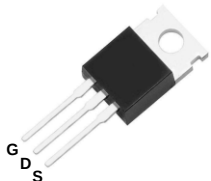
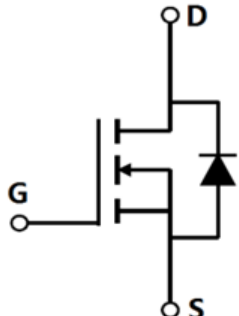


N-channel 60V, 2.6mΩ typ., 120A  
 SGT MOSFET S2 in TO-220 and TO-263

Datasheet - production data

## 1. Descriptions

| TO-220                                                                                                         | TO-263                                                                            |
|----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
|                               |  |
| <b>Schematic Diagram</b><br> |                                                                                   |

## Key Performance Parameters

| Parameters       | Value | Unit |
|------------------|-------|------|
| $BV_{DSS}$       | 60    | V    |
| $R_{DS(on),max}$ | 3     | mΩ   |
| $Q_{g,typ}$      | 42    | nC   |
| $I_{D,pulse}$    | 240   | A    |
| $E_{AS}$         | 650   | mJ   |

## Features

- Extremely low losses due to very low FOM  $R_{dson} \cdot Q_g$ .
- High-speed switching.
- Qualified for industrial grade applications according to JEDEC.
- 100% UIS Tested.

## Applications

High-Efficiency DC-DC Converters, Switching Voltage Regulators and Motor Drivers.

| Type/Ordering Code | Package | Marking  | Related Links  |
|--------------------|---------|----------|----------------|
| CSP030N06S2        | TO-220  | 030N06S2 | See Appendix A |
| CSB030N06S2        | TO-263  |          |                |

## Contents

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## 2. Maximum Ratings

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

**Table 1. Absolute Maximum Ratings**

| Symbol         | Parameter                                    | Values |      |      | Unit             | Test Condition                 |
|----------------|----------------------------------------------|--------|------|------|------------------|--------------------------------|
|                |                                              | Min.   | Typ. | Max. |                  |                                |
| $V_{DS}$       | Drain-source voltage <sup>1)</sup>           | -      | -    | 60   | V                | $V_{GS}=0V$ , $I_D=1mA$        |
| $I_D$          | Continuous drain current (Silicon Limited)   | -      | -    | 190  | A                | $T_C=25^\circ\text{C}$         |
|                | Continuous drain current (Package Limited)   | -      | -    | 120  | A                | $T_C=25^\circ\text{C}$         |
| $I_{D,pulse}$  | Pulsed drain current                         | -      | -    | 240  | A                | $T_C=25^\circ\text{C}$         |
| $E_{AS}$       | Avalanche energy, single pulse <sup>2)</sup> | -      | -    | 650  | mJ               | $I_D=51A$ ; $V_{DD}=50V$       |
| $I_{AS}$       | Avalanche current                            | -      | -    | 51   | A                | -                              |
| $V_{GS}$       | Gate source voltage                          | -20    | -    | 20   | V                | static; AC ( $f>1\text{ Hz}$ ) |
| $P_{tot}$      | Power dissipation                            | -      | -    | 211  | W                | $T_C=25^\circ\text{C}$         |
| $T_j, T_{stg}$ | Operating and storage temperature            | -55    | -    | 175  | $^\circ\text{C}$ | -                              |
| $I_S$          | Continuous diode forward current             | -      | -    | 120  | A                | $T_C=25^\circ\text{C}$         |
| $I_{S,pulse}$  | Diode pulse current <sup>2)</sup>            | -      | -    | 240  | A                | $T_C=25^\circ\text{C}$         |

1) Limited by  $T_j$  max. Maximum duty cycle  $D=0.75$ .

2)  $V_{DD}=50V$ ,  $L=0.5mH$ ,  $R_G=25\Omega$ , Starting  $T_j=25^\circ\text{C}$ .

### 3. Thermal Characteristics

**Table 2. Thermal Characteristics**

| Symbol     | Parameter                                                     | Values |      |      | Unit | Test Condition                          |
|------------|---------------------------------------------------------------|--------|------|------|------|-----------------------------------------|
|            |                                                               | Min.   | Typ. | Max. |      |                                         |
| $R_{thJC}$ | Thermal resistance, junction - case                           | -      | -    | 0.59 | °C/W | $T_C = 25^{\circ}\text{C}$              |
| $R_{thJA}$ | Thermal resistance, junction - ambient                        | -      | -    | 50   | °C/W | $T_C = 25^{\circ}\text{C}$              |
| $T_{sold}$ | Soldering temperature,<br>wavesoldering only allowed at leads | -      | -    | 260  | °C   | Lead Temperature<br>(Soldering, 10 sec) |

## 4. Electrical Characteristics

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

**Table 3. Static Characteristics**

| Symbol        | Parameter                        | Values |      |           | Unit       | Test Condition                          |
|---------------|----------------------------------|--------|------|-----------|------------|-----------------------------------------|
|               |                                  | Min.   | Typ. | Max.      |            |                                         |
| $V_{(BR)DSS}$ | Drain-source breakdown voltage   | 60     | -    | -         | V          | $V_{GS}=0V, I_D=1mA$                    |
| $V_{(GS)th}$  | Gate threshold voltage           | 1.0    | 1.7  | 2.5       | V          | $V_{DS}=V_{GS}, I_D=250\mu A$           |
| $I_{DSS}$     | Zero gate voltage drain current  | -      | -    | 1         | $\mu A$    | $V_{DS}=60V, V_{GS}=0V, T_j=25^\circ C$ |
| $I_{GSS}$     | Gate-source leakage current      | -      | -    | $\pm 100$ | nA         | $V_{GS}=\pm 20V, V_{DS}=0V$             |
| $R_{DS(on)}$  | Drain-source on-state resistance | -      | 2.6  | 3         | m $\Omega$ | $V_{GS}=10V, I_D=20A, T_j=25^\circ C$   |
| $R_G$         | Gate resistance                  | -      | 2.6  | -         | $\Omega$   | $V_{DD}=0V, V_{GS}=0V, F=1MHz$          |
| $g_{fs}$      | Transconductance                 |        | 130  |           | S          | $V_{DS}=5V, I_D=20A$                    |

**Table 4. Dynamic Characteristics**

| Symbol       | Parameter                    | Values |      |      | Unit | Test Condition                                  |
|--------------|------------------------------|--------|------|------|------|-------------------------------------------------|
|              |                              | Min.   | Typ. | Max. |      |                                                 |
| $C_{iss}$    | Input capacitance            | -      | 4200 | -    | pF   | $V_{GS}=0V, V_{DS}=25V, f=250kHz$               |
| $C_{oss}$    | Output capacitance           | -      | 1080 | -    | pF   | $V_{GS}=0V, V_{DS}=25V, f=250kHz$               |
| $C_{rss}$    | Reverse transfer capacitance | -      | 41   | -    | pF   | $V_{GS}=0V, V_{DS}=25V, f=250kHz$               |
| $t_{d(on)}$  | Turn-on delay time           | -      | 13.5 | -    | ns   | $V_{DD}=30V, V_{GS}=10V, I_D=100A, R_G=3\Omega$ |
| $t_r$        | Rise time                    | -      | 96   | -    | ns   | $V_{DD}=30V, V_{GS}=10V, I_D=100A, R_G=3\Omega$ |
| $t_{d(off)}$ | Turn-off delay time          | -      | 40   | -    | ns   | $V_{DD}=30V, V_{GS}=10V, I_D=100A, R_G=3\Omega$ |
| $t_f$        | Fall time                    | -      | 115  | -    | ns   | $V_{DD}=30V, V_{GS}=10V, I_D=100A, R_G=3\Omega$ |

**Table 5. Gate Charge Characteristics**

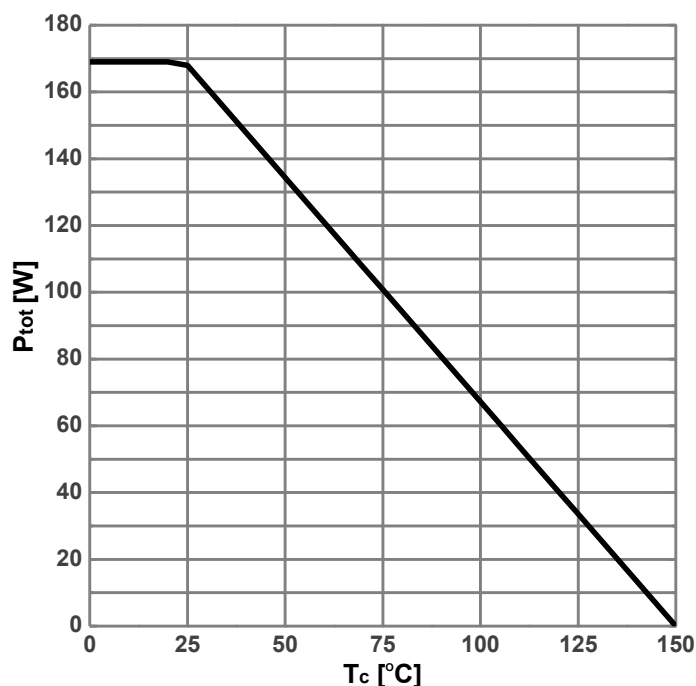
| Symbol        | Parameter             | Values |      |      | Unit | Test Condition                                  |
|---------------|-----------------------|--------|------|------|------|-------------------------------------------------|
|               |                       | Min.   | Typ. | Max. |      |                                                 |
| $Q_{gs}$      | Gate to source charge | -      | 10   | -    | nC   | $V_{DD}=30V, I_D=20A, V_{GS}=0 \text{ to } 10V$ |
| $Q_{gd}$      | Gate to drain charge  | -      | 12   | -    | nC   | $V_{DD}=30V, I_D=20A, V_{GS}=0 \text{ to } 10V$ |
| $Q_g$         | Gate charge total     | -      | 42   | -    | nC   | $V_{DD}=30V, I_D=20A, V_{GS}=0 \text{ to } 10V$ |
| $V_{plateau}$ | Gate plateau voltage  | -      | 1.9  | -    | V    | $V_{DD}=30V, I_D=20A, V_{GS}=0 \text{ to } 10V$ |

**Table 6. Reverse Diode Characteristics**

| Symbol    | Parameter                     | Values |      |      | Unit | Test Condition                         |
|-----------|-------------------------------|--------|------|------|------|----------------------------------------|
|           |                               | Min.   | Typ. | Max. |      |                                        |
| $V_{SD}$  | Diode forward voltage         | -      | 0.8  | -    | V    | $V_{GS}=0V, I_F=20A, T_j=25^\circ C$   |
| $t_{rr}$  | Reverse recovery time         | -      | 35   | -    | ns   | $V_R=30V, I_F=60A, di_F/dt=100A/\mu s$ |
| $Q_{rr}$  | Reverse recovery charge       | -      | 30   | -    | nC   | $V_R=30V, I_F=60A, di_F/dt=100A/\mu s$ |
| $I_{rrm}$ | Peak reverse recovery current | -      | 1.5  | -    | A    | $V_R=30V, I_F=60A, di_F/dt=100A/\mu s$ |

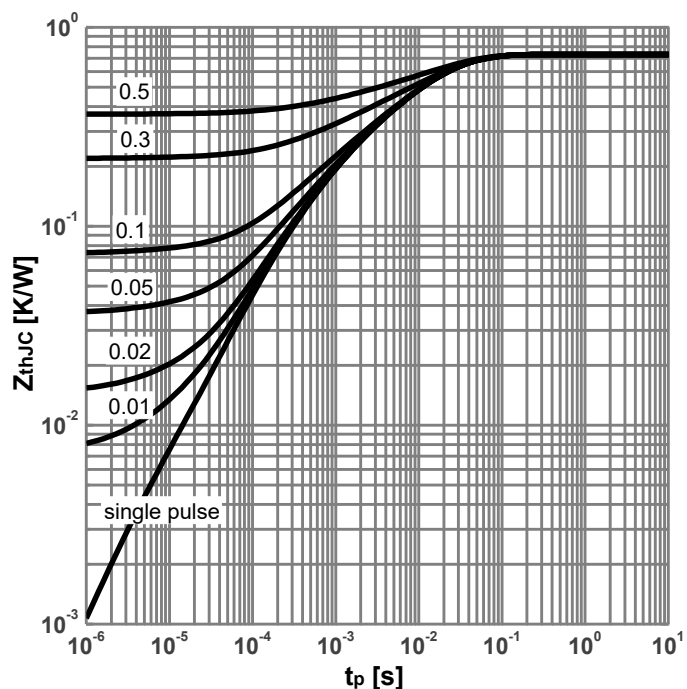
## 5. Electrical Characteristics Diagrams

Diagram 1: Power dissipation



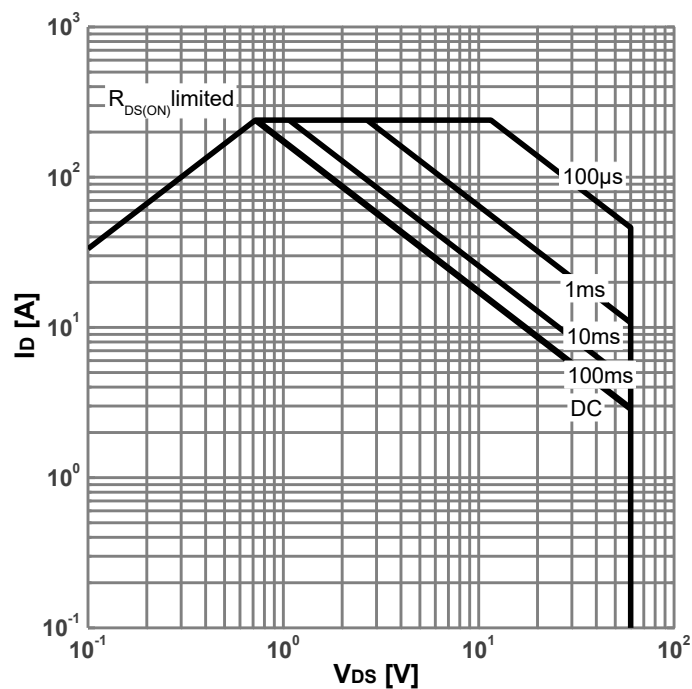
$$P_{tot}=f(T_c)$$

Diagram 2: Max. transient thermal impedance



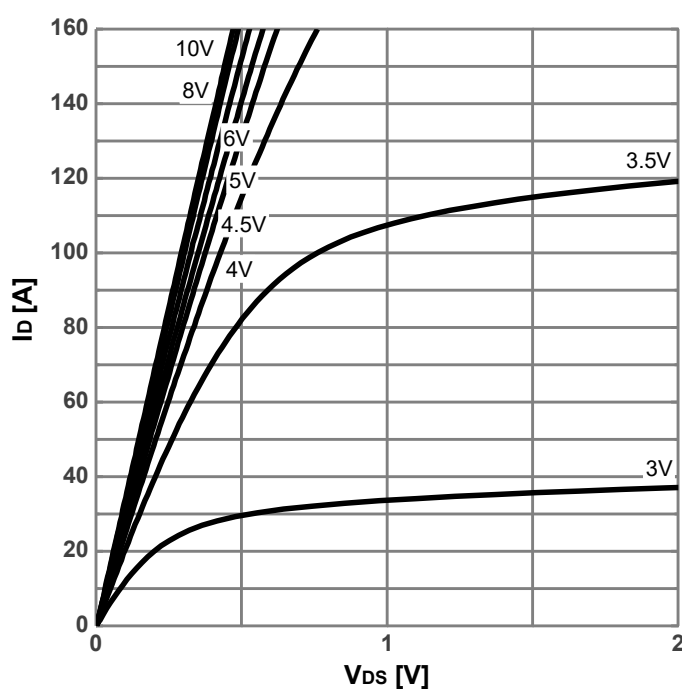
$$Z_{thJC}=f(t_p); \text{ parameter: } D= t_p/T$$

Diagram 3: Safe operating area



$$I_D=f(V_{DS}); T_J=25^\circ\text{C}; D=0; \text{ parameter: } t_p$$

Diagram 4: Typ. output characteristics



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

Diagram 5: Typ. output characteristics

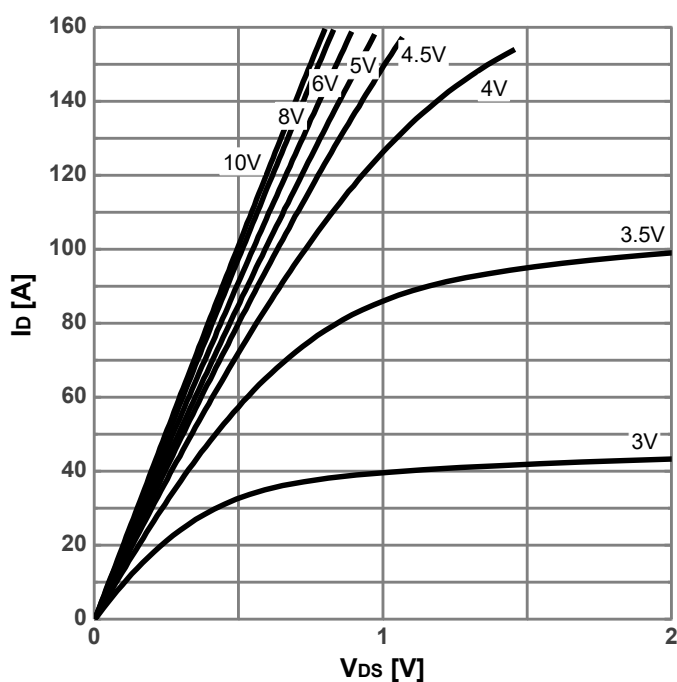

 $I_D = f(V_{DS}); T_J = 125^\circ\text{C}; \text{parameter: } V_{GS}$ 

Diagram 6: Typ. transfer characteristics

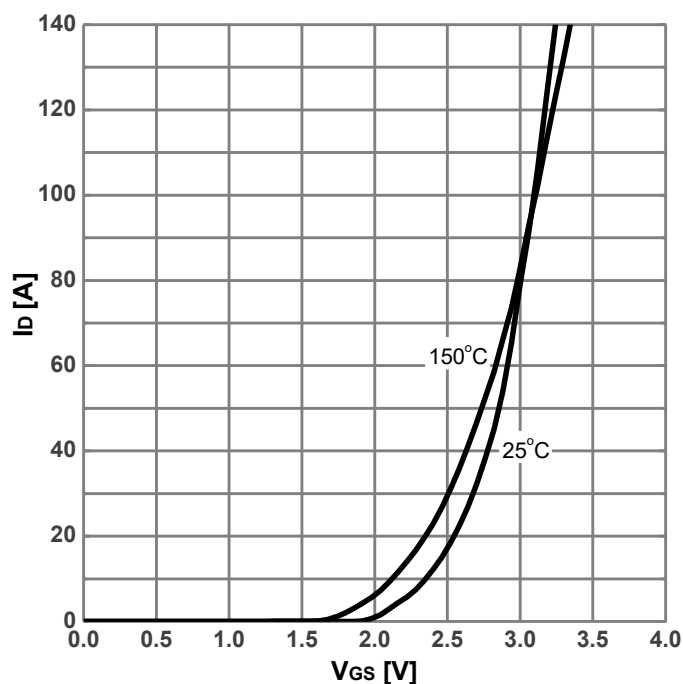

 $I_D = f(V_{GS}); V_{DS} = 20\text{V}; \text{parameter: } T_J$ 

Diagram 7: Gate threshold voltage vs. Junction temperature

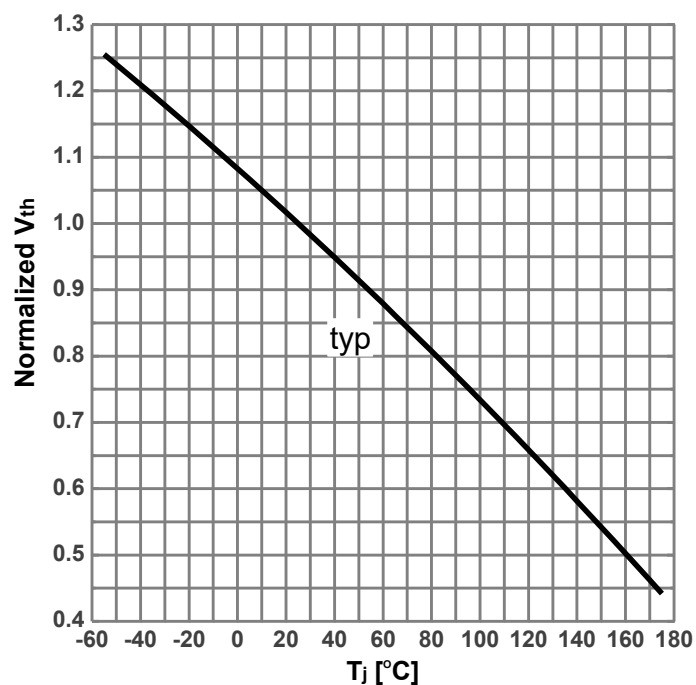
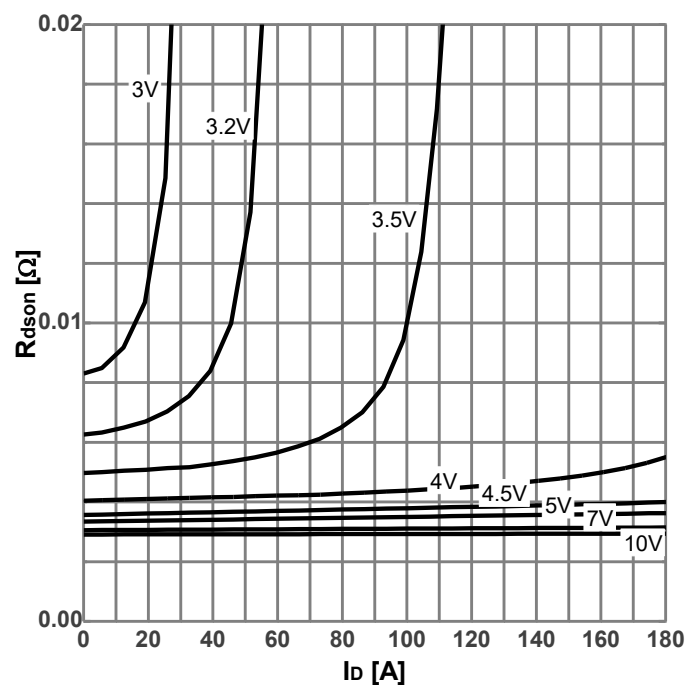
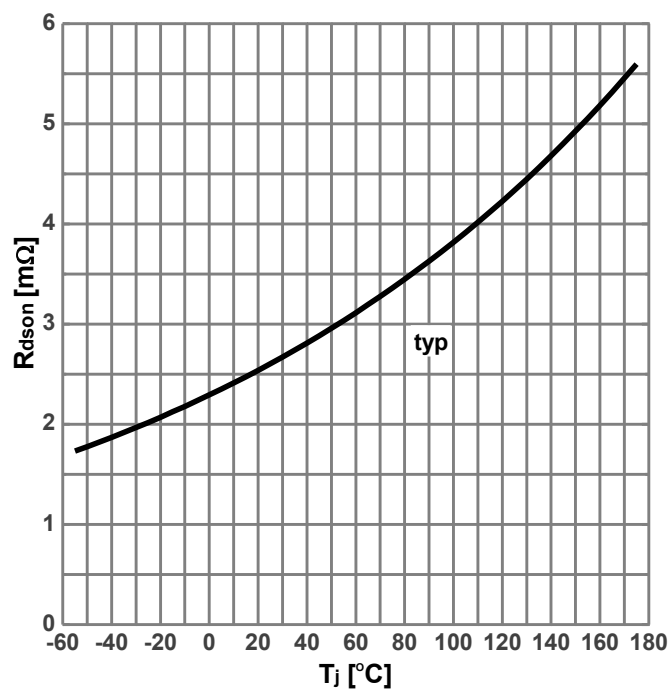
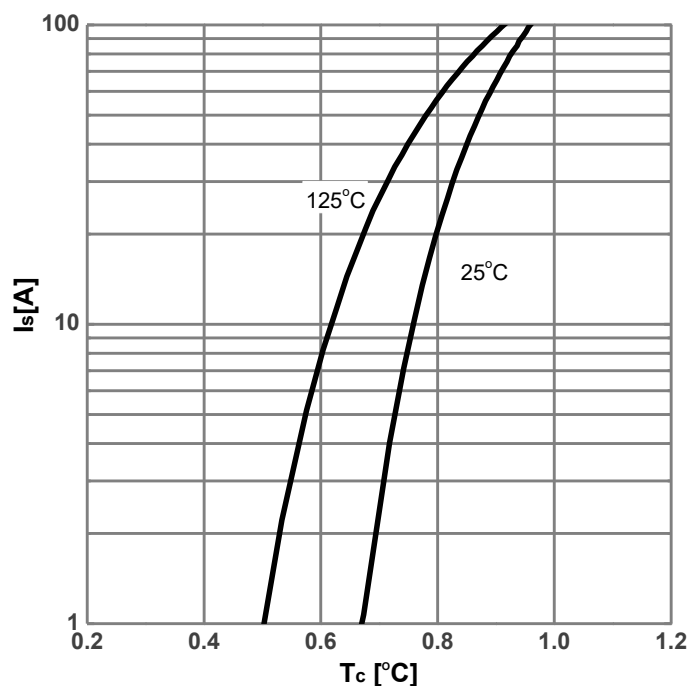

 $V_{th} = f(T_J); I_D = 250\mu\text{A}$ 

Diagram 8: On-state resistance vs. Drain current

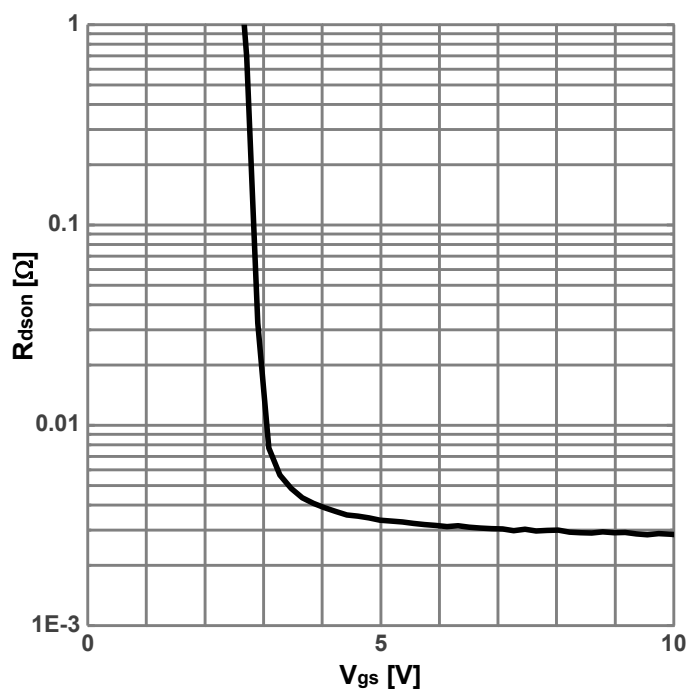

 $R_{DS(on)} = f(I_D); T_J = 25^\circ\text{C}; \text{parameter: } V_{GS}$

**Diagram 9: On-state resistance vs. Junction temperature**

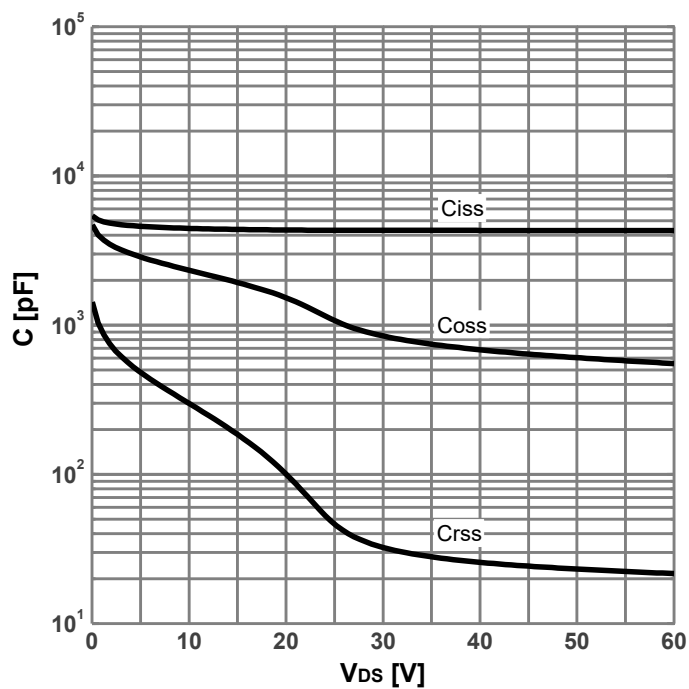
$$R_{DS(on)}=f(T_j); I_D=20A; V_{GS}=10V$$

**Diagram 10: Forward characteristics of reverse diode**

$$I_F=f(V_{SD}); \text{parameter: } T_j$$

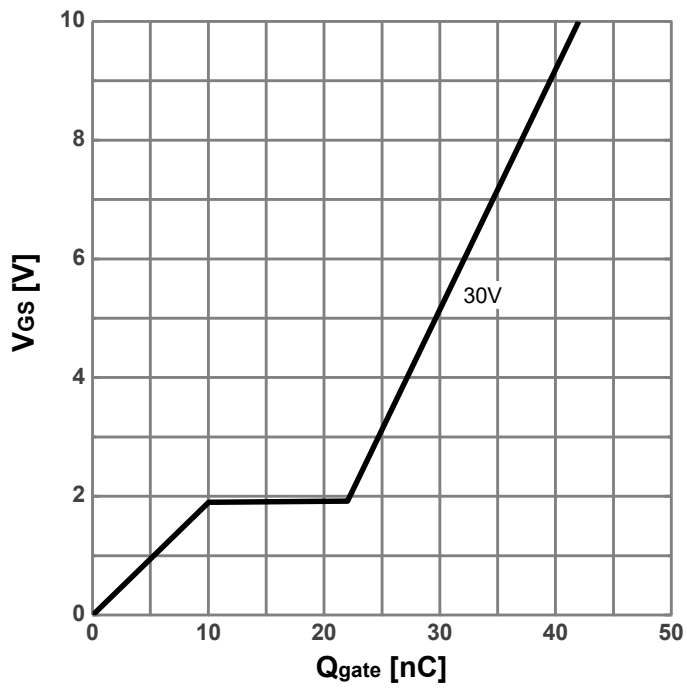
**Diagram 11: On-state resistance vs. Vgs characteristics**

$$R_{DS(on)}=f(V_{gs}); T_j=25^{\circ}C; I_D=20A$$

**Diagram 12: Typ. capacitances**

$$C=f(V_{DS}); V_{GS}=0V; f=250kHz$$



**Diagram 13: Typ. gate charge**

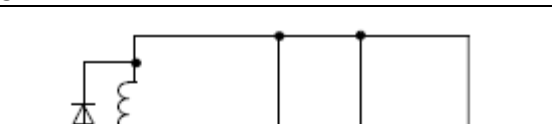
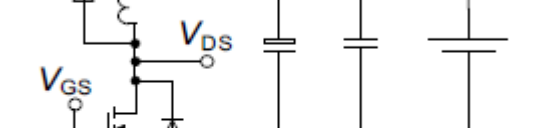
$V_{GS}=f(Q_{gate})$ ;  $I_D=20A$  pulsed;  $V_{DS}=30V$

## 6. Test Circuits

### Table 7. Diode Characteristics

|                                                                                                                                                                     |                                                                                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Test circuit for diode characteristics</p>  <p><math>R_{g1} = R_{g2}</math></p> | <p>Diode recovery waveform</p>  <p><math>t_{tr} = t_F + t_S</math><br/> <math>Q_{tr} = Q_F + Q_S</math></p> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### Table 8. Switching Times

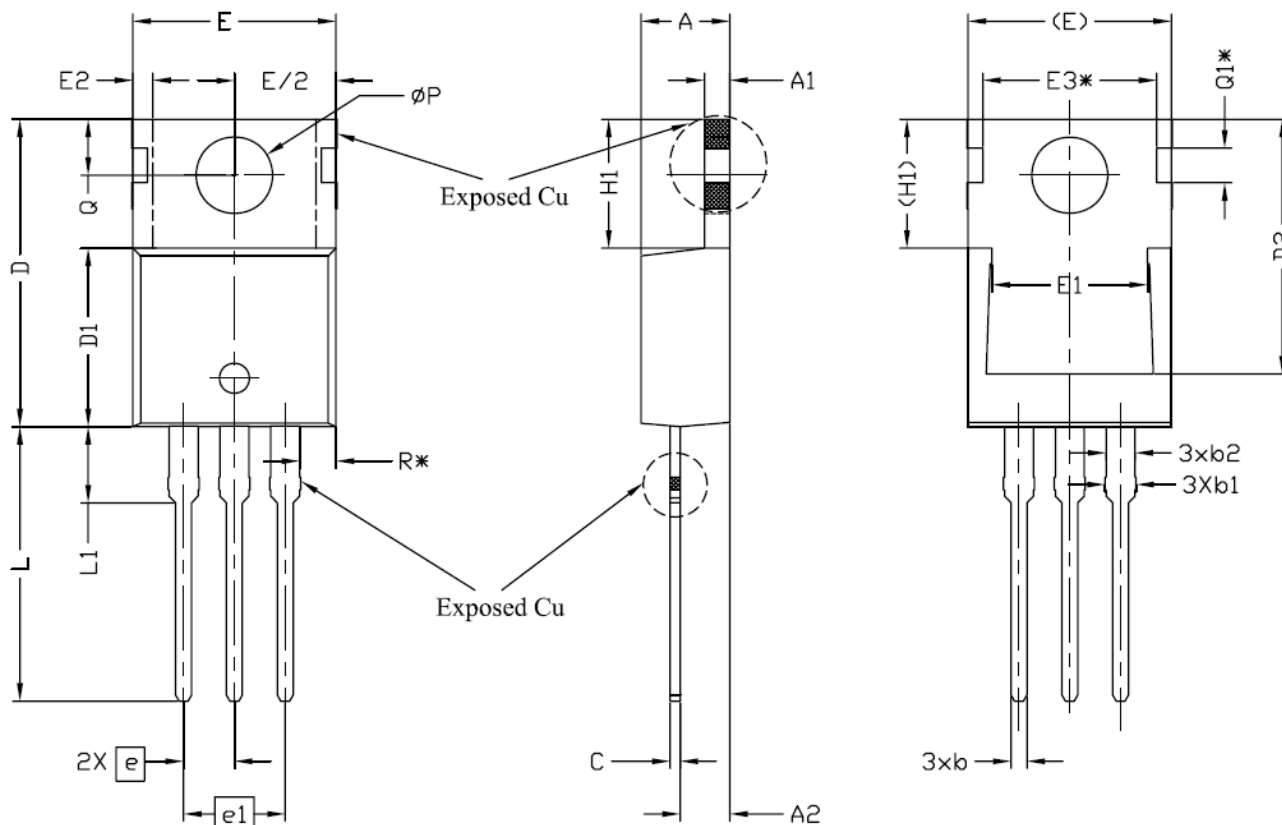
|                                                                                                                                           |                                                                                                                     |
|-------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <p>Switching times test circuit for inductive load</p>  | <p>Switching times waveform</p>  |
|-------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|

### Table 9. Unclamped Inductive Load

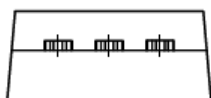
|                                              |                                     |
|----------------------------------------------|-------------------------------------|
| <p>Unclamped inductive load test circuit</p> | <p>Unclamped inductive waveform</p> |
|----------------------------------------------|-------------------------------------|

## 7. Package Outlines

Figure 1 Outline TO-220 Dimensions in mm



| SYMBOL | DIMENSIONS |       |       | NOTES |
|--------|------------|-------|-------|-------|
|        | MIN.       | NOM.  | MAX.  |       |
| A      | 4.24       | 4.44  | 4.64  |       |
| A1     | 1.15       | 1.27  | 1.40  |       |
| A2     | 2.30       | 2.48  | 2.70  |       |
| b      | 0.70       | 0.80  | 0.90  |       |
| b1     | 1.20       | 1.55  | 1.75  |       |
| b2     | 1.20       | 1.45  | 1.70  |       |
| c      | 0.40       | 0.50  | 0.60  |       |
| D      | 14.70      | 15.37 | 16.00 | 4     |
| D1     | 8.82       | 8.92  | 9.02  |       |
| D2     | 12.43      | 12.73 | 12.83 | 5     |
| E      | 9.96       | 10.16 | 10.36 | 4,5   |
| E1     | 6.86       | 7.77  | 8.89  | 5     |
| E2     | -          | -     | 0.76  | 6     |
| E3*    | 8.70REF.   |       |       |       |
| e      | 2.54BSC    |       |       |       |
| e1     | 5.08BSC    |       |       |       |
| H1     | 6.30       | 6.45  | 6.60  | 5,6   |
| L      | 13.47      | 13.72 | 13.97 |       |
| L1     | 3.60       | 3.80  | 4.00  |       |
| ØP     | 3.75       | 3.84  | 3.93  |       |
| Q      | 2.60       | 2.80  | 3.00  |       |
| Q1*    | 1.73REF.   |       |       |       |
| R*     | 1.82REF.   |       |       |       |



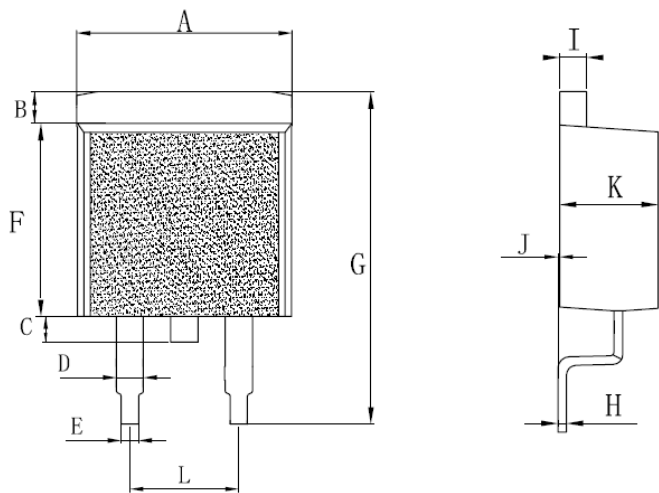
Note:

1. Package Reference: JEDEC TO220, Variation AB.
2. All Dimensions Are In mm.
3. Slot Required, Notch May Be Rounded
4. Dimension D & E Do Not Include Mold Flash. Mold Flash Shall Not Exceed 0.127mm Pre Side. These Dimensions Are Measured At The Outermost Extreme Of The Plastic Body.
5. Thermal Pad Contour Optional Within Dimensions E, H1, D2 & E1.
6. Dimension E2 & H1 Define A Zone Where Stamping And Singulation Irregularities Are Allowed.
7. "\*" is reference .

Figure 2 Outline TO-263 Dimensions in mm

PACKAGE OUTLINE DIMENSIONS

TO-263



| DIM. | Unit(mm) |      | Unit(inch) |       |
|------|----------|------|------------|-------|
|      | Min      | Max  | Min        | Max   |
| A    | 9.7      | 10.4 | 0.381      | 0.409 |
| B    | 1.31     | 1.62 | 0.051      | 0.063 |
| C    | 0.65     | 1.22 | 0.025      | 0.048 |
| D    | 1.15     | 1.36 | 0.045      | 0.053 |
| E    | 0.62     | 0.95 | 0.024      | 0.037 |
| F    | 8.75     | 9.32 | 0.344      | 0.366 |
| G    | 14.75    | 15.8 | 0.580      | 0.622 |
| H    | 0.32     | 0.48 | 0.012      | 0.018 |
| I    | 1.18     | 1.36 | 0.046      | 0.053 |
| J    | 0        | 0.15 | 0          | 0.005 |
| K    | 4.38     | 4.86 | 0.172      | 0.191 |
| L    | 4.85     | 5.23 | 0.190      | 0.205 |

## 8. Appendix

CoolSemi Webpage: [www.coolsemi.com](http://www.coolsemi.com).