

AUTOMOTIVE 4-BITS BI-DIRECTIONAL LEVEL SHIFTER WITH AUTO-DIRECTION SENSING, 110Mbps, PUSH-PULL APPLICATIONS

Description

The LXB0104Q is an automotive 4-bits bi-directional level shifter for push-pull applications which incorporates a buffered architecture and edge rate accelerators (one shots) to improve the speed up to 100Mbps at 3.3V to 5.0V translation. This device is a universal level translator with A port operating from 1.2V to 3.6V (V_{CCA}) and B port 1.65V to 5.5V (V_{CCB}). This allows for universal low-voltage bi-directional translation between any of the 1.2V, 1.5V, 1.8V, 2.5V, 3.3V, and 5V voltage nodes.

The output-enable (OE) input circuit is designed to be supplied by V_{CCA} and when the output-enable (OE) input is low, all outputs are placed in the high-impedance state. To ensure the high-impedance state during power-up or power-down, OE should be tied to GND through a pull-down resistor. The minimum value of the pull-down resistor to ground is determined by the current-sourcing capability of the driver which is recommended to be 10k Ω .

For proper operations, V_{CCA} must not exceed V_{CCB} and the device driving the data I/Os of the LXB0104Q must be at least $\pm 2\text{mA}$. If an external pullup or pull-down resistor is applied on the device I/O ports, the resistor values must be larger than 50k Ω to avoid affecting V_{OH} or V_{OL} .

The LXB0104Q is available in TSSOP-14 and U-QFN1720-12 (Type CJ) packages where U-QFN1720-12 (Type CJ) is only 1.7mm x 2.0mm x 0.55mm. The main benefit of this package is most apparent in small portable electronic devices, especially the space-constraint applications. The operation temperature is specified from -40°C to +125°C.

Features

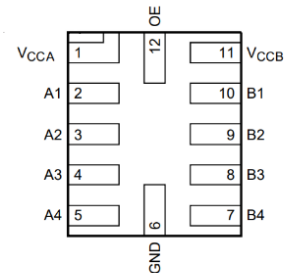
- Bi-Directional Voltage Translation for Push-Pull Applications
- AEC-Q100 Grade 1
- Specified from -40°C to +125°C
- Translation Up & Down, Among Full Temperature Range
 - Max Data Rate \leq 110Mbps, $C_L = 15\text{pF}$, 3.3V to 5.0V
 - Max Data Rate \leq 65Mbps, $C_L = 15\text{pF}$, 1.8V to 3.3V
 - Max Data Rate \leq 30Mbps, $C_L = 15\text{pF}$, 1.2V to 1.8V
- I_{OFF} Circuitry Provides Partial-Power-Down Mode Operation
- OE Pin Supports High-Impedance Exists Between Ports
- Auto Direction, No Control Pin Required.
- ESD Protection Exceeds JESD 22
 - 7000V HBM (B Port), 3000V HBM (A Port)
 - 1500V CDM (C101)
- Latchup Exceeds 100mA per JESD 31
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **The LXB0104Q is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF16949 certified facilities.**

<https://www.diodes.com/quality/product-definitions/>

- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
 2. See <https://www.diodes.com/quality/lead-free/> for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

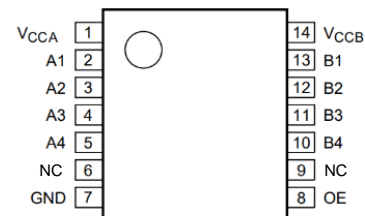
Pin Assignments

(Top View)



(Transparent Top View)

U-QFN1720-12 (Type CJ)



TSSOP-14

Applications

- GPIO, SPI, SDIO, UART
- Automotive digital clusters
- Automotive infotainments
- Automotive ADAS
- Automotive telematics

Pin Descriptions

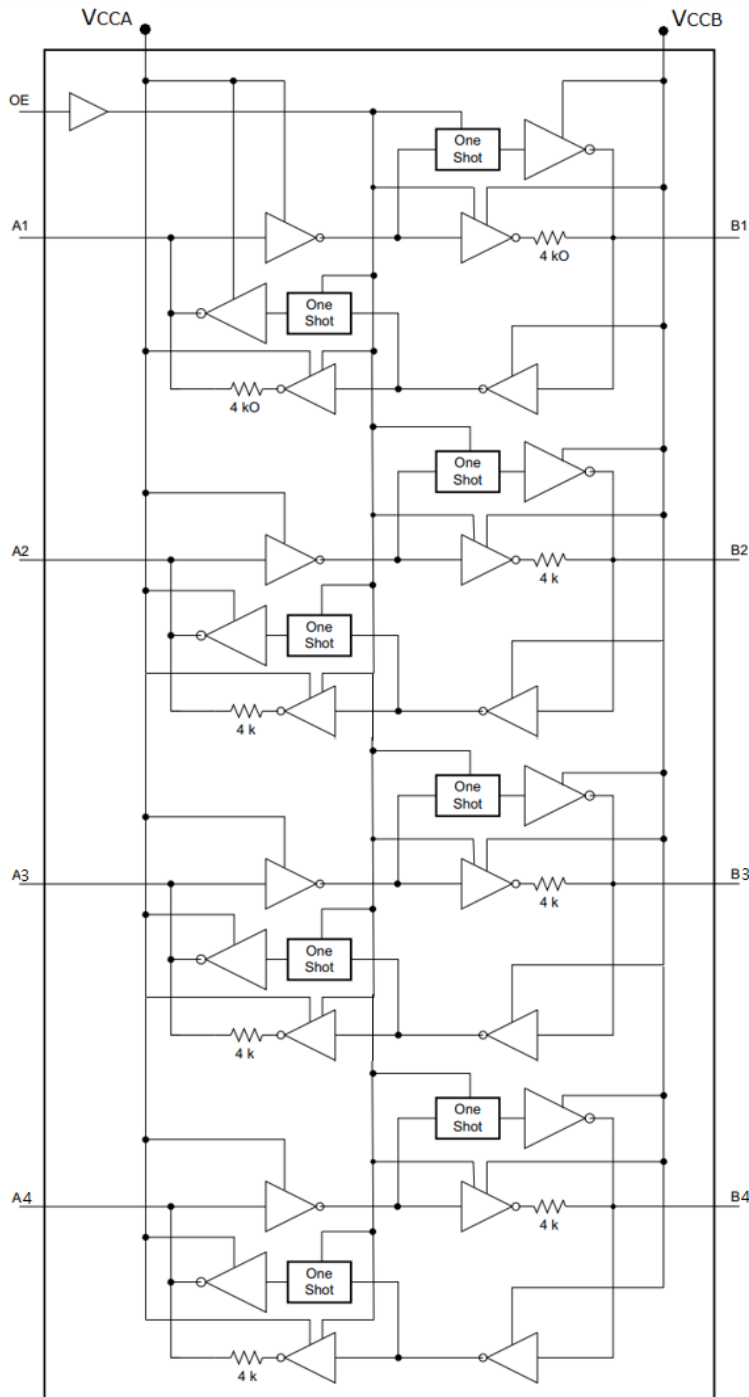
Pin Name	Pin Number		Function
	TSSOP-14	U-QFN1720-12 (Type CJ)	
V _{CCA}	1	1	Supply voltage, A port
A1	2	2	Input/output 1
A2	3	3	Input/output 2
A3	4	4	Input/output 3
A4	5	5	Input/output 4
NC	6	—	No connection. Not internally connected.
GND	7	6	Ground
OE	8	12	Output Enable; OE is high-active.
NC	9	—	No connection. Not internally connected.
B4	10	7	Input/output 4
B3	11	8	Input/output 3
B2	12	9	Input/output 2
B1	13	10	Input/output 1
V _{CCB}	14	11	Supply voltage, B port

Absolute Maximum Ratings (Note 4)

Symbol	Parameter	Rating	Unit
ESD HBM	Human Body Model ESD Protection (B port)	±7	kV
	Human Body Model ESD Protection (A Port)	±3	kV
ESD CDM	Charged Device Model ESD Protection	±1.5	kV
V _{CCA} , V _{CCB}	Supply Reference Voltage Range	-0.5 to +6.0	V
V _I	Input Voltage Range	-0.5 to +6.0	V
V _O	Voltage Range Applied to Any Output in the High-Z or Power-Off State	-0.5 to +6.0	V
I _{IK}	Input Clamp Current, V _I < 0	-50	mA
I _{OK}	Output Clamp Current, V _O < 0	-50	mA
I _O	Continuous Output Current	±50	mA
	Continuous Current Through V _{CCA} , V _{CCB} , or GND	±100	mA
T _J	Operating Junction Temperature	-40 to +150	°C
T _{STG}	Storage Temperature	-65 to +150	°C

Note: 4. Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability.

Functional Diagram



For proper operation, cares shall be taken in consideration:

1. VCCA must not exceed VCCB and the device driving the data I/Os of the LXB0104Q must have drive strength of at least $\pm 2\text{mA}$.
2. OE pin is the input for the device and should never be left floating. OE pin should be tied to GND through a pull-down resistor before VCCA becomes stable, the value of the resistor is recommended to be $10\text{k}\Omega$ which is determined by the current-sourcing capability of the driver.
3. If an external pullup or pull-down resistor is used on the device I/O ports, the resistor values must be larger than $50\text{k}\Omega$ to avoid affecting V_{OH} or V_{OL} .

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Units
V _{CCA}	Reference voltage, A port	1.2	3.6	V
V _{CCB}	Reference voltage, B port	1.65	5.5	V
V _{IH}	Data Input pins, high-level input requirement	V _{CCI} × 0.65	V _{CCI}	V
	Output Enable pin, high-level input requirement to enable chip	V _{CCA} × 0.65	5.5	V
V _{IL}	Data Input pins, low-level input requirement	0	V _{CCI} × 0.35	V
	Output Enable pin, low-level input requirement to disable chip	0	V _{CCA} × 0.35	V
V _O	A-port at high-impedance or power-off state	0	3.6	V
	B-port at high-impedance or power-off state	0	5.5	V
Δt/ΔV	Input transition rise or fall rate	0	40	ns/V
T _A	Operating free-air temperature	-40	+125	°C

Electrical Characteristics (All typical values are measured at T_A = +25°C, unless otherwise specified, Notes 5 & 6.)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V _{CCA}	A port supply voltage	—	1.2	—	3.6	V
V _{CCB}	B port supply voltage	—	1.65	—	5.5	V
V _{IH}	Input high-level voltage	A port & B port, data input	V _{CCI} × 0.65	—	V _{CCI}	V
V _{IL}	Input low-level voltage	A port & B port, data input	0	—	V _{CCI} × 0.35	V
V _{OHA}	Output high-level voltage	A port, V _{CCA} = 1.2V, I _{OH} = -20μA	V _{CCA} × 0.8	—	—	V
		A port, V _{CCA} = 1.4V to 4.5V, I _{OH} = -20μA	V _{CCA} - 0.4	—	—	V
V _{OLA}	Output low-level voltage	A port, V _{CCA} = 1.2V, I _{OL} = +20μA	—	—	V _{CCA} × 0.2	V
		A port, V _{CCA} = 1.4V to 4.5V, I _{OL} = +20μA	—	—	0.4	V
V _{OHB}	Output high-level voltage	B port, I _{OH} = -20μA	V _{CCB} - 0.4	—	—	V
V _{OLB}	Output low-level voltage	B port, I _{OL} = +20μA	—	—	0.4	V
C _{IOE}	OE pin capacitance	V _{CCA} = 1.2V to 3.6V	—	3	—	pF
C _{IOA}	A port I/O capacitance	V _{CCA} = 1.2V to 3.6V	—	5	—	pF
C _{IOB}	B port I/O capacitance	V _{CCB} = 1.65V to 5.5V	—	11	—	pF
I _{CCA} + I _{CCB}	Total supply current	V _{IN} = GND, I _O = 0, V _{CCA} = 1.2V to 3.6V V _{CCB} = 1.65V to 5.5V	—	1	20	μA
I _{CCA}	A port supply current	V _{IN} = GND, I _O = 0, V _{CCA} = 1.2V to 3.6V V _{CCB} = 1.65V to 5.5V	—	0.5	10	μA
		V _{IN} = GND, I _O = 0, V _{CCA} = 3.6V, V _{CCB} = 0V	—	0.5	8	μA
		V _{IN} = GND, I _O = 0, V _{CCA} = 0V, V _{CCB} = 5.5V	—	0.5	-8	μA
I _{CCB}	B port supply current	V _{IN} = GND, I _O = 0, V _{CCA} = 1.2V to 3.6V V _{CCB} = 1.65V to 5.5V	—	0.5	10	μA
		V _{IN} = GND, I _O = 0, V _{CCA} = 3.6V, V _{CCB} = 0V	—	0.5	-8	μA
		V _{IN} = GND, I _O = 0, V _{CCA} = 0V, V _{CCB} = 5.5V	—	0.5	8	μA
I _{CCZA}	High impedance state V _{CCA} current	OE = V _{IN} = GND, I _O = 0, V _{CCA} = 1.2V to 3.6V V _{CCB} = 1.65V to 5.5V	—	0.5	5	μA
I _{CCZB}	High impedance state V _{CCB} current	OE = V _{IN} = GND, I _O = 0, V _{CCA} = 1.2V to 3.6V V _{CCB} = 1.65V to 5.5V	—	0.5	5	μA
I _{OZ}	Off-state output current	OE = GND, A port: 1.2V to 3.6V, B port: 1.65V to 5.5V	—	±0.5	±5	μA
I _{OFF}	Off-state leakage current	A port, V _I or V _O = 0 to 3.6V, V _{CCA} = 0V V _{CCB} = 0V to 5.5V	—	±0.5	±10	μA
		B port, V _I or V _O = 0 to 5.5V, V _{CCB} = 0V V _{CCA} = 0V to 3.6V	—	±0.5	±10	μA

Notes: 5. V_{CCA} must be less than or equal to V_{CCB}. V_{CCI} is the supply voltage associated with the input port.

6. All of DC current are measured at T_A = +25°C as typical values and maximum values are measured among T_A = -40°C to +125°C.

Dynamic Switching Characteristics (Notes 7 & 8, unless otherwise specified.)

V_{CCA} = 1.2V, T_A = +25°C & +125°C

Parameter	From (Input)	To (Output)	V _{CCB} = 1.8V	V _{CCB} = 2.5V	V _{CCB} = 3.3V	V _{CCB} = 5.0V	Unit
			Max	Max	Max	Max	
t _{PD}	A	B	12.5	10.5	11.0	11.0	ns
	B	A	17.5	16.5	17.0	17.0	ns
t _{EN}	OE	A	1.0	1.0	1.0	1.0	μs
	OE	B	1.0	1.0	1.0	1.0	μs
t _{DIS}	OE	A	380	360	330	330	ns
	OE	B	350	330	320	320	ns
t _{RA} , t _{FA}	A port rise time and fall time		9.5	9.3	9.2	9.2	ns
t _{RB} , t _{FB}	B port rise time and fall time		5.5	5.3	5.2	5.2	ns
t _{SKO}	Skew time, between channels		0.5	0.5	0.5	0.5	ns
Data rate	—		30	30	30	30	Mbps

Test Conditions: C_L = 15pF includes probe and jig capacitance. R_L = Load resistance. For measuring data rate, pulse width, propagation delay, output rise and fall time and enable time, R_L = 1MΩ. For measuring disable time, R_L = 50kΩ. All input pulses are supplied by generators having the following characteristics: PRR = 10MHz, Z_O = 50Ω, dv / dt ≥ 1V/ns. See load circuit for details.

V_{CCA} = 1.8V, T_A = +125°C

Parameter	From (Input)	To (Output)	V _{CCB} = 1.8V	V _{CCB} = 2.5V	V _{CCB} = 3.3V	V _{CCB} = 5.0V	Unit
			Max	Max	Max	Max	
t _{PD}	A	B	—	7.4	7.1	7.0	ns
	B	A	—	8.5	7.9	7.6	ns
t _{EN}	OE	A	—	0.8	0.8	0.8	μs
	OE	B	—	0.8	0.8	0.8	μs
t _{DIS}	OE	A	—	240	240	240	ns
	OE	B	—	210	210	210	ns
t _{RA} , t _{FA}	A port rise time and fall time		—	6.2	6.1	6.0	ns
t _{RB} , t _{FB}	B port rise time and fall time		—	5.3	4.9	4.8	ns
t _{SKO}	Skew time, between channels		—	0.5	0.5	0.5	ns
Data rate	—		—	55	65	65	Mbps

Test Conditions: C_L = 15pF includes probe and jig capacitance. R_L = Load resistance. For measuring data rate, pulse width, propagation delay, output rise and fall time and enable time, R_L = 1MΩ. For measuring disable time, R_L = 50kΩ. All input pulses are supplied by generators having the following characteristics: PRR = 10MHz, Z_O = 50Ω, dv / dt ≥ 1V/ns. See load circuit for details.

V_{CCA} = 2.5V, T_A = +125°C

Parameter	From (Input)	To (Output)	V _{CCB} = 1.8V	V _{CCB} = 2.5V	V _{CCB} = 3.3V	V _{CCB} = 5.0V	Unit
			Max	Max	Max	Max	
t _{PD}	A	B	—	—	6.2	5.9	ns
	B	A	—	—	6.5	6.2	ns
t _{EN}	OE	A	—	—	0.7	0.7	μs
	OE	B	—	—	0.7	0.7	μs
t _{DIS}	OE	A	—	—	220	220	ns
	OE	B	—	—	210	210	ns
t _{RA} , t _{FA}	A port rise time and fall time		—	—	5.5	5.5	ns
t _{RB} , t _{FB}	A port rise time and fall time		—	—	4.8	4.7	ns
t _{SKO}	Skew time, between channels		—	—	0.5	0.5	ns
Data rate	—		—	—	75	80	Mbps

Test Conditions: C_L = 15pF includes probe and jig capacitance. R_L = Load resistance. For measuring data rate, pulse width, propagation delay, output rise and fall time and enable time, R_L = 1MΩ. For measuring disable time, R_L = 50kΩ. All input pulses are supplied by generators having the following characteristics: PRR = 10MHz, Z_O = 50Ω, dv / dt ≥ 1V/ns. See load circuit for details.

- Notes: 7. For correct operation, the device driving the data I/Os of the LXB0104Q must have a minimum drive capability of ±2mA.
 8. See Figure 1, t_{PD} is the same as t_{PLH} and t_{PHL}; t_{EN} is the same as t_{PZL} and t_{PZH}; t_{DIS} is the same as t_{PLZ} and t_{PHZ}.

Dynamic Switching Characteristics (Notes 7 & 8, unless otherwise specified.) (continued)

 $V_{CCA} = 3.3V, T_A = +125^{\circ}C$

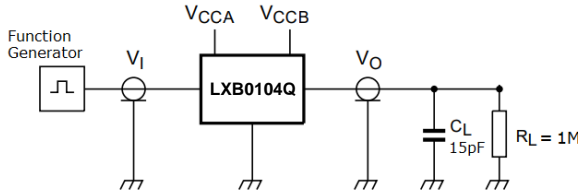
Parameter	From (Input)	To (Output)	$V_{CCB} = 1.8V$	$V_{CCB} = 2.5V$	$V_{CCB} = 3.3V$	$V_{CCB} = 5.0V$	Unit
			Max	Max	Max	Max	
t_{PD}	A	B	—	—	—	3.9	ns
	B	A	—	—	—	4.8	ns
t_{EN}	OE	A	—	—	—	0.7	μs
	OE	B	—	—	—	0.7	μs
t_{DIS}	OE	A	—	—	—	210	ns
	OE	B	—	—	—	210	ns
t_{RA}, t_{FA}	A port rise time and fall time		—	—	—	4.8	ns
t_{RB}, t_{FB}	A port rise time and fall time		—	—	—	4.6	ns
t_{SKO}	Skew time, between channels		—	—	—	0.5	ns
Data rate	—		—	—	—	110	Mbps

Test Conditions: $C_L = 15pF$ includes probe and jig capacitance. $R_L =$ Load resistance. For measuring data rate, pulse width, propagation delay, output rise and fall time and enable time, $R_L = 1M\Omega$. For measuring disable time, $R_L = 50k\Omega$. All input pulses are supplied by generators having the following characteristics: PRR = 10MHz, $Z_O = 50\Omega$, $dv / dt \geq 1V/ns$. See load circuit for details.

- Notes:
7. For correct operation, the device driving the data I/Os of the LXB0104Q must have a minimum drive capability of $\pm 2mA$.
 8. See Figure 1, t_{PD} is the same as t_{PLH} and t_{PHL} ; t_{EN} is the same as t_{PZL} and t_{PZH} ; t_{DIS} is the same as t_{PLZ} and t_{PHZ} .

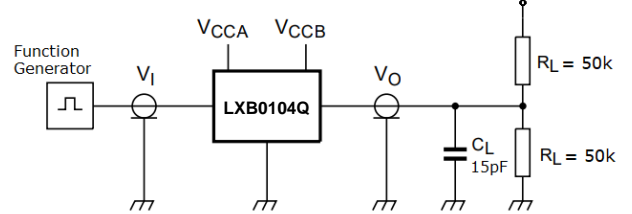
Parameter Measurement Information

DATA RATE and t_{PD} MEASUREMENTS

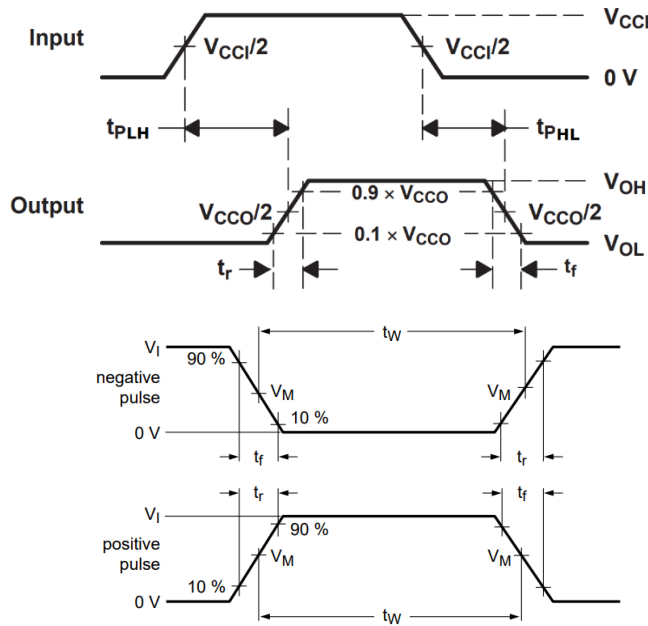


ENABLE and DISABLE MEASUREMENTS

t_{PZL}, t_{PLZ} = 2xV_o
t_{PHZ}, t_{PZH} = Open



VOLTAGE WAVEFORMS FOR PROPAGATION DELAY TIMES



DISABLE MEASUREMENT WAVEFORMS

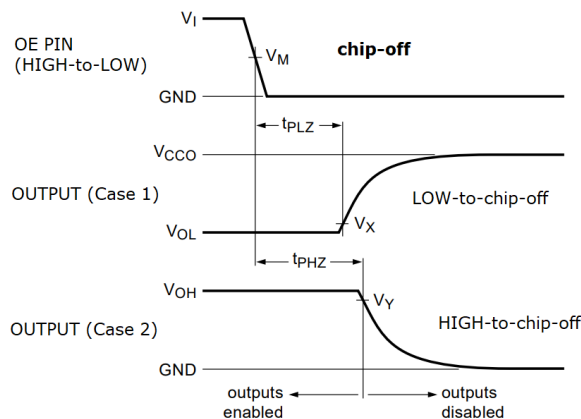


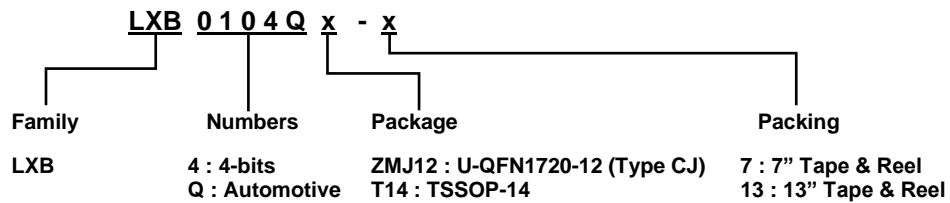
Figure 1. The LXB0104Q must be driven at least ±2mA for proper operation.
Load circuit and function generators having the following characteristics: PRR ≤ 10MHz, Z_O = 50Ω, dv / dt ≥ 1.0V/ns

Package Characteristics

Symbol	Parameter	Package	Test Conditions	Min	Typ	Max	Unit
θ _{JA}	Thermal Resistance Junction-to-Ambient	U-QFN1720-12 (Type CJ)	Note 9	—	102	—	°C/W
		TSSOP-14		—	110	—	
θ _{JC}	Thermal Resistance Junction-to-Case	U-QFN1720-12 (Type CJ)	Note 9	—	32	—	
		TSSOP-14		—	54	—	

Note: 9. Test condition for each of the package type(s): device mounted on JEDEC standard PCB per JESD51, with minimum recommended pad layout.

Ordering Information



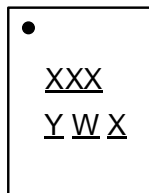
Orderable Part Number	Part Number Suffix	Package Code	Package	Packing (Note 10)	
				Qty.	Carrier
LXB0104QZMJ12-7	-7	ZMJ12	U-QFN1720-12 (Type CJ)	3,000	7" Tape and Reel
LXB0104QT14-13	-13	T14	TSSOP-14	2,500	13" Tape and Reel

Notes: 10. The taping orientation is located on our website at <https://www.diodes.com/assets/Packaging-Support-Docs/AP02007.pdf>.
 11. For packaging details, go to our website at <https://www.diodes.com/design/support/packaging/diodes-packaging/>.
 12. Pad layout as shown in Diodes Incorporated's package outline PDFs, which can be found on our website at <http://www.diodes.com/package-outlines.html>.

Marking Information

(1) U-QFN1720-12 (Type CJ)

(Top View)

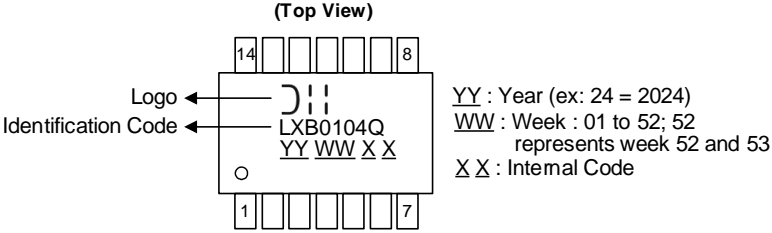


XXX : Identification Code
Y : Year : 0 to 9 (ex: 4 = 2024)
W : Week : A to Z : week 1 to 26;
 a to z : week 27 to 52; z represents week 52 and 53
X : Internal Code

Orderable Part Number	Package	Identification Code
LXB0104QZMJ12-7	U-QFN1720-12 (Type CJ)	BUQ

Marking Information (continued)

(2) TSSOP-14

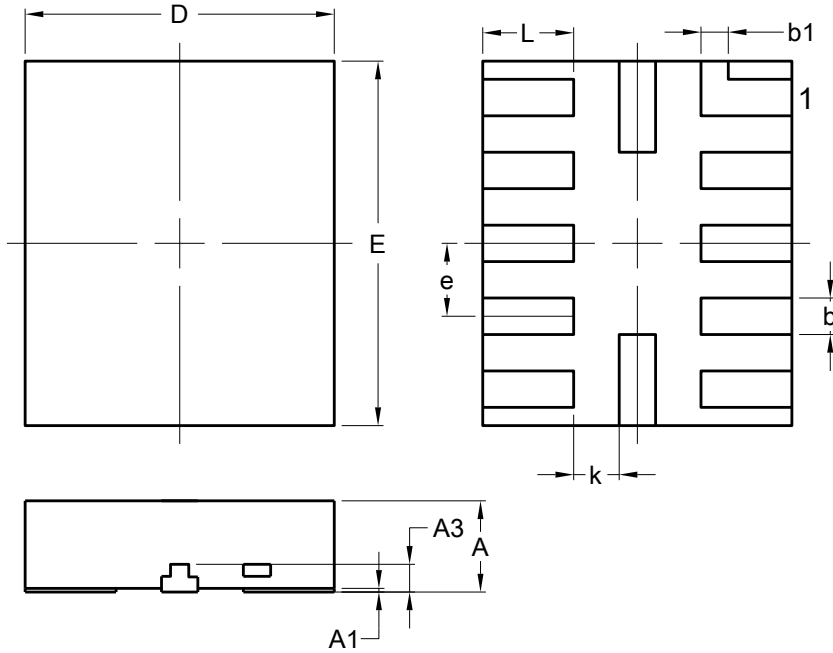


Orderable Part Number	Package	Identification code
LXB0104QT14-13	TSSOP-14	LXB0104Q

Package Outline Dimensions

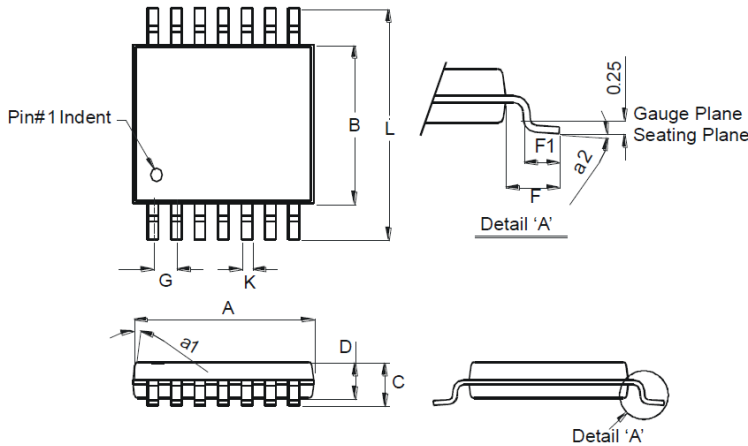
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

U-QFN1720-12 (Type CJ)



U-QFN1720-12 (Type CJ)			
Dim	Min	Max	Typ
A	0.450	0.550	--
A1	0.00	0.050	--
A3	0.152 REF		
b	0.150	0.250	--
b1	0.150 REF		
D	1.600	1.800	--
E	1.900	2.100	--
e	0.400 BSC		
k	0.250 REF		
L	0.400	0.600	--
All Dimensions in mm			

TSSOP-14

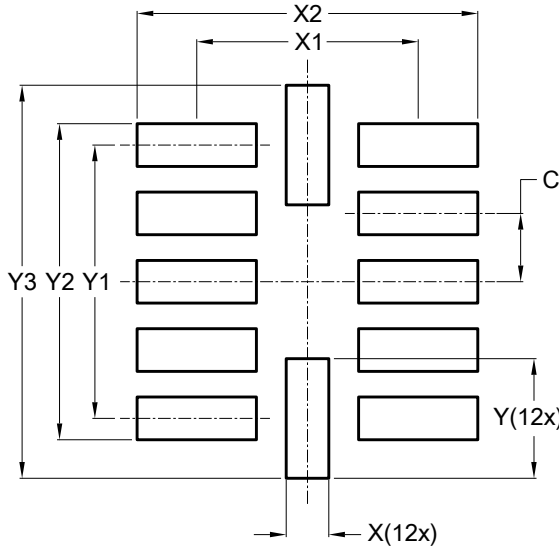


TSSOP-14		
Dim	Min	Max
a1	7° (4X)	
a2	0°	8°
A	4.9	5.10
B	4.30	4.50
C	-	1.2
D	0.8	1.05
F	1.00 Typ	
F1	0.45	0.75
G	0.65 Typ	
K	0.19	0.30
L	6.40 Typ	
All Dimensions in mm		

Suggested Pad Layout

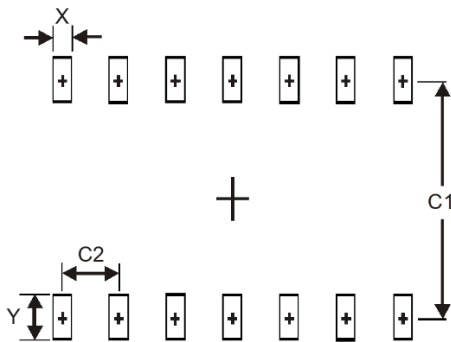
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

U-QFN1720-12 (Type CJ)



Dimensions	Value (in mm)
C	0.400
X	0.250
X1	1.300
X2	2.000
Y	0.700
Y1	1.600
Y2	1.850
Y3	2.300

TSSOP-14



Dimensions	Value (in mm)
X	0.45
Y	1.45
C1	5.9
C2	0.65

Mechanical Data

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 ③
- Max Soldering Temperature +260°C for 30 secs as per JEDEC J-STD-020
- Weight:
 - U-QFN1720-12 (Type CJ): 21.5mg (Approximate)
 - TSSOP: 82.5mg (Approximate)

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