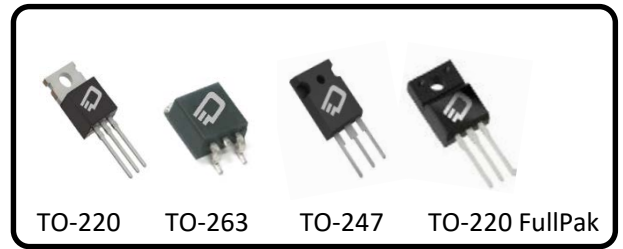


## 650V, 99mΩ, 33.6 A Super Junction Power MOSFET

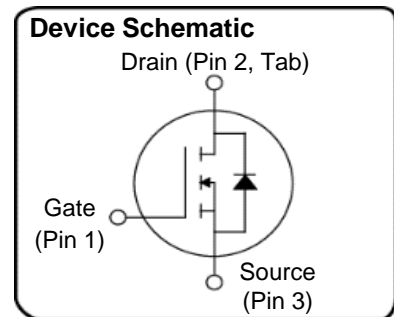
### Ordering Information

| Part Number  | Package Option |
|--------------|----------------|
| D3S099N65B-U | TO-220         |
| D3S099N65D-U | TO-247         |
| D3S099N65E-T | TO-263         |
| D3S099N65F-U | TO-220 FullPak |



### Description

+FET™ is an advanced Super Junction Power MOSFET offering excellent efficiency through low  $R_{DS(ON)}$  and low gate charge. +FET™ is a rugged device with precision charge balance implementation designed for demanding uses such as enterprise power computing power supplies, motor control, lighting and other challenging power conversion applications.



#### Features

- LOW  $R_{DS(ON)}$
- FAST SWITCHING
- HIGH  $E_{AS}$
- REL TEST SPEC: JESD-22
- LOW OUTPUT CAPACITANCE

#### Benefits

- LOW CONDUCTION LOSSES
- HIGH EFFICIENCY
- EXCELLENT AVALANCHE PERFORMANCE

**Table 1 Key Performance Parameters**

| Parameters                 | Value | Unit |
|----------------------------|-------|------|
| $V_{DS} @ T_J \text{ max}$ | 710   | V    |
| $R_{DS(on),max}$           | <99   | mΩ   |
| $Q_g, \text{typ}$          | 56    | nC   |
| $I_D @ 25^\circ\text{C}$   | 33.6  | A    |
| $C_{oss}$                  | 72    | pf   |

#### Applications

- POWER FACTOR CORRECTION
- SERVER POWER SUPPLIES
- TELECOM POWER SUPPLIES
- INVERTERS
- MOTOR CONTROL

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@  $T_J = 25^\circ\text{C}$ , unless otherwise specified

**Table 2 Maximum ratings**

| Parameter                         | Symbol         | Values |      |                |       | Unit             | Note/Test Condition  |
|-----------------------------------|----------------|--------|------|----------------|-------|------------------|--|
|                                   |                | Min.   | Typ. | Max            |       |                  |  |
|                                   |                |        |      | 220, 263 & 247 | 220FP |                  |  |
| Continuous drain current(1)       | $I_D$          |        |      | 33.6           | 15.9  | A                | $T_C = 25^\circ\text{C}$   |
|                                   |                |        |      | 21.3           | 10.1  |                  | $T_C = 100^\circ\text{C}$  |
| Pulsed drain current(2)           | $I_{D,pulse}$  |        |      | 135            | 63.8  | A                | $T_C = 25^\circ\text{C}$   |
| Avalanche energy, single pulse    | $E_{AS}$       |        |      | 534            | 534   | mJ               | $I_D=6.6\text{A}, V_{DD}=50\text{V}$                               |
| Avalanche energy, repetitive      | $E_{AR}$       |        |      | 1.34           | 1.34  | mJ               | $I_D=6.6\text{A}, V_{DD}=50\text{V}$                               |
| Avalanche current, repetitive     | $I_{AR}$       |        |      | 6.6            | 6.6   | A                |  |
| MOSFET dv/dt ruggedness           | dv/dt          |        |      | 50             | 50    | V/ns             | $V_{DS}=\dots 480\text{V}$   |
| Gate source voltage               | $V_{GS}$       | -30    |      | 30             | 30    | V                | static   |
|                                   |                | -30    |      | 30             | 30    |                  | AC (f > 1HZ)   |
| Power dissipation for TO-220      | $P_{tot}$      |        |      | 272            | 61    | W                | $T_C = 25^\circ\text{C}$   |
| Operating and storage temperature | $T_J, T_{stg}$ | -55    |      | 150            | 150   | $^\circ\text{C}$ |  |
| Mounting torque                   |                |        |      | 60             |       | Ncm              | M3 and M3.5 screws   |
|                                   |                |        |      |                | 50    |                  | M3 screws  |
| Continuous diode forward current  | $I_S$          |        |      | 33.6           | 15.9  | A                | $T_C = 25^\circ\text{C}$   |
| Diode pulsed current              | $I_{S,pulse}$  |        |      | 135            | 63.8  | A                | $T_C = 25^\circ\text{C}$   |
| Reverse diode dv/dt(3)            | dv/dt          |        |      | 15             | 15    | V/ns             | $V_{DS}=\dots 480\text{V}, I_{SD}<I_D$<br>$T_J = 25^\circ\text{C}$ |
| Maximum diode commutation speed   | dif/dt         |        |      | 500            | 500   | A/us             |  |

**Table 3 Thermal characteristics**

| Parameter  | Symbol     | Values |      |                |       | Unit                      | Note/Test Condition     |
|--|------------|--------|------|----------------|-------|---------------------------|-------------------------|
|  |            | Min.   | Typ. | Max            |       |                           |                         |
|  |            |        |      | 220, 263 & 247 | 220FP |                           |                         |
| Thermal resistance, Junction-case                          | $R_{thJC}$ |        |      | 0.5            | 2.25  | $^\circ\text{C}/\text{W}$ |                         |
| Thermal resistance, Junction-ambient                       | $R_{thJA}$ |        |      | 43.4           | 46    | $^\circ\text{C}/\text{W}$ | Leaded                  |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ |        |      | 260            | 260   | $^\circ\text{C}$          | 1.6mm form case for 10s |

**Table 4 Static characteristics**

| Parameter                         | Symbol        | Values |      |      | Unit       | Note/Test Condition                         |
|-----------------------------------|---------------|--------|------|------|------------|---|
|                                   |               | Min.   | Typ. | Max. |            |   |
| Drain to source breakdown voltage | $V_{(BR)DSS}$ | 650    |      |      | V          | $V_{GS}=0V, I_D=1mA$                        |
| Gate threshold voltage            | $V_{GS(TH)}$  | 2.3    | 3.2  | 4.5  | V          | $V_{DS}=V_{GS}, I_D=194\mu A$               |
| Zero gate voltage drain current   | $I_{DSS}$     |        |      | 1    | uA         | $V_{DS}=650V, V_{GS}=0V, T_J = 25^\circ C$  |
|                                   |               |        |      | 40   |            | $V_{DS}=650V, V_{GS}=0V, T_J = 150^\circ C$ |
| Gate to source leakage current    | $I_{GSS}$     |        |      | 100  | nA         | $V_{GS}=\pm 20V, V_{DS}=0V$                 |
| Drain-source on-state resistance  | $R_{DS(on)}$  |        | 94   | 99   | m $\Omega$ | $V_{GS}=10V, I_D=16.8A, T_J = 25^\circ C$   |
|                                   |               |        | 190  |      | m $\Omega$ | $V_{GS}=10V, I_D=16.8A, T_J = 150^\circ C$  |
| Gate resistance                   | $R_G$         |        | 1    |      | $\Omega$   | Scaf-F                                      |

**Table 5 Dynamic characteristics**

| Parameter                                      | Symbol       | Values |      |      | Unit | Note/Test Condition                                 |
|--|--------------|--------|------|------|------|---|
|  |              | Min.   | Typ. | Max. |      |   |
| Input capacitance                              | $C_{iss}$    |        | 2222 |      | pF   | $V_{GS}=0V, V_{DS}=100V, f=1MHz$                    |
| Output capacitance                             | $C_{oss}$    |        | 72   |      | pF   |   |
| Reverse transfer capacitance                   | $C_{rss}$    |        | 13   |      | pF   |   |
| Effective output capacitance, energy related 1 | $C_{o(er)}$  |        | 105  |      | pF   | $V_{DS}=0\dots 480V, V_{GS}= 0V$                    |
| Effective output capacitance, time related 2   | $C_{o(tr)}$  |        | 331  |      | pF   | $I_D=constant, V_{DS}=0\dots 480V, V_{GS}= 0V$      |
| Turn on delay time                             | $t_{d(on)}$  |        | 18   |      | ns   | $V_{DD}=400V, I_D=16.8A, R_G=1.0\Omega, V_{GS}=10V$ |
| Rising time                                    | $t_r$        |        | 25   |      | ns   |   |
| Turn off delay time                            | $t_{d(off)}$ |        | 41   |      | ns   |   |
| Fall time                                      | $t_f$        |        | 22   |      | ns   |   |

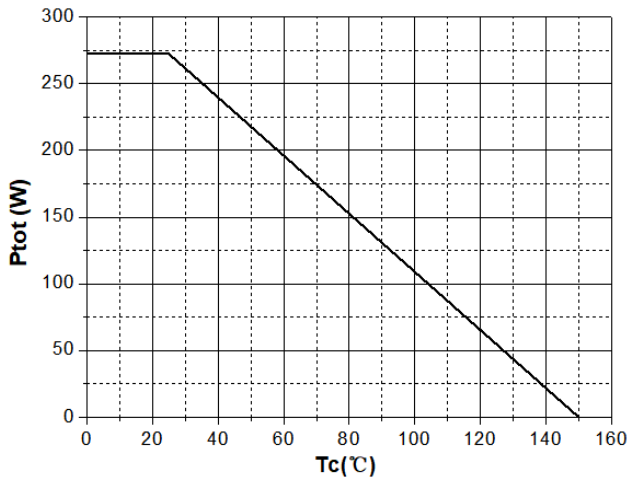
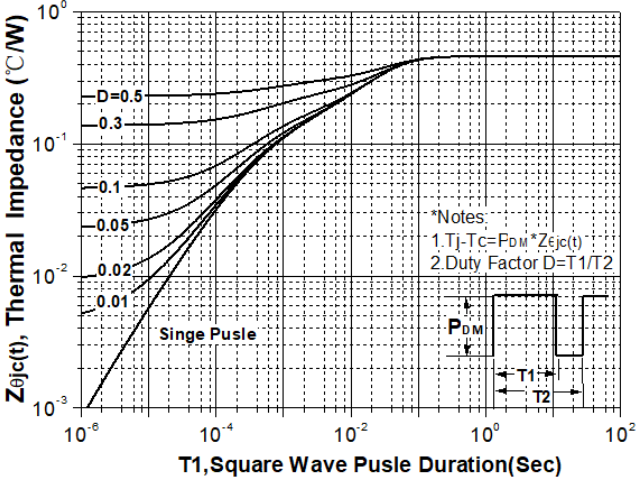
**Table 6 Gate charge characteristics**

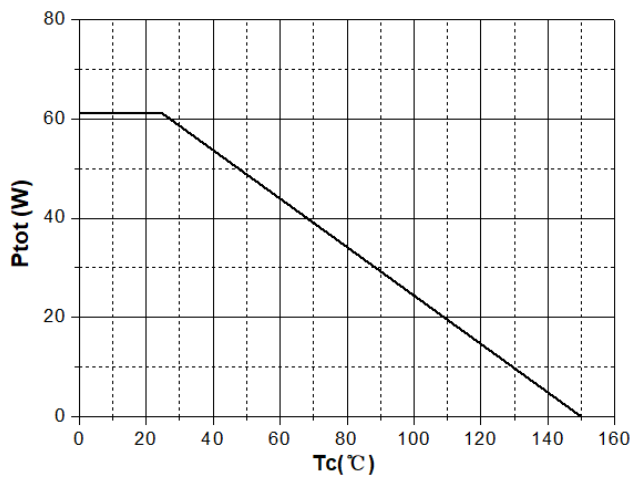
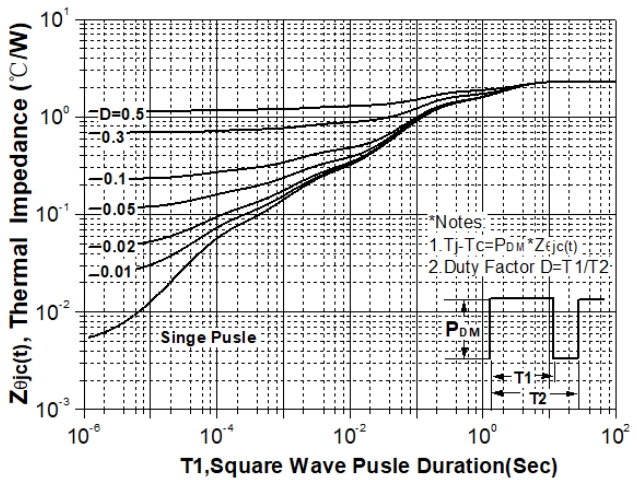
| Parameter            | Symbol        | Values |      |      | Unit | Note/Test Condition                                |
|----------------------|---------------|--------|------|------|------|--|
|                      |               | Min.   | Typ. | Max. |      |  |
| Total gate charge    | $Q_g$         |        | 56   |      | nC   | $V_{DD}=480V, V_{GS}=0 \text{ to } 10V, I_D=16.8A$ |
| Gate-source charge   | $Q_{gs}$      |        | 14   |      | nC   |  |
| Gate-drain charge    | $Q_{gd}$      |        | 23   |      | nC   |  |
| Gate plateau voltage | $V_{plateau}$ |        | 5.0  |      | V    |  |

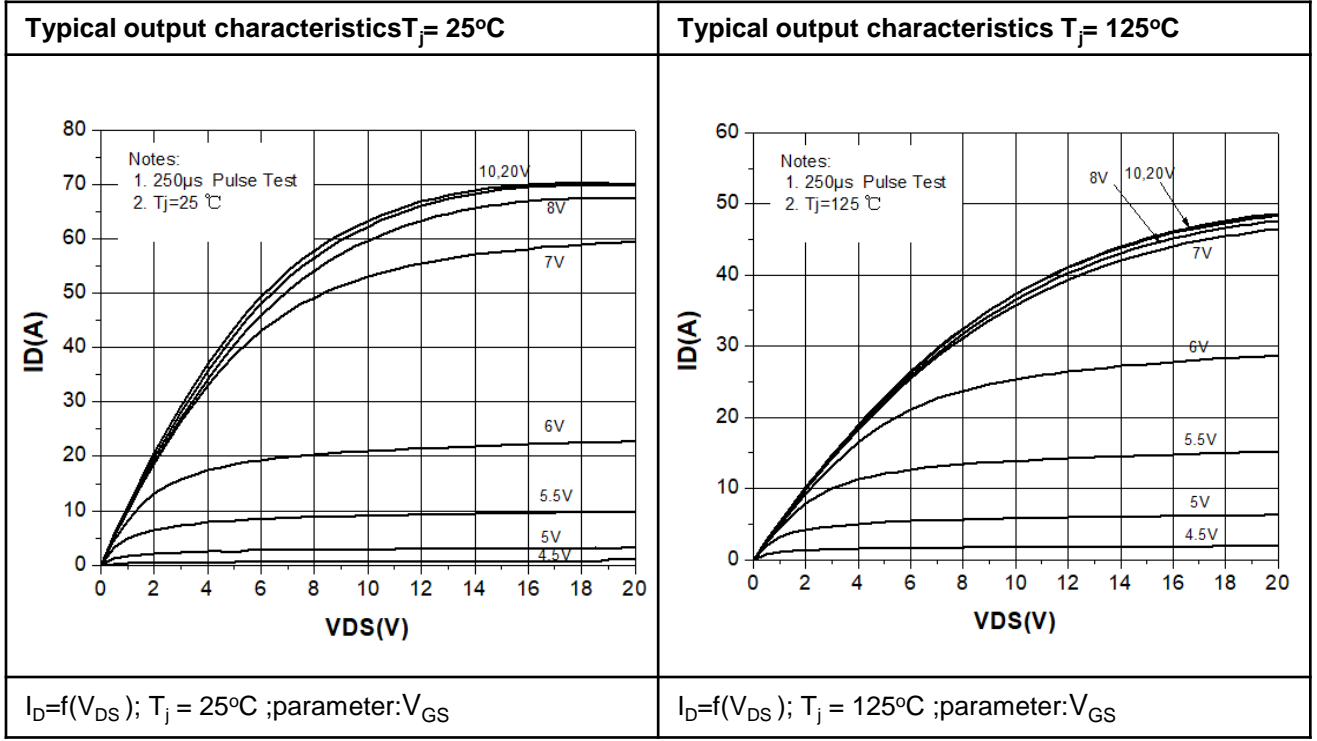
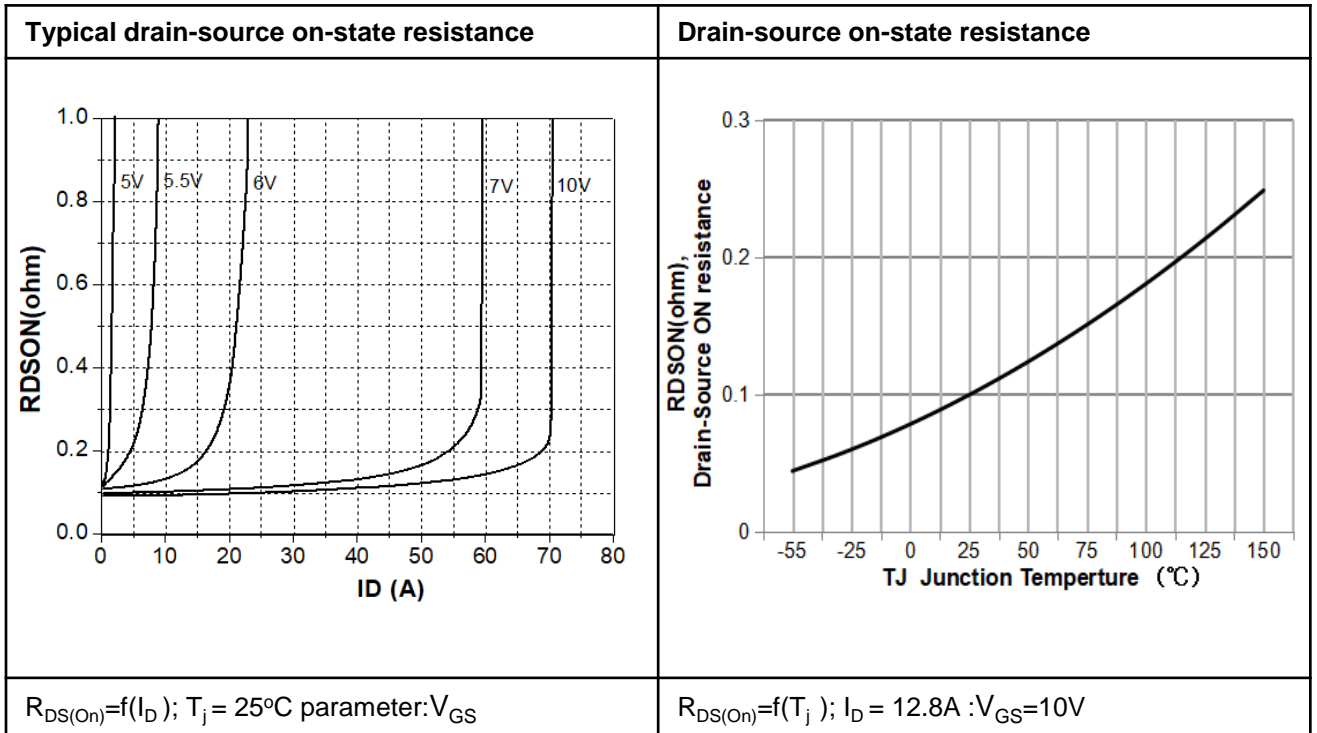
**Table 7 Reverse diode characteristics**

| Parameter                     | Symbol    | Values |      |      | Unit | Note/Test Condition                      |
|-------------------------------|-----------|--------|------|------|------|--|
|                               |           | Min    | Typ  | Max  |      |  |
| Diode forward voltage         | $V_{SD}$  |        | 0.87 | 0.96 | V    | $I_F=33.6A, V_{GS}=0V, T_J = 25^\circ C$ |
| Reverse recovery time         | $t_{rr}$  |        | 452  |      | ns   | $I_F=33.6A, dI_F/dt=100A/us$             |
| Reverse recovery charge       | $Q_{rr}$  |        | 8.0  |      | uC   |  |
| Peak reverse recovery current | $I_{rrm}$ |        | 36   |      | A    |  |

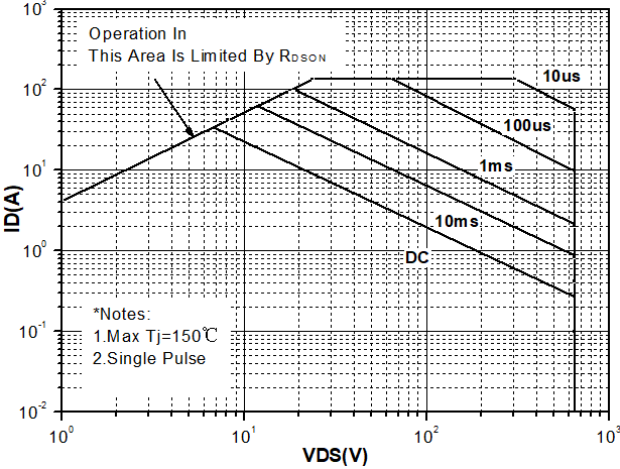
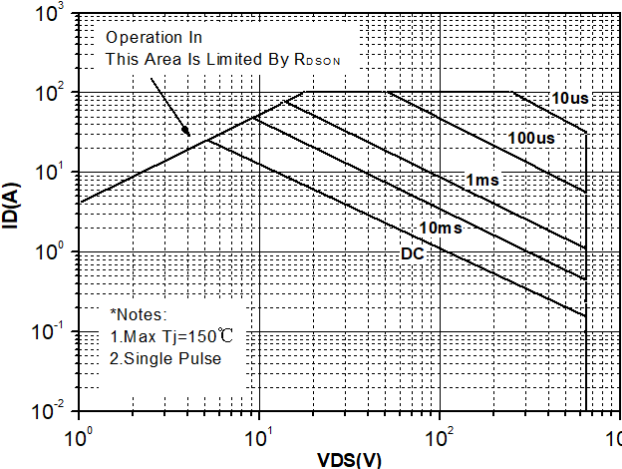
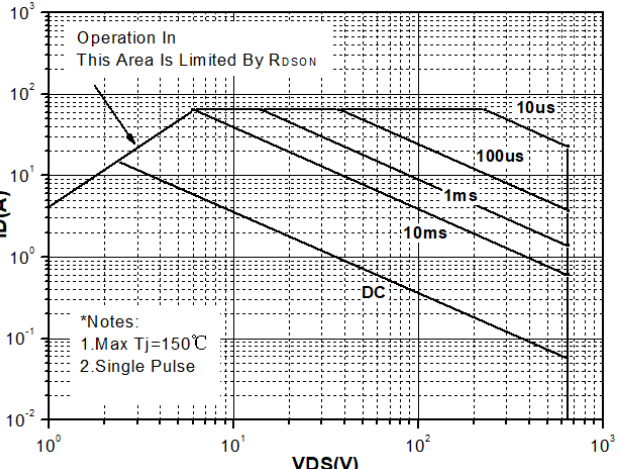
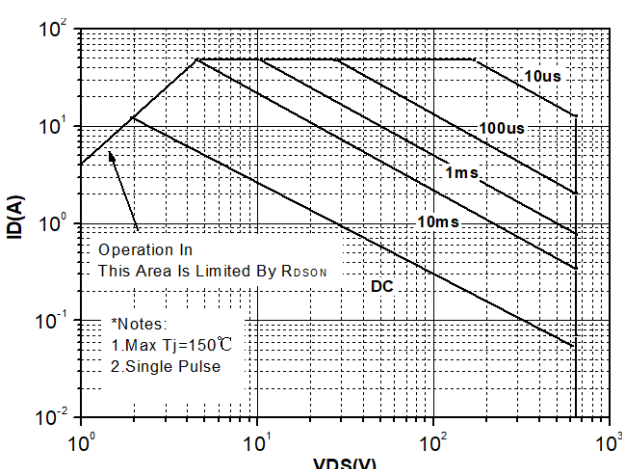
**Table 8 Thermal Performance**

| Power dissipation (TO220, TO263 & TO247)   | Max. transient thermal impedance (TO220, TO263 & TO247)  |
|--|--|
|  |  <p>*Notes:<br/> 1. <math>T_J - T_C = P_{DM} * Z_{thJC}(t)</math><br/> 2. Duty Factor <math>D = T_1 / T_2</math></p> |
| $P_{tot} = f(T_C)$   | $Z_{thJC} = f(t_p); \text{parameter: } D = t_p / T$  |

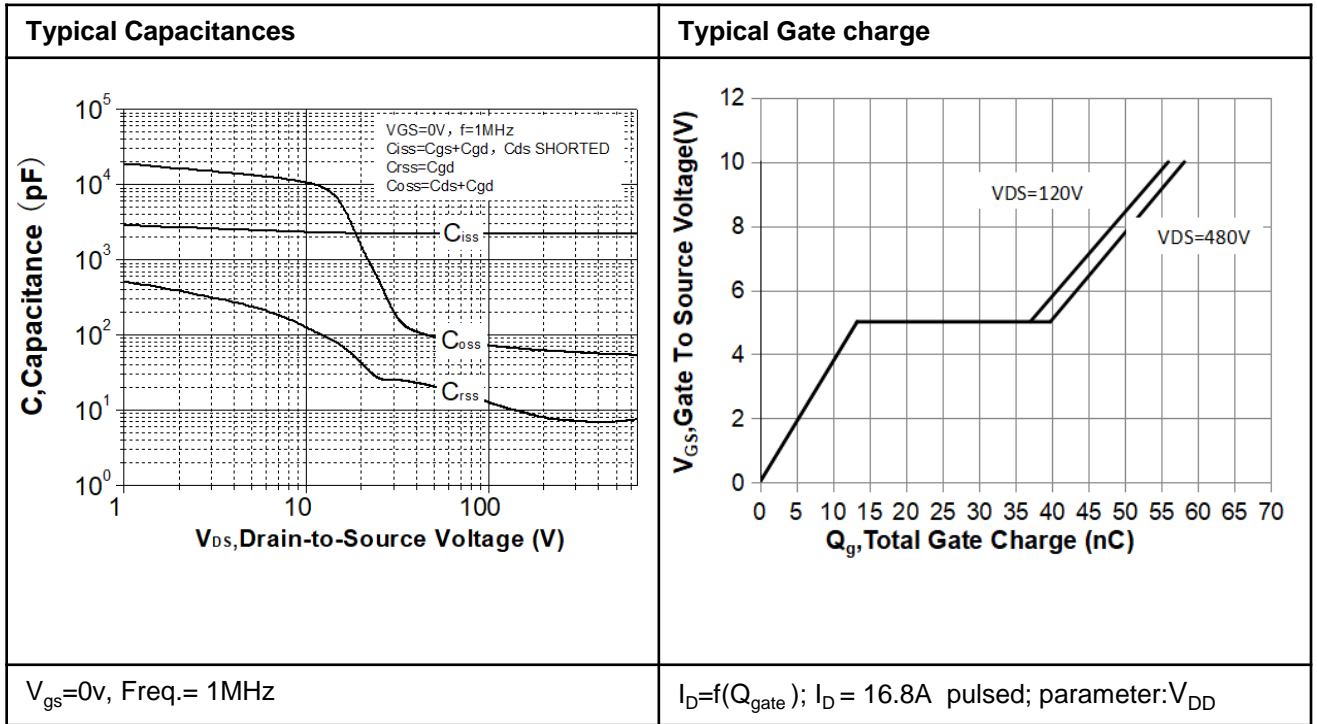
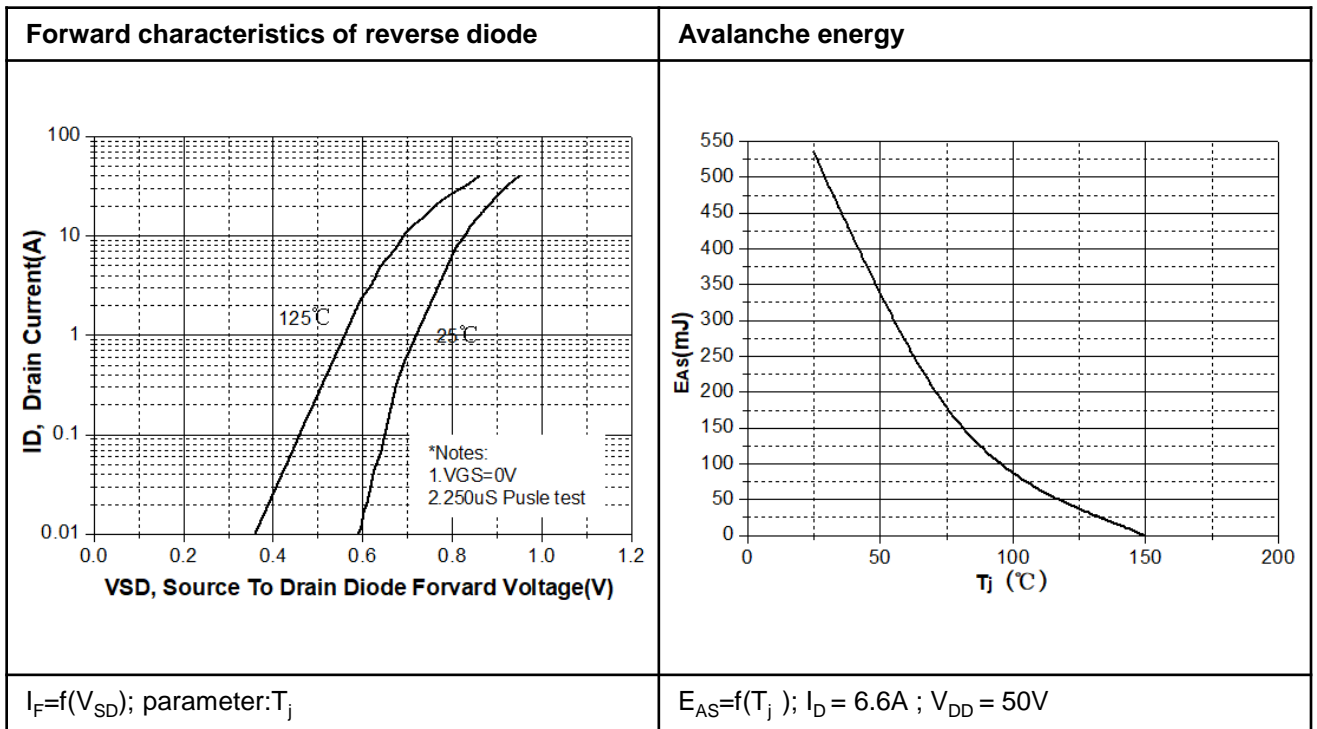
| Power dissipation (TO220F)   | Max. transient thermal impedance (TO220F)  |
|--|--|
|  |  <p>*Notes:<br/> 1. <math>T_J - T_C = P_{DM} * Z_{thJC}(t)</math><br/> 2. Duty Factor <math>D = T_1 / T_2</math></p> |
| $P_{tot} = f(T_C)$   | $Z_{thJC} = f(t_p); \text{parameter: } D = t_p / T$  |

**Table 9 Output Characteristics**

**Table 10 Drain Source Resistance**


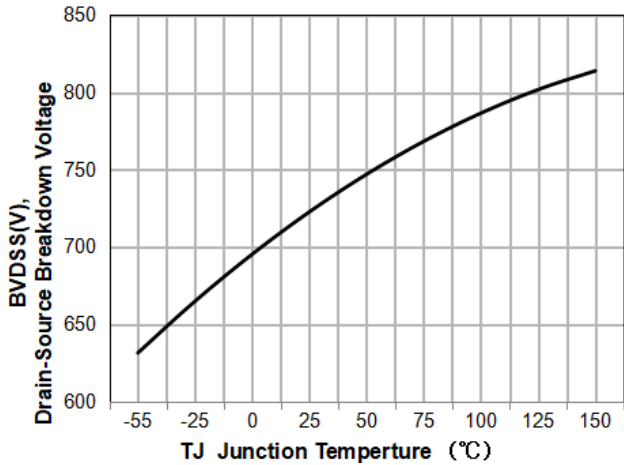
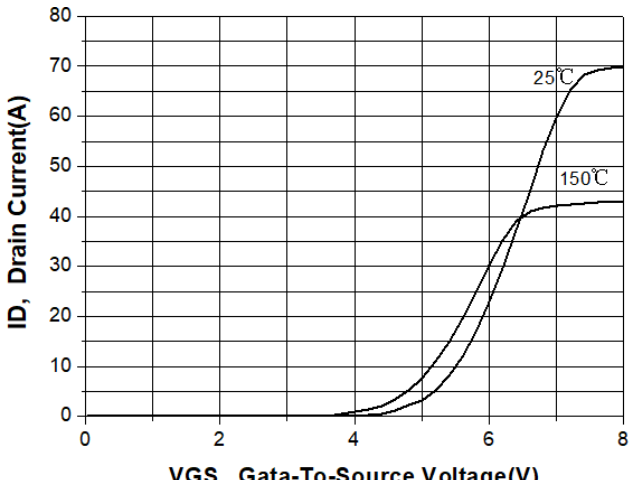
**Table 11 Safe Operating Area**

| Safe operating area $T_C = 25^\circ\text{C}$ (TO220, TO263 & TO247)                | Safe operating area $T_C = 80^\circ\text{C}$ (TO220, TO263 & TO247)                  |
|--|--|
|    |    |
| $I_D = f(V_{DS})$ ; $T_C = 25^\circ\text{C}$ ; $D=0$ ; parameter: $t_p$            | $I_D = f(V_{DS})$ ; $T_C = 80^\circ\text{C}$ ; $D=0$ ; parameter: $t_p$              |
| Safe operating area $T_C = 25^\circ\text{C}$ (TO220F)                              | Safe operating area $T_C = 80^\circ\text{C}$ (TO220F)                                |
|  |  |
| $I_D = f(V_{DS})$ ; $T_C = 25^\circ\text{C}$ ; $D=0$ ; parameter: $t_p$            | $I_D = f(V_{DS})$ ; $T_C = 80^\circ\text{C}$ ; $D=0$ ; parameter: $t_p$              |

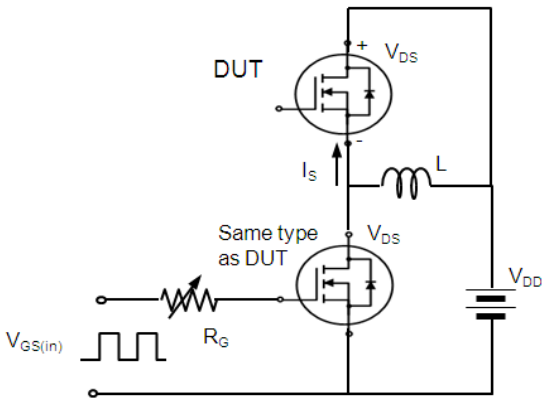
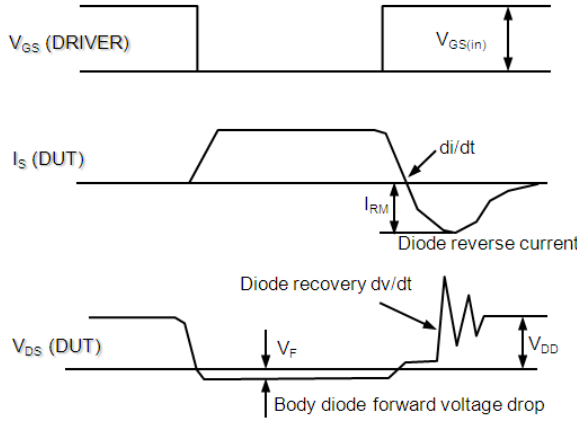


**Table 12 Capacitances and Gate Charge**

**Table 13 Diode Characteristics and Avalanche Energy**


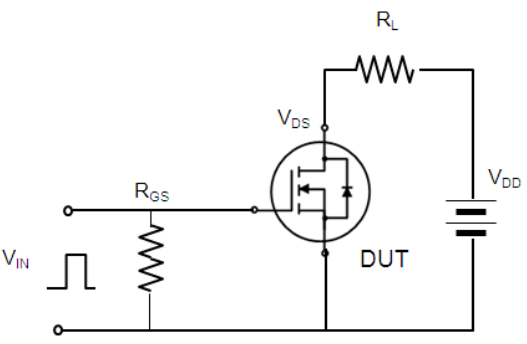
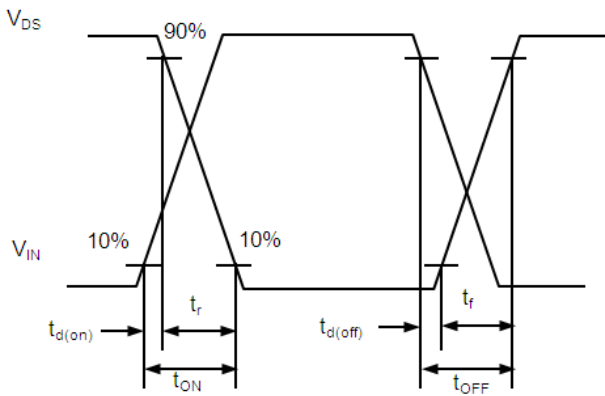
**Table 14 Breakdown Voltage and Transfer Characteristics**

| Drain-source breakdown voltage  | Transfer Characteristics   |
|---|--|
|  <p>The graph shows the Drain-Source Breakdown Voltage (BV<sub>DSS</sub>) in Volts (V) on the y-axis (ranging from 600 to 850) versus the TJ Junction Temperature in degrees Celsius (°C) on the x-axis (ranging from -55 to 150). The curve shows a non-linear increase in breakdown voltage as temperature rises, starting at approximately 630V at -55°C and reaching about 815V at 150°C.</p> |  <p>The graph shows the Drain Current (I<sub>D</sub>) in Amperes (A) on the y-axis (ranging from 0 to 80) versus the Gate-To-Source Voltage (V<sub>GS</sub>) in Volts (V) on the x-axis (ranging from 0 to 8). Two curves are shown for different temperatures: 25°C and 150°C. The 25°C curve shows a higher drain current for a given gate voltage compared to the 150°C curve, indicating a decrease in transconductance with increasing temperature.</p> |
| $V_{BR(DSS)} = f(T_j); I_D = 1\text{mA}$  | $I_D = f(V_{GS});  V_{DS}  > 2 I_D R_{DS(On)max}; \text{parameter: } T_j$  |

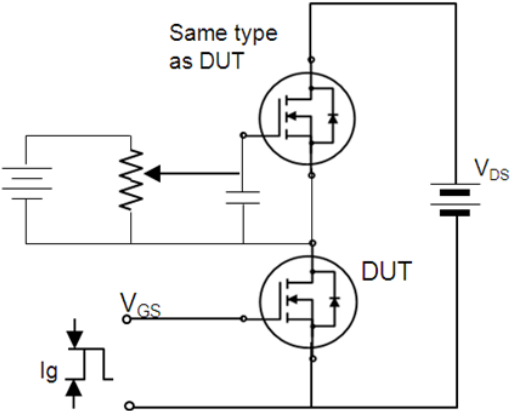
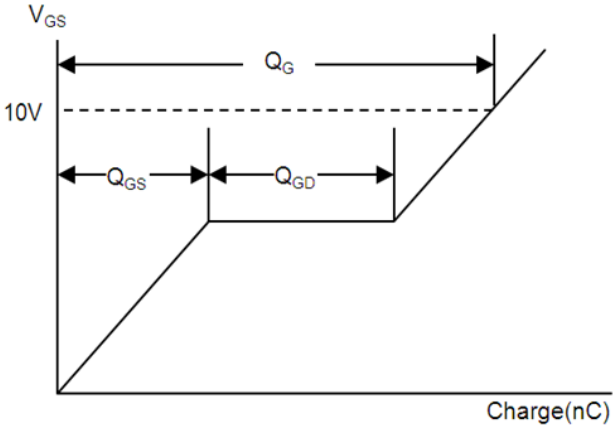
**Table 15 Diode Recovery Characteristic**

| Test Circuit For Diode Recovery  | Test Waveform For Diode Recovery   |
|--|--|
|  <p>*. <math>dv/dt</math> controlled by <math>R_G</math><br/>         *. <math>I_S</math> controlled by pulse period</p> |  |

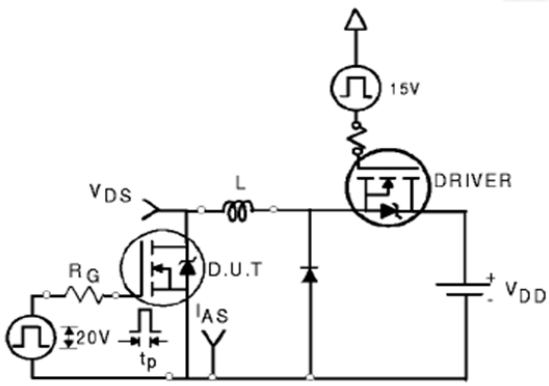
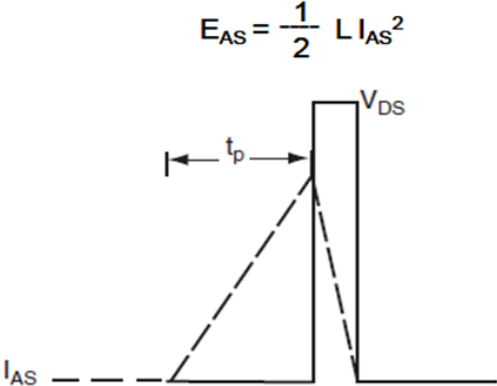
**Table 16 Switching Time Characteristic**

| Test Circuit for Switching Time   | Test Waveform for Switching Time   |
|---|--|
|  |  |

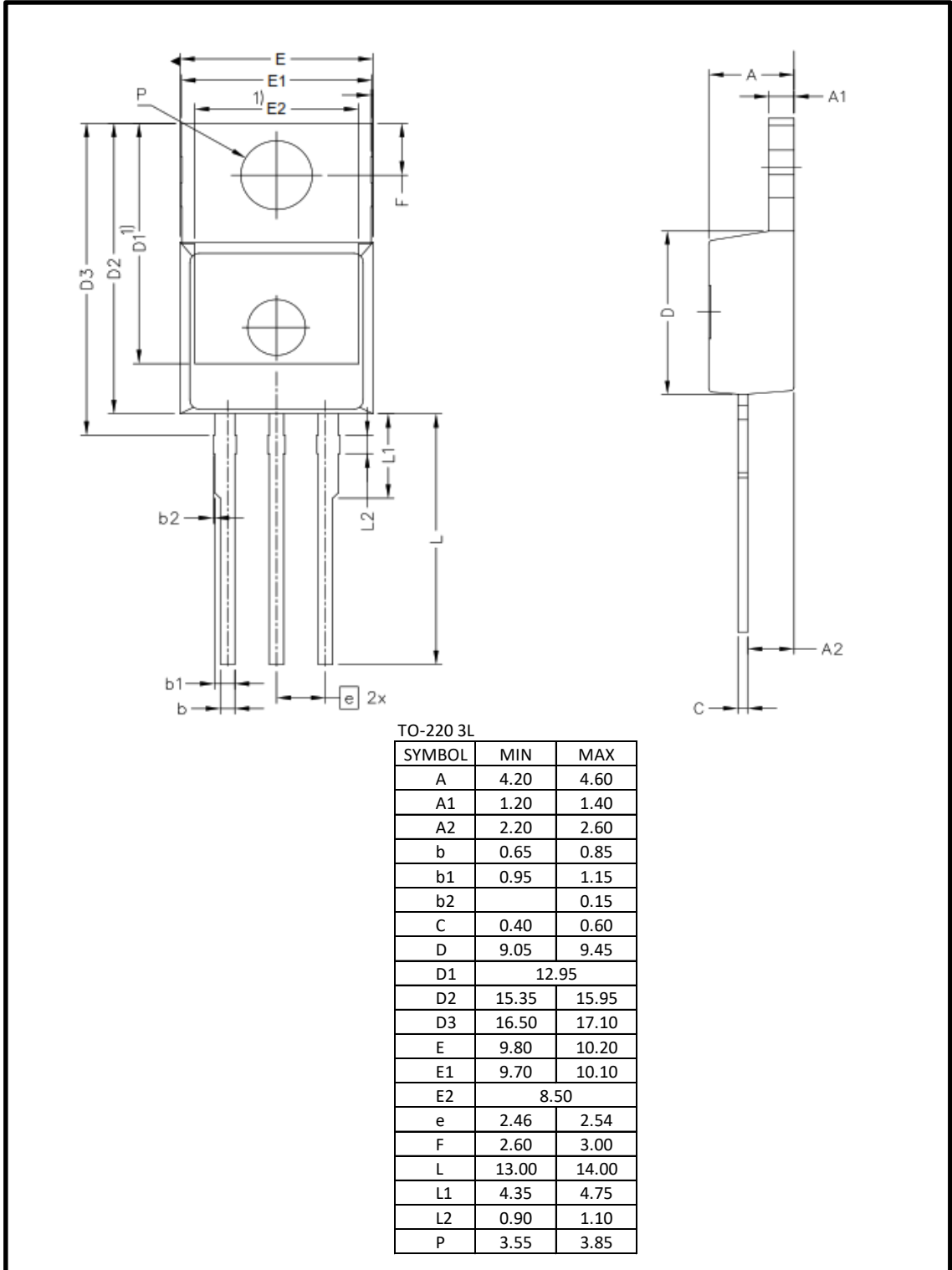
**Table 17 Gate Charge Characteristic**

| Test Circuit For Gate Charge  | Test Waveform For Gate Charge  |
|---|--|
|  |  |

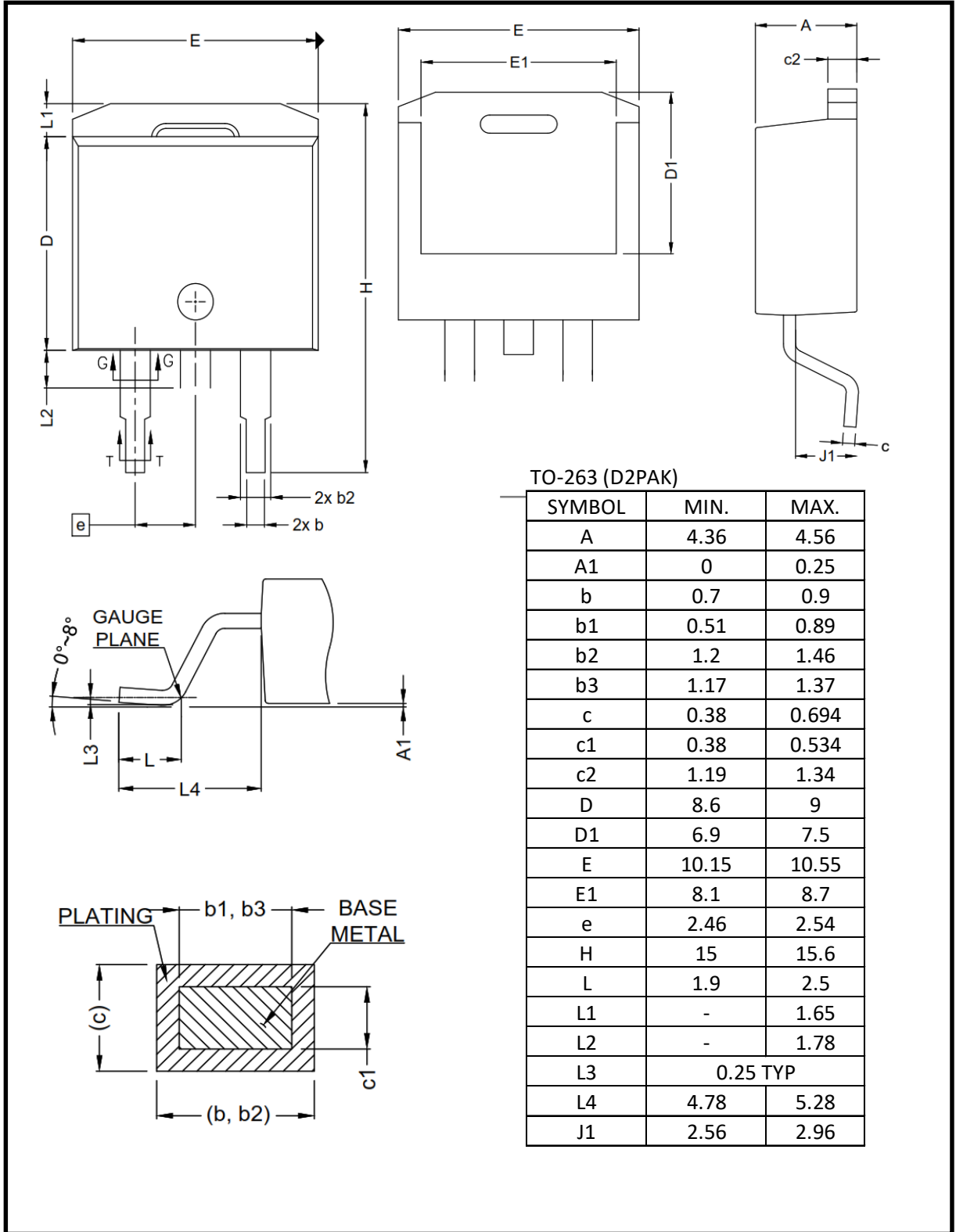
**Table 18 Unclamped Inductive Characteristic**

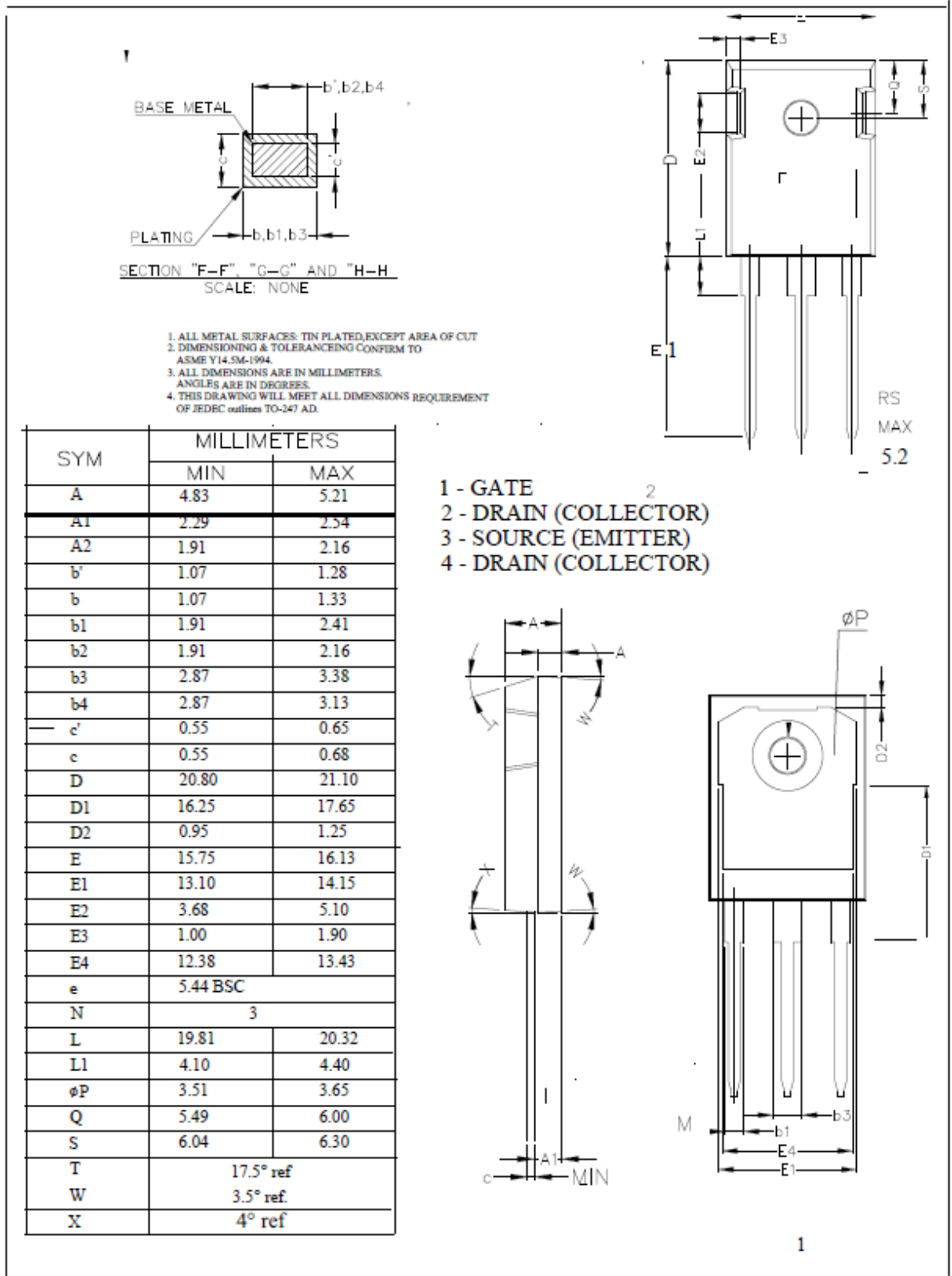
| Test Circuit For Unclamped Inductive   | Test Waveform For Unclamped Inductive  |
|--|--|
|  |  $E_{AS} = \frac{1}{2} L I_{AS}^2$ |

**4a) TO-220**

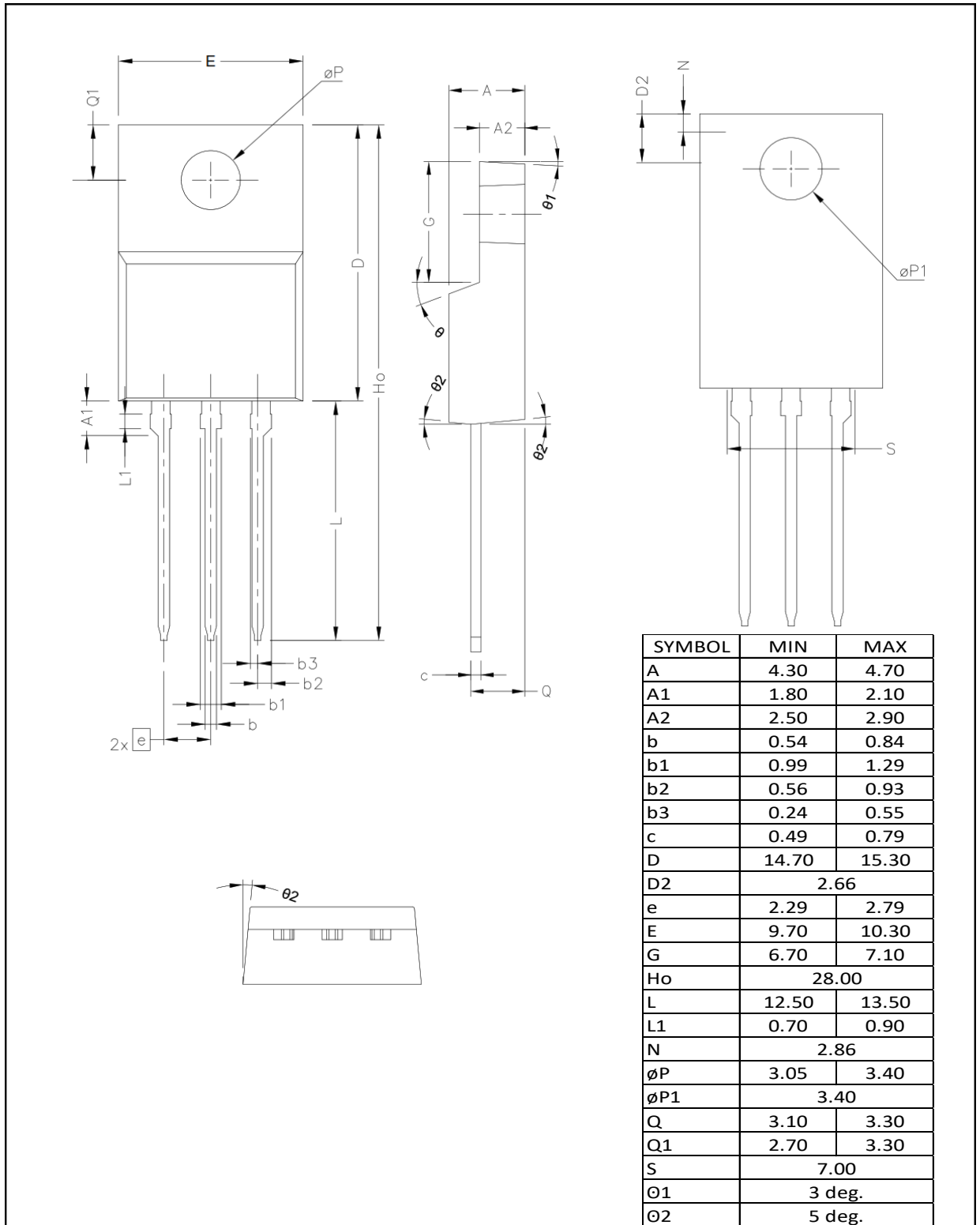


4b) TO-263



**4c) TO-247**


**4d) TO-220 FullPak**





## Revision History

| Revision | Release Date | Comments                         |
|----------|--------------|----------------------------------|
| 1.0      | 1-Nov-2016   | Preliminary Datasheet Draft      |
| 2.0      | 1-July-2017  | Update tables and package detail |
| 2.5      | 20-Nov-2017  | Added TO247 Package              |
| 2.6      | 11-Dec-2017  | Added Test Circuits              |
| 3.0      | 2-Jan 2019   | Updated/update tables and charts |


## Resources

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