

P-Channel Enhancement Mode MOSFET

Feature

- -40V/-90A
 R_{DS(ON)}= 5.9 @VGS = -10V
 R_{DS(ON)}= 9.2 @VGS = -4.5V
- 100% Avalanche Tested
- 100% DVDS
- Reliable and Rugged
- Halogen Free and Green Devices Available
 (RoHS Compliant)

Pin Description

G D S

G D S

Applications

- Switching application
- Li-battery protection
- DC-DC
- Motor control

Ordering and Marking Information

| | | | | |
|--|-----------|-----------|----------------|-------------|
| | P | B | Package Code | |
| | HYG060P04 | HYG060P04 | P: TO-220FB-3L | B:TO-263-2L |
| | XYMXXXXXX | XYMXXXXXX | Date Code | |
| | | | XYMXXXXXX | |

Absolute Maximum Ratings

| Symbol | Parameter | Rating | Unit | |
|--|--|------------|------|------|
| Common Ratings (Tc=25°C Unless Otherwise Noted) | | | | |
| V _{DSS} | Drain-Source Voltage | -40 | V | |
| V _{GSS} | Gate-Source Voltage | ±20 | V | |
| T _J | Junction Temperature Range | -55 to 175 | °C | |
| T _{STG} | Storage Temperature Range | | °C | |
| I _S | Source Current-Continuous(Body Diode) | Tc=25°C | -90 | A |
| Mounted on Large Heat Sink | | | | |
| I _{DM} | Pulsed Drain Current * | Tc=25°C | -324 | A |
| I _D | Continuous Drain Current | Tc=25°C | -90 | A |
| | | Tc=100°C | -63 | A |
| P _D | Maximum Power Dissipation | Tc=25°C | 125 | W |
| | | Tc=100°C | 62 | W |
| R _{JC} | Thermal Resistance, Junction-to-Case | | 1.2 | °C/W |
| R _{JA} | Thermal Resistance, Junction-to-Ambient ** | | 62.5 | °C/W |
| E _{AS} | Single Pulsed-Avalanche Energy *** | L=0.3mH | 320 | mJ |

Note: * Repetitive rating; pulse width limited by max.junction temperature.

** Surface mounted on 1in2 FR-4 board.

*** Limited by T_{Jmax}, starting T_J=25°C, L = 0.3mH, R_c= 25 , V_{GS} =-10V.

Electrical Characteristics(Tc =25°C Unless Otherwise Noted)

| Symbol | Parameter | Test Conditions | HYG060P04LQ2 | | | Unit |
|-------------------------------|----------------------------------|--|--------------|-------|------|------|
| | | | Min | Typ. | Max | |
| Static Characteristics | | | | | | |
| BV _{DSS} | Drain-Source Breakdown Voltage | V _{GS} =0V, I _{DS} =-250 A | -40 | - | - | V |
| I _{DSS} | Drain-to-Source Leakage Current | V _{DS} =-40V, V _{GS} =0V | - | - | -1 | A |
| | | T _J =125°C | - | - | -50 | A |
| V _{GS(th)} | Gate Threshold Voltage | V _{DS} =V _{GS} , I _{DS} =-250 A | -1 | | -2 | V |
| I _{GSS} | Gate-Source Leakage Current | V _{GS} =±20V, V _{DS} =0V | - | - | ±100 | nA |
| R _{DS(ON)} | Drain-Source On-State Resistance | V _{GS} =-10V, I _{DS} =-20A | - | 5.9 | 7.5 | m |
| | | V _{GS} =-4.5V, I _{DS} =-20A | | 9.2 | 12 | m |
| Diode Characteristics | | | | | | |
| V _{SD} | Diode Forward Voltage | I _{SD} =-20A, V _{GS} =0V | - | -0.84 | -1.3 | V |
| t _{rr} | Reverse Recovery Time | I _{SD} =-20A, dI _{SD} /dt=100A/ | - | 21.3 | - | ns |
| Q _{rr} | Reverse Recovery Charge | | - | 14.8 | - | nC |

Electrical Characteristics (Cont.) (Tc =25°C Unless Otherwise Noted)

| Symbol | Parameter | Test Conditions | HYG060P04LQ2 | | | Unit |
|------------------------------------|---|--|--------------|------|-----|------|
| | | | Min | Typ. | Max | |
| Dynamic Characteristics | | | | | | |
| R _G | Gate Resistance | V _{GS} =0V, V _{DS} =0V, F=500KHz | - | 4.8 | - | |
| C _{iss} | Input Capacitance | V _{GS} =0V, V _{DS} =-25V, Frequency=500KHz | - | 3506 | - | pF |
| C _{oss} | Output Capacitance | | | | | |
| C _{rss} | Reverse Transfer Capacitance | | | | | |
| t _{d(ON)} | Turn-on Delay Time | V _{DD} =-20V, R _G =4 I _{DS} =-20A, V _{GS} =-10V | - | 8.9 | - | ns |
| T _r | Turn-on Rise Time | | | | | |
| t _{d(OFF)} | Turn-off Delay Time | | | | | |
| T _f | Turn-off Fall Time | | | | | |
| Gate Charge Characteristics | | | | | | |
| Q _g | Total Gate Charge(V _{GS} =-10V) | V _{DS} =-32V, I _{DS} =-20A | - | 86.8 | - | nC |
| | Total Gate Charge(V _{GS} =-4.5V) | | - | 46.4 | - | |
| Q _{gs} | Gate-Source Charge | | - | 12.5 | - | |
| Q _{gd} | Gate-Drain Charge | | - | 24.8 | - | |
| V _{plateau} | Gate plateau voltage | | - | -3.2 | - | V |

Note: *Pulse test, pulse width 300us, duty cycle 2%

Typical Operating Characteristics

Figure 1: Power Dissipation

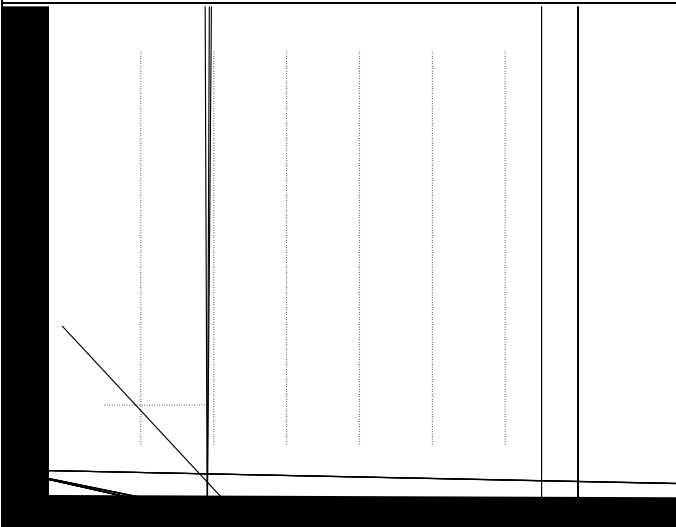


Figure 2: Drain Current

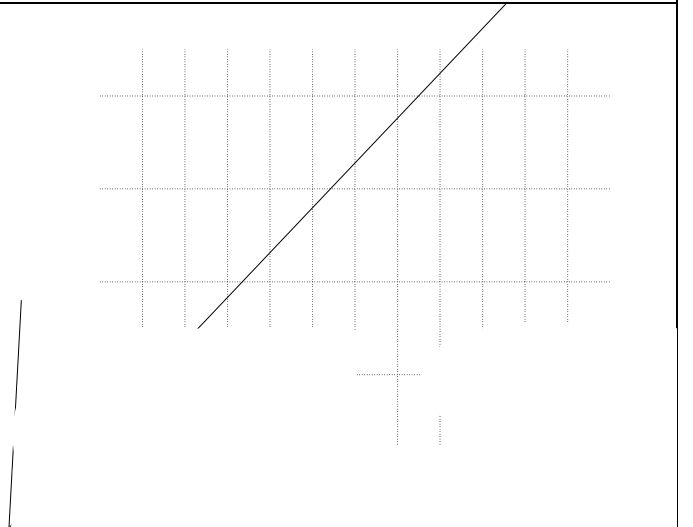


Figure 3: Safe Operation Area

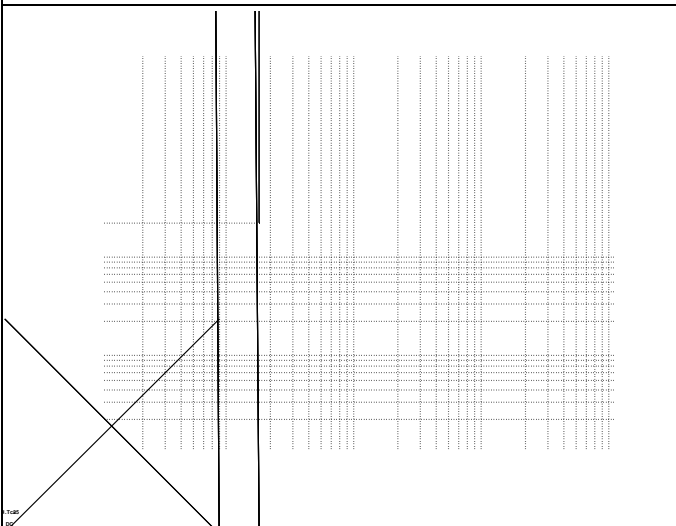


Figure 4: Thermal Transient Impedance

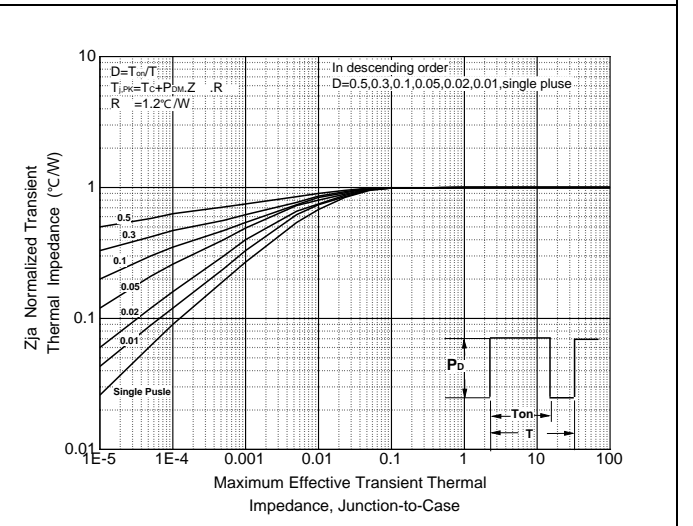


Figure 5: Output Characteristics

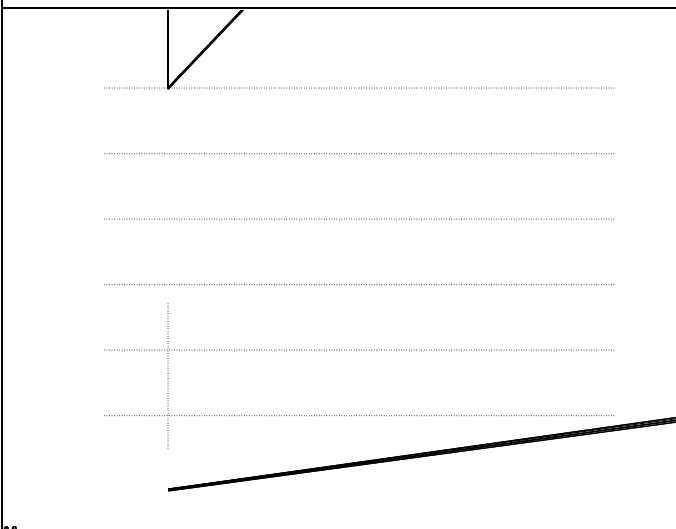
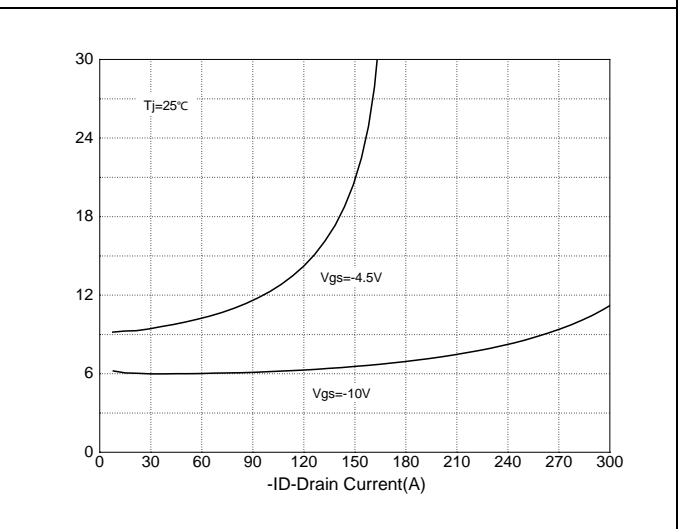
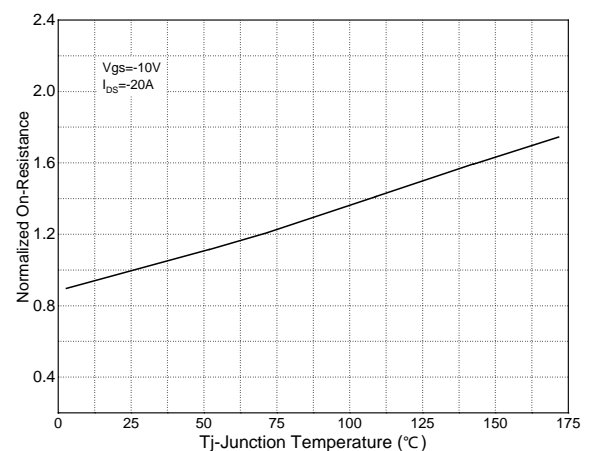
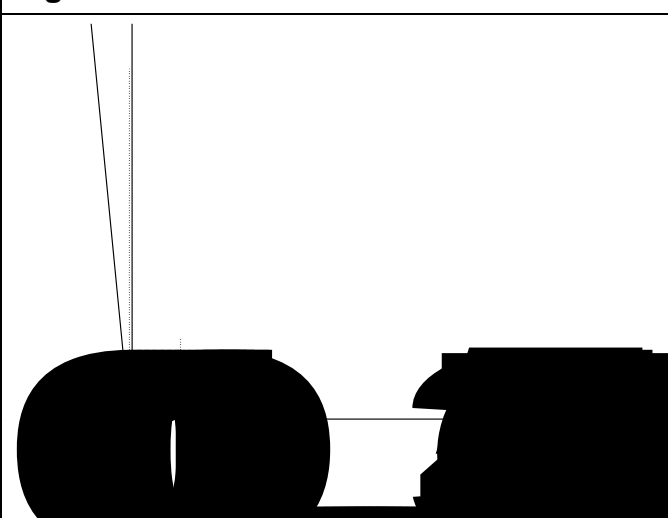
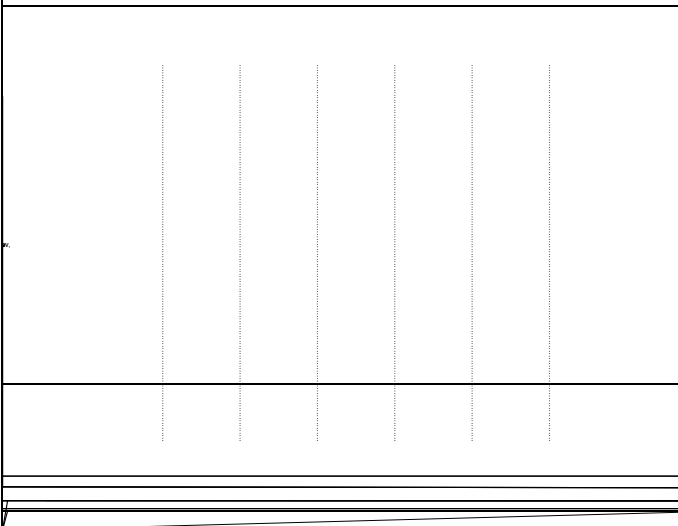
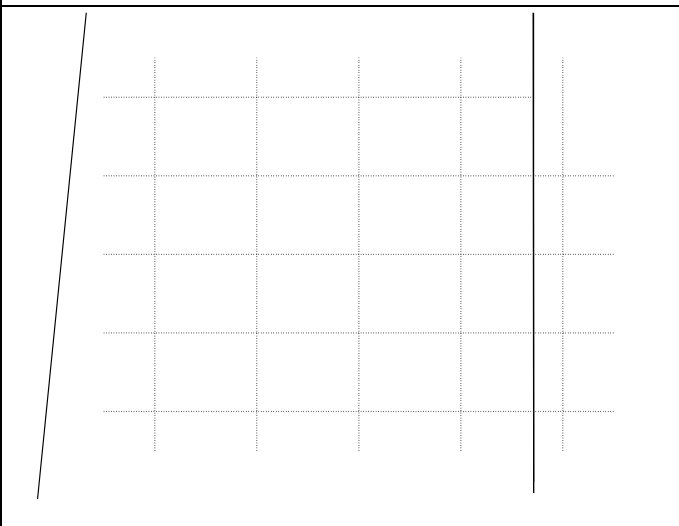


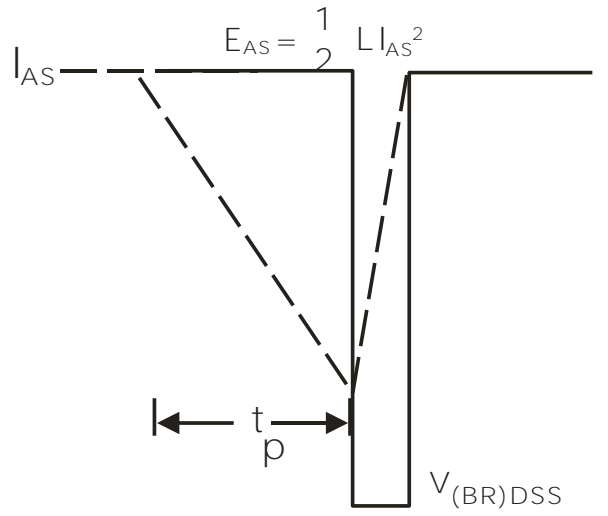
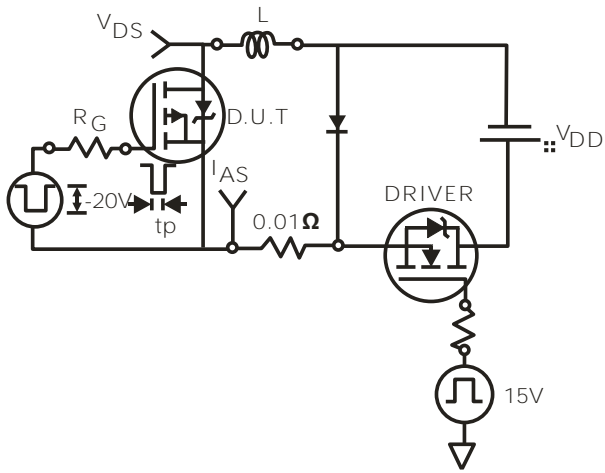
Figure 6: Drain-Source On Resistance



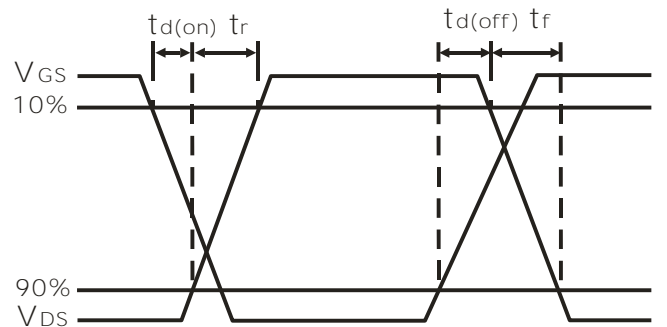
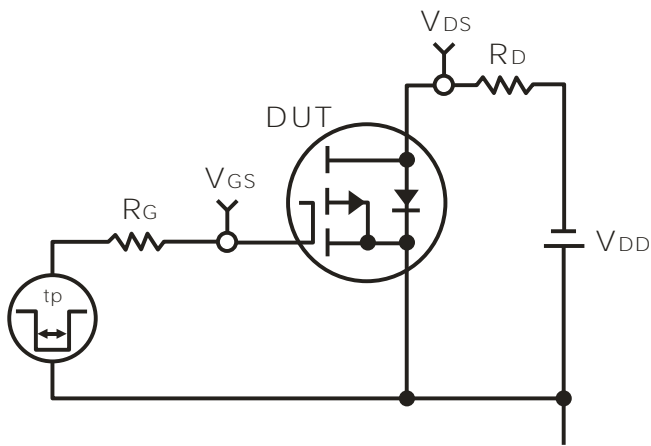
Typical Operating Characteristics(Cont.)

| | |
|---|--|
| <p>Figure 7: On-Resistance vs. Temperature</p>  <p>Normalized On-Resistance</p> <p>T_j-Junction Temperature (°C)</p> <p>V_{gs}=-10V I_{ds}=-20A</p> | <p>Figure 8: Source-Drain Diode Forward</p>  |
| <p>Figure 9: Capacitance Characteristics</p>  | <p>Figure 10: Gate Charge Characteristics</p>  |

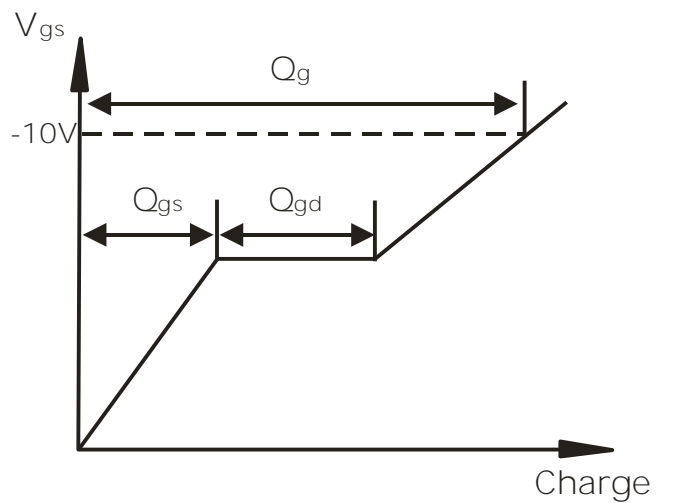
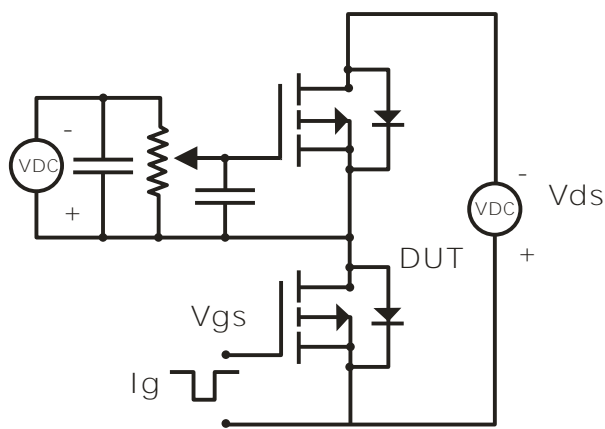
Avalanche Test Circuit



Switching Time Test Circuit



Gate Charge Test Circuit



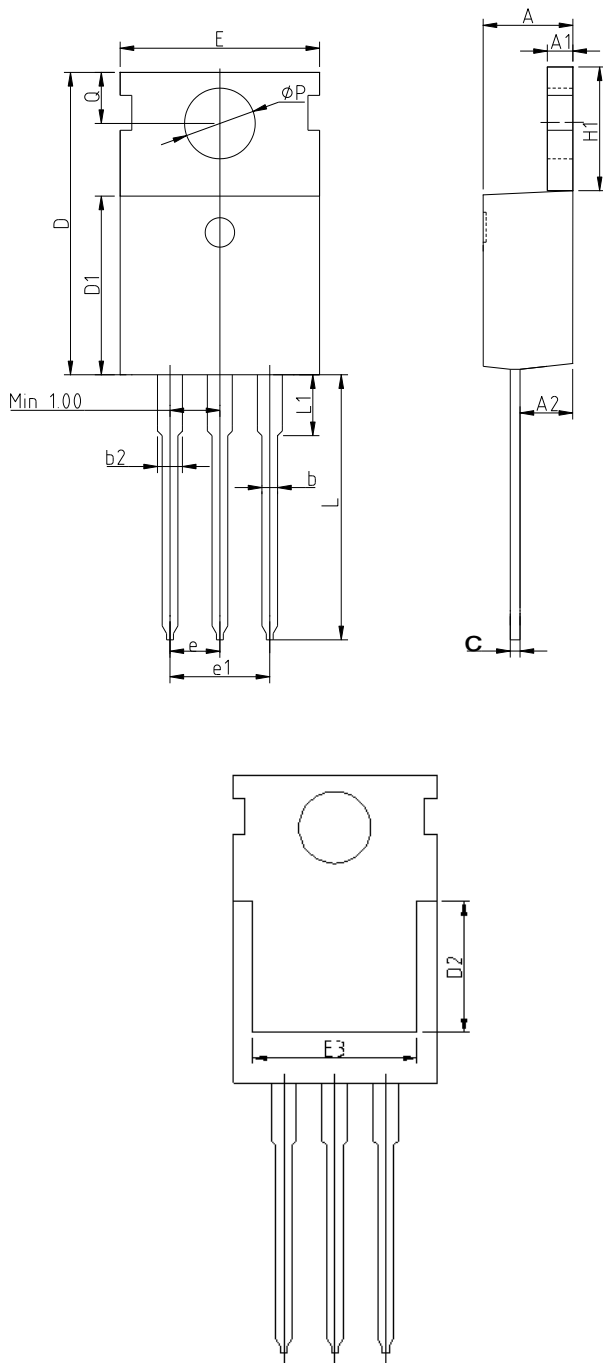
Device Per Unit

| Package Type | Unit | Quantity |
|--------------|------|----------|
| TO-220FB-3L | Tube | 50 |
| TO-263-2L | Reel | 800 |

Package Information

TO-220FB-3L

(unit:mm)

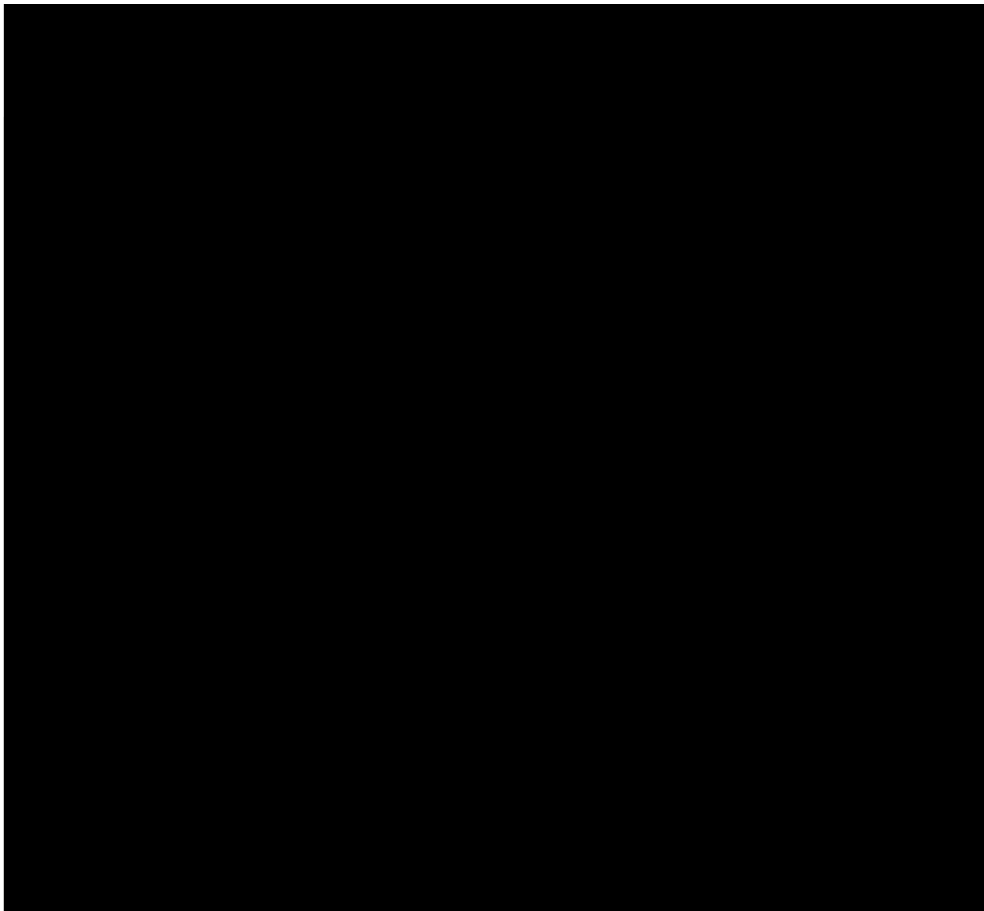


| COMMON DIMENSIONS | | | |
|-------------------|----------|-------|-------|
| SYMBOL | mm | | |
| | MIN | NOM | MAX |
| A | 4.37 | 4.57 | 4.77 |
| A1 | 1.25 | 1.30 | 1.40 |
| A2 | 2.20 | 2.40 | 2.60 |
| b | 0.70 | 0.80 | 0.95 |
| b2 | 1.17 | 1.27 | 1.47 |
| c | 0.45 | 0.50 | 0.60 |
| D | 15.10 | 15.60 | 16.10 |
| D1 | 8.80 | 9.10 | 9.40 |
| D2 | 5.50 | 6.30 | 7.10 |
| E | 9.70 | 10.00 | 10.30 |
| E3 | 7.00 | 7.80 | 8.60 |
| e | 2.54 BSC | | |
| e1 | 5.08 BSC | | |
| H1 | 6.25 | 6.50 | 6.85 |
| L | 12.75 | 13.50 | 13.80 |
| L1 | - | 3.10 | 3.40 |
| | 3.40 | 3.60 | 3.80 |
| Q | 2.60 | 2.80 | 3.00 |

TO-263-2L

| COMMON DIMENSIONS | | | |
|-------------------|----------|-------|-------|
| SYMBOL | mm | | |
| | MIN | NOM | MIN |
| 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 | 0.70 | 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 |
| 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 | | |
| | 0° | 5° | 9° |

Classification Profile



Classification Reflow Profiles

| Profile Feature | Sn-Pb Eutectic Assembly | Pb-Free Assembly |
|--|------------------------------------|------------------------------------|
| Preheat & Soak | | |
| Temperature min (T_{smin}) | 100 °C | 150 °C |
| Temperature max (T_{smax}) | 150 °C | 200 °C |
| Time (T_{smin} to T_{smax}) (t_s) | 60-120 seconds | 60-120 seconds |
| Average ramp-up rate (T_{smax} to T_p) | 3 °C/second max. | 3°C/second max. |
| Liquidous temperature (T_L) | 183 °C | 217 °C |
| Time at liquidous (t_l) | 60-150 seconds | 60-150 seconds |
| Peak package body Temperature (T_p)* | See Classification Temp in table 1 | See Classification Temp in table 2 |
| Time (t_p)** within 5°C of the specified classification temperature (T_c) | 20** seconds | 30** seconds |
| Average ramp-down rate (T_p to T_{smax}) | 6 °C/second max. | 6 °C/second max. |
| Time 25°C to peak temperature | 6 minutes max. | 8 minutes max. |
| *Tolerance for peak profile Temperature (T_p) is defined as a supplier minimum and a user maximum. | | |
| ** Tolerance for time at peak profile temperature (t_p) is defined as a supplier minimum and a user maximum. | | |

Table 1. SnPb Eutectic Process Classification Temperatures (Tc)

| Package Thickness | Volume mm ³ <350 | Volume mm ³ ≥350 |
|-------------------|--------------------------------|--------------------------------|
| <2.5 mm | 235 °C | 220 °C |
| | 220 °C | 220 °C |

Table 2. Pb-free Process Classification Temperatures (Tc)

| Package Thickness | Volume mm ³ <350 | Volume mm ³ 350-2000 | Volume mm ³ ≥2000 |
|-------------------|--------------------------------|------------------------------------|---------------------------------|
| <1.6 mm | 260 °C | 260 °C | 260 °C |
| 1.6 mm 2.5 mm | 260 °C | 250 °C | 245 °C |
| ≥2.5 mm | 250 °C | 245 °C | 245 °C |

Reliability Test Program

| Test item | Method | Description |
|---------------|---------------|--------------------------------------|
| SOLDERABILITY | JESD-22, B102 | 5 Sec, 245°C |
| HTRB | JESD-22, A108 | 168/500 Hrs, Bias @ 150°C |
| HTGB | JESD-22, A108 | 168 /500 Hrs, V _{gs} 100% @ |