

GTL2003

8-bit bidirectional low voltage translator

Rev. 2 — 3 July 2012

Product data sheet

1. General description

The Gunning Transceiver Logic - Transceiver Voltage Clamps (GTL-TVC) provide high-speed voltage translation with low ON-state resistance and minimal propagation delay. The GTL2003 provides eight NMOS pass transistors (Sn and Dn) with a common gate (GREF) and a reference transistor (SREF and DREF). The device allows bidirectional voltage translations between 0.8 V and 5.0 V without use of a direction pin. Voltage translation below 0.8 V can be achieved when properly biased. For more information, refer to application note AN11127 ([Ref. 1](#)).

When the Sn or Dn port is LOW, the clamp is in the ON-state and a low resistance connection exists between the Sn and Dn ports. Assuming the higher voltage is on the Dn port, when the Dn port is HIGH, the voltage on the Sn port is limited to the voltage set by the reference transistor (SREF). When the Sn port is HIGH, the Dn port is pulled to V_{DD1} by the pull-up resistors. This functionality allows a seamless translation between higher and lower voltages selected by the user, without the need for directional control.

All transistors have the same electrical characteristics and there is minimal deviation from one output to another in voltage or propagation delay. This is a benefit over discrete transistor voltage translation solutions, since the fabrication of the transistors is symmetrical. Because all transistors in the device are identical, SREF and DREF can be located on any of the other eight matched Sn/Dn transistors, allowing for easier board layout. The translator's transistors provide excellent ESD protection to lower voltage devices and at the same time protect less ESD-resistant devices.

2. Features and benefits

- 8-bit bidirectional low voltage translator
- Allows voltage level translation between 0.8 V, 0.9 V, 1.0 V, 1.2 V, 1.5 V, 1.8 V, 2.5 V, 3.3 V, and 5 V buses which allows direct interface with GTL, GTL+, LVTTTL/TTL and 5 V CMOS levels
- Provides bidirectional voltage translation with no direction pin
- Low $6.5\ \Omega$ ON-state resistance (R_{on}) between input and output pins (Sn/Dn)
- Supports hot insertion
- No power supply required: will not latch up
- 5 V tolerant inputs
- Low standby current
- Flow-through pinout for ease of printed-circuit board trace routing
- ESD protection exceeds 2000 V HBM per JESD22-A114, and 1000 V CDM per JESD22-C101
- Packages offered: TSSOP20, DHVQFN20



3. Applications

- Any application that requires bidirectional or unidirectional voltage level translation from any voltage from 0.8 V to 5.0 V to any voltage from 0.8 V to 5.0 V
- The open-drain construction with no direction pin is ideal for bidirectional low voltage (for example, 0.8 V, 0.9 V, 1.0 V, 1.2 V, 1.5 V, or 1.8 V) processor I²C-bus port translation to the normal 3.3 V and/or 5.0 V I²C-bus signal levels or GTL/GTL+ translation to LVTTTL/TTL signal levels.

4. Ordering information

Table 1. Ordering information

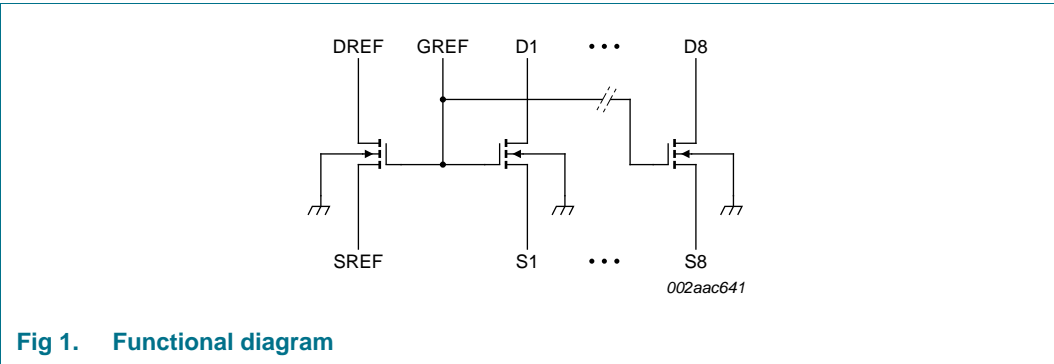
Type number	Package		Version
	Name	Description	
GTL2003BQ	DHVQFN20	plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 20 terminals; body 2.5 × 4.5 × 0.85 mm	SOT764-1
GTL2003PW	TSSOP20	plastic thin shrink small outline package; 20 leads; body width 4.4 mm	SOT360-1

4.1 Ordering options

Table 2. Ordering options

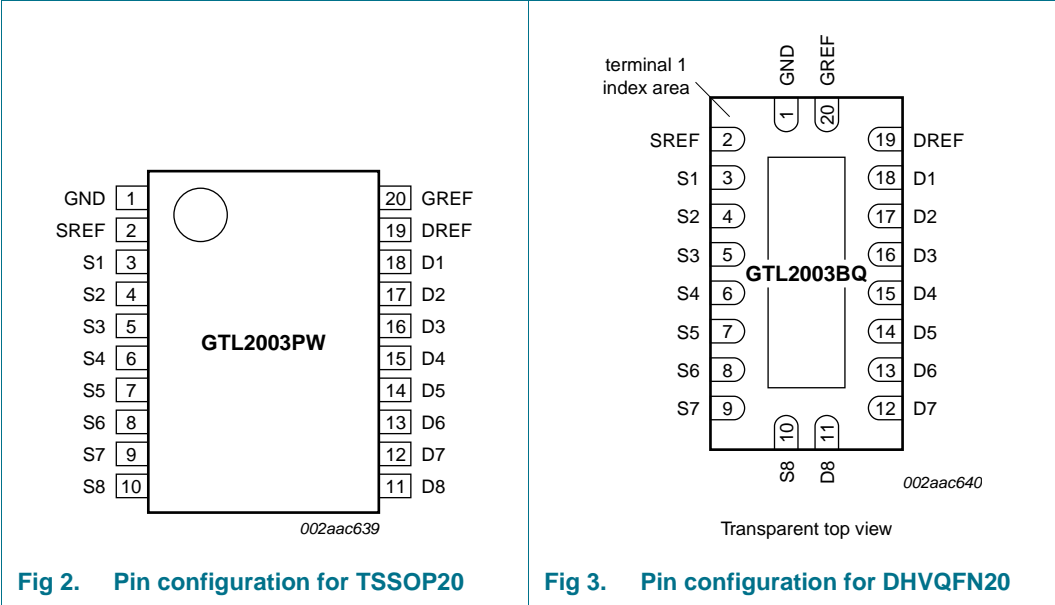
Type number	Topside mark	Temperature range
GTL2003BQ	2003	−40 °C to +85 °C
GTL2003PW	GTL2003	−40 °C to +85 °C

5. Functional diagram



6. Pinning information

6.1 Pinning



6.2 Pin description

Table 3. Pin description

Symbol	Pin	Description
GND	1 ^[1]	ground (0 V)
SREF	2	source of reference transistor
S1 to S8	3, 4, 5, 6, 7, 8, 9, 10	Port S1 to Port S8
D1 to D8	18, 17, 16, 15, 14, 13, 12, 11	Port D1 to Port D8
DREF	19	drain of reference transistor
GREF	20	gate of reference transistor

[1] DHVQFN20 package die supply ground is connected to both GND pin and exposed center pad. GND pin must be connected to supply ground for proper device operation. For enhanced thermal, electrical, and board level performance, the exposed pad needs to be soldered to the board using a corresponding thermal pad on the board and for proper heat conduction through the board, thermal vias need to be incorporated in the printed-circuit board in the thermal pad region.

7. Functional description

Refer also to [Figure 1 “Functional diagram”](#).

7.1 Function selection

Table 4. Function selection, HIGH-to-LOW translation

Assumes Dn is at the higher voltage level.

H = HIGH voltage level; L = LOW voltage level; X = Don't care

GREF ^[1]	DREF	SREF	Input Dn	Output Sn	Transistor
H	H	0 V	X	X	off
H	H	V_T ^[2]	H	V_T ^{[2][3]}	on
H	H	V_T ^[2]	L	L ^[4]	on
L	L	$0\text{ V} - V_T$ ^[2]	X	X	off

[1] GREF should be at least 1.5 V higher than SREF for best translator operation.

[2] V_T is equal to the SREF voltage.

[3] Sn is not pulled up or pulled down.

[4] Sn follows the Dn input LOW.

Table 5. Function selection, LOW-to-HIGH translation

Assumes Dn is at the higher voltage level.

H = HIGH voltage level; L = LOW voltage level; X = Don't care

GREF ^[1]	DREF	SREF	Input Sn	Output Dn	Transistor
H	H	0 V	X	X	off
H	H	V_T ^[2]	V_T ^[2]	H ^[3]	nearly off
H	H	V_T ^[2]	L	L ^[4]	on
L	L	$0\text{ V} - V_T$ ^[2]	X	X	off

[1] GREF should be at least 1.5 V higher than SREF for best translator operation.

[2] V_T is equal to the SREF voltage.

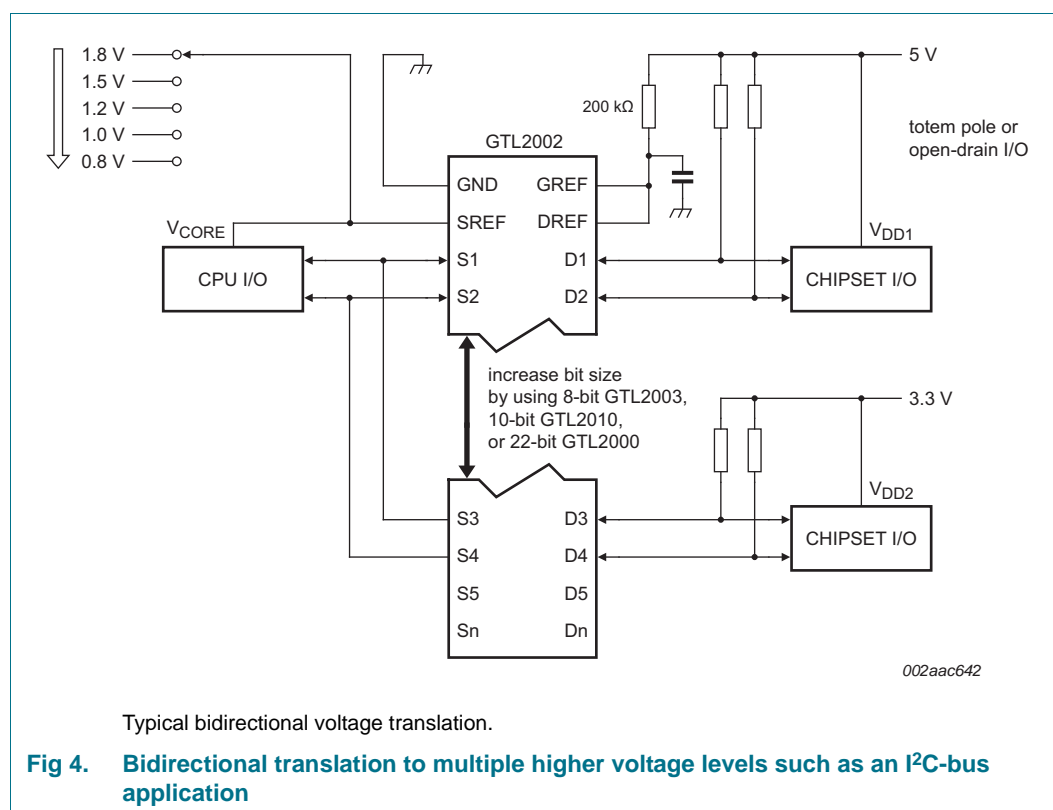
[3] Dn is pulled up to V_{DD1} through an external resistor.

[4] Dn follows the Sn input LOW.

8. Application design-in information

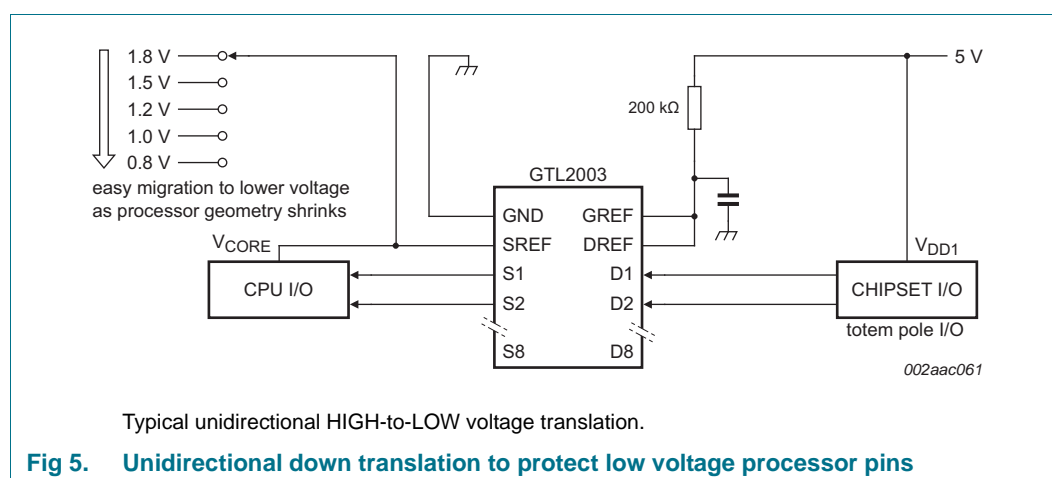
8.1 Bidirectional translation

For the bidirectional clamping configuration, higher voltage to lower voltage or lower voltage to higher voltage, the GREF input must be connected to DREF and both pins pulled to HIGH side V_{DD1} through a pull-up resistor (typically 200 k Ω). A filter capacitor on DREF is recommended. The processor output can be totem pole or open-drain (pull-up resistors may be required) and the chip set output can be totem pole or open-drain (pull-up resistors are required to pull the Dn outputs to V_{DD1}). However, if either output is totem pole, data must be unidirectional or the outputs must be 3-stateable and the outputs must be controlled by some direction control mechanism to prevent HIGH-to-LOW contentions in either direction. If both outputs are open-drain, no direction control is needed. The opposite side of the reference transistor (SREF) is connected to the processor core power supply voltage. When DREF is connected through a 200 k Ω resistor to a 3.3 V to 5.5 V V_{DD1} supply and SREF can be set between 0.8 V to ($V_{DD1} - 1.5$ V), without the need for pull-up resistors on the low voltage side. The output of each Sn will have a maximum output voltage equal to SREF and the output of each Dn has a maximum output voltage equal to V_{DD1} . It is recommended that V_{DD1} be greater than 1.5 V for proper operation.



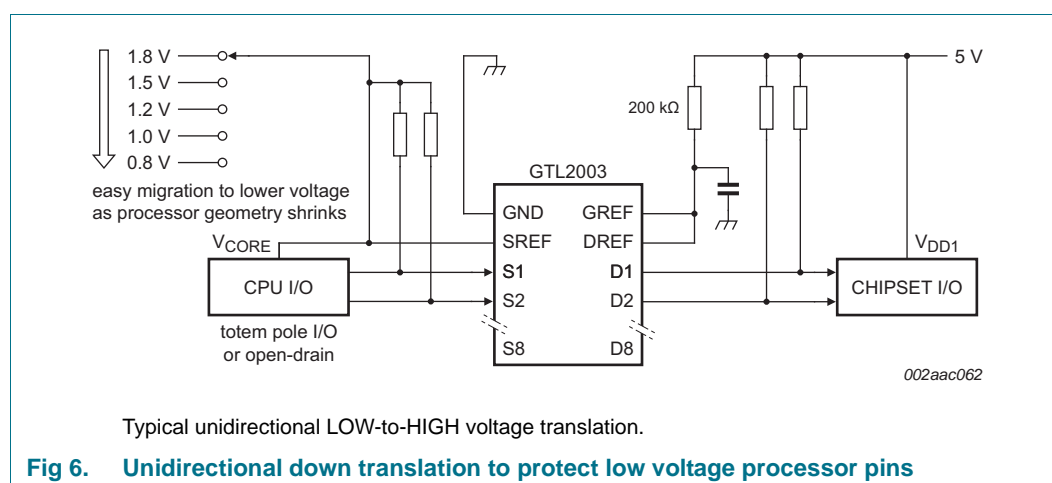
8.2 Unidirectional down translation

For unidirectional clamping, higher voltage to lower voltage, the GREF input must be connected to DREF and both pins pulled to the higher side V_{DD1} through a pull-up resistor (typically 200 k Ω). A filter capacitor on DREF is recommended. Pull-up resistors are required if the chip set I/O are open-drain. The opposite side of the reference transistor (SREF) is connected to the processor core supply voltage. When DREF is connected through a 200 k Ω resistor to a 3.3 V to 5.5 V V_{DD1} supply and SREF can be set between 0.8 V to ($V_{DD1} - 1.5$ V), without the need for pull-up resistors on the low voltage side. The output of each S_n will have a maximum output voltage equal to SREF. It is recommended that V_{DD1} be greater than 1.5 V for proper operation.



8.3 Unidirectional up translation

For unidirectional up translation, lower voltage to higher voltage, the reference transistor is connected the same as for a down translation. A pull-up resistor is required on the higher voltage side (D_n or S_n) to get the full HIGH level, since the GTL-TVC device will only pass the reference source (SREF) voltage as a HIGH when doing an up translation. The driver on the lower voltage side only needs pull-up resistors if it is open-drain.



8.4 Sizing pull-up resistor

The pull-up resistor value needs to limit the current through the pass transistor when it is in the 'on' state to about 15 mA. This will guarantee a pass voltage of 260 mV to 350 mV. If the current through the pass transistor is higher than 15 mA, the pass voltage will also be higher in the 'on' state. To set the current through each pass transistor at 15 mA, the pull-up resistor value is calculated as shown in [Equation 1](#):

$$\text{resistor value } (\Omega) = \frac{\text{pull-up voltage (V)} - 0.35 \text{ V}}{0.015 \text{ A}} \quad (1)$$

When using open-drain devices, it is always required to use pull-up resistors at D-side, and they must be sized so as not to overload the output. If $V_{DD1} - V_{SREF} < 1.5 \text{ V}$, then pull-up resistor is required on S-side to pull up the Sn outputs to V_{SREF} . It is important to note that if pull-up resistors are required on both the S-side and D-side, the equivalent pull-up resistor value becomes the parallel combination of the two resistors when pass transistor is ON. If $V_{DD1} - V_{SREF} \geq 1.5 \text{ V}$, then pull-up resistors on the S-side are not required.

[Table 6](#) summarizes resistor values for various reference voltages and currents at 15 mA and also at 10 mA and 3 mA for $V_{DD1} - V_{SREF} \geq 1.5 \text{ V}$. The resistor value shown in the +10 % column or a larger value should be used to ensure that the pass voltage of the transistor would be 350 mV or less. The external driver must be able to sink the total current from the resistors on both sides of the GTL-TVC device at 0.175 V, although the 15 mA only applies to current flowing through the GTL-TVC device. See application note AN10145, "Bidirectional low voltage translators" ([Ref. 2](#)) for more information.

Table 6. Pull-up resistor values

Calculated for $V_{OL} = 0.35 \text{ V}$. Assumes output driver $V_{OL} = 0.175 \text{ V}$ at stated current.

Pull-up resistor value (Ω)						
Voltage	15 mA		10 mA		3 mA	
	Nominal	+ 10 % ^[1]	Nominal	+ 10 % ^[1]	Nominal	+ 10 % ^[1]
5.0 V	310	341	465	512	1550	1705
3.3 V	197	217	295	325	983	1082
2.5 V	143	158	215	237	717	788
1.8 V	97	106	145	160	483	532
1.5 V	77	85	115	127	383	422
1.2 V	57	63	85	94	283	312
1.1 V	50	55	75	83	250	275
1.0 V	44	48	65	72	217	239
0.95 V	40	44	60	66	200	220
0.9 V	37	41	55	61	183	201
0.85 V	34	37	50	55	167	184
0.8 V	30	33	45	50	150	165

[1] + 10 % to compensate for V_{DD} range and resistor tolerance.

9. Limiting values

Table 7. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).^[1]

Symbol	Parameter	Conditions	Min	Max	Unit
V _{SREF}	voltage on pin SREF		-0.5 ^[2]	+7.0	V
V _{DREF}	voltage on pin DREF		-0.5 ^[2]	+7.0	V
V _{GREF}	voltage on pin GREF		-0.5 ^[2]	+7.0	V
V _{Sn}	voltage on port Sn		-0.5 ^[2]	+7.0	V
V _{Dn}	voltage on port Dn		-0.5 ^[2]	+7.0	V
I _{IK}	input clamping current	SREF, DREF, GREF; V _I < 0 V	-	-50	mA
		port Sn; V _I < 0 V	-	-50	mA
		port Dn; V _I < 0 V	-	-50	mA
I _{ch}	channel current (DC)	channel in ON-state	-	±128	mA
T _{stg}	storage temperature		-65	+150	°C

[1] The performance capability of a high-performance integrated circuit in conjunction with its thermal environment can create junction temperatures which are detrimental to reliability. The maximum junction temperature of this integrated circuit should not exceed 150 °C.

[2] The input and output negative voltage ratings may be exceeded if the input and output clamp current ratings are observed.

10. Recommended operating conditions

Table 8. Recommended operating conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V _{I/O}	voltage on an input/output pin	Sn, Dn	0	-	5.5	V
V _{Sn}	voltage on port Sn	Sn	0	-	5.5	V
V _{SREF}	voltage on pin SREF	^[1]	0	-	5.5	V
V _{DREF}	voltage on pin DREF		0	-	5.5	V
V _{GREF}	voltage on pin GREF		0	-	5.5	V
I _{sw(pass)}	pass switch current		-	-	64	mA
T _{amb}	ambient temperature	operating in free-air	-40	-	+85	°C

[1] V_{SREF} ≤ V_{DREF} - 1.5 V for best results in level shifting applications.

11. Static characteristics

Table 9. Static characteristics

$T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ ^[1]	Max	Unit	
V _{OL}	LOW-level output voltage	V _{DD} = 3.0 V; V _{SREF} = 1.365 V; V _{Sn} or V _{Dn} = 0.175 V; I _{IK} = 15.2 mA	-	260	350	mV	
V _{IK}	input clamping voltage	I _I = −18 mA; V _{GREF} = 0 V	-	-	−1.2	V	
I _{LI(G)}	gate input leakage current	V _I = 5 V; V _{GREF} = 0 V	-	-	5	μA	
C _{ig}	input capacitance at gate	GREF; V _I = 3 V or 0 V	-	56	-	pF	
C _{io(off)}	off-state input/output capacitance	V _O = 3 V or 0 V; V _{GREF} = 0 V	-	7.4	-	pF	
C _{io(on)}	on-state input/output capacitance	V _O = 3 V or 0 V; V _{GREF} = 3 V	-	18.6	-	pF	
R _{on}	ON-state resistance	V _{Sn} = 0 V; I _O = 64 mA	[2]				
		V _{GREF} = 4.5 V	-	3.5	5	Ω	
		V _{GREF} = 3 V	-	4.4	7	Ω	
		V _{GREF} = 2.3 V	-	5.5	9	Ω	
		V _{GREF} = 1.5 V	-	67	105	Ω	
		V _{Sn} = 0 V; I _O = 30 mA; V _{GREF} = 1.5 V	[2]	-	9	15	Ω
		V _{Sn} = 2.4 V; I _O = 15 mA; V _{GREF} = 4.5 V	[2]	-	7	10	Ω
		V _{Sn} = 2.4 V; I _O = 15 mA; V _{GREF} = 3 V	[2]	-	58	80	Ω
		V _{Sn} = 1.7 V; I _O = 15 mA; V _{GREF} = 2.3 V	[2]	-	50	70	Ω

[1] All typical values are measured at $T_{amb} = 25\text{ }^{\circ}\text{C}$.

[2] Measured by the voltage drop between the Sn and the Dn terminals at the indicated current through the switch. ON-state resistance is determined by the lowest voltage of the two (Sn or Dn) terminals.

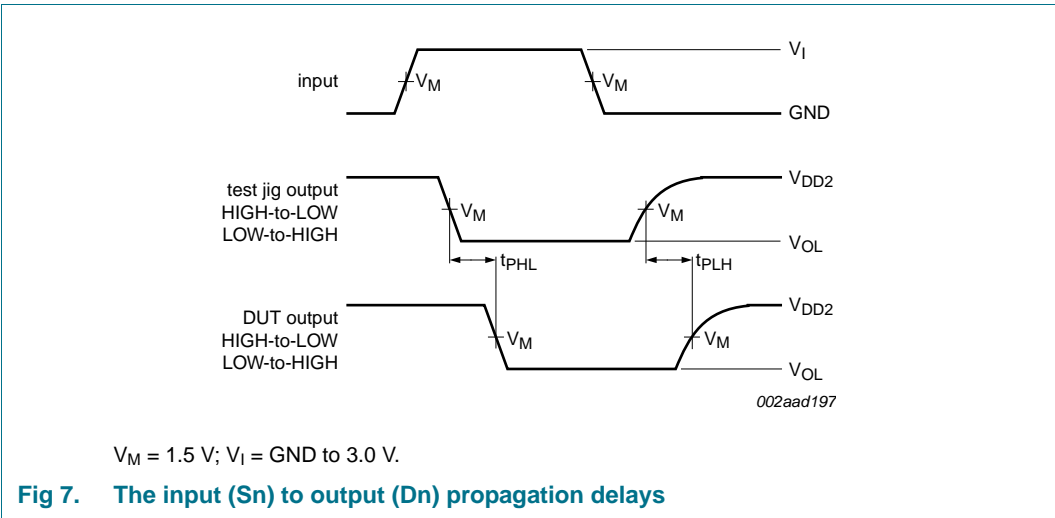
12. Dynamic characteristics

12.1 Dynamic characteristics for translator-type application

Table 10. Dynamic characteristics
T_{amb} = -40 °C to +85 °C; V_{ref} = 1.365 V to 1.635 V; V_{DD1} = 3.0 V to 3.6 V; V_{DD2} = 2.36 V to 2.64 V; GND = 0 V; t_r = t_f ≤ 3.0 ns; unless otherwise specified. Refer to [Figure 9](#).

Symbol	Parameter	Conditions	Min	Typ ^[1]	Max	Unit
t _{PLH}	LOW to HIGH propagation delay	Sn to Dn; Dn to Sn	[2][3] 0.5	1.5	5.5	ns
t _{PHL}	HIGH to LOW propagation delay	Sn to Dn; Dn to Sn	[2][3] 0.5	1.5	5.5	ns

- [1] All typical values are measured at V_{DD1} = 3.3 V, V_{DD2} = 2.5 V, V_{ref} = 1.5 V and T_{amb} = 25 °C.
- [2] Propagation delay is measured using [Figure 9](#) and is a difference measurement. It is not production tested and is guaranteed by ON-state resistance.
- [3] C_{io(on)} maximum of 30 pF and C_{io(off)} maximum of 15 pF is guaranteed by design.

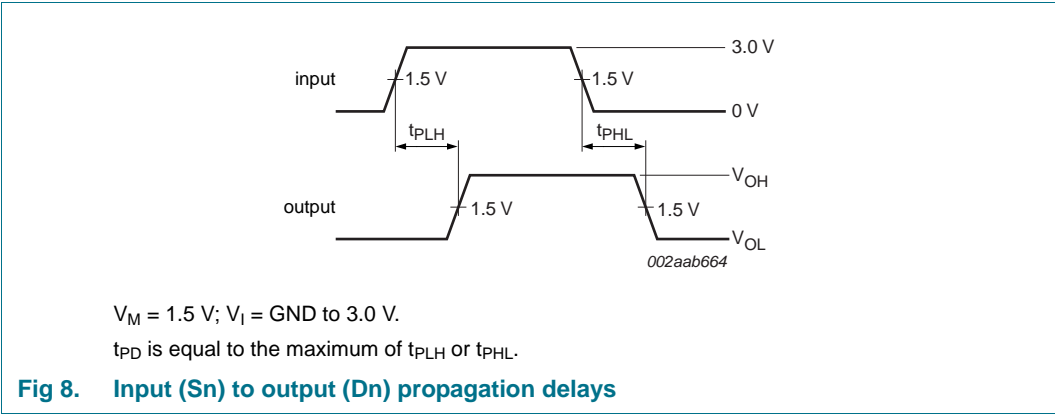


12.2 Dynamic characteristics for CBT-type application

Table 11. Dynamic characteristics
 $T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$; $V_{GREF} = 5\text{ V} \pm 0.5\text{ V}$; $GND = 0\text{ V}$; $C_L = 50\text{ pF}$; unless otherwise specified.
Refer to [Figure 10](#).

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_{PD}	propagation delay	[1]	-	-	250	ps

[1] This parameter is warranted by the ON-state resistance, but is not production tested. The propagation delay is based on the RC time constant of the typical ON-state resistance of the switch and a load capacitance of 50 pF, when driven by an ideal voltage source (zero output impedance).



13. Test information

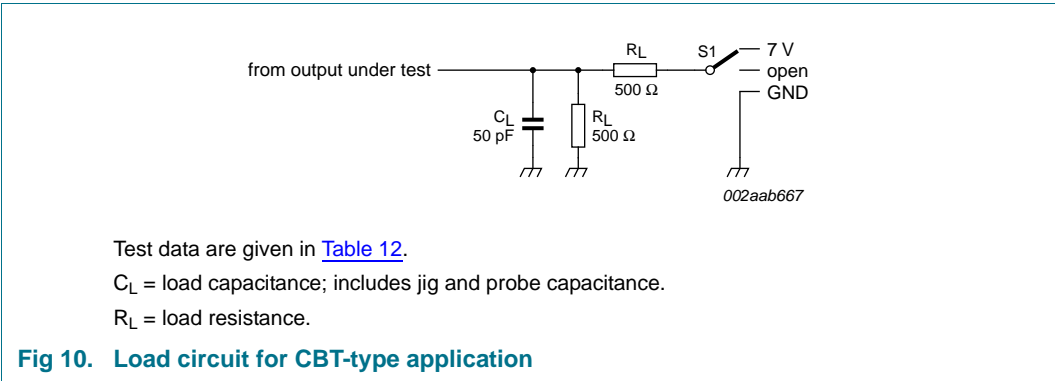
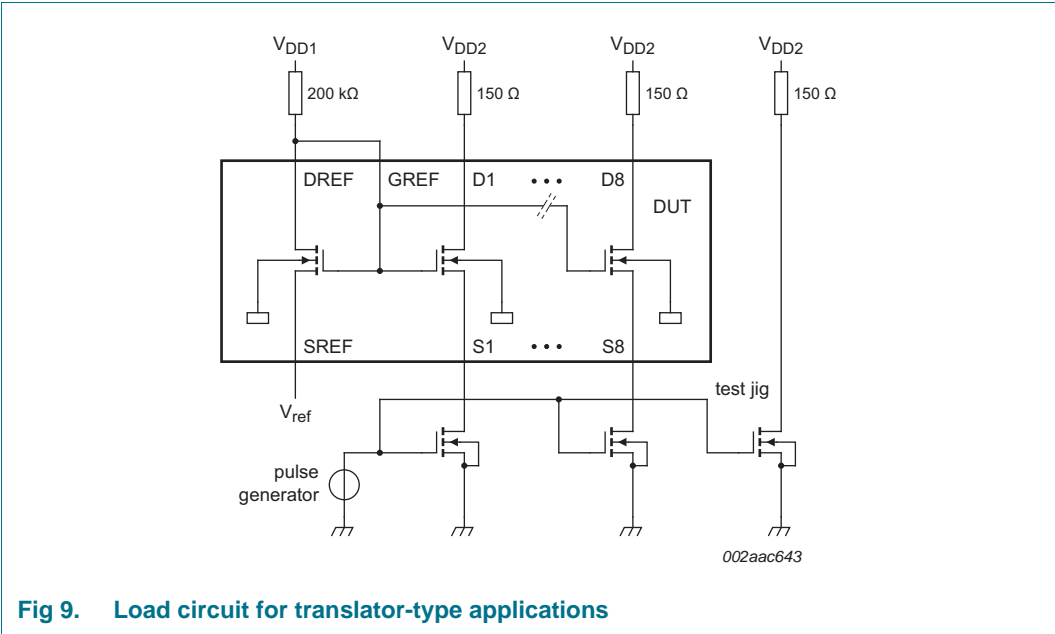


Table 12. Test data

Test	Load		Switch
	C_L	R_L	
t_{PD}	50 pF	500 Ω	open
t_{PLZ} , t_{PZL}	50 pF	500 Ω	7 V
t_{PHZ} , t_{PZH}	50 pF	500 Ω	open

14. Package outline

TSSOP20: plastic thin shrink small outline package; 20 leads; body width 4.4 mm

SOT360-1

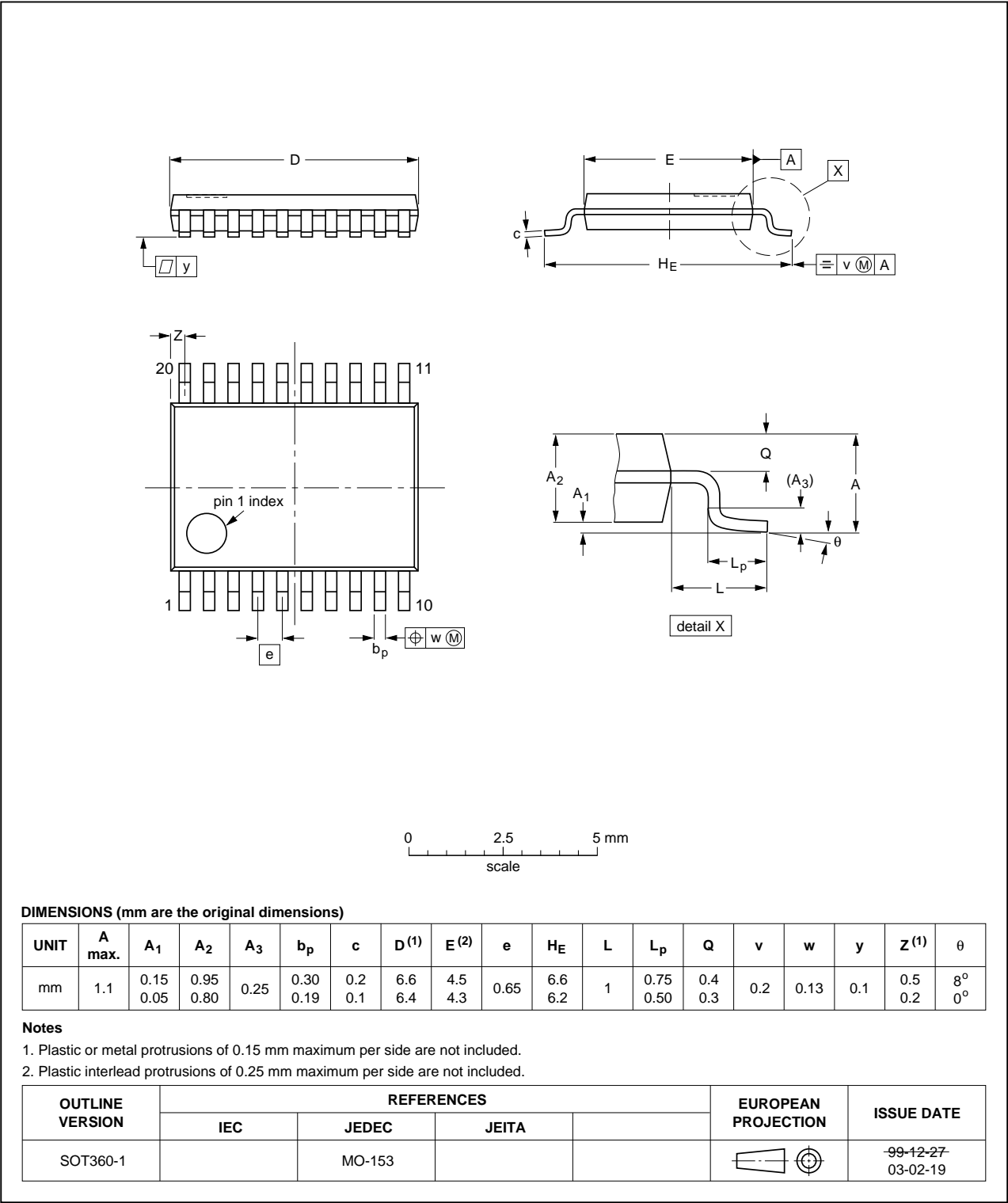


Fig 11. Package outline SOT360-1 (TSSOP20)

DHVQFN20: plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 20 terminals; body 2.5 x 4.5 x 0.85 mm SOT764-1

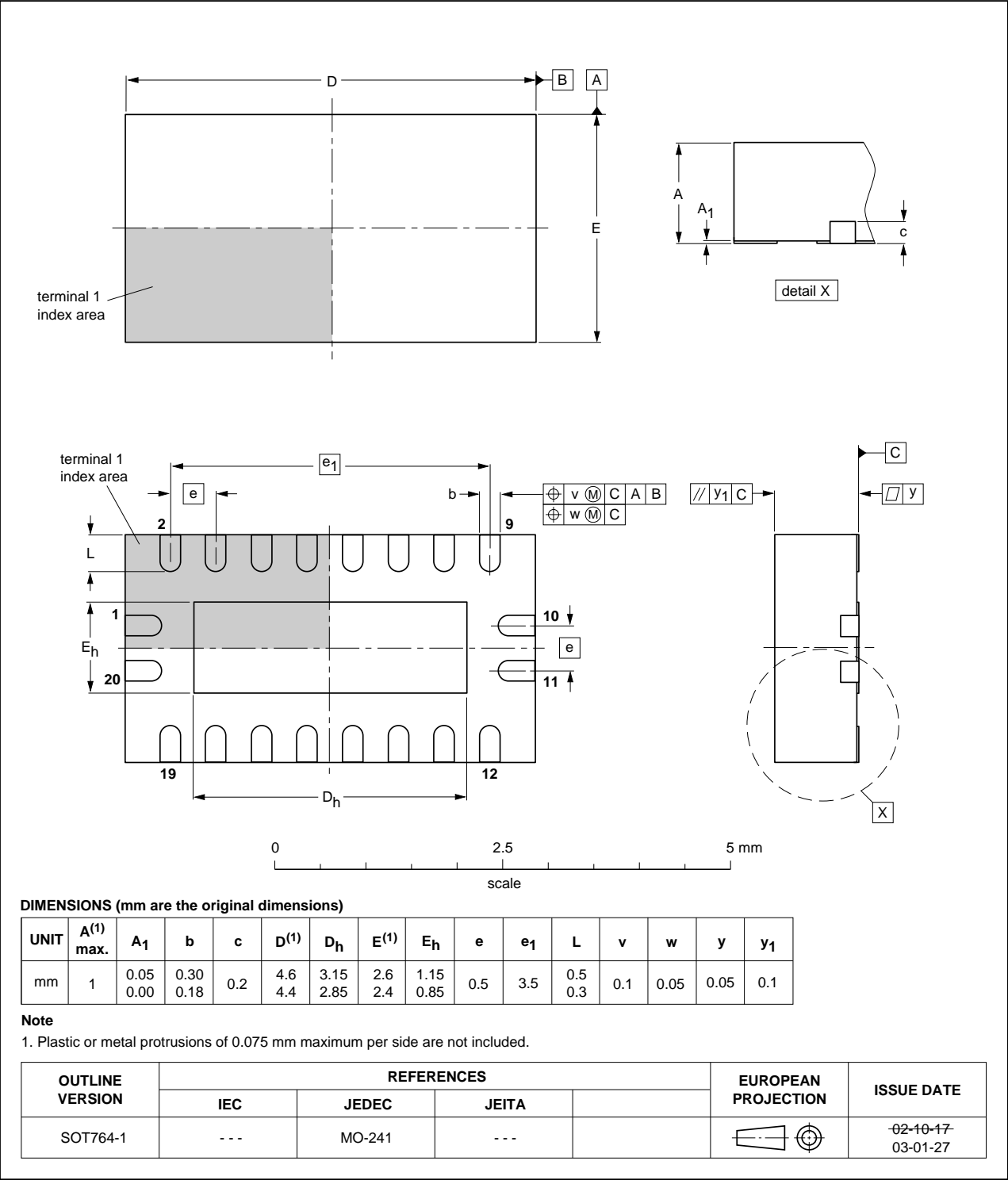


Fig 12. Package outline SOT764-1 (DHVQFN20)

15. Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 "Surface mount reflow soldering description"*.

15.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

15.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leadless or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leadless SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leadless packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

15.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

15.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see [Figure 13](#)) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with [Table 13](#) and [14](#)

Table 13. SnPb eutectic process (from J-STD-020C)

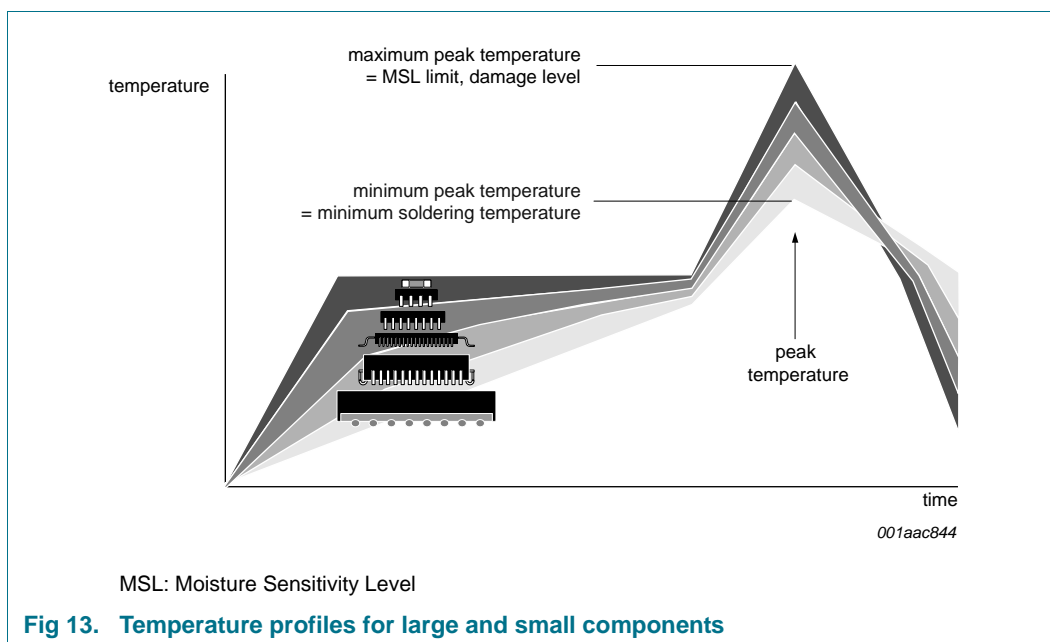
Package thickness (mm)	Package reflow temperature (°C)	
	Volume (mm ³)	
	< 350	≥ 350
< 2.5	235	220
≥ 2.5	220	220

Table 14. Lead-free process (from J-STD-020C)

Package thickness (mm)	Package reflow temperature (°C)		
	Volume (mm ³)		
	< 350	350 to 2000	> 2000
< 1.6	260	260	260
1.6 to 2.5	260	250	245
> 2.5	250	245	245

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see [Figure 13](#).



For further information on temperature profiles, refer to Application Note *AN10365* "Surface mount reflow soldering description".

16. Soldering: PCB footprints

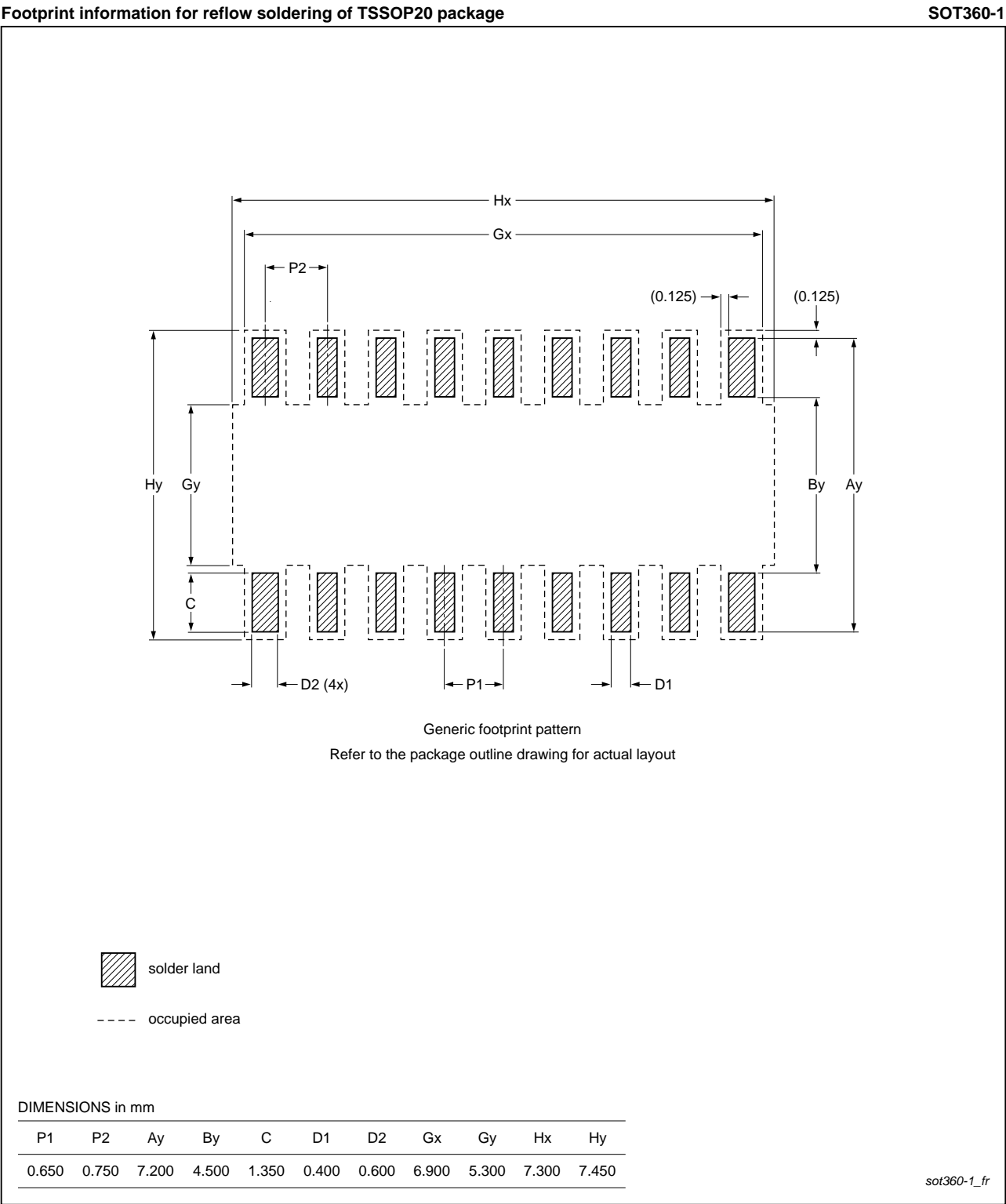
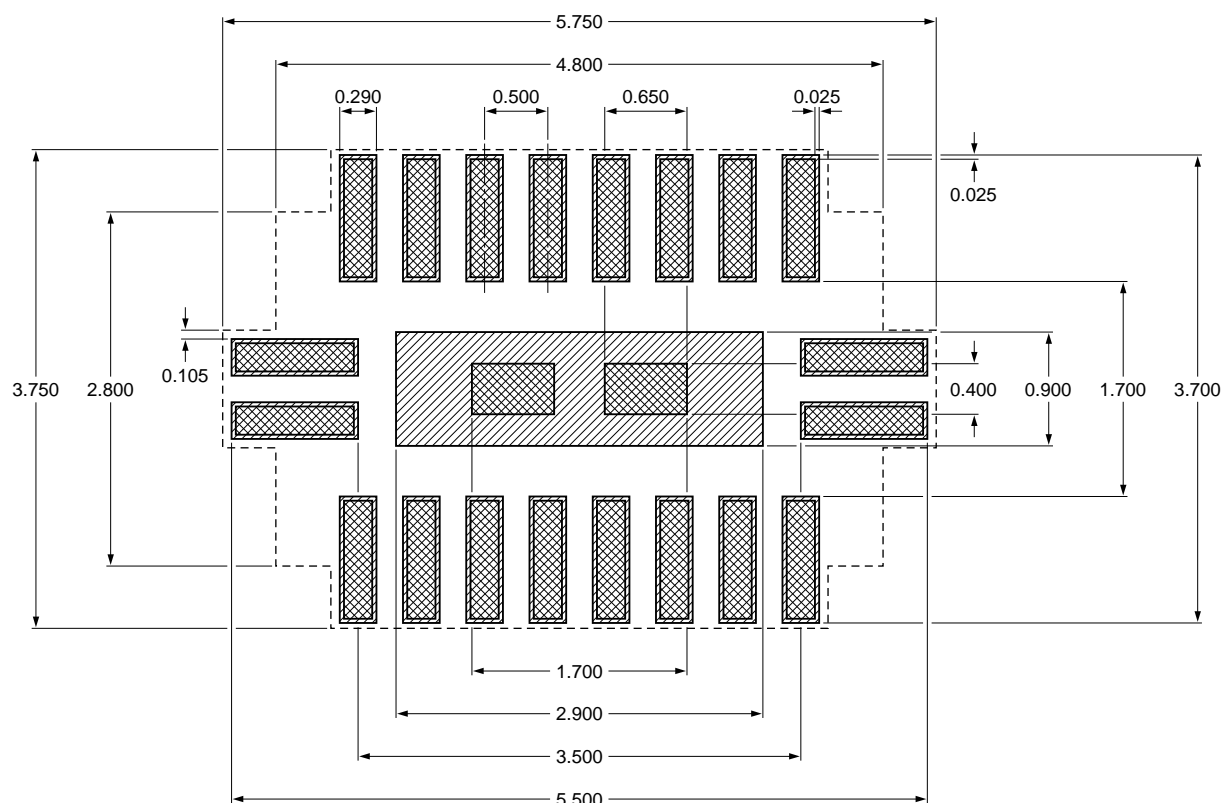


Fig 14. PCB footprint for SOT360-1 (TSSOP20); reflow soldering

Footprint information for reflow soldering of DHVQFN20 package

SOT764-1



Refer to the package outline drawing for actual layout




-  solder land
-  solder paste deposit
-  solder land plus solder paste
- occupied area

Fig 15. PCB footprint for SOT764-1 (TSSOP20); reflow soldering

17. Abbreviations

Table 15. Abbreviations

Acronym	Description
CDM	Charged Device Model
CMOS	Complementary Metal Oxide Semiconductor
DUT	Device Under Test
ESD	ElectroStatic Discharge
GTL	Gunning Transceiver Logic
HBM	Human Body Model
I ² C-bus	Inter-Integrated Circuit bus
LVTTL	Low Voltage Transistor-Transistor Logic
NMOS	Negative-channel Metal Oxide Semiconductor
TTL	Transistor-Transistor Logic
TVC	Transceiver Voltage Clamps

18. References

- [1] **AN11127, “Bidirectional voltage translators NVT2001/02/03/04/06/08/10, PCA9306, GTL2000/02/03/10”** — application note; NXP Semiconductors; www.nxp.com/documents/application_note/AN11127.pdf
- [2] **AN10145, “Bidirectional low voltage translators”** — application note; NXP Semiconductors; www.nxp.com/documents/application_note/AN10145.pdf

19. Revision history

Table 16. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
GTL2003 v.2	20120703	Product data sheet	-	GTL2003 v.1
Modifications:	<ul style="list-style-type: none"> • Section 1 “General description”: <ul style="list-style-type: none"> – first paragraph, third sentence changed from “between 1.0 V and 5.0 V” to “between 0.8 V and 5.0 V” – first paragraph: added (new) fourth sentence. – second paragraph, third sentence: changed from “V_{CC}” to “V_{DD1}” • Section 2 “Features and benefits”: <ul style="list-style-type: none"> – second bullet: added “0.8 V, 0.9 V” – tenth bullet: deleted phrase “200 V MM per JESD22-A115” • Section 3 “Applications”: <ul style="list-style-type: none"> – first bullet: changed from “1.0 V” to “0.8 V” (two places) – second bullet: added “0.8 V, 0.9 V” • Table 5 “Function selection, LOW-to-HIGH translation”, Table note [3]: changed from “V_{CC}” to “V_{DD1}” • Section 8.1 “Bidirectional translation”: <ul style="list-style-type: none"> – first sentence: changed from “V_{CC}” to “V_{DD1}” – third sentence: changed from “V_{CC}” to “V_{DD1}” – seventh sentence re-written – eighth sentence re-written – added (new) ninth sentence – Figure 4 “Bidirectional translation to multiple higher voltage levels such as an I²C-bus application” updated • Section 8.2 “Unidirectional down translation”: <ul style="list-style-type: none"> – first sentence: changed from “V_{CC}” to “V_{DD1}” – fifth sentence re-written (split into fifth and sixth sentences) – added (new) seventh sentence – Figure 5 “Unidirectional down translation to protect low voltage processor pins” updated • Figure 6 “Unidirectional down translation to protect low voltage processor pins” updated • Section 8.4 “Sizing pull-up resistor”: <ul style="list-style-type: none"> – added (new) second paragraph – third paragraph, first sentence: appended “for V_{DD1} – V_{SREF} ≥ 1.5 V” – Table 6 “Pull-up resistor values”: added six rows, 1.1 V through 0.8 V • Table 8 “Recommended operating conditions”: added row V_{Sn} • Table 9 “Static characteristics”: <ul style="list-style-type: none"> – Conditions for R_{on}: changed from “V_I” to “V_{Sn}” • Figure 9 “Load circuit for translator-type applications”: corrected resistors’ values from “150 kΩ” to “150 Ω” (3 places) • Added Section 16 “Soldering: PCB footprints” • Added Section 18 “References” 			
GTL2003_1	20070727	Product data sheet	-	-

20. Legal information

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Document status ^{[1][2]}	Product status ^[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
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22. Contents

1	General description	1
2	Features and benefits	1
3	Applications	2
4	Ordering information	2
4.1	Ordering options	2
5	Functional diagram	2
6	Pinning information	3
6.1	Pinning	3
6.2	Pin description	3
7	Functional description	4
7.1	Function selection	4
8	Application design-in information	5
8.1	Bidirectional translation	5
8.2	Unidirectional down translation	6
8.3	Unidirectional up translation	6
8.4	Sizing pull-up resistor	7
9	Limiting values	8
10	Recommended operating conditions	8
11	Static characteristics	9
12	Dynamic characteristics	10
12.1	Dynamic characteristics for translator-type application	10
12.2	Dynamic characteristics for CBT-type application	11
13	Test information	12
14	Package outline	13
15	Soldering of SMD packages	15
15.1	Introduction to soldering	15
15.2	Wave and reflow soldering	15
15.3	Wave soldering	15
15.4	Reflow soldering	16
16	Soldering: PCB footprints	18
17	Abbreviations	20
18	References	20
19	Revision history	21
20	Legal information	22
20.1	Data sheet status	22
20.2	Definitions	22
20.3	Disclaimers	22
20.4	Trademarks	23
21	Contact information	23
22	Contents	24

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