STLM20

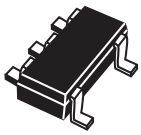
Ultra-low current 2.4 V precision analog temperature sensor

Features

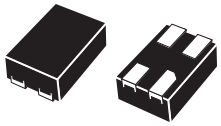
- Precision analog voltage output temperature sensor
- ±1.5 °C maximum temperature accuracy at 25 °C (±0.5 °C typical)
- Ultra-low quiescent supply current: 4.8 µA (typ) and 8.0 µA (max)
- Operating voltage range: 2.4 V to 5.5 V
- Operating temperature range: –55 °C to 130 °C (grade 7) –40 °C to 85 °C (grade 9)
- SOT323-5L 5-lead package
- UDFN-4L 4-lead package

Applications

- Smartphones
- Multimedia PDA devices
- GPS devices
- Portable medical instruments
- Voltage-controlled crystal oscillator temperature monitors
- RF power transistor monitor



SOT323-5L



UDFN-4L

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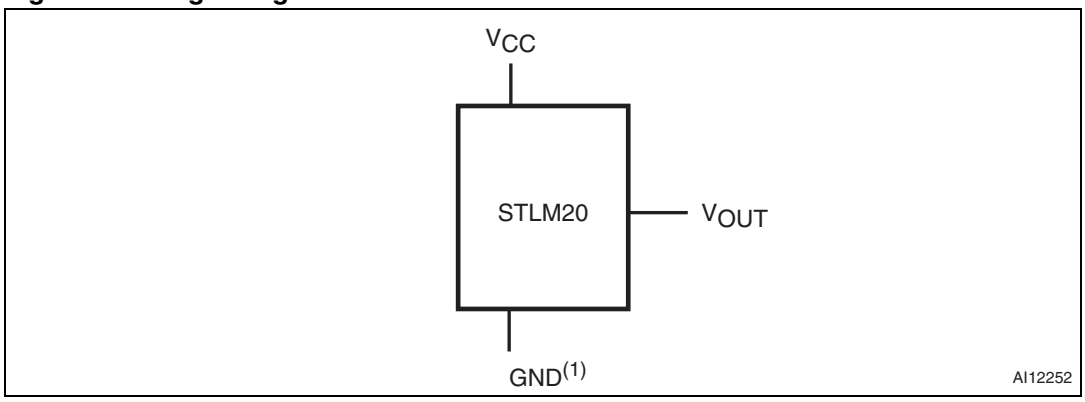
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1 Description

The STLM20 is a precision analog output temperature sensor for low current applications where maximizing battery life is important. It operates over a –55 °C to 130 °C (grade 7) or –40 °C to 85 °C (grade 9) temperature range. The power supply operating range is 2.4 V to 5.5 V. The maximum temperature accuracy of the STLM20 is ± 1.5 °C (±0.5 °C typ) at an ambient temperature of 25 °C and V_{CC} of 2.7 V. The temperature error increases linearly and reaches a maximum of ±2.5 °C at the temperature range extremes. The temperature range is affected by the power supply voltage. For the temperature grade 7 device, a power supply voltage of 2.7 V to 5.5 V, the temperature range extremes are +130 °C and –55 °C (decreasing the power supply voltage from 2.7 V to 2.4 V changes the low end of the operating temperature range from –55 °C to –30 °C, while the positive remains at +130 °C).

The STLM20 has a maximum quiescent supply current of 8 µA. Therefore, self-heating is negligible.

Figure 1. Logic diagram

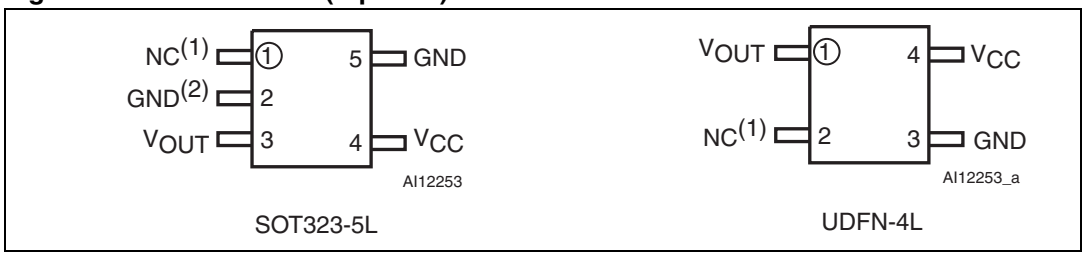


1. Pin 2 GND may be grounded or left floating (SOT323-5L only). For optimum thermal conductivity to the PC board ground plane, it should be grounded.

Table 1. Signal names

V_{CC}	Supply voltage
GND	Ground
V_{OUT}	Output voltage
NC	No connect

Figure 2. Connections (top view)



1. Pin 1 NC should be left floating or grounded.
2. Pin 2 GND may be grounded or left floating. For optimum thermal conductivity to the PC board ground plane, it should be grounded.

2 Transfer function

The STLM20's transfer function can be described in different ways, with varying levels of precision. A simple linear transfer function, with good accuracy near 25 °C is expressed as:

Equation 1 (first order linear equation)

$$V_O = (-11.69\text{mV})/°\text{C} \times T + 1.8663\text{V}$$

Over the specified operating temperature range, the best accuracy can be obtained by using the parabolic transfer function:

Equation 2 (second order parabolic equation)

$$V_O = (-3.88 \times 10^{-6} \times T^2) + (-1.15 \times 10^{-2} \times T) + 1.8639$$

and solving for T:

$$T = -1481.96 + \sqrt{2.1962 \times 10^6 + \frac{(1.8639 - V_O)}{3.88 \times 10^{-6}}}$$

The best fit linear transfer function for many popular temperature ranges was calculated in *Table 2*, where the error introduced by the linear transfer function increases with wider temperature ranges.

Table 2. First order equations optimized for different temperature ranges

Temperature range		Linear equation V_O =	Maximum deviation of linear equation from parabolic equation (°C)
T_{min} (°C)	T_{max} (°C)		
–55	130	–11.79 mV/°C * T + 1.8528 V	±1.41
–40	110	–11.77 mV/°C * T + 1.8577 V	±0.93
–30	100	–11.77 mV/°C * T + 1.8605 V	±0.70
–40	85	–11.67 mV/°C * T + 1.8583 V	±0.65
–10	65	–11.71 mV/°C * T + 1.8641 V	±0.23
35	45	–11.81 mV/°C * T + 1.8701 V	±0.004
20	30	–11.69 mV/°C * T + 1.8663 V	±0.004

Table 3. Second order parabolic equation (V_{CC} = 2.7 V)

Parameter	Conditions	Min	Typ	Max	Unit
Temperature error based on: $V_{OUT} = (-3.88 \times 10^{-6} \times T^2) + (-1.15 \times 10^{-2} \times T) + 1.8639$ where T is the temperature	T_A = –55 °C	2.457	2.485	2.512	V
	T_A = –40 °C	2.292	2.318	2.343	
	T_A = –30 °C	2.181	2.205	2.230	
	T_A = –20 °C	2.069	2.092	2.116	
	T_A = 0 °C	1.842	1.864	1.886	
	T_A = 25 °C	1.556	1.574	1.592	
	T_A = 50 °C	1.255	1.279	1.303	
	T_A = 85 °C	0.833	0.859	0.884	
	T_A = 130 °C	0.272	0.303	0.335	

Table 4. Second order parabolic equation for operation over the full voltage range (V_{CC} = 2.4 V to 5.5 V)

Parameter(1)	Conditions	Min	Max	Unit
Temperature error based on: $V_{OUT} = (-3.88 \times 10^{-6} \times T^2) + (-1.15 \times 10^{-2} \times T) + 1.8639$, where T is the temperature	T_A = –55 °C(2)(3)	2.457	2.531	V
	T_A = –40 °C(2)	2.292	2.362	
	T_A = –30 °C	2.180	2.249	
	T_A = –20 °C	2.068	2.135	
	T_A = 0 °C	1.841	1.904	
	T_A = 25 °C	1.555	1.610	
	T_A = 50 °C	1.254	1.322	
	T_A = 85 °C	0.832	0.903	
	T_A = 130 °C(3)	0.271	0.353	

1. V_{OUT} tolerance is ±4% (temperature grade 9 only).
2. Valid for V_{CC} min = 2.7 V.
3. Valid for temperature grade 7 only.

3 Maximum ratings

Stressing the device above the rating listed in the absolute maximum ratings table may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 5. Absolute maximum ratings

Symbol	Parameter		Value	Unit
T_{STG}	Storage temperature		–65 to +150	°C
T_{SLD}(1)	Lead solder temperature for 10 seconds		260	°C
V_O	Output voltage		–0.3 to V_{CC} + 0.3	V
V_{CC}	Supply voltage		–0.2 to 6.5	V
I_O	Output current		10	mA
$T_{J(max)}$	Maximum junction temperature		150	°C
θ_{JA}	Thermal resistance	SOT323-5L	331.4	°C/W
		UDFN-4L	160.2	°C/W
T_A(2)	Ambient operating temperature	Grade 7	–55 to 130	°C
		Grade 9	–40 to 85	°C

1. Reflow at peak temperature of 260 °C. The time above 255 °C must not exceed 30 seconds.
2. Grade 7: STLM20W87F
   Grade 9: STLM20DD9F

4 DC and AC characteristics

This section summarizes the DC and AC characteristics of the device. The parameters in the DC and AC characteristics table that follows are derived from tests performed under the test conditions. Designers should check that the operating conditions in their circuit match the operating conditions when relying on the quoted parameters.

Table 6. DC and AC characteristics

Sym	Description	Test condition(1)	Min	Typ(2)	Max	Unit
V_{CC}	Supply voltage	T_A = –30 °C to 130 °C	2.4		5.5	V
		T_A = –55 °C to 130 °C or –40 °C to 85 °C	2.7		5.5	V
V_O	Output voltage	T_A = 0 °C		1.8639		V
	Second order parabolic equation Temperature to voltage error(3) $V_O = (–3.88 \times 10^{–6} * T^2) + (–1.15 \times 10^{–2} * T) + 1.8639$ V	T_A = 125 °C to 130 °C			±2.5	°C
		T_A = 80 °C to 85 °C		±1.00	±2.1	°C
		T_A = 25 °C to 30 °C		±0.5	±1.5	°C
		T_A = 0 °C		±0.75	±1.9	°C
		T_A = –40 °C			±2.3	°C
		T_A = –55 °C			±2.5	°C
I_Q	Quiescent current	2.4 V ≤ V_{CC} ≤ 5.5 V		4.8	8	µA
	Sensor gain (temperature sensitivity or average slope), V_O = –11.77 mV/°C * T + 1.860 V	–30 °C ≤ T_A ≤ 100 °C	–11.4	–11.77	–12.2	mV/°C
	Non-linearity	–20 °C ≤ T_A ≤ 80 °C		±0.4		%
ΔI_Q	Change of quiescent current	2.4 V ≤ V_{CC} ≤ 5.5 V		0.7		µA
$T_C V_O$	Temperature coefficient of quiescent current			–11		nA/°C
I_{SD}	Shutdown current	V_{CC} ≤ 0.8 V		0.02		µA
Z_O	Output impedance	0 µA ≤ I_L ≤ 16 µA(4)(5)			160	Ω
RegL	Load regulation(6)				–2.5	mV
RegI1	Line regulation	2.4 V ≤ V_{CC} ≤ 5.0 V			3.3	mV/V
RegI2		5.0 V ≤ V_{CC} ≤ 5.5 V			11	mV

1. Valid for ambient operating temperature: T_A = –55 to 130 °C or T_A = –40 to 85 °C; V_{CC} = 2.7 V (except where noted).
2. $T_J = T_A$ = 25 °C, unless otherwise noted under test condition.
3. Accuracy is defined as the error between the measured and calculated output voltage at specified conditions of voltage, current, and temperature.
4. Positive load currents flow out of the device (sourcing) and can typically be 16 µA. For negative load currents (sinking), the device can sink less than 1 µA.
5. Over the supply range of 2.4 to 5.5 V.
6. Measured at constant junction temperature, with pulse testing and low duty cycle. Output changes due to heating may be calculated by multiplying internal dissipation by thermal resistance.

5 Capacitive load

The STLM20 will handle capacitive loads of up to 300 pF. Over the specified temperature range, the STLM20 has a maximum output impedance of 160 Ω.

In a noisy environment, it may be advisable to add some filtering to minimize noise in the output voltage. A 0.1 µF capacitor added between the supply voltage and ground is recommended.

In an extremely noisy environment, it may be necessary to add a low-pass filter network to the output of the device. A 1 µF capacitor, in addition to the output impedance of the device, and a 200 Ω series resistor, will provide a low-pass filter that will pass the slow thermal time constant of the STLM20, while filtering the higher frequency noise.

Figure 3. Filter network for noisy environments or capacitive loads > 300 pF

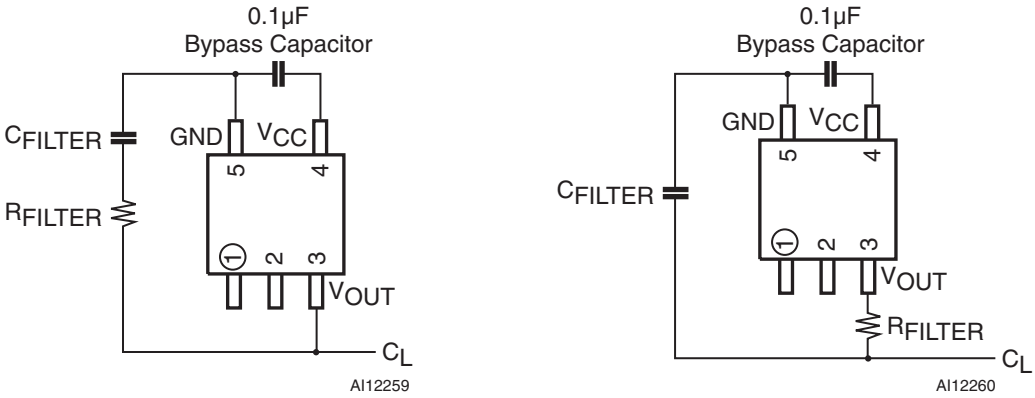


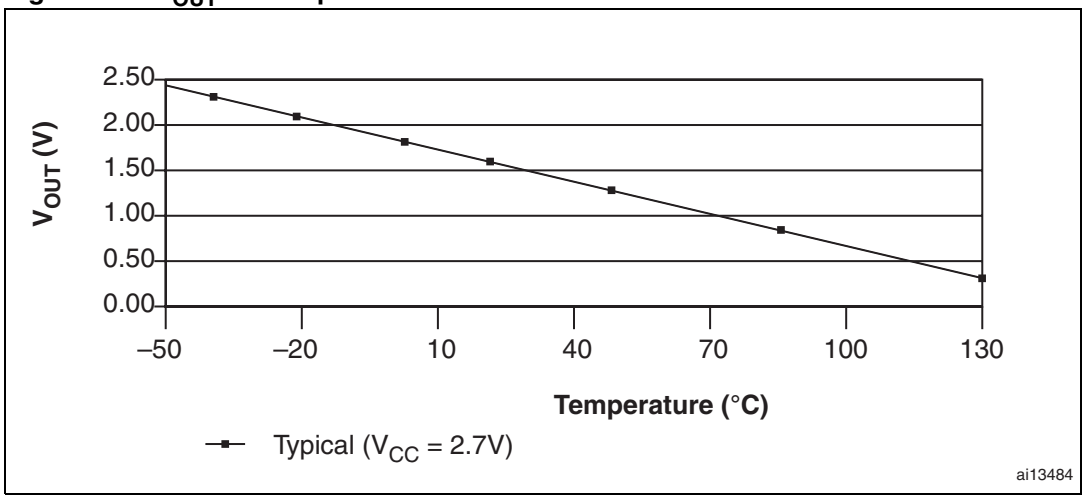
Table 7. Resistor/capacitor combinations for the filter network

R_{FILTER}	C_{FILTER}
200 Ω	1 µF
470 Ω	0.1 µF
680 Ω	0.01 µF
1000 Ω	1000 pF
10 kΩ	100 pF
100 kΩ	10 pF

6 Typical operating characteristics

The graph shown in *Figure 4* represents V_{OUT} according to temperature.

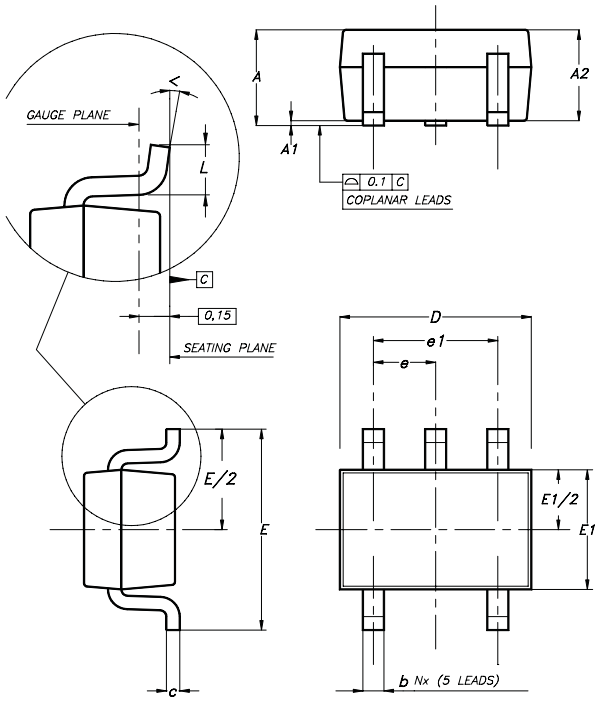
Figure 4. V_{OUT} vs. temperature



7 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*.
ECOPACK® is an ST trademark.

Figure 5. SOT323-5L – 5-lead small outline transistor package outline

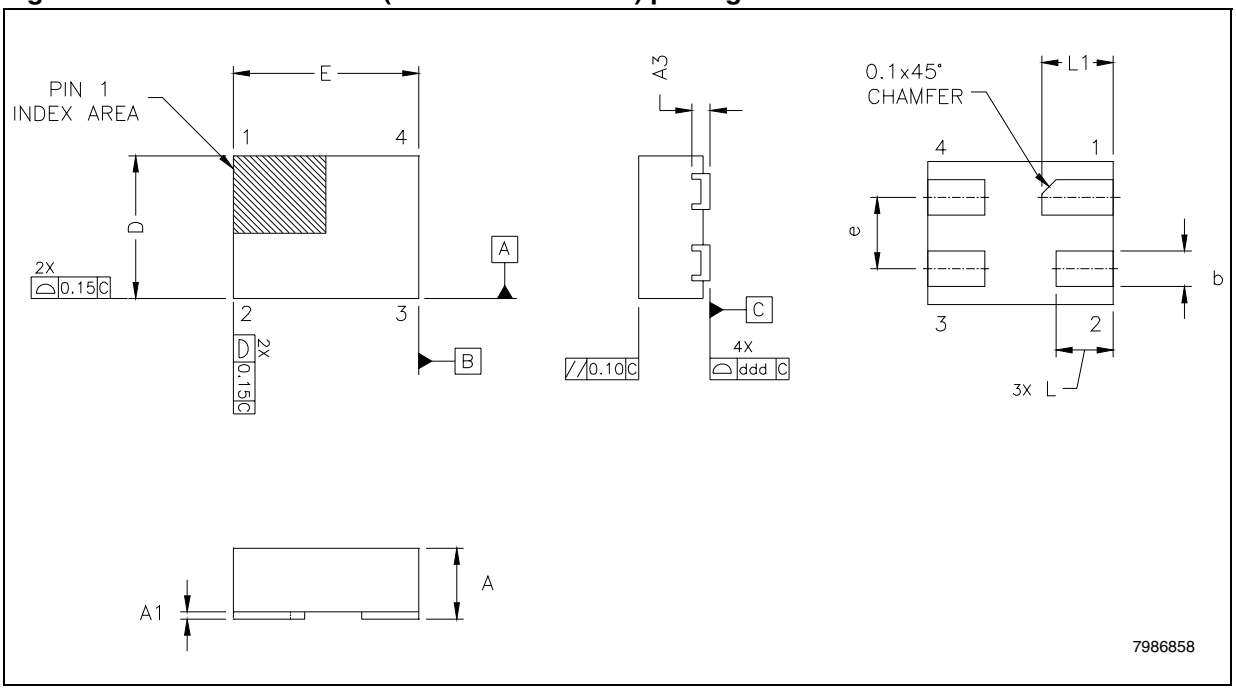


1. Drawing is not to scale.

Table 8. SOT323-5L – 5-lead small outline transistor package mechanical data

Symbol	mm			inches		
	Typ	Min	Max	Typ	Min	Max
A	–	0.80	1.10	–	0.031	0.043
A1	–	0	0.10	–	0.000	0.004
A2	0.90	0.80	1.00	0.035	0.031	0.039
b	–	0.15	0.30	–	0.006	0.012
c	–	0.10	0.22	–	0.004	0.009
D	2.00	1.80	2.20	0.079	0.071	0.087
E	2.10	1.80	2.40	0.083	0.071	0.094
E1	1.25	1.15	1.35	0.049	0.045	0.053
e	0.65	–	–	0.026	–	–
e1	1.30	–	–	0.051	–	–
L	0.36	0.26	0.46	0.014	0.010	0.018
<	–	0°	8°	–	0°	8°

Figure 6. UDFN-4L – 4-lead (1.00 mm x 1.30 mm) package outline



Note: Drawing is not to scale.

Table 9. UDFN-4L – 4-lead (1.00 mm x 1.30 mm) package mechanical data

Symbol	mm			inches		
	Min	Typ	Max	Min	Typ	Max
A	0.45	0.50	0.55	0.018	0.020	0.022
A1	0	0.025	0.05	0	0.001	0.002
A3	0.119	0.127	0.177	0.0046	0.0050	0.0069
b	0.20	0.25	0.30	0.008	0.010	0.012
D	0.95	1.00	1.05	0.037	0.039	0.041
E	1.25	1.30	1.35	0.049	0.051	0.053
e	0.45	0.50	0.55	0.018	0.020	0.022
L	0.35	0.40	0.45	0.014	0.016	0.018
L1	0.45	0.50	0.55	0.018	0.020	0.022
ddd	0	0.04	0.08	0	0.0016	0.0031

Figure 7. Carrier tape for SOT323-5L and UDFN-4L packages

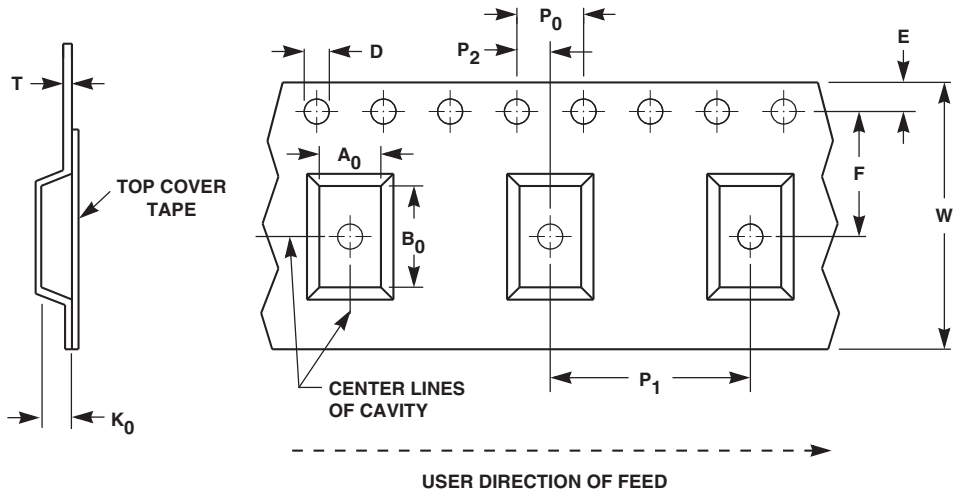


Table 10. Carrier tape dimensions for SOT323-5L and UDFN-4L packages

Package	W	D	E	P_0	P_2	F	A_0	B_0	K_0	P_1	T	Unit	Bulk Qty
SOT323-5L	8.00 +0.30 –0.10	1.50 +0.10/ –0.00	1.75 ±0.10	4.00 ±0.10	2.00 ±0.10	3.50 ±0.05	2.25 ±0.10	2.40 ±0.10	1.22 ±0.10	4.00 ±0.10	0.30 ±0.05	mm	3000
UDFN-4L	8.00 +0.30 –0.10	1.50 +0.10/ –0.00	1.75 ±0.10	4.00 ±0.10	2.00 ±0.10	3.50 ±0.05	1.25 ±0.10	1.55 ±0.10	0.65 ±0.05	4.00 ±0.10	0.250 ±0.05	mm	3000

Figure 8. Reel schematic

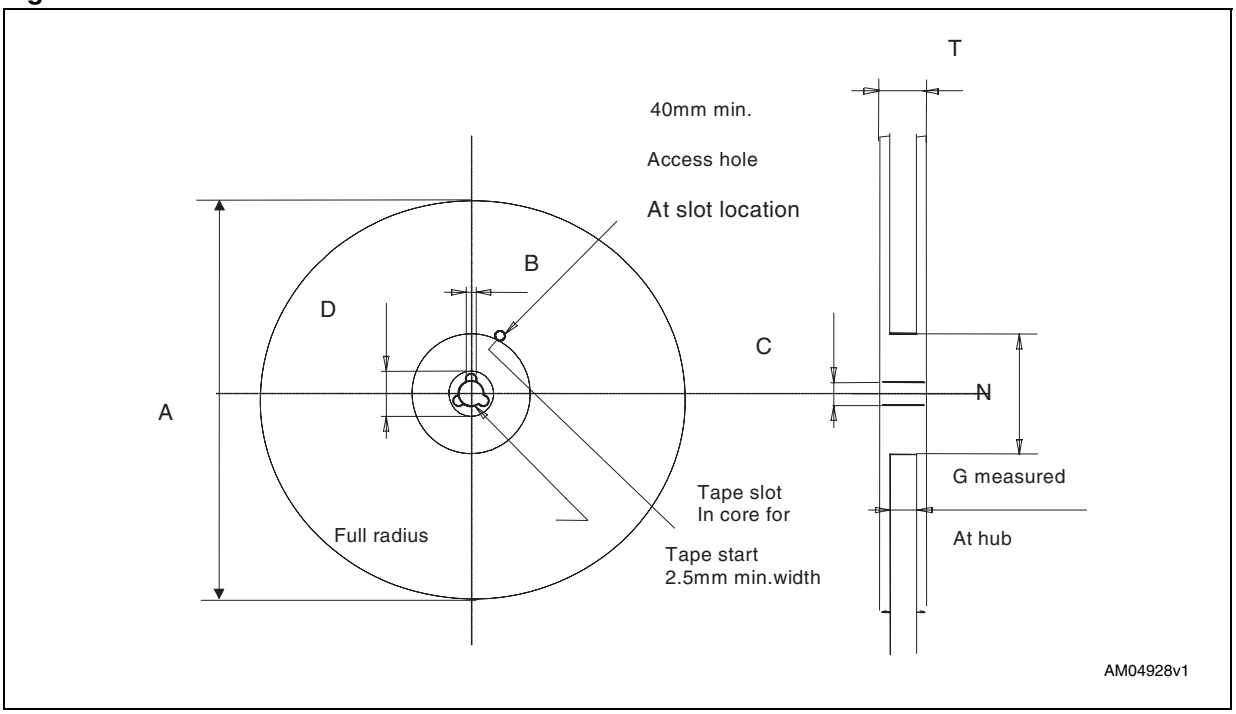


Table 11. Reel dimensions for 8 mm carrier tape - SOT323-5L and UDFN-4L packages

A (max)	B (min)	C	D (min)	N (min)	G	T (max)
180 mm (7-inch)	1.5 mm	13 mm ± 0.2 mm	20.2 mm	60 mm	8.4 mm + 2/–0 mm	14.4 mm

Note: The dimensions given in Table 11 incorporate tolerances that cover all variations on critical parameters.

8 Part numbering

Table 12. Ordering information scheme

Example: STLM20 DD 9 F

Device type

STLM20

Package

W8 = SOT323-5L(1)(2)

DD= UDFN-4L - ultra-thin DFN 4-lead(3)

Temperature range

7 = –55 to 130°C

9 = –40 to 85°C

Shipping method

F = ECOPACK® package, tape & reel

1. Available in temperature grade 7 (–55 to 130 °C) only
2. SOT323-5L also referred to as SC70-5L
3. Available in temperature grade 9 (–40 to 85 °C) only

Table 13. Marking description

Part number	Package	Marking
STLM20W87F	SOT323-5L	M20
STLM20DD9F	UDFN-4L	20

For other options, or for more information on any aspect of this device, please contact the ST sales office nearest you.

9 Revision history

Table 14. Document revision history

Date	Revision	Changes
28-Jun-2006	1	Initial release.
19-Jul-2006	2	Added *Table 13: Marking description*
28-Aug-2006	3	Added a footnote concerning package availability in *Features on page 1* and to *Table 12* and *Table 13*; updated package mechanical data in *Table 9*
05-Sep-2006	4	Amended text in the *Features on page 1*, *Section 1: Description*, *Section 2: Transfer function*, *Table 6*, and *Table 12* to elucidate that two packages exist each with specific temperature ranges: SOT323-5 (SC70-5) 5-lead package (–55 to 130 °C) and UDFN 4-lead package (–40 to 85 °C)
25-Sep-2006	5	Updated operating temperature ranges (now 7 and 9); updated *Table 6: DC and AC characteristics*
10-Oct-2006	6	*Table 3: Second order parabolic equation (V_{CC} = 2.7 V)* and *Table 4: Second order parabolic equation for operation over the full voltage range (V_{CC} = 2.4 V to 5.5 V)* added. *Section 6: Typical operating characteristics* added. T_A added to *Table 5: Absolute maximum ratings*.
04-Dec-2006	7	Document status updated to full datasheet; updated text in the title of *Table 4: Second order parabolic equation for operation over the full voltage range (V_{CC} = 2.4 V to 5.5 V)*; added footnotes regarding temperature ranges in *Table 12: Ordering information scheme*.
08-Feb-2007	8	Added thermal resistance in *Table 5: Absolute maximum ratings*.
09-May-2007	9	Modified *Equation 1*, *2*.
26-Nov-2007	10	Updated footnote 2 in *Table 5*; minor text updates.
07-Nov-2008	11	Updated *Figure 6: UDFN-4L – 4-lead (1.00 mm x 1.30 mm) package outline* to reflect location of pin 1 with respect to the orientation of the topside marking; updated *Figure 5*, *Table 5*, *8*, *12*.
10-Sep-2009	12	Updated *Table 5*, text in *Section 7: Package mechanical data*; added tape and reel specifications (*Figure 7* and *Table 10*); reformatted document.
09-Jul-2010	13	Updated *Features*, *Section 1: Description*, *Section 2: Transfer function*, *Table 5*, *6*, *12*; added reel information (*Figure 8*, *Table 11*); removed references to SC70-5L package; minor textual changes.

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