



General description

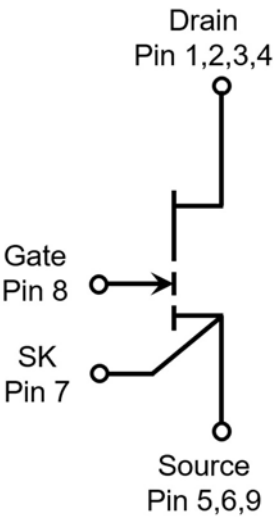
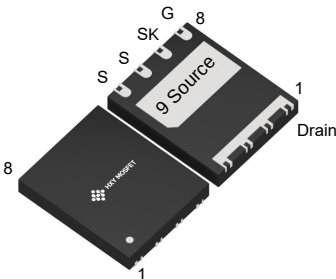
650V GaN-on-Silicon Enhancement-mode  
Power Transistor in Dual Flat No-lead  
Package (DFN) with 5 mm × 6 mm size.

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

Applications

- AC-DC converters
- DC-DC converters
- Totem pole PFC
- Fast battery charging
- High-density power conversion
- High-efficiency power conversion



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



## Maximum ratings

at  $T_j = 25\text{ }^{\circ}\text{C}$  unless otherwise specified. Continuous application of maximum ratings can deteriorate transistor lifetime.  
For further information, contact CloudSemi sales office.

**Table 3 Maximum rating**

| Parameters                                   | Symbols                    | Values |      |      | Units              | Notes/Test Conditions                                                                                                                              |
|----------------------------------------------|----------------------------|--------|------|------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
|                                              |                            | Min.   | Typ. | Max. |                    |                                                                                                                                                    |
| Drain-source voltage                         | $V_{DS, \max}$             | -      | -    | 650  | V                  | $V_{GS} = 0\text{ V}$ , $I_D = 10\text{ }\mu\text{A}$                                                                                              |
| Drain-source voltage transient <sup>1</sup>  | $V_{DS, \text{transient}}$ | -      | -    | 750  | V                  | $V_{GS} = 0\text{ V}$ , $V_{DS} = 750\text{ V}$                                                                                                    |
| Continuous current, drain-source             | $I_D$                      | -      | -    | 10   | A                  | $T_c = 25\text{ }^{\circ}\text{C}$                                                                                                                 |
| Pulsed current, drain-source <sup>2</sup>    | $I_{D, \text{pulse}}$      | -      | -    | 18   | A                  | $T_c = 25\text{ }^{\circ}\text{C}$ ; $V_G = 6\text{ V}$                                                                                            |
| Pulsed current, drain-source <sup>2</sup>    | $I_{D, \text{pulse}}$      | -      | -    | 10   | A                  | $T_c = 125\text{ }^{\circ}\text{C}$ ; $V_G = 6\text{ V}$                                                                                           |
| Gate-source voltage, continuous <sup>3</sup> | $V_{GS}$                   | -1.4   | -    | +7   | V                  | $T_j = -55\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                                               |
| Gate-source voltage, pulsed                  | $V_{GS, \text{pulse}}$     | -      | -    | +10  | V                  | $T_j = -55\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$ ;<br>$t_{\text{Pulse}} = 50\text{ ns}$ , $f = 100\text{ kHz}$ ;<br>open drain |
| Power dissipation                            | $P_{\text{tot}}$           | -      | -    | 75   | W                  | $T_c = 25\text{ }^{\circ}\text{C}$                                                                                                                 |
| Operating temperature                        | $T_j$                      | -55    | -    | +150 | $^{\circ}\text{C}$ |                                                                                                                                                    |
| Storage temperature                          | $T_{\text{stg}}$           | -55    | -    | +150 | $^{\circ}\text{C}$ |                                                                                                                                                    |

1.  $V_{DS, \text{transient}}$  is intended for surge rating during non-repetitive events,  $t_{\text{Pulse}} < 1\text{ }\mu\text{s}$ .

2. Pulse width =  $10\text{ }\mu\text{s}$ .

3. The minimum  $V_{GS}$  is clamped by ESD protection circuit, as shown in Figure 8.

## Thermal characteristics

**Table 4 Thermal characteristics**

| Parameters                        | Symbols           | Values |      |      | Units                       | Notes/Test Conditions |
|-----------------------------------|-------------------|--------|------|------|-----------------------------|-----------------------|
|                                   |                   | Min.   | Typ. | Max. |                             |                       |
| Thermal resistance, junction-case | $R_{\text{thJC}}$ | -      | -    | 1.65 | $^{\circ}\text{C}/\text{W}$ |                       |
| Reflow soldering temperature      | $T_{\text{sold}}$ | -      | -    | 260  | $^{\circ}\text{C}$          | MSL3                  |



## Electrical characteristics

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

**Table 5 Static characteristics**

| Parameters                       | Symbols      | Values |      |      | Units            | Notes/Test Conditions                                                                 |
|----------------------------------|--------------|--------|------|------|------------------|---------------------------------------------------------------------------------------|
|                                  |              | Min.   | Typ. | Max. |                  |                                                                                       |
| Gate threshold voltage           | $V_{GS(TH)}$ | 1.2    | 1.6  | 2.5  | V                | $I_D = 11\text{ mA}$ ; $V_{DS} = V_{GS}$ ; $T_j = 25\text{ }^{\circ}\text{C}$         |
|                                  |              | -      | 1.6  | -    |                  | $I_D = 11\text{ mA}$ ; $V_{DS} = V_{GS}$ ; $T_j = 125\text{ }^{\circ}\text{C}$        |
| Drain-source leakage current     | $I_{DSS}$    | -      | 0.4  | 20   | $\mu\text{A}$    | $V_{DS} = 650\text{ V}$ ; $V_{GS} = 0\text{ V}$ ; $T_j = 25\text{ }^{\circ}\text{C}$  |
|                                  |              | -      | 4    | -    |                  | $V_{DS} = 650\text{ V}$ ; $V_{GS} = 0\text{ V}$ ; $T_j = 125\text{ }^{\circ}\text{C}$ |
| Gate-source leakage current      | $I_{GSS}$    | -      | -    | 200  | $\mu\text{A}$    | $V_{GS} = 6\text{ V}$ ; $V_{DS} = 0\text{ V}$                                         |
| Drain-source on-state resistance | $R_{DS(on)}$ | -      | 160  | 200  | $\text{m}\Omega$ | $V_{GS} = 6\text{ V}$ ; $I_D = 3\text{ A}$ ; $T_j = 25\text{ }^{\circ}\text{C}$       |
|                                  |              | -      | 330  | -    | $\text{m}\Omega$ | $V_{GS} = 6\text{ V}$ ; $I_D = 3\text{ A}$ ; $T_j = 125\text{ }^{\circ}\text{C}$      |
| Gate resistance                  | $R_G$        | -      | 3.5  | -    | $\Omega$         | $f = 5\text{ MHz}$ ; open drain                                                       |

**Table 6 Dynamic characteristics**

| Parameters                                                | Symbols      | Values |      |      | Units | Notes/Test Conditions                                                                                                                                              |
|-----------------------------------------------------------|--------------|--------|------|------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                           |              | Min.   | Typ. | Max. |       |                                                                                                                                                                    |
| Input capacitance                                         | $C_{iss}$    | -      | 83   | -    | pF    | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 400\text{ V}$ ; $f = 100\text{ kHz}$                                                                                             |
| Output capacitance                                        | $C_{oss}$    | -      | 27   | -    | pF    | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 400\text{ V}$ ; $f = 100\text{ kHz}$                                                                                             |
| Reverse transfer capacitance                              | $C_{rss}$    | -      | 0.4  | -    | pF    | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 400\text{ V}$ ; $f = 100\text{ kHz}$                                                                                             |
| Effective output capacitance, energy related <sup>1</sup> | $C_{o(er)}$  | -      | 35   | -    | pF    | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 0\text{ to }400\text{ V}$                                                                                                        |
| Effective output capacitance, time related <sup>2</sup>   | $C_{o(tr)}$  | -      | 54   | -    | pF    | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 0\text{ to }400\text{ V}$                                                                                                        |
| Output charge                                             | $Q_{OSS}$    | -      | 22   | -    | nC    | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 0\text{ to }400\text{ V}$                                                                                                        |
| Turn-on delay time                                        | $t_{d(on)}$  | -      | 2    | -    | ns    | $V_{DS} = 400\text{ V}$ ; $I_D = 6\text{ A}$ ; $L = 318\text{ }\mu\text{H}$ ;<br>$V_{GS} = 6\text{ V}$ ; $R_{on} = 10\text{ }\Omega$ ; $R_{off} = 2\text{ }\Omega$ |
| Turn-off delay time                                       | $t_{d(off)}$ | -      | 4    | -    | ns    |                                                                                                                                                                    |
| Rise time                                                 | $t_r$        | -      | 5    | -    | ns    |                                                                                                                                                                    |
| Fall time                                                 | $t_f$        | -      | 6    | -    | ns    |                                                                                                                                                                    |

1.  $C_{o(er)}$  is the fixed capacitance that gives the same stored energy as  $C_{OSS}$  while  $V_{DS}$  is rising from 0 to 400 V.

2.  $C_{o(tr)}$  is the fixed capacitance that gives the same charging time as  $C_{OSS}$  while  $V_{DS}$  is rising from 0 to 400 V.



**Table 7 Gate charge characteristics**

| Parameters           | Symbols    | Values |      |      | Units | Notes/Test Conditions                                                                |
|----------------------|------------|--------|------|------|-------|--------------------------------------------------------------------------------------|
|                      |            | Min.   | Typ. | Max. |       |                                                                                      |
| Gate charge          | $Q_G$      | -      | 2.3  | -    | nC    | $V_{GS} = 0 \text{ to } 6 \text{ V}; V_{DS} = 400 \text{ V};$<br>$I_D = 3 \text{ A}$ |
| Gate-source charge   | $Q_{GS}$   | -      | 0.2  | -    | nC    |                                                                                      |
| Gate-drain charge    | $Q_{GD}$   | -      | 0.9  | -    | nC    |                                                                                      |
| Gate plateau voltage | $V_{Plat}$ | -      | 2.4  | -    | V     | $V_{DS} = 400 \text{ V}; I_D = 3 \text{ A}$                                          |

**Table 8 Reverse conduction characteristics**

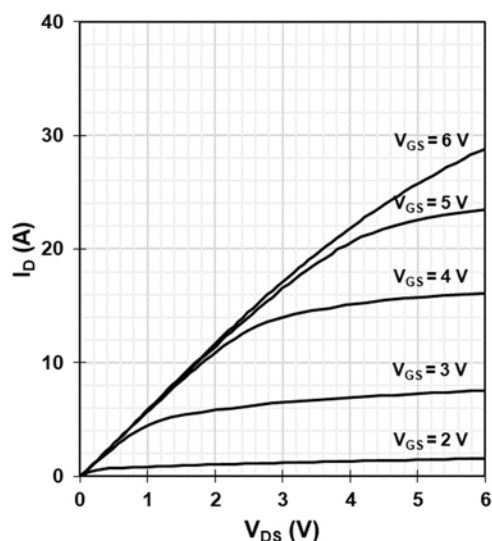
| Parameters                    | Symbols        | Values |      |      | Units | Notes/Test Conditions                          |
|-------------------------------|----------------|--------|------|------|-------|------------------------------------------------|
|                               |                | Min.   | Typ. | Max. |       |                                                |
| Source-drain reverse voltage  | $V_{SD}$       | -      | 2.5  | -    | V     | $V_{GS} = 0 \text{ V}; I_{SD} = 3 \text{ A}$   |
| Pulsed current, reverse       | $I_{S, pulse}$ | -      | 20   | -    | A     | $V_{GS} = 6 \text{ V}$                         |
| Reverse recovery charge       | $Q_{rr}$       | -      | 0    | -    | nC    | $I_{SD} = 3 \text{ A}; V_{DS} = 400 \text{ V}$ |
| Reverse recovery time         | $t_{rr}$       | -      | 0    | -    | ns    |                                                |
| Peak reverse recovery current | $I_{rrm}$      | -      | 0    | -    | A     |                                                |



## Electrical characteristics diagrams

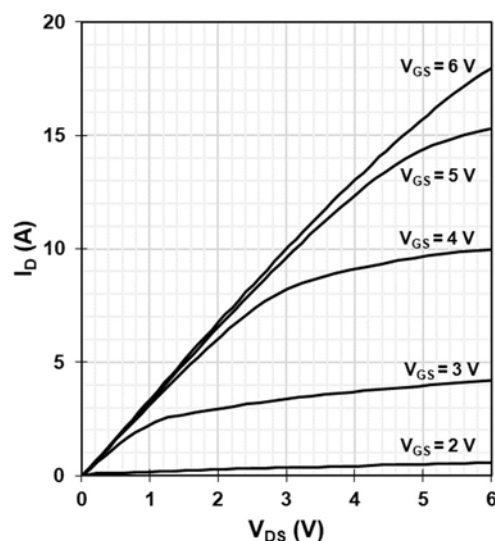
at  $T_j = 25\text{ }^{\circ}\text{C}$ , unless specified otherwise.

Figure 1 Typ. output characteristics



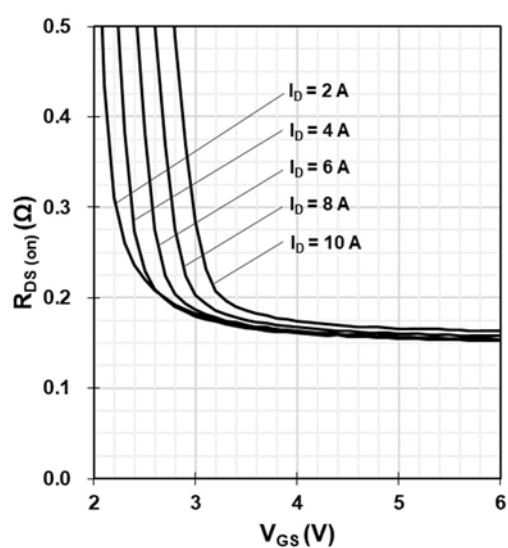
$$I_D = f(V_{DS}, V_{GS}); T_j = 25\text{ }^{\circ}\text{C}$$

Figure 2 Typ. output characteristics



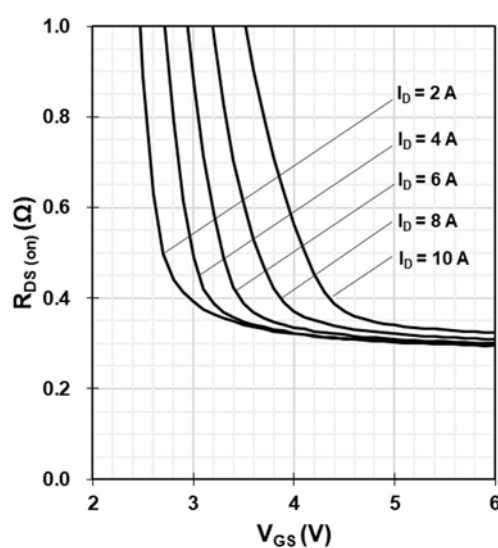
$$I_D = f(V_{DS}, V_{GS}); T_j = 125\text{ }^{\circ}\text{C}$$

Figure 3 Typ. drain-source on-state resistance



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

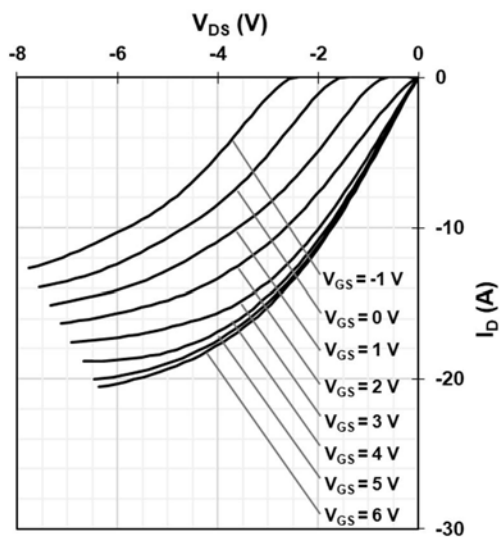
Figure 4 Typ. drain-source on-state resistance



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

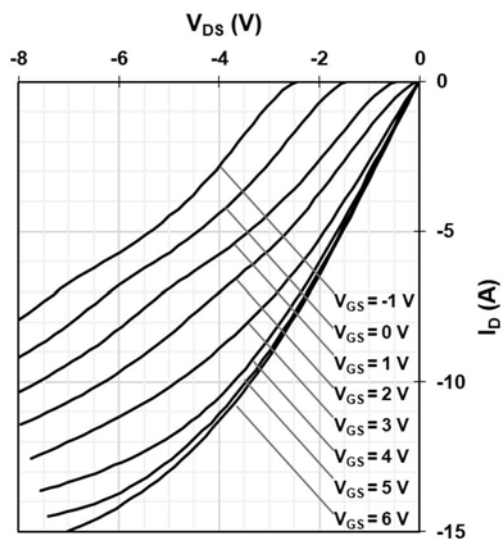


Figure 5 Typ. channel reverse characteristics



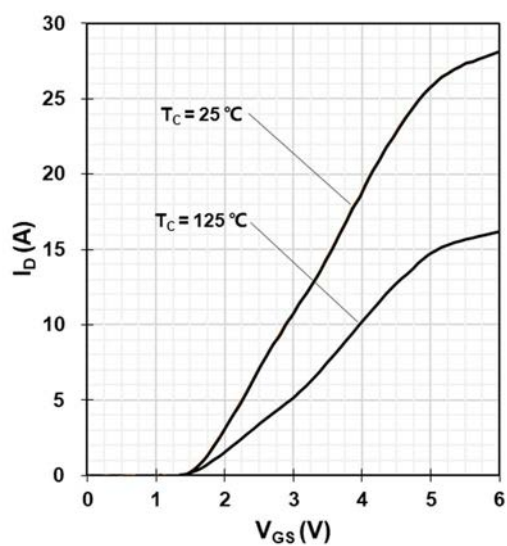
$$I_D = f(V_{DS}, V_{GS}); T_J = 25\text{ }^{\circ}\text{C}$$

Figure 6 Typ. channel reverse characteristics



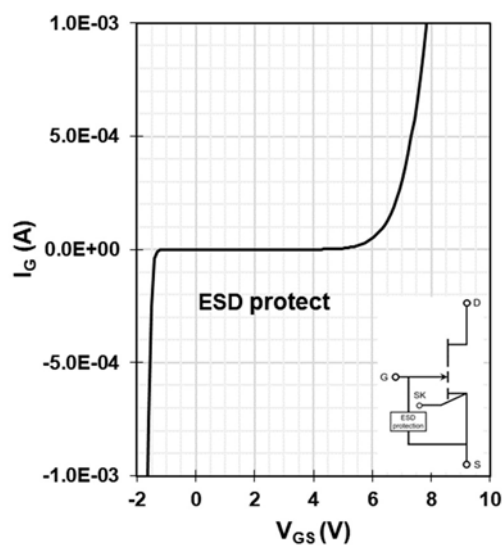
$$I_D = f(V_{DS}, V_{GS}); T_J = 125\text{ }^{\circ}\text{C}$$

Figure 7 Typ. transfer characteristics



$$I_D = f(V_{GS}); V_{DS} = 5\text{ V}$$

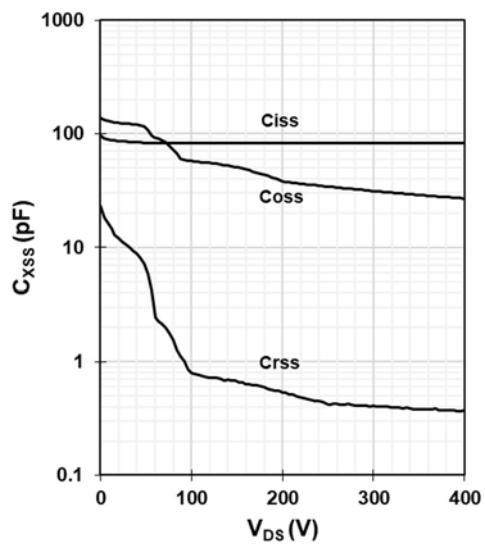
Figure 8 Typ. gate-to-source leakage



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

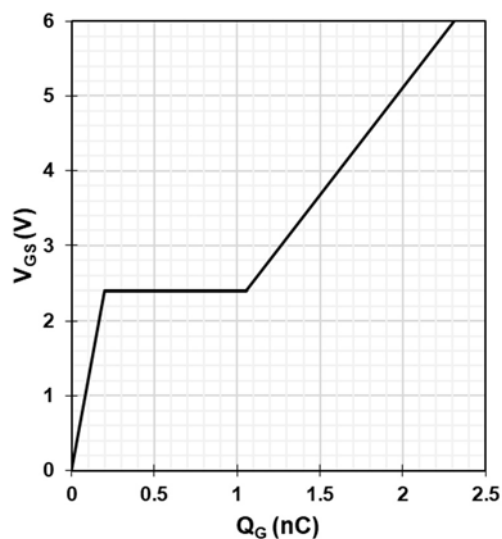


Figure 9 Typ. capacitances



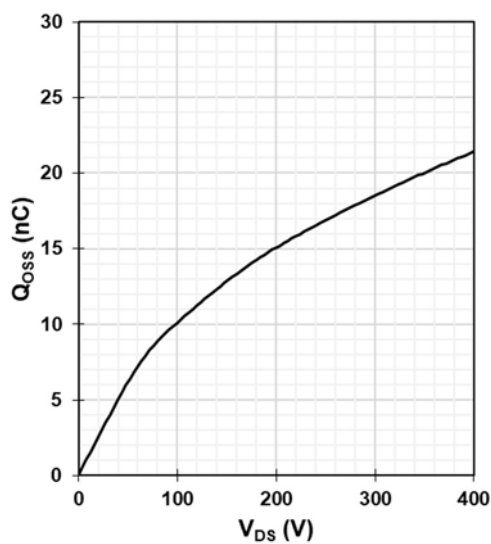
$C_{XSS} = f(V_{DS})$ ; Freq. = 100 kHz

Figure 10 Typ. gate charge



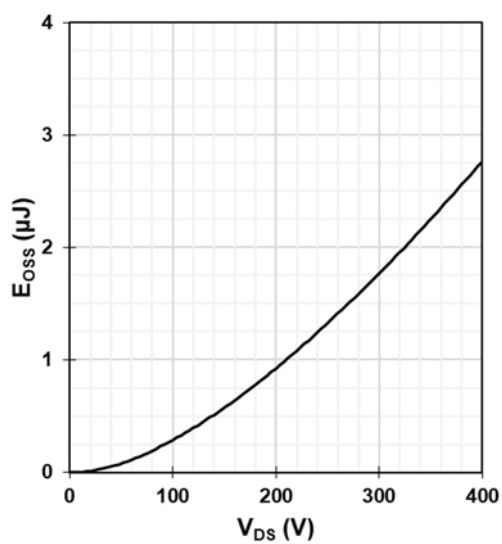
$V_{GS} = f(Q_G)$ ; V<sub>DC-LINK</sub> = 400 V; I<sub>D</sub> = 3 A

Figure 11 Typ. output charge



$Q_{OSS} = f(V_{DS})$ ; Freq. = 100 kHz

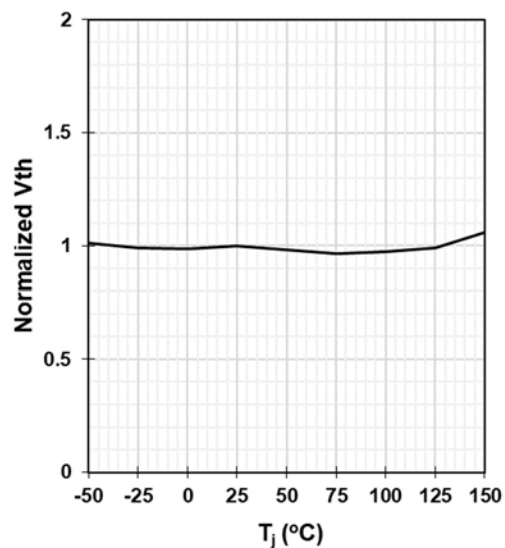
Figure 12 Typ. C<sub>OSS</sub> stored energy



$E_{OSS} = f(V_{DS})$ ; Freq. = 100 kHz

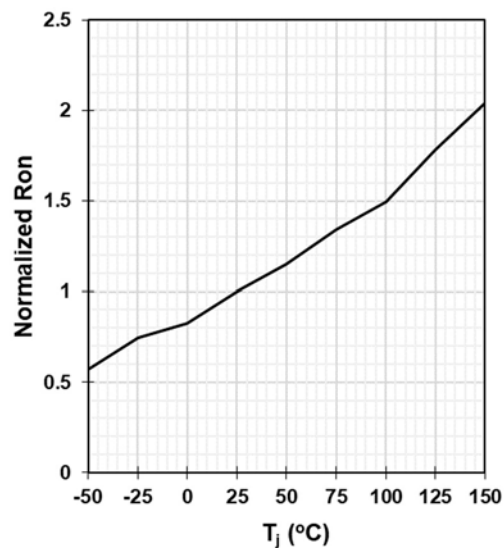


Figure 13 Gate threshold voltage



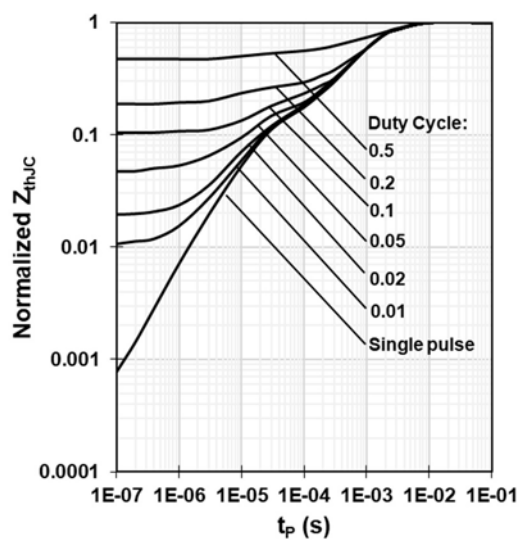
$$V_{TH} = f(T_j); V_{GS} = V_{DS}; I_D = 11 \text{ mA}$$

Figure 14 Drain-source on-state resistance



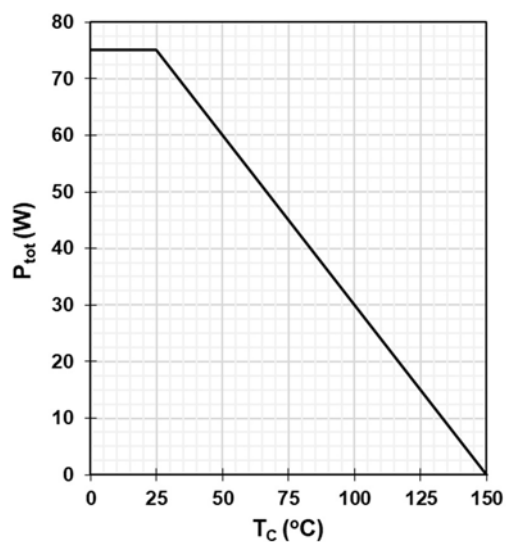
$$R_{DS(on)} = f(T_j); I_D = 3 \text{ A}; V_{GS} = 6 \text{ V}$$

Figure 15 Max. transient thermal impedance



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

Figure 16 Power dissipation

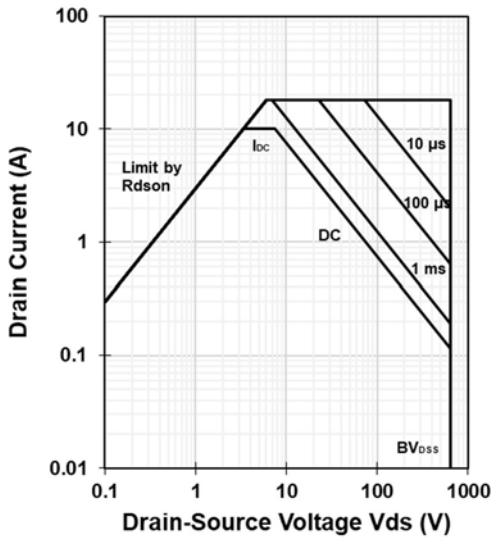


$$P_{tot} = f(T_c)$$



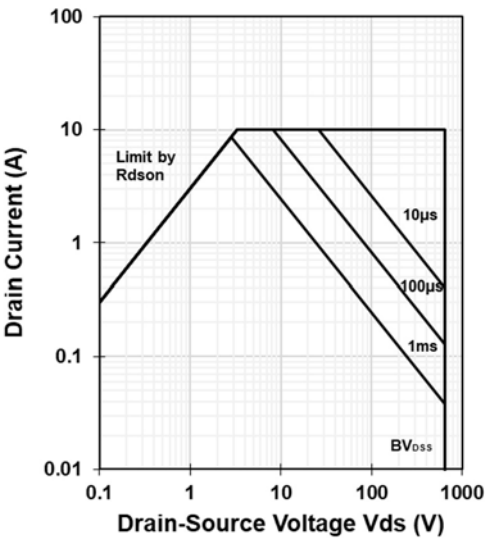


Figure 17 Safe operating area



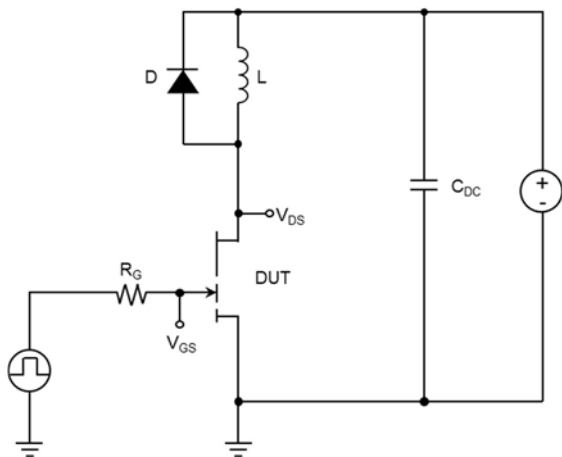
$I_D = f(V_{DS}); T_C = 25\text{ }^{\circ}\text{C}$

Figure 18 Safe operating area



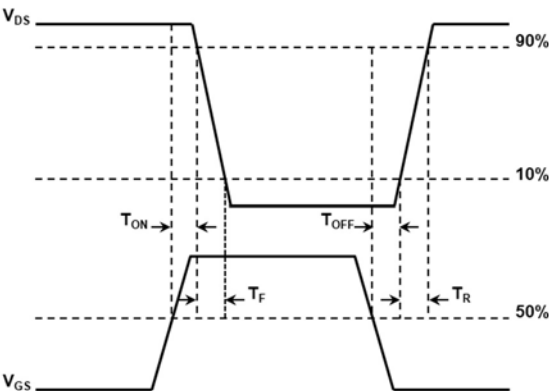
$I_D = f(V_{DS}); T_C = 125\text{ }^{\circ}\text{C}$

Figure 19 Max. transient thermal impedance



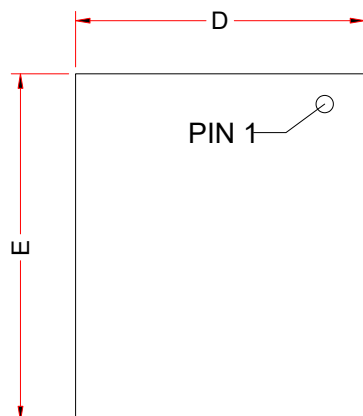
$V_{DS} = 400\text{ V}, I_D = 6\text{ A}, L = 318\text{ }\mu\text{H}, V_{GS} = 6\text{ V},$   
 $R_{on} = 10\text{ }\Omega, R_{off} = 2\text{ }\Omega$

Figure 20 Typ. switching times waveform

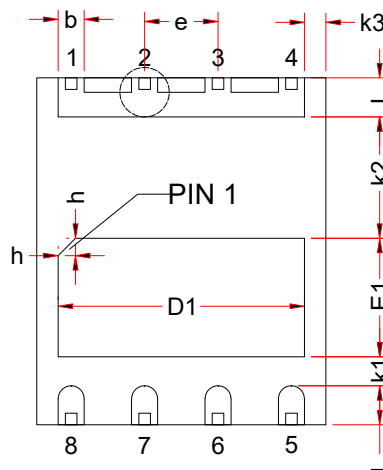




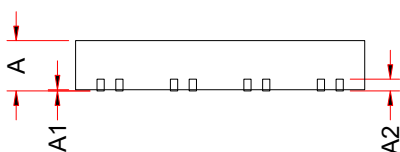
## Package outlines



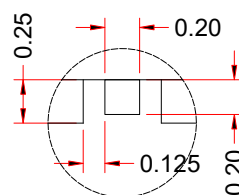
TOP VIEW



BOTTOM VIEW



SIDE VIEW



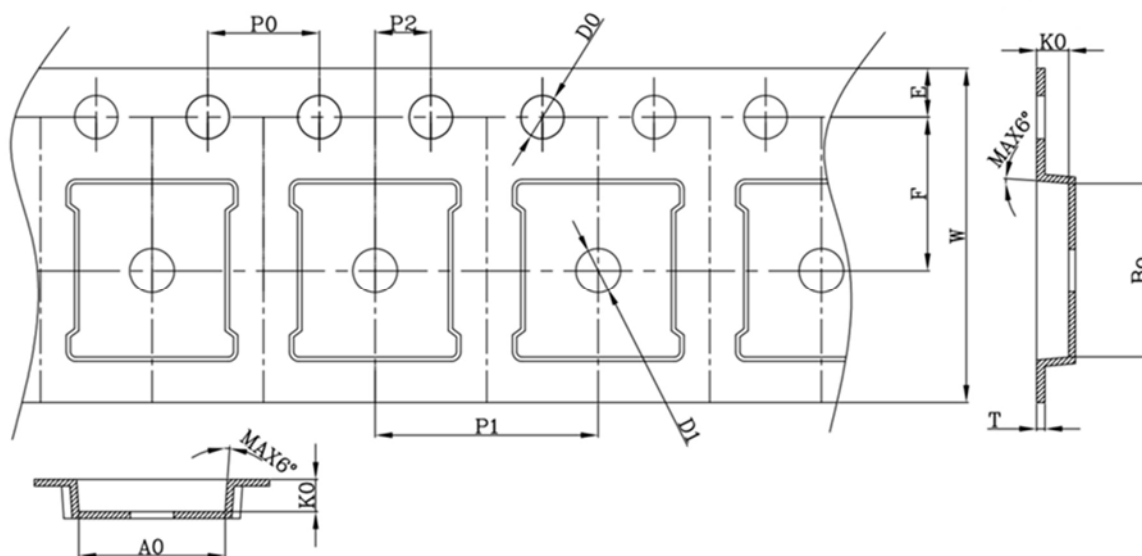
LEAD DETAIL

|    | MIN      | MID   | MAX   |
|----|----------|-------|-------|
| A  | 0.75     | 0.85  | 0.95  |
| A1 | 0.00     | 0.02  | 0.05  |
| A2 | 0.203REF |       |       |
| b  | 0.40     | 0.45  | 0.50  |
| D  | 4.90     | 5.00  | 5.10  |
| D1 | 4.16     | 4.26  | 4.36  |
| E  | 5.90     | 6.00  | 6.10  |
| E1 | 1.95     | 2.05  | 2.15  |
| h  | 0.20     | 0.30  | 0.40  |
| L  | 0.575    | 0.675 | 0.775 |
| e  | 1.270BSC |       |       |
| k1 | 0.400MIN |       |       |
| k2 | 2.000MIN |       |       |
| k3 | 0.270MIN |       |       |

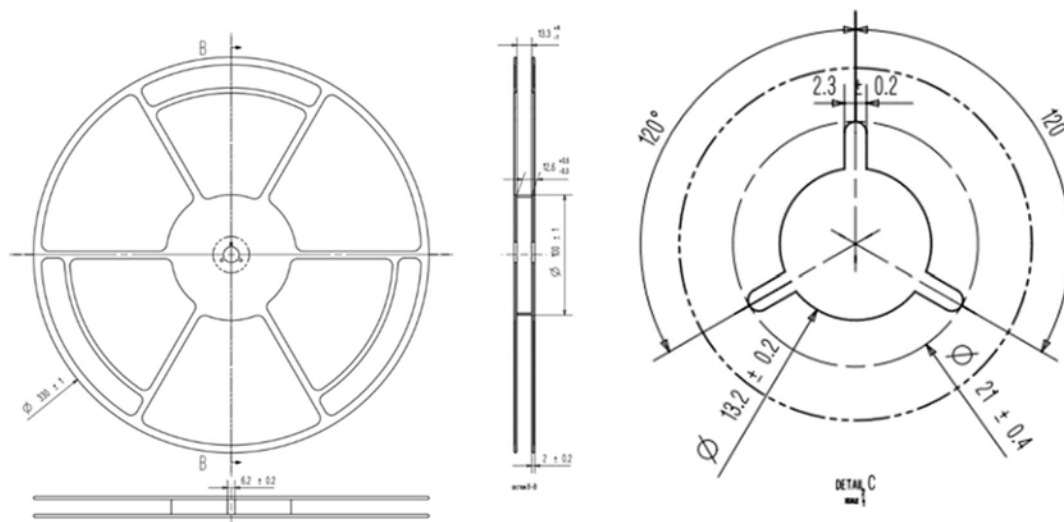


## GaN-on-Silicon Enhancement-mode

## Reel information



| SYMBOL | DIMENSION  | SYMBOL | DIMENSION  |
|--------|------------|--------|------------|
| W      | 12.00±0.30 | 10P0   | 40.00±0.20 |
| E      | 1.75±0.10  | P1     | 8.00±0.10  |
| F      | 5.50±0.05  | A0     | 5.25±0.10  |
| D0     | 1.55±0.05  | B0     | 6.25±0.10  |
| D1     | 1.55±0.10  | K0     | 1.15±0.10  |
| P0     | 4.00±0.10  | T      | 0.25±0.05  |
| P2     | 2.00±0.05  |        |            |





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