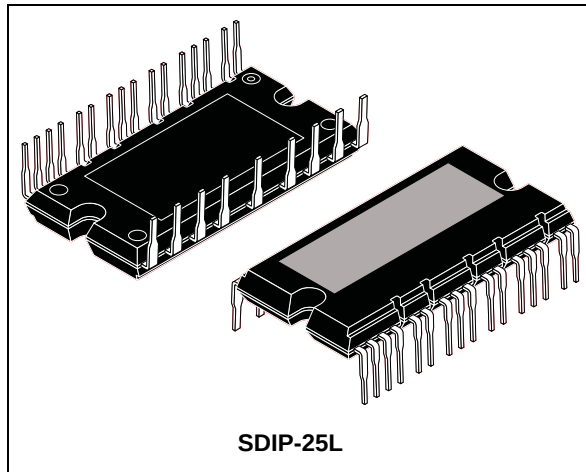


## SLLIMM™ (small low-loss intelligent molded module) IPM, 3-phase inverter - 10 A, 600 V short-circuit rugged IGBT

Datasheet - production data



### Applications

- 3-phase inverters for motor drives
- Home appliances, such as washing machines, refrigerators, air conditioners and sewing machines

### Description

This intelligent power module provides a compact, high performance AC motor drive in a simple, rugged design. Combining ST proprietary control ICs with the most advanced short-circuit-rugged IGBT system technology, this device is ideal for 3-phase inverters in applications such as home appliances and air conditioners. SLLIMM™ is a trademark of STMicroelectronics.

### Features

- IPM 10 A, 600 V 3-phase IGBT inverter bridge including control ICs for gate driving and free-wheeling diodes
- Short-circuit rugged IGBTs
- $V_{CE(sat)}$  negative temperature coefficient
- 3.3 V, 5 V, 15 V CMOS/TTL inputs comparators with hysteresis and pull down / pull up resistors
- Undervoltage lockout
- Internal bootstrap diode
- Interlocking function
- Shut down function
- DBC substrate leading to low thermal resistance
- Isolation rating of 2500 Vrms/min
- 4.7 k $\Omega$  NTC for temperature control
- UL recognized: UL1557 file E81734

Table 1. Device summary

| Order code   | Marking    | Package  | Packaging |
|--------------|------------|----------|-----------|
| STGIPS10K60T | GIPS10K60T | SDIP-25L | Tube      |

## Contents

|          |                                                     |           |
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# 1 Internal block diagram and pin configuration

Figure 1. Internal block diagram

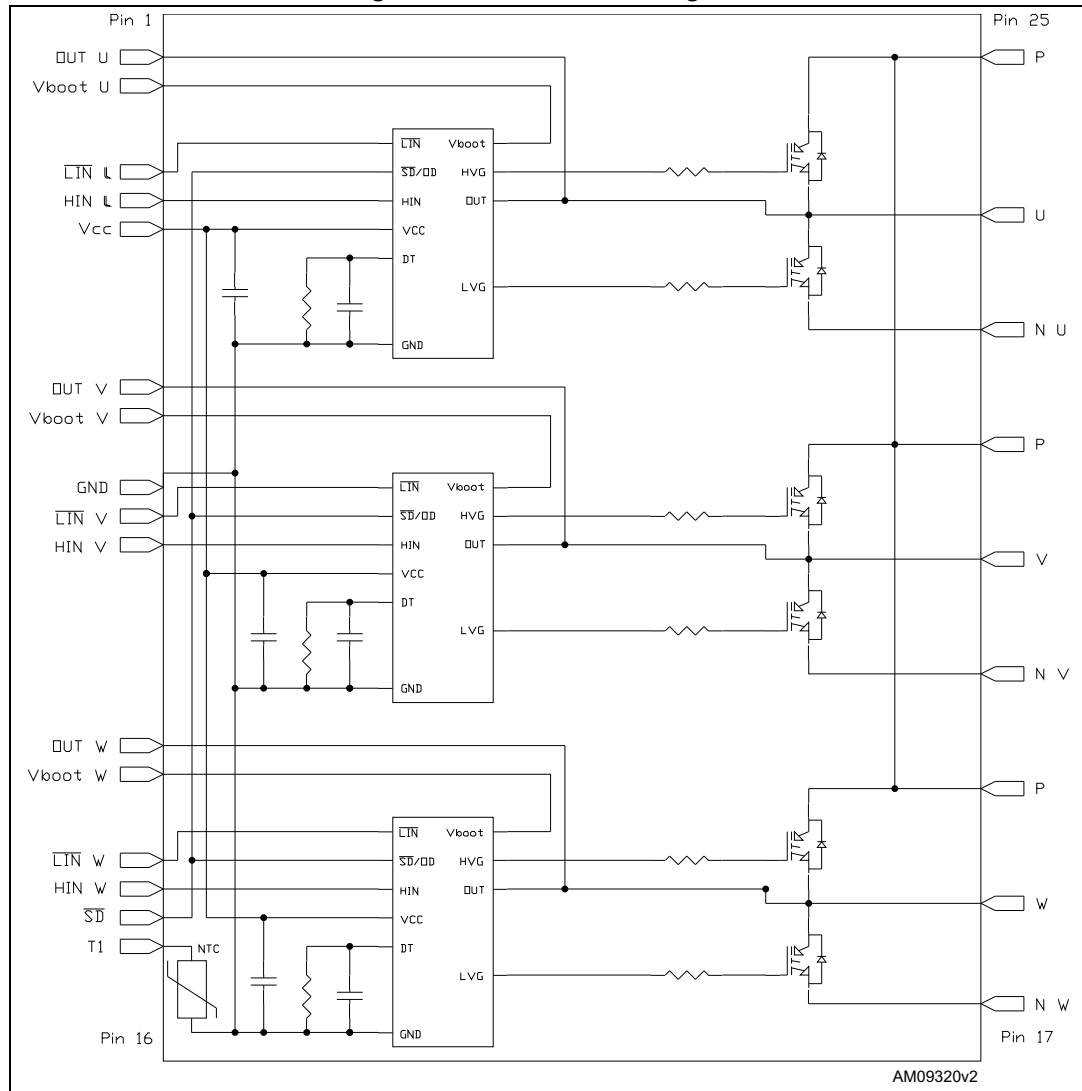
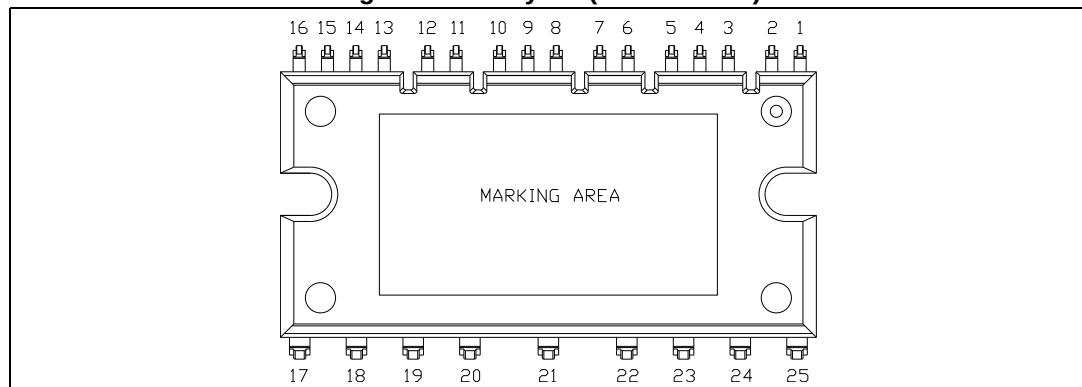


Table 2. Pin description

| Pin n° | Symbol              | Description                            |
|--------|---------------------|----------------------------------------|
| 1      | OUT <sub>U</sub>    | High side reference output for U phase |
| 2      | V <sub>boot U</sub> | Bootstrap voltage for U phase          |
| 3      | LIN <sub>U</sub>    | Low side logic input for U phase       |
| 4      | HIN <sub>U</sub>    | High side logic input for U phase      |
| 5      | V <sub>CC</sub>     | Low voltage power supply               |
| 6      | OUT <sub>V</sub>    | High side reference output for V phase |
| 7      | V <sub>boot V</sub> | Bootstrap voltage for V phase          |
| 8      | GND                 | Ground                                 |
| 9      | LIN <sub>V</sub>    | Low side logic input for V phase       |
| 10     | HIN <sub>V</sub>    | High side logic input for V phase      |
| 11     | OUT <sub>W</sub>    | High side reference output for W phase |
| 12     | V <sub>boot W</sub> | Bootstrap voltage for W phase          |
| 13     | LIN <sub>W</sub>    | Low side logic input for W phase       |
| 14     | HIN <sub>W</sub>    | High side logic input for W phase      |
| 15     | SD                  | Shut down logic input (active low)     |
| 16     | T1                  | NTC thermistor terminal                |
| 17     | N <sub>W</sub>      | Negative DC input for W phase          |
| 18     | W                   | W phase output                         |
| 19     | P                   | Positive DC input                      |
| 20     | N <sub>V</sub>      | Negative DC input for V phase          |
| 21     | V                   | V phase output                         |
| 22     | P                   | Positive DC input                      |
| 23     | N <sub>U</sub>      | Negative DC input for U phase          |
| 24     | U                   | U phase output                         |
| 25     | P                   | Positive DC input                      |

Figure 2. Pin layout (bottom view)



## 2 Electrical ratings

### 2.1 Absolute maximum ratings

Table 3. Inverter part

| Symbol             | Parameter                                                                                                                                            | Value | Unit          |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-------|---------------|
| $V_{PN}$           | Supply voltage applied between P - $N_U$ , $N_V$ , $N_W$                                                                                             | 450   | V             |
| $V_{PN(surge)}$    | Supply voltage (surge) applied between P - $N_U$ , $N_V$ , $N_W$                                                                                     | 500   | V             |
| $V_{CES}$          | Each IGBT collector emitter voltage ( $V_{IN}^{(1)} = 0$ )                                                                                           | 600   | V             |
| $\pm I_C^{(2)}$    | Each IGBT continuous collector current at $T_C = 25^\circ\text{C}$                                                                                   | 10    | A             |
| $\pm I_{CP}^{(3)}$ | Each IGBT pulsed collector current                                                                                                                   | 20    | A             |
| $P_{TOT}$          | Each IGBT total dissipation at $T_C = 25^\circ\text{C}$                                                                                              | 33    | W             |
| $t_{scw}$          | Short-circuit withstand time, $V_{CE} = 0.5 V_{(BR)CES}$<br>$T_J = 125^\circ\text{C}$ , $V_{CC} = V_{boot} = 15\text{ V}$ , $V_{IN(1)} = 5\text{ V}$ | 5     | $\mu\text{s}$ |

1. Applied between  $HIN_i$ ,  $\overline{LIN_i}$  and  $G_{ND}$  for  $i = U, V, W$ .
2. Calculated according to the iterative formula:

$$I_C(T_C) = \frac{T_{J(max)} - T_C}{R_{thj-c} \times V_{CE(sat)(max)}(T_{J(max)}, I_C(T_C))}$$

3. Pulse width limited by max junction temperature.

Table 4. Control part

| Symbol        | Parameter                                                            | Min.            | Max.             | Unit |
|---------------|----------------------------------------------------------------------|-----------------|------------------|------|
| $V_{OUT}$     | Output voltage applied between $OUT_U$ , $OUT_V$ , $OUT_W$ - GND     | $V_{boot} - 21$ | $V_{boot} + 0.3$ | V    |
| $V_{CC}$      | Low voltage power supply                                             | - 0.3           | 21               | V    |
| $V_{boot}$    | Bootstrap voltage                                                    | - 0.3           | 620              | V    |
| $V_{IN}$      | Logic input voltage applied between $HIN$ , $\overline{LIN}$ and GND | - 0.3           | 15               | V    |
| $V_{SD}$      | SD voltage                                                           | - 0.3           | 15               | V    |
| $dV_{OUT}/dt$ | Allowed output slew rate                                             |                 | 50               | V/ns |

Table 5. Total system

| Symbol    | Parameter                                                                                                   | Value      | Unit             |
|-----------|-------------------------------------------------------------------------------------------------------------|------------|------------------|
| $V_{ISO}$ | Isolation withstand voltage applied between each pin and heatsink plate (AC voltage, $t = 60\text{ sec.}$ ) | 2500       | V                |
| $T_C$     | Module case operation temperature                                                                           | -40 to 125 | $^\circ\text{C}$ |
| $T_J$     | Power chips operating junction temperature                                                                  | -40 to 150 | $^\circ\text{C}$ |

## 2.2 Thermal data

**Table 6. Thermal data**

| Symbol     | Parameter                                          | Value | Unit |
|------------|----------------------------------------------------|-------|------|
| $R_{thJC}$ | Thermal resistance junction-case single IGBT max.  | 3.8   | °C/W |
|            | Thermal resistance junction-case single diode max. | 5.5   | °C/W |

### 3 Electrical characteristics

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

**Table 7. Inverter part**

| Symbol                                          | Parameter                                                        | Test conditions                                                                                                                                                | Value |      |      | Unit          |
|-------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|---------------|
|                                                 |                                                                  |                                                                                                                                                                | Min.  | Typ. | Max. |               |
| $V_{CE(sat)}$                                   | Collector-emitter saturation voltage                             | $V_{CC} = V_{boot} = 15\text{ V}$ ,<br>$V_{IN}^{(1)} = 5\text{ V}$ ,<br>$I_C = 5\text{ A}$                                                                     | -     | 2.1  | 2.5  | V             |
|                                                 |                                                                  | $V_{CC} = V_{boot} = 15\text{ V}$ ,<br>$V_{IN}^{(1)} = 5\text{ V}$ ,<br>$I_C = 5\text{ A}$ , $T_J = 125\text{ °C}$                                             | -     | 1.8  |      |               |
| $I_{CES}$                                       | Collector-cut off current<br>( $V_{IN}^{(1)} = 0$ "logic state") | $V_{CE} = 550\text{ V}$<br>$V_{CC} = V_{boot} = 15\text{ V}$                                                                                                   | -     |      | 150  | $\mu\text{A}$ |
| $V_F$                                           | Diode forward voltage                                            | ( $V_{IN}^{(1)} = 0$ "logic state"), $I_C = 5\text{ A}$                                                                                                        | -     |      | 1.9  | V             |
| <b>Inductive load switching time and energy</b> |                                                                  |                                                                                                                                                                |       |      |      |               |
| $t_{on}$                                        | Turn-on time                                                     | $V_{DD} = 300\text{ V}$ ,<br>$V_{CC} = V_{boot} = 15\text{ V}$ ,<br>$V_{IN}^{(1)} = 0 \div 5\text{ V}$ ,<br>$I_C = 5\text{ A}$ (see <a href="#">Figure 4</a> ) | -     | 320  | -    | ns            |
| $t_{c(on)}$                                     | Crossover time (on)                                              |                                                                                                                                                                | -     | 70   | -    |               |
| $t_{off}$                                       | Turn-off time                                                    |                                                                                                                                                                | -     | 430  | -    |               |
| $t_{c(off)}$                                    | Crossover time (off)                                             |                                                                                                                                                                | -     | 135  | -    |               |
| $t_{rr}$                                        | Reverse recovery time                                            |                                                                                                                                                                | -     | 130  | -    |               |
| $E_{on}$                                        | Turn-on switching losses                                         |                                                                                                                                                                | -     | 65   | -    | $\mu\text{J}$ |
| $E_{off}$                                       | Turn-off switching losses                                        |                                                                                                                                                                | -     | 75   | -    |               |

1. Applied between  $HIN_i$ ,  $\overline{LIN_i}$  and GND for  $i = U, V, W$  (LIN inputs are active-low).

Note:  $t_{ON}$  and  $t_{OFF}$  include the propagation delay time of the internal drive.  $t_{C(ON)}$  and  $t_{C(OFF)}$  are the switching time of IGBT itself under the internally given gate driving condition.

Figure 3. Switching time test circuit

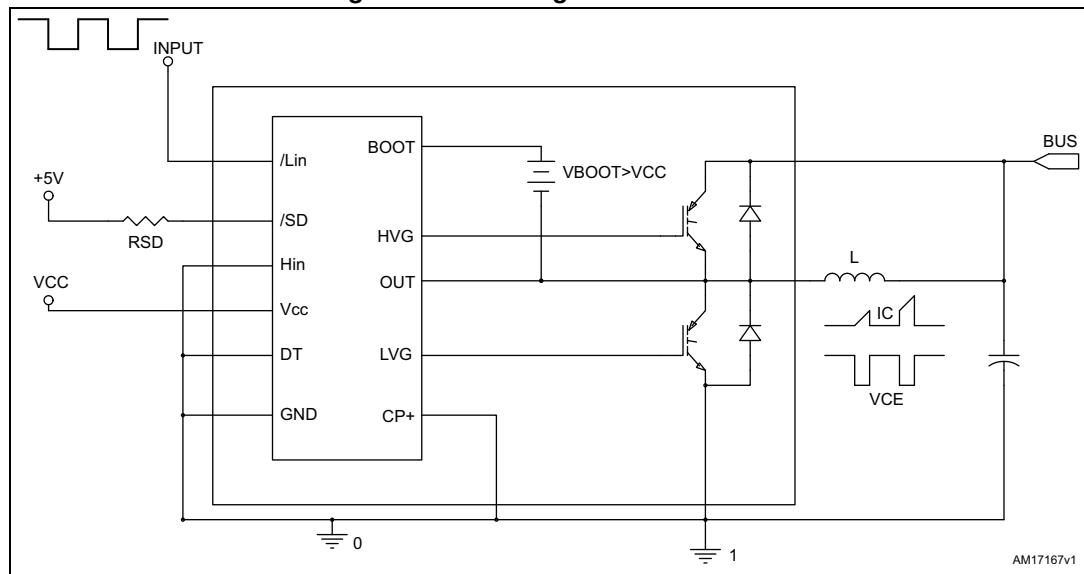
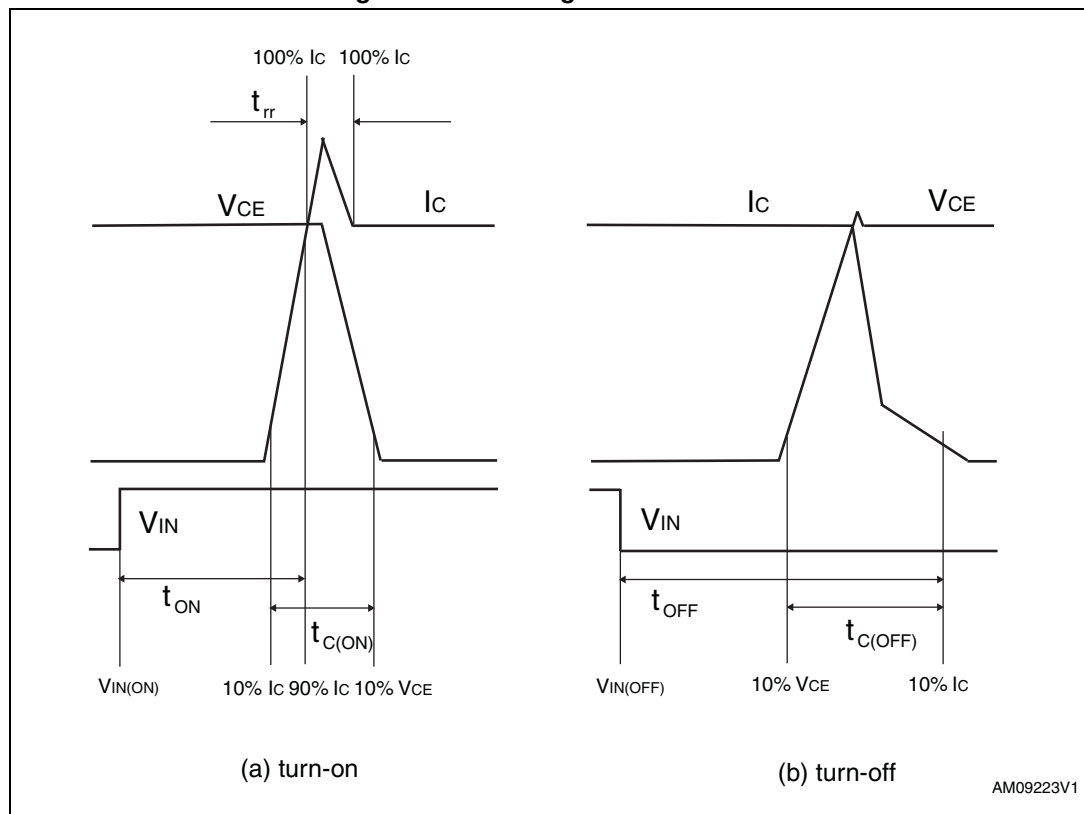


Figure 4. Switching time definition



Note: Figure 4 "Switching time definition" refers to  $H_{IN}$  inputs (active high). For  $\overline{L}_{IN}$  inputs (active low),  $V_{IN}$  polarity must be inverted for turn-on and turn-off.

### 3.1 Control part

**Table 8. Low voltage power supply ( $V_{CC} = 15\text{ V}$  unless otherwise specified)**

| Symbol          | Parameter                             | Test conditions                                                                                          | Min. | Typ. | Max. | Unit          |
|-----------------|---------------------------------------|----------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $V_{CC\_hys}$   | $V_{CC}$ UV hysteresis                |                                                                                                          | 1.2  | 1.5  | 1.8  | V             |
| $V_{CC\_thON}$  | $V_{CC}$ UV turn ON threshold         |                                                                                                          | 11.5 | 12   | 12.5 | V             |
| $V_{CC\_thOFF}$ | $V_{CC}$ UV turn OFF threshold        |                                                                                                          | 10   | 10.5 | 11   | V             |
| $I_{qccu}$      | Undervoltage quiescent supply current | $V_{CC} = 10\text{ V}$<br>$\overline{SD} = 5\text{ V}$ ; $\overline{LIN} = 5\text{ V}$ ;<br>$H_{IN} = 0$ |      |      | 450  | $\mu\text{A}$ |
| $I_{qcc}$       | Quiescent current                     | $V_{CC} = 15\text{ V}$<br>$\overline{SD} = 5\text{ V}$ ; $\overline{LIN} = 5\text{ V}$<br>$H_{IN} = 0$   |      |      | 3.5  | mA            |

**Table 9. Bootstrapped voltage ( $V_{CC} = 15\text{ V}$  unless otherwise specified)**

| Symbol          | Parameter                               | Test conditions                                                                                        | Min. | Typ. | Max. | Unit          |
|-----------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $V_{BS\_hys}$   | $V_{BS}$ UV hysteresis                  |                                                                                                        | 1.2  | 1.5  | 1.8  | V             |
| $V_{BS\_thON}$  | $V_{BS}$ UV turn ON threshold           |                                                                                                        | 11.1 | 11.5 | 12.1 | V             |
| $V_{BS\_thOFF}$ | $V_{BS}$ UV turn OFF threshold          |                                                                                                        | 9.8  | 10   | 10.6 | V             |
| $I_{QBSU}$      | Undervoltage $V_{BS}$ quiescent current | $V_{BS} < 9\text{ V}$<br>$\overline{SD} = 5\text{ V}$ ; $\overline{LIN}$ and<br>$H_{IN} = 5\text{ V}$  |      | 70   | 110  | $\mu\text{A}$ |
| $I_{QBS}$       | $V_{BS}$ quiescent current              | $V_{BS} = 15\text{ V}$<br>$\overline{SD} = 5\text{ V}$ ; $\overline{LIN}$ and<br>$H_{IN} = 5\text{ V}$ |      | 200  | 300  | $\mu\text{A}$ |
| $R_{DS(on)}$    | Bootstrap driver on resistance          | LVG ON                                                                                                 |      | 120  |      | W             |

**Table 10. Logic inputs ( $V_{CC} = 15\text{ V}$  unless otherwise specified)**

| Symbol     | Parameter                                     | Test conditions                | Min. | Typ. | Max. | Unit          |
|------------|-----------------------------------------------|--------------------------------|------|------|------|---------------|
| $V_{il}$   | Low logic level voltage                       |                                | 0.8  |      | 1.1  | V             |
| $V_{ih}$   | High logic level voltage                      |                                | 1.9  |      | 2.25 | V             |
| $I_{HINh}$ | HIN logic "1" input bias current              | $H_{IN} = 15\text{ V}$         | 110  | 175  | 260  | $\mu\text{A}$ |
| $I_{HINl}$ | HIN logic "0" input bias current              | $H_{IN} = 0\text{ V}$          |      |      | 1    | $\mu\text{A}$ |
| $I_{LINl}$ | $\overline{LIN}$ logic "1" input bias current | $\overline{LIN} = 0\text{ V}$  | 3    | 6    | 20   | $\mu\text{A}$ |
| $I_{LINh}$ | $\overline{LIN}$ logic "0" input bias current | $\overline{LIN} = 15\text{ V}$ |      |      | 1    | $\mu\text{A}$ |
| $I_{SDh}$  | $\overline{SD}$ logic "0" input bias current  | $\overline{SD} = 15\text{ V}$  | 30   | 120  | 300  | $\mu\text{A}$ |
| $I_{SDl}$  | $\overline{SD}$ logic "1" input bias current  | $\overline{SD} = 0\text{ V}$   |      |      | 3    | $\mu\text{A}$ |
| Dt         | Dead time                                     | see <a href="#">Figure 9</a>   |      | 600  |      | ns            |

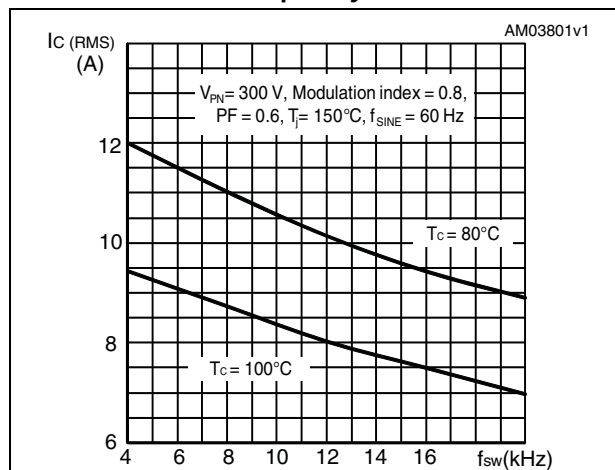
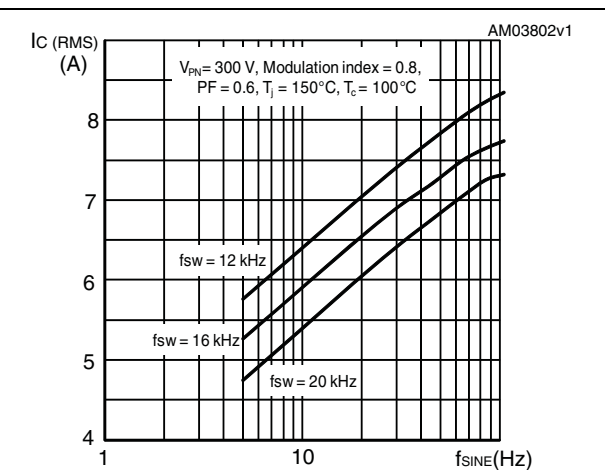
**Table 11. Shut down characteristics ( $V_{CC} = 15\text{ V}$  unless otherwise specified)**

| Symbol   | Parameter                                             | Test conditions                                                         | Min. | Typ. | Max. | Unit |
|----------|-------------------------------------------------------|-------------------------------------------------------------------------|------|------|------|------|
| $t_{sd}$ | Shut down to high / low side driver propagation delay | $V_{OUT} = 0$ , $V_{boot} = V_{CC}$ ,<br>$V_{IN} = 0$ to $3.3\text{ V}$ | 50   | 125  | 200  | ns   |

**Table 12. Truth table**

| Condition                                   | Logic input ( $V_I$ ) |                  |     | Output |     |
|---------------------------------------------|-----------------------|------------------|-----|--------|-----|
|                                             | $\overline{SD}$       | $\overline{LIN}$ | HIN | LVG    | HVG |
| Shutdown enable<br>half-bridge tri-state    | L                     | X                | X   | L      | L   |
| Interlocking<br>half-bridge tri-state       | H                     | L                | H   | L      | L   |
| 0 "logic state"<br>half-bridge tri-state    | H                     | H                | L   | L      | L   |
| 1 "logic state"<br>low side direct driving  | H                     | L                | L   | H      | L   |
| 1 "logic state"<br>high side direct driving | H                     | H                | H   | L      | H   |

Note: X: don't care

**Figure 5. Maximum  $I_{C(RMS)}$  current vs. switching frequency <sup>(1)</sup>****Figure 6. Maximum  $I_{C(RMS)}$  current vs.  $f_{SINE}$  <sup>(1)</sup>**

1. Simulated curves refer to typical IGBT parameters and maximum  $R_{thJC}$ .

3.1.1 NTC thermistor

Table 13. NTC thermistor

| Symbol           | Parameter             | Test conditions    | Min. | Typ. | Max. | Unit. |
|------------------|-----------------------|--------------------|------|------|------|-------|
| R <sub>25</sub>  | Resistance            | T = 25 °C          |      | 4.7  |      | kΩ    |
| R <sub>125</sub> | Resistance            | T = 125 °C         |      | 160  |      | Ω     |
| B                | B-constant            | T = 25 °C to 85 °C |      | 3950 |      | K     |
| T                | Operating temperature |                    | -40  |      | 150  | °C    |

Equation 1: resistance variation vs. temperature

$$R(T) = R_{25} \cdot e^{B\left(\frac{1}{T} - \frac{1}{298}\right)}$$

Where T are temperatures in Kelvins

Figure 7. NTC resistance vs. temperature

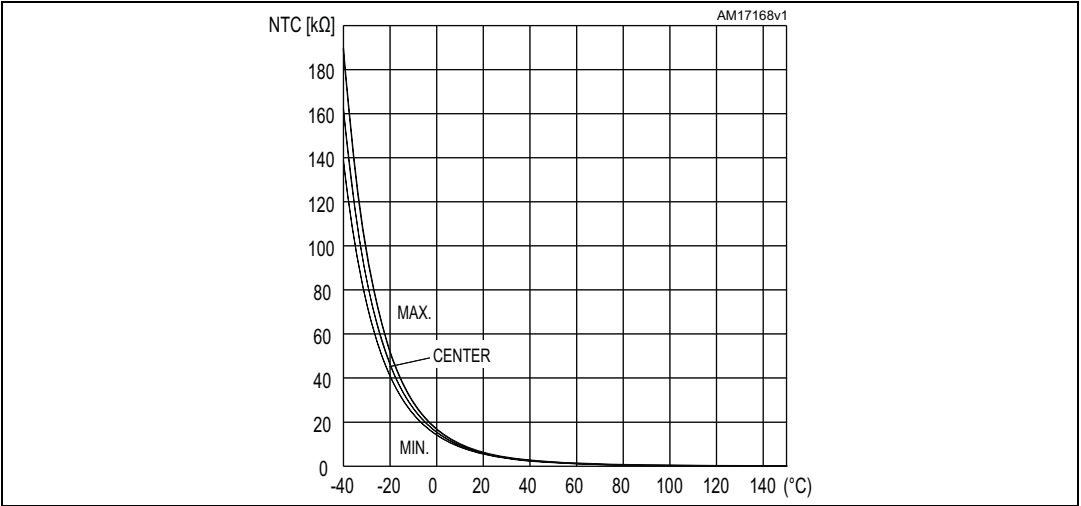
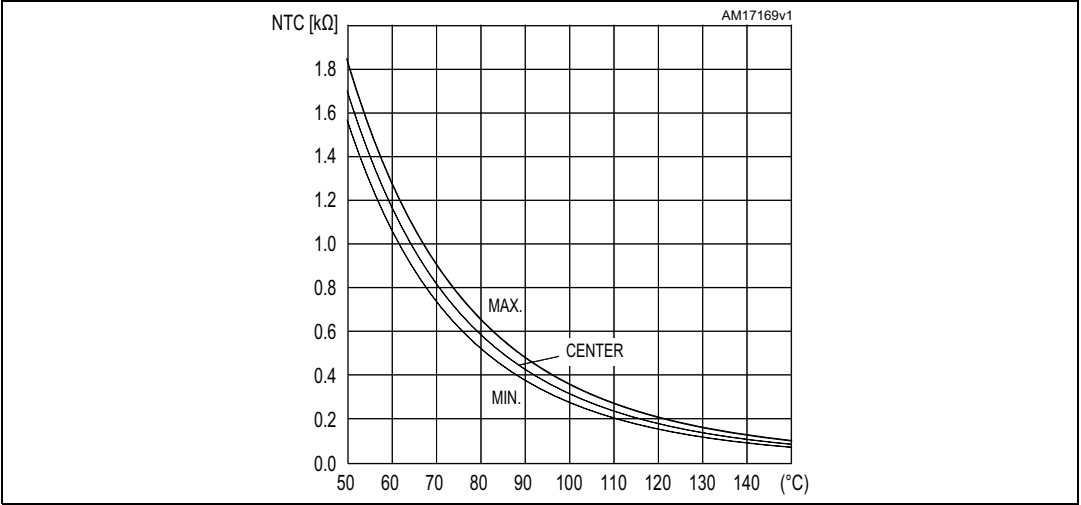
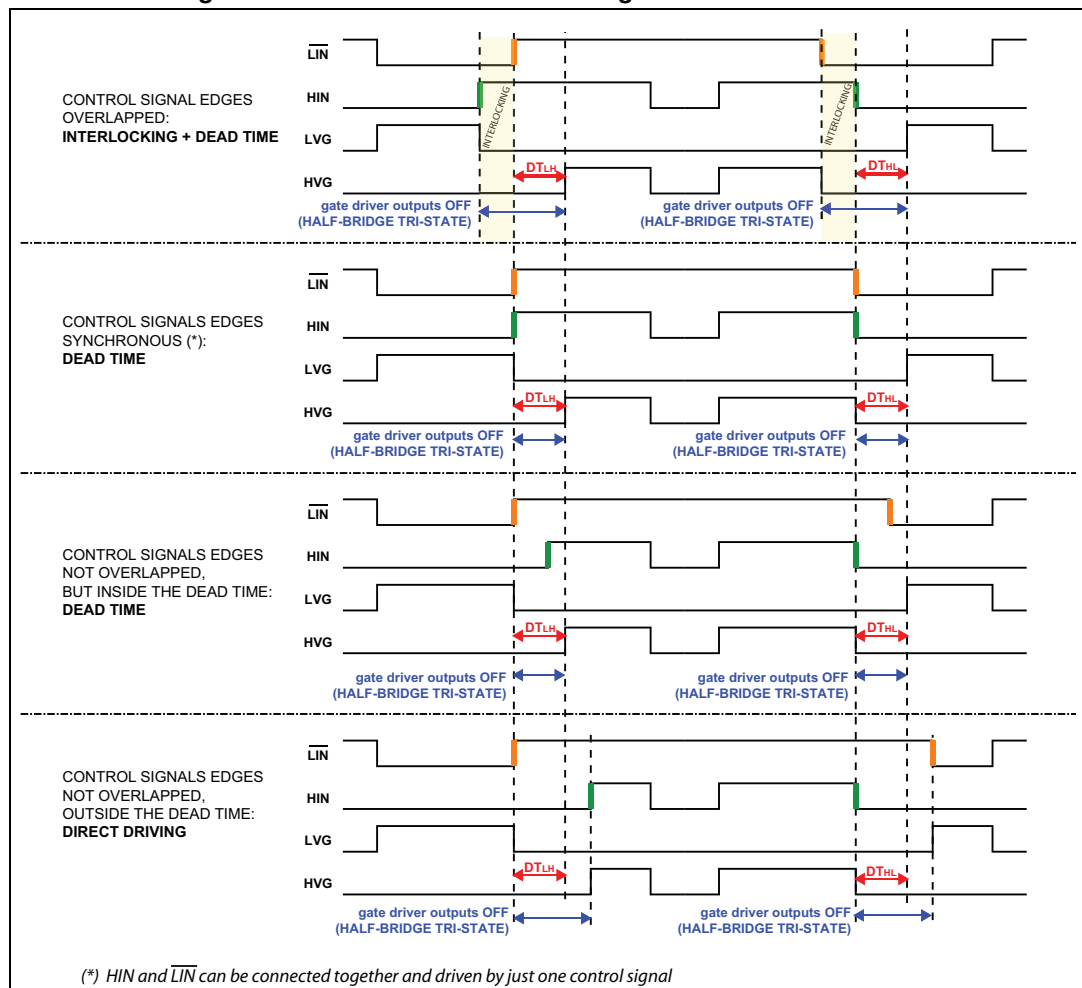


Figure 8. NTC resistance vs. temperature (zoom)



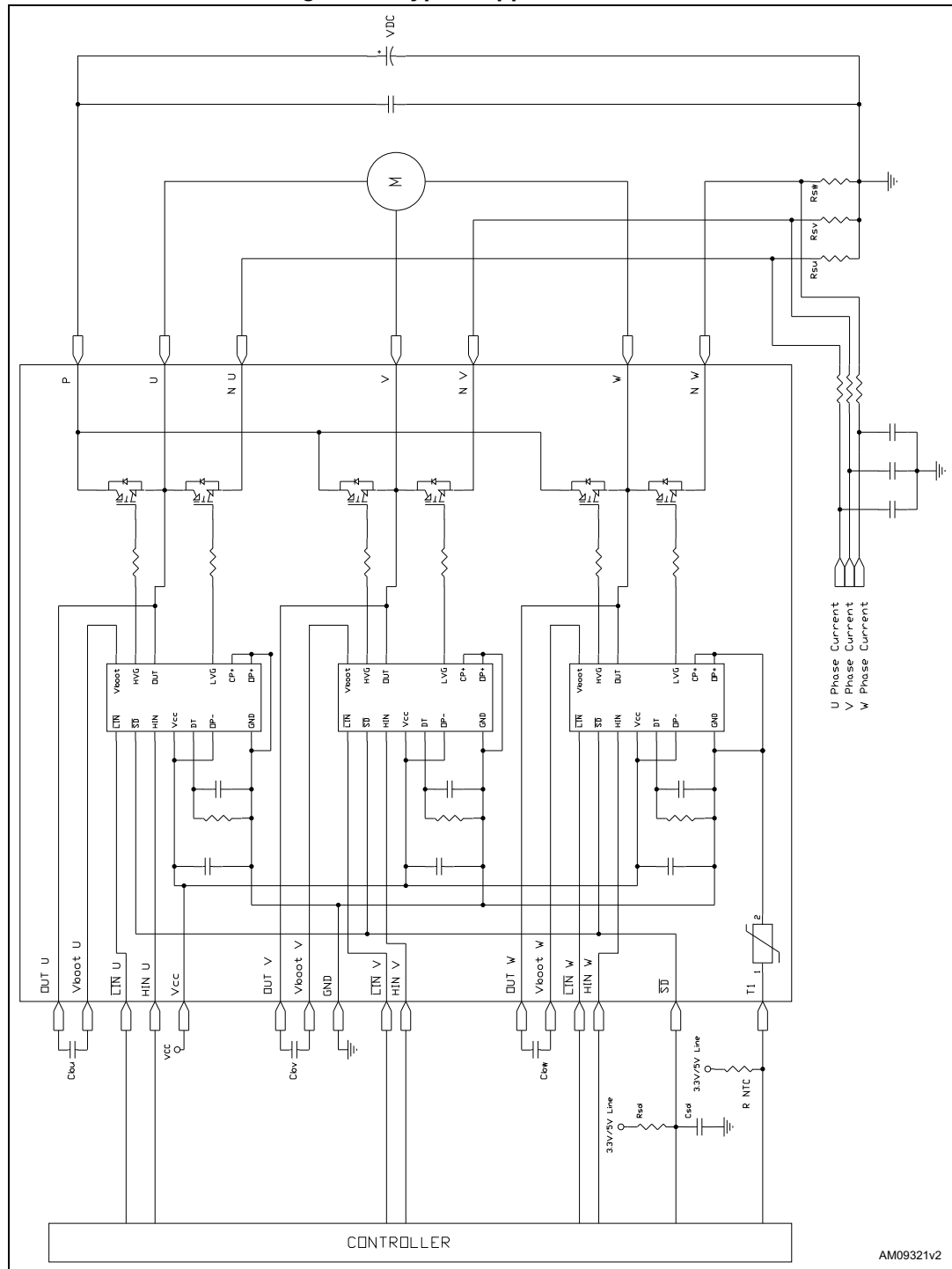
## 3.2 Waveforms definitions

Figure 9. Dead time and interlocking waveforms definitions



## 4 Applications information

### Figure 10. Typical application circuit



## 4.1 Recommendations

- Input signal HIN is active high logic. A 85 k $\Omega$  (typ.) pull down resistor is built-in for each high side input. If an external RC filter is used, for noise immunity, pay attention to the variation of the input signal level.
- Input signal /LIN is active low logic. A 720 k $\Omega$  (typ.) pull-up resistor, connected to an internal 5 V regulator through a diode, is built-in for each low side input.
- To prevent the input signals oscillation, the wiring of each input should be as short as possible.
- By integrating an application specific type HVIC inside the module, direct coupling to MCU terminals without any opto-coupler is possible.
- Each capacitor should be located as nearby the pins of IPM as possible.
- Low inductance shunt resistors should be used for phase leg current sensing.
- Electrolytic bus capacitors should be mounted as close to the module bus terminals as possible. Additional high frequency ceramic capacitor mounted close to the module pins will further improve performance.
- The  $\overline{SD}$  signal should be pulled up to 5 V / 3.3 V with an external resistor.

**Table 14. Recommended operating conditions**

| Symbol            | Parameter                          | Conditions                                                           | Value |      |      | Unit    |
|-------------------|------------------------------------|----------------------------------------------------------------------|-------|------|------|---------|
|                   |                                    |                                                                      | Min.  | Typ. | Max. |         |
| V <sub>PN</sub>   | Supply voltage                     | Applied between P-Nu, Nv, Nw                                         |       | 300  | 400  | V       |
| V <sub>CC</sub>   | Control supply voltage             | Applied between V <sub>CC</sub> -GND                                 | 13.5  | 15   | 18   | V       |
| V <sub>BS</sub>   | High side bias voltage             | Applied between V <sub>BOOTi</sub> -OUT <sub>i</sub> for i = U, V, W | 13    |      | 18   | V       |
| t <sub>dead</sub> | Blanking time to prevent arm-short | For each input signal                                                | 1     |      |      | $\mu$ s |
| f <sub>PWM</sub>  | Pwm input signal                   | -40°C < T <sub>C</sub> < 100°C<br>-40°C < T <sub>J</sub> < 125°C     |       |      | 20   | kHz     |
| T <sub>C</sub>    | Case operation temperature         |                                                                      |       |      | 100  | °C      |

For further details refer to AN3338.

## 5 Package mechanical data

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](http://www.st.com). ECOPACK® is an ST trademark.

Please refer to dedicated technical note TN0107 for mounting instructions.

**Table 15. SDIP-25L mechanical data**

| Dim. | mm.   |       |       |
|------|-------|-------|-------|
|      | Min.  | Typ.  | Max.  |
| A    | 43.90 | 44.40 | 44.90 |
| A1   | 1.15  | 1.35  | 1.55  |
| A2   | 1.40  | 1.60  | 1.80  |
| A3   | 38.90 | 39.40 | 39.90 |
| B    | 21.50 | 22.00 | 22.50 |
| B1   | 11.25 | 11.85 | 12.45 |
| B2   | 24.83 | 25.23 | 25.63 |
| C    | 5.00  | 5.40  | 6.00  |
| C1   | 6.50  | 7.00  | 7.50  |
| C2   | 11.20 | 11.70 | 12.20 |
| e    | 2.15  | 2.35  | 2.55  |
| e1   | 3.40  | 3.60  | 3.80  |
| e2   | 4.50  | 4.70  | 4.90  |
| e3   | 6.30  | 6.50  | 6.70  |
| D    |       | 33.30 |       |
| D1   |       | 5.55  |       |
| E    |       | 11.20 |       |
| E1   |       | 1.40  |       |
| F    | 0.85  | 1.00  | 1.15  |
| F1   | 0.35  | 0.50  | 0.65  |
| R    | 1.55  | 1.75  | 1.95  |
| T    | 0.45  | 0.55  | 0.65  |
| V    | 0°    |       | 6°    |

Figure 11. SDIP-25L drawing dimensions data

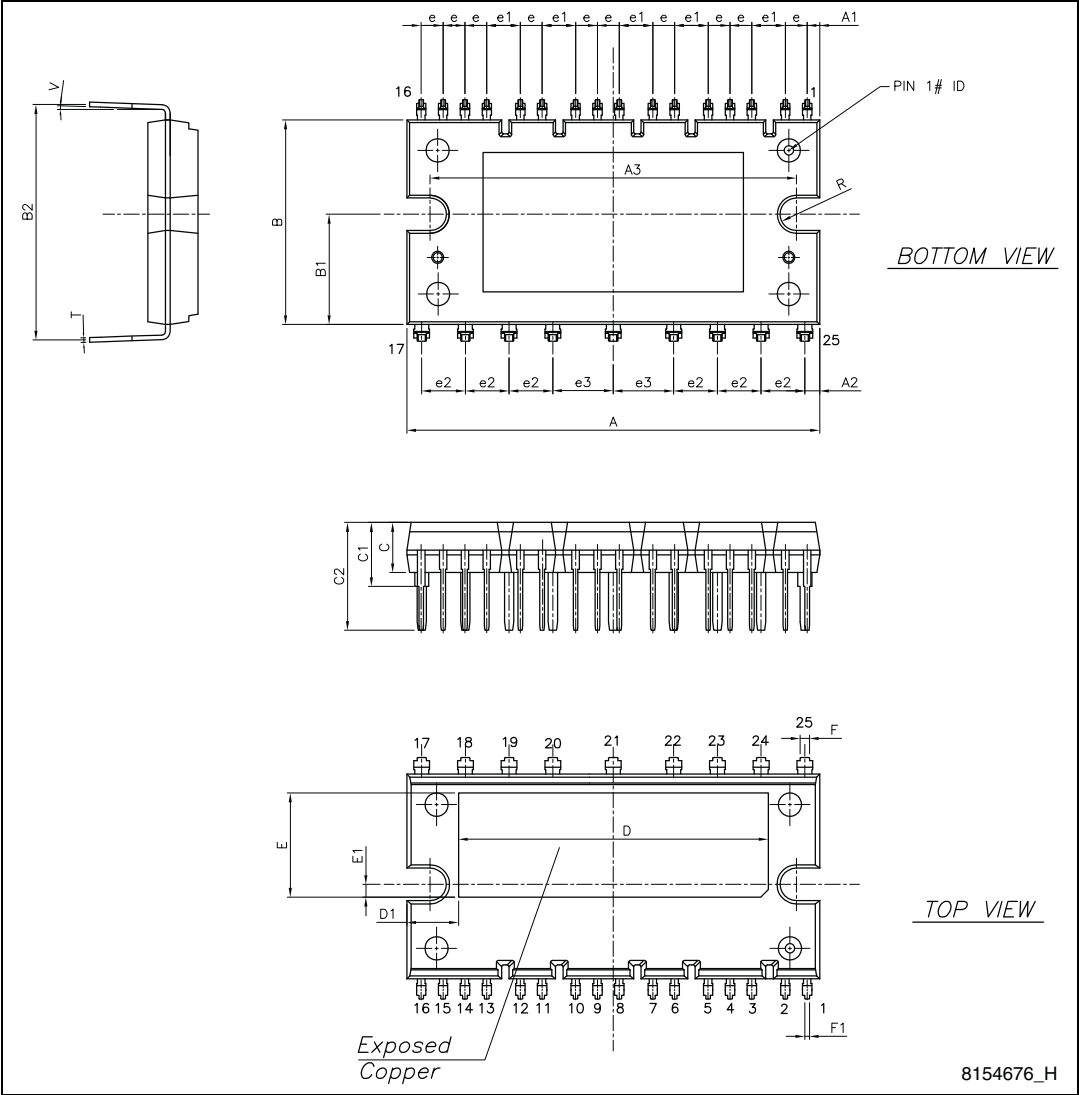


Figure 12. Packaging specifications of SDIP-25L package

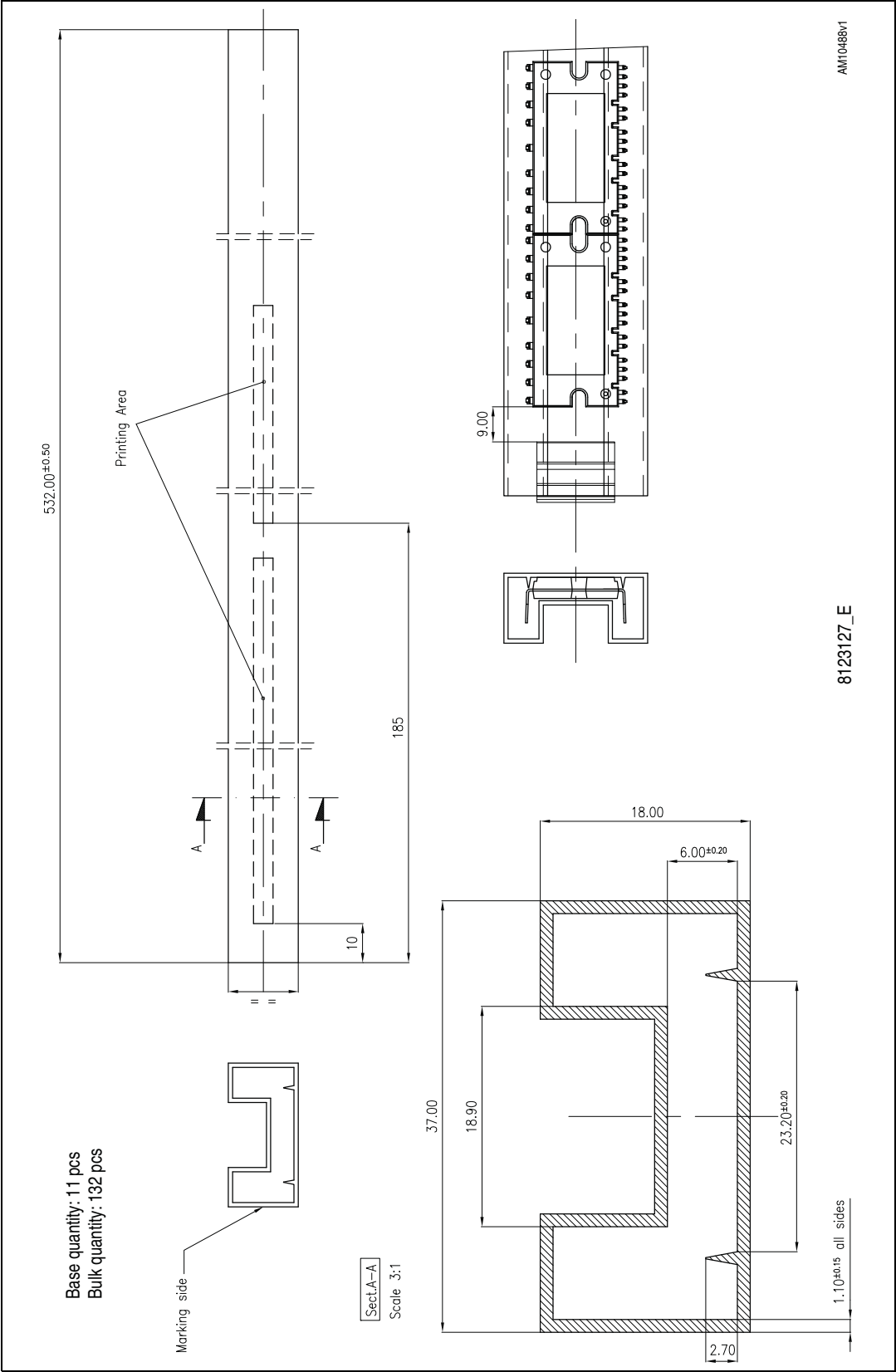
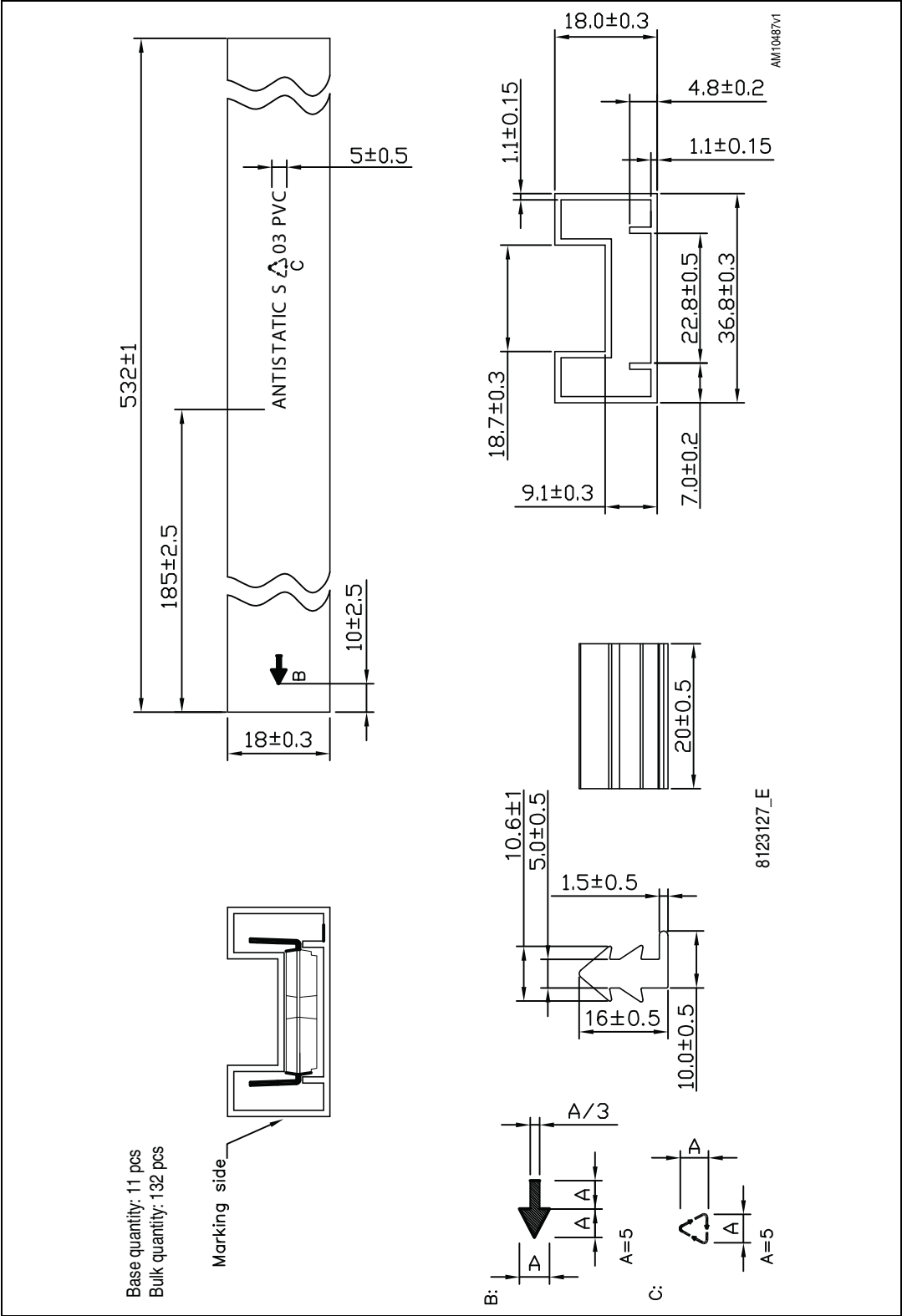


Figure 13. SDIP-25L shipping tube type B (dimensions are in mm.)



## 6 Revision history

Table 16. Document revision history

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                               |
|-------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 07-Mar-2011 | 1        | Initial release.                                                                                                                                                                                                                                                                                                                                                      |
| 14-Sep-2011 | 2        | Modified <a href="#">Section 3.1.1 on page 11</a> .                                                                                                                                                                                                                                                                                                                   |
| 28-Aug-2012 | 3        | Modified: Min. and Max. value <a href="#">Table 4 on page 5</a> .<br>Updated: <a href="#">Table 15 on page 15</a> , <a href="#">Figure 11 on page 16</a> and <a href="#">Figure 12 on page 17</a> .<br>Added: <a href="#">Figure 13 on page 18</a> .                                                                                                                  |
| 30-Apr-2013 | 4        | Modified: <ul style="list-style-type: none"><li>– description pin 15 <a href="#">Table 2 on page 4</a>,<br/>V<sub>SD</sub> parameter <a href="#">Table 4 on page 5</a>.</li><li>– <a href="#">Figure 3 on page 8</a> and <a href="#">Figure 7 on page 11</a>.</li></ul> Added: <ul style="list-style-type: none"><li>– <a href="#">Figure 8 on page 11</a>.</li></ul> |

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