

## N-Channel Super Junction Power MOSFET II

### General Description

The series of devices use advanced 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.

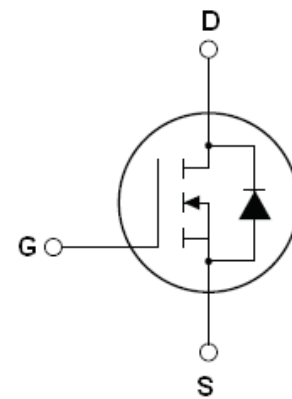
|                   |      |    |
|-------------------|------|----|
| $V_{DS@T_{jmax}}$ | 650  | V  |
| $R_{DS(ON) MAX}$  | 1200 | mΩ |
| $I_D$             | 4    | A  |

### 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

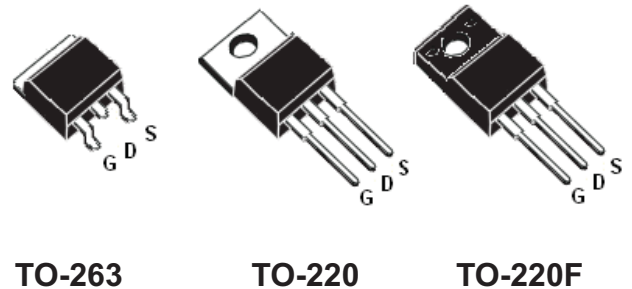
- Power factor correction (PFC)
- Switched mode power supplies(SMPS)
- Uninterruptible Power Supply (UPS)



Schematic diagram

### Package Marking And Ordering Information

| Device    | Device Package | Marking |
|-----------|----------------|---------|
| RM4N650T2 | TO-220         | 4N650   |
| RM4N650HD | TO-263         | 4N650   |
| RM4N650TI | TO-220F        | 4N650   |



TO-263

TO-220

TO-220F

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

| Parameter                                                            | Symbol           | RM4N650T2<br>RM4N650HD | RM4N650TI | Unit                |
|----------------------------------------------------------------------|------------------|------------------------|-----------|---------------------|
| Drain-Source Voltage ( $V_{GS}=0V$ )                                 | $V_{DS}$         | 650                    |           | V                   |
| Gate-Source Voltage ( $V_{DS}=0V$ )                                  | $V_{GS}$         | $\pm 30$               |           | V                   |
| Continuous Drain Current at $T_c=25^\circ\text{C}$                   | $I_{D(DC)}$      | 4                      | 4*        | A                   |
| Continuous Drain Current at $T_c=100^\circ\text{C}$                  | $I_{D(DC)}$      | 2.5                    | 2.5       | A                   |
| Pulsed drain current (Note 1)                                        | $I_{DM (pulse)}$ | 12                     | 12        | A                   |
| Maximum Power Dissipation ( $T_c=25^\circ\text{C}$ )                 | $P_D$            | 46                     | 28.5      | W                   |
| Derate above $25^\circ\text{C}$                                      |                  | 0.37                   | 0.23      | W/ $^\circ\text{C}$ |
| Single pulse avalanche energy (Note2)                                | $E_{AS}$         | 130                    |           | mJ                  |
| Avalanche current (Note 1)                                           | $I_{AR}$         | 2                      |           | A                   |
| Repetitive Avalanche energy, $t_{AR}$ limited by $T_{jmax}$ (Note 1) | $E_{AR}$         | 0.2                    |           | mJ                  |

| Parameter                                                | Symbol         | RM4N650T2<br>RM4N650HD | RM4N650TI | 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     | Value |     | Unit  |
|---------------------------------------------------|------------|-------|-----|-------|
| Thermal Resistance, Junction-to-Case (Maximum)    | $R_{thJC}$ | 2.7   | 4.4 | °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 <sub>DSS</sub>   | V <sub>GS</sub> =0V I <sub>D</sub> =250μA                                               | 650 |      |      | V    |
| Zero Gate Voltage Drain Current(Tc=25℃)  | I <sub>DSS</sub>    | V <sub>DS</sub> =600V,V <sub>GS</sub> =0V                                               |     |      | 1    | μA   |
| Zero Gate Voltage Drain Current(Tc=125℃) | I <sub>DSS</sub>    | V <sub>DS</sub> =600V,V <sub>GS</sub> =0V                                               |     |      | 50   | μA   |
| Gate-Body Leakage Current                | I <sub>GSS</sub>    | V <sub>GS</sub> =±30V,V <sub>DS</sub> =0V                                               |     |      | ±100 | nA   |
| Gate Threshold Voltage                   | V <sub>GS(th)</sub> | V <sub>DS</sub> =V <sub>GS</sub> ,I <sub>D</sub> =250μA                                 | 2.5 | 3    | 3.5  | V    |
| Drain-Source On-State Resistance         | R <sub>DS(ON)</sub> | V <sub>GS</sub> =10V, I <sub>D</sub> =2.5A                                              |     | 1000 | 1200 | mΩ   |
| Dynamic Characteristics                  |                     |                                                                                         |     |      |      |      |
| Forward Transconductance                 | g <sub>FS</sub>     | V <sub>DS</sub> = 20V, I <sub>D</sub> = 2.5A                                            |     | 4    |      | S    |
| Input Capacitance                        | C <sub>iss</sub>    | V <sub>DS</sub> =50V,V <sub>GS</sub> =0V,<br>F=1.0MHz                                   |     | 280  |      | PF   |
| Output Capacitance                       | C <sub>oss</sub>    |                                                                                         |     | 26   |      | PF   |
| Reverse Transfer Capacitance             | C <sub>rss</sub>    |                                                                                         |     | 2.3  |      | PF   |
| Total Gate Charge                        | Q <sub>g</sub>      | V <sub>DS</sub> =480V,I <sub>D</sub> =4A,<br>V <sub>GS</sub> =10V                       |     | 6.5  | 10   | nC   |
| Gate-Source Charge                       | Q <sub>gs</sub>     |                                                                                         |     | 1.3  |      | nC   |
| Gate-Drain Charge                        | Q <sub>gd</sub>     |                                                                                         |     | 2.5  |      | nC   |
| Intrinsic gate resistance                | R <sub>G</sub>      | f = 1 MHz open drain                                                                    |     | 2.5  |      | Ω    |
| Switching times                          |                     |                                                                                         |     |      |      |      |
| Turn-on Delay Time                       | t <sub>d(on)</sub>  | V <sub>DD</sub> =380V,I <sub>D</sub> =2.5A,<br>R <sub>G</sub> =20Ω,V <sub>GS</sub> =10V |     | 6    |      | nS   |
| Turn-on Rise Time                        | t <sub>r</sub>      |                                                                                         |     | 3    |      | nS   |
| Turn-Off Delay Time                      | t <sub>d(off)</sub> |                                                                                         |     | 48   | 60   | nS   |
| Turn-Off Fall Time                       | t <sub>f</sub>      |                                                                                         |     | 8    | 15   | nS   |
| Source- Drain Diode Characteristics      |                     |                                                                                         |     |      |      |      |
| Source-drain current(Body Diode)         | I <sub>SD</sub>     | T <sub>C</sub> =25℃                                                                     |     |      | 4    | A    |
| Pulsed Source-drain current(Body Diode)  | I <sub>SDM</sub>    |                                                                                         |     |      | 12   | A    |
| Forward On Voltage                       | V <sub>SD</sub>     | T <sub>j</sub> =25℃,I <sub>SD</sub> =4A,V <sub>GS</sub> =0V                             |     | 1    | 1.3  | V    |
| Reverse Recovery Time                    | t <sub>rr</sub>     | T <sub>j</sub> =25℃,I <sub>F</sub> =4A,di/dt=100A/μs                                    |     | 150  |      | nS   |
| Reverse Recovery Charge                  | Q <sub>rr</sub>     |                                                                                         |     | 0.85 |      | uC   |
| Peak reverse recovery current            | I <sub>rrm</sub>    |                                                                                         |     | 11   |      | A    |

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

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

## RATING AND CHARACTERISTICS CURVES (RM4N650T2/HD/TI)

Figure1. Safe operating area for TO-220,TO-263

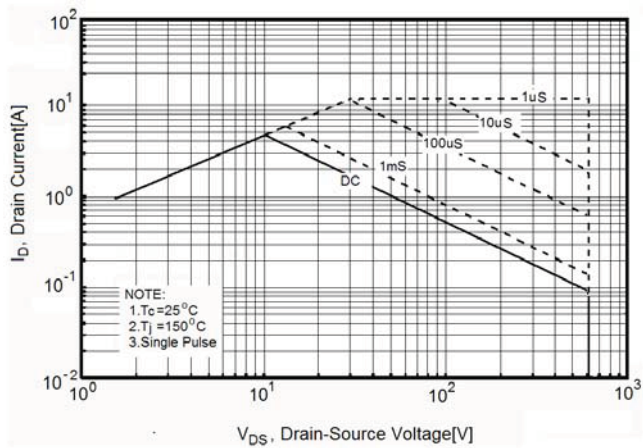


Figure2. Source-Drain Diode Forward Voltage

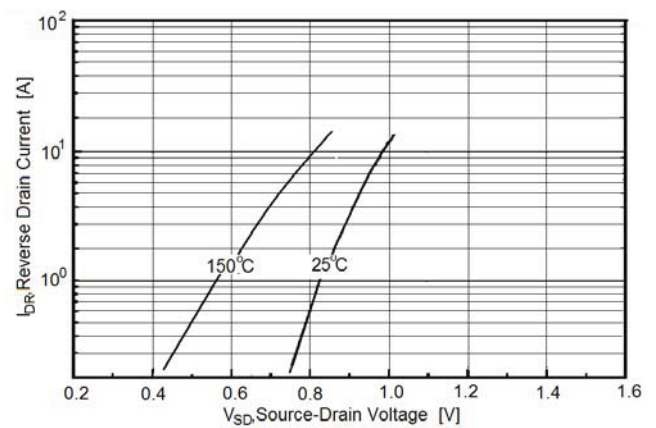


Figure3. Output characteristics

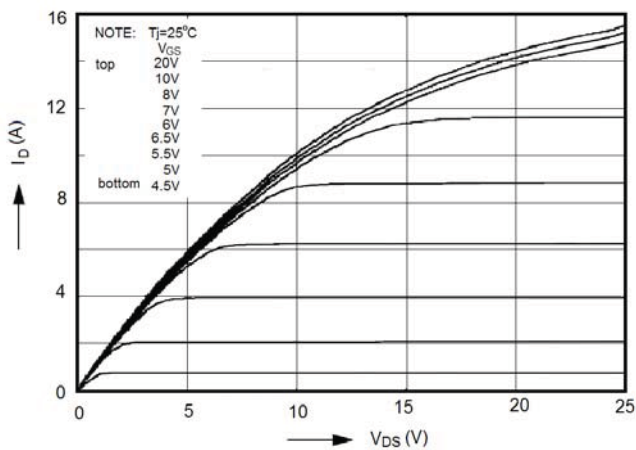


Figure4. Transfer characteristics

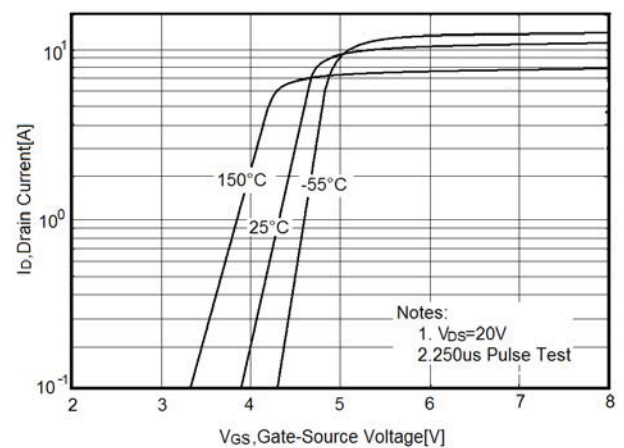


Figure5. Static drain-source on resistance

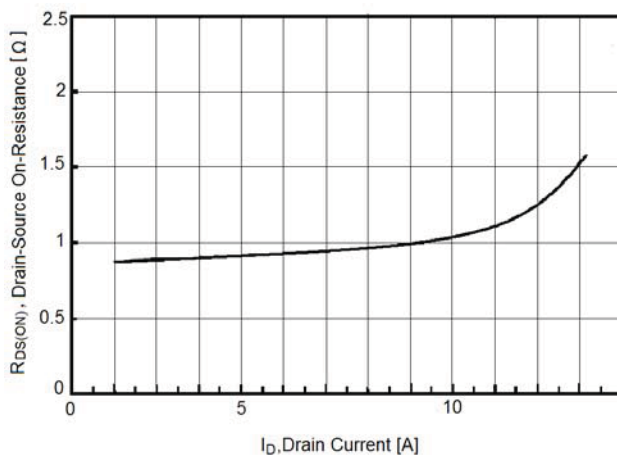
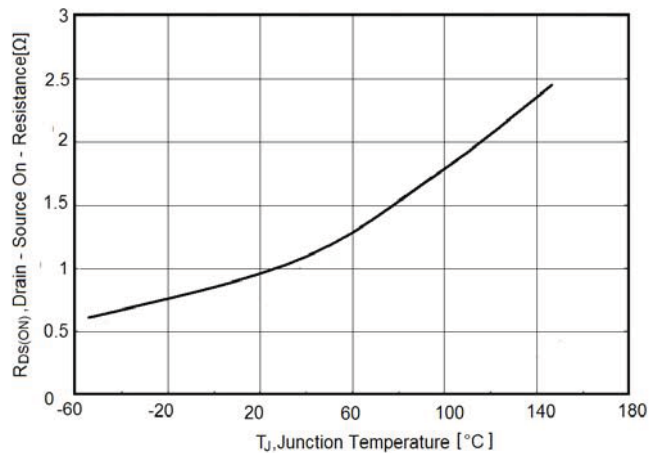


Figure6.  $R_{DS(ON)}$  vs Junction Temperature



## RATING AND CHARACTERISTICS CURVES (RM4N650T2/HD/TI)

Figure7.  $BV_{DSS}$  vs Junction Temperature

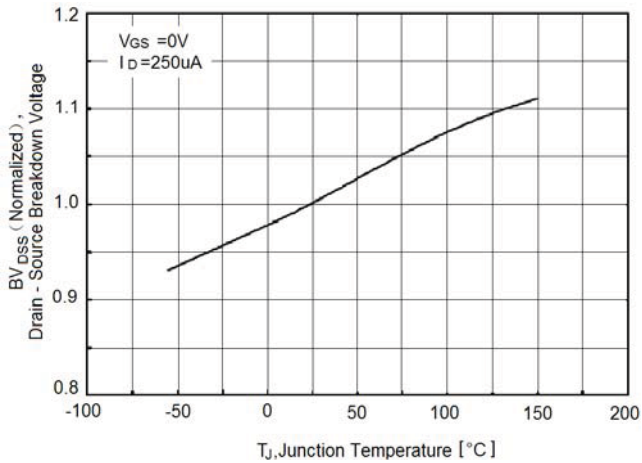


Figure8. Maximum  $I_D$  vs Junction Temperature

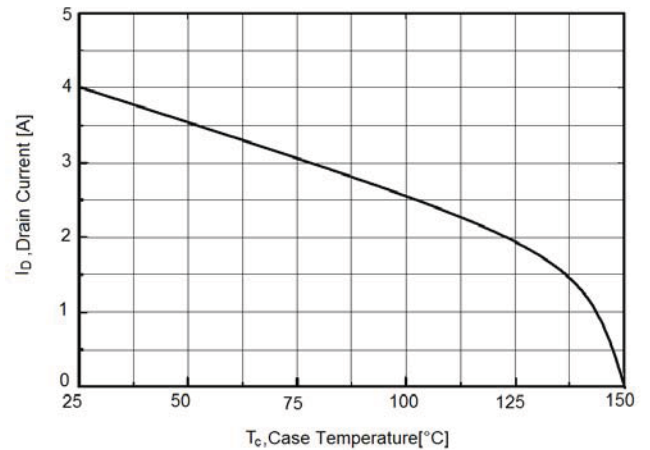


Figure9. Gate charge waveforms

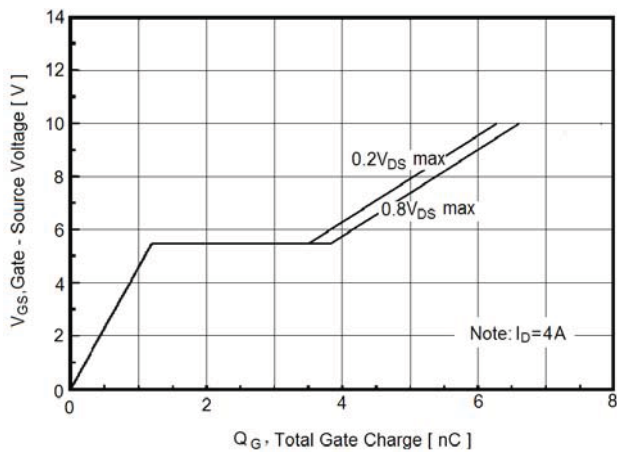


Figure10. Capacitance

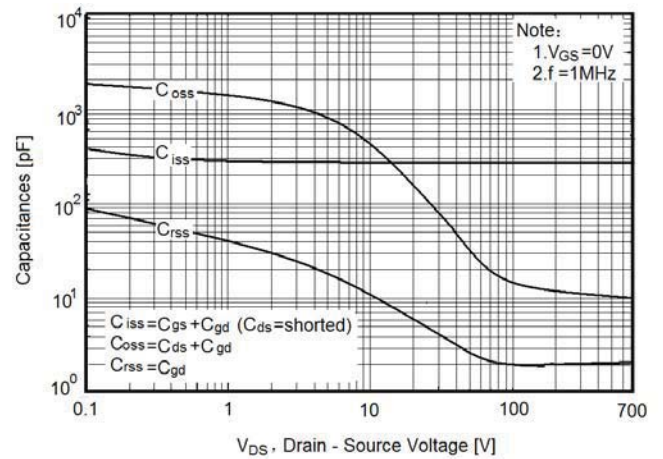


Figure11. Transient Thermal Impedance for TO-220, TO-263

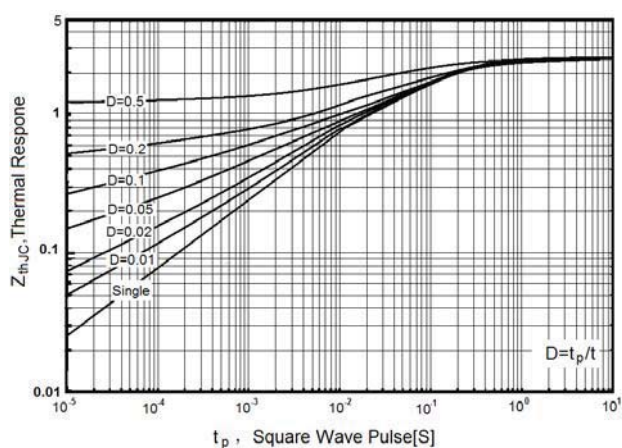
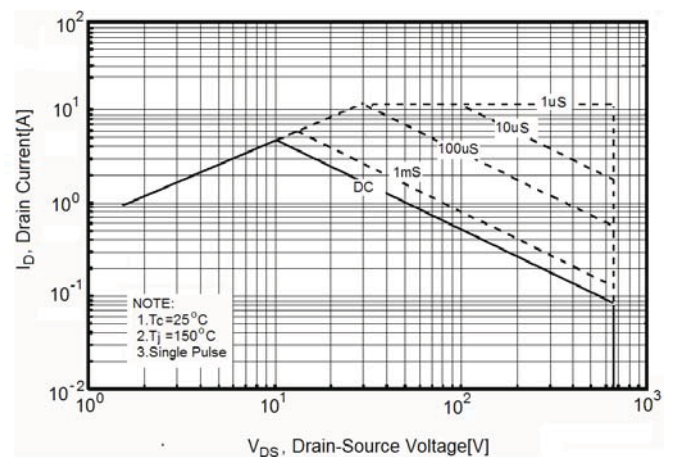
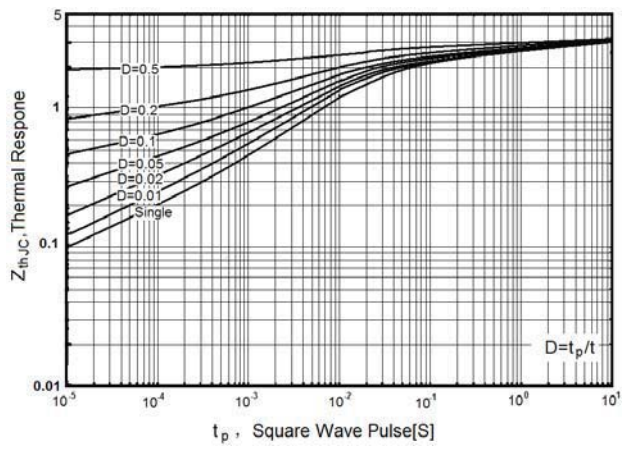


Figure12. Safe operating area for TO-220F



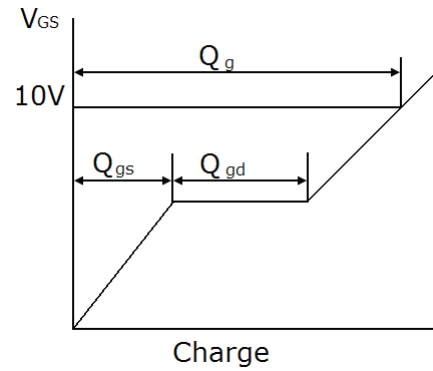
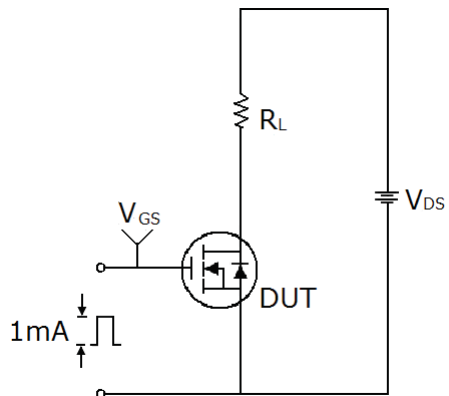
## RATING AND CHARACTERISTICS CURVES (RM4N650T2/HD/TI)

Figure13. Transient Thermal Impedance for TO-220F

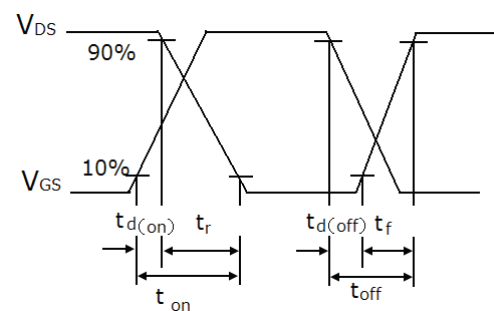
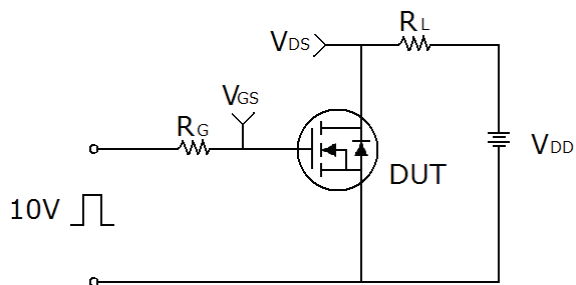


# Test circuit

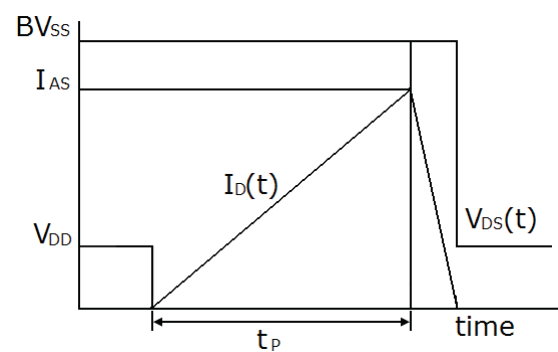
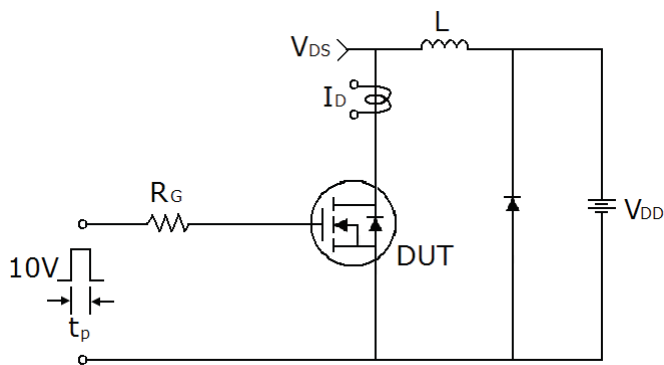
## 1) Gate charge test circuit & Waveform



## 2) Switch Time Test Circuit:



## 3) Unclamped Inductive Switching Test Circuit & Waveforms





# RECTRON

## Marking on the body



← Rectron Logo

**4 N 6 5 0** ← Part No.

**1 7** **X X**

Year – Code

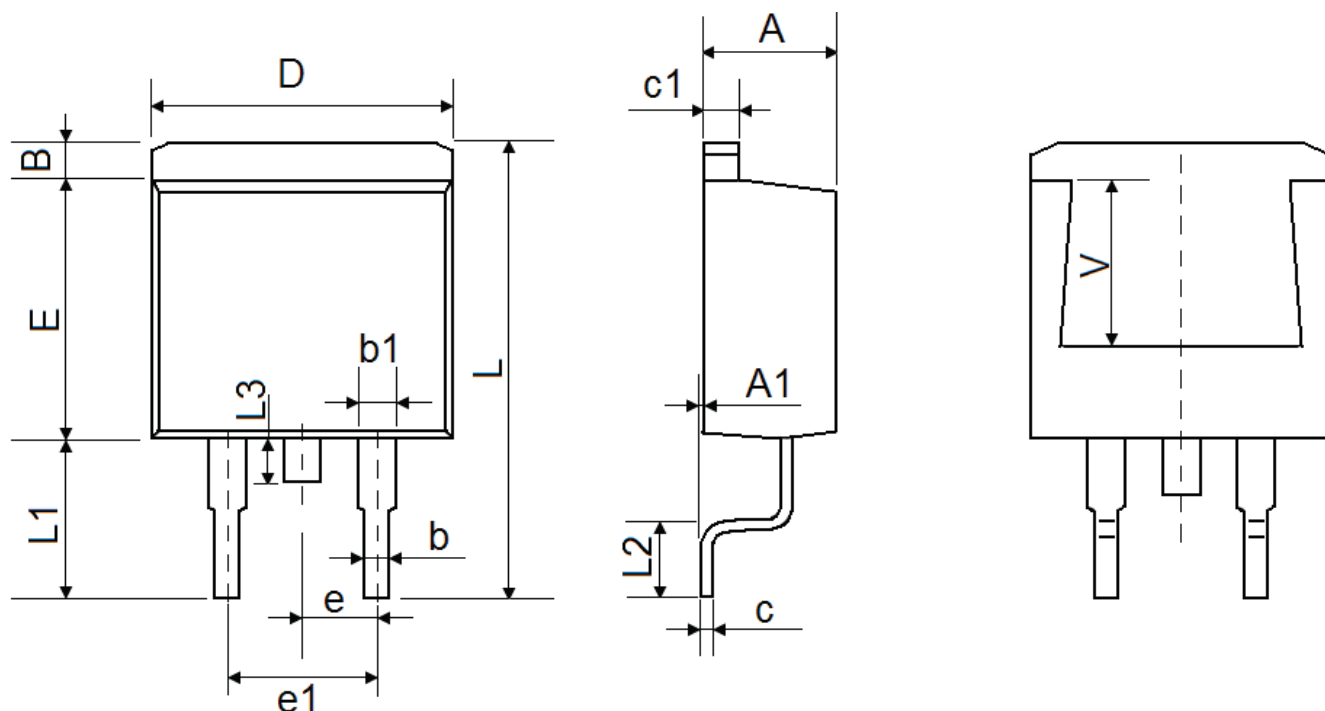
(Y:17-----2017

18-----2018.....)

Week – code

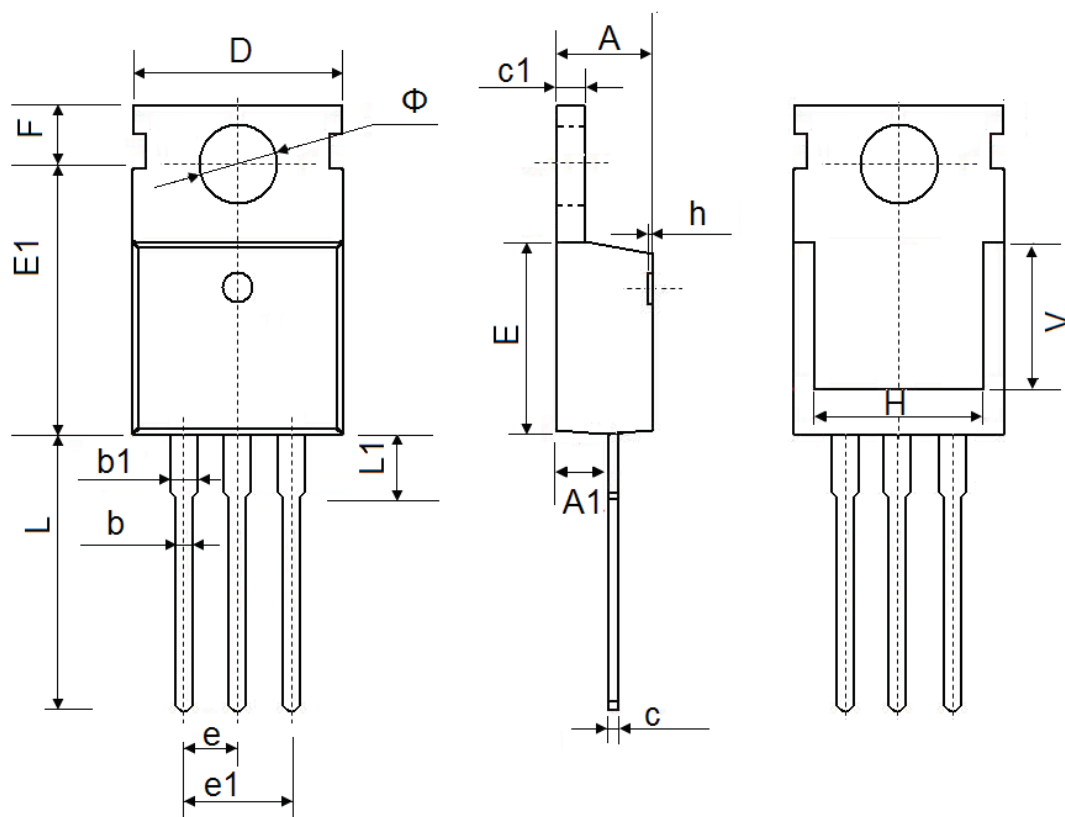
(WW:01~52)

# TO-263-2L Package Information



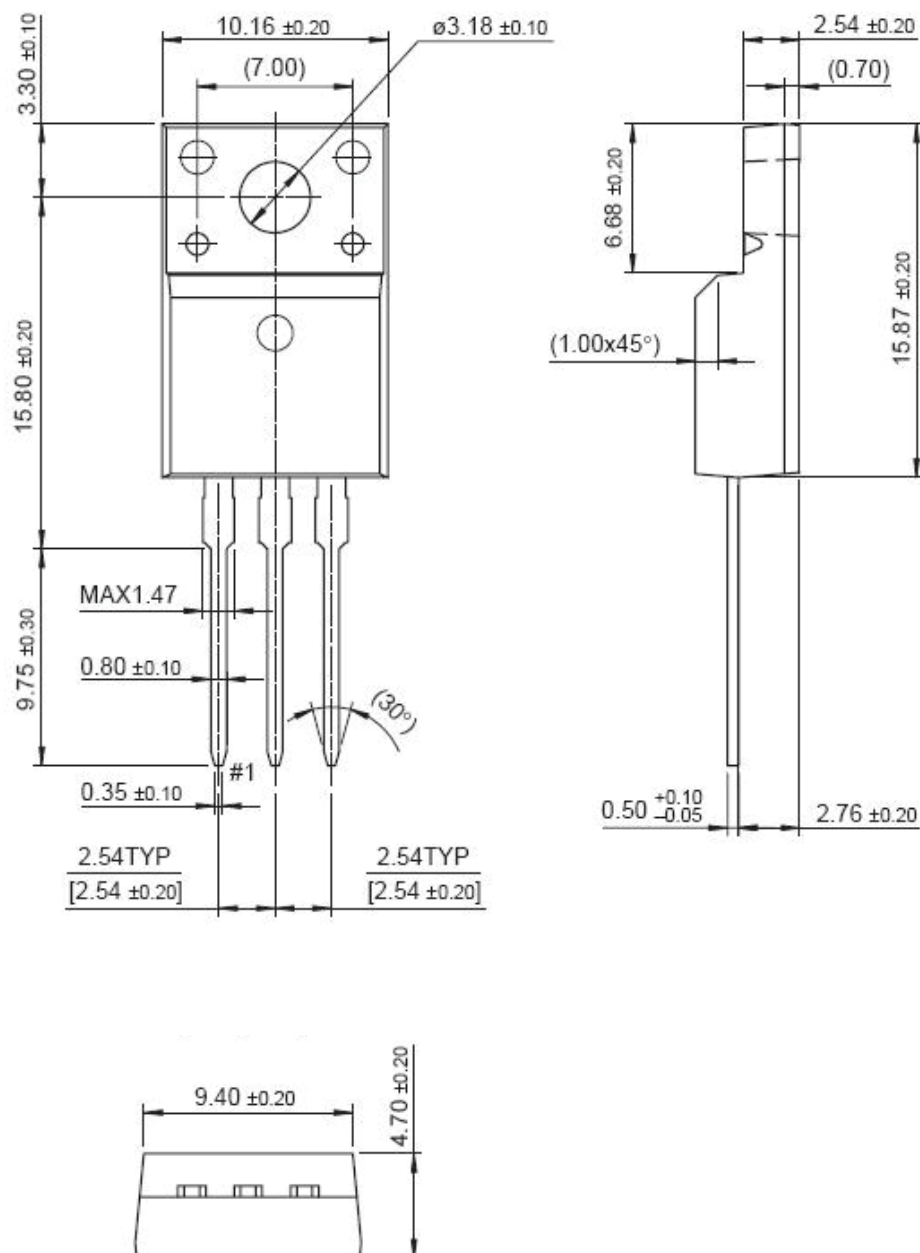
| Symbol | Dimensions In Millimeters |        | Dimensions In Inches |       |
|--------|---------------------------|--------|----------------------|-------|
|        | Min.                      | Max.   | Min.                 | Max.  |
| A      | 4.470                     | 4.670  | 0.176                | 0.184 |
| A1     | 0.000                     | 0.150  | 0.000                | 0.006 |
| B      | 1.170                     | 1.370  | 0.046                | 0.054 |
| b      | 0.710                     | 0.910  | 0.028                | 0.036 |
| b1     | 1.170                     | 1.370  | 0.046                | 0.054 |
| c      | 0.310                     | 0.530  | 0.012                | 0.021 |
| c1     | 1.170                     | 1.370  | 0.046                | 0.054 |
| D      | 10.010                    | 10.310 | 0.394                | 0.406 |
| E      | 8.500                     | 8.900  | 0.335                | 0.350 |
| e      | 2.540 TYP.                |        | 0.100 TYP.           |       |
| e1     | 4.980                     | 5.180  | 0.196                | 0.204 |
| L      | 15.050                    | 15.450 | 0.593                | 0.608 |
| L1     | 5.080                     | 5.480  | 0.200                | 0.216 |
| L2     | 2.340                     | 2.740  | 0.092                | 0.108 |
| L3     | 1.300                     | 1.700  | 0.051                | 0.067 |
| V      | 5.600 REF                 |        | 0.220 REF            |       |

## 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



Dimensions in Millimeters

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