# MMSFA60R115S6Z

## 600V 0.115Ω N-channel MOSFET

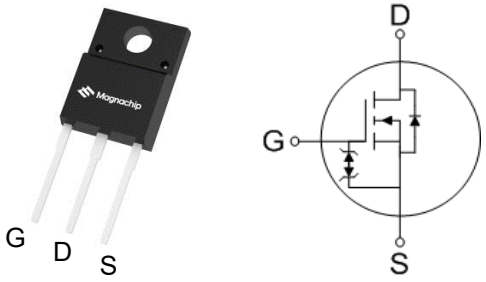
## ■ Description

Superior 6th generation SJ MOSFETs (S6-series) are cutting-edge high voltage power MOSFETs, based on Magnachip's extensive design expertise and years of experience. The main strengths of S6-series are low on-resistance, low gate charge and reduced tendency for ringing. As a result, its switching loss is very low, making it optimized for switching applications. Moreover, these user-friendly devices offer the advantages of improved ruggedness and remarkable ESD capability by integrated Zener diode, making it an ideal choice for designers.

## ■ Key Parameters

| Parameter | Value | Unit |
|---|---|---|
| $V_{DS}$ @ $T_{j,max}$ | 650 | V |
| $R_{DS(on),max}$ | 0.115 | Ω |
| $V_{TH,typ}$ | 3.5 | V |
| $I_D$ | 26 | A |
| $Q_{g,typ}$ | 43.9 | nC |

## ■ Package & internal circuit




RoHS Compliant
HALOGEN-FREE

## ■ Features

- Low power loss by high speed switching and low on-resistance
- 100% avalanche tested
- Green package – Pb free plating, Halogen free
- Zener-integrated

## ■ Applications

- PFC power supply stages
- Switching applications
- Adapters
- DC-DC converters

## ■ Ordering Information

| Order Code | Marking | Temp. ange | Package | Packing | RoHS Status |
|---|---|---|---|---|---|
| MMSFA60R115S6ZTH | A60R115S6ZS | -55 ~ 150℃ | TO-220SFA | Tube | Compliant |

## ■ Absolute Maximum Rating ($T_c$=25℃ unless otherwise specified)

| Parameter | Symbol | Rating | Unit | Note |
|---|---|---|---|---|
| Drain – source voltage | $V_{DSS}$ | 600 | V | |
| Gate – source voltage | $V_{GSS}$ | ±25 | V | |
| Continuous drain current[1] | $I_D$ | 26 | A | $T_C$=25℃ |
| | | 16.4 | A | $T_C$=100℃ |
| Pulsed drain current[2] | $I_{DM}$ | 78 | A | |
| Power dissipation | $P_D$ | 28 | W | |
| Single - pulse avalanche energy[3] | $E_{AS}$ | 82 | mJ | |
| MOSFET d$v$/d$t$ ruggedness | d$v$/d$t$ | 80 | V/ns | |
| Continuous diode forward current | $I_{SD}$ | 26 | A | |
| Diode d$v$/d$t$ ruggedness[4] | d$v$/d$t$ | 50 | V/ns | |
| Storage temperature | $T_{stg}$ | -55 ~150 | ℃ | |
| Maximum operating junction temperature | $T_j$ | 150 | ℃ | |

1) $I_D$ limited by maximum junction temperature, Duty cycle $D$=0.5
2) Pulse width $t_P$ limited by $T_{j,max}$
3) $I_{AS}$ : 3.7 A
4) $I_{SD} \le I_D$, $V_{DS\ peak} \le$ 400V, d$i$/d$t \le$ 900A/μs

## ■ Thermal Characteristics

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Thermal resistance, junction-case max | $R_{thJC}$ | 4.46 | ℃/W |
| Thermal resistance, junction-ambient max | $R_{thJA}$ | 65.3 | ℃/W |

## ■ Static Characteristics ($T_c$=25℃ unless otherwise specified)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Condition |
|---|---|---|---|---|---|---|
| Drain – source breakdown voltage | $V_{(BR)DSS}$ | 600 | - | - | V | $V_{GS}$ = 0V, $I_D$ = 1mA |
| Gate Threshold Voltage | $V_{GS(th)}$ | 2.5 | 3.5 | 4.5 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = 250μA |
| Zero gate voltage drain current | $I_{DSS}$ | - | - | 1 | μA | $V_{DS}$ = 600V, $V_{GS}$ = 0V |
| Gate leakage current | $I_{GSS}$ | - | - | 10 | uA | $V_{GS}$ = ±25V, $V_{DS}$ =0V |
| Drain-source on-state resistance | $R_{DS(ON)}$ | - | 0.103 | 0.115 | Ω | $V_{GS}$ = 10V, $I_D$ = 8.2A |

## ■ Dynamic Characteristics ($T_c$=25℃ unless otherwise specified)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Condition |
|---|---|---|---|---|---|---|
| Input capacitance | $C_{iss}$ | - | 1933 | - | pF | $V_{DS}$ = 400V, $V_{GS}$ = 0V, $f$ = 250kHz |
| Output capacitance | $C_{oss}$ | - | 41 | - | | |
| Reverse transfer capacitance | $C_{rss}$ | - | 4.7 | - | | |
| Effective output capacitance energy related[5] | $C_{o(er)}$ | - | 58 | - | | $V_{DS}$ = 0V to 400V, $V_{GS}$ = 0V, $f$ = 250kHz |
| Effective output capacitance time related[6] | $C_{o(tr)}$ | | 346 | | | $V_{DS}$ = 0V to 400V, $V_{GS}$ = 0V, $f$ = 250kHz |
| Turn on delay time | $t_{d(on)}$ | - | 37 | - | ns | $V_{GS}$ = 10V, $R_G$ = 25Ω, $V_{DD}$ = 300V, $I_D$ = 26A |
| Rise time | $t_r$ | - | 53 | - | | |
| Turn off delay time | $t_{d(off)}$ | - | 91 | - | | |
| Fall time | $t_f$ | - | 24 | - | | |
| Total gate charge | $Q_g$ | - | 37 | - | nC | $V_{GS}$ = 10V, $V_{DD}$ = 400V, $I_D$ = 8.2A |
| Gate – source charge | $Q_{gs}$ | - | 9.6 | - | | |
| Gate – drain charge | $Q_{gd}$ | - | 14.6 | - | | |
| Gate resistance | $R_G$ | - | 3.5 | - | Ω | $V_{GS}$ = 0V, $f$ = 1MHz |

5) $C_{o(er)}$ is a capacitance that gives the same stored energy as $C_{oss}$ while $V_{DS}$ is rising from 0 to 400V
6) $C_{o(tr)}$ is a capacitance that gives the same charging time as $C_{oss}$ while $V_{DS}$ is rising from 0 to 400V

## ■ Reverse Diode Characteristics ($T_c$=25℃ unless otherwise specified)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Condition |
|---|---|---|---|---|---|---|
| Diode forward voltage | $V_{SD}$ | - | - | 1.4 | V | $I_{SD}$ = 8.2A, $V_{GS}$ = 0V |
| Reverse recovery time | $t_{rr}$ | - | 249 | - | ns | $I_{SD}$ = 8.2A<br>d$i$/d$t$ = 100A/μs<br>$V_{DD}$ = 400V |
| Reverse recovery charge | $Q_{rr}$ | - | 2.4 | - | μC | |
| Reverse recovery current | $I_{rrm}$ | - | 19 | - | A | |

## ■ Characteristic graph

Fig.1 On-region characteristics.

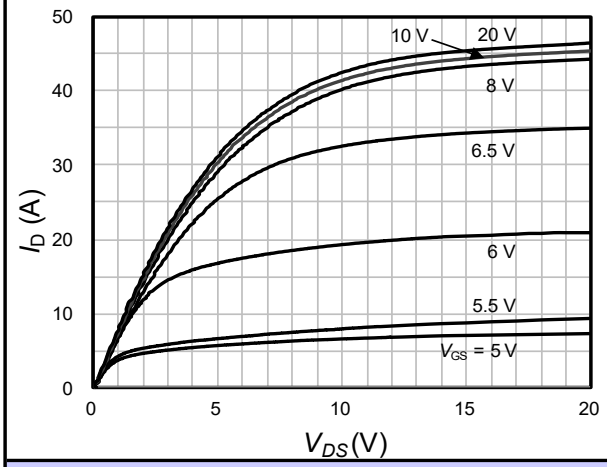



Fig.2 On-resistance variation with drain current

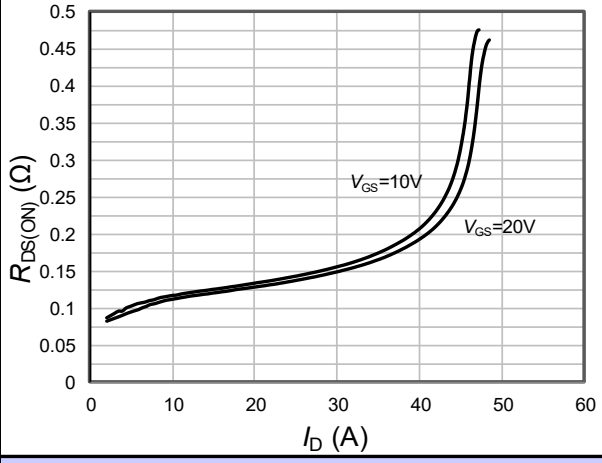



Fig.3 On-resistance variation with junction temperature (normalized)

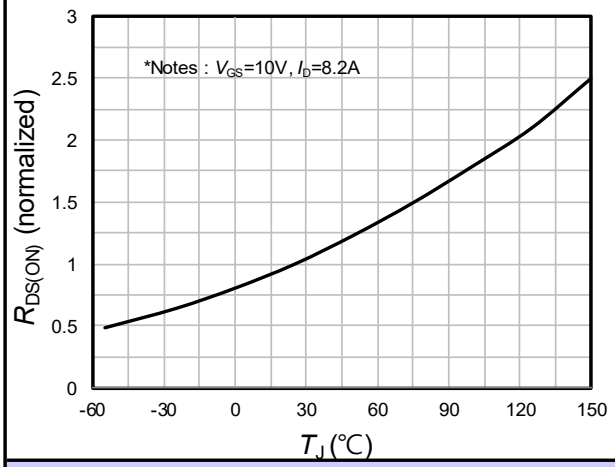



Fig.4 Breakdown voltage variation with temperature (normalized)

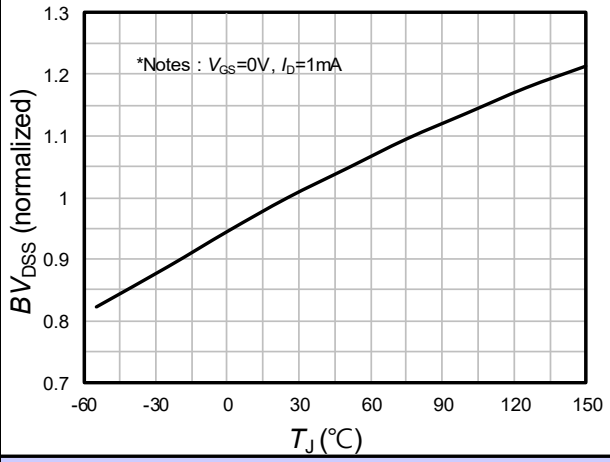



Fig.5 Transfer characteristics

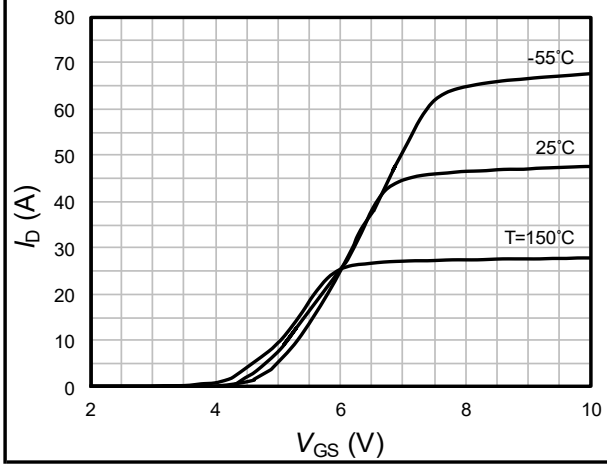



Fig.6 Diode forward characteristics

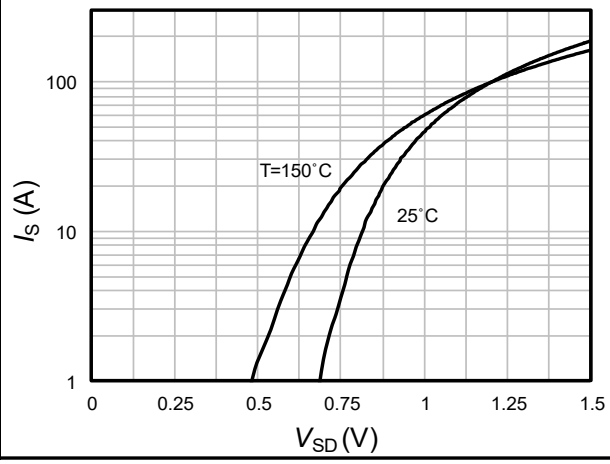


Fig.7 Gate charge characteristics

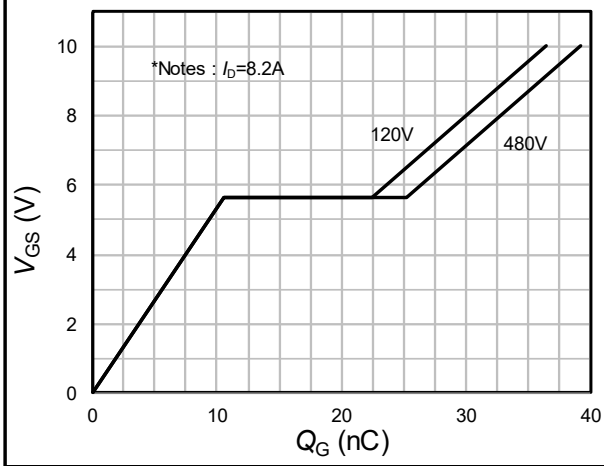



Fig.8 Capacitance characteristics

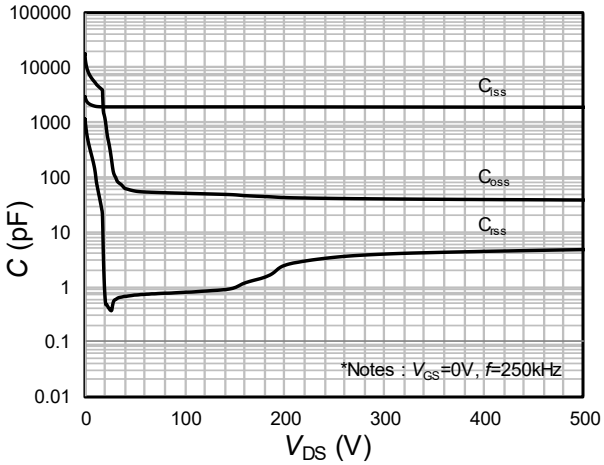



Fig.9 Threshold voltage variation with junction temperature

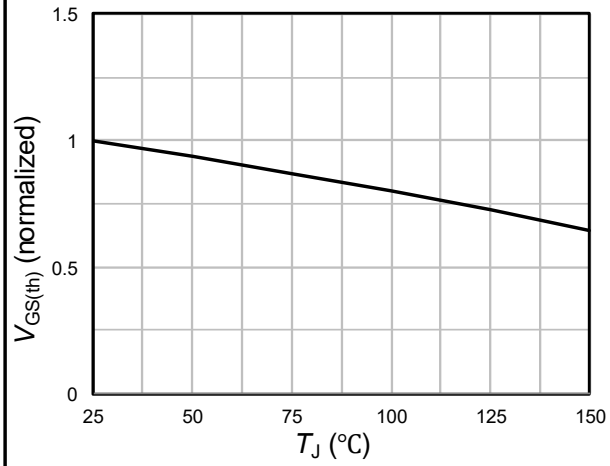



Fig.10 Drain current

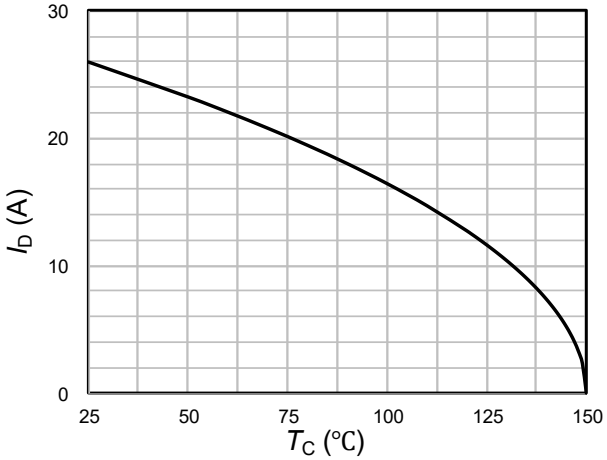



Fig.11 Power dissipation variation with pulse time

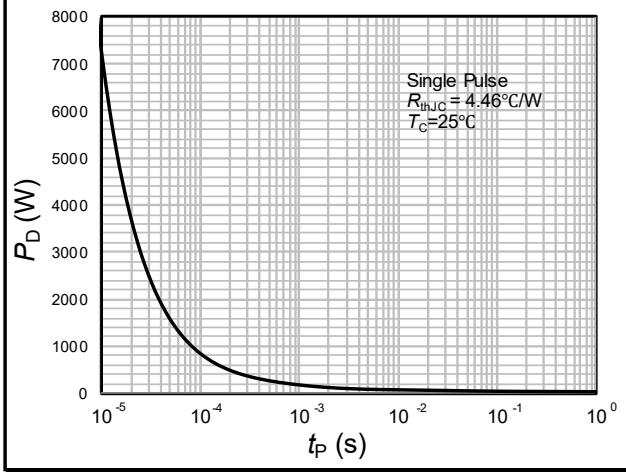



Fig.12 Output capacitance stored energy

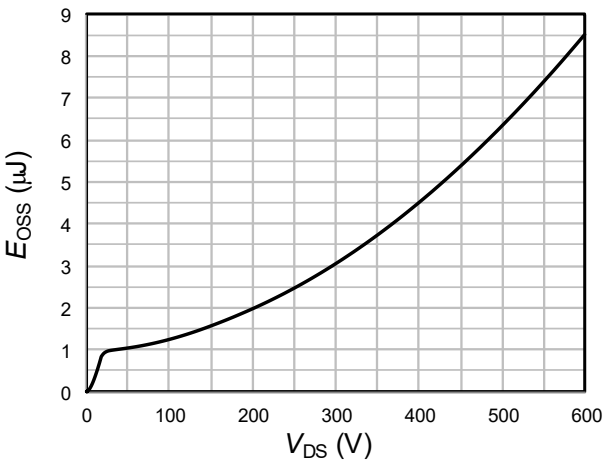


Fig.13 Transient thermal response

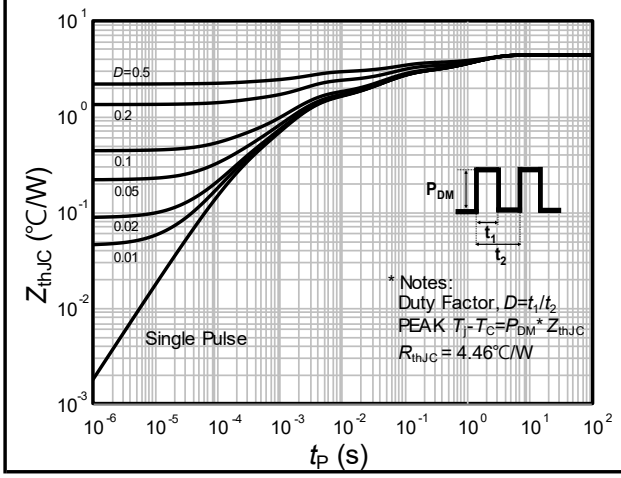
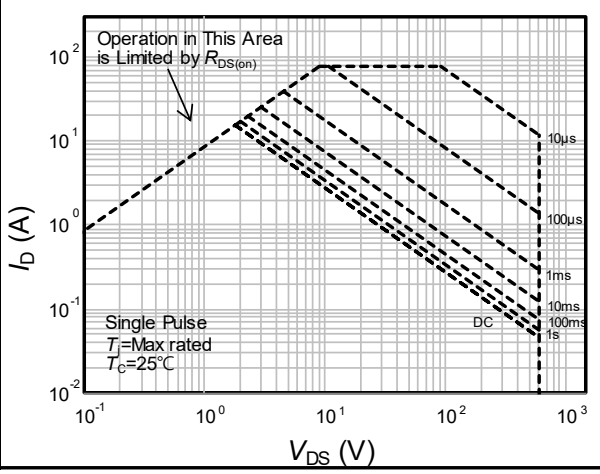



Fig.14 Safe operating area



## ■ Test Circuit

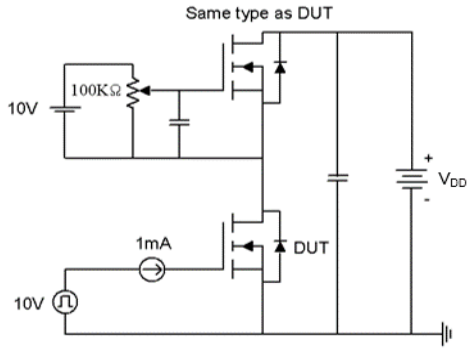



Fig15-1. Gate charge measurement circuit

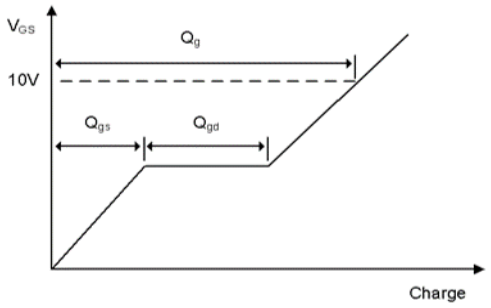



Fig15-2. Gate charge waveform

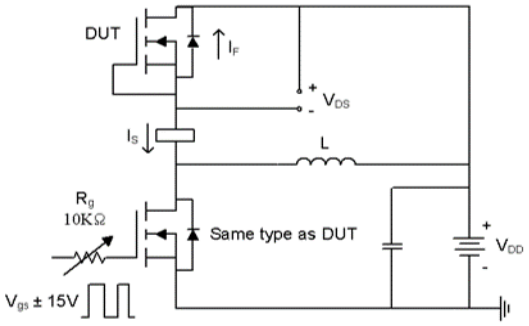



Fig16-1. Diode reverse recovery test circuit

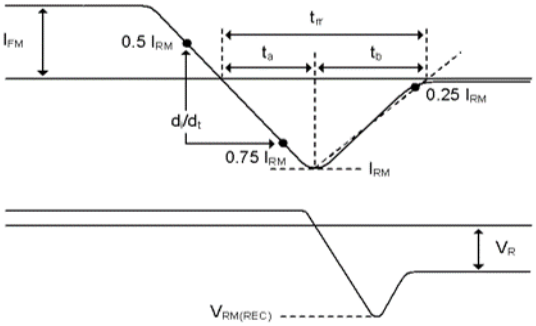



Fig16-2. Diode reverse recovery test waveform

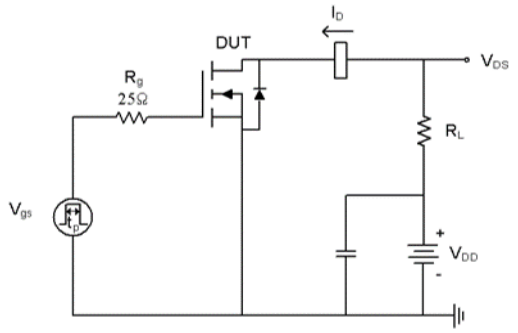



Fig17-1. Switching time test circuit for resistive load

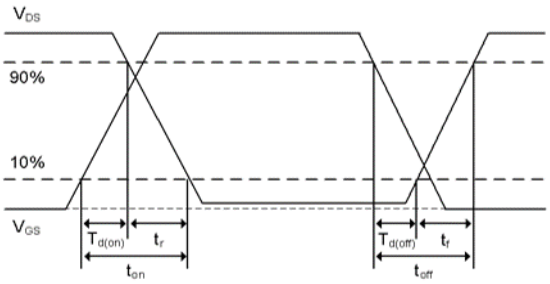



Fig17-2. Switching time waveform

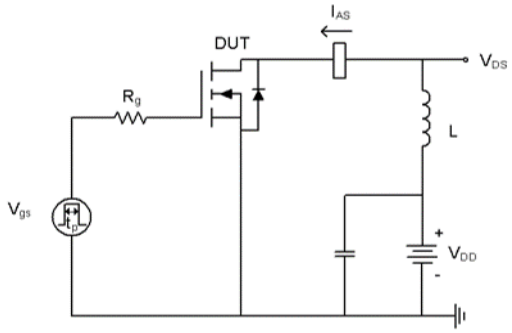



Fig18-1. Unclamped inductive load test circuit

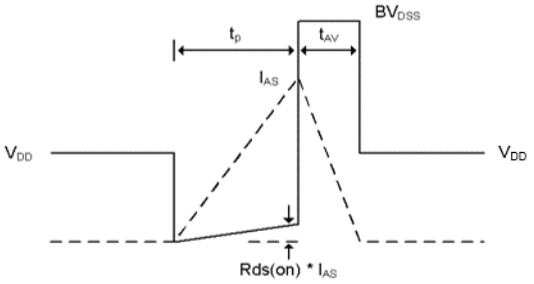
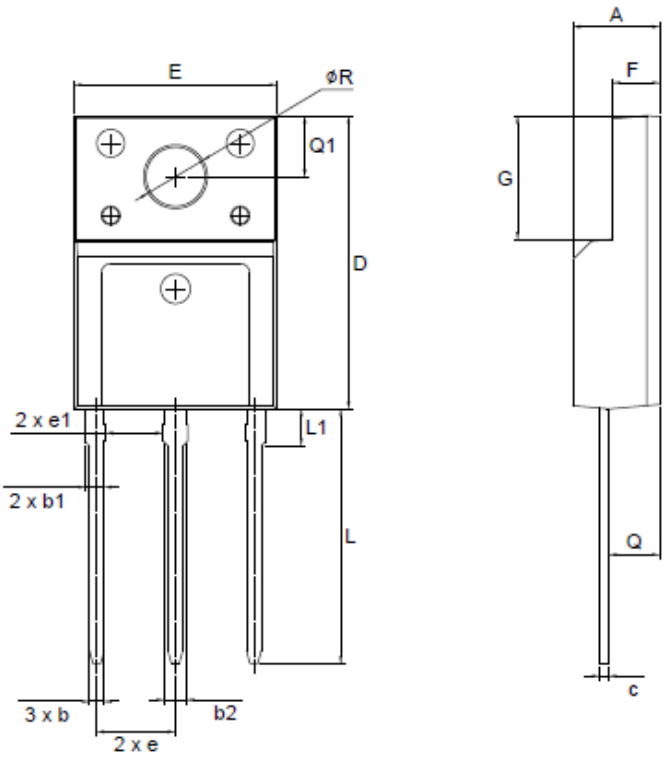



Fig18-2. Unclamped inductive waveform

## ■ Physical Dimension

### TO-220SFA (3L)

**Dimensions are in millimeters unless otherwise specified**




| Symbol | Dimension [mm] | | |
|---|---|---|---|
| | Min | Nom | Max |
| A | 4.5 | - | 4.9 |
| b | 0.7 | - | 0.9 |
| b1 | 0.9 | - | 1.3 |
| b2 | 1.0 | - | 1.4 |
| c | 0.45 | - | 0.60 |
| D | 15.67 | - | 16.07 |
| E | 10.8 | | 11.2 |
| e | 4.25 BSC | | |
| e1 | 3.0 | - | - |
| F | 2.34 | - | 2.74 |
| G | 6.48 | - | 6.88 |
| L | 13.58 | - | 13.98 |
| L1 | 1.8 | - | 2.20 |
| Q | 2.65 | - | - |
| Q1 | 3.20 | - | 3.40 |
| ΦR | 3.08 | - | 3.28 |
| θ | 3° Ref | | |

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