



## CoolGaN™ Transistor 650 V N-Channel Enhancement Mode



### General description

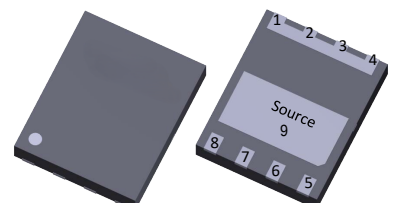
650V GaN-on-Silicon Enhancement-mode Power Transistor in Dual Flat No-lead Package (DFN) with 5 mm × 6 mm Size

### Features

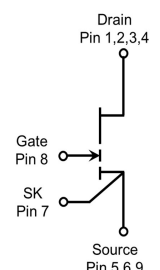
- Enhancement-mode transistor - normally-OFF power switch
- Ultra-high switching frequency
- No reverse-recovery charge
- Low gate charge, low output charge
- ESD safeguard
- RoHS, Pb-free, REACH-compliant

### 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    |



**ORDERING INFORMATION**  
 HT65N23EVDRZ

$T_A = -55^\circ$  to  $150^\circ$  C for all packages

**Table 1 Key Performance Parameters at  $T_j = 25^\circ\text{C}$**

| Parameters                | Values | Units      |
|---------------------------|--------|------------|
| $V_{DS, \max}$            | 650    | V          |
| $R_{DS(on), \max}$        | 140    | m $\Omega$ |
| $Q_G, \text{typ}$         | 3.3    | nC         |
| $I_D, \text{Pulse}$       | 32     | A          |
| $Q_{OSS} @ 400 \text{ V}$ | 33     | nC         |
| $Q_{rr}$                  | 0      | nC         |

## 1 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             | $I_D$                      | -      | -    | 17   | A                  | $T_c = 25\text{ }^{\circ}\text{C}$                                                                                                                 |
| Pulsed current, drain-source <sup>2</sup>    | $I_{D, \text{pulse}}$      | -      | -    | 32   | A                  | $T_c = 25\text{ }^{\circ}\text{C}$ ; $V_G = 6\text{ V}$                                                                                            |
| Pulsed current, drain-source <sup>2</sup>    | $I_{D, \text{pulse}}$      | -      | -    | 18   | 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                            | $P_{\text{tot}}$           | -      | -    | 113  | 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.

## 2 Thermal characteristics

**Table 4 Thermal characteristics**

| Parameters                        | Symbols           | Values |      |      | Units                | Notes/Test Conditions |
|-----------------------------------|-------------------|--------|------|------|----------------------|-----------------------|
|                                   |                   | Min.   | Typ. | Max. |                      |                       |
| Thermal resistance, junction-case | $R_{thJC}$        | -      | -    | 1.1  | $^{\circ}\text{C/W}$ |                       |
| Reflow soldering temperature      | $T_{\text{sold}}$ | -      | -    | 260  | $^{\circ}\text{C}$   | MSL3                  |

### 3 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    | 1.7  | 2.5  | V                | $I_D = 17.2\text{ mA}$ ; $V_{DS} = V_{GS}$ ; $T_j = 25\text{ }^{\circ}\text{C}$       |
|                                  |              | -      | 1.6  | -    |                  | $I_D = 17.2\text{ mA}$ ; $V_{DS} = V_{GS}$ ; $T_j = 125\text{ }^{\circ}\text{C}$      |
| Drain-source leakage current     | $I_{DSS}$    | -      | 0.6  | 20   | $\mu\text{A}$    | $V_{DS} = 650\text{ V}$ ; $V_{GS} = 0\text{ V}$ ; $T_j = 25\text{ }^{\circ}\text{C}$  |
|                                  |              | -      | 1    | -    |                  | $V_{DS} = 650\text{ V}$ ; $V_{GS} = 0\text{ V}$ ; $T_j = 125\text{ }^{\circ}\text{C}$ |
| Gate-source leakage current      | $I_{GSS}$    | -      | 40   | 200  | $\mu\text{A}$    | $V_{GS} = 6\text{ V}$ ; $V_{DS} = 0\text{ V}$                                         |
| Drain-source on-state resistance | $R_{DS(on)}$ | -      | 100  | 140  | $\text{m}\Omega$ | $V_{GS} = 6\text{ V}$ ; $I_D = 5\text{ A}$ ; $T_j = 25\text{ }^{\circ}\text{C}$       |
|                                  |              | -      | 200  | -    | $\text{m}\Omega$ | $V_{GS} = 6\text{ V}$ ; $I_D = 5\text{ A}$ ; $T_j = 125\text{ }^{\circ}\text{C}$      |
| 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                                         | $C_{iss}$   | -      | 125  | -    | pF    | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 400\text{ V}$ ; $f = 100\text{ kHz}$ |
| Output capacitance                                        | $C_{oss}$   | -      | 40   | -    | 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 <sup>1</sup> | $C_{o(er)}$ | -      | 53   | -    | pF    | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 0\text{ to }400\text{ V}$            |
| Effective output capacitance, time related <sup>2</sup>   | $C_{o(tr)}$ | -      | 81   | -    | pF    | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 0\text{ to }400\text{ V}$            |
| Output charge                                             | $Q_{oss}$   | -      | 33   | -    | nC    | $V_{GS} = 0\text{ V}$ ; $V_{DS} = 0\text{ to }400\text{ V}$            |

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          | $Q_G$      | -      | 3.3  | -    | nC    | $V_{GS} = 0 \text{ to } 6 \text{ V}; V_{DS} = 400 \text{ V};$<br>$I_D = 5 \text{ A}$ |
| Gate-source charge   | $Q_{GS}$   | -      | 0.3  | -    | nC    |                                                                                      |
| Gate-drain charge    | $Q_{GD}$   | -      | 1.25 | -    | nC    |                                                                                      |
| Gate plateau voltage | $V_{plat}$ | -      | 2.4  | -    | V     | $V_{DS} = 400 \text{ V}; I_D = 5 \text{ A}$                                          |

**Table 8 Reverse conduction characteristics**

| Parameters                    | Symbols        | Values |      |      | Units | Notes/Test Conditions                          |
|-------------------------------|----------------|--------|------|------|-------|------------------------------------------------|
|                               |                | Min.   | Typ. | Max. |       |                                                |
| Source-drain reverse voltage  | $V_{SD}$       | -      | 2.5  | -    | V     | $V_{GS} = 0 \text{ V}; I_{SD} = 5 \text{ A}$   |
| Pulsed current, reverse       | $I_{S, pulse}$ | -      | 28   | -    | A     | $V_{GS} = 6 \text{ V}$                         |
| Reverse recovery charge       | $Q_{rr}$       | -      | 0    | -    | nC    | $I_{SD} = 5 \text{ A}; V_{DS} = 400 \text{ V}$ |
| Reverse recovery time         | $t_{rr}$       | -      | 0    | -    | ns    |                                                |
| Peak reverse recovery current | $I_{rrm}$      | -      | 0    | -    | A     |                                                |

## 4 Electrical characteristics diagrams

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

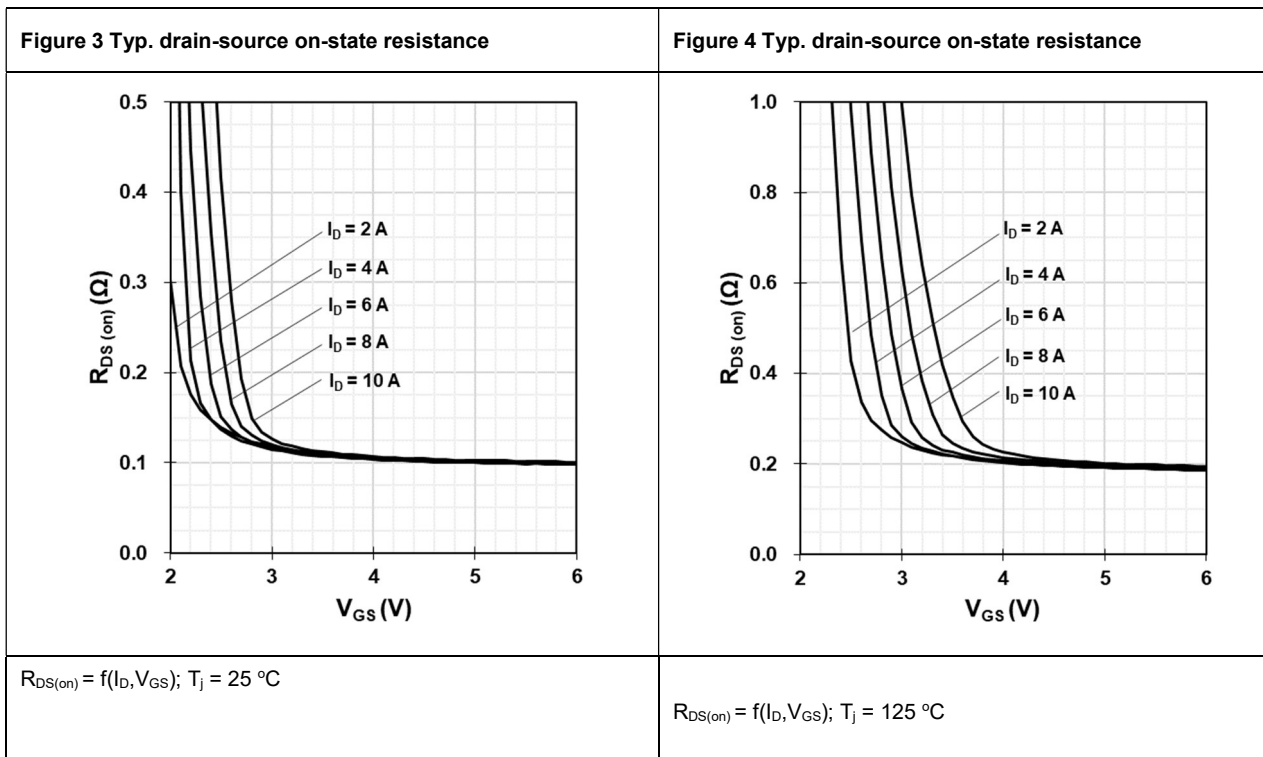
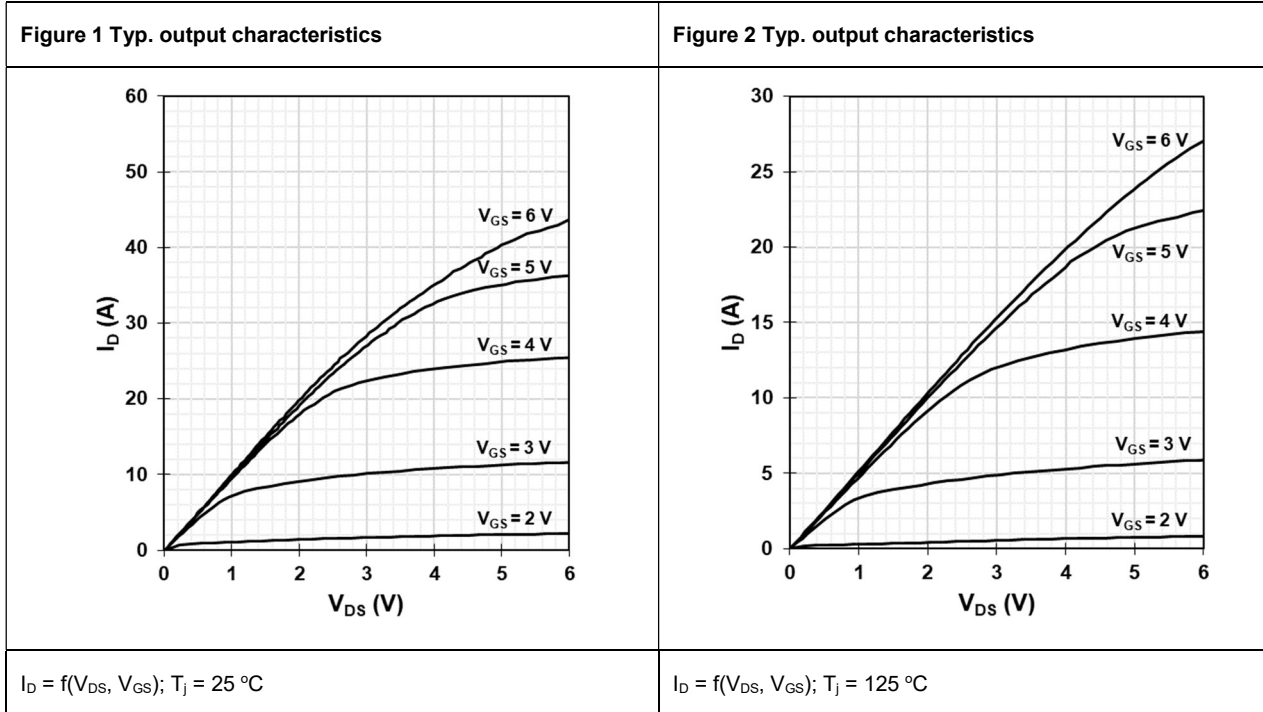
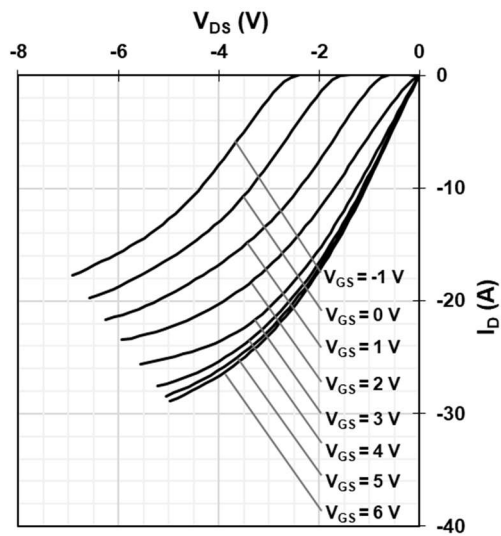
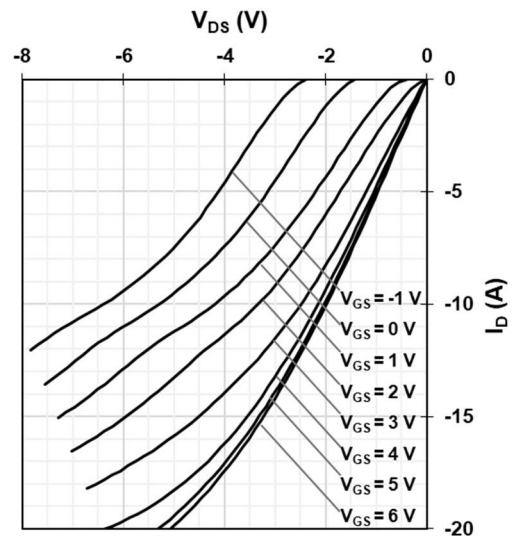


Figure 5 Typ. channel reverse characteristics



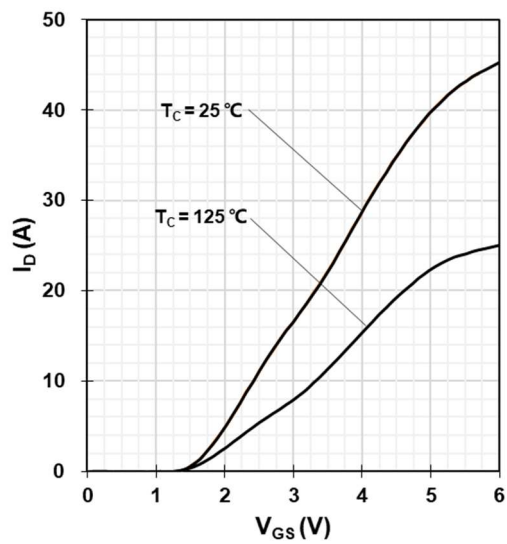
$$I_D = f(V_{DS}, V_{GS}); T_J = 25^\circ\text{C}$$

Figure 6 Typ. channel reverse characteristics



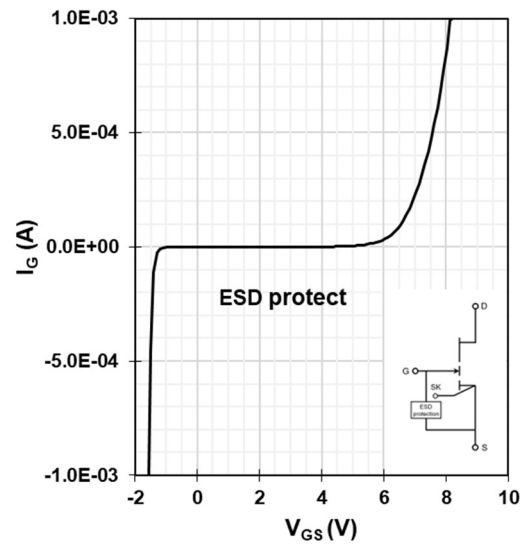
$$I_D = f(V_{DS}, V_{GS}); T_J = 125^\circ\text{C}$$

Figure 7 Typ. transfer characteristics



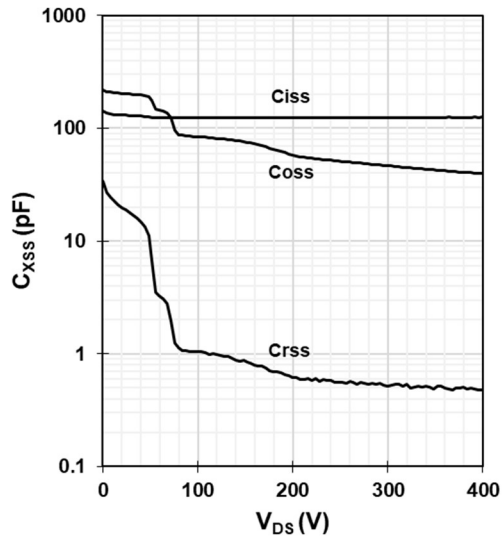
$$I_D = f(V_{GS}); V_{DS} = 5\text{ V}$$

Figure 8 Typ. gate-to-source leakage



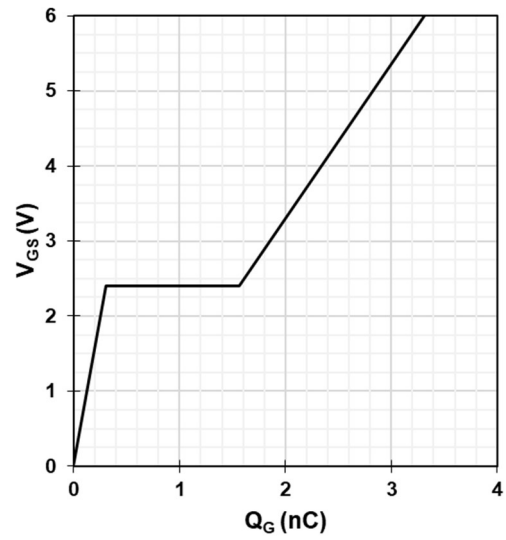
$$I_G = f(V_{GS}); I_G \text{ reverse turn on by ESD unit; } V_D = \text{open}$$

Figure 9 Typ. capacitances



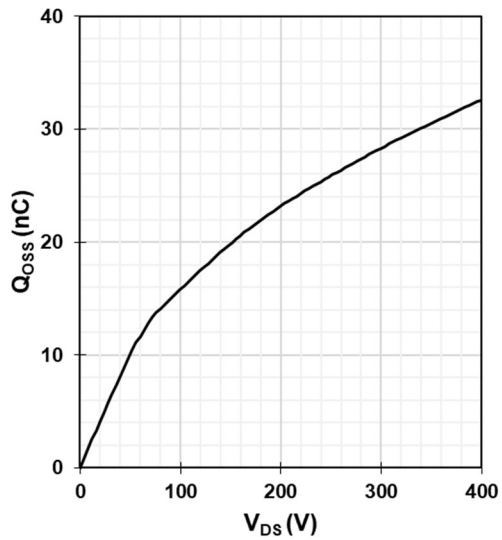
$C_{XSS} = f(V_{DS})$ ; Freq. = 100 kHz

Figure 10 Typ. gate charge



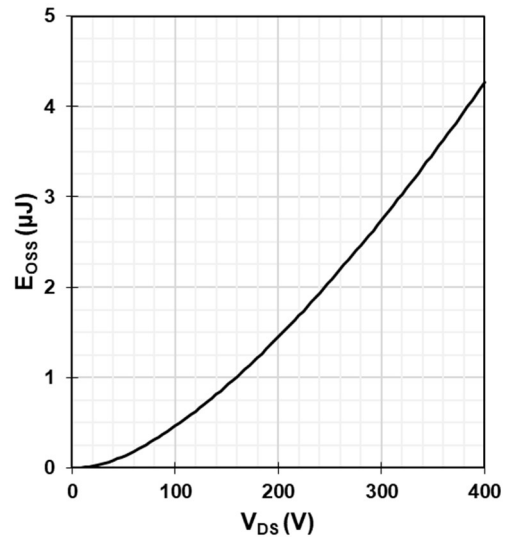
$V_{GS} = f(Q_G)$ ;  $V_{DS} = 400$  V;  $I_D = 5$  A

Figure 11 Typ. output charge



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

Figure 12 Typ.  $C_{OSS}$  stored energy



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

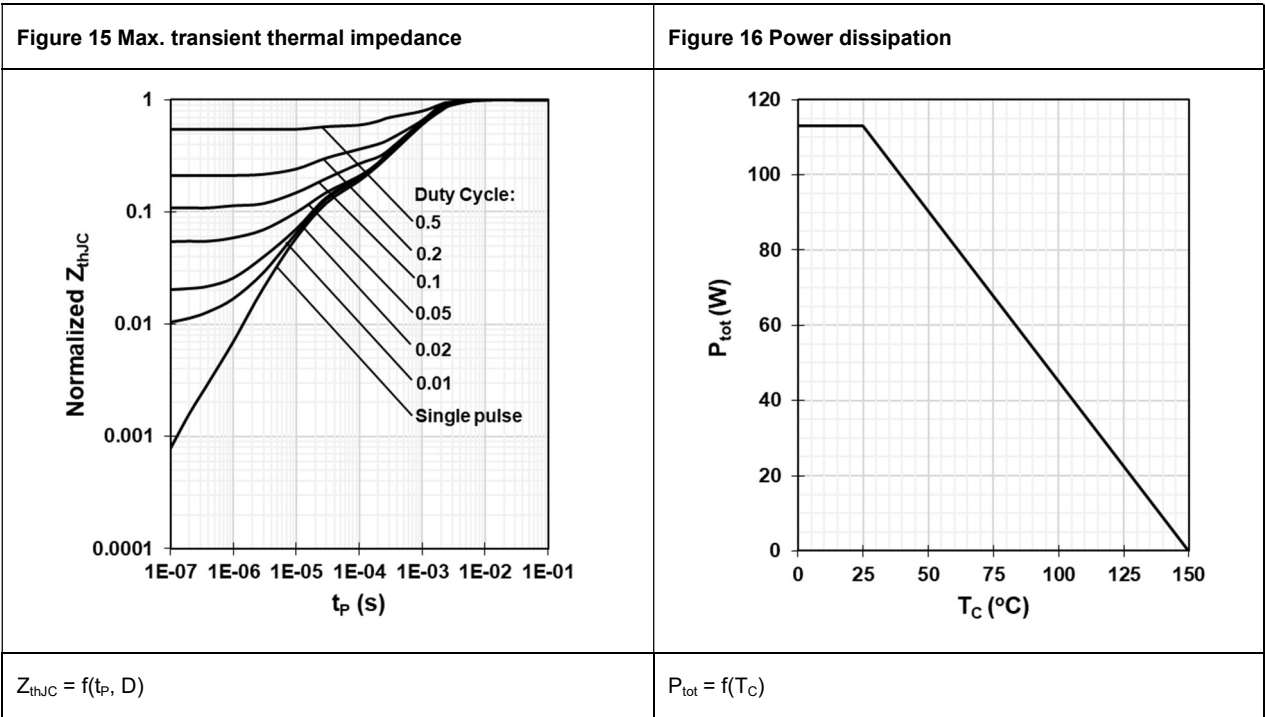
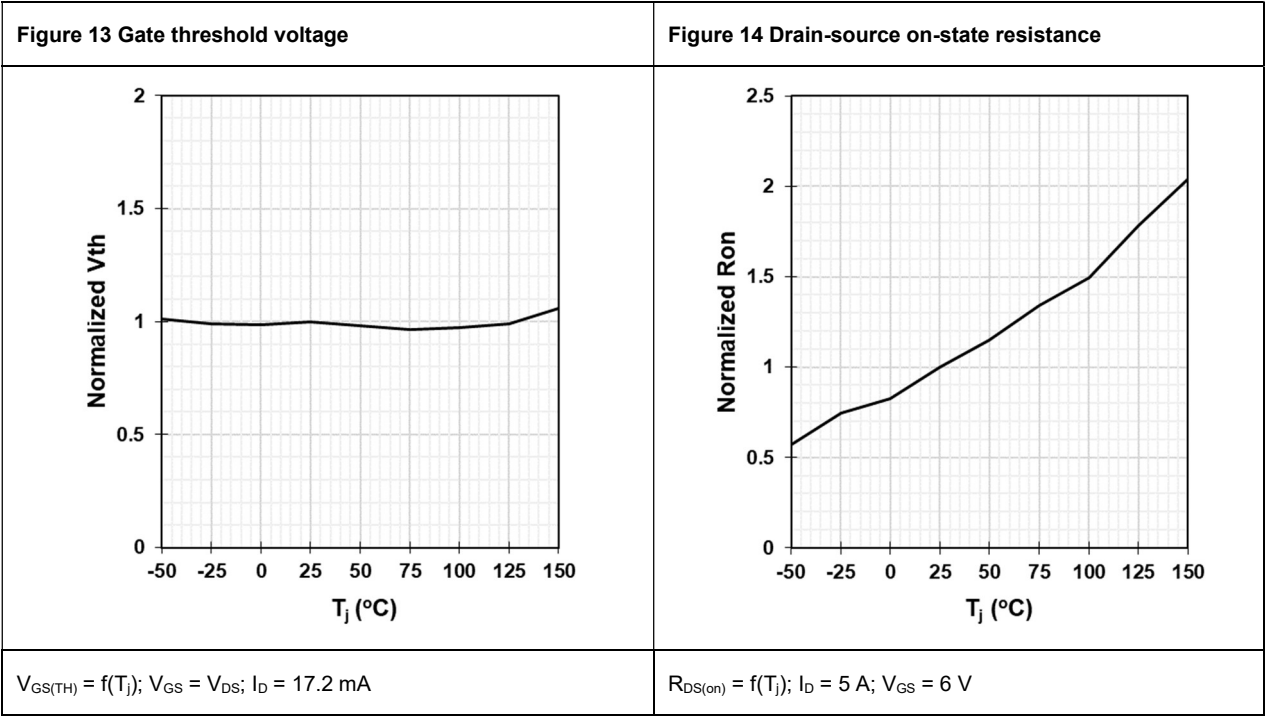
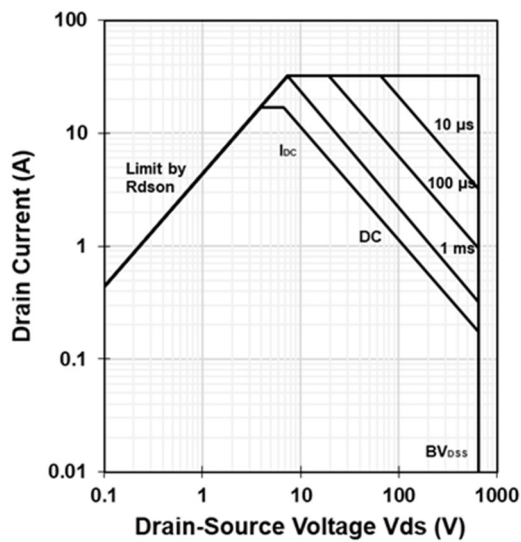
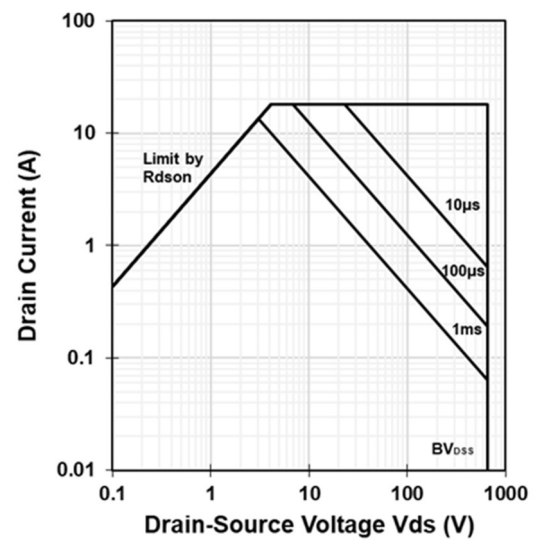


Figure 17 Safe operating area



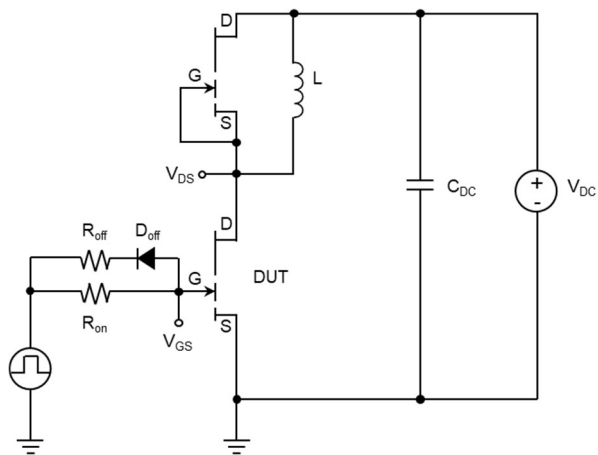
$I_D = f(V_{DS}); T_C = 25\text{ }^{\circ}\text{C}$

Figure 18 Safe operating area



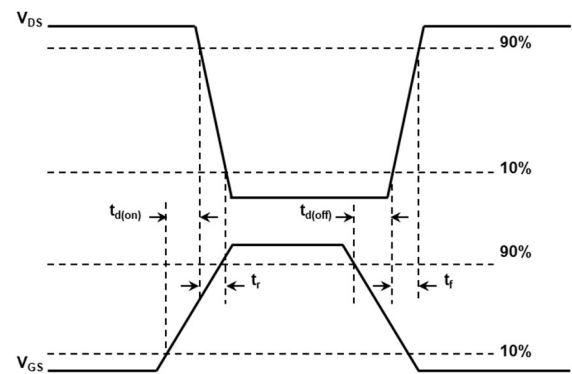
$I_D = f(V_{DS}); T_C = 125\text{ }^{\circ}\text{C}$

Figure 19 Switching times test circuit

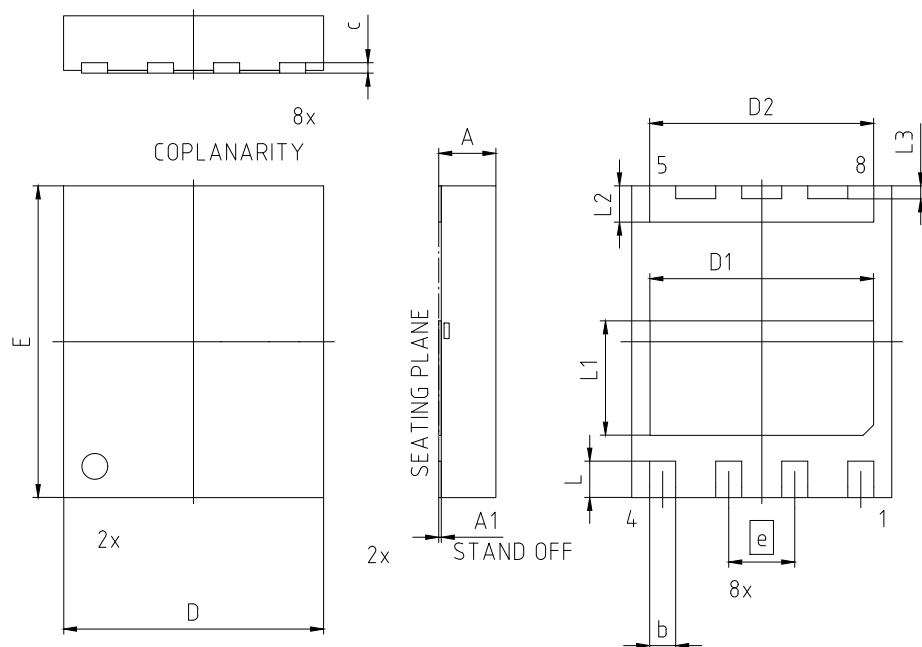


$V_{DS} = 400\text{ V}, I_D = 10\text{ A}, L = 318\text{ }\mu\text{H}, V_{GS} = 6\text{ V},$   
 $R_{on} = 10\text{ }\Omega, R_{off} = 2\text{ }\Omega$

Figure 20 Typ. switching times waveform

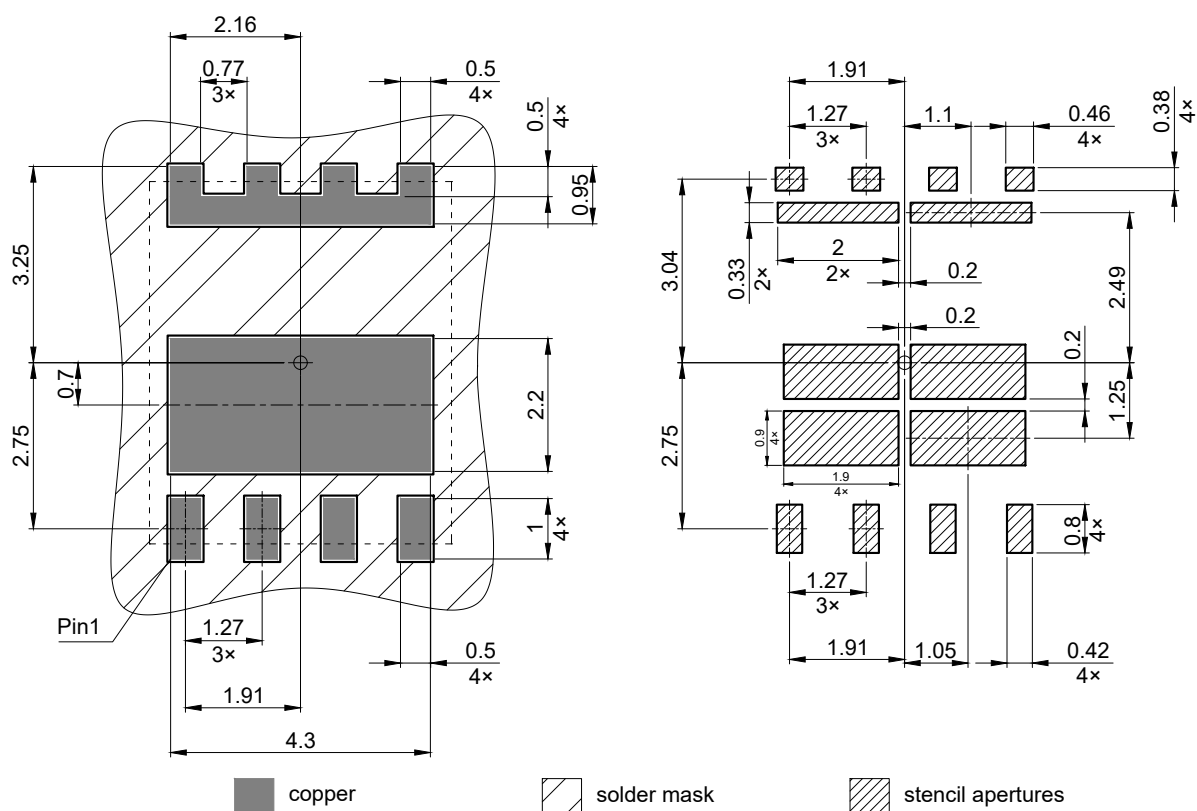


## 5 Package outlines



| PACKAGE - GROUP<br>NUMBER: <b>DFN8-5*6</b> |             |      |
|--------------------------------------------|-------------|------|
| DIMENSIONS                                 | MILLIMETERS |      |
|                                            | MIN.        | MAX. |
| <b>A</b>                                   | -           | 1.10 |
| <b>A1</b>                                  | -           | 0.05 |
| <b>b</b>                                   | 0.45        | 0.55 |
| <b>c</b>                                   | <b>0.20</b> |      |
| <b>D</b>                                   | <b>5.00</b> |      |
| <b>D1</b>                                  | 4.20        | 4.40 |
| <b>D2</b>                                  | 4.21        | 4.41 |
| <b>E</b>                                   | <b>6.00</b> |      |
| <b>e</b>                                   | <b>1.27</b> |      |
| <b>L</b>                                   | 0.60        | 0.80 |
| <b>L1</b>                                  | 2.10        | 2.30 |
| <b>L2</b>                                  | 0.60        | 0.80 |
| <b>L3</b>                                  | 0.15        | 0.35 |

## 5 Package outlines



All pads are non-solder mask defined  
All dimensions are in units mm