# Velosti N-channel 650V, 20A, 0.15Ω Power MOSFET

## Description

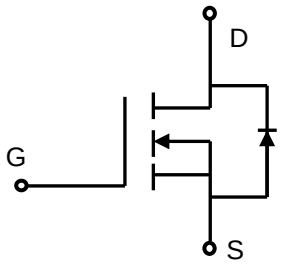
Velosti Power MOSFET is fabricated using advanced super junction technology. The resulting device has extremely low on resistance, making it especially suitable for applications which require superior power density and outstanding efficiency.

## Features

- Ultra low $R_{DS(on)}$
- Ultra low gate charge (typ. $Q_g$ = 65nC)
- 100% UIS tested
- RoHS compliant

## Product Summary

| | |
|---|---|
| $V_{DS}$ @ $T_{j,max}$ | 700V |
| $R_{DS(on),max}$ | 0.15Ω |
| $I_{DM}$ | 60A |
| $Q_{g,typ}$ | 65nC |




N-Channel MOSFET

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## Absolute Maximum Ratings

| Parameter | Symbol | VSQ652015A2 | Unit |
|---|---|---|---|
| Drain-Source Voltage | $V_{DS}$ | 650 | V |
| Continuous drain current ( $T_C$ = 25°C ) | $I_D$ | 20 | A |
| ( $T_C$ = 100°C ) | | 13 | A |
| Pulsed drain current [1] | $I_{DM}$ | 60 | A |
| Gate-Source voltage | $V_{GS}$ | ±30 | V |
| Avalanche energy, single pulse [2] | $E_{AS}$ | 700 | mJ |
| Avalanche energy, repetitive [1] | $E_{AR}$ | 20.5 | mJ |
| Avalanche current, repetitive [1] | $I_{AR}$ | 20 | A |
| Power Dissipation ( $T_C$ = 25°C ) | $P_D$ | 205 | W |
| - Derate above 25°C | | 1.64 | W/°C |
| Operating and Storage Temperature Range | $T_J$, $T_{STG}$ | -55 to +150 | °C |
| Continuous diode forward current | $I_S$ | 20 | A |
| Diode pulse current | $I_{S,pulse}$ | 60 | A |

## Thermal Characteristics

| Parameter | Symbol | VSQ652015A2 | Unit |
|---|---|---|---|
| Thermal Resistance, Junction-to-Case | $R_{\theta JC}$ | 0.61 | °C/W |
| Thermal Resistance, Junction-to-Ambient | $R_{\theta JA}$ | 60 | °C/W |

## Package Marking and Ordering Information

| Device | Device Package | Marking |
|---|---|---|
| VSQ652015A2 | TO-220 | VSQ652015A2 |

## Electrical Characteristics

$T_c$ = 25°C unless otherwise noted

| Parameter | Symbol | Test Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **Static characteristics** | | | | | | |
| Drain-source breakdown voltage | $BV_{DSS}$ | $V_{GS}$=0 V, $I_D$=0.25 mA | 650 | - | - | V |
| Gate threshold voltage | $V_{GS(th)}$ | $V_{DS}$=$V_{GS}$, $I_D$=0.25mA | 2 | | 5 | V |
| Drain cut-off current | $I_{DSS}$ | $V_{DS}$=600 V, $V_{GS}$=0 V, | - | - | 1 | μA |
| Gate leakage current, Forward | $I_{GSSF}$ | $V_{GS}$=30 V, $V_{DS}$=0 V | - | - | 100 | nA |
| Gate leakage current, Reverse | $I_{GSSR}$ | $V_{GS}$=-30 V, $V_{DS}$=0 V | - | - | -100 | nA |
| Drain-source on-state resistance | $R_{DS(on)}$ | $V_{GS}$=10 V, $I_D$=10 A<br>$T_j$ = 25°C<br>$T_j$ = 150°C | -<br>-<br>- | <br>0.13<br>0.39 | <br>0.15<br>- | Ω |
| Gate resistance | $R_G$ | f=1 MHz, open drain | - | 1.8 | - | Ω |
| **Dynamic characteristics** | | | | | | |
| Input capacitance | $C_{iss}$ | $V_{DS}$ = 25 V, $V_{GS}$ = 0 V, | - | 2100 | - | pF |
| Output capacitance | $C_{oss}$ | f = 1 MHz | - | 1700 | - | |
| Reverse transfer capacitance | $C_{rss}$ | | - | 17 | - | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD}$ = 380V, $I_D$ = 10A | - | 25 | - | ns |
| Rise time | $t_r$ | $R_G$ = 4.7Ω, $V_{GS}$=10V | - | 21 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 60 | - | |
| Fall time | $t_f$ | | - | 4 | - | |
| **Gate charge characteristics** | | | | | | |
| Gate to source charge | $Q_{gs}$ | $V_{DD}$=480 V, $I_D$=10A, | - | 12 | - | nC |
| Gate to drain charge | $Q_{gd}$ | $V_{GS}$=0 to 10 V | - | 31 | - | |
| Gate charge total | $Q_g$ | | - | 65 | - | |
| Gate plateau voltage | $V_{plateau}$ | | - | 5.7 | - | V |
| **Reverse diode characteristics** | | | | | | |
| Diode forward voltage | $V_{SD}$ | $V_{GS}$=0 V, $I_F$=10A | - | - | 1.4 | V |
| Reverse recovery time | $t_{rr}$ | $V_R$=50 V, $I_F$=20A, | - | 520 | - | ns |
| Reverse recovery charge | $Q_{rr}$ | $dI_F/dt$=100 A/μs | - | 5.7 | - | μC |
| Peak reverse recovery current | $I_{rrm}$ | | - | 19 | - | A |

Notes:

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

2. $I_{AS}$ = 7A, $V_{DD}$ = 60V, $R_G$ = 25Ω, Starting $T_J$ = 25°C

## Electrical Characteristics Diagrams

Figure 1. On-Region Characteristics

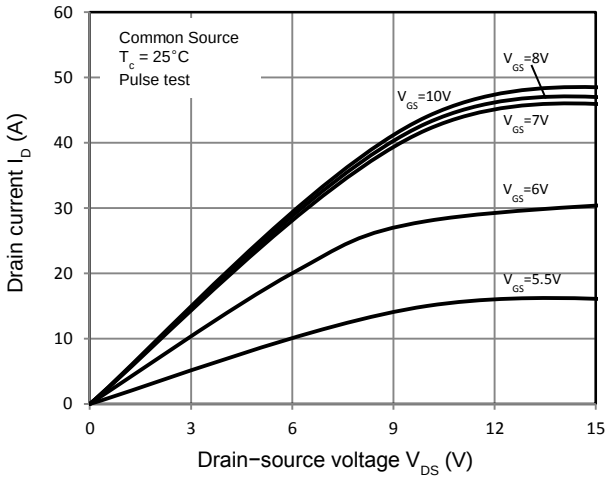



Figure 2. Transfer Characteristics

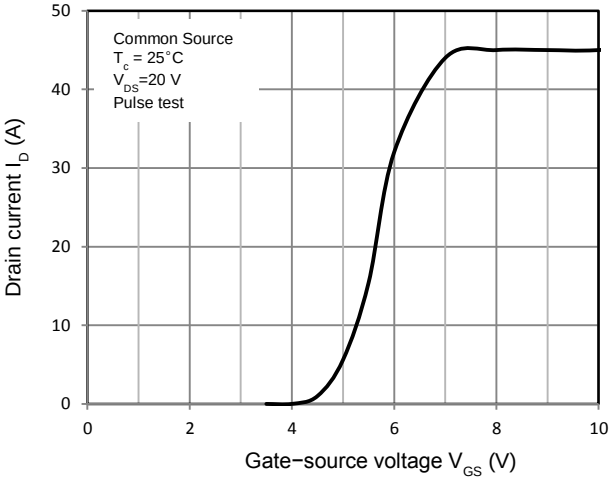



Figure 3. On-Resistance Variation vs. Drain Current

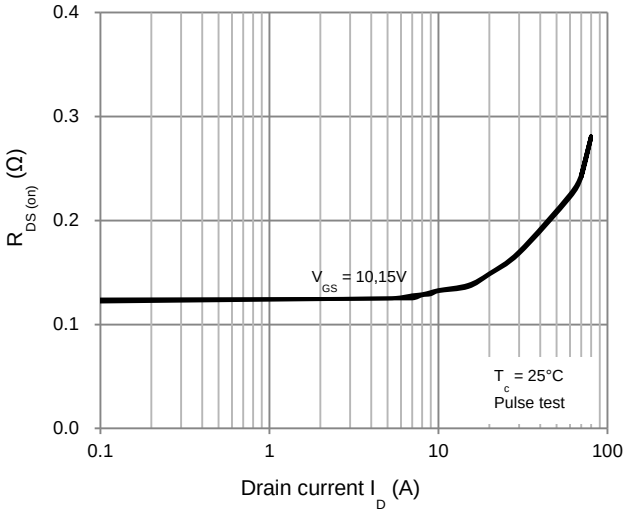



Figure 4. Threshold Voltage vs. Temperature

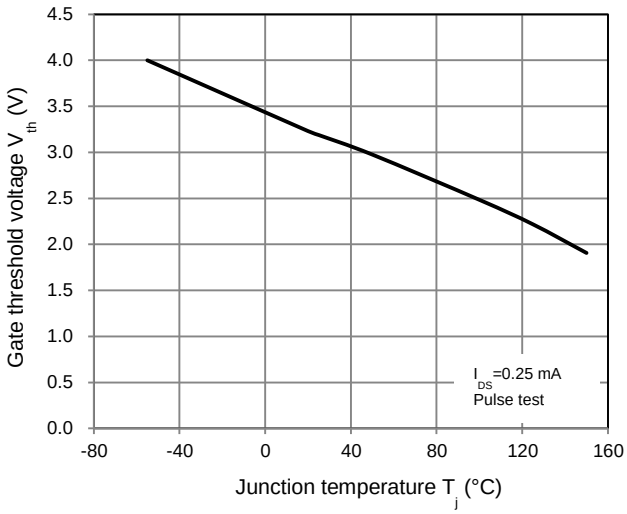



Figure 5. Breakdown Voltage vs. Temperature

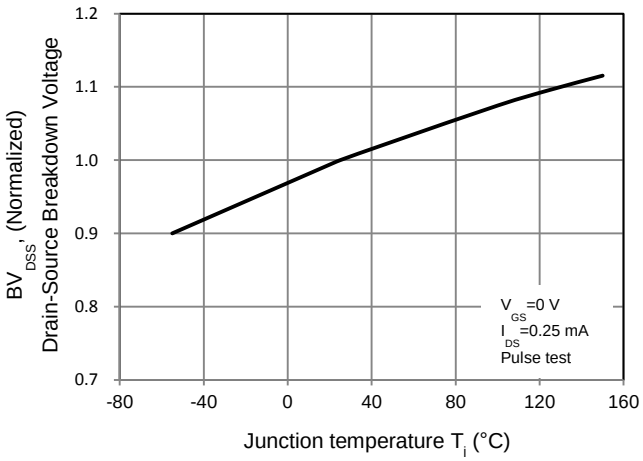



Figure 6. On-Resistance vs. Temperature

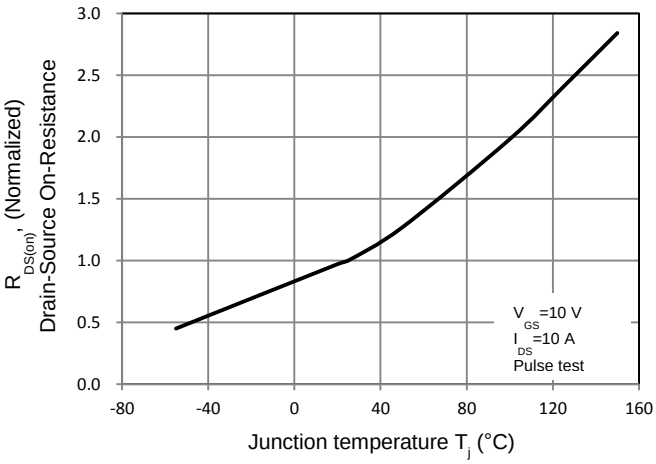


Figure 7. Capacitance Characteristics

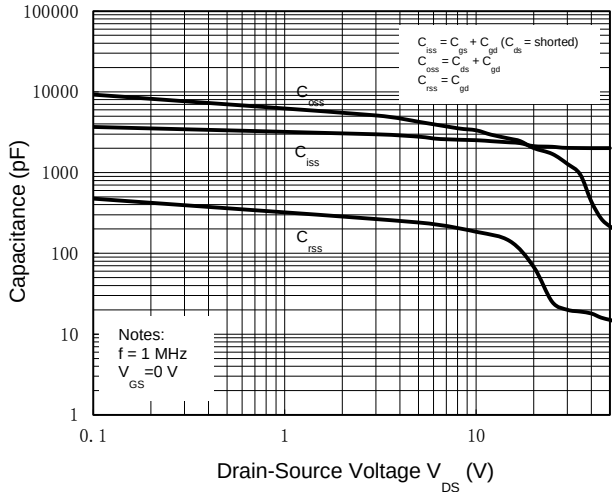



Figure 8. Gate Charge Characteristics

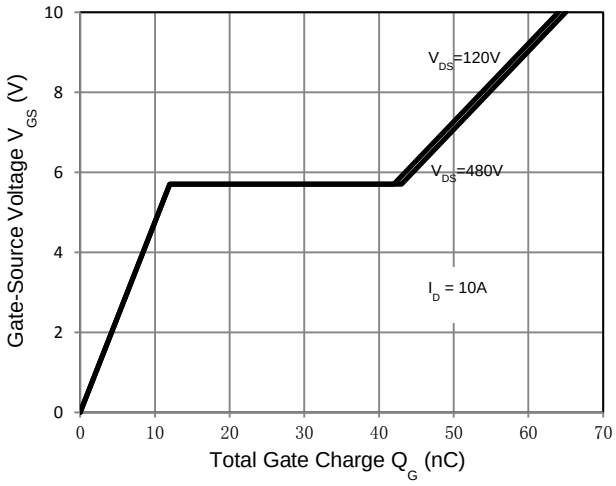



Figure 9. Maximum Safe Operating Area
VSP652015A2, VSQ652015A2

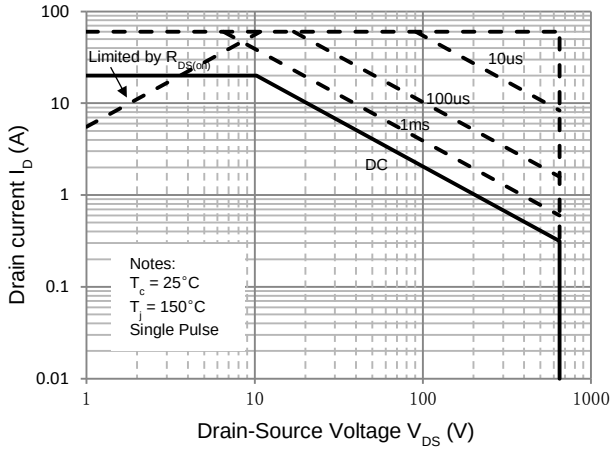



Figure 10. Power Dissipation vs. Temperature
VSP652015A2, VSQ652015A2

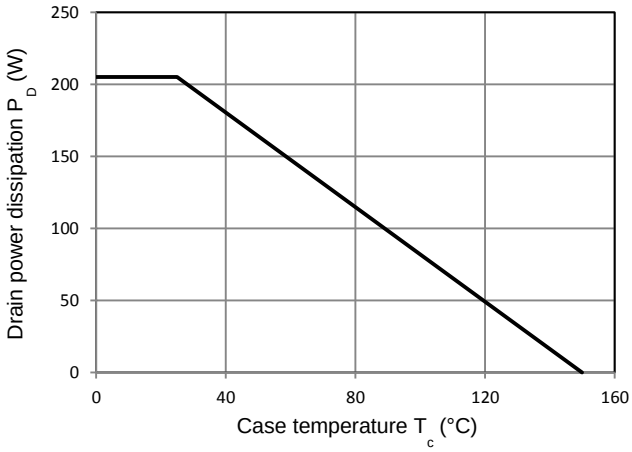
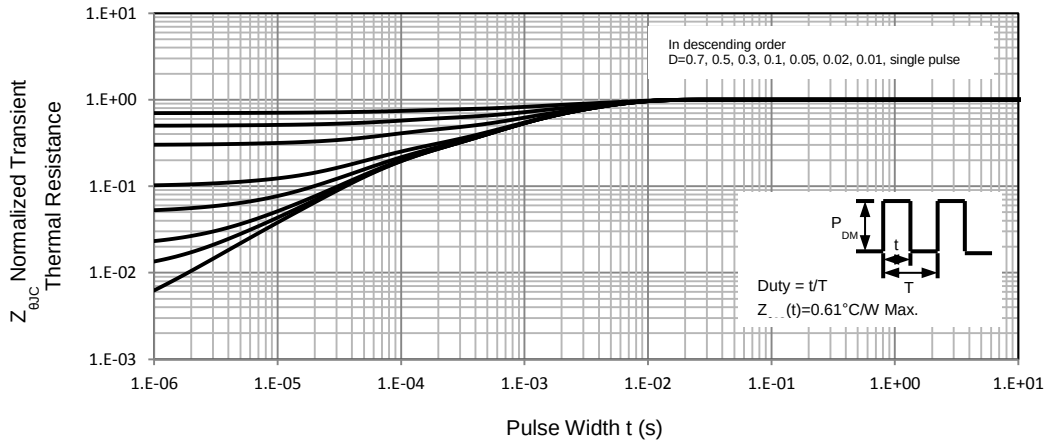
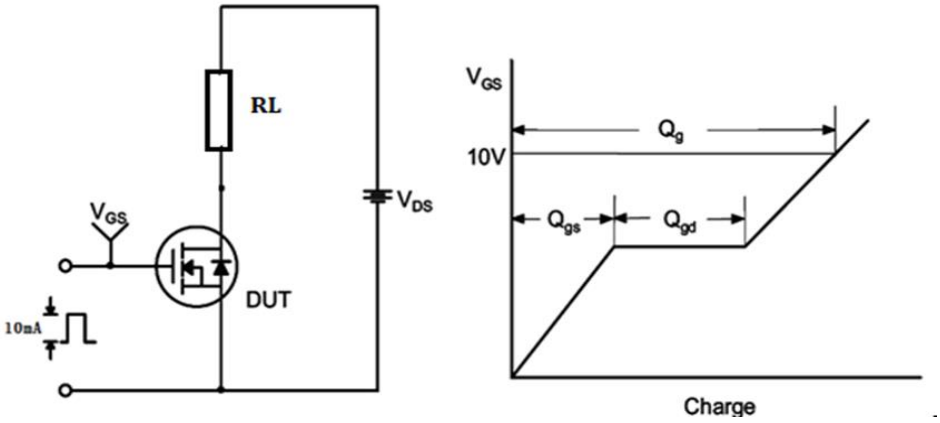


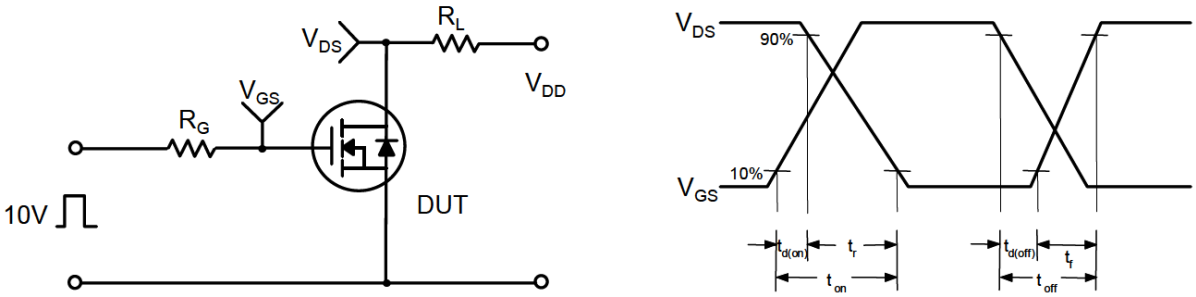

Figure 11. Transient Thermal Response Curve
VSP652015A2, VSQ652015A2



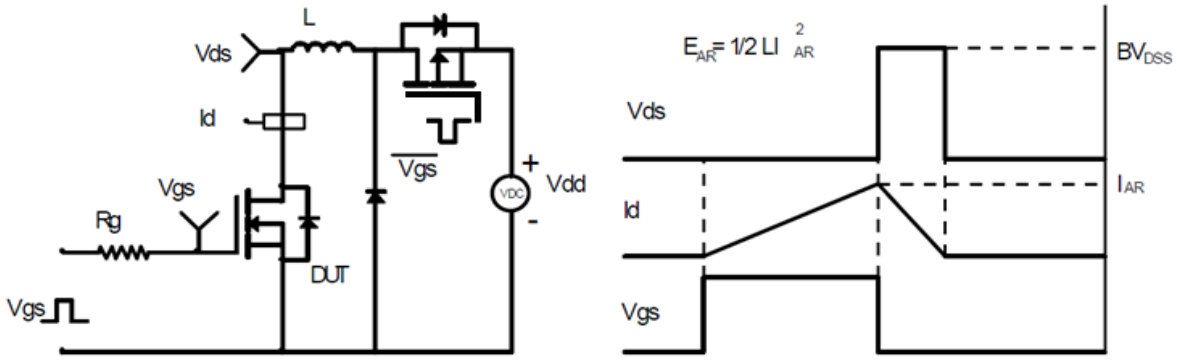
## Gate Charge Test Circuit & Waveform



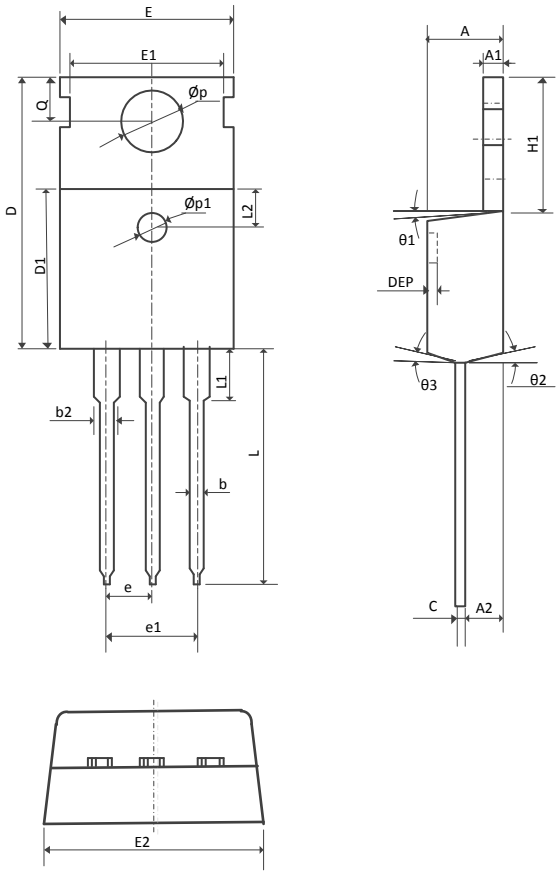

## Switching Test Circuit & Waveforms




## Unclamped Inductive Switching Test Circuit & Waveforms



## Mechanical Dimensions for TO-220




| COMMON DIMENSIONS | | | | | | |
|---|---|---|---|---|---|---|
| SYMBOL | MM | | | INCH | | |
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | 4.40 | 4.57 | 4.70 | 0.173 | 0.180 | 0.185 |
| A1 | 1.27 | 1.30 | 1.37 | 0.050 | 0.051 | 0.054 |
| A2 | 2.35 | 2.40 | 2.50 | 0.091 | 0.094 | 0.098 |
| b | 0.77 | 0.80 | 0.90 | 0.030 | 0.031 | 0.035 |
| b2 | 1.17 | 1.27 | 1.36 | 0.046 | 0.050 | 0.054 |
| c | 0.48 | 0.50 | 0.56 | 0.019 | 0.020 | 0.022 |
| D | 15.40 | 15.60 | 15.80 | 0.606 | 0.614 | 0.622 |
| D1 | 9.00 | 9.10 | 9.20 | 0.354 | 0.358 | 0.362 |
| DEP | 0.05 | 0.10 | 0.20 | 0.002 | 0.004 | 0.008 |
| E | 9.80 | 10.00 | 10.20 | 0.386 | 0.394 | 0.402 |
| E1 | – | 8.70 | – | – | 0.343 | – |
| E2 | 9.80 | 10.00 | 10.20 | 0.386 | 0.394 | 0.401 |
| Øp1 | 1.40 | 1.50 | 1.60 | 0.055 | 0.059 | 0.063 |
| e | 2.54BSC | | | 0.1BSC | | |
| e1 | 5.08BSC | | | 0.2BSC | | |
| H1 | 6.40 | 6.50 | 6.60 | 0.252 | 0.256 | 0.260 |
| L | 12.75 | 13.50 | 13.65 | 0.502 | 0.531 | 0.537 |
| L1 | – | 3.10 | 3.30 | – | 0.122 | 0.130 |
| L2 | | 2.50REF | | | 0.098REF | |
| Øp | 3.50 | 3.60 | 3.63 | 0.137 | 0.142 | 0.143 |
| Q | 2.73 | 2.80 | 2.87 | 0.107 | 0.110 | 0.116 |
| θ1 | 5° | 7° | 9° | 5° | 7° | 9° |
| θ2 | 1° | 3° | 5° | 1° | 3° | 5° |
| θ3 | 1° | 3° | 5° | 1° | 3° | 5° |

## Revision History

| Date | Revision | Changes |
|---|---|---|
| 2012-5-9 | 2.0 | First release |
| 2012-12-10 | 2.1 | Updated page header |
| 2013-1-9 | 2.2 | Fixed display error in Mac OS environment |
| 2013-10-25 | 2.3 | Updated the parameters of turn on/turn off, Qg, Qg chart and test condition |
| 2013-11-6 | 2.4 | Revised label marks of figure 4-6 |
| 2013-11-22 | 2.5 | Changed label $T_c$ to $T_j$ in figure 4-6. Unified the display format of $R_{DS(on)}$. |