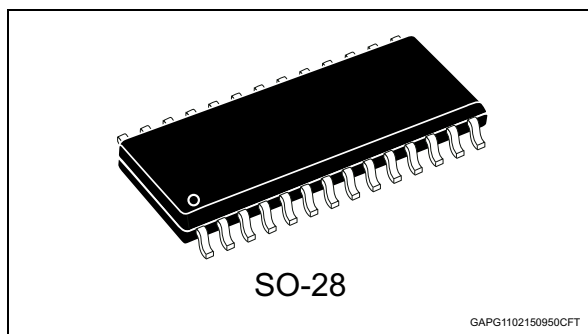


Quad smart power solid state relay for complete H-bridge configurations

Datasheet - production data



Description

The VN771KP-E is a device formed by three monolithic chips housed in a standard SO-28 package: a double high-side and two low-side switches. Both the double high-side and low-side switches are made using STMicroelectronics VIPower[®] M0-3 Technology.

This device is suitable to drive a DC motor in a bridge configuration as well as to be used as a quad switch for any low voltage application.

The dual high-side switches have built-in thermal shutdown to protect the chips from overtemperature and current limiter blocks to protect the device from short circuit. Status output is provided to indicate open-load in OFF and ON-state and overtemperature.

The low-side switches are two OMNIFET II types (fully auto protected Power MOSFET in VIPower technology). They have built-in thermal shutdown, linear current limitation and overvoltage clamping. Fault feedback for thermal intervention can be detected by monitoring the voltage at the input pin.

Features

| Type | R _{DS(on)} | I _{OUT} | V _{CC} |
|-----------|----------------------|--------------------|-----------------|
| VN771KP-E | 95 mΩ ⁽¹⁾ | 9 A ⁽²⁾ | 36 V |

1. Total resistance of one side in bridge configuration
2. Typical current limitation value

- ECOPACK[®]: lead free and RoHS compliant
- Automotive Grade: compliant with AEC guidelines
- Suited as low voltage bridge
- Linear current limitation
- Very low standby power dissipation
- Short circuit protected
- Status flag diagnostic (open drain)
- Integrated clamping circuits
- Undervoltage protection
- ESD protection

Table 1. Device summary

| Package | Order codes | |
|---------|-------------|---------------|
| | Tube | Tape and reel |
| SO-28 | VN771KP-E | VN771KPTR-E |

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1 Block diagrams and pins descriptions

Figure 1. Block diagram

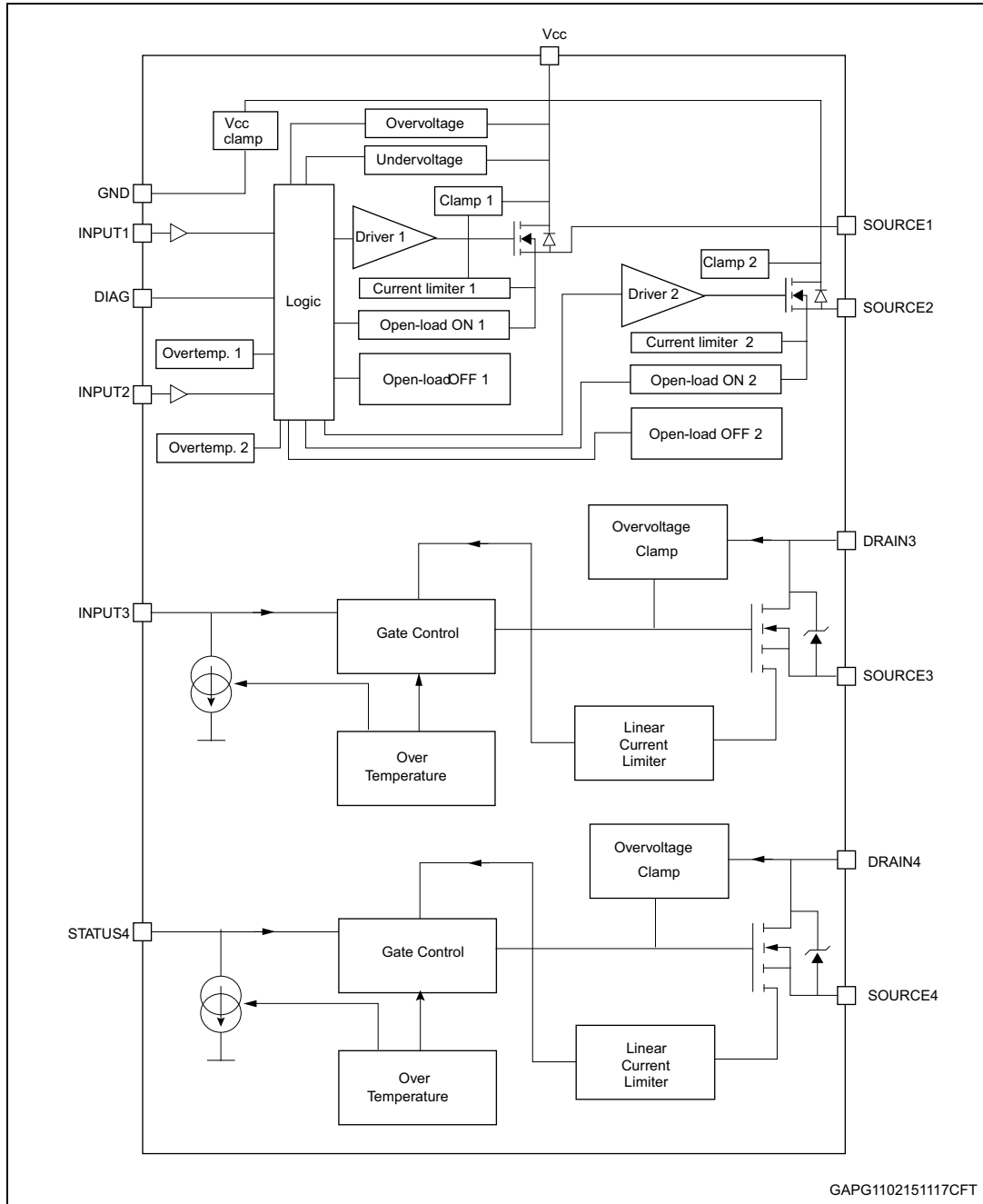
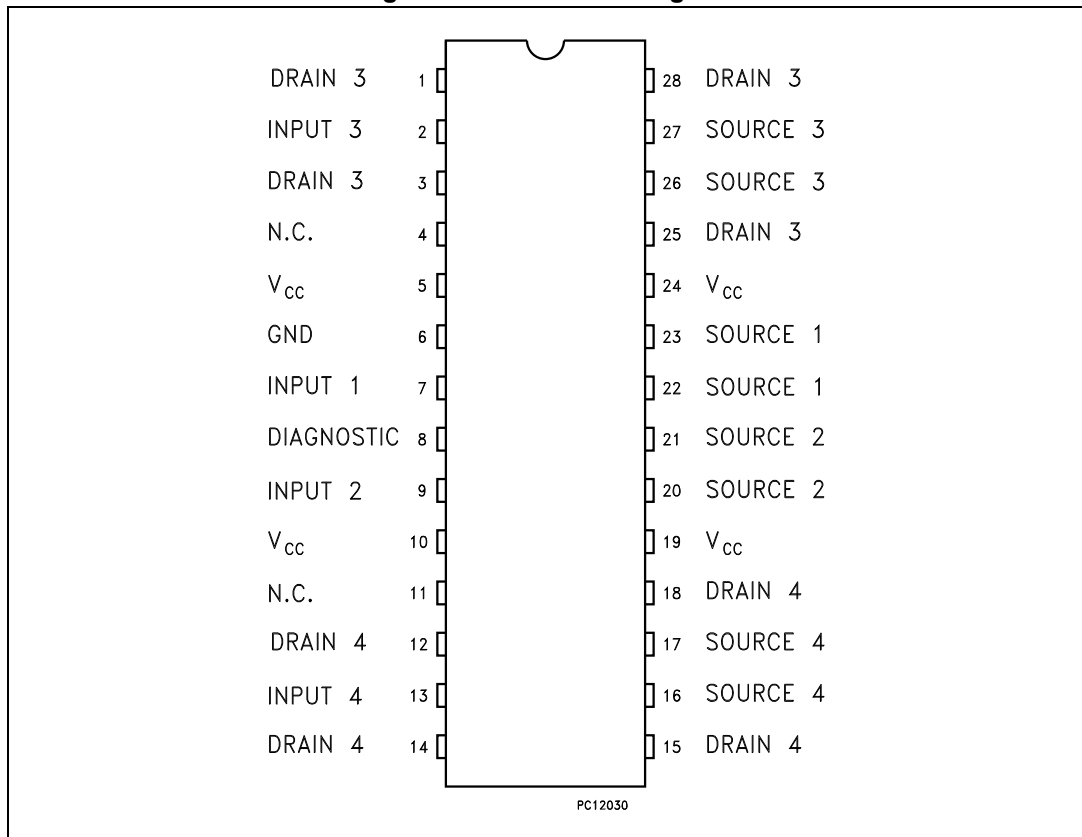


Table 2. Pin definition and function

| No | Name | Function |
|----------------|-----------------|---|
| 1, 3, 25, 28 | DRAIN 3 | Drain of switch 3 (low-side switch) |
| 2 | INPUT 3 | Input of switch 3 (low-side switch) |
| 4, 11 | N.C. | Not connected |
| 5, 10, 19, 24 | V _{CC} | Drain of switches 1 and 2 (high-side switches) and power supply voltage |
| 6 | GND | Ground of switches 1 and 2 (high-side switches) |
| 7 | INPUT 1 | Input of switch 1 (high-side switches) |
| 8 | DIAGNOSTIC | Diagnostic of switches 1 and 2 (high-side switches) |
| 9 | INPUT 2 | Input of switch 2 (high-side switch) |
| 12, 14, 15, 18 | DRAIN 4 | Drain of switch 4 (low-side switch) |
| 13 | INPUT 4 | Input of switch 4 (low-side switch) |
| 16, 17 | SOURCE 4 | Source of switch 4 (low-side switch) |
| 20, 21 | SOURCE 2 | Source of switch 2 (high-side switch) |
| 22, 23 | SOURCE 1 | Source of switch 1 (high-side switch) |
| 26, 27 | SOURCE 3 | Source of switch 3 (low-side switch) |

Figure 2. Connection diagram



2 Electrical specifications

2.1 Thermal data

Table 3. Thermal data

| Symbol | Parameter | Value max (°C/W) |
|----------------|--|-------------------------------|
| $R_{thj-case}$ | Thermal resistance junction-case (high side switch) | 20 |
| $R_{thj-case}$ | Thermal resistance junction-case (low side switch) | 20 |
| $R_{thj-amb}$ | Thermal resistance junction-ambient (with 6 cm ² of Cu heat sink) | See Figure 49 |

2.2 Absolute maximum ratings

Table 4. Dual high-side switch

| Symbol | Parameter | Value | Unit |
|------------|---|--------------------|------|
| V_{CC} | DC supply voltage | 41 | V |
| $-V_{CC}$ | Reverse DC supply voltage | -0.3 | V |
| $-I_{GND}$ | DC reverse ground pin current | -200 | mA |
| I_{OUT} | DC output current | Internally limited | A |
| $-I_{OUT}$ | Reverse DC output current | -6 | A |
| I_{IN} | DC input current | ±10 | mA |
| I_{STAT} | DC status current | ±10 | mA |
| V_{ESD} | Electrostatic discharge (human body model: R = 1.5 kΩ; C = 100 pF) | | |
| | – Input | 4000 | V |
| | – Status | 4000 | V |
| | – Output | 5000 | V |
| | – VCC | 5000 | V |
| P_{tot} | Power dissipation (T _c = 25 °C) | 6 | W |
| T_j | Junction operating temperature | Internally limited | °C |
| T_c | Case operating temperature | -40 to 150 | °C |
| T_{stg} | Storage temperature | -55 to 150 | °C |

Table 5. Low-side switch

| Symbol | Parameter | Value | Unit |
|----------|--|--------------------|------|
| V_{DS} | Drain source voltage (V _{IN} = 0 V) | Internally clamped | V |
| V_{IN} | Input voltage | Internally clamped | V |
| I_{IN} | Input current | ±20 | mA |

Table 5. Low-side switch (continued)

| Symbol | Parameter | Value | Unit |
|---------------|--|--------------------|----------|
| $R_{IN\ MIN}$ | Minimum input series impedance | 10 | Ω |
| I_D | Drain current | Internally limited | A |
| I_R | Reverse DC output current | -15 | A |
| V_{ESD1} | Electrostatic discharge (R = 1.5 K Ω , C = 100 pF) | 4000 | V |
| V_{ESD2} | Electrostatic discharge on output pin only (human body model: R = 330 Ω , C = 150 pF) | 5000 | V |
| P_{tot} | Power dissipation (T _c = 25 °C) | 6 | W |
| T_j | Operating junction temperature | Internally limited | °C |
| T_c | Case operating temperature | Internally limited | °C |
| T_{stg} | Storage temperature | -55 to 150 | °C |

2.3 Electrical characteristics for dual high side switch

8 V < V_{CC} < 36 V; -40 °C < T_j < 150 °C, unless otherwise specified.

Table 6. Power outputs (for each channel)

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|-----------------|--------------------------|---|-----|-----|-----|------------|
| $V_{CC}^{(1)}$ | Operating supply voltage | | 5.5 | 13 | 36 | V |
| $V_{USD}^{(1)}$ | Undervoltage shutdown | | 3 | 4 | 5.5 | V |
| $V_{OV}^{(1)}$ | Overvoltage shutdown | | 36 | | | V |
| R_{ON} | On-state resistance | $I_{OUT} = 2\ A; T_j = 25\ ^\circ C$ | | | 60 | m Ω |
| | | $I_{OUT} = 2\ A; V_{CC} > 8\ V$ | | | 120 | m Ω |
| $I_S^{(1)}$ | Supply current | Off-state; $V_{CC} = 13\ V;$ $V_{IN} = V_{OUT} = 0\ V$ | | 12 | 40 | μA |
| | | Off-state; $V_{CC} = 13\ V;$ $V_{IN} = V_{OUT} = 0\ V; T_j = 25\ ^\circ C$ | | 12 | 25 | μA |
| | | On-state; $V_{CC} = 13\ V$ | | 5 | 7 | mA |
| $I_{L(off1)}$ | Off-state output current | $V_{IN} = V_{OUT} = 0\ V; V_{CC} = 36\ V;$ $T_j = 125\ ^\circ C$ | 0 | | 50 | μA |
| $I_{L(off2)}$ | Off-state output current | $V_{IN} = 0\ V; V_{OUT} = 3.5\ V$ | -75 | | 0 | μA |
| $I_{L(off3)}$ | Off-state output current | $V_{IN} = V_{OUT} = 0\ V; V_{CC} = 13\ V;$ $T_j = 125\ ^\circ C$ | | | 5 | μA |
| $I_{L(off4)}$ | Off-state output current | $V_{IN} = V_{OUT} = 0\ V; V_{CC} = 13\ V;$ $T_j = 25\ ^\circ C$ | | | 3 | μA |

1. For device.

Table 7. Switching (for each channel) ($V_{CC} = 13V$)

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|-----------------------|------------------------|---|-----|-----|-----|-----------|
| $t_{d(on)}$ | Turn-on delay time | $R_L = 6.5 \Omega$ from V_{IN} rising edge to $V_{OUT} = 1.3 V$ | — | 30 | — | μs |
| $t_{d(off)}$ | Turn-off delay time | $R_L = 6.5 \Omega$ from V_{IN} falling edge to $V_{OUT} = 11.7 V$ | — | 30 | — | μs |
| $dV_{OUT}/dt_{(on)}$ | Turn-on voltage slope | $R_L = 6.5 \Omega$ from $V_{OUT} = 1.3 V$ to $V_{OUT} = 10.4 V$ | — | (1) | — | $V/\mu s$ |
| $dV_{OUT}/dt_{(off)}$ | Turn-off voltage slope | $R_L = 6.5 \Omega$ from $V_{OUT} = 11.7 V$ to $V_{OUT} = 1.3 V$ | — | (1) | — | $V/\mu s$ |

1. See relative diagram.

Table 8. Logic input (for each channel)

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|---------------|--------------------------|-------------------|------|------|------|---------|
| V_{IL} | Input low level | | | | 1.25 | V |
| I_{IL} | Low level input current | $V_{IN} = 1.25 V$ | 1 | | | μA |
| V_{IH} | Input high level | | 3.25 | | | V |
| I_{IH} | High level input current | $V_{IN} = 3.25 V$ | | | 10 | μA |
| $V_{I(hyst)}$ | Input hysteresis voltage | | 0.5 | | | V |
| V_{ICL} | Input clamp voltage | $I_{IN} = 1 mA$ | 6 | 6.8 | 8 | V |
| | | $I_{IN} = -1 mA$ | | -0.7 | | V |

Table 9. Status pin (for each channel)

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|-------------|------------------------------|------------------------------------|-----|------|-----|---------|
| V_{STAT} | Status low output voltage | $I_{STAT} = 1.6 mA$ | | | 0.5 | V |
| I_{LSTAT} | Status leakage current | Normal operation; $V_{STAT} = 5 V$ | | | 10 | μA |
| C_{STAT} | Status pin input capacitance | Normal operation; $V_{STAT} = 5 V$ | | | 100 | pF |
| V_{SCL} | Status clamp voltage | $I_{STAT} = 1 mA$ | 6 | 6.8 | 8 | V |
| | | $I_{STAT} = -1 mA$ | | -0.7 | | V |

Table 10. Protections (for each channel)

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|------------|-------------------------------------|-----------------|-----|-----|-----|-------------|
| T_{TSD} | Shutdown temperature | | 150 | 175 | 200 | $^{\circ}C$ |
| T_R | Reset temperature | | 135 | | | $^{\circ}C$ |
| T_{hyst} | Thermal hysteresis | | 7 | 15 | | $^{\circ}C$ |
| t_{SDL} | Status delay in overload conditions | $T_j > T_{TSD}$ | | | 20 | μs |

Table 10. Protections (for each channel) (continued)

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|-------------|-------------------------------|---|-------------|-------------|-------------|------|
| I_{lim} | Current limitation | | 6 | 9 | 15 | A |
| | | $T_j = 125\text{ °C}$ | 8.5 | | 15 | A |
| | | $5.5\text{ V} < V_{CC} < 36\text{ V}$ | | | 15 | A |
| V_{demag} | Turn-off output clamp voltage | $I_{OUT} = 2\text{ A}; L = 6\text{ mH}$ | $V_{CC}-41$ | $V_{CC}-48$ | $V_{CC}-55$ | V |

Note: To ensure long term reliability under heavy overload or short circuit conditions, protection and related diagnostic signals must be used together with a proper software strategy. If the device is subjected to abnormal conditions, this software must limit the duration and number of activation cycles.

Table 11. Open-load detection (for each channel)

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|----------------|---|------------------------|-----|-----|------|---------------|
| I_{OL} | Open-load on-state detection threshold | $V_{IN} = 5\text{ V}$ | 50 | 100 | 200 | mA |
| $t_{DOL(on)}$ | Open-load on-state detection delay | $I_{OUT} = 0\text{ A}$ | | | 200 | μs |
| V_{OL} | Open-load off-state voltage detection threshold | $V_{IN} = 0\text{ V}$ | 1.5 | 2.5 | 3.5 | V |
| $t_{DOL(off)}$ | Open-load detection delay at turn-off | | | | 1000 | μs |

2.4 Electrical characteristics for low side switches

$-40\text{ °C} < T_j < 150\text{ °C}$, unless otherwise specified.

Table 12. Off-state

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|-------------|--|---|------|-----|------|---------------|
| V_{CLAMP} | Drain source clamp voltage | $V_{IN} = 0\text{ V}; I_D = 7\text{ A}$ | 40 | 45 | 55 | V |
| V_{CLTH} | Drain source clamp threshold voltage | $V_{IN} = 0\text{ V}; I_D = 2\text{ mA}$ | 36 | | | V |
| V_{INTH} | Input threshold voltage | $V_{DS} = V_{IN}; I_D = 1\text{ mA}$ | 0.5 | | 2.5 | V |
| I_{ISS} | Supply current from input pin | $V_{DS} = 0\text{ V}; V_{IN} = 5\text{ V}$ | | 100 | 150 | μA |
| V_{INCL} | Input-source clamp voltage | $I_{IN} = 1\text{ mA}$ | 6 | 6.8 | 8 | V |
| | | $I_{IN} = -1\text{ mA}$ | -1.0 | | -0.3 | V |
| I_{DSS} | Zero input voltage drain current ($V_{IN} = 0\text{ V}$) | $V_{DS} = 13\text{ V}; V_{IN} = 0\text{ V}; T_j = 25\text{ °C}$ | | | 30 | μA |
| | | $V_{DS} = 25\text{ V}; V_{IN} = 0\text{ V}$ | | | 75 | μA |

Table 13. On-state

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|--------------|-----------------------------------|---|-----|-----|-----|------------|
| $R_{DS(on)}$ | Static drain source on resistance | $V_{IN} = 5\text{ V}; I_D = 7\text{ A}; T_j = 25\text{ °C}$ | — | — | 35 | m Ω |
| | | $V_{IN} = 5\text{ V}; I_D = 7\text{ A}$ | — | — | 70 | m Ω |

$T_j = 25\text{ °C}$, unless otherwise specified.

Table 14. Dynamic

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|----------------|---------------------------|---|-----|-----|-----|------|
| $g_{fs}^{(1)}$ | Forward trans conductance | $V_{DD} = 13\text{ V}; I_D = 7\text{ A}$ | — | 18 | — | S |
| C_{OSS} | Output capacitance | $V_{DS} = 13\text{ V}; f = 1\text{ MHz}; V_{IN} = 0\text{ V}$ | — | 400 | — | pF |

1. Pulsed: Pulse duration = 300 μs , duty cycle 1.5 %.

Table 15. Switching

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|----------------|-----------------------|--|-----|------|------|------------------|
| $t_{d(on)}$ | Turn-on delay time | $V_{DD} = 15\text{ V}; I_D = 7\text{ A}; V_{gen} = 5\text{ V}; R_{gen} = R_{IN\text{ MIN}} = 10\ \Omega$ | — | 80 | 250 | ns |
| t_r | Rise time | | — | 350 | 1000 | ns |
| $t_{d(off)}$ | Turn-off delay time | | — | 450 | 1350 | ns |
| t_f | Fall time | | — | 150 | 500 | ns |
| $t_{d(on)}$ | Turn-on delay time | $V_{DD} = 15\text{ V}; I_D = 7\text{ A}; V_{gen} = 5\text{ V}; R_{gen} = 2.2\text{ k}\Omega$ | — | 1.5 | 4.5 | μs |
| t_r | Rise time | | — | 9.7 | 30 | μs |
| $t_{d(off)}$ | Turn-off delay time | | — | 9 | 25 | μs |
| t_f | Fall time | | — | 10.2 | 30 | μs |
| $(di/dt)_{on}$ | Turn-on current slope | $V_{DD} = 15\text{ V}; I_D = 7\text{ A}; V_{gen} = 5\text{ V}; R_{gen} = R_{IN\text{ MIN}} = 10\ \Omega$ | — | 16 | | A/ μs |
| Q_i | Total input charge | $V_{DD} = 12\text{ V}; I_D = 7\text{ A}; V_{IN} = 5\text{ V}; I_{gen} = 2.13\text{ mA}$ | — | 36.8 | | nC |

Table 16. Source drain diode

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|----------------|--------------------------|--|-----|------|-----|---------------|
| $V_{SD}^{(1)}$ | Forward on voltage | $I_{SD} = 7\text{ A}; V_{IN} = 0\text{ V}$ | — | 0.8 | — | V |
| t_{rr} | Reverse recovery time | $I_{SD} = 7\text{ A}; di/dt = 40\text{ A}/\mu\text{s}; V_{DD} = 30\text{ V}; L = 200\ \mu\text{H}$ | — | 300 | — | ns |
| Q_{rr} | Reverse recovery charge | | — | 0.80 | — | μC |
| I_{RRM} | Reverse recovery current | | — | 5 | — | A |

1. Pulsed: Pulse duration = 300 μs , duty cycle 1.5%.

-40 °C < T_j < 150 °C, unless otherwise specified.

Table 17. Protections

| Symbol | Parameter | Test conditions | Min | Typ | Max | Unit |
|-------------------|-------------------------------|---|-----|-----|-----|------|
| I _{lim} | Drain current limit | V _{IN} = 5 V; V _{DS} = 13 V | 12 | 18 | 24 | A |
| | | V _{IN} = 5 V; V _{DS} = 13 V; T _j = 125 °C | 15 | | 24 | A |
| t _{dlim} | Step response current limit | V _{IN} = 5 V; V _{DS} = 13 V | | 45 | | µs |
| T _{jsh} | Overtemperature shutdown | | 150 | 175 | | °C |
| T _{jrs} | Overtemperature reset | | 135 | | | °C |
| I _{gf} | Fault sink current | V _{IN} = 5 V; V _{DS} = 13 V; T _j = T _{jsh} | 10 | 15 | 20 | mA |
| E _{as} | Single pulse avalanche energy | starting T _j = 25 °C; V _{DD} = 24 V V _{IN} = 5 V; R _{gen} = R _{IN MIN} = 10 Ω; L = 24 mH | 400 | | | mJ |

2.5 Dual high-side switch timing data

Figure 3. Switching time waveforms

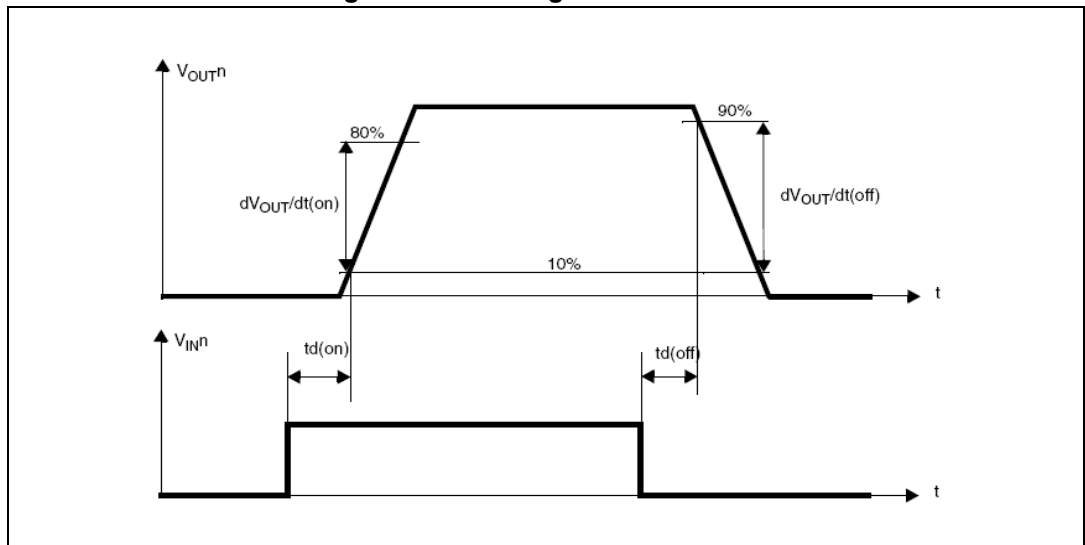


Table 18. Truth table

| Conditions | Input | Output | Status |
|---------------------------|-------|--------|--|
| Normal operation | L | L | H |
| | H | H | H |
| Current limitation | L | L | H |
| | H | X | ($T_j < T_{TSD}$) H ($T_j > T_{TSD}$) L |
| Over temperature | L | L | H |
| | H | L | L |
| Undervoltage | L | L | X |
| | H | L | X |
| Overvoltage | L | L | H |
| | H | L | H |
| Output voltage $> V_{OL}$ | L | H | L |
| | H | H | H |
| Output current $< I_{OL}$ | L | L | H |
| | H | H | L |

Figure 4. Open-load status timing (with external pull-up)

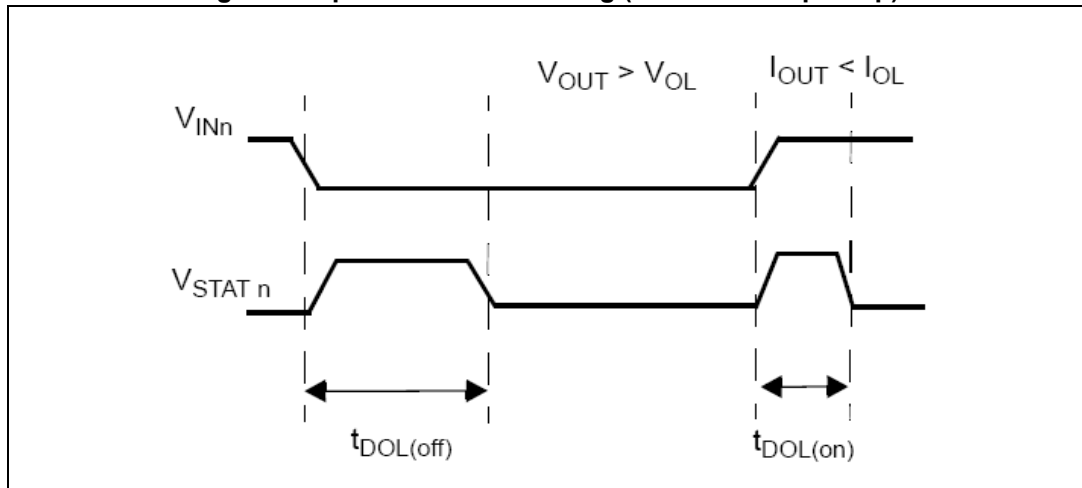
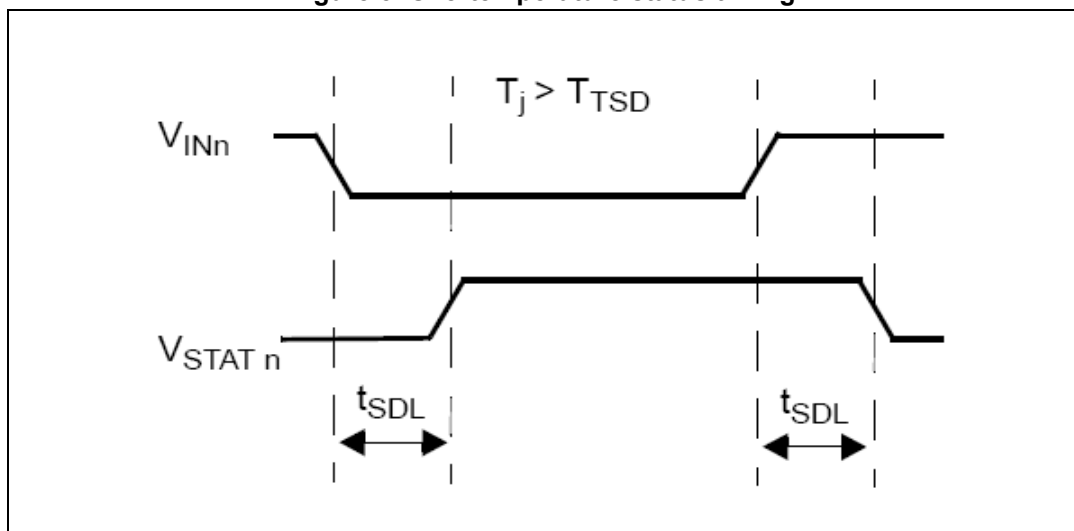
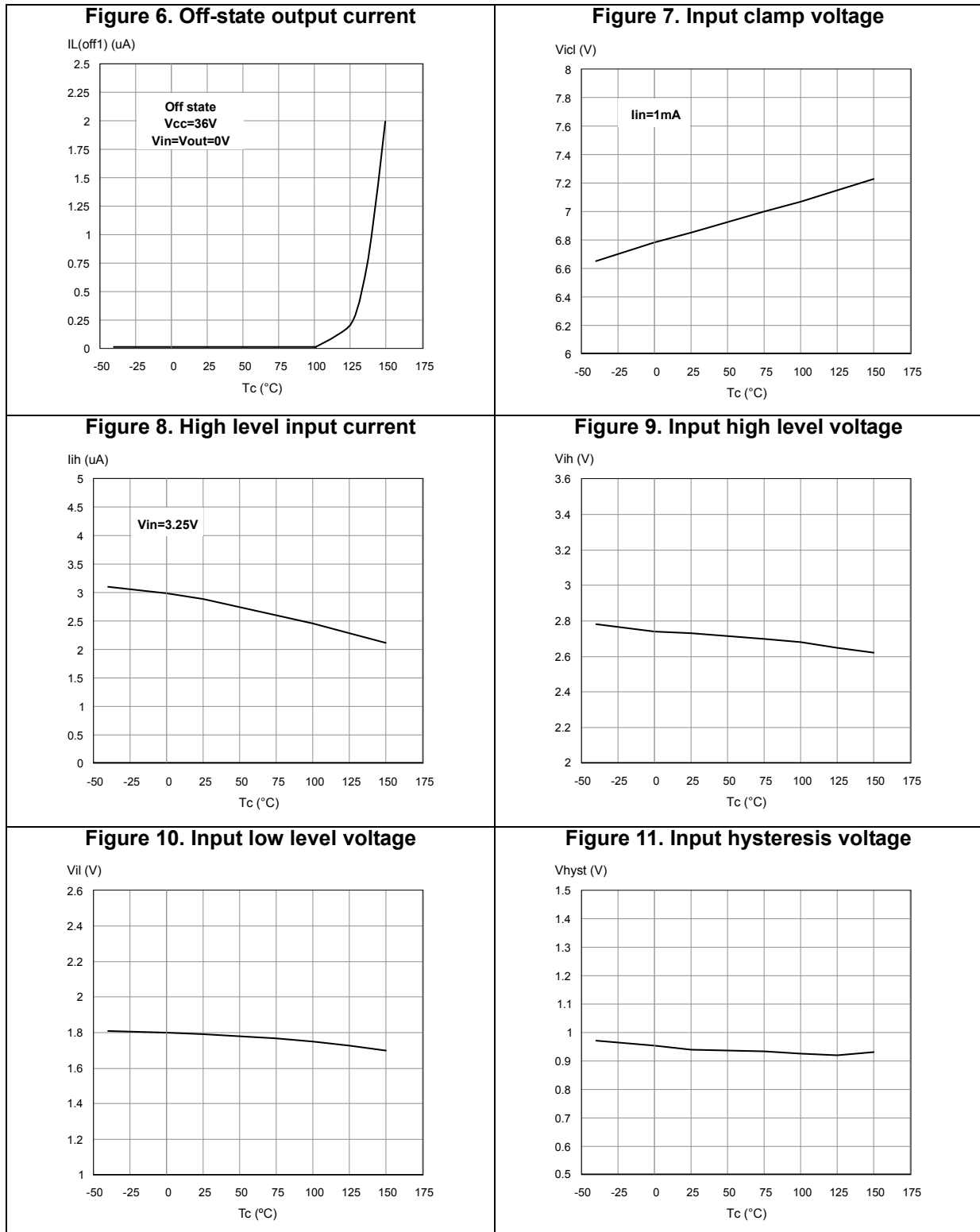


Figure 5. Overtemperature status timing



2.6 Electrical characterization for dual high-side switch



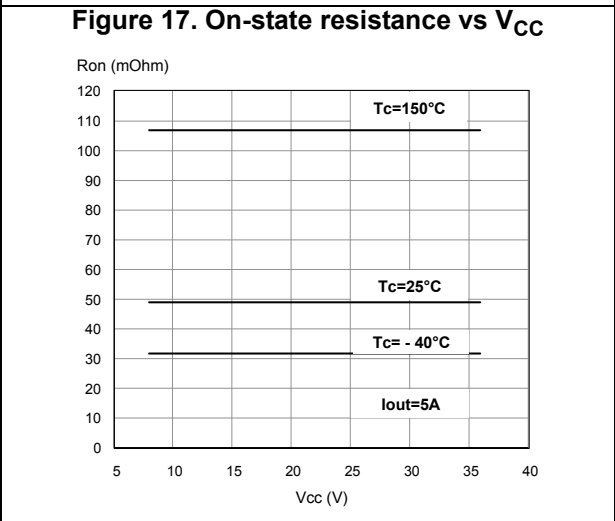
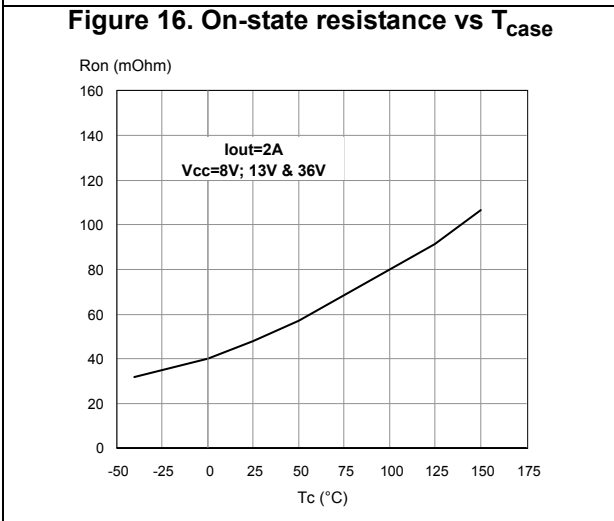
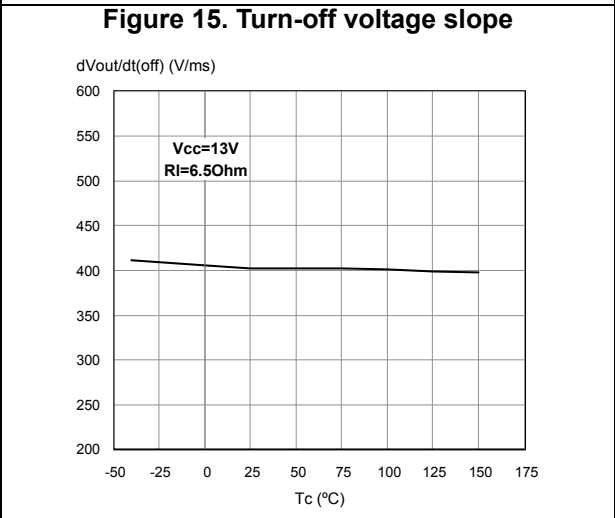
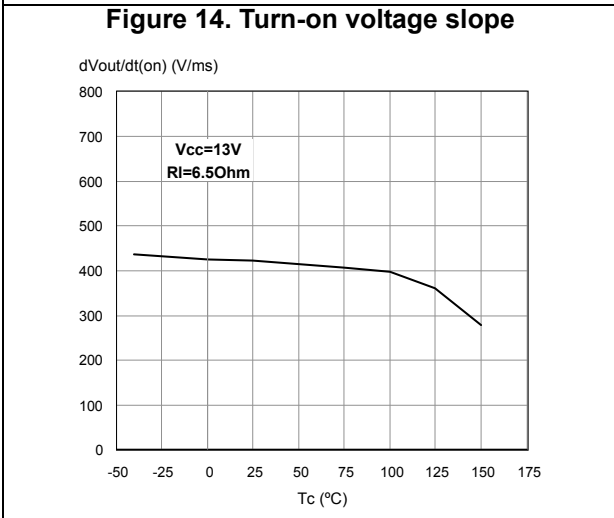
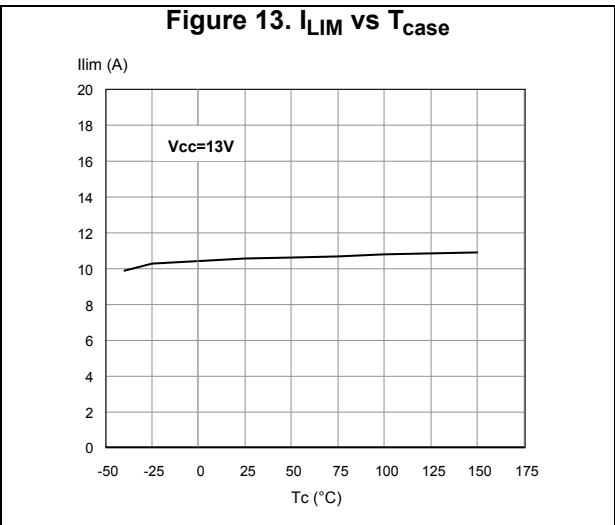
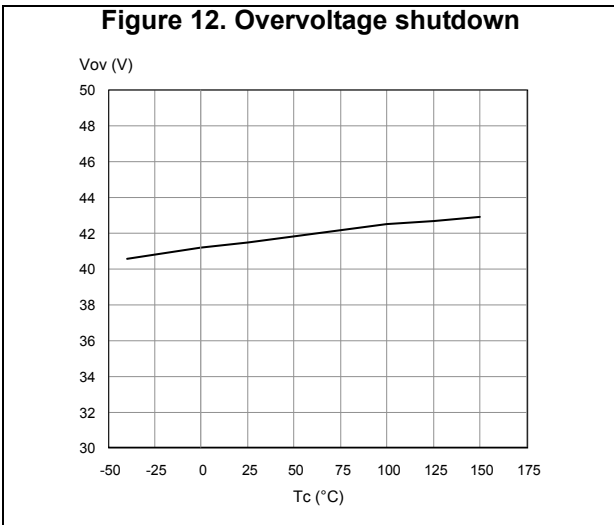


Figure 18. Status leakage current

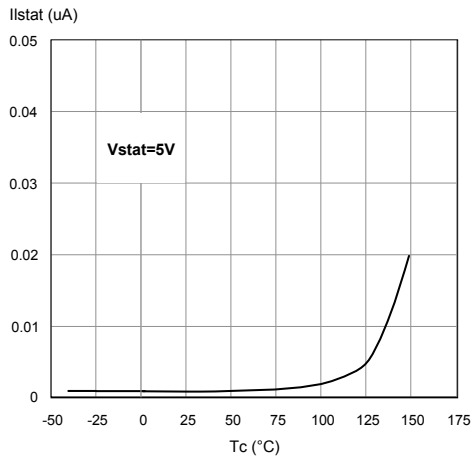


Figure 19. Status low output voltage

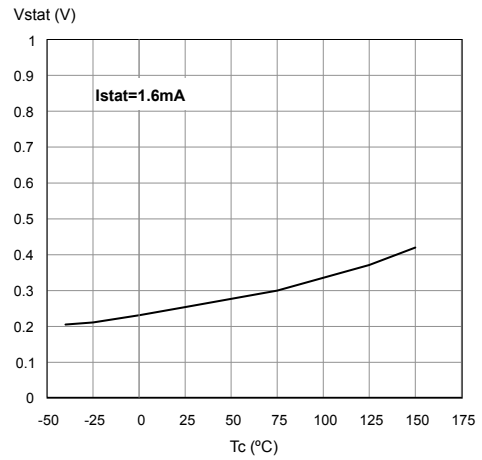


Figure 20. Open-load on-state detection threshold

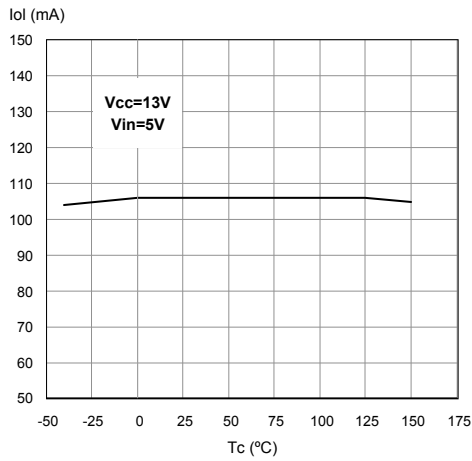


Figure 21. Open-load off-state voltage detection threshold

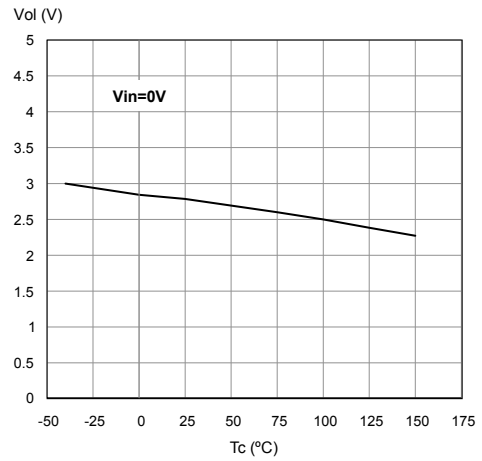
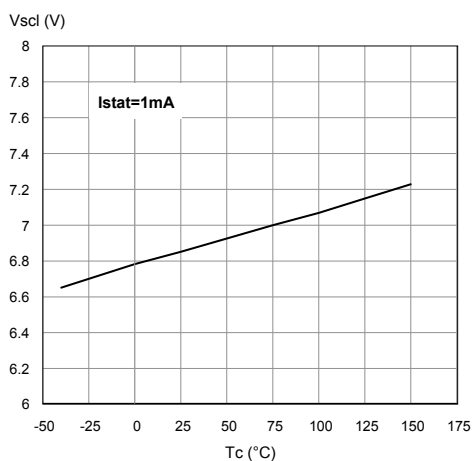


Figure 22. Status clamp voltage



2.7 Electrical characterization for low-side switches

Figure 23. Static drain source on resistance

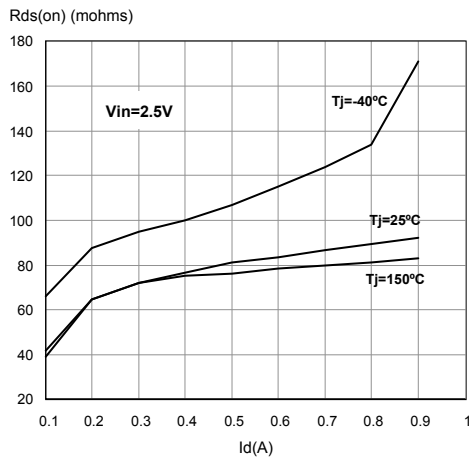


Figure 24. Derating curve

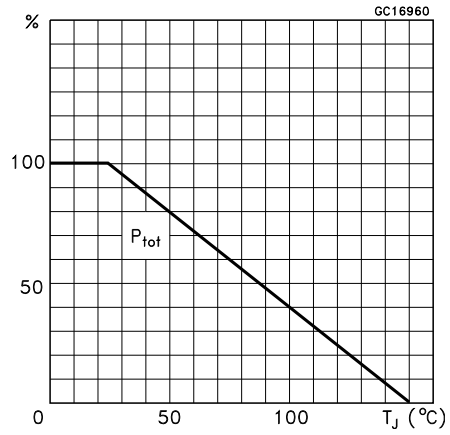


Figure 25. Transconductance

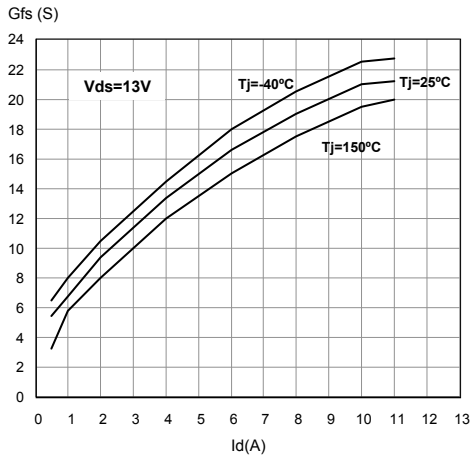


Figure 26. Transfer characteristics

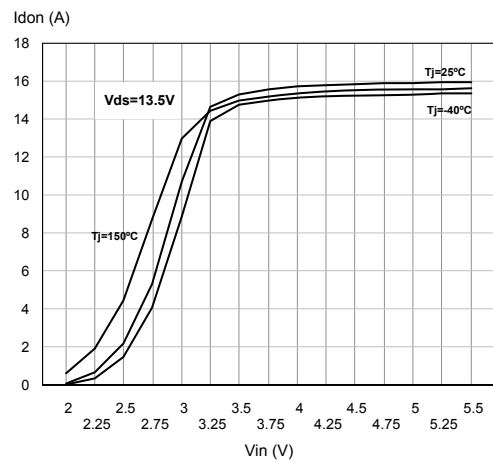


Figure 27. Turn-on current slope ($V_{IN} = 5 V$)

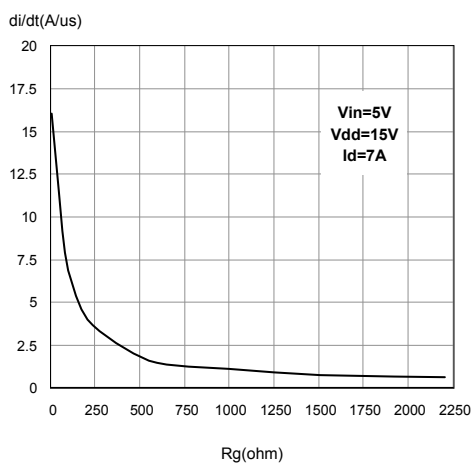


Figure 28. Turn-on current slope ($V_{IN} = 3.5 V$)

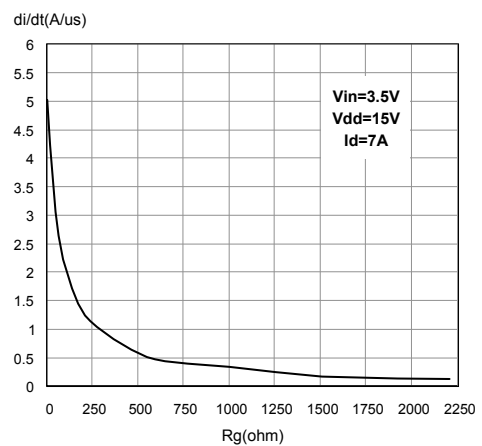


Figure 29. Input voltage vs input charge

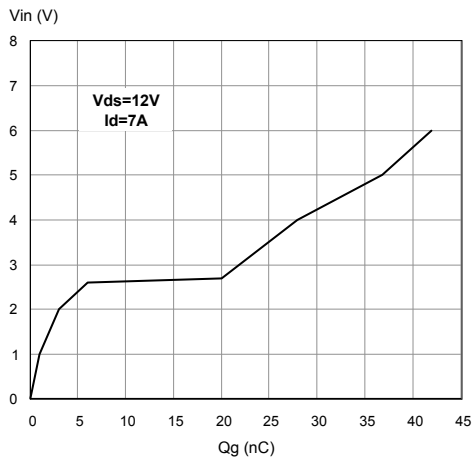


Figure 30. Capacitance variations

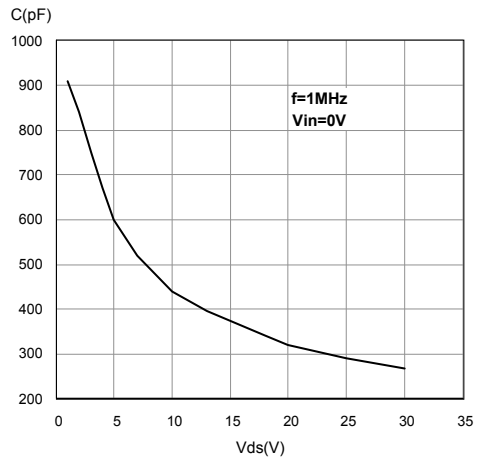


Figure 31. Switching time resistive load ($V_{IN} = 5 V$)

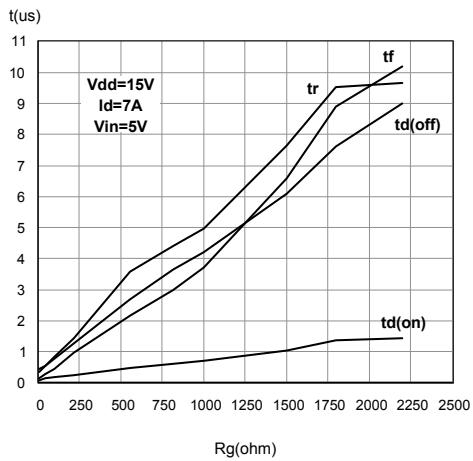


Figure 32. Switching time resistive load ($R_G = 10 \Omega$)

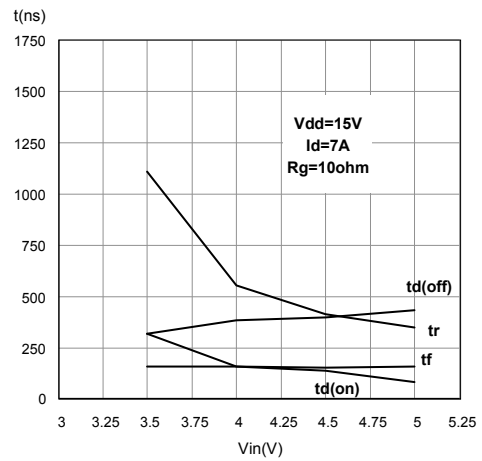


Figure 33. Output characteristics

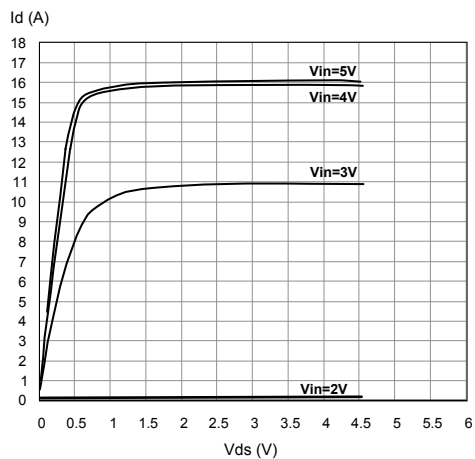


Figure 34. Step response current limit

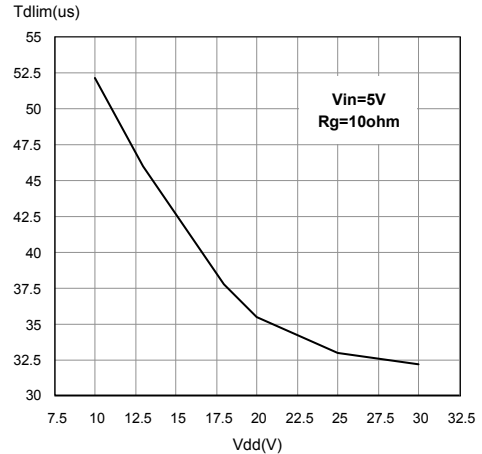


Figure 35. Source drain diode forward characteristics

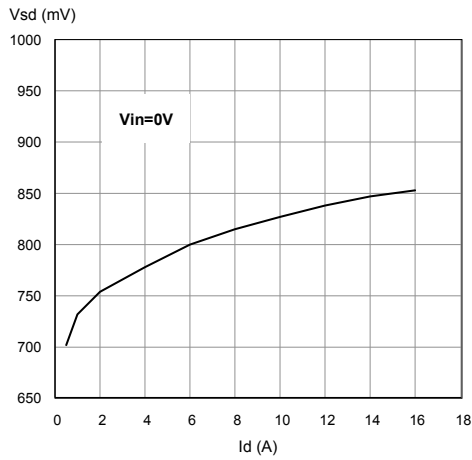


Figure 36. Static drain source on resistance vs I_D

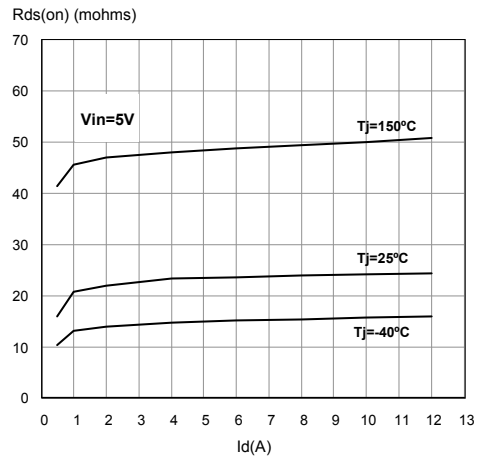


Figure 37. Static drain source on resistance vs input voltage ($I_D = 7\text{ A}$)

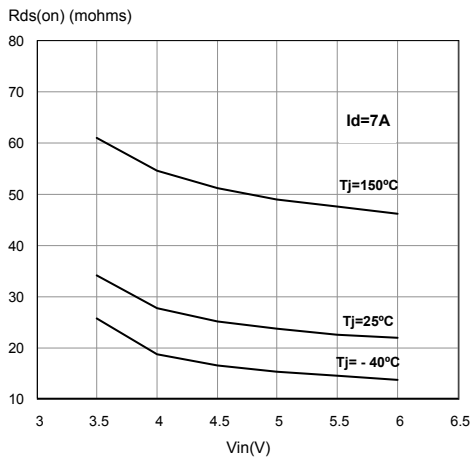


Figure 38. Static drain source on resistance vs input voltage

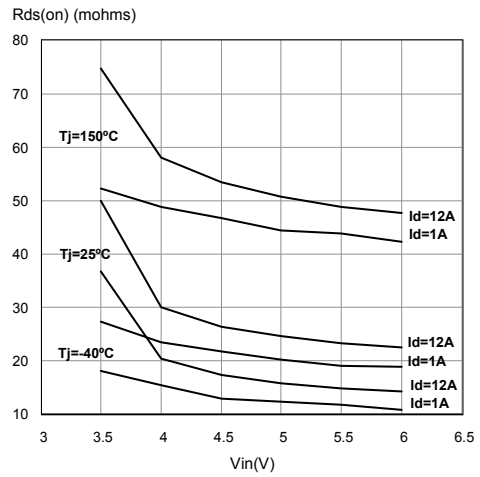


Figure 39. Normalized input threshold voltage vs temperature

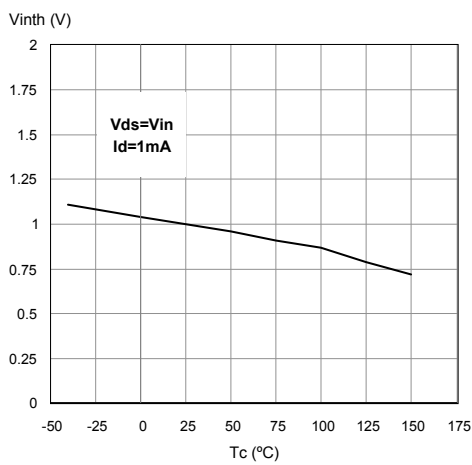


Figure 40. Normalized on resistance vs temperature

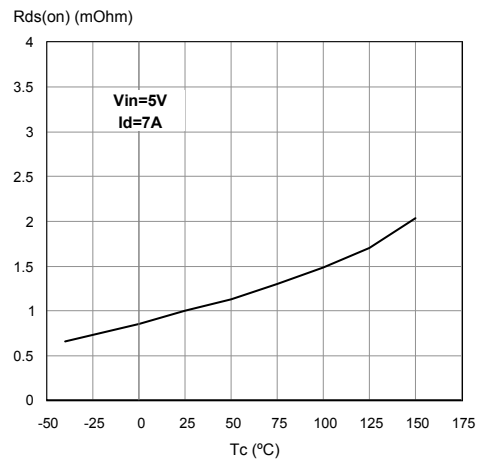


Figure 41. Turn-off drain source voltage slope
($V_{IN} = 3.5\text{ V}$)

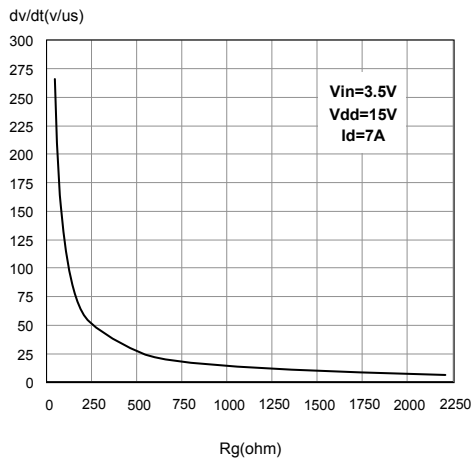


Figure 42. Turn-off drain source voltage slope
($V_{IN} = 5\text{ V}$)

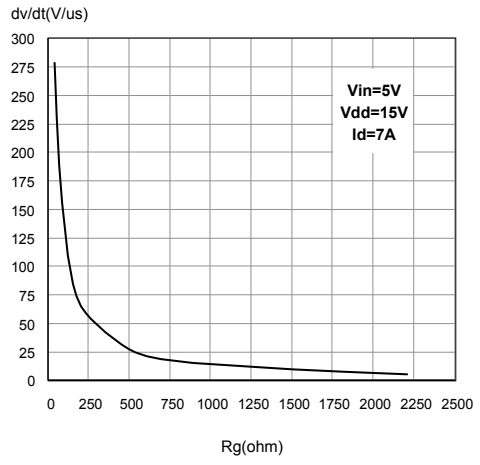
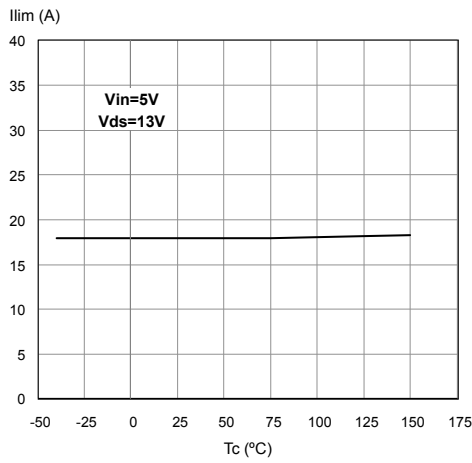
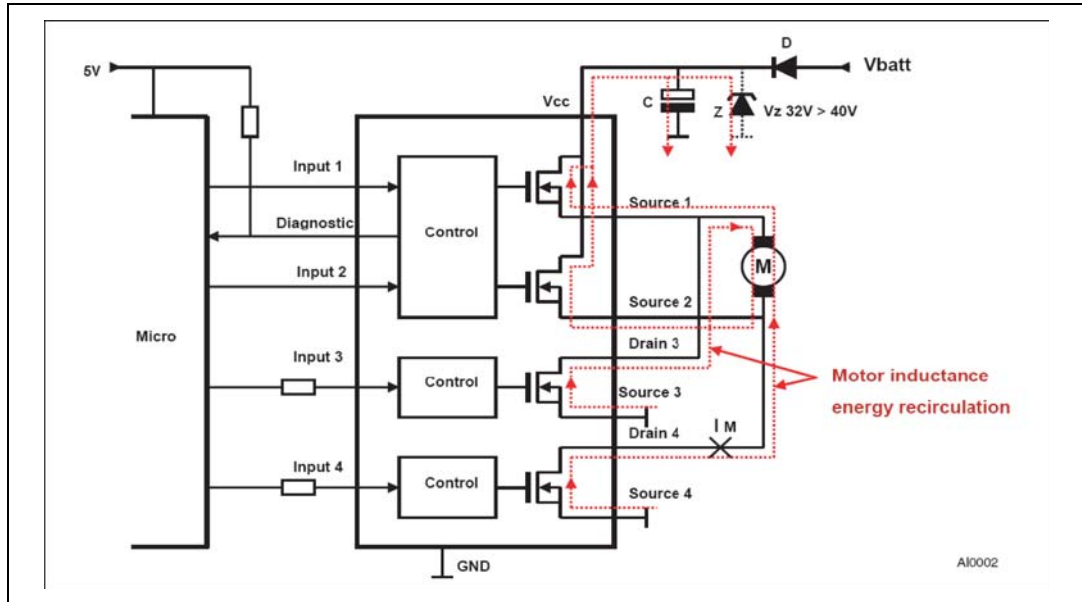


Figure 43. Current limit vs junction temperature



3 Application recommendations

Figure 44. Application diagram bridge drivers



Most motor bridge drivers use a reverse battery protection diode (D) inside the supply rail. This diode prevents a reverse current flow back to V_{BATT} in case the bridge becomes disabled via the logic inputs while motor inductance still carries energy. In order to prevent a hazardous overvoltage at circuit supply terminal (V_{CC}), a blocking capacitor (C) is needed to limit the voltage overshoot. As basic orientation, 50 μF per 1 A load current is recommended. As an alternative, a Zener protection (Z) is also suitable.

Even if a reverse polarity diode is not present, it is recommended to use a capacitor or Zener at V_{CC} because a similar problem appears in case the supply terminal of the module has intermittent electrical contact to the battery or gets disconnected while the motor is operating.

Figure 45. Recommended motor operation

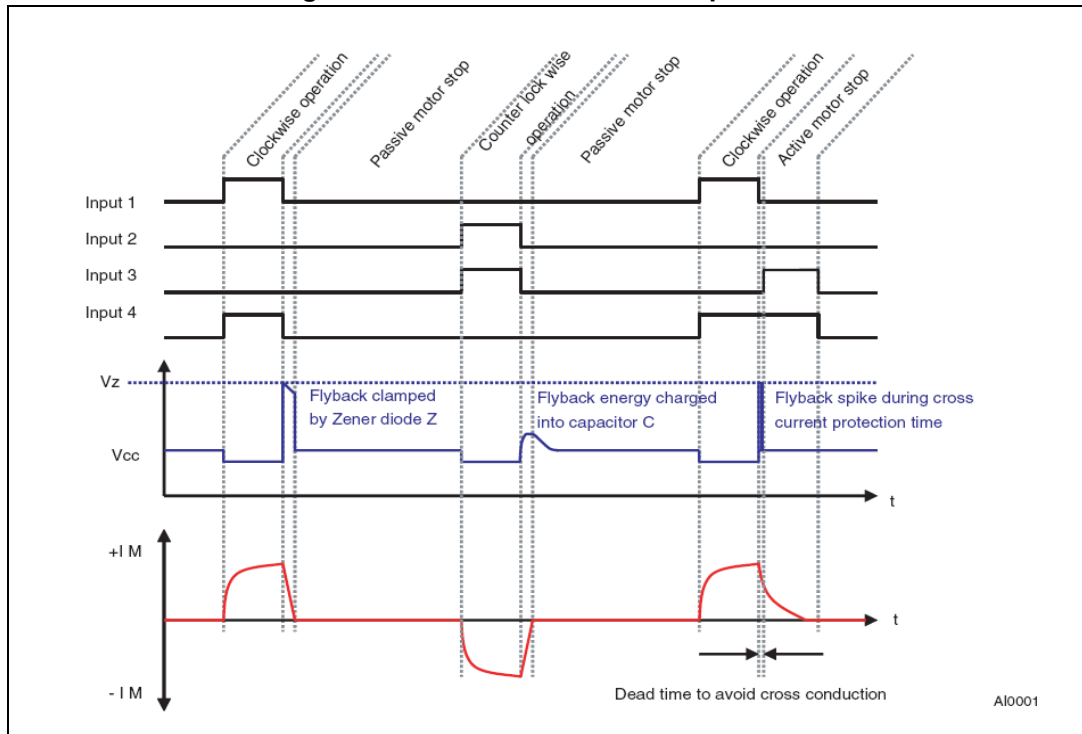
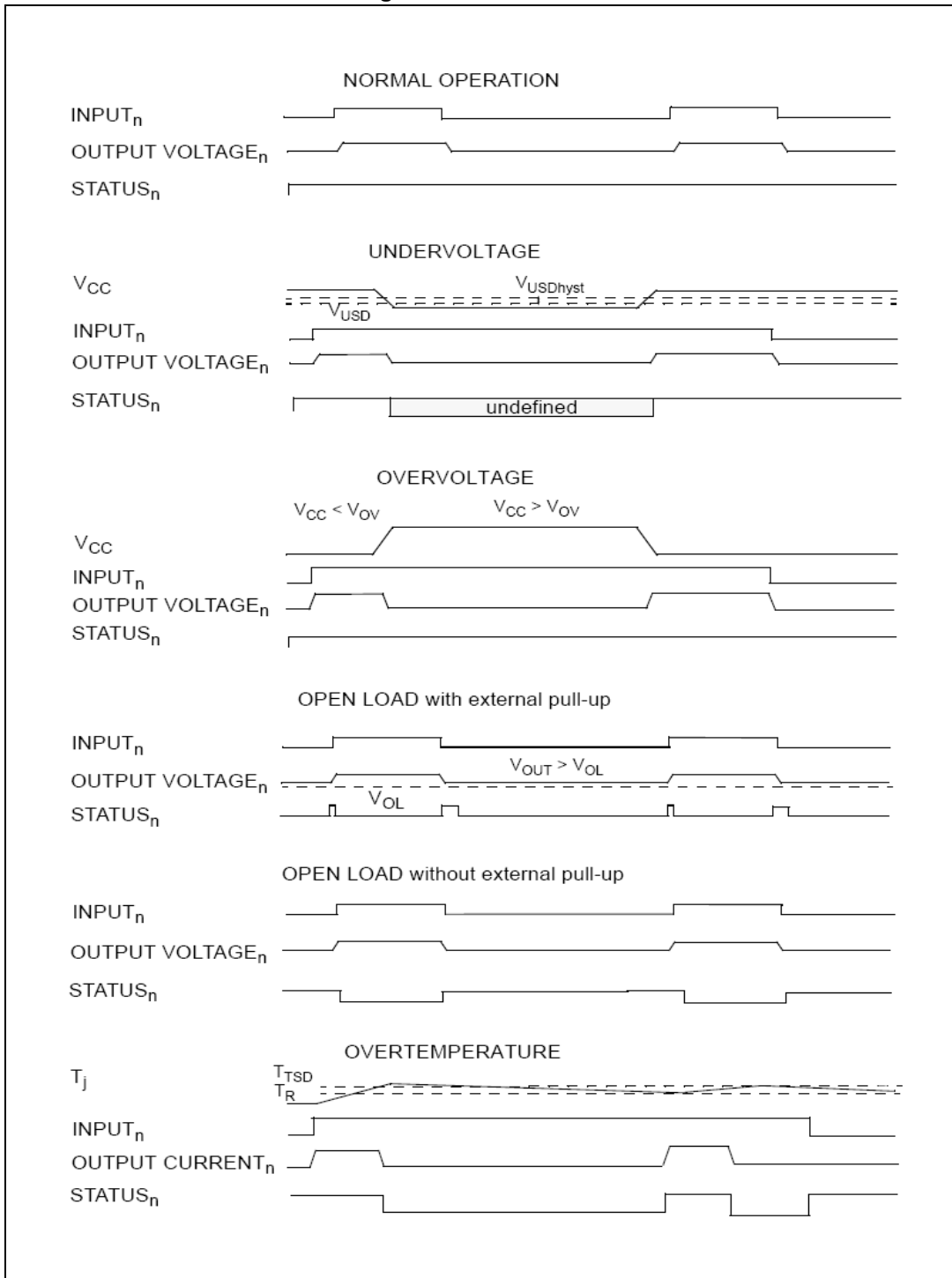


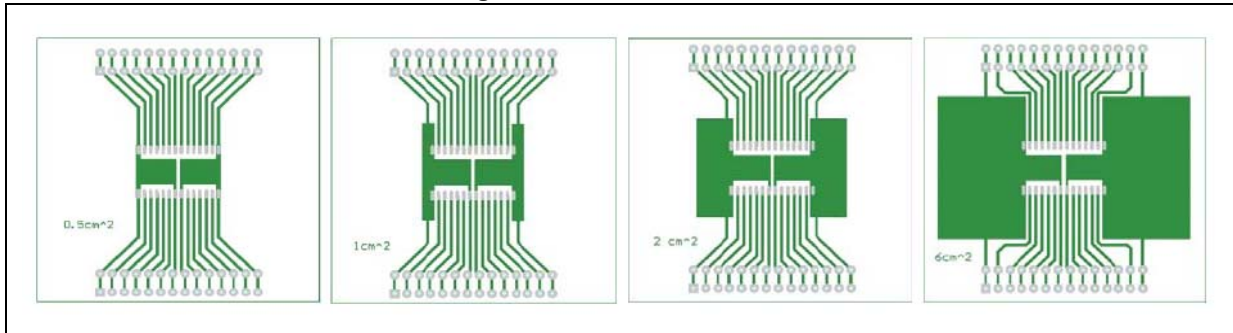
Figure 46. Waveforms



4 Thermal data

4.1 SO-28 thermal data

Figure 47. SO-28 PC board



Note: Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area = 58mm x 58mm, PCB thickness = 2mm, Cu thickness = 35 μ m, Copper areas: from minimum pad layout to 6cm²).

Figure 48. Chipset configuration

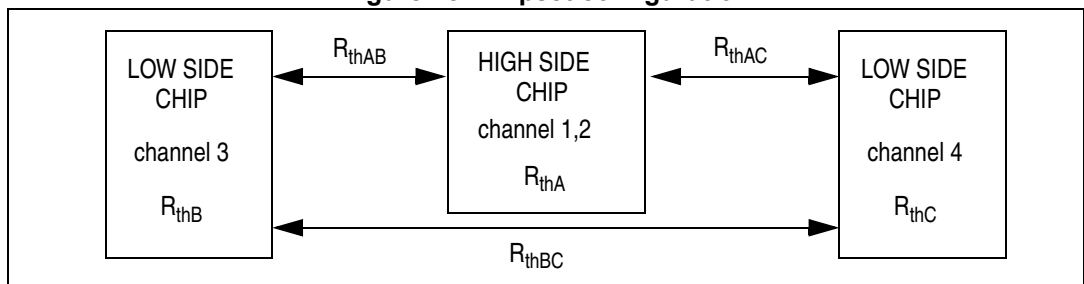
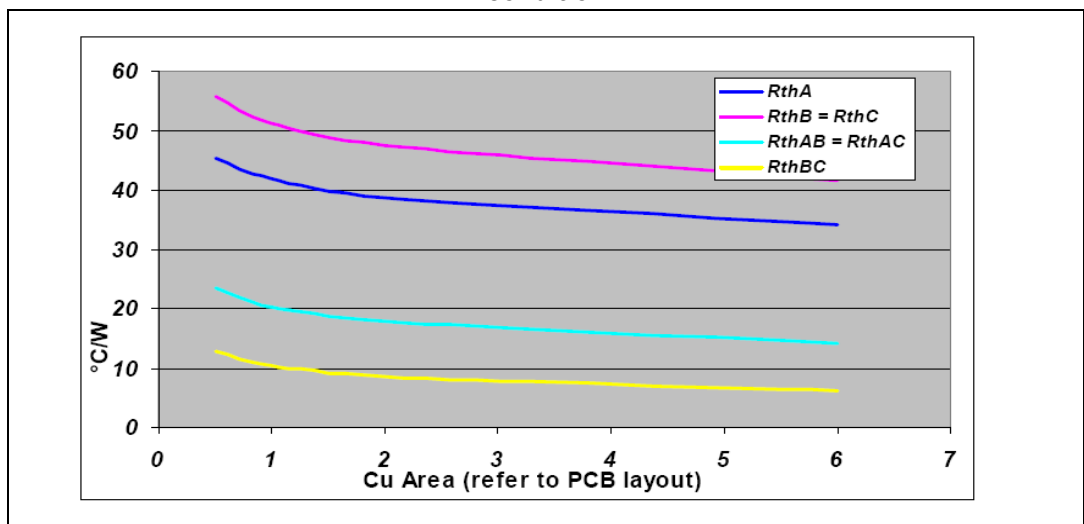


Figure 49. Auto and mutual $R_{thj-amb}$ vs PCB copper area in open box free air condition



1. See definitions in [Section 5.2](#).

4.2 Thermal calculation in clockwise and anti-clockwise operation in steady state mode

Table 19. Thermal calculation in clockwise and anti-clockwise operation in steady state mode

| HS ₁ | HS ₂ | LS ₃ | LS ₄ | T _{JHS12} | T _{JLS3} | T _{JLS4} |
|-----------------|-----------------|-----------------|-----------------|--|--|--|
| On | Off | Off | On | $\frac{P_{dHS1} \times R_{thHS} + P_{dLS4} \times R_{thHSLs}}{R_{thHSLs} + T_{amb}}$ | $\frac{P_{dHS1} \times R_{thHSLs} + P_{dLS4} \times R_{thLSLS}}{R_{thLSLS} + T_{amb}}$ | $\frac{P_{dHS1} \times R_{thHSLs} + P_{dLS4} \times R_{thLS}}{R_{thLS} + T_{amb}}$ |
| Off | On | On | Off | $\frac{P_{dHS2} \times R_{thHS} + P_{dLS3} \times R_{thHSLs}}{R_{thHSLs} + T_{amb}}$ | $\frac{P_{dHS2} \times R_{thHSLs} + P_{dLS3} \times R_{thLS}}{R_{thLS} + T_{amb}}$ | $\frac{P_{dHS2} \times R_{thHSLs} + P_{dLS3} \times R_{thLSLS}}{R_{thLSLS} + T_{amb}}$ |

4.2.1 Thermal resistances definition

Values according to the PCB heatsink area.

$R_{thHS} = R_{thHS1} = R_{thHS2}$ = high side chip thermal resistance junction to ambient (HS₁ or HS₂ in on-state)

$R_{thLS} = R_{thLS3} = R_{thLS4}$ = low side chip thermal resistance junction to ambient

$R_{thHSLs} = R_{thHS1LS4} = R_{thHS2LS3}$ = mutual thermal resistance junction to ambient between high side and low side chips

$R_{thLSLS} = R_{thLS3LS4}$ = mutual thermal resistance junction to ambient between low side chips

4.2.2 Thermal calculation in transient mode

$$T_{JHS12} = Z_{thHS} \times P_{dHS12} + Z_{thHSLs} \times (P_{dLS3} + P_{dLS4}) + T_{amb}$$

$$T_{JLS3} = Z_{thHSLs} \times P_{dHS12} + Z_{thLS} \times P_{dLS3} + Z_{thLSLS} \times P_{dLS4} + T_{amb}$$

$$T_{JLS4} = Z_{thHSLs} \times P_{dHS12} + Z_{thLSLS} \times P_{dLS3} + Z_{thLS} \times P_{dLS4} + T_{amb}$$

Note: Calculation is valid in any dynamic operating condition. P_d values set by user.

4.2.3 Single pulse thermal impedance definition

Values according to the PCB heatsink area.

Z_{thHS} = high side chip thermal impedance junction to ambient

$Z_{thLS} = Z_{thLS3} = Z_{thLS4}$ = low side chip thermal impedance junction to ambient

$Z_{thHSLs} = Z_{thHS12LS3} = Z_{thHS12LS4}$ = mutual thermal impedance junction to ambient between high side and low side chips

$Z_{thLSLS} = Z_{thLS3LS4}$ = mutual thermal impedance junction to ambient between low side chips

4.2.4 Pulse calculation formula

$$Z_{TH\delta} = R_{TH} \cdot \delta + Z_{THtp}(1 - \delta)$$

where $\delta = t_p/T$

Figure 50. SO-28 HSD thermal impedance junction ambient single pulse

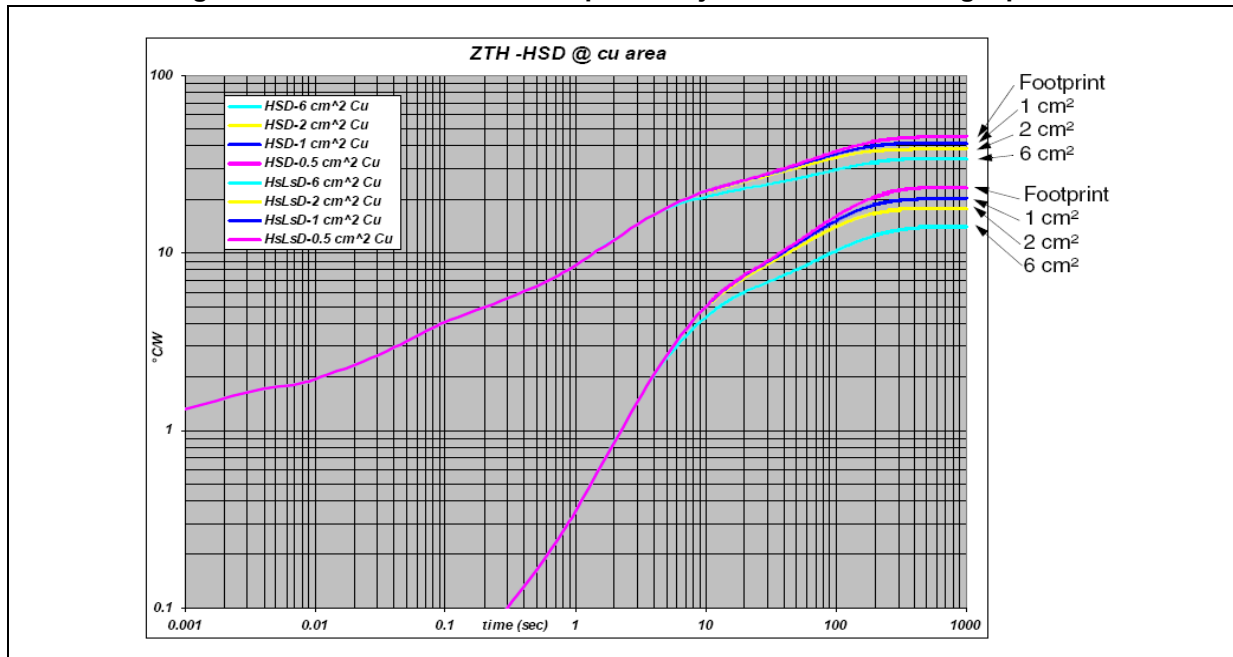


Figure 51. SO-28 LSD thermal impedance junction ambient single pulse

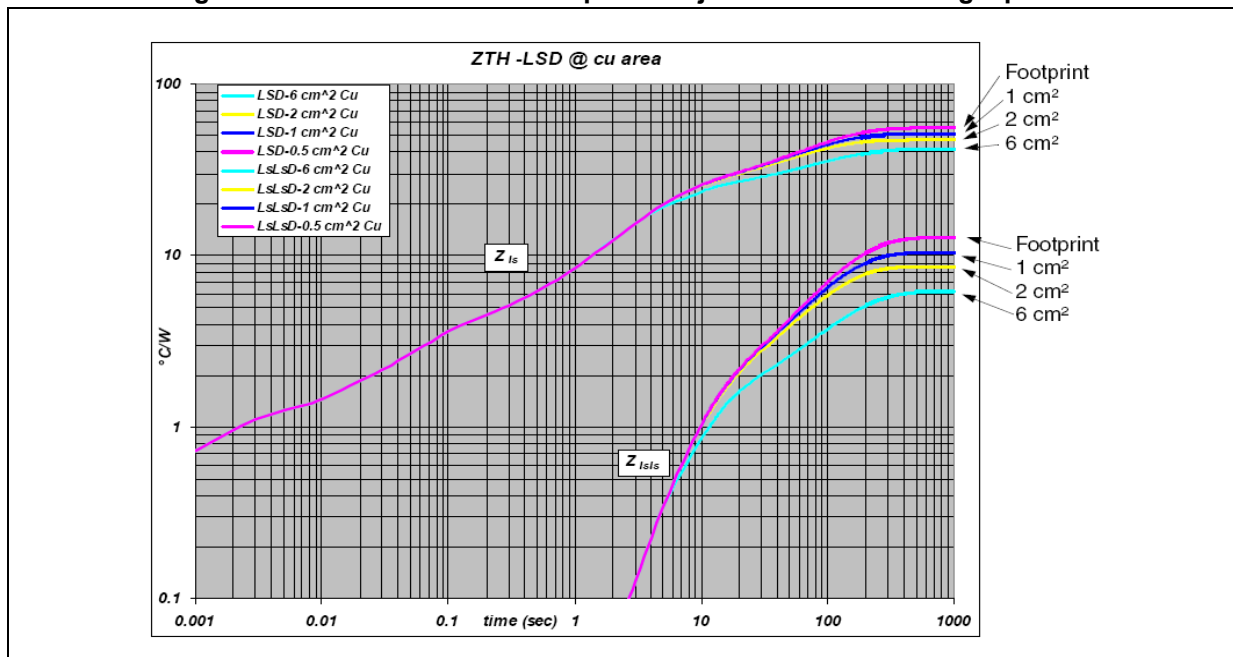


Figure 52. Thermal fitting model of an H-bridge in SO-28

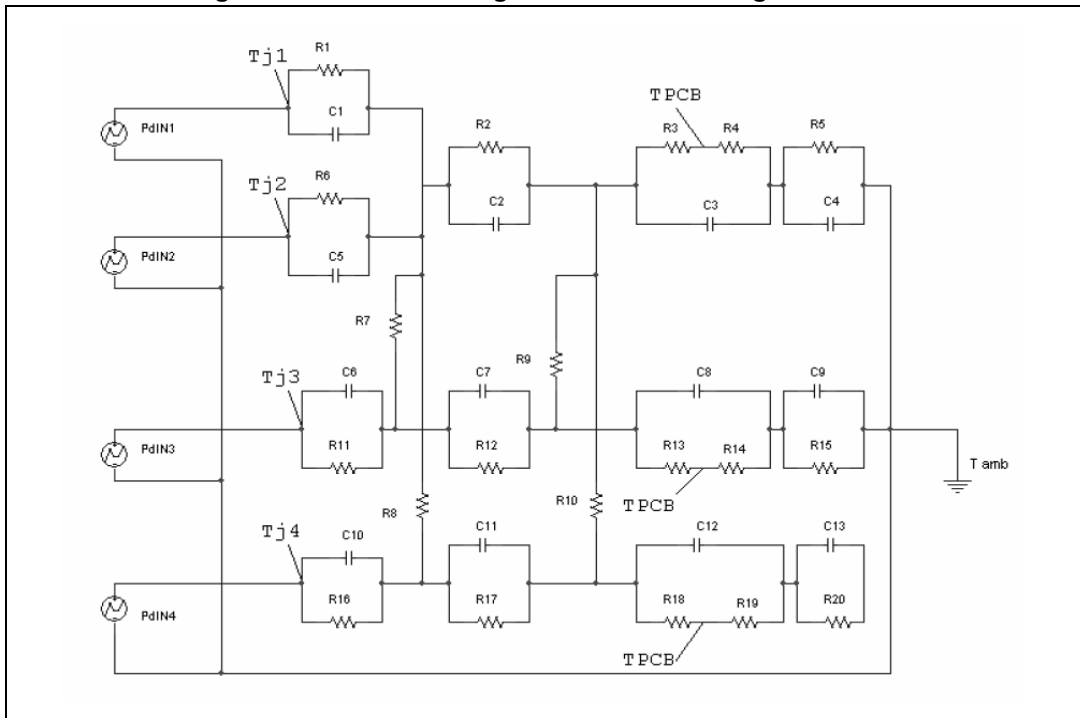


Table 20. Thermal parameters

| Area/island (cm ²) | Footprint | 1 | 2 | 6 |
|--------------------------------|-----------|---------|---------|---------|
| R1 = R6 (°C/W) | 1.5 | 1.5 | 1.5 | 1.5 |
| R2 (°C/W) | 2.6 | 2.6 | 2.6 | 2.6 |
| R12 = R17 (°C/W) | 2.6 | 2.6 | 2.6 | 2.6 |
| R3 = R13 = R 18 (°C/W) | 15.5 | 15.5 | 15.5 | 15.5 |
| R4 = R14 = R19 (°C/W) | 10.5 | 10.5 | 10.5 | 10.5 |
| R5 = R15 = R20 (°C/W) | 62.28 | 52.28 | 44.28 | 32.28 |
| R7 = R8 = R9 = R10 (°C/W) | 150 | 150 | 150 | 150 |
| R11 = R16 (°C/W) | 1 | 1 | 1 | 1 |
| C1 = C5 (W.s/°C) | 0.00035 | 0.00035 | 0.00035 | 0.00035 |
| C2 = C7 = C11 (W.s/°C) | 0.024 | 0.024 | 0.024 | 0.024 |
| C3 = C8 = C 12 (W.s/°C) | 0.2 | 0.2 | 0.2 | 0.2 |
| C4 = C9 = C13 (W.s/°C) | 1.6 | 1.61 | 1.7 | 3.25 |
| C6 = C10 (W.s/°C) | 0.0009 | 0.0009 | 0.0009 | 0.0009 |

5 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK[®] packages, depending on their level of environmental compliance. ECOPACK[®] specifications, grade definitions and product status are available at: www.st.com. ECOPACK[®] is an ST trademark.

5.1 SO-28 package information

Figure 53. SO-28 package outline

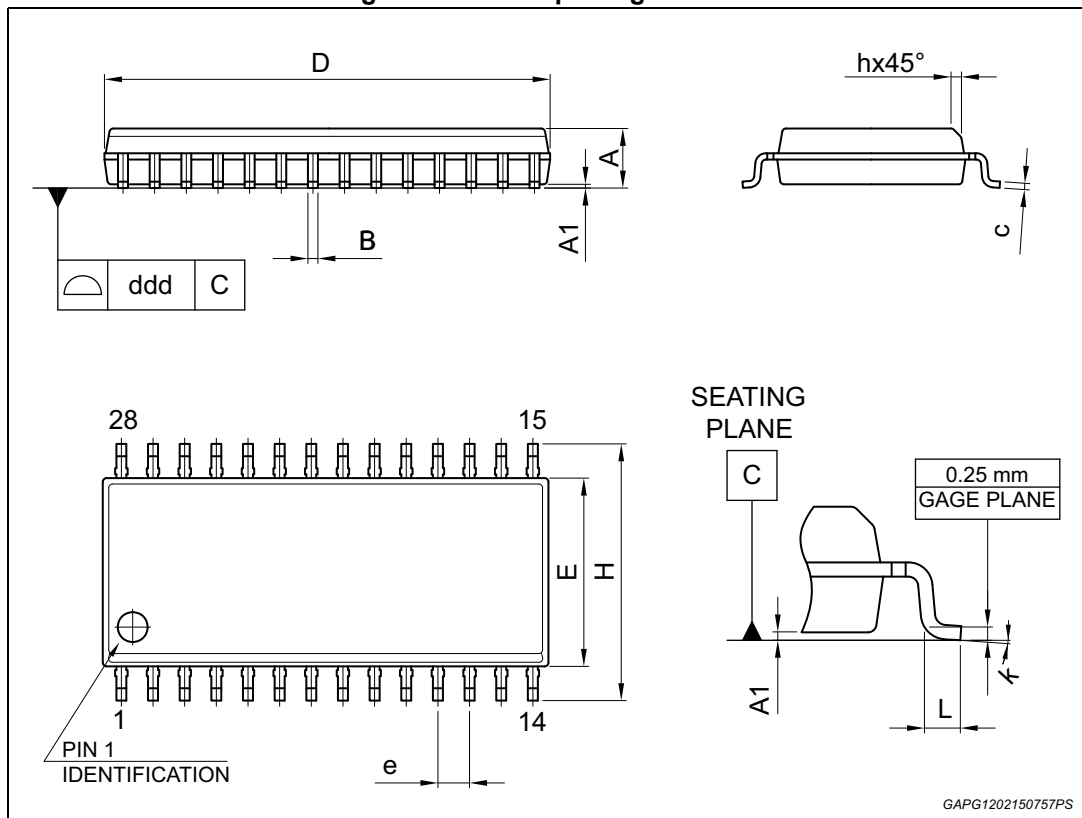


Table 21. SO-28 mechanical data

| Ref. | Dimension | | |
|------------------|-------------|------|-------|
| | Millimeters | | |
| | Min. | Typ | Max. |
| A | 2.35 | | 2.65 |
| A1 | 0.10 | | 0.30 |
| B | 0.33 | | 0.51 |
| C | 0.23 | | 0.32 |
| D ⁽¹⁾ | 17.70 | | 18.10 |
| E | 7.40 | | 7.60 |
| e | | 1.27 | |
| H | 10.00 | | 10.65 |
| h | 0.25 | | 0.75 |
| L | 0.40 | | 1.27 |
| k | 0° | | 8° |
| ddd | | | 0.10 |

1. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm per side.

5.2 SO-28 Packing information

Figure 54. Tube dimensions (no suffix)

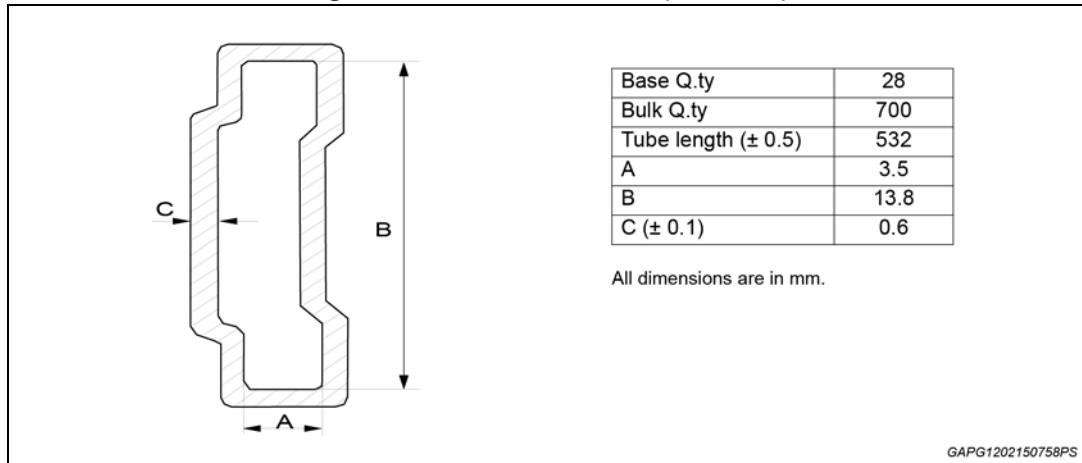
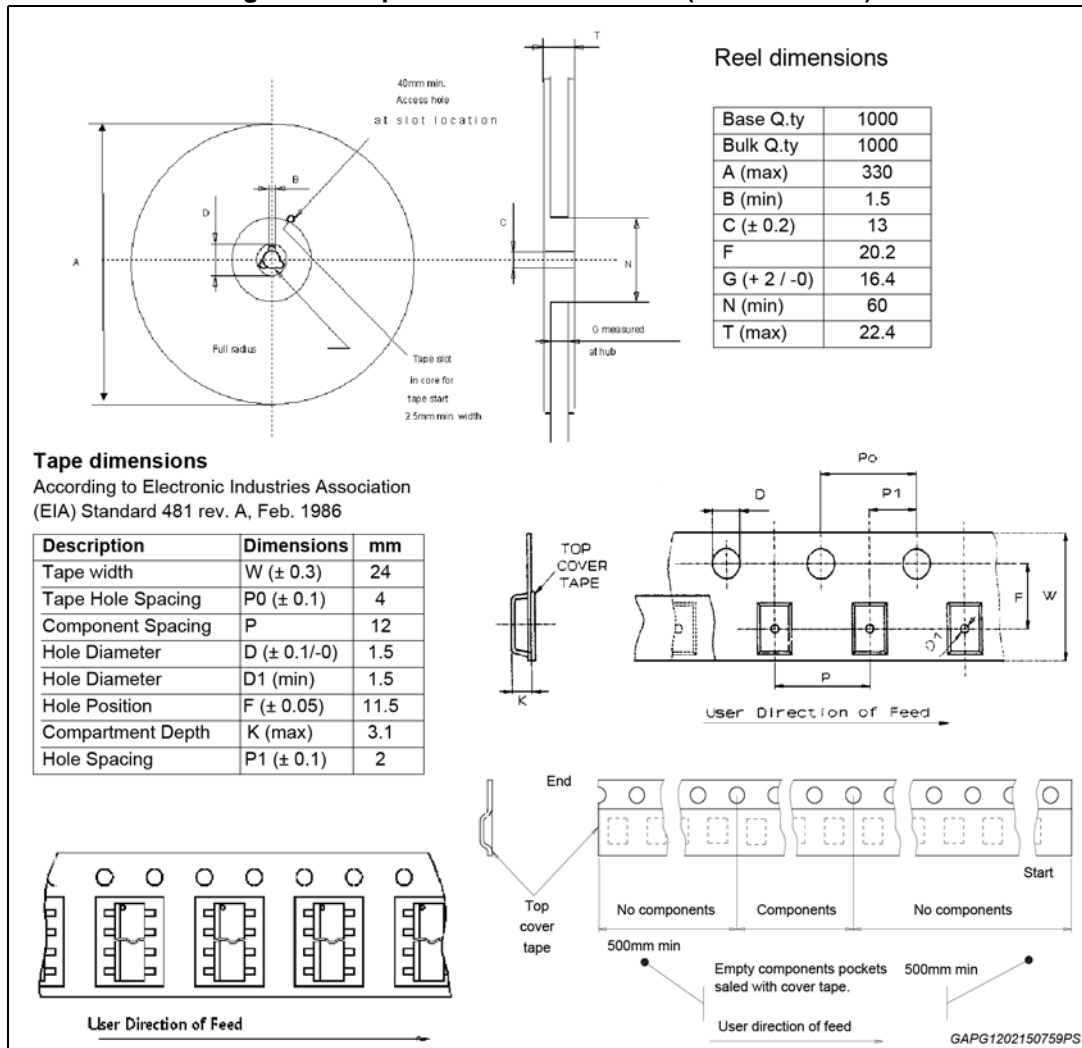


Figure 55. Tape and reel dimensions (suffix "13TR")



6 Revision history

Table 22. Document revision history

| Date | Revision | Changes |
|-------------|----------|--|
| 01-Jun-2011 | 1 | Initial release. |
| 18-Sep-2013 | 2 | Updated Disclaimer |
| 16-Feb-2015 | 3 | Updated Chapter 5: Package information |

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