

# 650V N-Channel Planar MOSFET

## MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## 650V N-Channel Planar MOSFET

650V N-Channel Planar MOSFET Power Transistor

## HRH4N65Ax Data Sheet

Rev. 2023 V1.2



## 650V N-Channel Planar MOSFET

### Description

#### 650V N-Channel Planar MOSFET

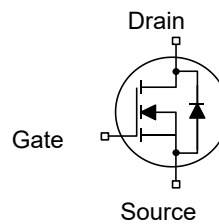
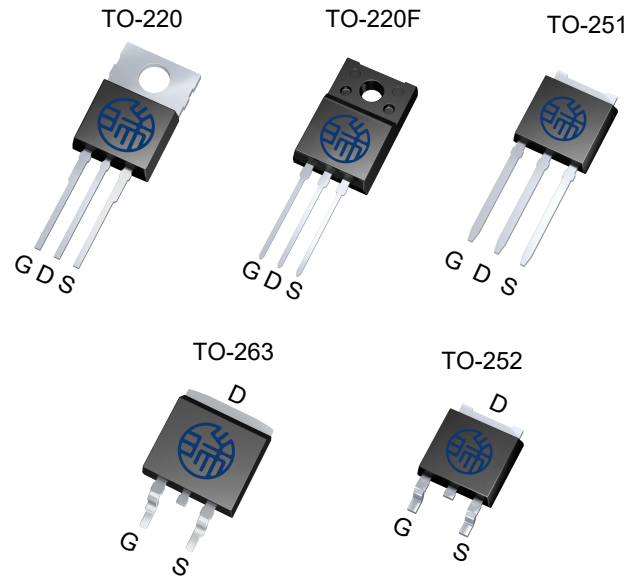
HRH4N65Ax is HRM high voltage MOSFET family based on advanced planar stripe DMOS technology. This advanced MOSFET family has optimized on-state resistance, and also provides superior switching performance and higher avalanche energy strength. This device family is suitable for high efficiency switch mode power supplies.

### Features

- $R_{DS(on)}=2.7\Omega$  @ $V_{GS}=10V$ ,  $I_D=2A$
- Low gate Charge(typical 12.6nC)
- Low  $C_{rss}$  (typical 1.3pF)
- Fast switching capability
- 100% avalanche tested
- Improved dv/dt capability

### Applications

- Switch Mode Power Supply
- Uninterruptible Power Supply (UPS)
- TV Power
- A dapter/Charger



### Key Performance Parameters

| Parameter        | Value | Unit     |
|------------------|-------|----------|
| $V_{DS}$         | 650   | V        |
| $R_{DS(on),typ}$ | 2.7   | $\Omega$ |
| $Q_{g,typ}$      | 12.6  | nC       |
| $I_D$            | 4     | A        |
| $I_{D,pulse}$    | 16    | A        |

### Device Marking and Package Information

| Device     | Package | Marking  |
|------------|---------|----------|
| HRH4N65AD  | TO-252  | H4N65AD  |
| HRH4N65AF  | TO-220F | H4N65AF  |
| HRH4N65AFT | TO-220F | H4N65AFT |
| HRH4N65AB  | TO-263  | H4N65AB  |
| HRH4N65AP  | TO-220  | H4N65AP  |
| HRH4N65AU  | TO-251  | H4N65AU  |

| Absolute Maximum Ratings T <sub>C</sub> = 25°C, unless otherwise noted |                        |                                   |          |      |
|------------------------------------------------------------------------|------------------------|-----------------------------------|----------|------|
| Parameter                                                              |                        | Symbol                            | Value    | Unit |
| Drain-Source Voltage(V <sub>GS</sub> =0V)                              |                        | V <sub>DS</sub>                   | 650      | V    |
| Continuous Drain Current <sup>1)</sup>                                 | T <sub>C</sub> = 25°C  | I <sub>D</sub>                    | 4        | A    |
|                                                                        | T <sub>C</sub> = 100°C |                                   | 2.4      |      |
| Pulsed Drain Current <sup>2)</sup>                                     |                        | I <sub>D,pulse</sub>              | 16       | A    |
| Gate-Source Voltage                                                    |                        | V <sub>GS</sub>                   | ±30      | V    |
| Single Pulse Avalanche Energy <sup>3)</sup>                            |                        | E <sub>AS</sub>                   | 208      | mJ   |
| Peak Diode Recovery dv/dt <sup>4)</sup>                                |                        | dv/dt                             | 5        | V/ns |
| Power Dissipation For TO-220F                                          |                        | P <sub>D</sub>                    | 26.7     | W    |
| Power Dissipation For TO-220、TO-263、TO-252、TO-251                      |                        |                                   | 34.4     |      |
| Continuous Diode Forward Current                                       |                        | I <sub>S</sub>                    | 4        | A    |
| Diode Pulsed Current <sup>2)</sup>                                     |                        | I <sub>S,pulse</sub>              | 16       |      |
| Operating Junction and Storage Temperature Range                       |                        | T <sub>J</sub> , T <sub>stg</sub> | -55~+150 | °C   |

| Thermal Resistance For TO-220F          |            |       |                           |
|-----------------------------------------|------------|-------|---------------------------|
| Parameter                               | Symbol     | Value | Unit                      |
| Thermal Resistance, Junction-to-Case    | $R_{thJC}$ | 4.69  | $^\circ\text{C}/\text{W}$ |
| Thermal Resistance, Junction-to-Ambient | $R_{thJA}$ | 80    |                           |

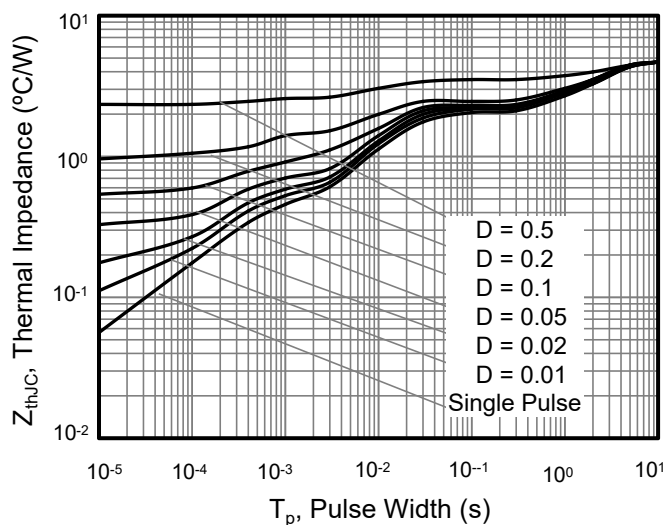
| Thermal Resistance For TO-220、TO-263、TO-252、TO-251 |            |       |                           |
|----------------------------------------------------|------------|-------|---------------------------|
| Parameter                                          | Symbol     | Value | Unit                      |
| Thermal Resistance, Junction-to-Case               | $R_{thJC}$ | 3.63  | $^\circ\text{C}/\text{W}$ |
| Thermal Resistance, Junction-to-Ambient            | $R_{thJA}$ | 62    |                           |

#### Notes

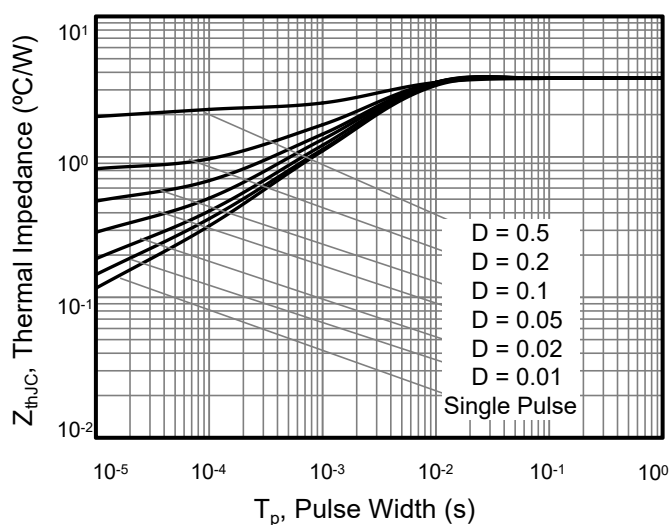
- 1) Limited by maximum junction temperature.
- 2) Repetitive Rating: Pulse width limited by maximum junction temperature.
- 3)  $L=26\text{mH}$ ,  $I_{AS}=4\text{A}$ ,  $R_G=25\Omega$ ,  $V_{DD}=80\text{V}$ , Start  $T_J=25^\circ\text{C}$ .
- 4)  $I_{SD} \leq 4\text{A}$ ,  $di/dt \leq 100\text{A}/\mu\text{s}$ ,  $V_{DD} \leq BV_{DSS}$ , Start  $T_J=25^\circ\text{C}$ .

| Electrical Characteristics T <sub>J</sub> = 25°C, unless otherwise noted |                      |                                                                                            |       |      |      |      |
|--------------------------------------------------------------------------|----------------------|--------------------------------------------------------------------------------------------|-------|------|------|------|
| Parameter                                                                | Symbol               | Test Conditions                                                                            | Value |      |      | Unit |
|                                                                          |                      |                                                                                            | Min.  | Typ. | Max. |      |
| Static Characteristics                                                   |                      |                                                                                            |       |      |      |      |
| Drain-Source Breakdown Voltage                                           | V <sub>(BR)DSS</sub> | V <sub>GS</sub> = 0V, I <sub>D</sub> = 250μA                                               | 650   | --   | --   | V    |
| Zero Gate Voltage Drain Current                                          | I <sub>DSS</sub>     | V <sub>DS</sub> = 650V<br>V <sub>GS</sub> = 0V, T <sub>J</sub> = 25°C                      | --    | --   | 1    | μA   |
|                                                                          |                      | V <sub>DS</sub> = 650V,<br>V <sub>GS</sub> = 0V, T <sub>J</sub> = 150°C                    | --    | --   | 100  |      |
| Gate-Source Leakage Current                                              | I <sub>GSS</sub>     | V <sub>GS</sub> = ±30V                                                                     | --    | --   | ±100 | nA   |
| Gate-Source Threshold Voltage                                            | V <sub>GS(th)</sub>  | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250μA                                 | 2     | --   | 4    | V    |
| Drain-Source On-State-Resistance                                         | R <sub>DS(on)</sub>  | V <sub>GS</sub> = 10V, I <sub>D</sub> = 2A                                                 | --    | 2.7  | 3.1  | Ω    |
| Gate Resistance                                                          | R <sub>G</sub>       | f = 1.0MHz open drain                                                                      | --    | 1.4  | --   | Ω    |
| Dynamic Characteristics                                                  |                      |                                                                                            |       |      |      |      |
| Input Capacitance                                                        | C <sub>iss</sub>     | V <sub>GS</sub> = 0V, V <sub>DS</sub> = 25V<br>f = 1.0MHz                                  | --    | 537  | --   | pF   |
| Output Capacitance                                                       | C <sub>oss</sub>     |                                                                                            | --    | 42   | --   |      |
| Reverse Transfer Capacitance                                             | C <sub>rss</sub>     |                                                                                            | --    | 1.3  | --   |      |
| Total Gate Charge                                                        | Q <sub>g</sub>       | V <sub>DD</sub> = 520V, I <sub>D</sub> = 4A<br>V <sub>GS</sub> = 10V                       | --    | 12.6 | --   | nC   |
| Gate-Source Charge                                                       | Q <sub>gs</sub>      |                                                                                            | --    | 4.2  | --   |      |
| Gate-Drain Charge                                                        | Q <sub>gd</sub>      |                                                                                            | --    | 2.6  | --   |      |
| Gate Plateau Voltage                                                     | V <sub>Plateau</sub> |                                                                                            | --    | 4.9  | --   | V    |
| Turn-on Delay Time                                                       | t <sub>d(on)</sub>   | V <sub>DD</sub> = 325V, I <sub>D</sub> = 4A<br>R <sub>G</sub> = 12Ω, V <sub>GS</sub> = 10V | --    | 14   | --   | ns   |
| Turn-on Rise Time                                                        | t <sub>r</sub>       |                                                                                            | --    | 16   | --   |      |
| Turn-off Delay Time                                                      | t <sub>d(off)</sub>  |                                                                                            | --    | 32   | --   |      |
| Turn-off Fall Time                                                       | t <sub>f</sub>       |                                                                                            | --    | 11   | --   |      |
| Drain-Source Body Diode Characteristics                                  |                      |                                                                                            |       |      |      |      |
| Body Diode Forward Voltage                                               | V <sub>SD</sub>      | T <sub>J</sub> = 25°C, I <sub>SD</sub> = 4A<br>V <sub>GS</sub> = 0V                        | --    | --   | 1.2  | V    |
| Reverse Recovery Time                                                    | t <sub>rr</sub>      | V <sub>R</sub> = 520V<br>I <sub>F</sub> = 4A, di <sub>F</sub> /dt = 100A/μs                | --    | 256  | --   | ns   |
| Reverse Recovery Charge                                                  | Q <sub>rr</sub>      |                                                                                            | --    | 1.2  | --   | μC   |

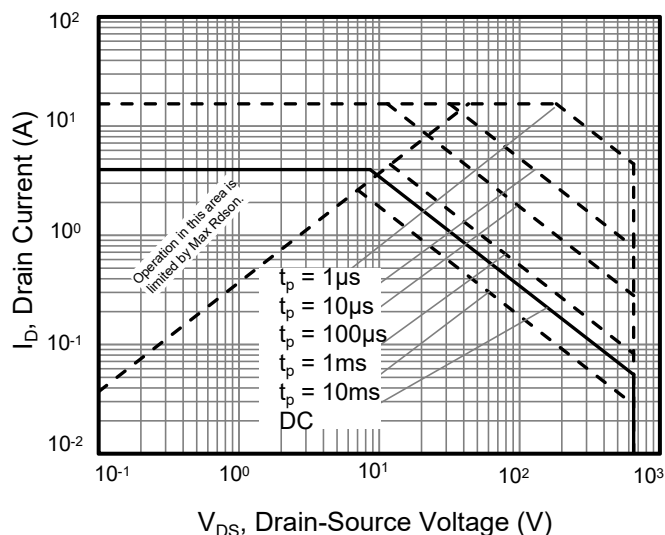
**Typical Characteristics**  $T_J = 25^\circ\text{C}$ , unless otherwise noted



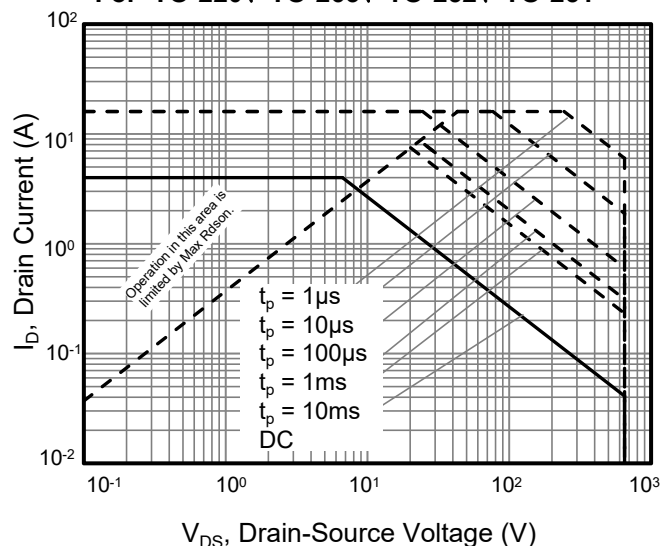
**Figure 1. Transient Thermal Impedance For TO-220F**



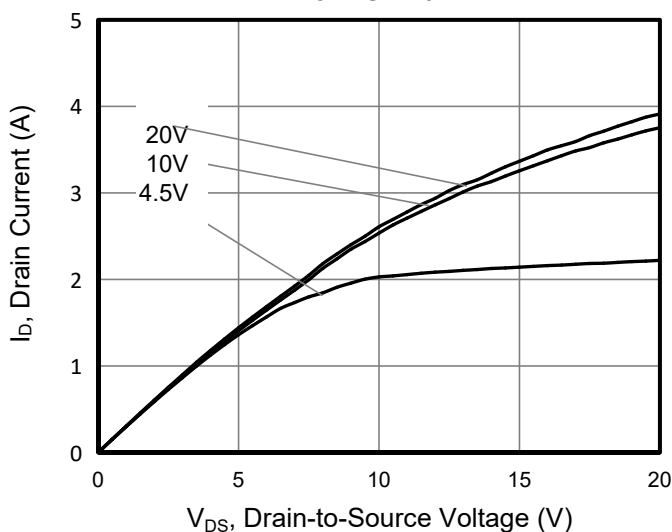
**Figure 2. Transient Thermal Impedance For TO-220, TO-263, TO-252, TO-251**



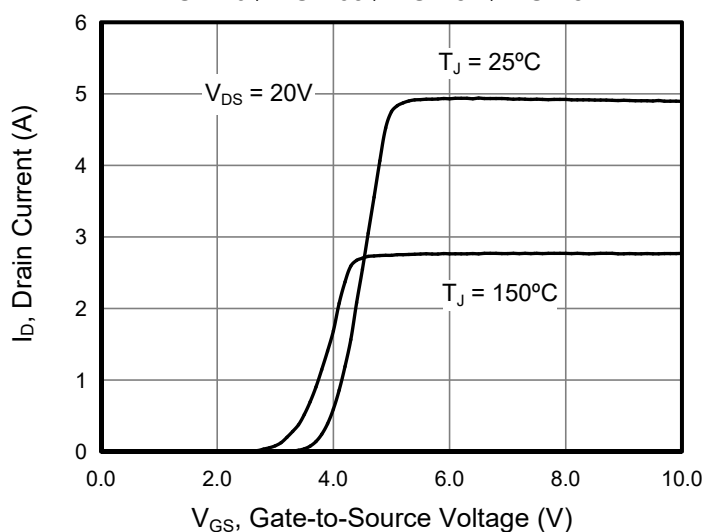
**Figure 3. Safe Operation Area For TO-220F**



**Figure 4. Safe Operation Area For TO-220, TO-263, TO-252, TO-251**



**Figure 5. Output Characteristics**



**Figure 6. Transfer Characteristics**

Typical Characteristics  $T_J = 25^\circ\text{C}$ , unless otherwise noted

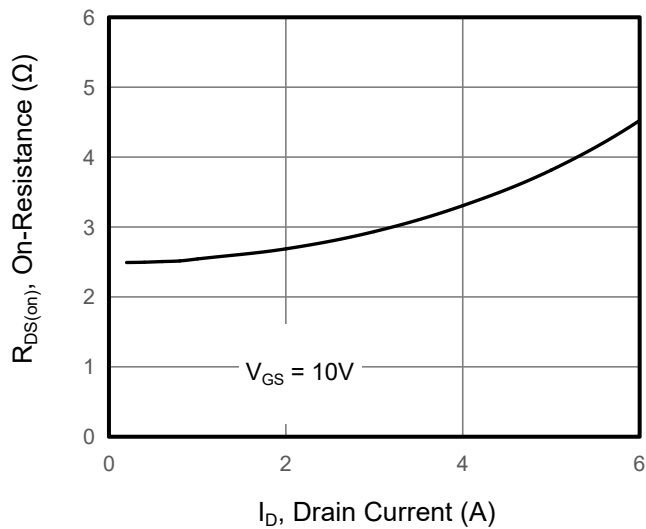


Figure 7. On-Resistance vs Drain Current

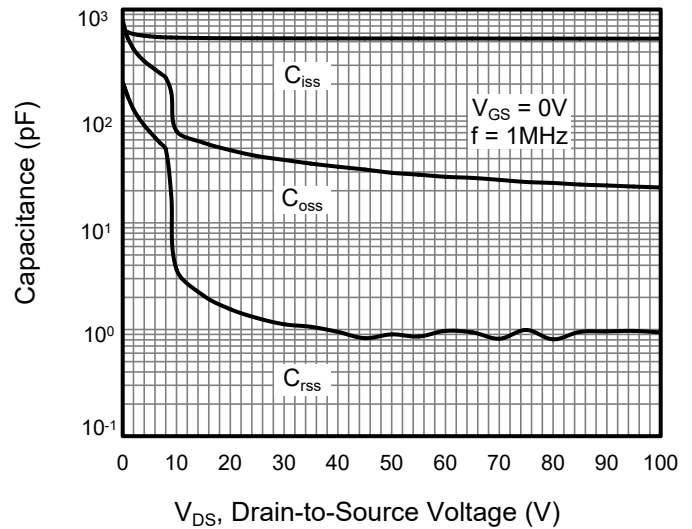


Figure 8. Capacitance

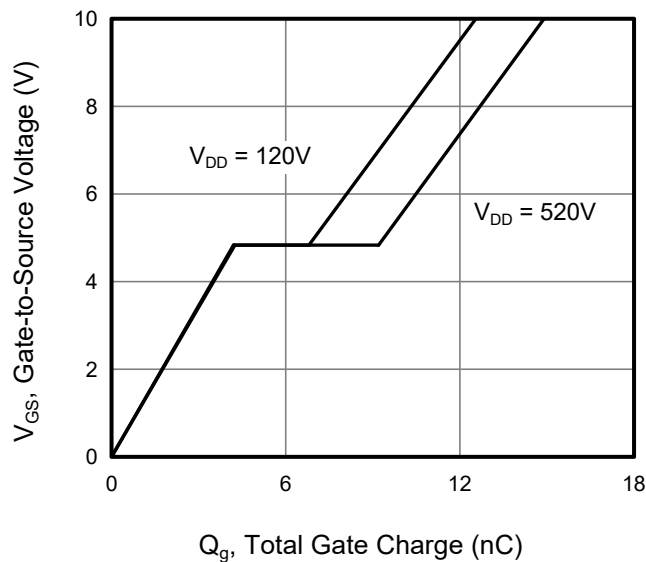


Figure 9. Gate Charge

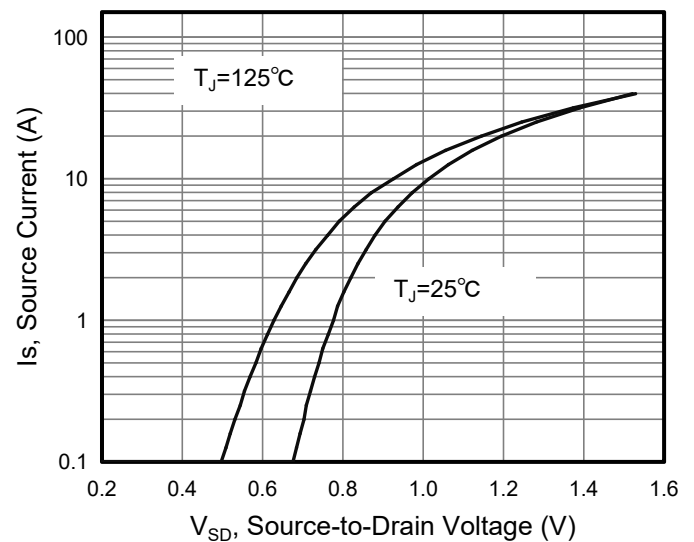


Figure 10. Body Diode Forward Voltage

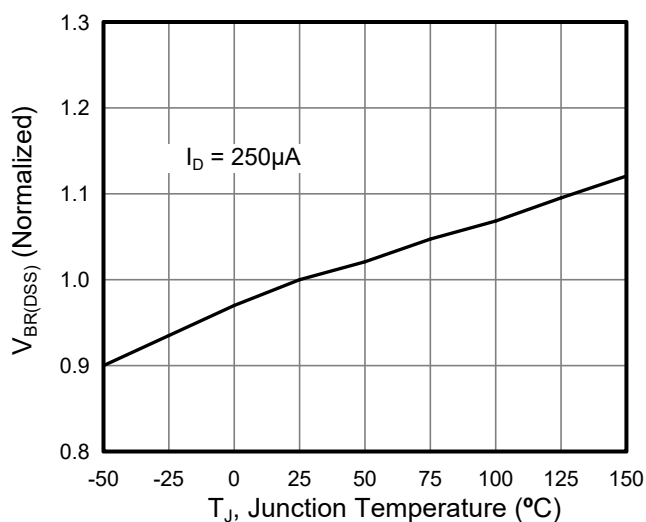


Figure 11. Breakdown Voltage vs Junction Temperature

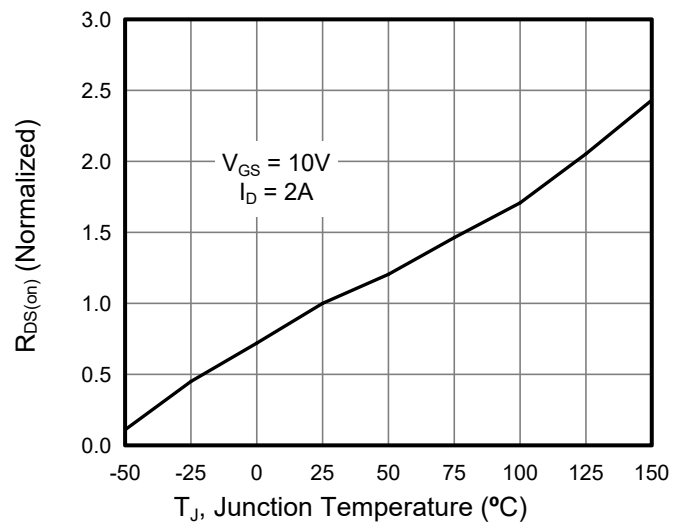


Figure 12. On-Resistance vs Temperature



Figure A: Gate Charge Test Circuit and Waveform

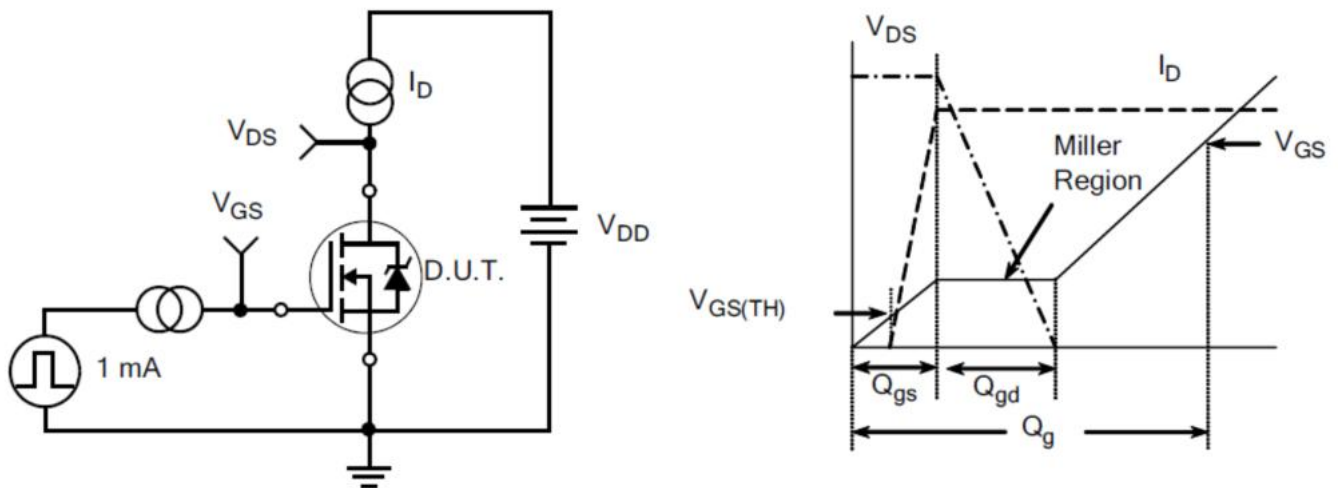


Figure B: Resistive Switching Test Circuit and Waveform

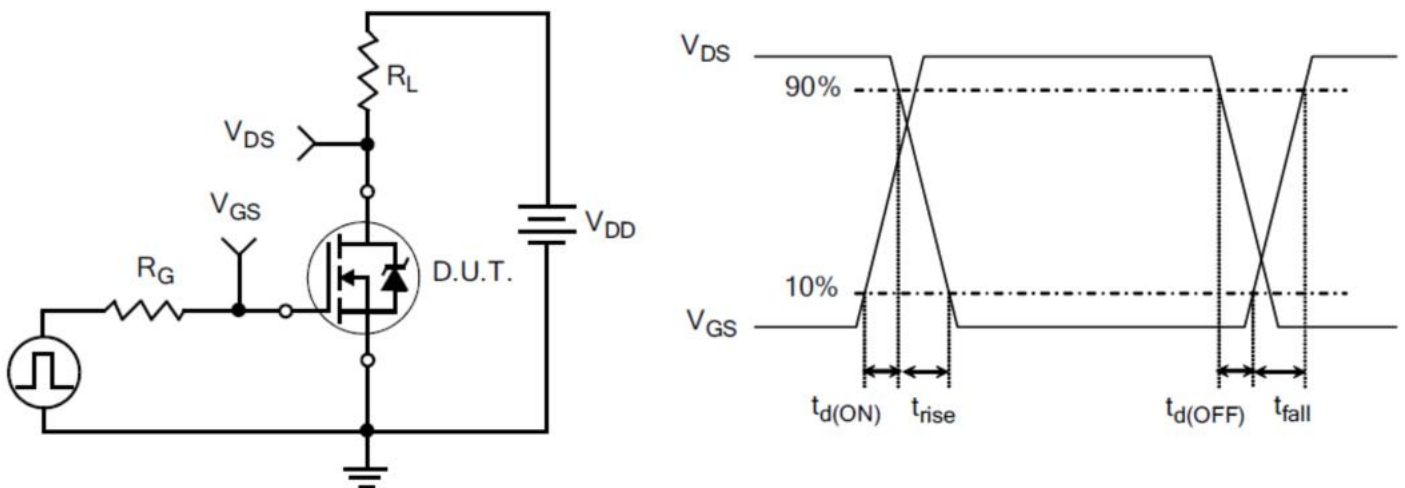
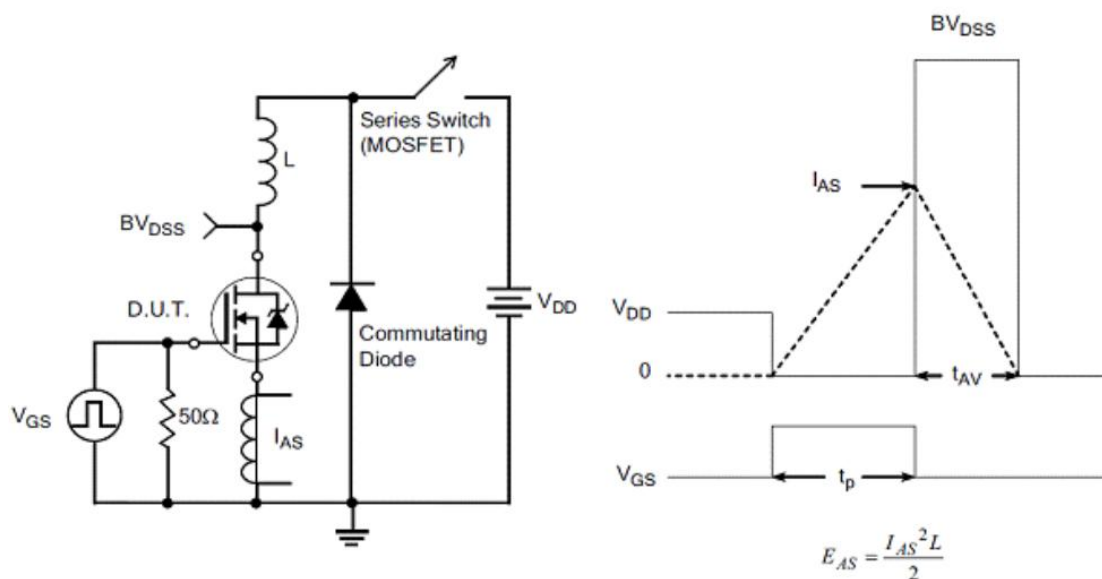
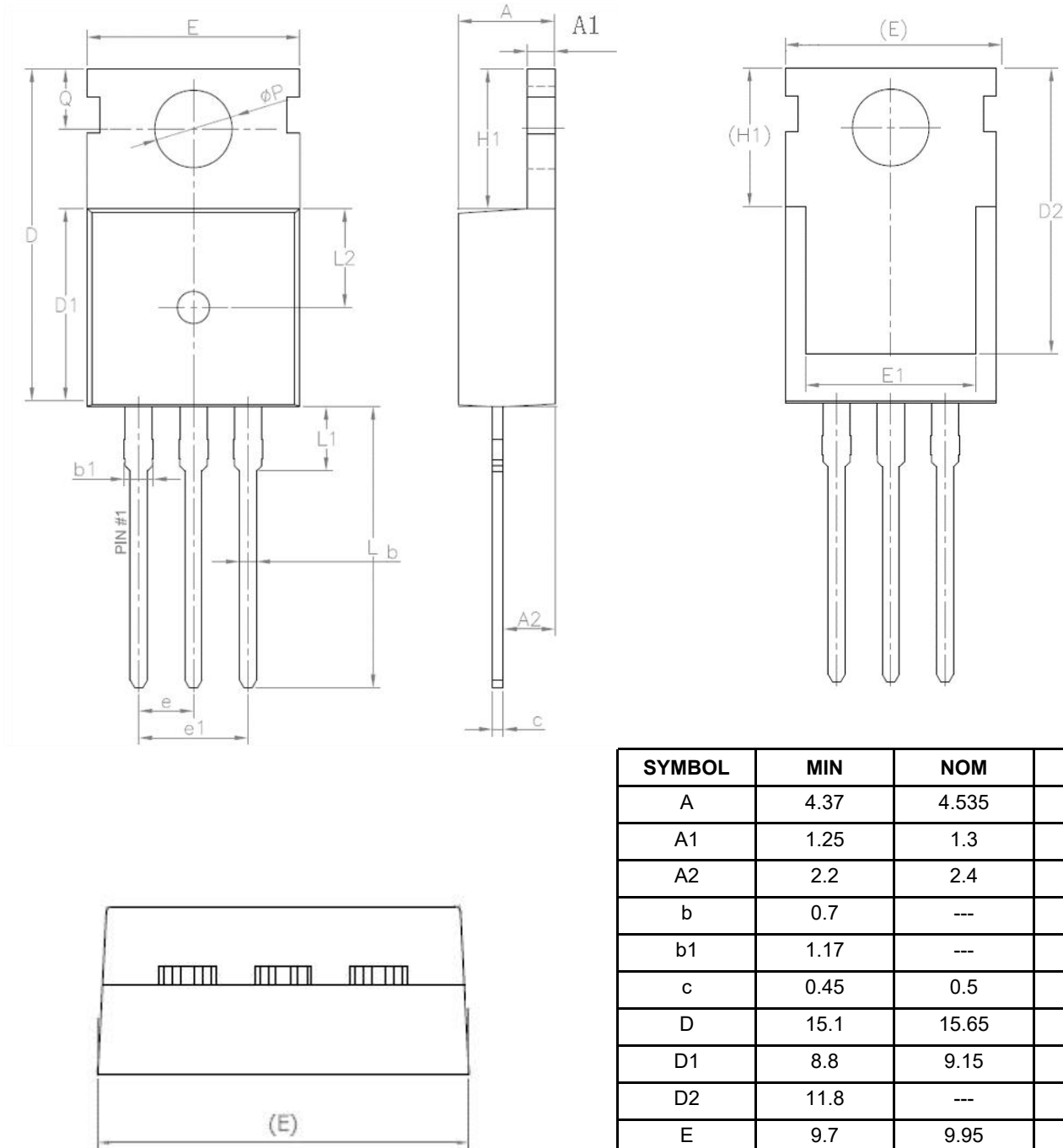


Figure C: Unclamped Inductive Switching Test Circuit and Waveform



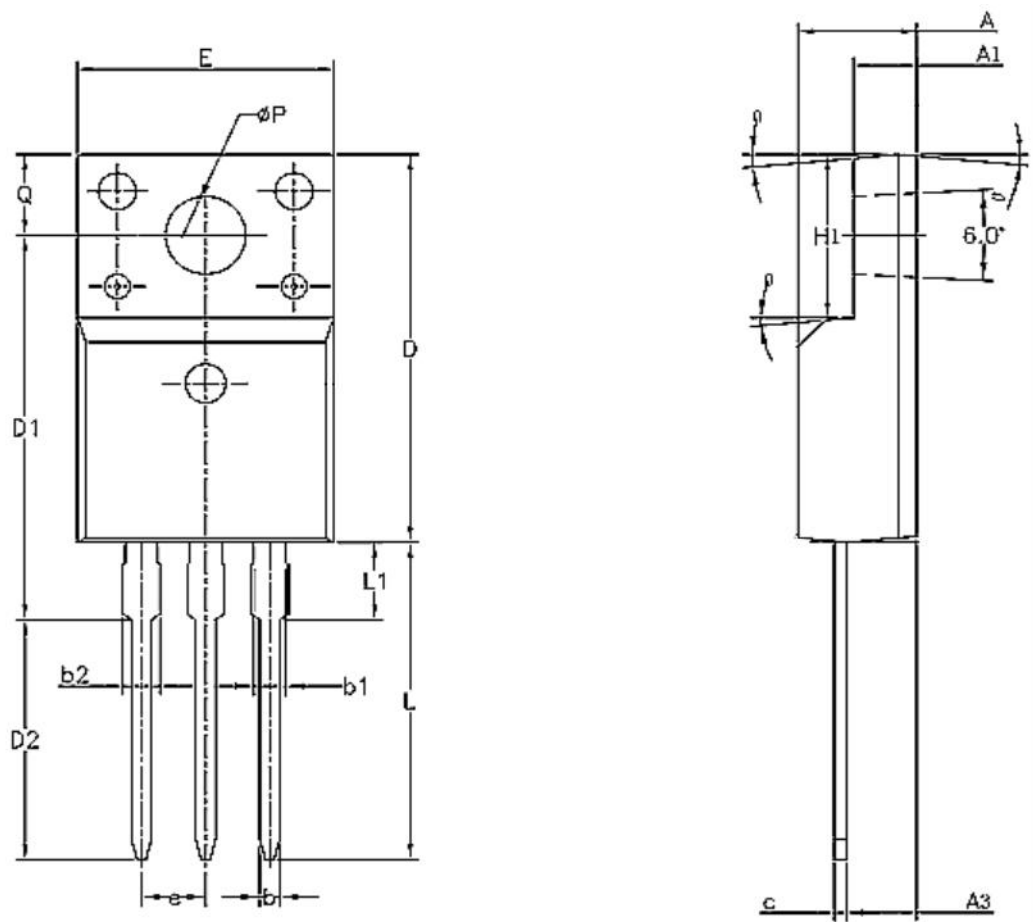
# Outlines TO-220 Package



| SYMBOL | MIN      | NOM   | MAX  |
|--------|----------|-------|------|
| A      | 4.37     | 4.535 | 4.7  |
| A1     | 1.25     | 1.3   | 1.4  |
| A2     | 2.2      | 2.4   | 2.6  |
| b      | 0.7      | ---   | 0.95 |
| b1     | 1.17     | ---   | 1.47 |
| c      | 0.45     | 0.5   | 0.6  |
| D      | 15.1     | 15.65 | 16.1 |
| D1     | 8.8      | 9.15  | 9.4  |
| D2     | 11.8     | ---   | ---  |
| E      | 9.7      | 9.95  | 10.3 |
| E1     | 7        | ---   | ---  |
| e      | 2.54 BSC |       |      |
| e1     | 5.08 BSC |       |      |
| H1     | 6.25     | 6.5   | 6.85 |
| L      | 12.75    | 13.29 | 13.8 |
| L1     | ---      | ---   | 3.5  |
| ΦP     | 3.4      | 3.67  | 3.8  |
| Q      | 2.6      | ---   | 3    |

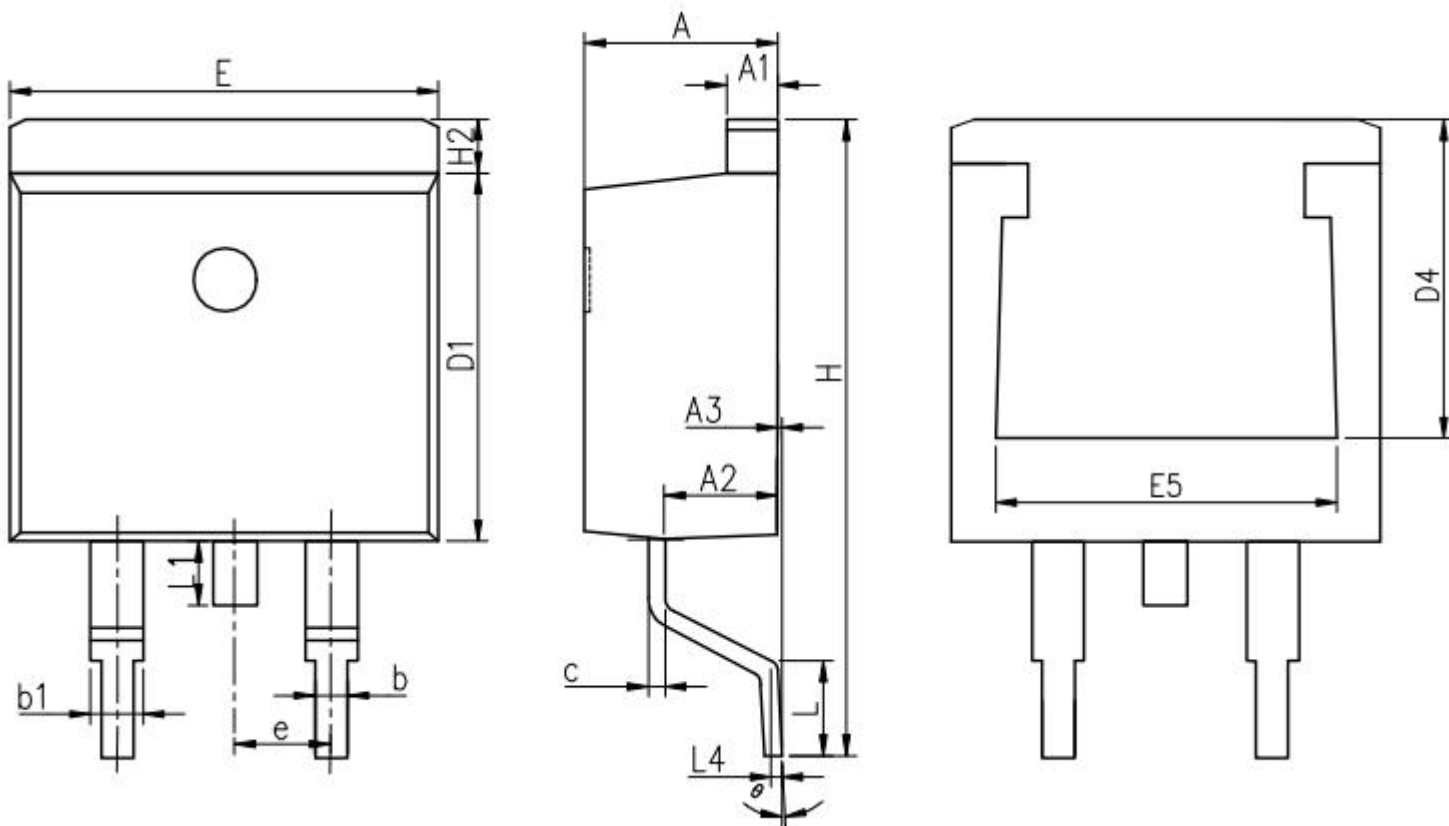


Outlines TO-220F Package



| SYMBOL | MIN      | NOM    | MAX   |
|--------|----------|--------|-------|
| A      | 4.5      | 4.7    | 4.9   |
| A1     | 2.34     | 2.54   | 2.74  |
| A3     | 2.56     | 2.76   | 2.96  |
| b      | 0.7      | ---    | 0.95  |
| b1     | 1.18     | ---    | 1.43  |
| b2     | ---      | ---    | 1.55  |
| c      | 0.4      | 0.5    | 0.65  |
| D      | 15.57    | 15.87  | 16.17 |
| D1     | 15.35    | 15.675 | 15.95 |
| D2     | 9.6      | 9.875  | 10.15 |
| E      | 9.96     | 10.16  | 10.36 |
| e      | 2.54 BSC |        |       |
| H1     | 6.48     | 6.68   | 6.88  |
| L      | 12.68    | 12.98  | 13.28 |
| L1     | ---      | ---    | 3.5   |

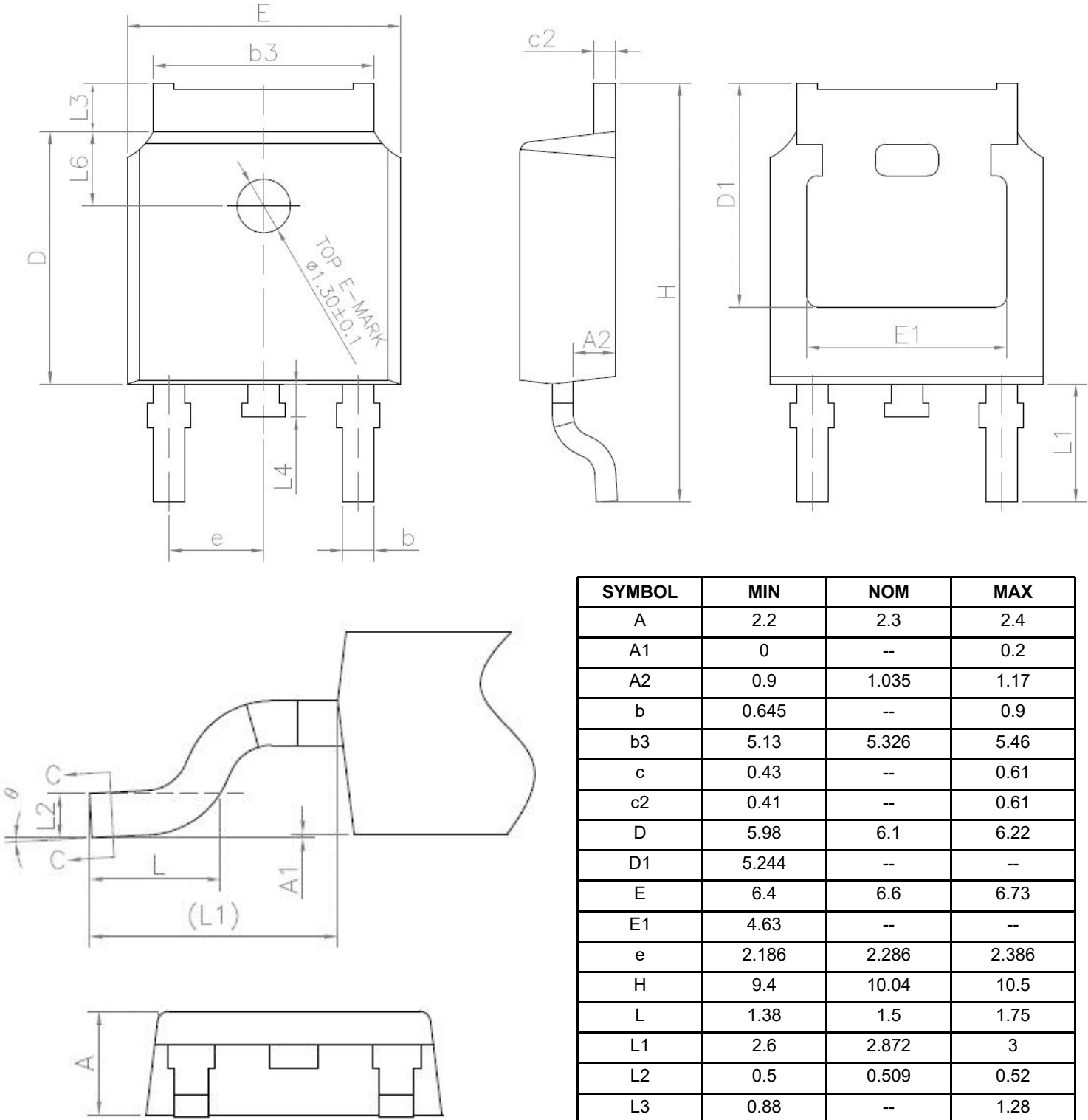
## Outlines TO-263 Package



| SYMBOL | MIN  | NOM   | MAX   |
|--------|------|-------|-------|
| A      | 4.37 | 4.57  | 4.77  |
| A1     | 1.22 | 1.27  | 1.42  |
| A2     | 2.49 | 2.69  | 2.89  |
| A3     | 0    | 0.13  | 0.25  |
| b      | 0.7  | 0.81  | 0.96  |
| b1     | 1.17 | 1.27  | 1.47  |
| c      | 0.30 | 0.38  | 0.53  |
| D1     | 8.50 | 8.70  | 8.90  |
| D4     | 6.60 | ---   | ---   |
| E      | 9.86 | 10.16 | 10.36 |

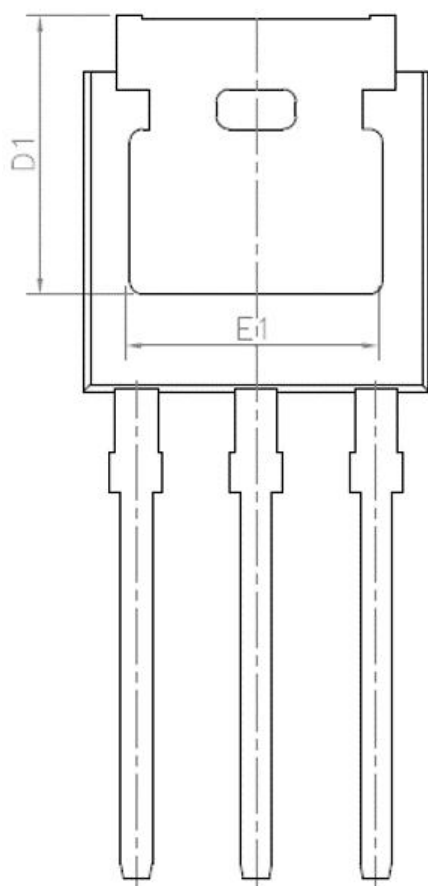
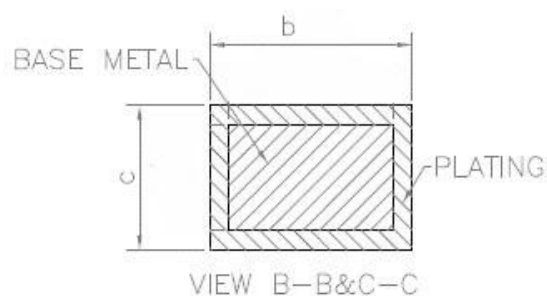
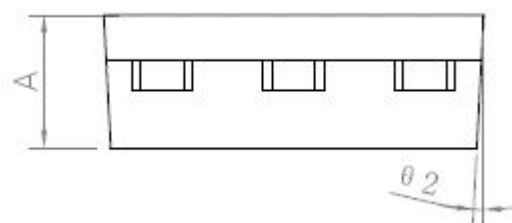
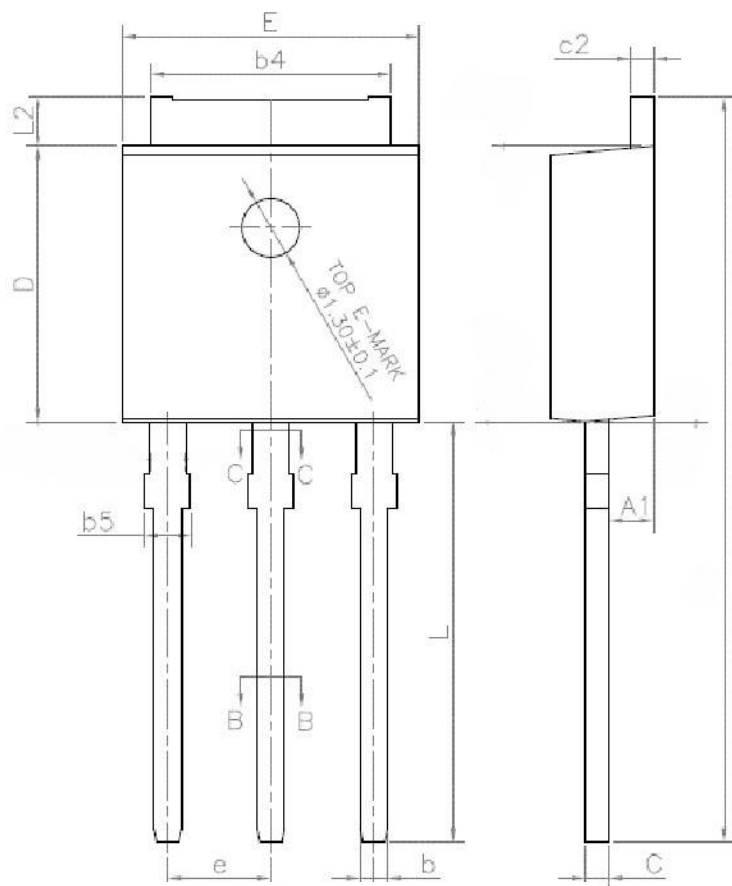
| SYMBOL | MIN      | NOM   | MAX   |
|--------|----------|-------|-------|
| E5     | 7.06     | ---   | ---   |
| e      | 2.54 BSC |       |       |
| H      | 14.70    | 15.10 | 15.50 |
| H2     | 1.07     | 1.27  | 1.47  |
| L      | 2.00     | 2.30  | 2.60  |
| L1     | 1.40     | 1.55  | 1.70  |
| L4     | 0.25 BSC |       |       |
| theta  | 0°       | 5°    | 9°    |
| Theta  | 0°       | --    | 8°    |
| Theta1 | 1°       | 3°    | 5°    |

Outlines TO-252 Package



| SYMBOL   | MIN   | NOM   | MAX   |
|----------|-------|-------|-------|
| A        | 2.2   | 2.3   | 2.4   |
| A1       | 0     | --    | 0.2   |
| A2       | 0.9   | 1.035 | 1.17  |
| b        | 0.645 | --    | 0.9   |
| b3       | 5.13  | 5.326 | 5.46  |
| c        | 0.43  | --    | 0.61  |
| c2       | 0.41  | --    | 0.61  |
| D        | 5.98  | 6.1   | 6.22  |
| D1       | 5.244 | --    | --    |
| E        | 6.4   | 6.6   | 6.73  |
| E1       | 4.63  | --    | --    |
| e        | 2.186 | 2.286 | 2.386 |
| H        | 9.4   | 10.04 | 10.5  |
| L        | 1.38  | 1.5   | 1.75  |
| L1       | 2.6   | 2.872 | 3     |
| L2       | 0.5   | 0.509 | 0.52  |
| L3       | 0.88  | --    | 1.28  |
| L4       | 0.5   | --    | 1     |
| L6       | 1.5   | 1.7   | 1.95  |
| $\theta$ | 0°    | --    | 10°   |

## Outlines TO-251 Package



| SYMBOL | MIN   | NOM   | MAX   |
|--------|-------|-------|-------|
| A      | 2.20  | 2.30  | 2.38  |
| A1     | 0.90  | 1.04  | 1.17  |
| b      | 0.56  | --    | 0.90  |
| b4     | 5.20  | 5.33  | 5.46  |
| b5     | --    | --    | 1.05  |
| c      | 0.43  | --    | 0.61  |
| c2     | 0.43  | --    | 0.61  |
| D      | 5.98  | 6.10  | 6.22  |
| D1     | 5.2   | --    | --    |
| E      | 6.40  | 6.60  | 6.73  |
| E1     | 4.60  | --    | --    |
| e      | 2.24  | 2.29  | 2.34  |
| e1     | 4.47  | 4.57  | 4.67  |
| H      | 16.18 | 16.50 | 16.82 |
| L      | 9     | 9.35  | 9.65  |
| L2     | 0.88  | 1.05  | 1.28  |

## Disclaimer

HRM has made reasonable commercial efforts to ensure that the information given in this datasheet is correct. However, it must clearly be understood that such information is for guidance only and does not constitute any representation or form part of any offer or contract.

For documents and material available from this datasheet, HRM does not warrant or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, product, technology or process disclosed hereunder.

HRM reserves the rights to at its own discretion to make any changes or improvements to this datasheet. Unless said datasheet is incorporated into the formal contract, any customer should not rely on the information as any specification or product parameters duly committed by HRM. Customers are hereby advised to verify that the information contained herein is current and complete before the entering of any contract or acknowledgement of any purchase order. Accordingly, all products specified hereunder shall be sold subject to HRM's terms and conditions supplied at the time of order acknowledgement. Except where agreed upon by contractual agreement, testing of all parameters of each product is not necessarily performed.

HRM does not warrant or convey any license either expressed or implied under its patent rights, nor the rights of others. Reproduction of information contained herein shall be only permissible if such reproduction is without any modification or alteration. Reproduction of this information with any alteration is an unfair and deceptive business practice. HRM is not responsible or liable for such altered documentation.

Resale of HRM's products with statements different from or beyond the parameters stated by HRM for that product or service voids all express or implied warranties for the associated HRM's product or service and is unfair and deceptive business practice. HRM is not responsible or liable for any such statements.

HRM's products are not authorized for use as critical components in life support devices or systems without the express written approval of HRM. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.