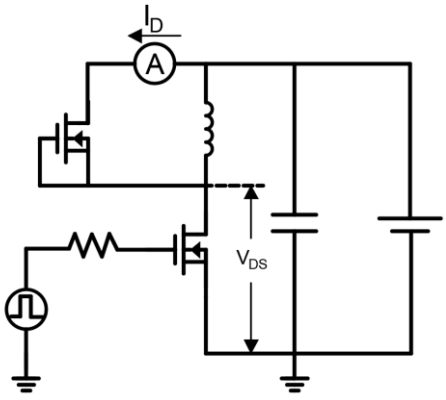


Figure 19. Diode Characteristic Test Circuits

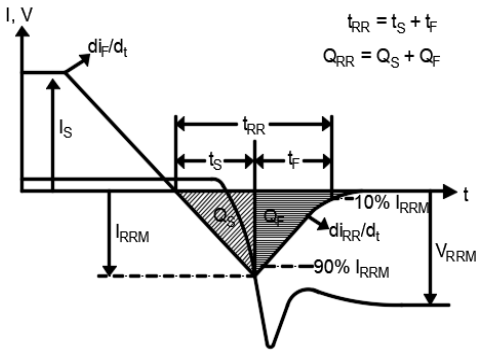


Figure 20. Diode Recovery Waveform

Design Considerations

Fast switching GaN device can reduce power conversion losses, and thus enable high frequency operations. Certain PCB design rules and instructions, however, need to be followed to take full advantages of fast switching GaN devices.

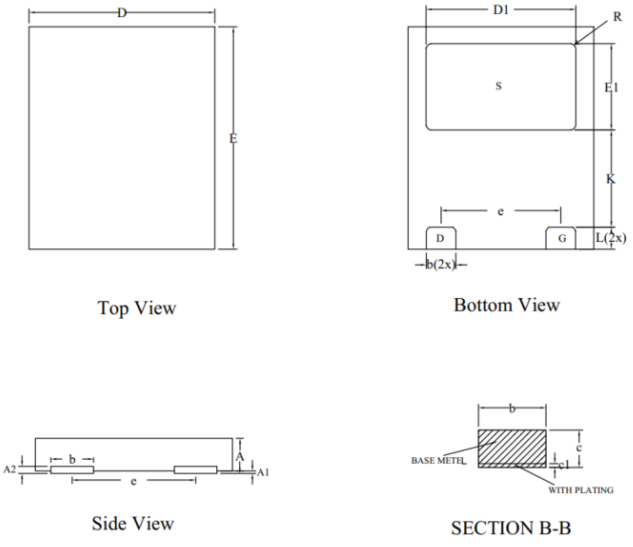
Before evaluating H&M Semi's GaN devices, please refer to the table below which provides some practical rules that should be followed during the evaluation.

When Evaluating H&M Semi 's GaN Devices:

DO	DO NOT
Make sure the traces are as short as possible for both drive and power loops to minimize parasitic inductance	Using H&M Semi 's devices in GDS board layouts
Use the test tool with the shortest inductive loop, and make sure test points should be placed close enough	Use differential mode probe or probe ground clip with long wires
Minimize the lead length of DFN 8*8mm packages when installing them to PCB	Use long traces in drive circuit, or long lead length of the devices

Package Outline

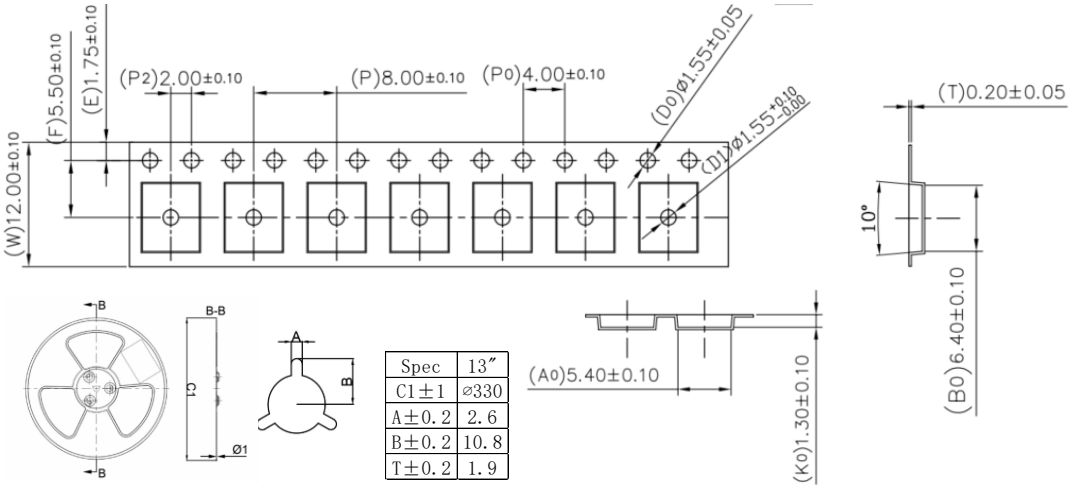
DFN 5 x 6mm (MS) Package



Symbol	Millimeter		
	Min	Nom	Max
A	0.85	1.00	1.15
A1	0.00	-	0.05
A2	-	0.20	0.22
b	0.82	0.87	0.92
c	-	0.20	-
c1	0.01	-	0.02
D	4.90	5.00	5.10
D1	4.09	4.24	4.39
E	5.90	6.00	6.10
E1	2.15	2.30	2.45
e	3.37BSC		
K	2.50	-	-
L	0.71	0.81	0.91
R	-	0.13	-

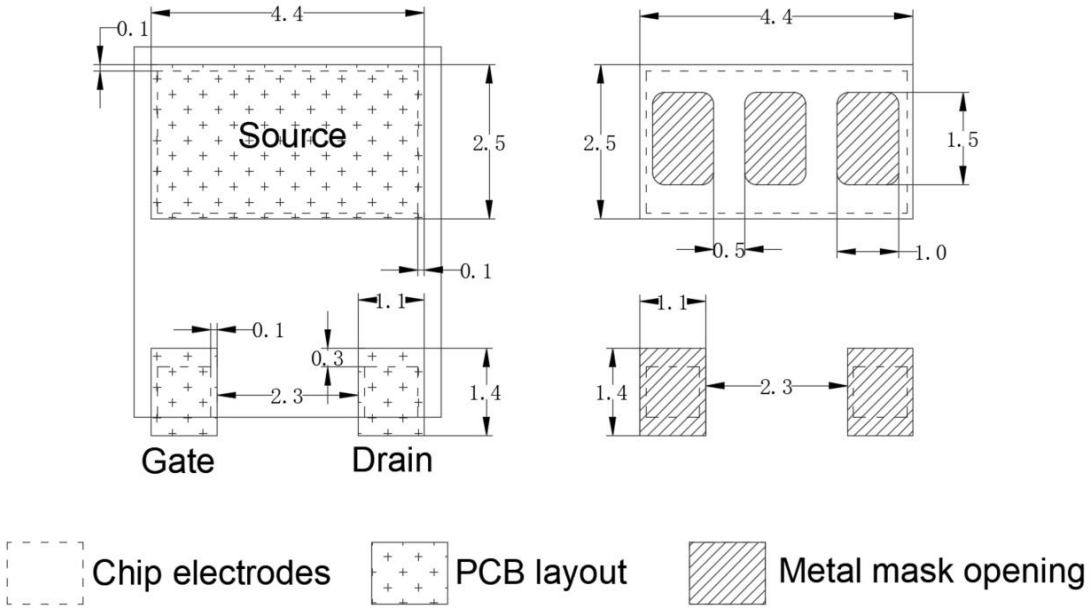
Tape and Reel Information

Dimensions are shown in millimeters



Spec	13″
C1±1	⌀330
A±0.2	2.6
B±0.2	10.8
T±0.2	1.9

Recommended PCB Layout & Metal mask opening Dimensions are shown in millimeters



Revision History

Version	Date	Change(s)
1.0	06/24/2022	Released Formal datasheet