Truesemi

RoHS Compliant

# TSB60R190S1

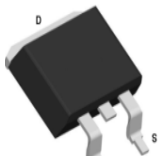
## 600V 20A N-Channel SJ-MOSFET

### General Description

Truesemi SJ-FET is new generation of high voltage MOSFET family that is utilizing an advanced charge balance mechanism for outstanding low on-resistance and lower gate charge performance.
This advanced technology has been tailored to minimize conduction loss, provide superior switching performance, and withstand extreme dv/dt rate and higher avalanche energy.
SJ-FET is suitable for various AC/DC power conversion in switching mode operation for higher efficiency.

### Features

- 650V @TJ = 150 ℃
- Typ. RDS(on) = 0.16Ω
- Ultra Low gate charge (typ. Qg = 70nC)
- 100% avalanche tested

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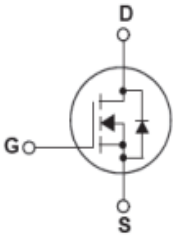


### Absolute Maximum Ratings

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{DSS}$ | Drain-Source Voltage | 600 | V |
| $I_D$ | Drain Current -Continuous (TC = 25℃)<br>-Continuous (TC = 100℃) | 20*<br>12.6* | A |
| $I_{DM}$ | Drain Current – Pulsed (Note 1) | 62* | A |
| $V_{GSS}$ | Gate-Source voltage | ±30 | V |
| $E_{AS}$ | Single Pulsed Avalanche Energy (Note 2) | 485 | mJ |
| $I_{AR}$ | Avalanche Current (Note 1) | 3.5 | A |
| $E_{AR}$ | Repetitive Avalanche Energy (Note 1) | 1 | mJ |
| dv/dt | Peak Diode Recovery dv/dt (Note 3) | 15 | V/ns |
| $P_D$ | Power Dissipation (TC = 25℃)<br>-Derate above 25℃ | 151<br>1.67 | W |
| $T_J$, $T_{STG}$ | Operating and Storage Temperature Range | -55 to +150 | ℃ |
| $T_L$ | Maximum Lead Temperature for Soldering Purpose,1/8” from Case for 5 Seconds | 300 | ℃ |

* Drain current limited by maximum junction temperature.

### Thermal Characteristics

| **Symbol** | **Parameter** | Value | **Unit** |
|---|---|---|---|
| $R_{\theta JC}$ | Thermal Resistance, Junction-to-Case | 0.83 | ℃/W |
| $R_{\theta CS}$ | Thermal Resistance, Case-to-Sink Typ. | 0.5 | ℃/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient | 62 | ℃/W |

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## Electrical Characteristics TC = 25℃ unless otherwise noted

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Off Characteristics | | | | | | |
| $BV_{DSS}$ | Drain-Source Breakdown Voltage | $V_{GS}$ = 0V, $I_D$ = 250μA, $T_J$ = 25℃ | 600 | -- | -- | V |
| | | $V_{GS}$ = 0V, $I_D$ = 250μA, $T_J$ = 150℃ | -- | 650 | -- | V |
| $\Delta BV_{DSS}$ / $\Delta_{TJ}$ | Breakdown Voltage Temperature Coefficient | $I_D$ = 250μA, Referenced to 25℃ | -- | 0.6 | -- | V/℃ |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | $V_{DS}$ = 600V, $V_{GS}$ = 0V<br>-$T_J$= 150℃ | -- | --<br>10 | 1<br>-- | μA<br>μA |
| $I_{GSSF}$ | Gate-Body Leakage Current, Forward | $V_{GS}$ = 30V, $V_{DS}$ = 0V | -- | -- | 100 | nA |
| $I_{GSSR}$ | Gate-Body Leakage Current, Reverse | $V_{GS}$ = -30V, $V_{DS}$ = 0V | -- | -- | -100 | nA |
| On Characteristics | | | | | | |
| $V_{GS(th)}$ | Gate Threshold Voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 250μA | 2.5 | -- | 4.5 | V |
| $R_{DS(on)}$ | Static Drain-Source On-Resistance | $V_{GS}$ = 10V, $I_D$ = 10A | -- | 0.16 | 0.19 | Ω |
| $g_{FS}$ | Forward Trans conductance | $V_{DS}$ = 40V, $I_D$ = 10A (Note 4) | -- | 16 | -- | S |
| Dynamic Characteristics | | | | | | |
| $C_{iss}$ | Input Capacitance | $V_{DS}$ = 25V, $V_{GS}$ = 0V, f = 1.0MHz | -- | 1440 | -- | pF |
| $C_{oss}$ | Output Capacitance | | -- | 300 | -- | pF |
| $C_{rss}$ | Reverse Transfer Capacitance | | -- | 10 | -- | pF |
| Switching Characteristics | | | | | | |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{DD}$ = 400V, $I_D$ = 10A $R_G$ = 20Ω(Note 4, 5) | -- | 25 | -- | ns |
| $t_r$ | Turn-On Rise Time | | -- | 55 | -- | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | -- | 70 | -- | ns |
| $t_f$ | Turn-Off Fall Time | | -- | 40 | -- | ns |
| $Q_g$ | Total Gate Charge | $V_{DS}$ = 480V, $I_D$ = 10A $V_{GS}$ = 10V (Note 4, 5) | -- | 70 | 90 | nC |
| $Q_{gs}$ | Gate-Source Charge | | -- | 7.8 | -- | nC |
| $Q_{gd}$ | Gate-Drain Charge | | -- | 9 | -- | nC |
| Drain-Source Diode Characteristics and Maximum Ratings | | | | | | |
| $I_S$ | Maximum Continuous Drain-Source Diode Forward Current | | -- | -- | 20 | A |
| $I_{SM}$ | Maximum Pulsed Drain-Source Diode Forward Current | | -- | -- | 60 | A |
| $V_{SD}$ | Drain-Source Diode Forward Voltage | $V_{GS}$ = 0V, $I_F$ = 10A | -- | 1 | 1.5 | V |
| $t_{rr}$ | Reverse Recovery Time | $V_{GS}$ = 0V, $I_F$ = 10A $di_F/dt$ =100A/μs (Note 4) | -- | 475 | -- | ns |
| $Q_{rr}$ | Reverse Recovery Charge | | -- | 5.8 | -- | μC |
| $I_{rrm}$ | Peak reverse recovery Current | | | 35 | -- | A |

**NOTES:**

1. Repetitive Rating: Pulse width limited by maximum junction temperature
2. $I_{AS}$=3.5A, $V_{DD}$=50V, Starting TJ=25 ℃
3. $I_{SD}$≤20A, di/dt ≤ 200A/us, $V_{DD}$ ≤ $BV_{DSS}$, Starting TJ = 25 ℃
4. Pulse Test: Pulse width ≤ 300us, Duty Cycle ≤ 2%
5. Essentially Independent of Operating Temperature Typical Characteristics



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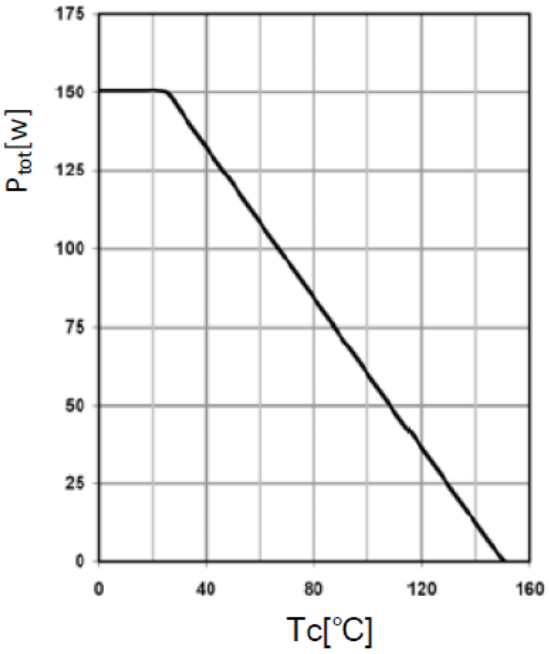
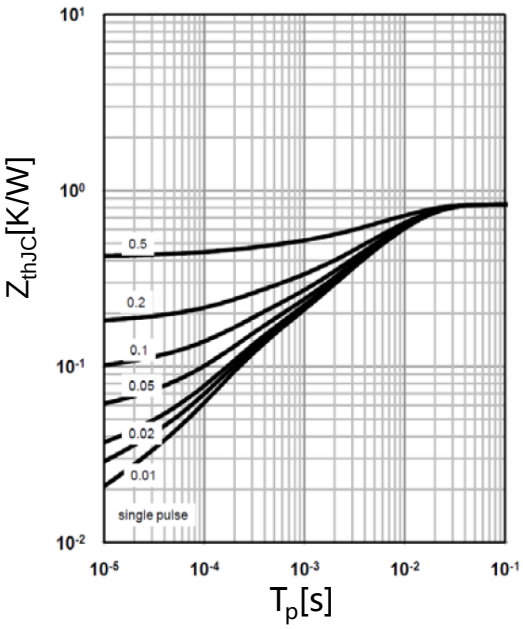
# Typical Performance Characteristics

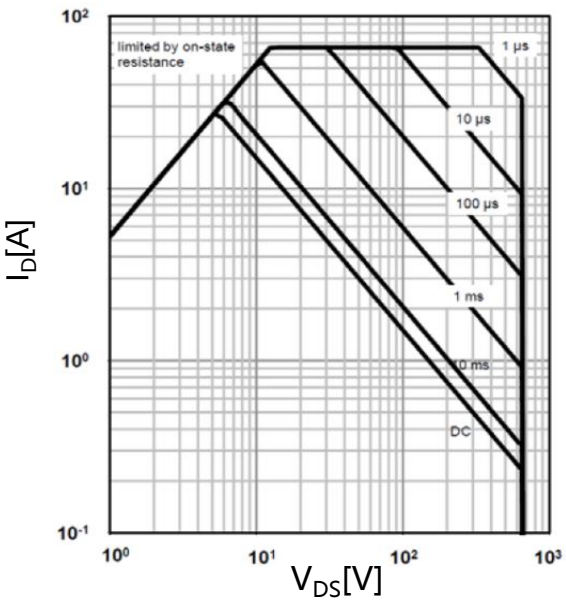
Power dissipation




Max. transient thermal impedance

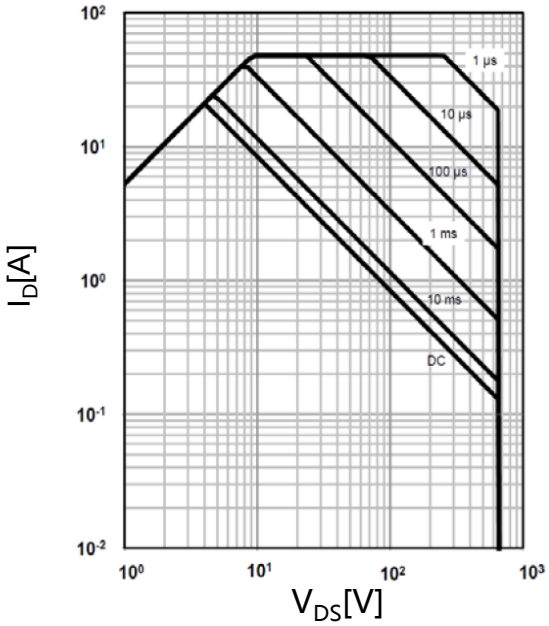



Safe operating area $T_C$=25 ℃




$I_D$=f($V_{DS}$); $T_C$=25 ℃; $V_{GS}$ > 7V; D=0; parameter $t_p$

Safe operating area $T_C$=80 ℃




$I_D$=f(VDS); TC=80 ℃; VGS > 7V; D=0; parameter $t_p$



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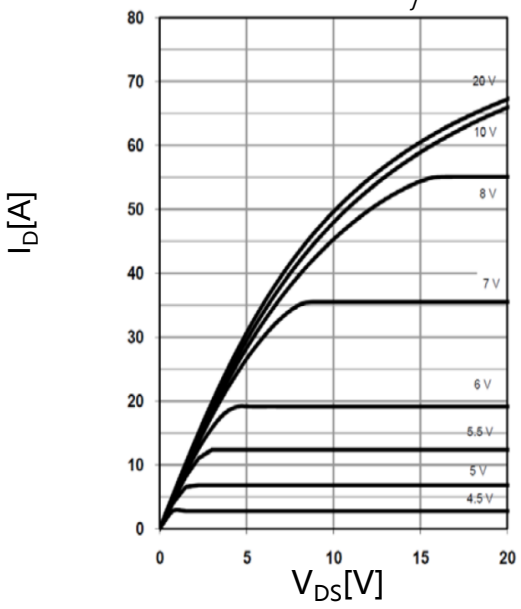
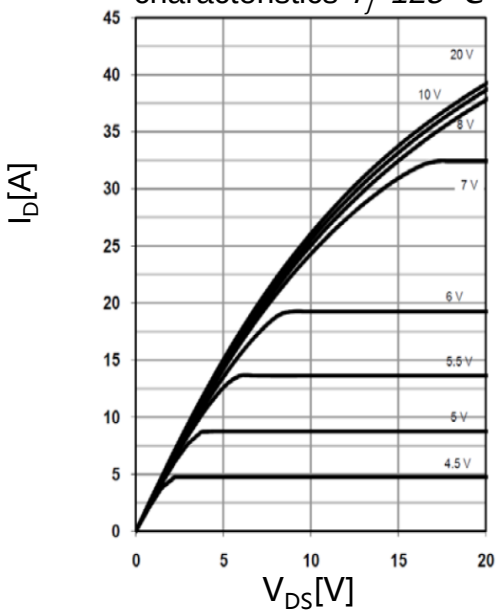
# Typical Performance Characteristics

Typ. output characteristics $T_j$=25 ℃



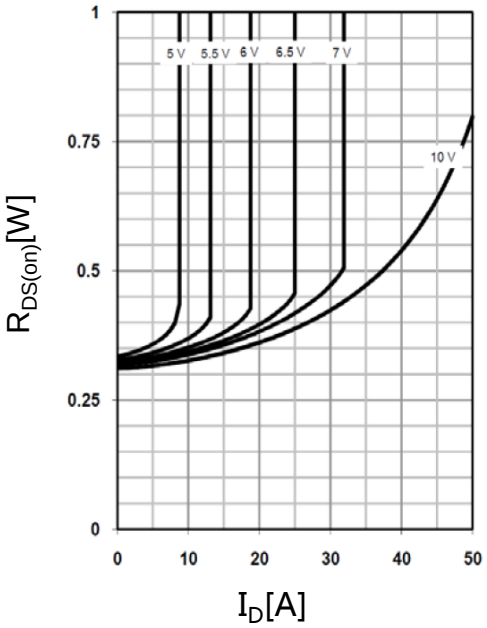

$I_D$=f($V_{DS}$); $T_j$=25 ℃ ; parameter: $V_{GS}$

Typ. output characteristics $T_j$=125 ℃



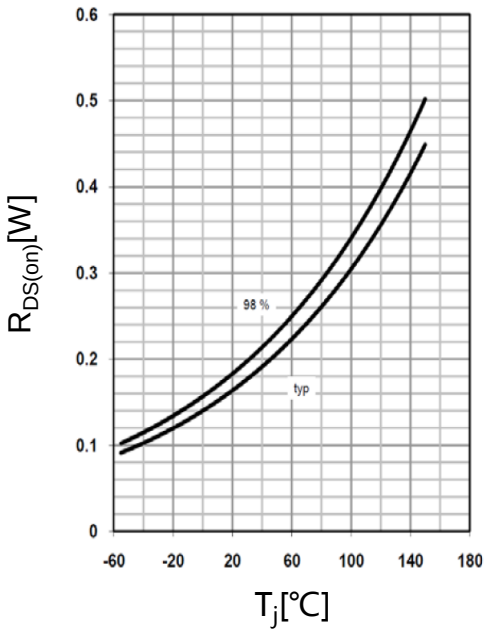

$I_D$=f($V_{DS}$); $T_j$=125 ℃ ; parameter: $V_{GS}$

Typ. drain-source on-state resistance




*$R_{DS}$(on)=f($I_D$); $T_j$=125 ℃ ; parameter:$V_{GS}$*

Typ. drain-source on-state resistance




$R_{DS}$(on)=f($T_j$); $I_D$=7.3 A; $V_{GS}$=10 V



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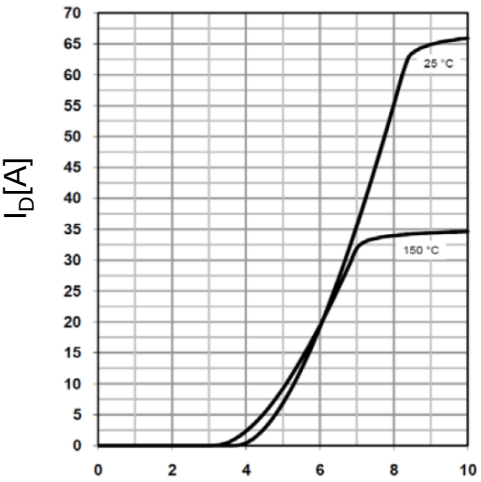
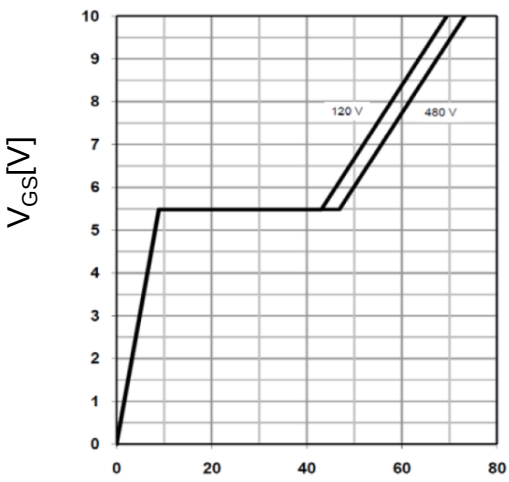
# Typical Performance Characteristics

Typ. transfer characteristics



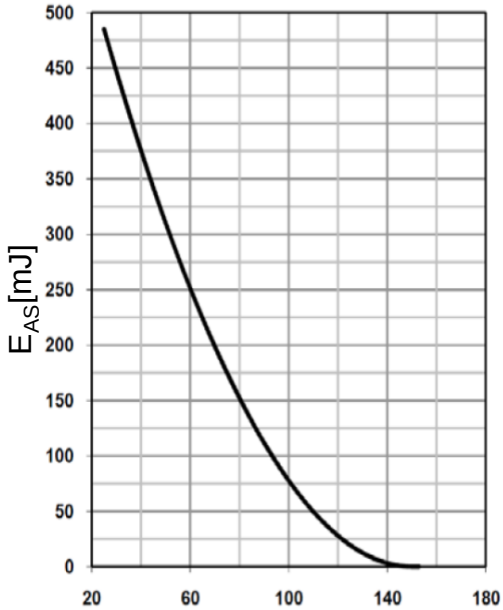

$I_D=f(V_{GS})$; $V_{DS}$=20V

Typ. gate charge



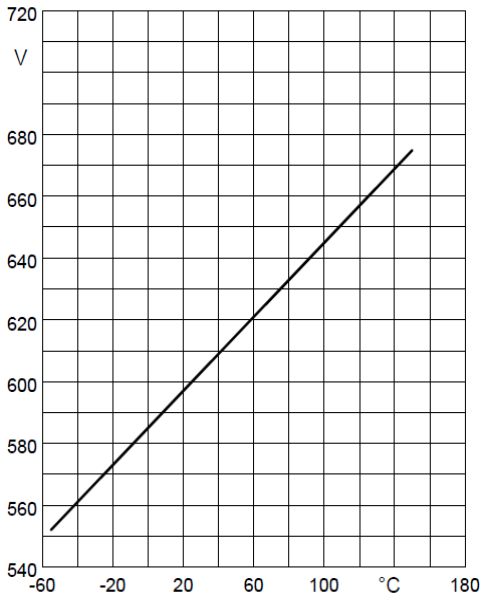

$V_{GS}=f(Q_g)$, $I_D$=11 A pulsed

Avalanche energy




$E_{AS}=f(T_j)$; $I_D$=3.5 A; $V_{DD}$=50 V

Drain-source breakdown voltage




$V_{BR(DSS)}=f(T_j)$; $I_D$=1.0 mA



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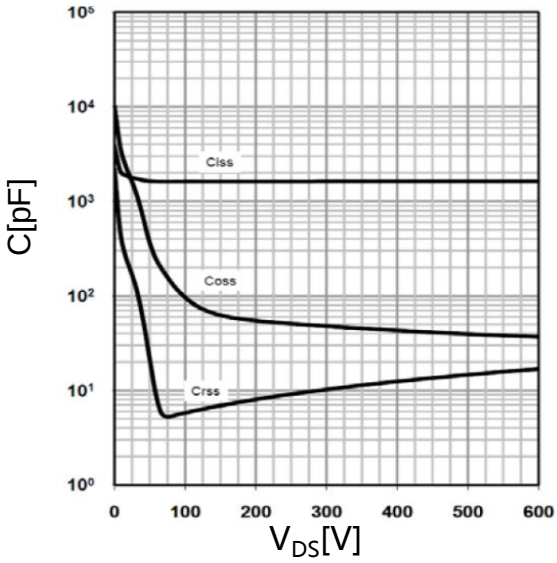
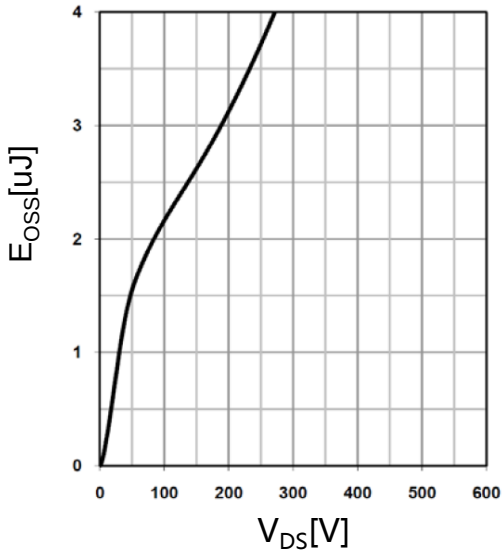
# Typical Performance Characteristics

Typ. capacitances



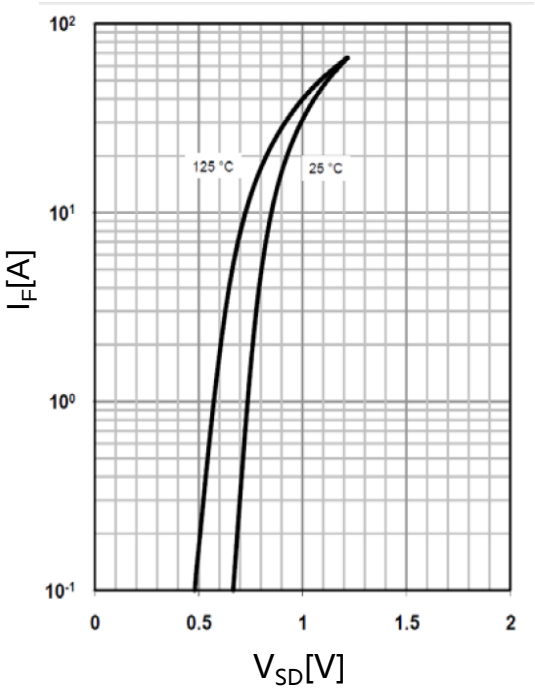

C=f($V_{DS}$); $V_{GS}$=0 V; f=1 MHz

Typ. *Coss stored energy*




$E_{OSS}$=f($V_{DS}$)

Forward characteristics of reverse diode




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



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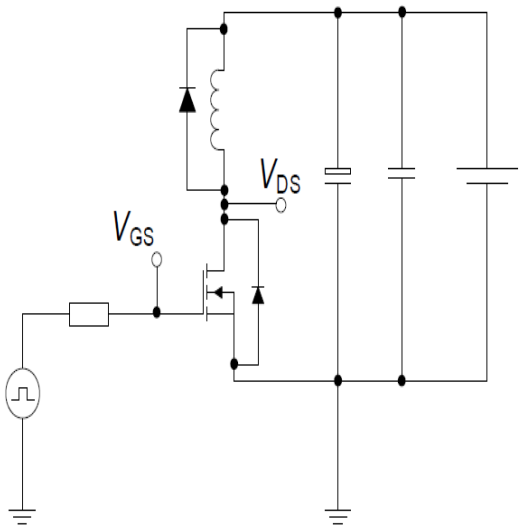
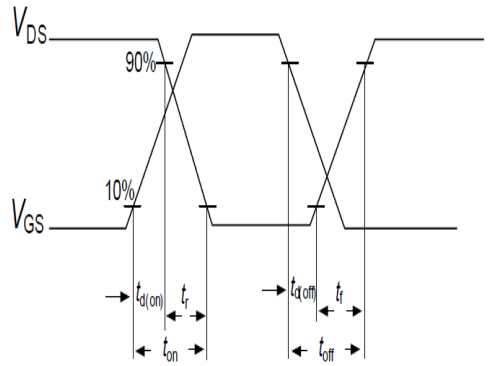
# Test circuits

**Switching times test circuit and waveform for inductive load**

Switching times test circuit for inductive load

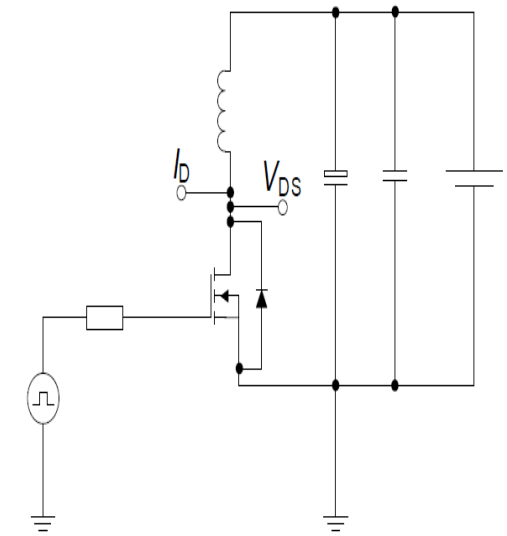



Switching time waveform

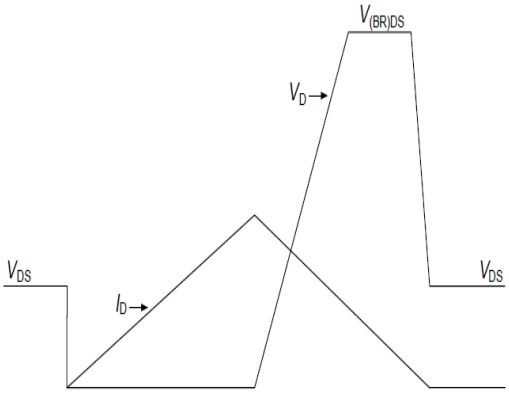



**Unclamped inductive load test circuit and waveform**

Unclamped inductive load test circuit




Unclamped inductive waveform



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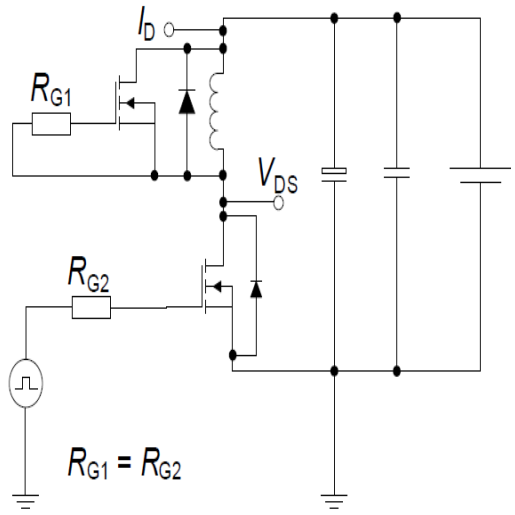
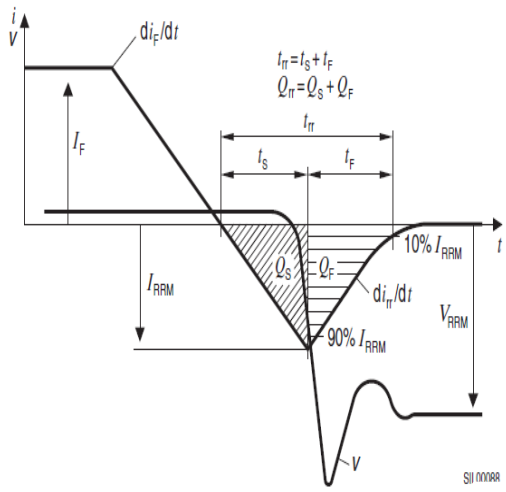
# Test circuits

**Test circuit and waveform for diode characteristics**

Test circuit for diode characteristics




Diode recovery waveform



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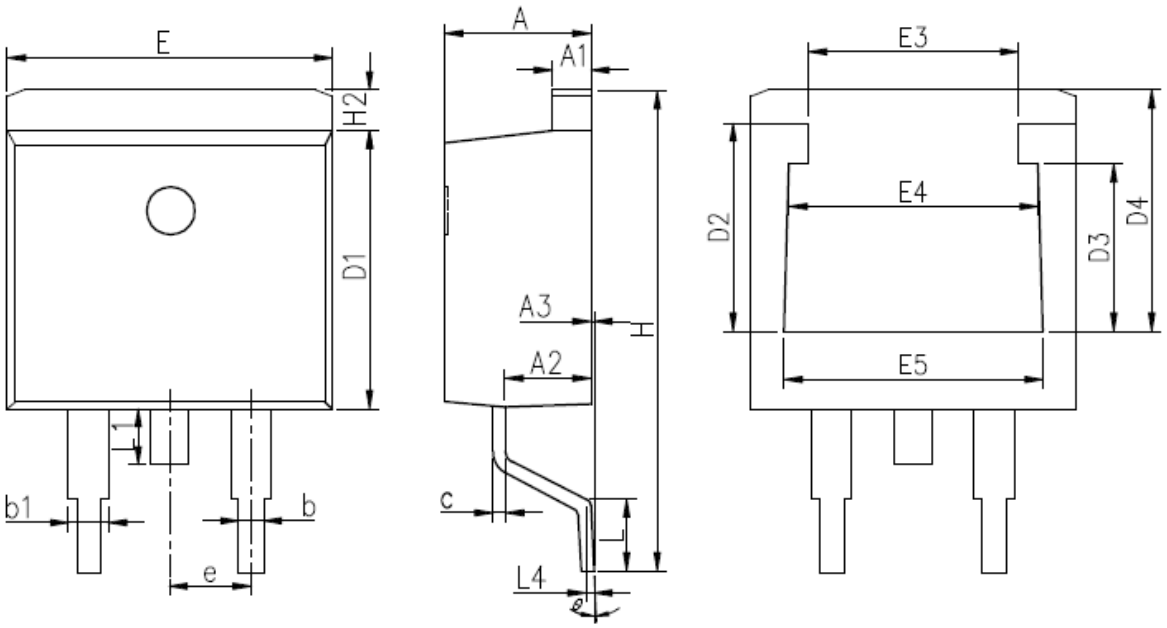
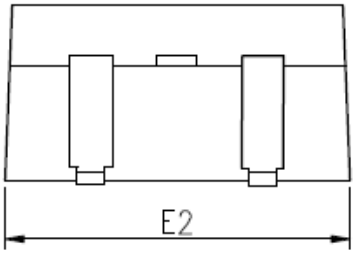
# Package Outline TO-263




COMMON DIMENSIONS

| SYMBOL | MM | | |
|---|---|---|---|
| | MIN | NOM | MAX |
| A | 4.27 | 4.57 | 4.87 |
| A1 | 1.22 | 1.27 | 1.42 |
| A2 | 2.39 | 2.69 | 2.99 |
| A3 | 0.00 | 0.13 | 0.20 |
| b | 0.70 | 0.81 | 1.01 |
| b1 | 1.17 | 1.27 | 1.50 |
| c | 0.30 | 0.38 | 0.53 |
| D1 | 8.40 | 8.70 | 9.00 |
| D2 | 5.33 | 6.33 | 6.63 |
| D3 | 4.54 | 5.54 | 5.84 |
| D4 | 6.60 | 7.60 | 8.00 |
| E | 9.88 | 10.16 | 10.50 |
| E2 | 9.80 | 10.10 | 10.40 |
| E3 | 4.94 | 5.94 | 6.24 |
| E4 | 6.67 | 7.67 | 7.97 |
| E5 | 7.06 | 8.06 | 8.36 |
| e | | 2.54 BSC | |
| H | 14.70 | 15.10 | 15.50 |
| H2 | 1.00 | 1.27 | 1.50 |
| L | 2.00 | 2.30 | 2.60 |
| L1 | 1.35 | 1.55 | 1.75 |
| L4 | | 0.25 BSC | |
| θ | 0° | 5° | 9° |



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