LSF0204-Q100

4-bit bidirectional multi-voltage level translator; open-drain; push-pull

Rev. 4 — 28 November 2023 Product data sheet

1. General description

The LSF0204-Q100 is an 4 channel bidirectional multi-voltage level translator for open-drain and push-pull applications. It supports up to 100 MHz up translation and ≥ 100 MHz down translation at ≤ 30 pF capacitive load. There is no need for a direction pin which minimizes system effort. The LSF0204-Q100 supports 5 V tolerant I/O pins for compatibility with TTL levels in a variety of applications. The ability to set up different voltage translation levels on each channel makes the device very flexible and suitable for a lot of different applications.

This product has been qualified to the Automotive Electronics Council (AEC) standard Q100 (Grade 1) and is suitable for use in automotive applications.

2. Features and benefits

- Automotive product qualification in accordance with AEC-Q100 (Grade 1)
  - Specified from -40 °C to +125 °C
- Bidirectional voltage translation with no direction pin
- Up translation
  - ≤ 100 MHz; C_L = 15 pF, 30 pF
  - ≤ 50 MHz; C_L = 50 pF
- Down translation
  - ≥ 100 MHz; C_L = 15 pF, 30 pF
  - ≥ 50 MHz; C_L = 50 pF
- Hot insertion
- Bidirectional voltage level translation between:
  - 0.8 V and 1.8 V, 2.5 V, 3.3 V and 5.0 V
  - 1.2 V and 1.8 V, 2.5 V, 3.3 V and 5.0 V
  - 1.8 V and 2.5 V, 3.3 V and 5.0 V
  - 2.5 V and 3.3 V and 5.0 V
  - 3.3 V and 5.0 V
- Low standby current
- 5 V tolerant I/O pins to support TTL
- Low R_{ON} provides less signal distortion
- Latch-up performance exceeds 100 mA per JESD78 class II level A
- Multiple package options
- ESD protection:
  - HBM: ANSI/ESDA/JEDEC JS-001 class 2 exceeds 2000 V
  - CDM: ANSI/ESDA/JEDEC JS-002 class C3 exceeds 1000 V

3. Applications

- GPIO, MDIO, PMBus, SMBus, SDIO, UART, I^2C, and other interfaces in Telecom infrastructure
- Industrial
- Personal computing

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4. Ordering information

Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
LSF0204PW-Q100	-40 °C to +125 °C	TSSOP14	plastic thin shrink small outline package; 14 leads; body width 4.4 mm	SOT402-1
LSF0204GU12-Q100	-40 °C to +125 °C	XQFN12	plastic, extremely thin quad flat package; no leads; 12 terminals; body 1.70 × 2.0 × 0.50 mm	SOT1174-1

5. Functional diagram

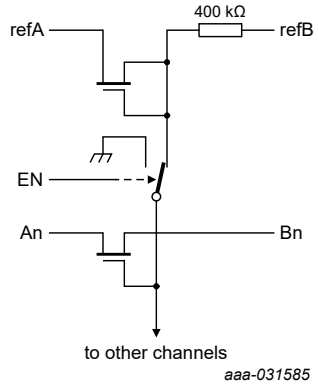


Fig. 1. Logic symbol

6. Pinning information

6.1. Pinning

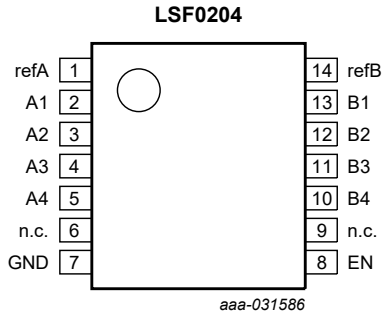


Fig. 2. Pin configuration SOT402-1 (TSSOP14)

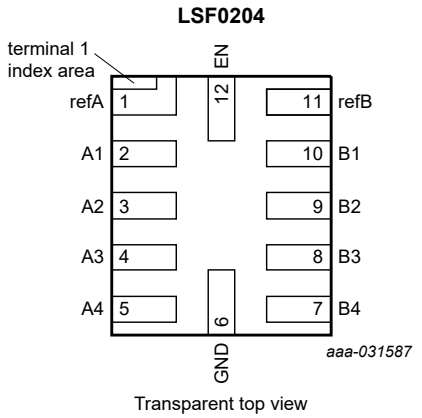


Fig. 3. Pin configuration SOT1174-1 (XQFN12)

6.2. Pin description

Table 2. Pin description

Symbol	Pin		Description
	TSSOP14	XQFN12	
refA	1	1	reference voltage A (EN input circuit is referenced to refA)
A1, A2, A3, A4	2, 3, 4, 5	2, 3, 4, 5	data input/output A
n.c.	6, 9	-	not connected
GND	7	6	ground (0 V)
EN	8	12	enable input (active HIGH)
B1, B2, B3, B4	13, 12, 11, 10	10, 9, 8, 7	data input/output B
refB	14	11	reference voltage B

7. Functional description

Table 3. Function table

H = HIGH voltage level; L = LOW voltage level; Z = high-impedance OFF-state.

Input	input/output
EN[1]	**An, Bn channel**
H	An = Bn
L	Z

[1] EN input circuit is referenced to refA

8. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions		Min	Max	Unit
V_I	input voltage	pins refA, refB, An, Bn and EN	[1]	-0.5	+7.0	V
$I_{I/O}$	input/ouput current	pins refA, refB, An and Bn; continuous channel current		-	+128	mA
I_{IK}	input clamping current	$V_I < 0$ V		-50	-	mA
T_{stg}	storage temperature			-65	+150	°C
P_{tot}	total power dissipation	TSSOP14 package	[2]	-	500	mW
		XQFN12 package		-	250	mW

[1] The minimum input voltage rating may be exceeded if the input current rating is observed.
[2] For SOT402-1 (TSSOP14) package: P_{tot} derates linearly with 7.3 mW/K above 81 °C.

9. Recommended operating conditions

Table 5. Recommended operating conditions

Symbol	Parameter	Conditions	Min	Max	Unit
V_I	input voltage	pins refA, refB, An, Bn and EN	0.0	5.0	V
$I_{I/O}$	input/ouput current	pins refA, refB, An and Bn; continuous channel current	-	+64	mA
T_{amb}	ambient temperature		-40	+125	°C
$\Delta t/\Delta V$	input transition rise and fall rate	EN input	-	10	ns/V

10. Static characteristics

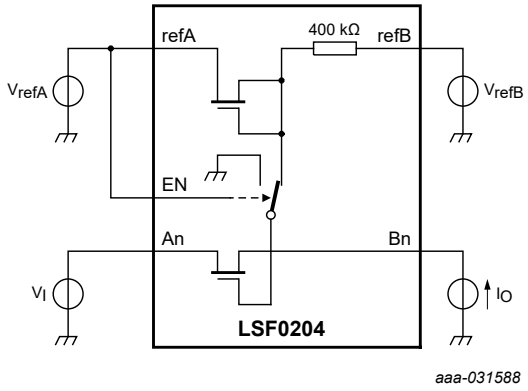
Table 6. Static characteristics

At recommended operating conditions voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions	T_{amb} = -40 °C to +125 °C			Unit
			Min	Typ [1]	Max	
V_{IK}	input clamping voltage	$V_{I(EN)}$ = 0 V; I_I = -18 mA	-1.2	-	-	V
I_{IH}	HIGH-level input current	V_I = 5 V; $V_{I(EN)}$ = 0 V	-	-	5	µA
I_I	input current	EN input; V_{refA} = 4.5 V; V_{refB} = 5.5 V; $V_{I(EN)}$ = 0 V to V_{refA}; I_O = 0 A	-	-	±1	µA
V_{IH}	HIGH-level input voltage	EN input				
		V_{refA} = 1.5 V to 4.5 V	$0.7V_{refA}$	-	-	V
		V_{refA} = 1.0 V to 1.5 V	$0.8V_{refA}$	-	-	V
V_{IL}	LOW-level input voltage	EN input				
		V_{refA} = 1.5 V to 4.5 V	-	-	$0.3V_{refA}$	V
		V_{refA} = 1.0 V to 1.5 V	-	-	$0.3V_{refA}$	V
I_{refB-A}	leakage current refB to refA	V_{refA} = $V_{I(EN)}$ = 1.8 V; V_{refB} = 3.3 V; I_O = 0 A; V_I = 3.3 V or GND	-	-	3.5	µA
I_{GND}	ground current	V_{refA} = $V_{I(EN)}$ = 1.8 V; V_{refB} = 3.3 V; I_O = 0 A; V_I = 3.3 V or GND	-	0.2	-	µA
I_{OFF}	power-off leakage current	V_{refA} = V_{refB} = $V_{I(EN)}$ = 0 V; I_O = 0 A; V_I = 5 V or GND	-	-	±1	µA
C_I	input capacitance	pins refA, refB and EN; V_I = 3 V or 0 V	-	7	-	pF
$C_{io(off)}$	OFF-state input/output capacitance	pins An, Bn; V_O = 0 V or 3 V; $V_{I(EN)}$ = 0 V	-	3	6	pF
$C_{io(on)}$	ON-state input/output capacitance	pins An, Bn; V_O = 0 V or 3 V; $V_{I(EN)}$ = 3.0 V	-	8	13	pF

Symbol	Parameter	Conditions	T_{amb} = -40 °C to +125 °C			Unit
			Min	Typ [1]	Max	
R_{ON}	ON resistance	see Fig. 4 [2]				
		V_I = 0 V; I_O = 64 mA;				
		V_{refA} = $V_{I(EN)}$ = 3.3 V; V_{refB} = 5 V	-	3	-	Ω
		V_{refA} = $V_{I(EN)}$ = 1.8 V; V_{refB} = 5 V	-	4	-	Ω
		V_I = 0 V; I_O = 32 mA;				
		V_{refA} = $V_{I(EN)}$ = 1.0 V; V_{refB} = 5 V	-	7	-	Ω
		V_{refA} = $V_{I(EN)}$ = 1.8 V; V_{refB} = 5 V	-	4	-	Ω
		V_{refA} = $V_{I(EN)}$ = 2.5 V; V_{refB} = 5 V	-	3.5	-	Ω
		V_I = 1.8 V; I_O = 15 mA; V_{refA} = $V_{I(EN)}$ = 3.3 V; V_{refB} = 5 V	-	5	-	Ω
		V_I = 1 V; I_O = 10 mA; V_{refA} = $V_{I(EN)}$ = 1.8 V; V_{refB} = 3.3 V	-	8	-	Ω
		V_I = 0 V; I_O = 10 mA; V_{refA} = $V_{I(EN)}$ = 1 V; V_{refB} = 3.3 V	-	6	-	Ω
		V_I = 0 V; I_O = 10 mA; V_{refA} = $V_{I(EN)}$ = 1 V; V_{refB} = 1.8 V	-	6	-	Ω

[1] All typical values are measured at T_{amb} = 25 °C.
[2] Measured by the voltage drop between the An and Bn pins at the indicated current through the switch. ON resistance is determined by the lowest voltage of the two (An or Bn) pins.



The An and Bn pins may be exchanged.

Fig. 4. Test circuit for measuring R_{ON}

11. Dynamic characteristics

Table 7. Dynamic characteristics

GND = 0 V; for waveforms see Fig. 5 and Fig. 6; for test circuit see Fig. 7

Symbol	Parameter	Conditions	T_{amb} = -40 °C to +125 °C			Unit
			Min	Typ[1]	Max	
Translating down (3.3 V to 1.8 V)						
t_{PLH}	LOW to HIGH propagation delay	An to Bn or Bn to An				
		V_{refA} = $V_{I(EN)}$ = 1.8 V; V_{refB} = 3.3 V; V_I = 3.3 V; V_M = 1.15 V				
		C_L = 15 pF	-	0.3	5.19	ns
		C_L = 30 pF	-	0.5	5.29	ns
		C_L = 50 pF	-	0.7	5.49	ns

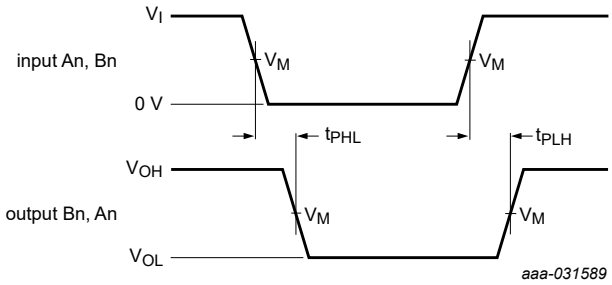
Symbol	Parameter	Conditions	T_{amb} = -40 °C to +125 °C			Unit
			Min	Typ[1]	Max	
t_{PHL}	HIGH to LOW propagation delay	An to Bn or Bn to An				
		$V_{refA} = V_{I(EN)}$ = 1.8 V; V_{refB} = 3.3 V; V_I = 3.3 V; V_M = 1.15 V				
		C_L = 15 pF	-	0.5	4.5	ns
		C_L = 30 pF	-	0.7	4.7	ns
		C_L = 50 pF	-	0.9	4.9	ns
t_{PLZ}	LOW to OFF-state propagation delay	EN to An or Bn				
		$V_{refA} = V_{I(EN)}$ = 1.8 V; V_{refB} = 3.3 V; V_M = 1.15 V				
		C_L = 15 pF	-	11	15	ns
		C_L = 30 pF	-	12	16.5	ns
		C_L = 50 pF	-	13	18	ns
t_{PZL}	OFF-state to LOW propagation delay	EN to An or Bn				
		$V_{refA} = V_{I(EN)}$ = 1.8 V; V_{refB} = 3.3 V; V_M = 1.15 V				
		C_L = 15 pF	-	23	37	ns
		C_L = 30 pF	-	30	40	ns
		C_L = 50 pF	-	33	45	ns
f_{max}	maximum frequency	$V_{refA} = V_{I(EN)}$ = 1.8 V; V_{refB} = 3.3 V; V_I = 3.3 V; V_M = 1.15 V				
		C_L = 15 pF	-	120	-	MHz
		C_L = 30 pF	-	120	-	MHz
		C_L = 50 pF	-	100	-	MHz
Translating down (3.3 V to 1.2 V)						
t_{PLH}	LOW to HIGH propagation delay	An to Bn or Bn to An				
		$V_{refA} = V_{I(EN)}$ = 1.2 V; V_{refB} = 3.3 V; V_I = 3.3 V; V_M = 0.85 V				
		C_L = 15 pF	-	0.3	3.8	ns
		C_L = 30 pF	-	0.5	3.9	ns
		C_L = 50 pF	-	0.8	4.1	ns
t_{PHL}	HIGH to LOW propagation delay	An to Bn or Bn to An				
		$V_{refA} = V_{I(EN)}$ = 1.2 V; V_{refB} = 3.3 V; V_I = 3.3 V; V_M = 0.85 V				
		C_L = 15 pF	-	0.6	4.3	ns
		C_L = 30 pF	-	0.7	4.5	ns
		C_L = 50 pF	-	0.9	4.7	ns
f_{max}	maximum frequency	$V_{refA} = V_{I(EN)}$ = 1.2 V; V_{refB} = 3.3 V; V_I = 3.3 V; V_M = 0.85 V				
		C_L = 15 pF	-	120	-	MHz
		C_L = 30 pF	-	120	-	MHz
		C_L = 50 pF	-	100	-	MHz

Symbol	Parameter	Conditions	T_{amb} = -40 °C to +125 °C			Unit
			Min	Typ[1]	Max	
Translating up (1.8 V to 3.3 V)						
t_{PLH}	LOW to HIGH propagation delay	An to Bn or Bn to An				
		V_{refA} = $V_{I(EN)}$= 1.8 V; V_{refB} = 3.3 V; V_I = 1.8 V; V_M = 0.9 V				
		C_L = 15 pF	-	0.2	5.1	ns
		C_L = 30 pF	-	0.4	5.3	ns
		C_L = 50 pF	-	0.6	5.7	ns
t_{PHL}	HIGH to LOW propagation delay	An to Bn or Bn to An				
		V_{refA} = $V_{I(EN)}$= 1.8 V; V_{refB} = 3.3 V; V_I = 1.8 V; V_M = 0.9 V				
		C_L = 15 pF	-	0.7	5.3	ns
		C_L = 30 pF	-	1	6.4	ns
		C_L = 50 pF	-	1.3	6.7	ns
t_{PLZ}	LOW to OFF-state propagation delay	EN to An or Bn				
		V_{refA} = $V_{I(EN)}$= 1.8 V; V_{refB} = 3.3 V; V_M = 0.9 V				
		C_L = 15 pF	-	11	15	ns
		C_L = 30 pF	-	12	16.5	ns
		C_L = 50 pF	-	13	18	ns
t_{PZL}	OFF-state to LOW propagation delay	EN to An or Bn				
		V_{refA} = $V_{I(EN)}$= 1.8 V; V_{refB} = 3.3 V; V_M = 0.9 V				
		C_L = 15 pF	-	23	37	ns
		C_L = 30 pF	-	30	40	ns
		C_L = 50 pF	-	33	45	ns
f_{max}	maximum frequency	V_{refA} = $V_{I(EN)}$= 1.8 V; V_{refB} = 3.3 V; V_I = 1.8 V; V_M = 0.9 V; R_L = 100 Ω				
		C_L = 15 pF	-	100	-	MHz
		C_L = 30 pF	-	100	-	MHz
		C_L = 50 pF	-	80	-	MHz
Translating up (1.2 V to 1.8 V)						
t_{PLH}	LOW to HIGH propagation delay	An to Bn or Bn to An				
		V_{refA} = $V_{I(EN)}$ = 1.2 V; V_{refB} = 1.8 V; V_I = 1.2 V; V_M = 0.6 V				
		C_L = 15 pF	-	0.2	6.85	ns
		C_L = 30 pF	-	0.4	7.05	ns
		C_L = 50 pF	-	0.65	7.25	ns
t_{PHL}	HIGH to LOW propagation delay	An to Bn or Bn to An				
		V_{refA} = $V_{I(EN)}$ = 1.2 V; V_{refB} = 1.8 V; V_I = 1.2 V; V_M = 0.6 V				
		C_L = 15 pF	-	1	5.4	ns
		C_L = 30 pF	-	1.3	6.5	ns
		C_L = 50 pF	-	1.6	7.03	ns

Symbol	Parameter	Conditions	T_{amb} = -40 °C to +125 °C			Unit
			Min	Typ[1]	Max	
f_{max}	maximum frequency	$V_{refA} = V_{I(EN)}$ = 1.2 V; V_{refB} = 1.8 V; V_I = 1.2 V; V_M = 0.6 V; R_L = 100 Ω				
		C_L = 15 pF	-	100	-	MHz
		C_L = 30 pF	-	100	-	MHz
		C_L = 50 pF	-	80	-	MHz

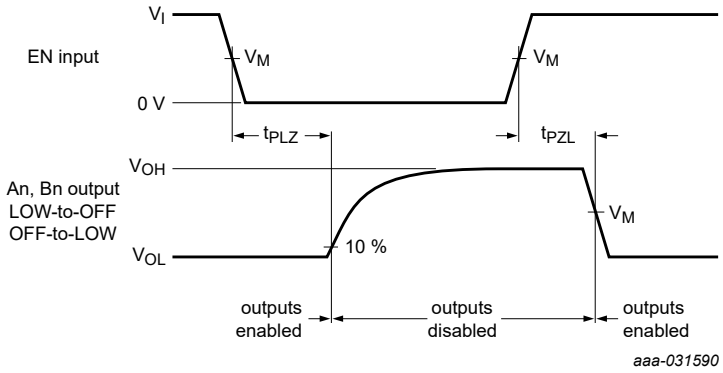
[1] All typical values are measured at T_{amb} = 25 °C.

11.1. Waveforms and test circuit



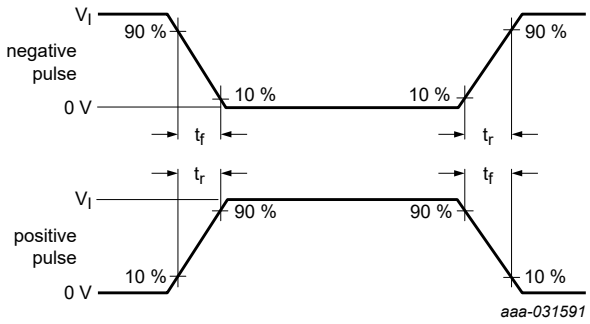
Measurement points are given in Table 8.
Logic levels: V_{OL} and V_{OH} are typical output voltage levels that occur with the output load.

Fig. 5. The data input (An, Bn) to output (Bn, An) propagation delay times

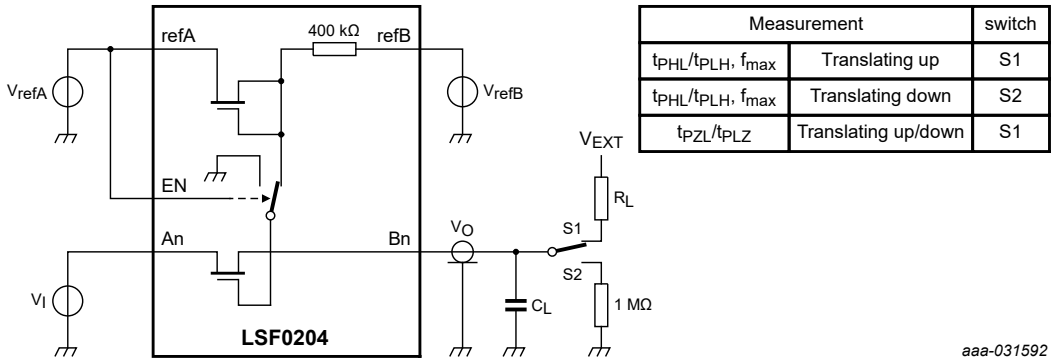


Measurement points are given in Table 8.
Logic levels: V_{OL} and V_{OH} are typical output voltage levels that occur with the output load.

Fig. 6. The enable (EN) to output (An, Bn) propagation delay times



a. V_I source waveform



Measurement		switch
t_{PHL}/t_{PLH}, f_{max}	Translating up	S1
t_{PHL}/t_{PLH}, f_{max}	Translating down	S2
t_{PZL}/t_{PLZ}	Translating up/down	S1

b. Test circuit

Test data is given in Table 8; The An and Bn pins may be exchanged.
All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz; Z_O = 50 Ω.
Definitions test circuit: C_L = Load capacitance including jig and probe capacitance; R_L = Load resistance; S1/S2 = Test selection switch.

Fig. 7. Test circuit for measuring switching times

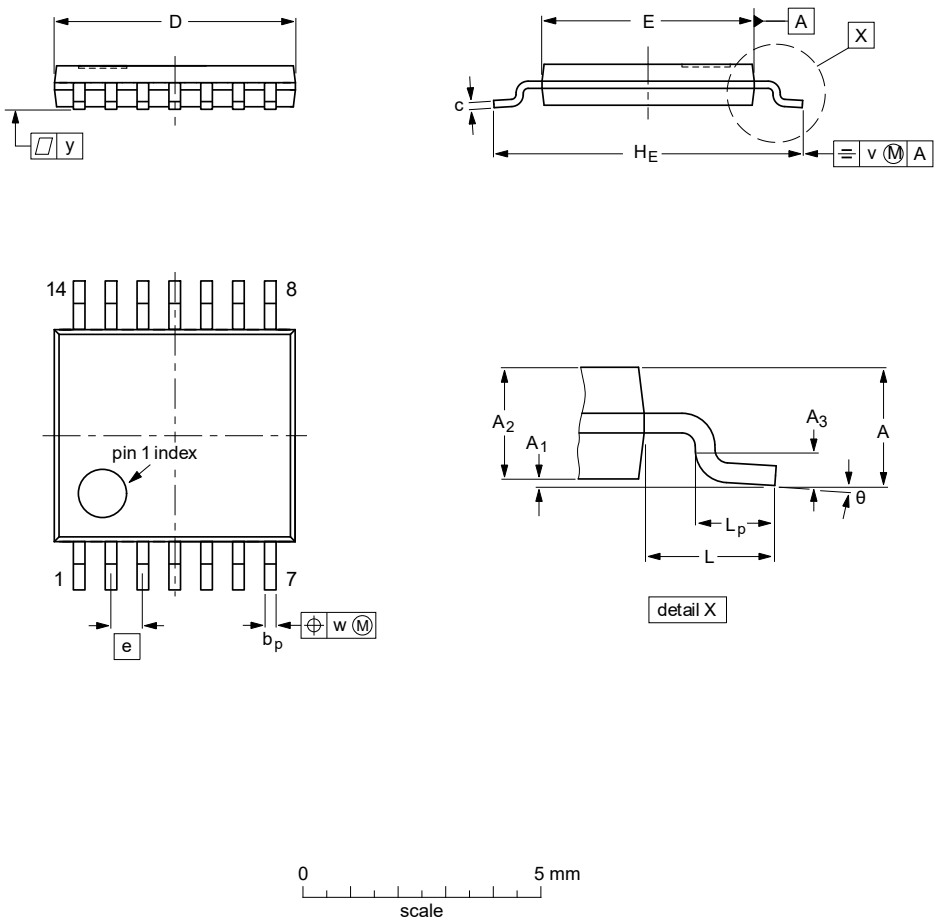
Table 8. Test data

Input	Load			V_{EXT}	
t_r, t_f	C_L	R_L			
		t_{PLH} , t_{PHL}, t_{PLZ}, t_{PZL}	f_{max}	t_{PLH}, t_{PHL}, f_{max}	t_{PLZ}, t_{PZL} [1]
≤ 2 ns	15 pF, 30 pF, 50 pF	500 Ω	100 Ω	V_{refB}	V_{refA}, V_{refB}

[1] For measuring t_{PLZ}, t_{PZL} (translating up) V_{EXT} = V_{refB}.
For measuring t_{PLZ}, t_{PZL} (translating down) V_{EXT} = V_{refA}.

12. Package outline

TSSOP14: plastic thin shrink small outline package; 14 leads; body width 4.4 mm **SOT402-1**



Dimensions (mm are the original dimensions)

Unit		A	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(2)}$	e	H_E	L	L_p	v	w	y	θ
mm	max	1.20	0.15	1.05		0.30	0.2	5.1	4.5		6.6		0.75				8°
	nom				0.25					0.65		1		0.2	0.1	0.1	
	min		0.05	0.80		0.19	0.09	4.9	4.3		6.2		0.45				0°

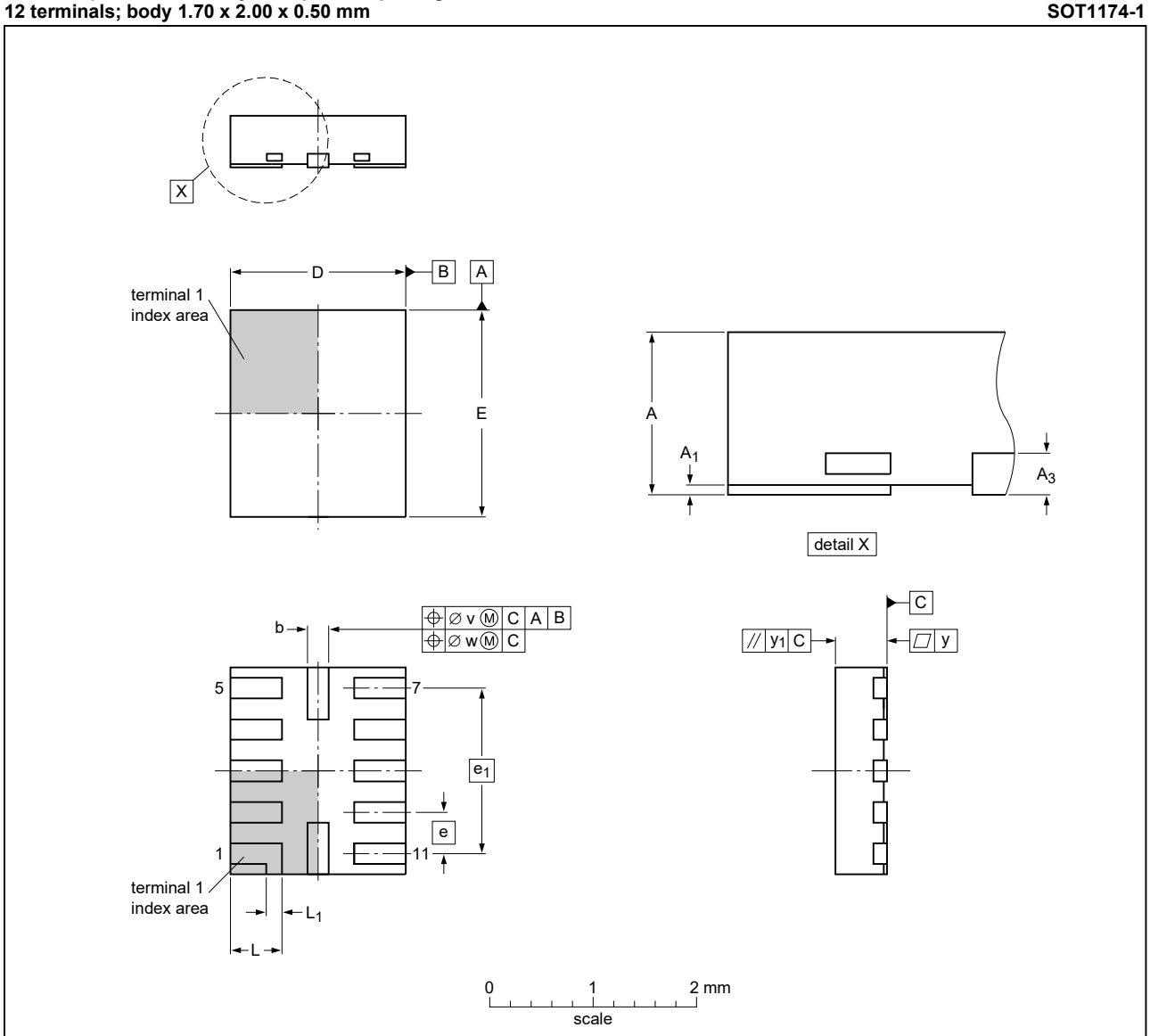
Note
1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

sot402-1_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT402-1		MO-153				~~03-02-18~~ 23-10-27

Fig. 8. Package outline SOT402-1 (TSSOP14)

XQFN12: plastic, extremely thin quad flat package; no leads; 12 terminals; body 1.70 x 2.00 x 0.50 mm **SOT1174-1**



Dimensions

Unit(1)		A	A_1	A_3	b	D	E	e	e_1	L	L_1	v	w	y	y_1
mm	max	0.5	0.05		0.25	1.8	2.1			0.55					
	nom			0.127	0.20	1.7	2.0	0.4	1.6	0.50	0.15	0.1	0.05	0.05	0.05
	min		0.00		0.15	1.6	1.9			0.45					

Note

1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

sot1174-1_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT1174-1	- - -	MO-288	- - -			10-04-07 10-04-21

Fig. 9. Package outline SOT1174-1 (XQFN12)

13. Abbreviations

Table 9. Abbreviations

Acronym	Description
CDM	Charged Device Model
ESD	ElectroStatic Discharge
HBM	Human Body Model
PRR	Pulse Rate Repetition
TTL	Transistor-Transistor Logic

14. Revision history

Table 10. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
LSF0204_Q100 v.4	20231128	Product data sheet	-	LSF0204_Q100 v.3
Modifications:	• Section 2: up- and down-translation typo corrected. • Fig. 8: SOT402-1 package outline drawing changed.			
LSF0204_Q100 v.3	20220502	Product data sheet	-	LSF0204_Q100 v.2
Modifications:	• Type number LSF0204GU12-Q100 (SOT1174-1/XQFN12) added.			
LSF0204_Q100 v.2	20201028	Product data sheet	-	LSF0204_Q100 v.1
Modifications:	• Section 2 updated. • Table 7: f_{max} values corrected.			
LSF0204_Q100 v.1	20200818	Product data sheet	-	-

15. Legal information

Data sheet status

Document status [1][2]	Product status [3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.
[2] The term 'short data sheet' is explained in section "Definitions".
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Date of release: 28 November 2023