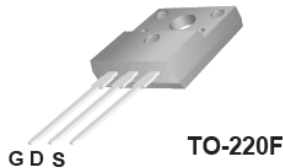


# TSF65R190S1

## 650V 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

- 700V @T<sub>J</sub> = 150 °C
- Typ. R<sub>DS(on)</sub> = 0.16Ω
- Ultra Low gate charge (typ. Q<sub>g</sub> = 70nC)
- 100% avalanche tested



### Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
V <sub>DSS</sub>	Drain-Source Voltage	650	V
I <sub>D</sub>	Drain Current -Continuous (TC = 25°C) -Continuous (TC = 100°C)	20* 12.6*	A
I <sub>DM</sub>	Drain Current – Pulsed (Note 1)	62*	A
V <sub>GSS</sub>	Gate-Source voltage	±30	V
E <sub>AS</sub>	Single Pulsed Avalanche Energy (Note 2)	485	mJ
I <sub>AR</sub>	Avalanche Current (Note 1)	3.5	A
E <sub>AR</sub>	Repetitive Avalanche Energy (Note 1)	1	mJ
dv/dt	Peak Diode Recovery dv/dt (Note 3)	15	V/ns
P <sub>D</sub>	Power Dissipation (TC = 25°C) -Derate above 25°C	35 0.3	W W/°C
T <sub>J</sub> , T <sub>STG</sub>	Operating and Storage Temperature Range	-55 to +150	°C
T <sub>L</sub>	Maximum Lead Temperature for Soldering Purpose, 1/8" from Case for 5 Seconds	300	°C

\* Drain current limited by maximum junction temperature.

### Thermal Characteristics

Symbol	Parameter	Value	Unit
R <sub>θJC</sub>	Thermal Resistance, Junction-to-Case	3.7	°C/W
R <sub>θCS</sub>	Thermal Resistance, Case-to-Sink Typ.	--	°C/W
R <sub>θJA</sub>	Thermal Resistance, Junction-to-Ambient	80	°C/W

## Electrical Characteristics TC = 25 °C unless otherwise noted

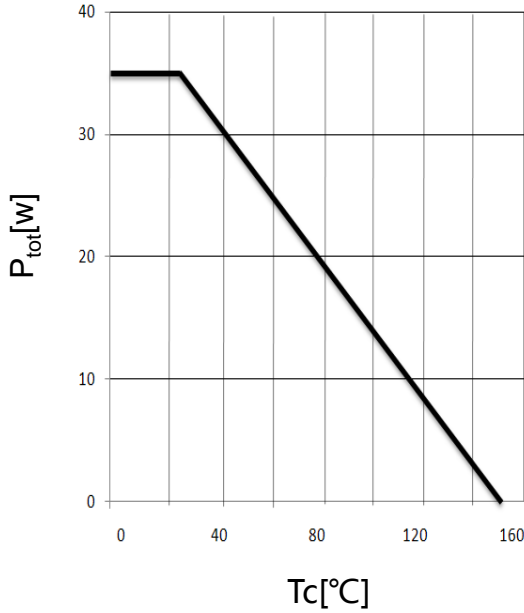
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Off Characteristics						
BV <sub>DSS</sub>	Drain-Source Breakdown Voltage	V <sub>GS</sub> = 0V, I <sub>D</sub> = 250μA, T <sub>J</sub> = 25 °C	650	--	--	V
		V <sub>GS</sub> = 0V, I <sub>D</sub> = 250μA, T <sub>J</sub> = 150 °C	--	700	--	V
ΔBV <sub>DSS</sub> / ΔT <sub>J</sub>	Breakdown Voltage Temperature Coefficient	I <sub>D</sub> = 250μA, Referenced to 25 °C	--	0.6	--	V/°C
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	V <sub>DS</sub> = 650V, V <sub>GS</sub> = 0V, T <sub>C</sub> = 25 °C	--	--	1	μA
		V <sub>DS</sub> = 650V, V <sub>GS</sub> = 0V, T <sub>C</sub> = 150 °C	--	10	--	μA
I <sub>GSSF</sub>	Gate-Body Leakage Current, Forward	V <sub>GS</sub> = 30V, V <sub>DS</sub> = 0V	--	--	100	nA
I <sub>GSSR</sub>	Gate-Body Leakage Current, Reverse	V <sub>GS</sub> = -30V, V <sub>DS</sub> = 0V	--	--	-100	nA
On Characteristics						
V <sub>GS(th)</sub>	Gate Threshold Voltage	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250μA	2.5	--	4.5	V
R <sub>DS(on)</sub>	Static Drain-Source On-Resistance	V <sub>GS</sub> = 10V, I <sub>D</sub> = 10A	--	0.16	0.19	Ω
g <sub>FS</sub>	Forward Trans conductance	V <sub>DS</sub> = 40V, I <sub>D</sub> = 10A (Note 4)	--	16	--	S
Dynamic Characteristics						
C <sub>iss</sub>	Input Capacitance	V <sub>DS</sub> = 25V, V <sub>GS</sub> = 0V, f = 1.0MHz	--	1440	--	pF
C <sub>oss</sub>	Output Capacitance		--	370	--	pF
C <sub>rss</sub>	Reverse Transfer Capacitance		--	11	--	pF
Switching Characteristics						
t <sub>d(on)</sub>	Turn-On Delay Time	V <sub>DD</sub> = 400V, I <sub>D</sub> = 10A, R <sub>G</sub> = 20Ω (Note 4, 5)	--	15	--	ns
t <sub>r</sub>	Turn-On Rise Time		--	11	--	ns
t <sub>d(off)</sub>	Turn-Off Delay Time		--	110	--	ns
t <sub>f</sub>	Turn-Off Fall Time		--	9	--	ns
Q <sub>g</sub>	Total Gate Charge	V <sub>DS</sub> = 480V, I <sub>D</sub> = 10A, V <sub>GS</sub> = 10V (Note 4, 5)	--	70	90	nC
Q <sub>gs</sub>	Gate-Source Charge		--	7.8	--	nC
Q <sub>gd</sub>	Gate-Drain Charge		--	9	--	nC
Drain-Source Diode Characteristics and Maximum Ratings						
I <sub>S</sub>	Maximum Continuous Drain-Source Diode Forward Current		--	--	20	A
I <sub>SM</sub>	Maximum Pulsed Drain-Source Diode Forward Current		--	--	60	A
V <sub>SD</sub>	Drain-Source Diode Forward Voltage	V <sub>GS</sub> = 0V, I <sub>F</sub> = 10A	--	1	1.5	V
t <sub>rr</sub>	Reverse Recovery Time	V <sub>GS</sub> = 0V, I <sub>F</sub> = 10A, di <sub>F</sub> /dt = 100A/μs (Note 4)	--	475	--	ns
Q <sub>rr</sub>	Reverse Recovery Charge		--	5.8	--	μC
I <sub>rrm</sub>	Peak reverse recovery Current				35	--

## NOTES:

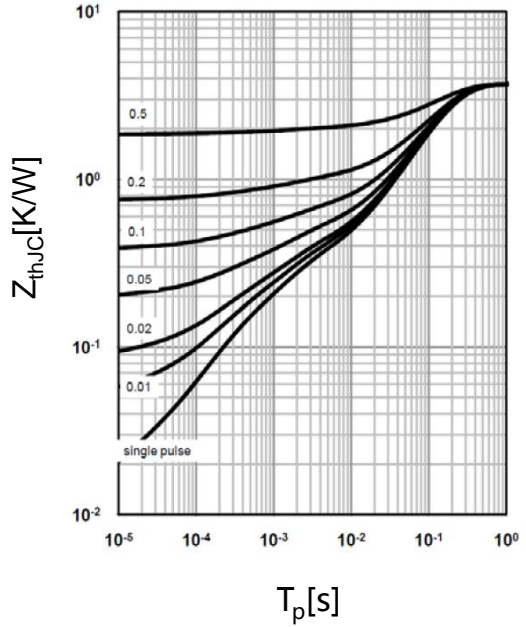
1. Repetitive Rating: Pulse width limited by maximum junction temperature
2. I<sub>AS</sub>=3.5A, V<sub>DD</sub>=50V, Starting T<sub>J</sub>=25 °C
3. I<sub>SD</sub>≤20A, di/dt ≤ 200A/μs, V<sub>DD</sub> ≤ BV<sub>DSS</sub>, Starting T<sub>J</sub> = 25 °C
4. Pulse Test: Pulse width ≤ 300μs, Duty Cycle ≤ 2%
5. Essentially Independent of Operating Temperature Typical Characteristics

# Typical Performance Characteristics

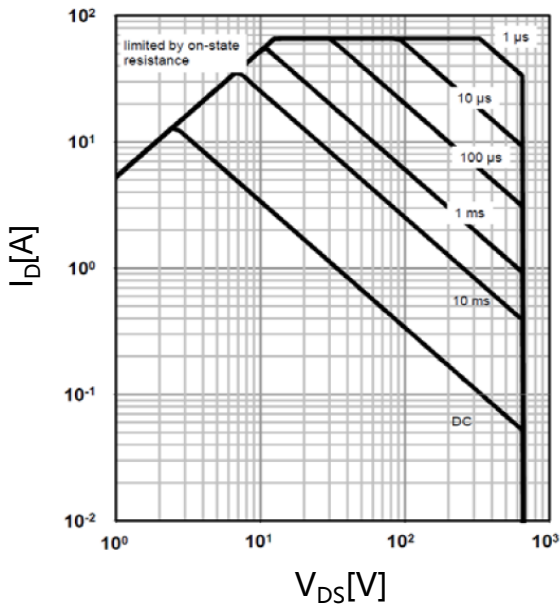
Power dissipation



Max. transient thermal impedance

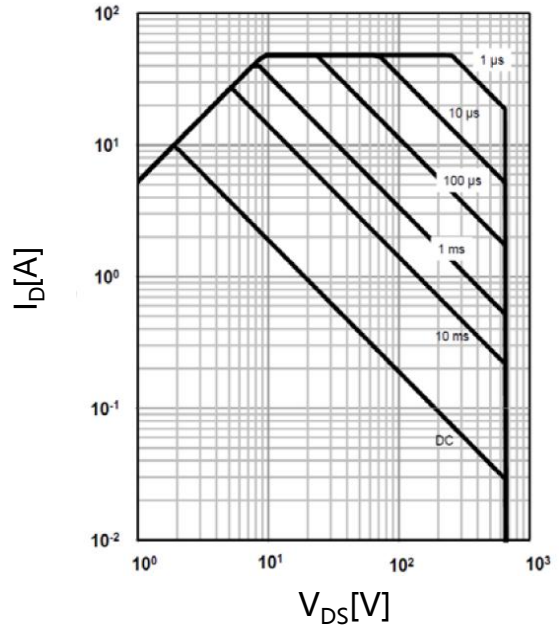


Safe operating area  $T_c=25^{\circ}C$



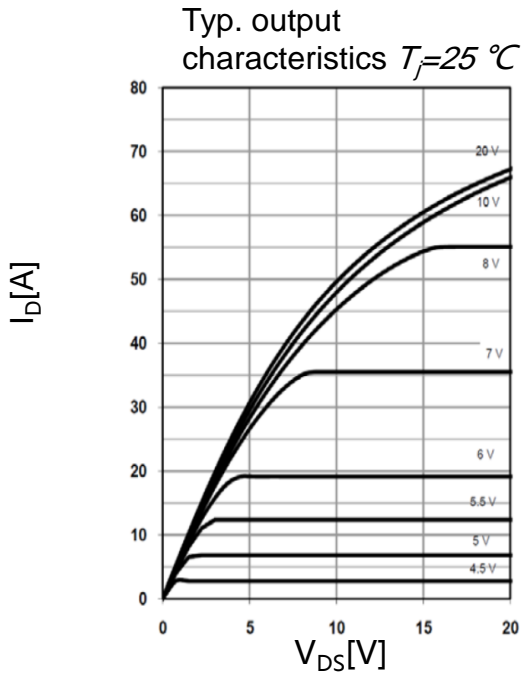
$I_D=f(V_{DS}); T_c=25^{\circ}C; V_{GS} > 7V;$   
 $D=0;$  parameter  $t_p$

Safe operating area  $T_c=80^{\circ}C$

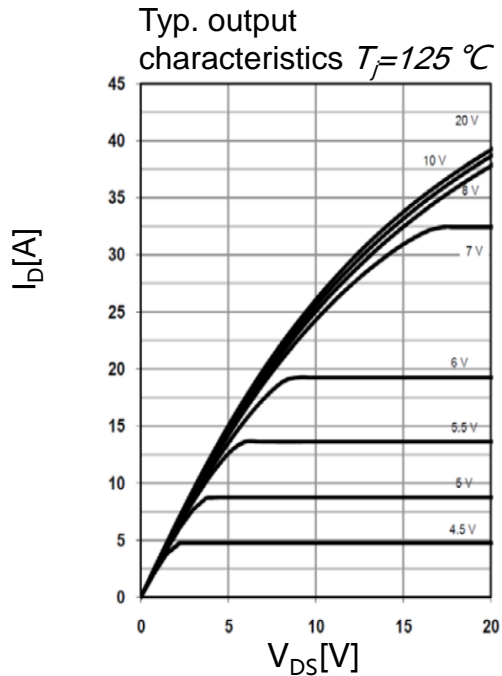


$I_D=f(V_{DS}); T_c=80^{\circ}C; V_{GS} > 7V;$   
 $D=0;$  parameter  $t_p$

# Typical Performance Characteristics

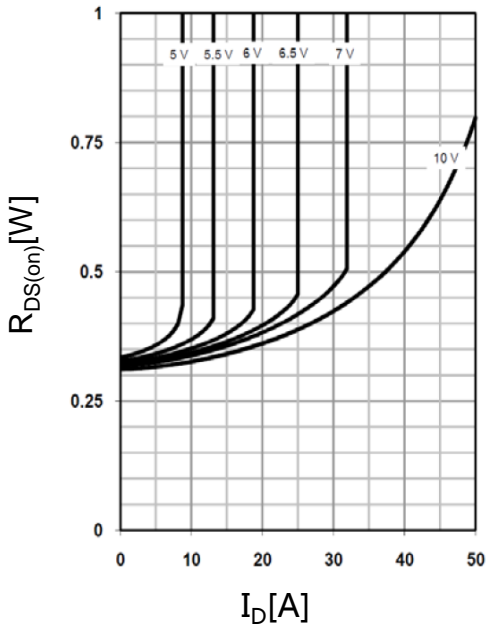


$I_D=f(V_{DS}); T_j=25^\circ\text{C}$  ; parameter:  $V_{GS}$



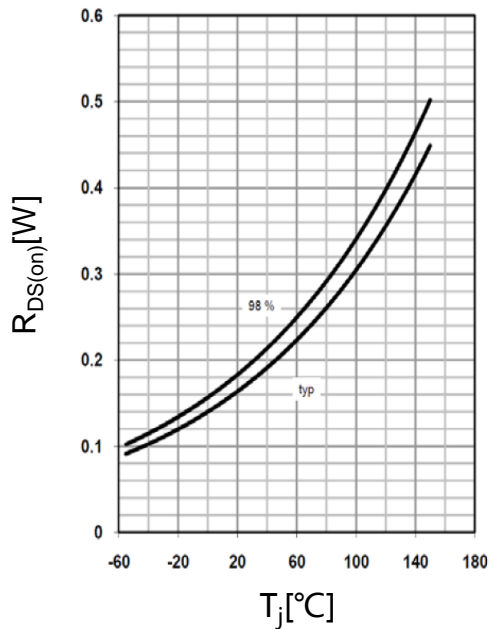
$I_D=f(V_{DS}); T_j=125^\circ\text{C}$  ; parameter:  $V_{GS}$

Typ. drain-source on-state resistance



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

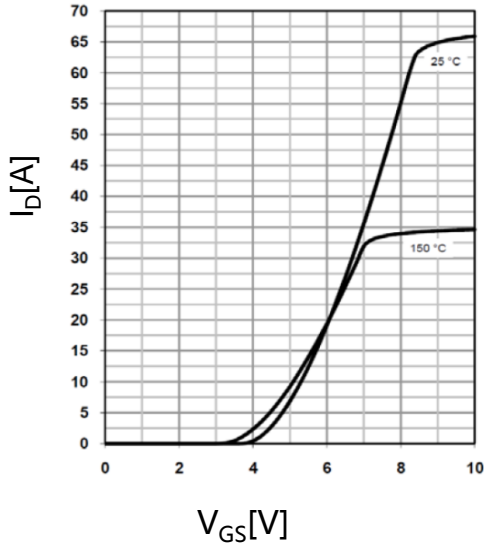
Typ. drain-source on-state resistance



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

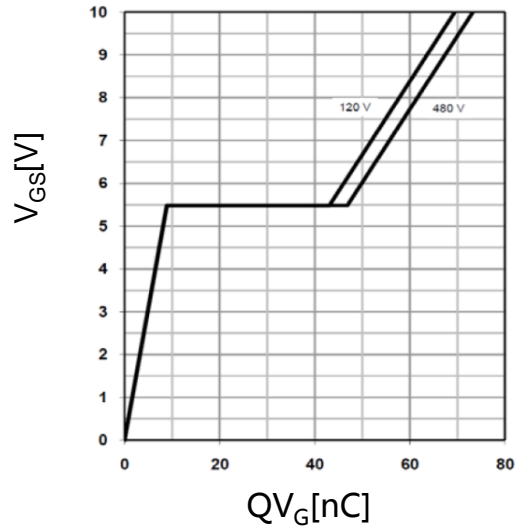
# Typical Performance Characteristics

Typ. transfer characteristics



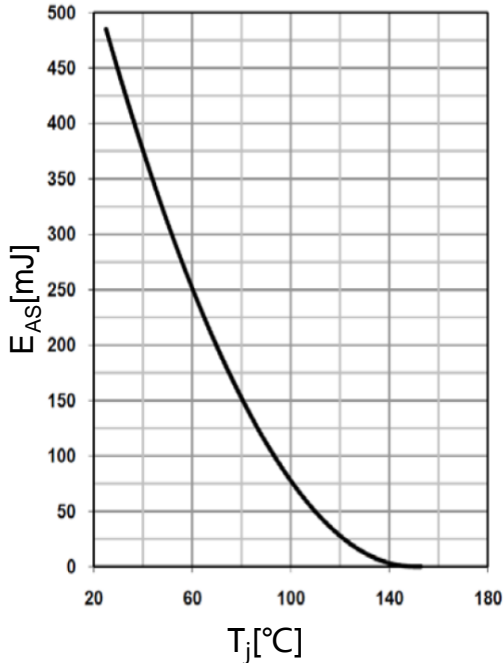
$I_D = f(V_{GS}); V_{DS} = 20V$

Typ. gate charge



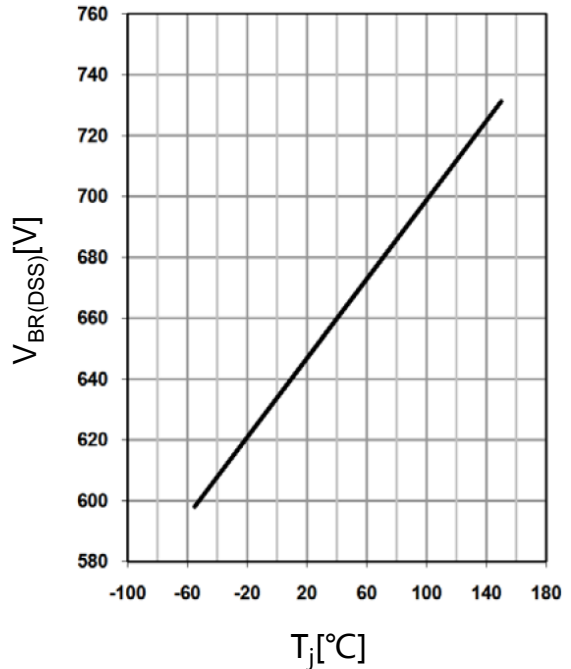
$V_{GS} = f(Q_g), I_D = 11A$  pulsed

Avalanche energy



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

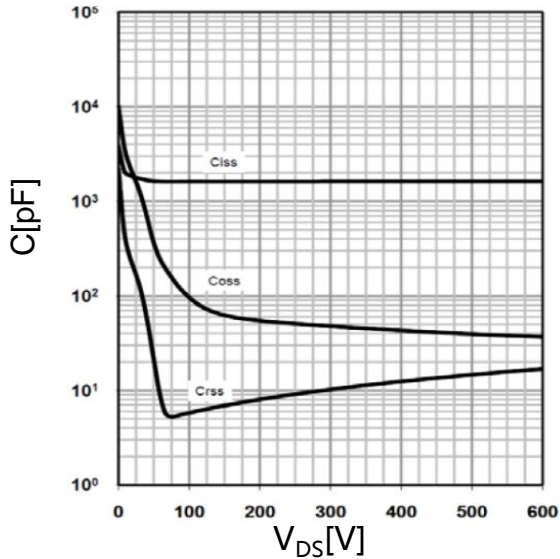
Drain-source breakdown voltage



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

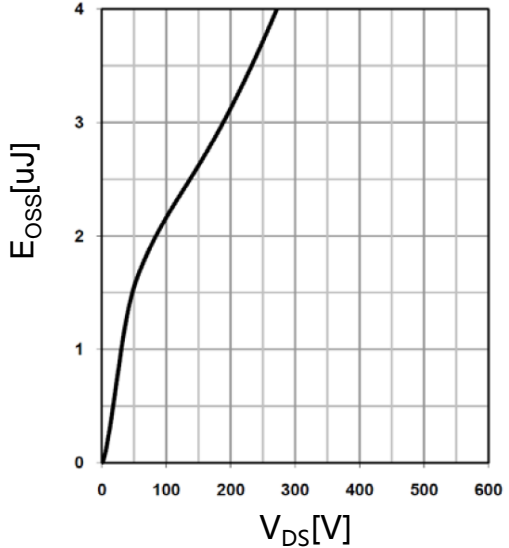
# Typical Performance Characteristics

Typ. capacitances



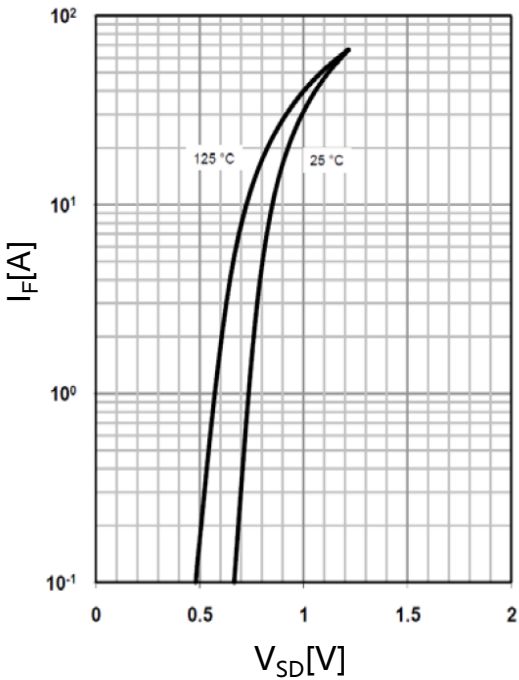
$C=f(V_{DS}); V_{GS}=0\text{ V}; f=1\text{ MHz}$

Typ. *Coss* stored energy



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

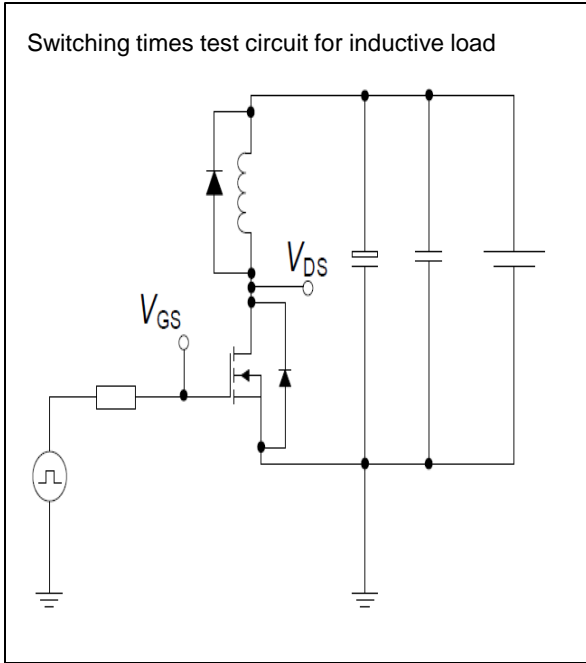
## Forward characteristics of reverse diode



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

# Test circuits

## Switching times test circuit and waveform for inductive load

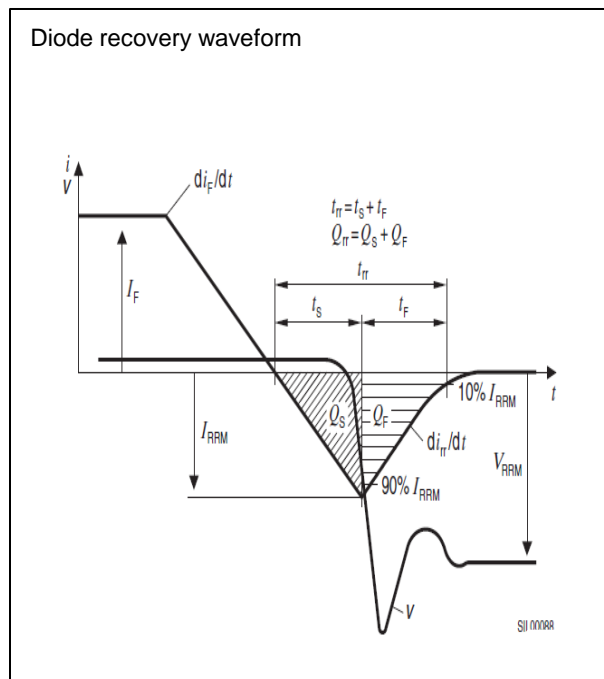
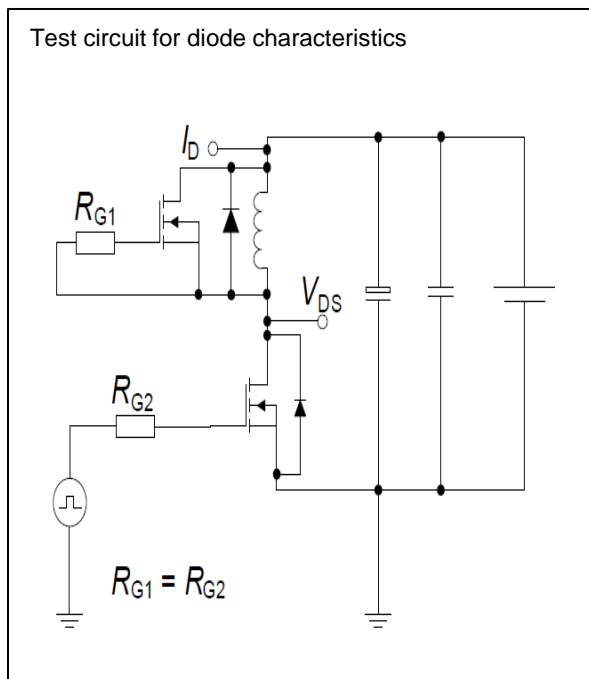


## Unclamped inductive load test circuit and waveform



# Test circuits

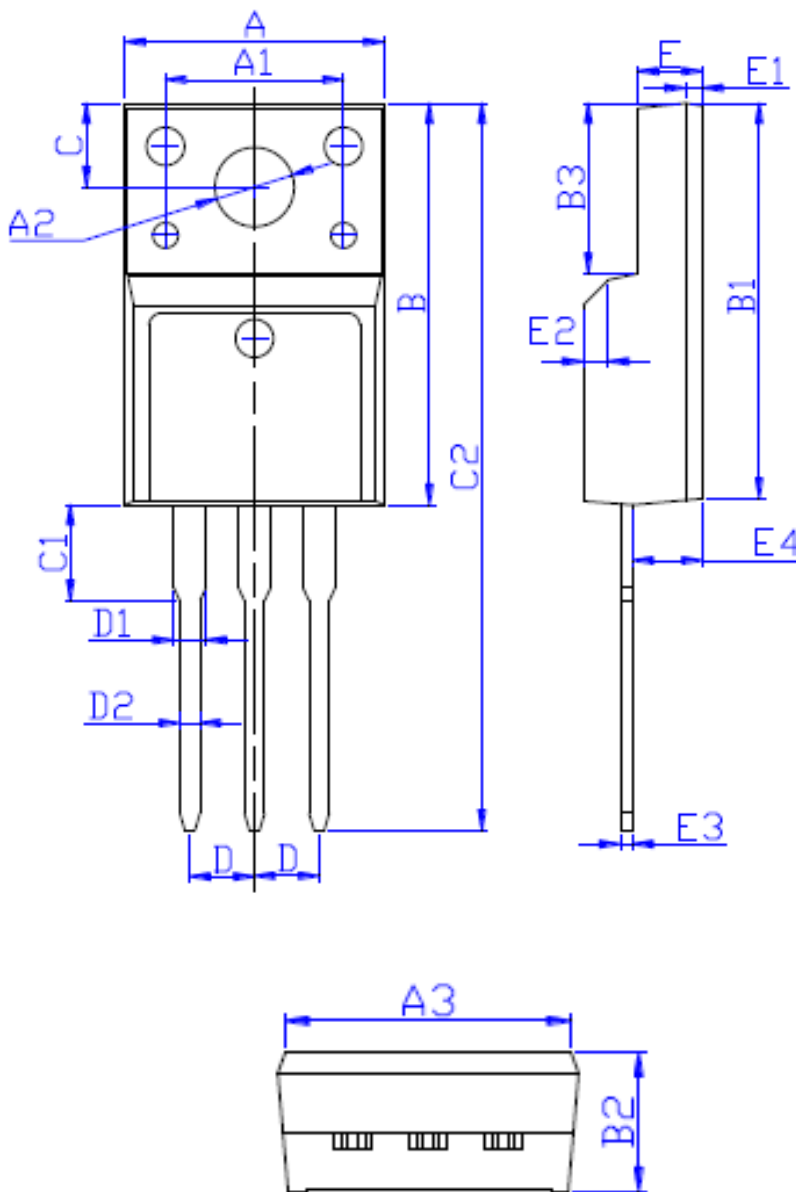
## Test circuit and waveform for diode characteristics





# Package Outline TO-220F

TSF65R190S1 650V 20A N-Channel SJ-MOSFET



DIM	MILLIMETERS
A	10.16 ± 0.30
A1	7.00 ± 0.20
A2	3.12 ± 0.20
A3	9.70 ± 0.30
B	15.90 ± 0.50
B1	15.60 ± 0.50
B2	4.70 ± 0.30
B3	6.70 ± 0.30
C	3.30 ± 0.25
C1	3.25 ± 0.30
C2	28.70 ± 0.50
D	Typical 2.54
D1	1.47 (MAX)
D2	0.80 ± 0.20
E	2.55 ± 0.25
E1	0.70 ± 0.25
E2	1.0 × 45°
E3	0.50 ± 0.20
E4	2.75 ± 0.30