Truesemi

RoHS Compliant

# TSB65R500S1

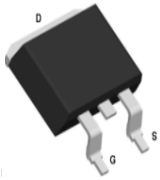
## 650V 9A N-Channel SJ-MOSFET

### 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

- 700V @TJ = 150 ℃
- Typ. RDS(on) = 0.45Ω
- Ultra Low gate charge (typ. Qg = 35nC)
- 100% avalanche tested

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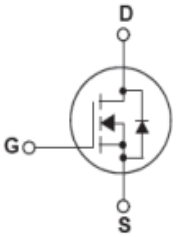



### Absolute Maximum Ratings

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{DSS}$ | Drain-Source Voltage | 650 | V |
| $I_D$ | Drain Current -Continuous (TC = 25℃)<br>-Continuous (TC = 100℃) | 9<br>5.5 | A |
| $I_{DM}$ | Drain Current – Pulsed (Note 1) | 26 | A |
| $V_{GSS}$ | Gate-Source voltage | ±30 | V |
| $E_{AS}$ | Single Pulsed Avalanche Energy (Note 2) | 120 | mJ |
| $I_{AR}$ | Avalanche Current (Note 1) | 2 | A |
| $E_{AR}$ | Repetitive Avalanche Energy (Note 1) | 0.32 | mJ |
| dv/dt | Peak Diode Recovery dv/dt (Note 3) | 15 | V/ns |
| $P_D$ | Power Dissipation (TC = 25℃)<br>-Derate above 25℃ | 83<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 | 1.5 | ℃/W |
| $R_{\theta CS}$ | Thermal Resistance, Case-to-Sink Typ. | 0.5 | ℃/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient | 62 | ℃/W |

## 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>-$T_C$ = 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, $I_D$ = 4.5A | -- | 0.45 | 0.5 | Ω |
| $g_{FS}$ | Forward Trans conductance | $V_{DS}$ = 40V, $I_D$ = 4.5A (Note 4) | -- | 16 | -- | S |
| $R_g$ | Gate resistance | f=1MHz,open drain | -- | 4.5 | -- | Ω |
| Dynamic Characteristics | | | | | | |
| $C_{iss}$ | Input Capacitance | $V_{DS}$ = 25V, $V_{GS}$ = 0V, f = 1.0MHz | -- | 550 | -- | pF |
| $C_{oss}$ | Output Capacitance | | -- | 140 | -- | pF |
| $C_{rss}$ | Reverse Transfer Capacitance | | -- | 7 | -- | pF |
| Switching Characteristics | | | | | | |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{DD}$ = 400V, $I_D$ = 4.5A<br>$R_G$ = 20Ω(Note 4, 5) | -- | 15 | -- | ns |
| $t_r$ | Turn-On Rise Time | | -- | 10 | -- | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | -- | 110 | -- | ns |
| $t_f$ | Turn-Off Fall Time | | -- | 9 | -- | ns |
| $Q_g$ | Total Gate Charge | $V_{DS}$ = 480V, $I_D$ = 4.5A<br>$V_{GS}$ = 10V (Note 4, 5) | -- | 35 | -- | nC |
| $Q_{gs}$ | Gate-Source Charge | | -- | 3.8 | -- | nC |
| $Q_{gd}$ | Gate-Drain Charge | | -- | 4 | -- | nC |
| Drain-Source Diode Characteristics and Maximum Ratings | | | | | | |
| $I_S$ | Maximum Continuous Drain-Source Diode Forward Current | | -- | -- | 9 | A |
| $I_{SM}$ | Maximum Pulsed Drain-Source Diode Forward Current | | -- | -- | 40 | A |
| $V_{SD}$ | Drain-Source Diode Forward Voltage | $V_{GS}$ = 0V, $I_F$ = 4.5A | -- | 0.9 | 1.5 | V |
| $t_{rr}$ | Reverse Recovery Time | $V_{GS}$ = 0V, $I_F$ = 4.5A<br>$di_F/dt$ =100A/μs (Note 4) | -- | 240 | -- | ns |
| $Q_{rr}$ | Reverse Recovery Charge | | -- | 3.1 | -- | μC |

**NOTES:**

1. Repetitive Rating: Pulse width limited by maximum junction temperature
2. L=60mH , $I_{AS}$=2A, $V_{DD}$=50V, Starting TJ=25 ℃
3. $I_{SD}$≤9A, 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

# Typical Performance Characteristics

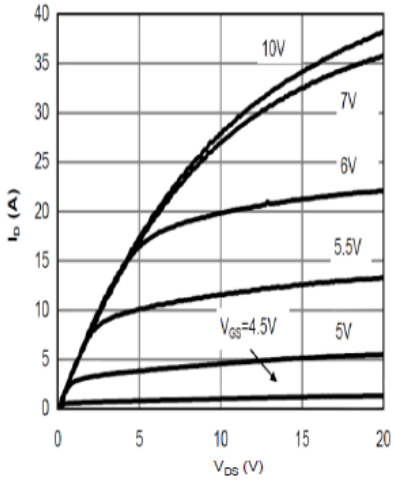



Figure 1: On-Region Characteristics@25°C

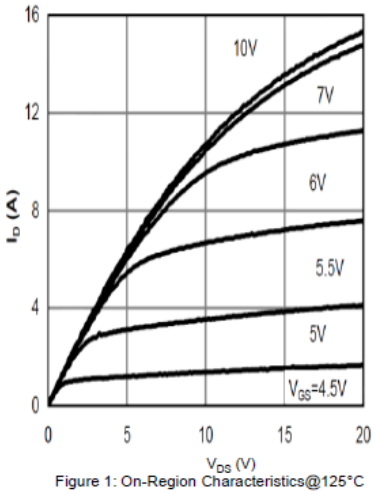



Figure 1: On-Region Characteristics@125°C

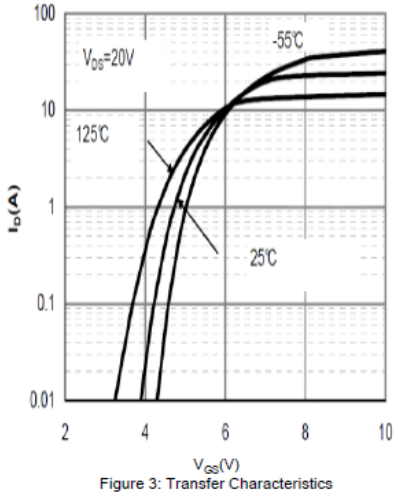



Figure 3: Transfer Characteristics

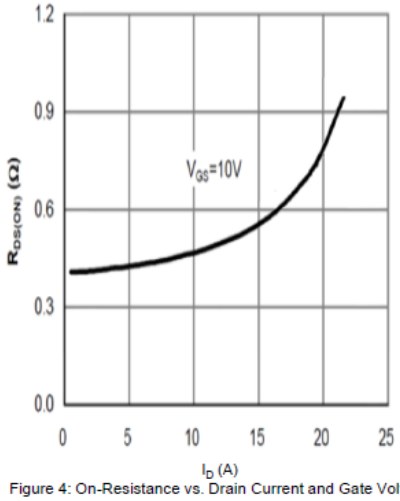



Figure 4: On-Resistance vs. Drain Current and Gate Voltage

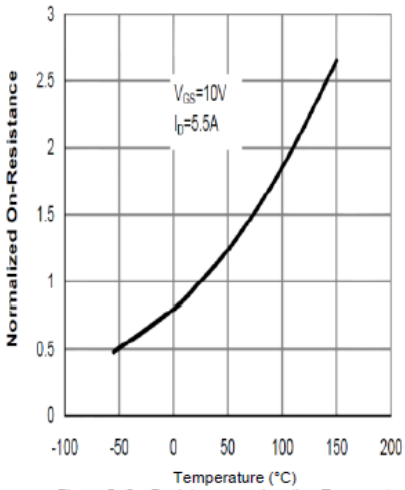



Figure 5: On-Resistance vs. Junction Temperature

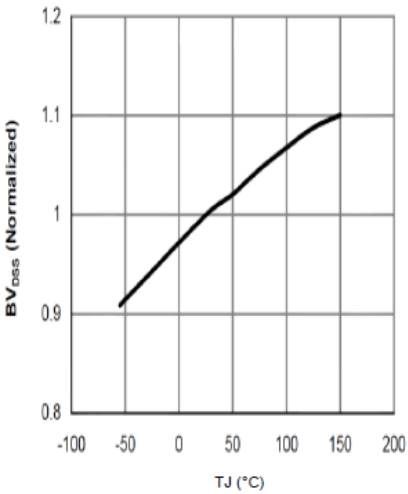



Figure 6: Break Down vs. Junction Temperature

# Typical Performance Characteristics

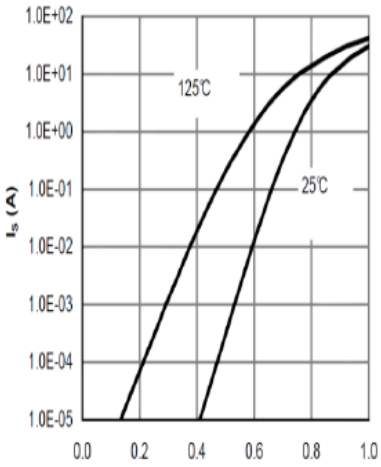


Figure 7: Body-Diode Characteristics

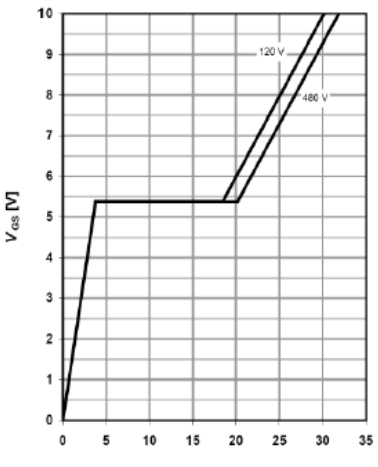


Figure 8: Gate-Charge Characteristics

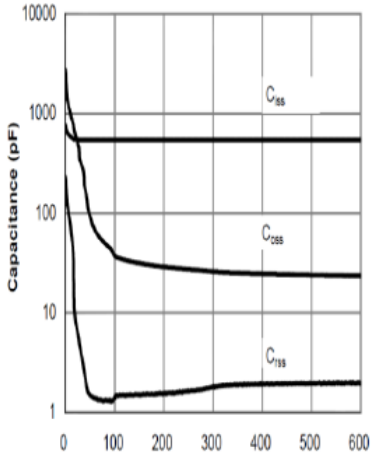


Figure 9: Capacitance Characteristics

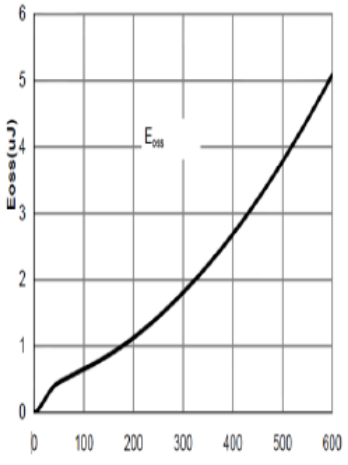


Figure 10: $C_{oss}$ stored Energy

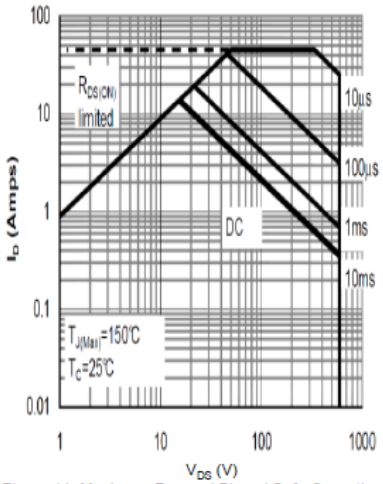


Figure 11: Maximum Forward Biased Safe Operating Area

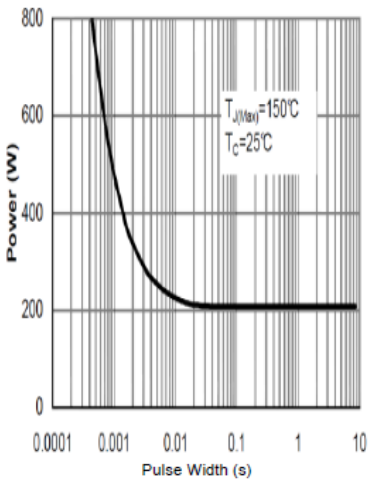


Figure 12: Single Pulse Power Rating Junction-to-Case

# Typical Performance Characteristics

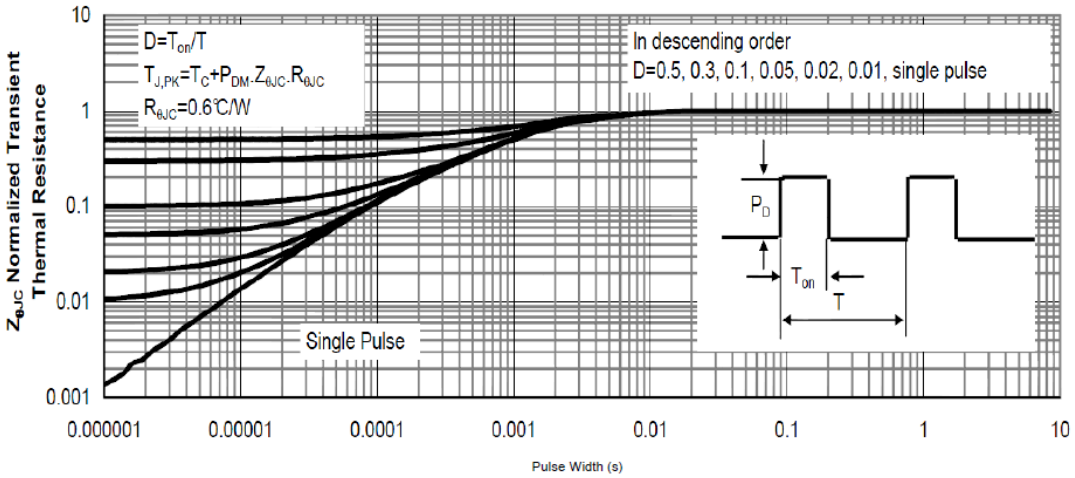



Figure 13: Normalized Maximum Transient Thermal Impedance

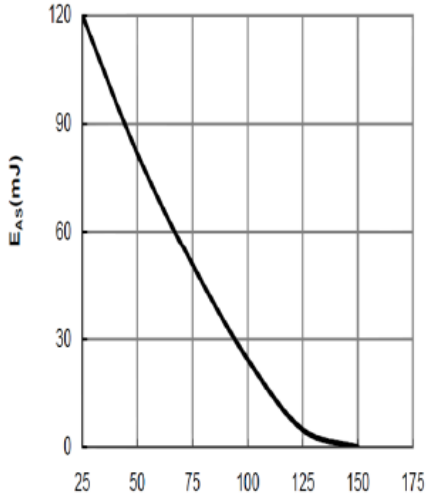



Figure 14: Avalanche energy

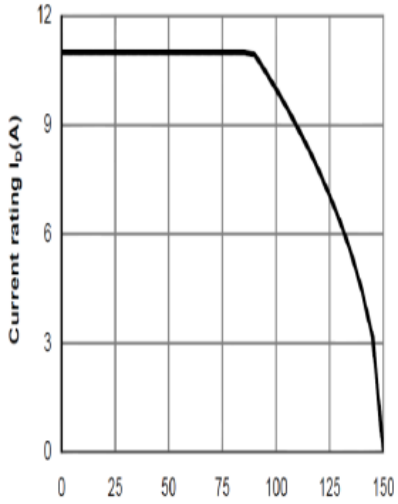



Figure 15: Current De-rating

# Typical Performance Characteristics

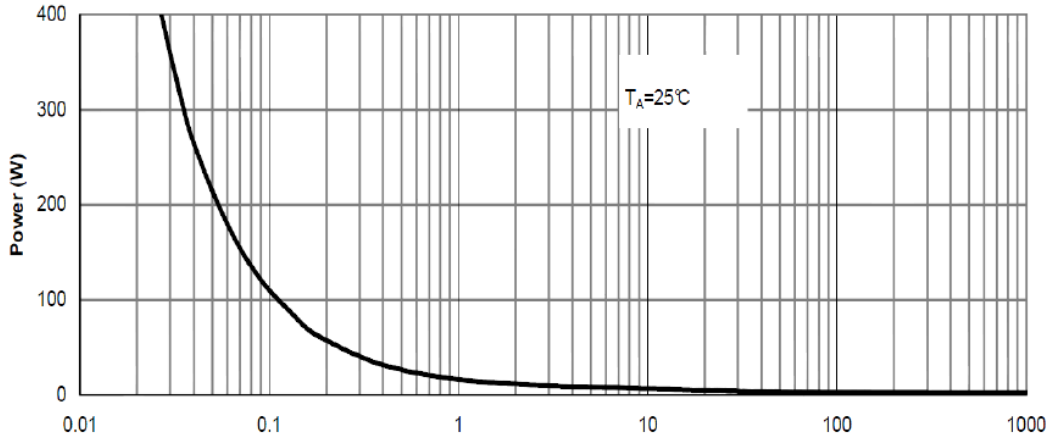



Figure 16: Single Pulse Power Rating Junction-to-Ambient

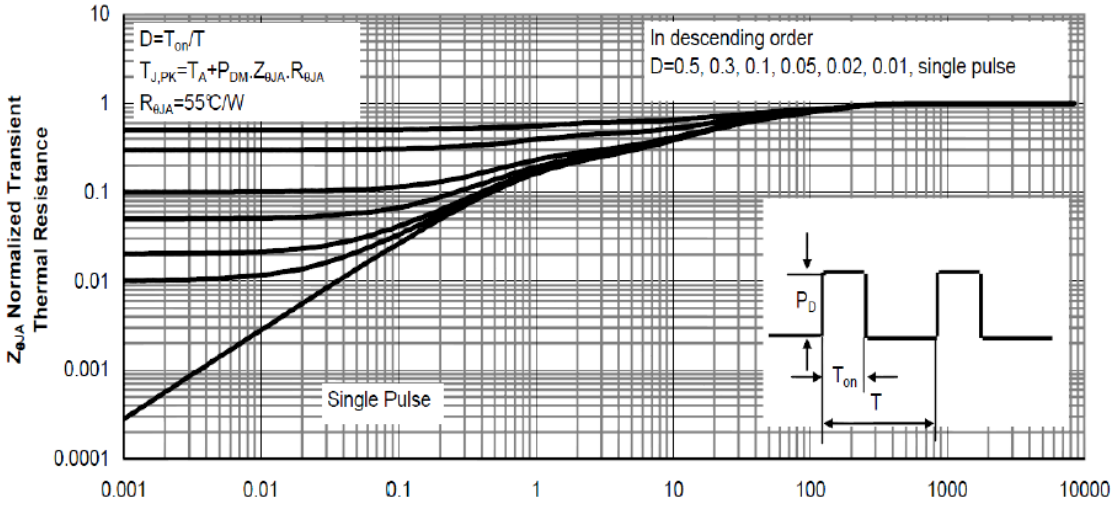
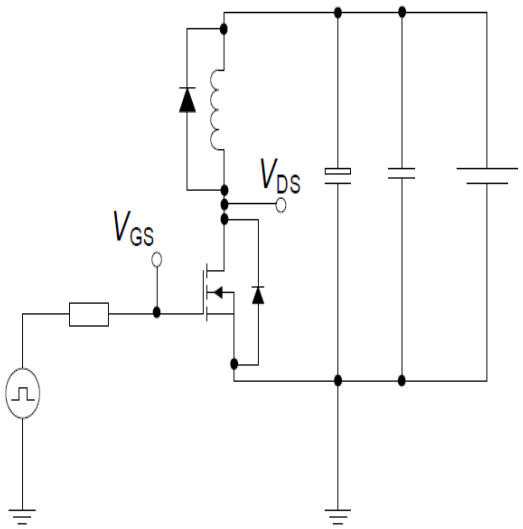



Figure 17: Normalized Maximum Transient Thermal Impedance

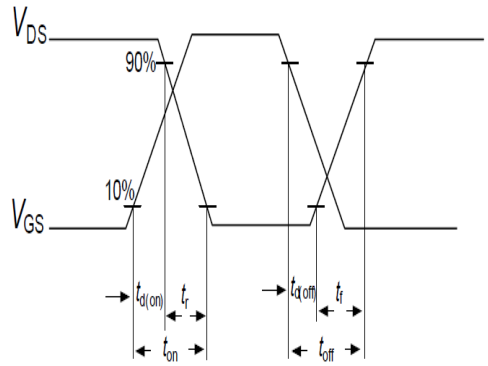
# Test circuits

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

Switching times test circuit for inductive load

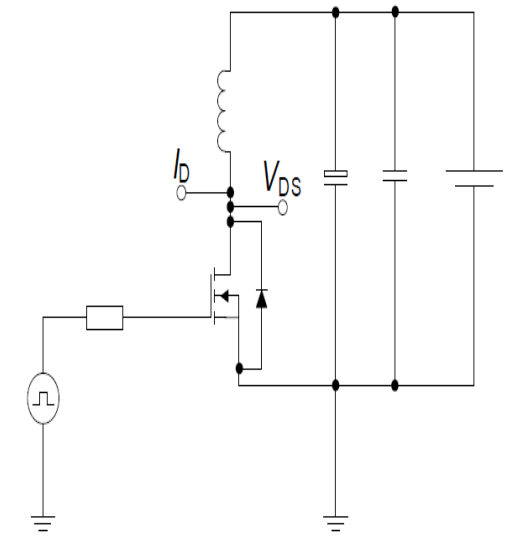



Switching time waveform

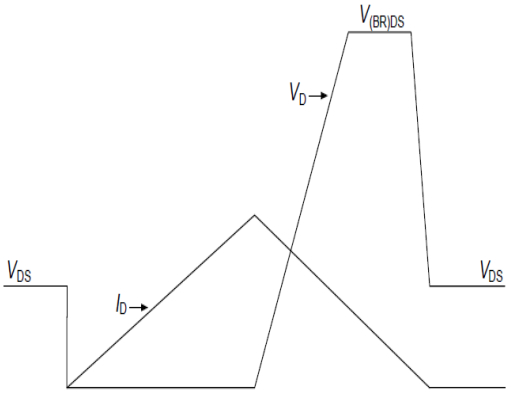



**Unclamped inductive load test circuit and waveform**

Unclamped inductive load test circuit



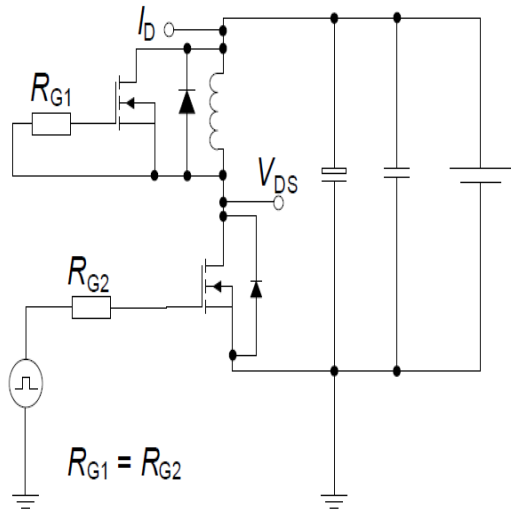

Unclamped inductive waveform



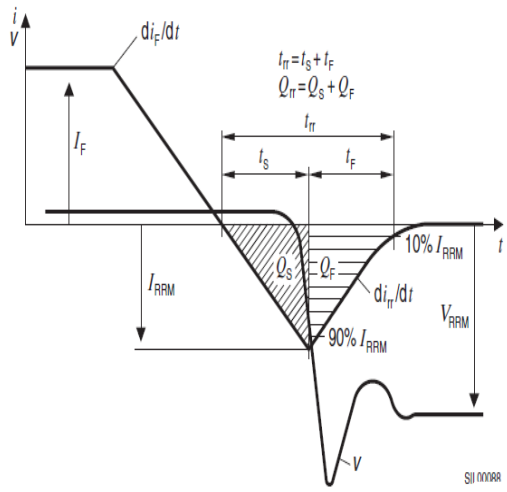
# Test circuits

**Test circuit and waveform for diode characteristics**

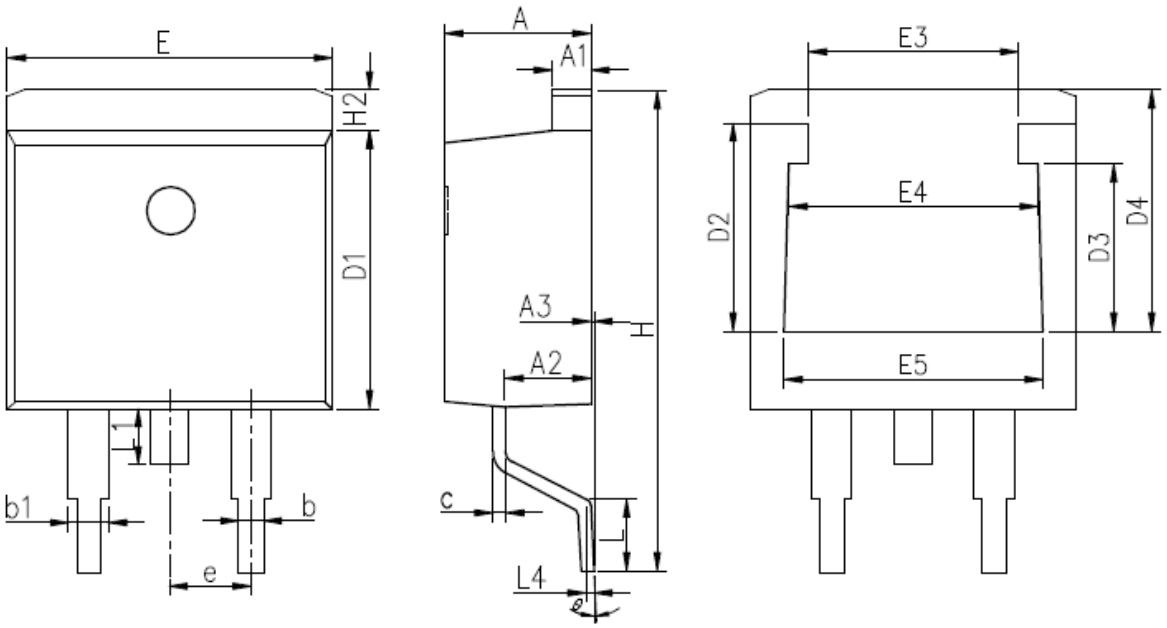
Test circuit for diode characteristics

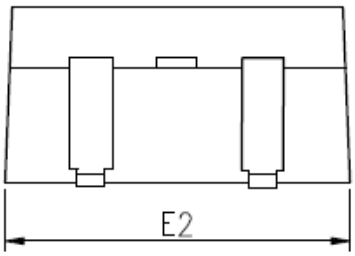



Diode recovery waveform



## 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° |