

## QIAOXIN N-Channel Super Junction Power MOSFET III

### General Description

The series of devices use advanced trench gate super junction technology and design to provide excellent  $R_{DS(ON)}$  with low gate charge. This super junction MOSFET fits the industry's AC-DC SMPS requirements for PFC, AC/DC power conversion, and industrial power applications.

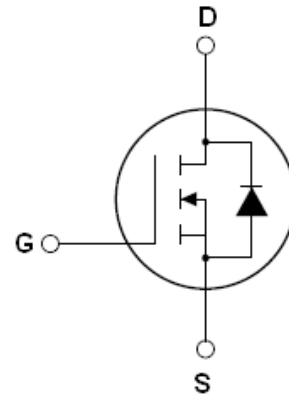
### Features

- New technology for high voltage device
- Low on-resistance and low conduction losses
- Small package
- Ultra Low Gate Charge cause lower driving requirements
- 100% Avalanche Tested
- ROHS compliant

### Application

- Power factor correction (PFC)
- Switched mode power supplies(SMPS)
- Uninterruptible Power Supply (UPS)

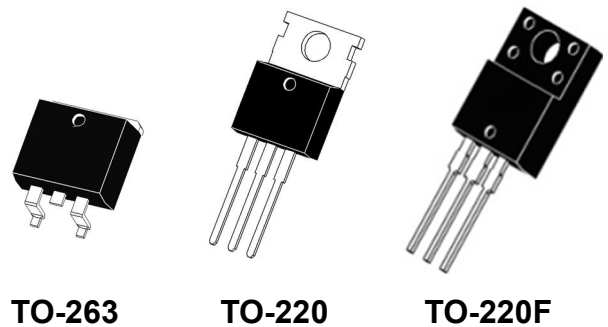
|                 |     |            |
|-----------------|-----|------------|
| $V_{DS}$        | 650 | V          |
| $R_{DS(ON)TYP}$ | 460 | m $\Omega$ |
| $I_D$           | 8   | A          |



**Schematic diagram**

### Package Marking And Ordering Information

| Device      | Device Package | Marking     |
|-------------|----------------|-------------|
| VCRR65T540D | TO-263         | VCRR65T540D |
| VCRR65T540  | TO-220         | VCRR65T540  |
| VCRR65T540F | TO-220F        | VCRR65T540F |



**TO-263**

**TO-220**

**TO-220F**

**Table 1. Absolute Maximum Ratings ( $T_c=25^\circ\text{C}$ )**

| Parameter                                                                              | Symbol          | VCRR65T540D<br>VCRR65T540 | VCRR65T540F  | Unit                     |
|----------------------------------------------------------------------------------------|-----------------|---------------------------|--------------|--------------------------|
| Drain-Source Voltage ( $V_{GS}=0V$ )                                                   | $V_{DS}$        | 650                       |              | V                        |
| Gate-Source Voltage ( $V_{DS}=0V$ ) AC ( $f>1\text{ Hz}$ )                             | $V_{GS}$        | $\pm 30$                  |              | V                        |
| Continuous Drain Current at $T_c=25^\circ\text{C}$                                     | $I_D(DC)$       | 8                         | 8*           | A                        |
| Continuous Drain Current at $T_c=100^\circ\text{C}$                                    | $I_D(DC)$       | 5.2                       | 5.2*         | A                        |
| Pulsed drain current <sup>(Note 1)</sup>                                               | $I_{DM(pluse)}$ | 32                        | 32*          | A                        |
| Maximum Power Dissipation( $T_c=25^\circ\text{C}$ )<br>Derate above $25^\circ\text{C}$ | $P_D$           | 69<br>0.55                | 31.6<br>0.25 | W<br>W/ $^\circ\text{C}$ |
| Single pulse avalanche energy <sup>(Note 2)</sup>                                      | $E_{AS}$        | 156                       |              | mJ                       |
| Avalanche current <sup>(Note 1)</sup>                                                  | $I_{AR}$        | 1.7                       |              | A                        |
| Repetitive Avalanche energy , $t_{AR}$ limited by $T_{jmax}$ <sup>(Note 1)</sup>       | $E_{AR}$        | 0.3                       |              | mJ                       |

| Parameter                                             | Symbol         | VCRR65T540D<br>VCRR65T540 | VCRR65T540F | Unit |
|-------------------------------------------------------|----------------|---------------------------|-------------|------|
| Drain Source voltage slope, $V_{DS} \leq 480V$ ,      | dv/dt          | 50                        |             | V/ns |
| Reverse diode dv/dt, $V_{DS} \leq 480V, I_{SD} < I_D$ | dv/dt          | 15                        |             | V/ns |
| Operating Junction and Storage Temperature Range      | $T_J, T_{STG}$ | -55...+150                |             | °C   |

\* limited by maximum junction temperature

**Table 2. Thermal Characteristic**

| Parameter                                         | Symbol     | VCRR65T540D<br>VCRR65T540 | VCRR65T540F | Unit |
|---------------------------------------------------|------------|---------------------------|-------------|------|
| Thermal Resistance, Junction-to-Case (Maximum)    | $R_{thJC}$ | 1.81                      | 3.95        | °C/W |
| Thermal Resistance, Junction-to-Ambient (Maximum) | $R_{thJA}$ | 62                        | 80          | °C/W |

**Table 3. Electrical Characteristics (TA=25°C unless otherwise noted)**

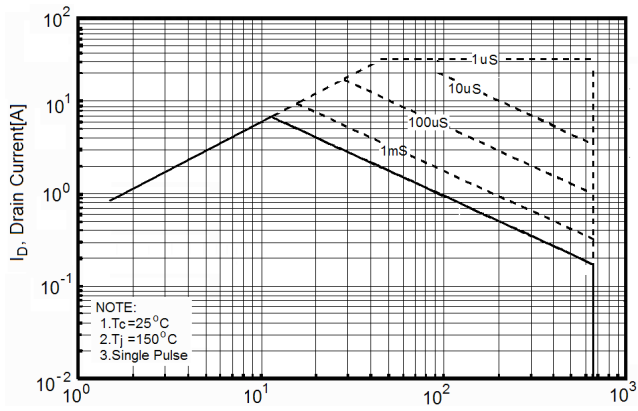
| Parameter                                             | Symbol       | Condition                                             | Min | Typ  | Max       | Unit       |
|-------------------------------------------------------|--------------|-------------------------------------------------------|-----|------|-----------|------------|
| On/off states                                         |              |                                                       |     |      |           |            |
| Drain-Source Breakdown Voltage                        | $BV_{DSS}$   | $V_{GS}=0V, I_D=250\mu A$                             | 650 |      |           | V          |
| Zero Gate Voltage Drain Current( $T_c=25^{\circ}C$ )  | $I_{DSS}$    | $V_{DS}=650V, V_{GS}=0V$                              |     |      | 1         | $\mu A$    |
| Zero Gate Voltage Drain Current( $T_c=125^{\circ}C$ ) | $I_{DSS}$    | $V_{DS}=650V, V_{GS}=0V$                              |     |      | 100       | $\mu A$    |
| Gate-Body Leakage Current                             | $I_{GSS}$    | $V_{GS}=\pm 20V, V_{DS}=0V$                           |     |      | $\pm 100$ | nA         |
| Gate Threshold Voltage                                | $V_{GS(th)}$ | $V_{DS}=V_{GS}, I_D=250\mu A$                         | 3   |      | 4         | V          |
| Drain-Source On-State Resistance                      | $R_{DS(ON)}$ | $V_{GS}=10V, I_D=4A$                                  |     | 460  | 540       | m $\Omega$ |
| Dynamic Characteristics                               |              |                                                       |     |      |           |            |
| Input Capacitance                                     | $C_{iss}$    | $V_{DS}=50V, V_{GS}=0V,$<br>$F=1.0MHz$                |     | 590  |           | pF         |
| Output Capacitance                                    | $C_{oss}$    |                                                       |     | 37   |           | pF         |
| Reverse Transfer Capacitance                          | $C_{rss}$    |                                                       |     | 0.9  |           | pF         |
| Total Gate Charge                                     | $Q_g$        | $V_{DS}=480V, I_D=8A,$<br>$V_{GS}=10V$                |     | 14.6 | 22        | nC         |
| Gate-Source Charge                                    | $Q_{gs}$     |                                                       |     | 4    |           | nC         |
| Gate-Drain Charge                                     | $Q_{gd}$     |                                                       |     | 6.7  |           | nC         |
| Switching times                                       |              |                                                       |     |      |           |            |
| Turn-on Delay Time                                    | $t_{d(on)}$  | $V_{DD}=380V, I_D=4A,$<br>$R_G=4.7\Omega, V_{GS}=10V$ |     | 8    |           | nS         |
| Turn-on Rise Time                                     | $t_r$        |                                                       |     | 6    |           | nS         |
| Turn-Off Delay Time                                   | $t_{d(off)}$ |                                                       |     | 59   | 75        | nS         |
| Turn-Off Fall Time                                    | $t_f$        |                                                       |     | 10   | 15        | nS         |
| Source- Drain Diode Characteristics                   |              |                                                       |     |      |           |            |
| Source-drain current(Body Diode)                      | $I_{SD}$     | $T_C=25^{\circ}C$                                     |     |      | 8         | A          |
| Pulsed Source-drain current(Body Diode)               | $I_{SDM}$    |                                                       |     |      | 32        | A          |
| Forward On Voltage                                    | $V_{SD}$     | $T_j=25^{\circ}C, I_{SD}=8A, V_{GS}=0V$               |     | 0.9  | 1.2       | V          |
| Reverse Recovery Time                                 | $t_{rr}$     | $T_j=25^{\circ}C, I_F=4A, di/dt=100A/\mu s$           |     | 230  |           | nS         |
| Reverse Recovery Charge                               | $Q_{rr}$     |                                                       |     | 1.2  |           | $\mu C$    |
| Peak Reverse Recovery Current                         | $I_{rrm}$    |                                                       |     | 10.5 |           | A          |

Notes 1.Repetitive Rating: Pulse width limited by maximum junction temperature

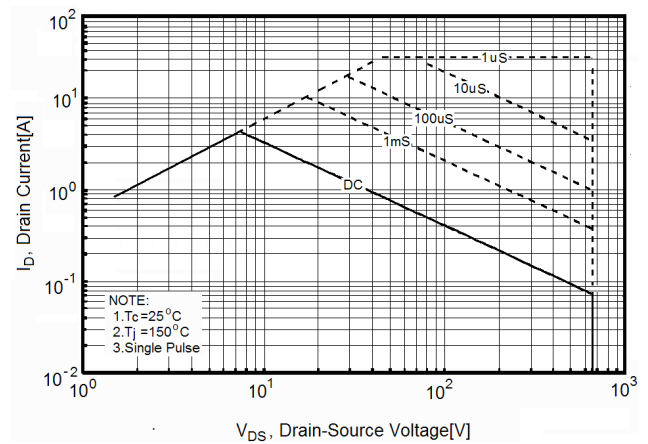
2.  $T_j=25^\circ C, V_{DD}=50V, V_G=10V, R_G=25\Omega$

## TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS (curves)

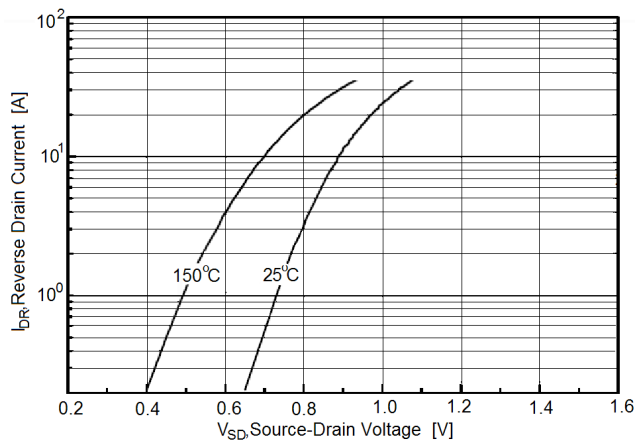
**Figure1. Safe operating area**



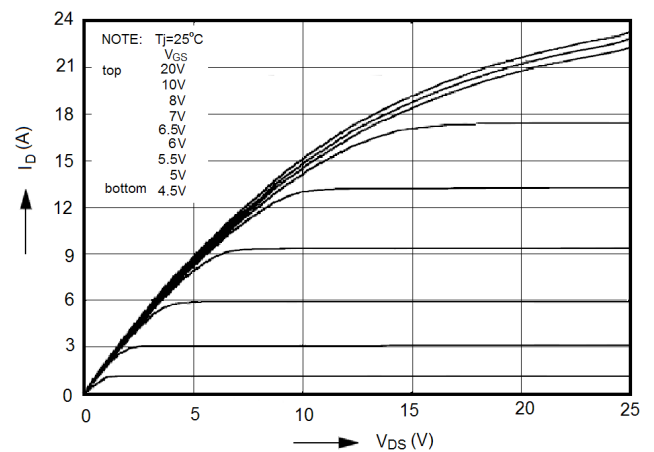
**Figure2. Safe operating area for TO-220F**



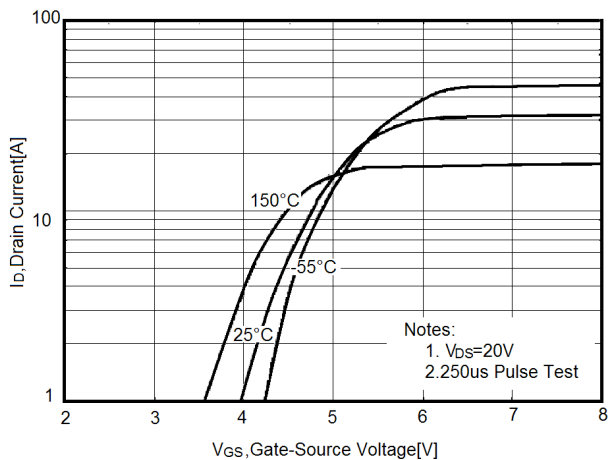
**Figure3. Source-Drain Diode Forward Voltage**



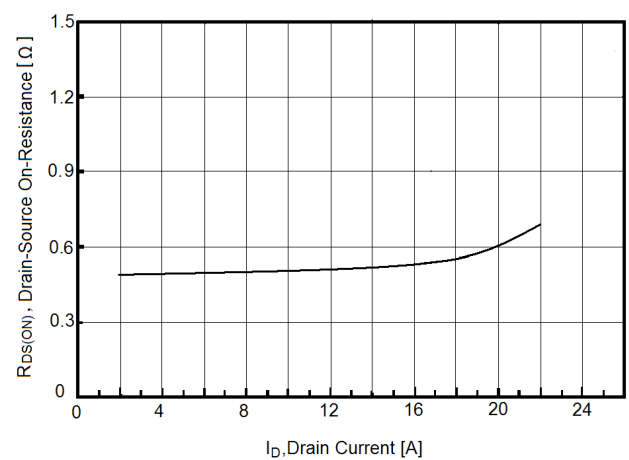
**Figure4. Output characteristics**



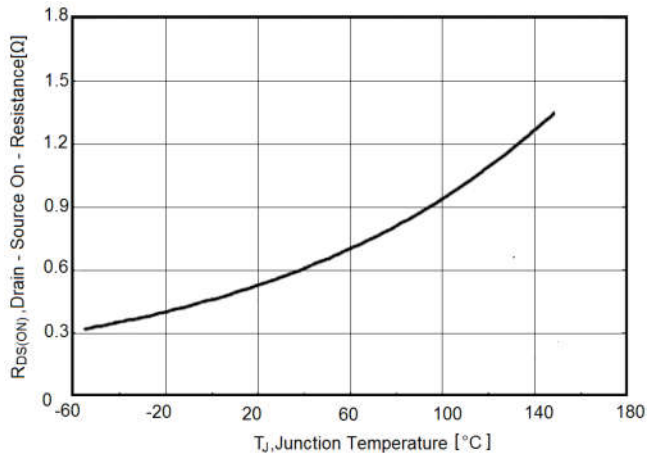
**Figure5. Transfer characteristics**



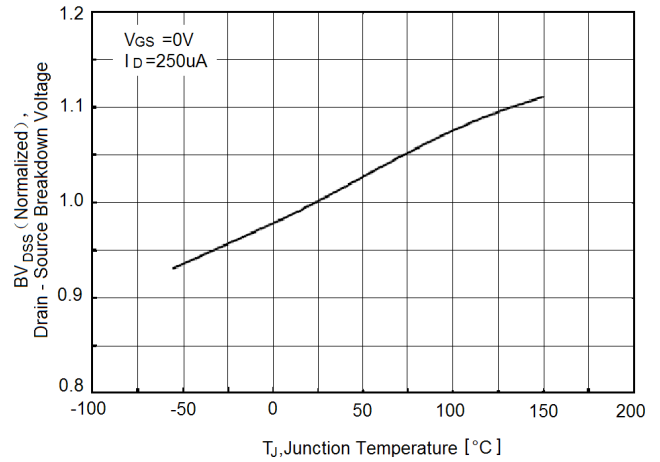
**Figure6. Static drain-source on resistance**



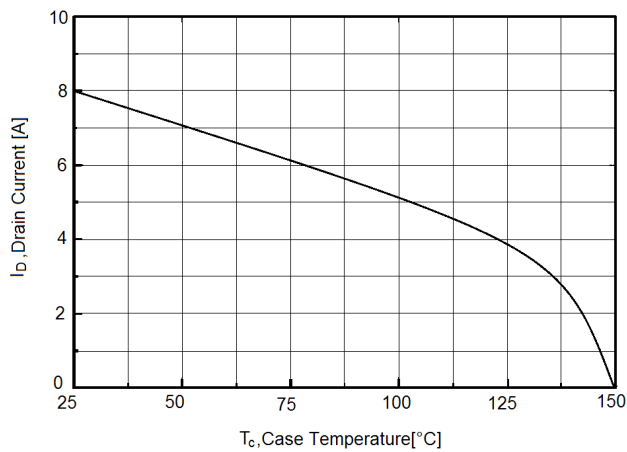
**Figure7.  $R_{DS(on)}$  vs Junction Temperature**



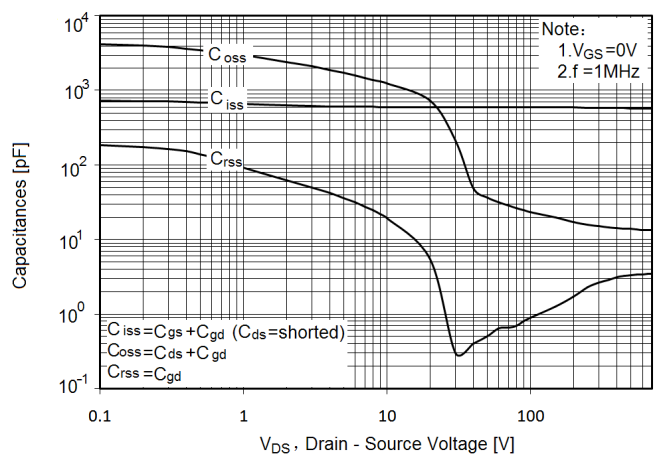
**Figure8.  $BV_{DSS}$  vs Junction Temperature**



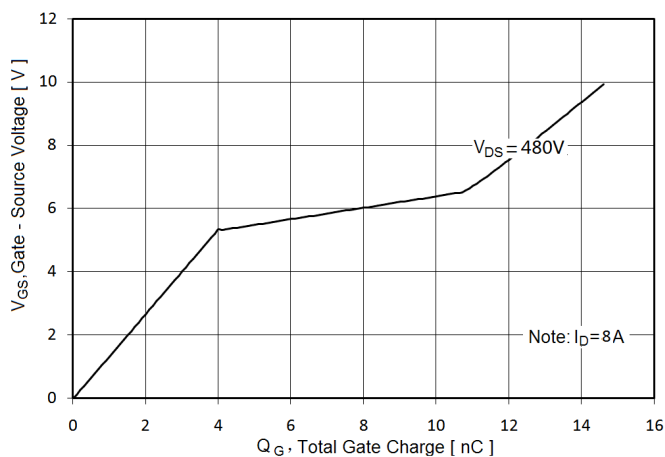
**Figure9. Maximum  $I_D$  vs Junction Temperature**



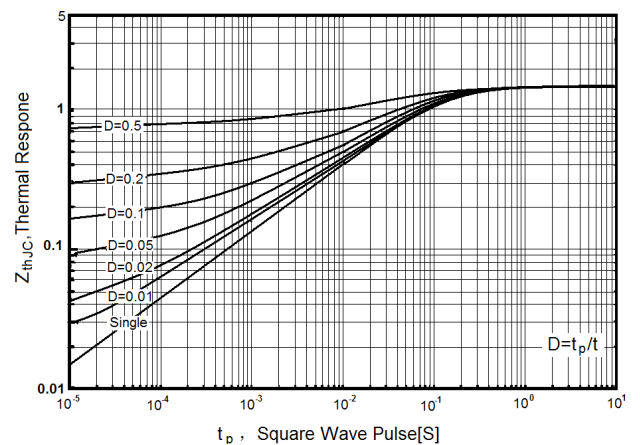
**Figure10. Capacitance**



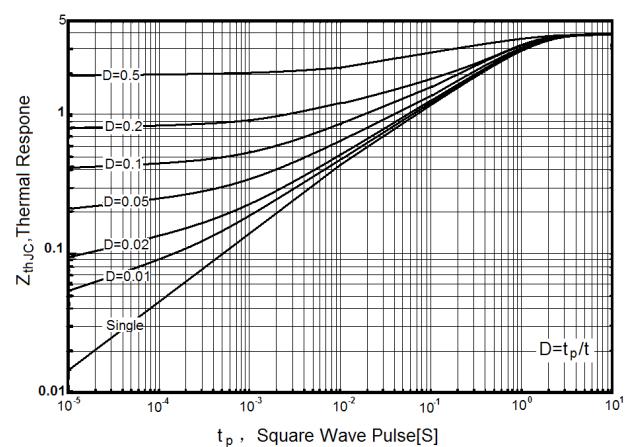
**Figure11. Gate charge waveforms**



**Figure12. Transient Thermal Impedance**

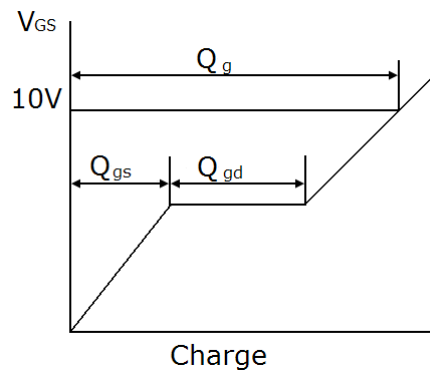
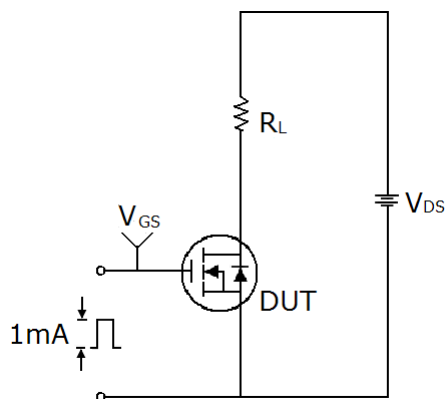


**Figure13. Transient Thermal Impedance for TO-220F**

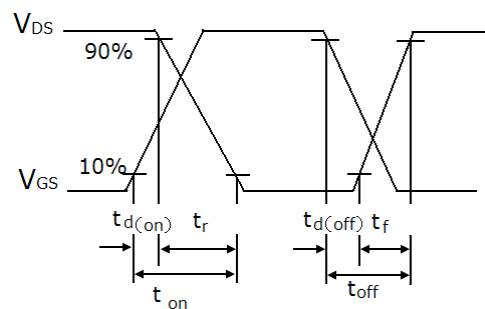
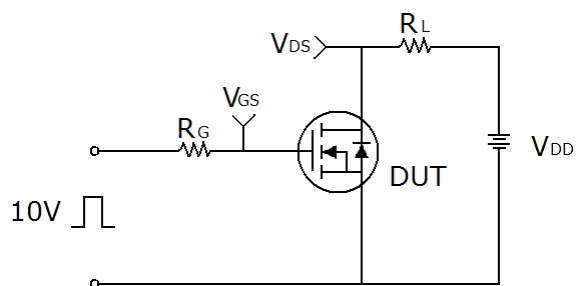


## Test circuit

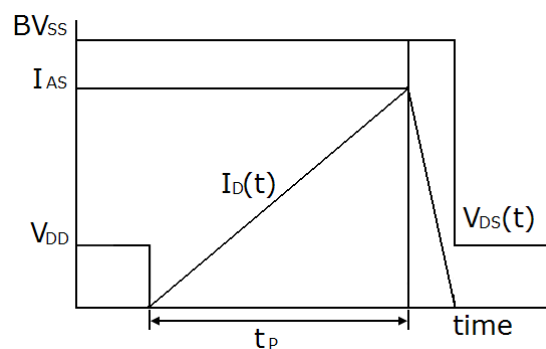
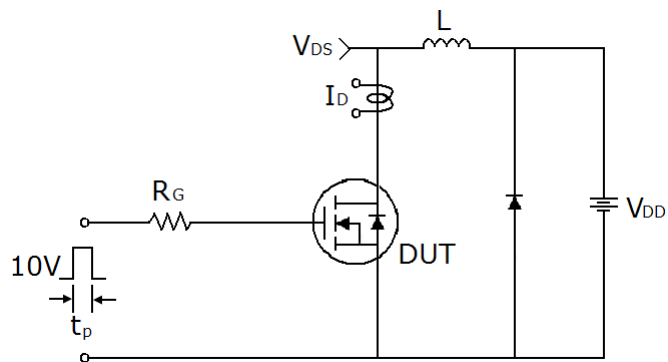
### 1) Gate charge test circuit & Waveform



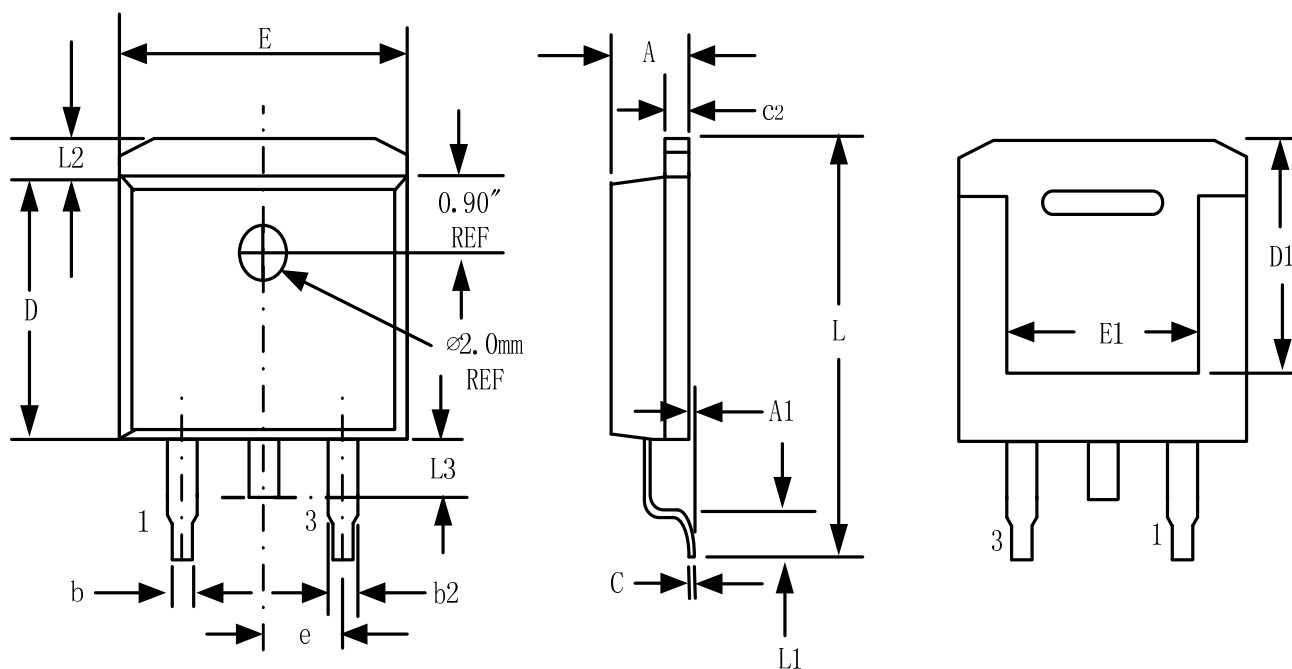
### 2) Switch Time Test Circuit:



### 3) Unclamped Inductive Switching Test Circuit & Waveforms

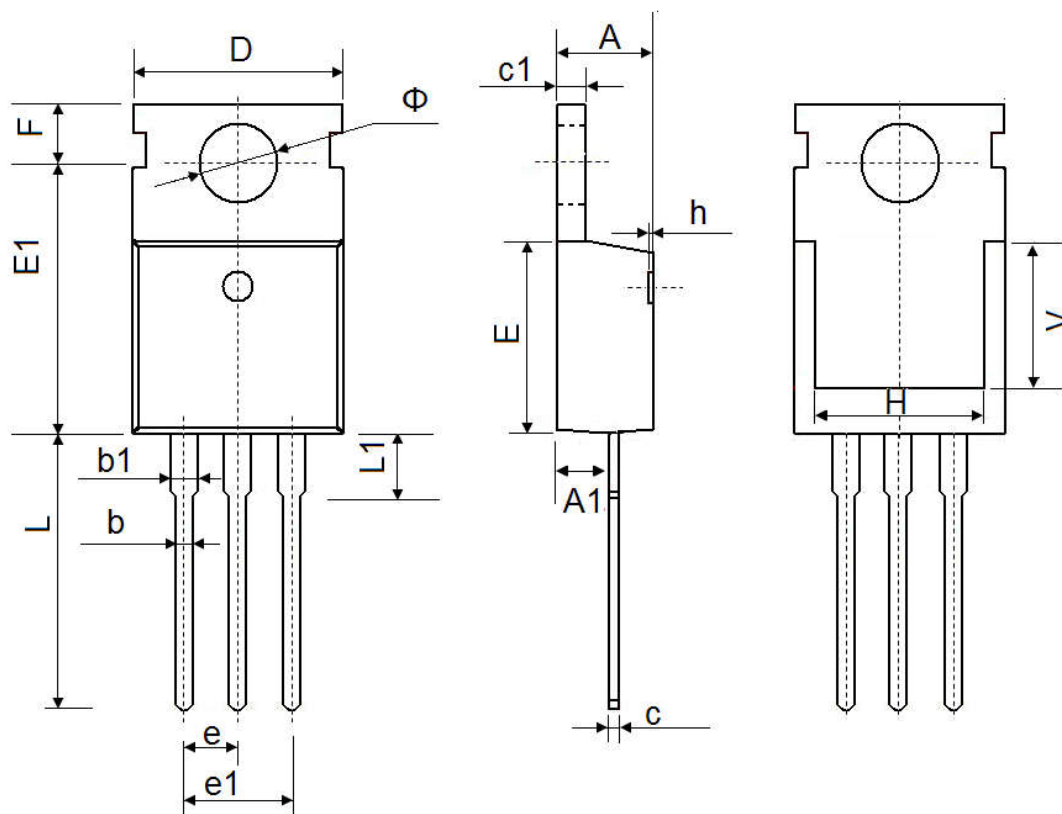


## TO-263-3L Package Information



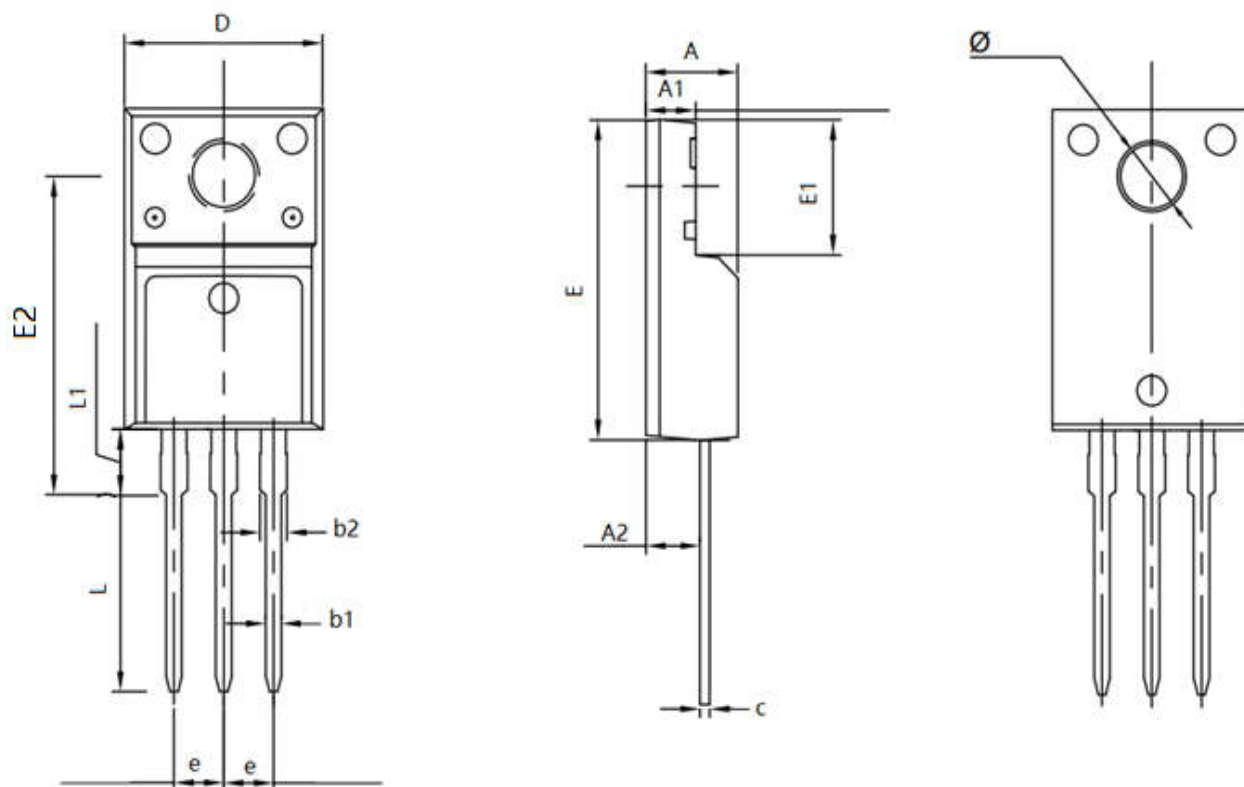
| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |       |
|--------|---------------------------|-------|----------------------|-------|
|        | Min.                      | Max.  | Min.                 | Max.  |
| A      | 4.32                      | 4.57  | 0.170                | 0.180 |
| A1     | -                         | 0.25  |                      | 0.010 |
| b      | 0.71                      | 0.94  | 0.028                | 0.037 |
| b2     | 1.15                      | 1.40  | 0.045                | 0.055 |
| c      | 0.46                      | 0.61  | 0.018                | 0.024 |
| c2     | 1.22                      | 1.40  | 0.048                | 0.055 |
| D      | 8.89                      | 9.40  | 0.350                | 0.370 |
| D1     | 8.01                      | 8.23  | 0.315                | 0.324 |
| E      | 10.04                     | 10.28 | 0.395                | 0.405 |
| E1     | 7.88                      | 8.08  | 0.310                | 0.318 |
| e      | 2.54 BSC                  |       | 0.100 BSC            |       |
| L      | 14.73                     | 15.75 | 0.580                | 0.620 |
| L1     | 2.29                      | 2.79  | 0.090                | 0.110 |
| L2     | 1.15                      | 1.39  | 0.045                | 0.055 |
| L3     | 1.27                      | 1.77  | 0.050                | 0.070 |

## TO-220-3L-C Package Information



| Symbol | Dimensions In Millimeters |        | Dimensions In Inches |       |
|--------|---------------------------|--------|----------------------|-------|
|        | Min.                      | Max.   | Min.                 | Max.  |
| A      | 4.400                     | 4.600  | 0.173                | 0.181 |
| A1     | 2.250                     | 2.550  | 0.089                | 0.100 |
| b      | 0.710                     | 0.910  | 0.028                | 0.036 |
| b1     | 1.170                     | 1.370  | 0.046                | 0.054 |
| c      | 0.330                     | 0.650  | 0.013                | 0.026 |
| c1     | 1.200                     | 1.400  | 0.047                | 0.055 |
| D      | 9.910                     | 10.250 | 0.390                | 0.404 |
| E      | 8.9500                    | 9.750  | 0.352                | 0.384 |
| E1     | 12.650                    | 12.950 | 0.498                | 0.510 |
| e      | 2.540 TYP.                |        | 0.100 TYP.           |       |
| e1     | 4.980                     | 5.180  | 0.196                | 0.204 |
| F      | 2.650                     | 2.950  | 0.104                | 0.116 |
| H      | 7.900                     | 8.100  | 0.311                | 0.319 |
| h      | 0.000                     | 0.300  | 0.000                | 0.012 |
| L      | 12.900                    | 13.400 | 0.508                | 0.528 |
| L1     | 2.850                     | 3.250  | 0.112                | 0.128 |
| V      | 7.500 REF.                |        | 0.295 REF.           |       |
| Φ      | 3.400                     | 3.800  | 0.134                | 0.150 |

## TO-220F Package Information



| Symbol | Dimensions In Millimeters |        | Dimensions In Inches |       |
|--------|---------------------------|--------|----------------------|-------|
|        | Min.                      | Max.   | Min.                 | Max.  |
| A      | 4.500                     | 4.900  | 0.177                | 0.193 |
| A1     | 2.340                     | 2.740  | 0.092                | 0.108 |
| A2     | 2.560                     | 2.960  | 0.101                | 0.117 |
| b1     | 0.700                     | 0.900  | 0.028                | 0.035 |
| b2     | 1.180                     | 1.580  | 0.046                | 0.062 |
| c      | 0.400                     | 0.600  | 0.016                | 0.024 |
| D      | 9.960                     | 10.360 | 0.392                | 0.408 |
| E      | 15.670                    | 15.970 | 0.617                | 0.629 |
| E1     | 6.500                     | 6.900  | 0.256                | 0.272 |
| E2     | 15.500                    | 16.100 | 0.610                | 0.634 |
| e      | 2.540 TYP                 |        | 0.100 TYP            |       |
| Φ      | 3.080                     | 3.280  | 0.121                | 0.129 |
| L      | 12.640                    | 13.240 | 0.498                | 0.521 |
| L1     | 3.030                     | 3.430  | 0.119                | 0.135 |

### ATTENTION

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