Bidirectional Voltage Level Translator for Open-Drain and Push-Pull Applications

UM2002S8 *SOP8*
UM2002U8 *TSSOP8*

General Description

The UM2002 is a bidirectional voltage level translator operational from 1.0V to 3.6V ($V_{ref(A)}$) and 1.8V to 5.5V ($V_{ref(B)}$), which allows bidirectional voltage translations between 1.0V and 5V without the need for a direction pin in open-drain or push-pull applications. Bit widths ranging from 1-bit or 2-bit are offered for level translation application with transmission speeds < 33 MHz for an open-drain system with a 50 pF capacitance and a pull-up of 197Ω.
The translators provide excellent ESD protection to lower voltage devices, and at the same time protect less ESD-resistant devices.

Applications

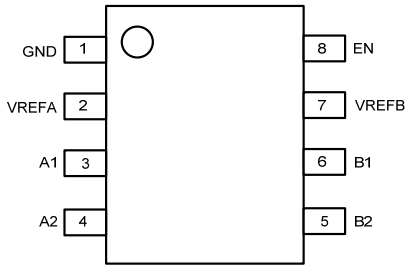
- SPI, MICROWIRE and I^2C Level Translation
- Low-Voltage ASIC Level Translation
- Smart Card Readers
- Cell-Phone Cradles
- Portable POS Systems
- Portable Communication Devices
- Low-Cost Serial Interfaces
- Cell-Phones
- GPS
- Telecommunications Equipment
- Consumer Electronics
- Household Appliances

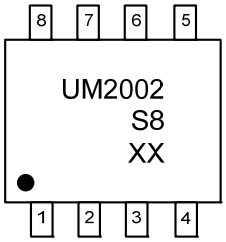
Features

- Provides Bidirectional Voltage Translation with No Direction Pin
- Less than 1.5ns Maximum Propagation Delay
- Allows Voltage Level Translation between:
  1). 1.0V $V_{ref(A)}$ and 1.8V, 2.5V, 3.3V or 5V $V_{ref(B)}$
  2). 1.2V $V_{ref(A)}$ and 1.8V, 2.5V, 3.3V or 5V $V_{ref(B)}$
  3). 1.8V $V_{ref(A)}$ and 3.3V or 5V $V_{ref(B)}$
  4). 2.0V $V_{ref(A)}$ and 5V $V_{ref(B)}$
  5). 3.3V $V_{ref(A)}$ and 5V $V_{ref(B)}$
- Low 3.5Ω ON-State Connection between Input and Output Ports Provides Less Signal Distortion
- 5V Tolerant I/O Ports to Support Mixed-Mode Signal Operation
- High-Impedance An and Bn Pins for EN=LOW
- Lock-up Free Operation
- Flow through Pinout for Ease of Printed-Circuit Board Trace Routing
- ESD Protection Exceeds:
  4kV HBM per JESD22-A114
  200V MM per JESD22-A115
  1000V CDM per JESD22-C101
- Packages Offered: SOP8, TSSOP8

Pin Configurations Top View

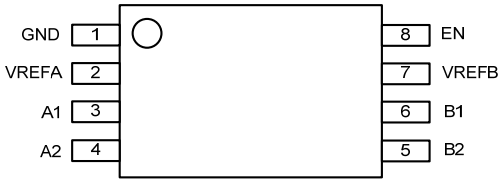
(Top View)

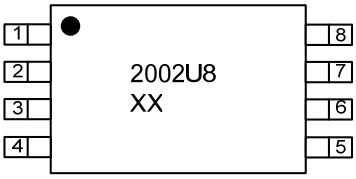




XX: Week Code
UM2002S8
SOP8

(Top View)





XX: Week Code
UM2002U8
TSSOP8

Pin Description

Pin Number	Symbol	Function
1	GND	Ground (0V)
2	VREFA	Low-voltage side reference supply voltage for An
3,4	A1,A2	Low-voltage side; connected to VREFA through a pull-up resistor
5,6	B1,B2	High-voltage side; connected to VREFB through a pull-up resistor
7	VREFB	High-voltage side reference supply voltage for Bn
8	EN	Switch enable input; connected to VREFB and pulled-up through a high resistor

Ordering Information

Part Number	Packaging Type	Marking Code	Shipping Qty
UM2002S8	SOP8	UM2002S8	2500pcs/13Inch Tape & Reel
UM2002U8	TSSOP8	2002U8	3000pcs/13Inch Tape & Reel

Absolute Maximum Ratings (Note 1)

Over operating free-air temperature range (unless otherwise noted)

Symbol	Parameter		Value	Unit
$V_{ref(A)}$	Reference Voltage (A)		-0.5 to +6	V
$V_{ref(B)}$	Reference Voltage (B)		-0.5 to +6	V
V_I	Input Voltage		-0.5(Note 2) to +6	V
$V_{I/O}$	Voltage on an input/output pin		-0.5(Note 2) to +6	V
I_{ch}	Channel Current (DC)		+128	mA
I_{IK}	Input Clamp Current	V_I 0V	-50	mA
T_{stg}	Storage Temperature		-65 to +150	°C

Note 1: Stresses beyond those listed under "absolute maximum ratings" may 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-rated conditions for extended periods may affect device reliability.

Note 2: The input and input/output negative voltage ratings may be exceeded if the input and input/output clamp current ratings are observed.

Recommended Operating Conditions

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{I/O}$	Voltage on an input/output pin	An, Bn	0	5.5	V
$V_{ref(A)}$ (Note 3)	Reference Voltage (A)	VREFA	0	5.4	V
$V_{ref(B)}$ (Note 3)	Reference Voltage (B)	VREFB	0	5.5	V
$V_{I(EN)}$	Input Voltage on pin EN		0	5.5	V
$I_{sw(pass)}$	Pass Switch Current			64	mA
T_{amb}	Ambient Temperature	Operating in free-air	-40	+85	°C

Note 3: $V_{ref(A)} \leq V_{ref(B)} - 1$ V for best results in level shifting applications.

Electrical Characteristics

T_{amb} = −40 °C to +85 °C, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ (Note 4)	Max	Unit
V_{IK}	Input Clamping Voltage	I_I = −18mA; $V_{I(EN)}$ = 0V			-1.2	V
I_{IH}	HIGH-level Input Current	V_I= 5V; $V_{I(EN)}$ = 0V			5	μA
$C_{i(EN)}$	Input Capacitance on pin EN	V_I= 0V or 3V		12		pF
$C_{io(off)}$	Off-state input/output capacitance	An, Bn; V_O= 0V or 3V ; $V_{I(EN)}$ = 0V		10	12	pF
$C_{io(on)}$	On-state input/output capacitance	An, Bn; V_O= 0V or 3V ; $V_{I(EN)}$ = 3V		8	12.5 (Note 5)	pF
R_{on}	ON-state resistance (Note 6)	An, Bn; V_I = 0V; I_O = 64mA; $V_{I(EN)}$ = 4.5V(Note 7)	1	2.5	5.0	Ω
		An, Bn; V_I = 2.4V; I_O = 15mA; $V_{I(EN)}$ = 4.5V		4.5	7.5	

Note 4: All typical values are at T_{amb} = 25°C.

Note 5: Not production tested, maximum value based on characterization data of typical parts.

Note 6: Measured by the voltage drop between the An and Bn terminals at the indicated current through the switch. ON-state resistance is determined by the lowest voltage of the two terminals.

Note 7: Guaranteed by design.

Switching Characteristics (translating down)

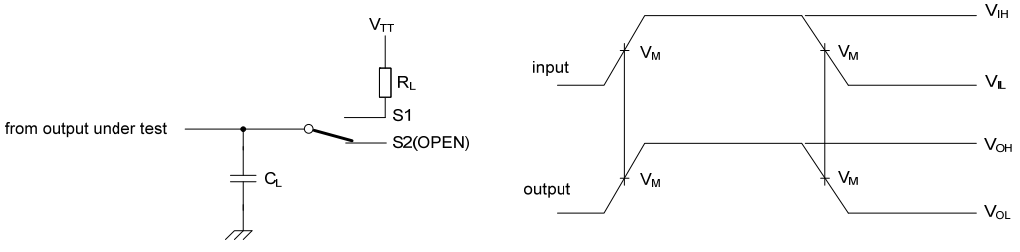
Over recommended operating free-air temperature range(unless otherwise noted). Values guaranteed by design.

Symbol	Parameter	Test Conditions	C_L=50pF		C_L=30pF		C_L=15pF		Unit
			Min	Max	Min	Max	Min	Max	
$V_{I(EN)}$ = 3.3V; V_{IH} = 3.3V; V_{IL} = 0V; V_M =1.15V(see Figure 1).									
t_{PLH}	LOW to HIGH propagation delay	from (input) Bn to (output) An.	0	3.5	0	2.7	0	2.2	ns
t_{PHL}	HIGH to LOW propagation delay		0	3.5	0	3.0	0	2.3	ns
$V_{I(EN)}$ =2.5V; V_{IH} = 2.5V; V_{IL} = 0V; V_M = 0.75V (see Figure 1).									
t_{PLH}	LOW to HIGH propagation delay	from (input) Bn to (output) An.	0	3.5	0	2.7	0	2.2	ns
t_{PHL}	HIGH to LOW propagation delay		0	4.0	0	3.0	0	2.3	ns

Switching Characteristics (translating up)

Over recommended operating free-air temperature range(unless otherwise noted). Values guaranteed by design.

Symbol	Parameter	Test Conditions	C_L=50pF		C_L=30pF		C_L=15pF		Unit
			Min	Max	Min	Max	Min	Max	
$V_{I(EN)}$ = 3.3V; V_{IH} = 2.3V; V_{IL} = 0V; V_{TT} = 3.3V; V_M = 1.15V; R_L = 300Ω(see Figure 1).									
t_{PLH}	LOW to HIGH propagation delay	from (input) An to (output) Bn.	0	3.35	0	2.5	0	2.0	ns
t_{PHL}	HIGH to LOW propagation delay		0	4.35	0	3.25	0	2.4	ns
$V_{I(EN)}$ =2.5V; V_{IH} = 1.5V; V_{IL} = 0V; V_{TT} = 2.5V; V_M = 0.75V; R_L = 300Ω (see Figure 1).									
t_{PLH}	LOW to HIGH propagation delay	from (input) An to (output) Bn.	0	3.35	0	2.5	0	2.0	ns
t_{PHL}	HIGH to LOW propagation delay		0	4.5	0	3.5	0	2.5	ns



a. Load circuit **B. Timing diagram; high-impedance scope probe used**

S1 = translating up; S2 = translating down.
C_L includes probe and jig capacitance.
All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz; Z_o = 50 Ω; t_r ≤ 5 ns; t_f ≤ 5 ns.
The outputs are measured one at a time, with one transition per measurement.

Fig 1. Load circuit for outputs

Applications Information

Detail Description

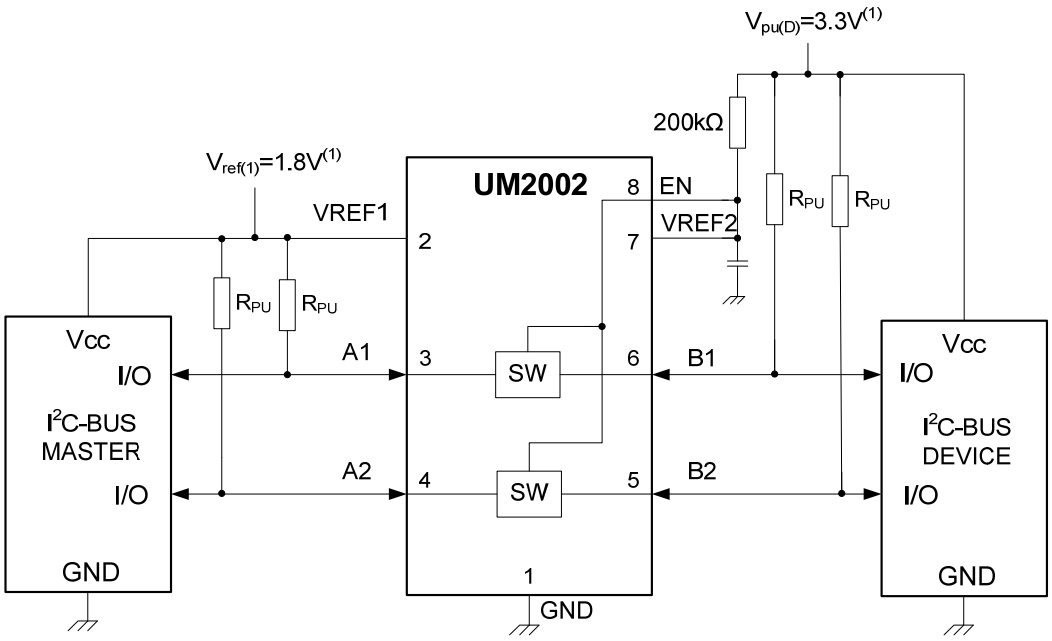
The UM2002 is a bidirectional voltage level translator operational from 1.0V to 3.6V ($V_{ref(A)}$) and 1.8V to 5.5V ($V_{ref(B)}$), which allows bidirectional voltage translations between 1.0V and 5V without the need for a direction pin in open-drain or push-pull applications.

When the An or Bn port is LOW, the clamp is in the ON-state and a low resistance connection exists between the An and Bn ports. The low ON-state resistance (R_{on}) of the switch allows connections to be made with minimal propagation delay. Assuming the higher voltage is on the Bn port when the Bn port is HIGH, the voltage on the An port is limited to the voltage set by $V_{ref(A)}$. When the An port is HIGH, the Bn port is pulled to the drain pull-up supply voltage ($V_{pu(D)}$) 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.

When EN is HIGH, the translator switch is on, and the An I/O are connected to the Bn I/O, respectively, allowing bidirectional data flow between ports. When EN is LOW, the translator switch is off, and a high-impedance state exists between ports. The EN input circuit is designed to be supplied by $V_{ref(B)}$. To ensure the high-impedance state during power-up or power-down, EN must be LOW.

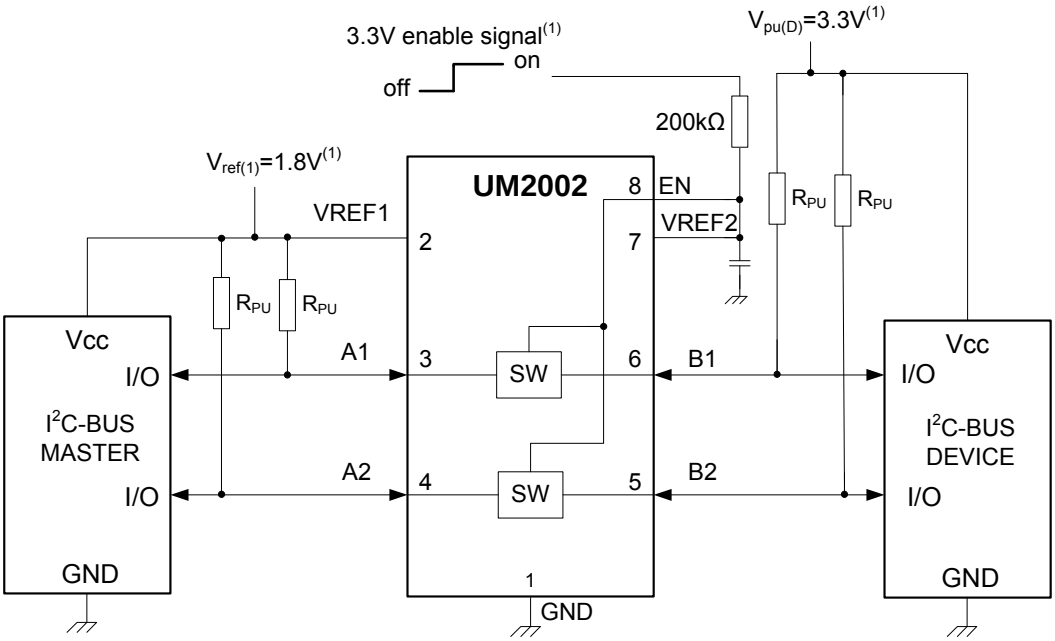
All channels have the same electrical characteristics and there is minimal deviation from one output to another in voltage or propagation delay. This is a benefit over discrete transistor voltage translation solutions, since the fabrication of the switch is symmetrical.

Enable and Disable



(1) The applied voltages at $V_{ref(1)}$ and $V_{pu(D)}$ should be such that $V_{bias(ref)(2)}$ is at least 1 V higher than $V_{ref(1)}$ for best translator operation.

Fig 2. Typical application circuit (switch always enabled)



(1) In the Enabled mode, the applied enable voltage $V_{I(EN)}$ and the applied voltage at $V_{ref(1)}$ should be such that $V_{bias(ref)(2)}$ is at least 1 V higher than $V_{ref(1)}$ for best translator operation.

Fig 3. Typical application circuit (switch enable control)

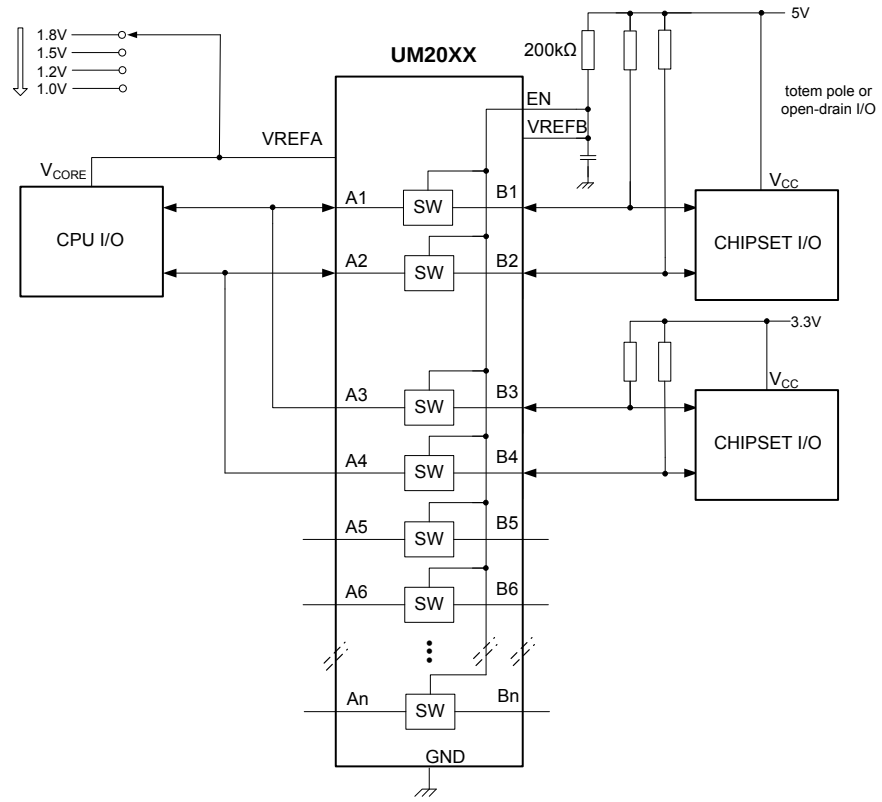


Fig 4. Bidirectional translation to multiple higher voltage levels

Bidirectional translation

For the bidirectional clamping configuration (higher voltage to lower voltage or lower voltage to higher voltage), the EN input must be connected to VREFB and both pins pulled to HIGH side $V_{pu(D)}$ through a pull-up resistor (typically 200kΩ). This allows VREFB to regulate the EN input. A filter capacitor on VREFB is recommended. The master output driver can be totem pole or open-drain (pull-up resistors may be required) and the slave device output can be totem pole or open-drain (pull-up resistors are required to pull the Bn outputs to $V_{pu(D)}$). However, if either output is totem pole, data must be unidirectional or the outputs must be 3-stateable and 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 reference supply voltage ($V_{ref(A)}$) is connected to the processor core power supply voltage. When VREFB is connected through a 200kΩ resistor to a 3.3V to 5.5V $V_{pu(D)}$ power supply, and $V_{ref(A)}$ is set between 1.0V and ($V_{pu(D)}$ −1V), the output of each An has a maximum output voltage equal to VREFA, and the output of each Bn has a maximum output voltage equal to $V_{pu(D)}$.

Application operating conditions

Refer to Figure 4

Symbol	Parameter	Conditions	Min	Typ (Note 8)	Max	Unit
$V_{ref(B)}$	Reference Bias Voltage (B)		$V_{ref(A)}$ + 0.6	2.1	5	V
$V_{I(EN)}$	Input Voltage on pin EN		$V_{ref(A)}$ + 0.6	2.1	5	V
$V_{ref(A)}$	Reference Voltage (A)		0	1.5	4.4	V
$I_{sw(pass)}$	Pass Switch Current			14		mA
I_{ref}	Reference Current	Transistor		5		μA
T_{amb}	Ambient Temperature	Operating in free-air	-40		+85	°C

Note 8: All typical values are at T_{amb} = 25 °C.

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 15mA. This ensures a pass voltage of 260mV to 350mV. If the current through the pass transistor is higher than 15mA, the pass voltage also is higher in the ON state. To set the current through each pass transistor at 15mA, the pull-up resistor value is calculated as:

$$R_{PU} = \frac{V_{pu(D)} - 0.35V}{0.015A}$$

The table below summarizes resistor reference voltages and currents at 15mA, 10mA, and 3mA. The resistor values 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 UM2002 device at 0.175V, although the 15mA only applies to current flowing through the UM2002 device.

Pull-up resistor values

Calculated for V_{OL} = 0.35V; assumes output driver V_{OL} = 0.175V at stated current.

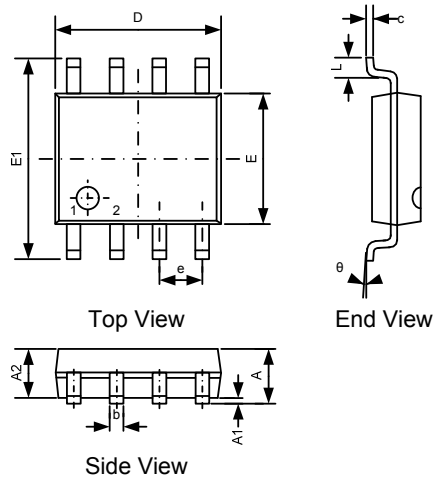
$V_{pu(D)}$	Pull-up resistor value (Ω)					
	15mA		10mA		3mA	
	Nominal	+10 % (Note 9)	Nominal	+10 % (Note 9)	Nominal	+10 % (Note 9)
5V	310	341	465	512	1550	1705
3.3V	197	217	295	325	983	1082
2.5V	143	158	215	237	717	788
1.8V	97	106	145	160	483	532
1.5V	77	85	115	127	383	422
1.2V	57	63	85	94	283	312

Note 9: +10 % to compensate for V_{CC} range and resistor tolerance.

Package Information

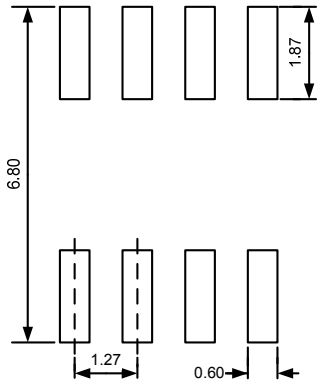
UM2002S8 SOP8

Outline Drawing



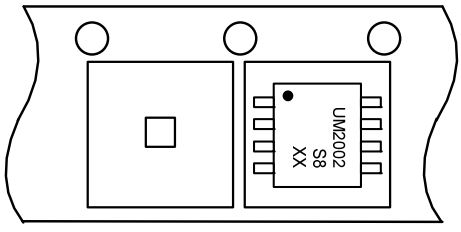
DIMENSIONS						
Symbol	MILLIMETERS			INCHES		
	Min	Typ	Max	Min	Typ	Max
A	1.35	1.55	1.75	0.053	0.061	0.069
A1	0.10	-	0.25	0.004	-	0.010
A2	1.25	-	1.65	0.049	-	0.065
b	0.30	-	0.51	0.012	-	0.020
c	0.15	-	0.25	0.006	-	0.010
D	4.70	4.90	5.10	0.185	0.193	0.200
E	3.80	3.90	4.00	0.150	0.154	0.157
E1	5.80	6.00	6.20	0.228	0.236	0.244
e	1.27BSC			0.050 BSC		
L	0.40	-	1.27	0.016	-	0.050
θ	0°	-	8°	0°	-	8°

Land Pattern



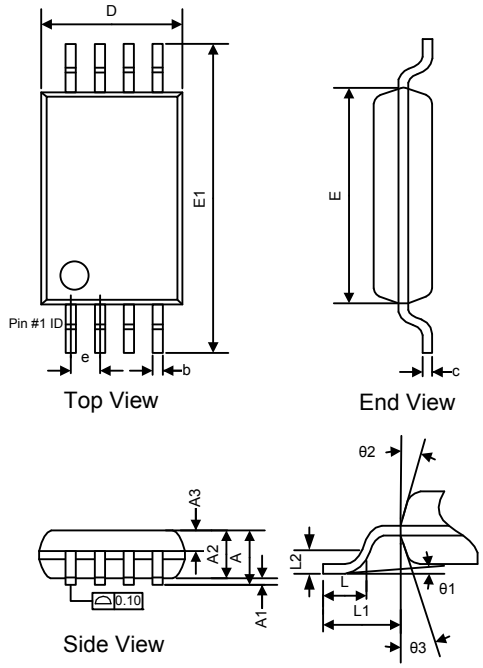
NOTES:
1. Compound dimension: 4.90×3.90;
2. Unit: mm;
3. General tolerance ±0.05mm unless otherwise specified;
4. The layout is just for reference.

Tape and Reel Orientation



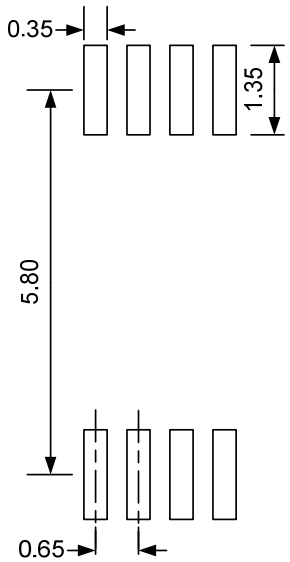
UM2002U8: TSSOP8

Outline Drawing



DIMENSIONS						
Symbol	MILLIMETERS			INCHES		
	Min	Typ	Max	Min	Typ	Max
A	-	-	1.20	-	-	0.047
A1	0.05	-	0.15	0.002	-	0.006
A2	0.80	-	1.05	0.031	-	0.041
A3	0.34	0.44	0.54	0.013	0.017	0.021
b	0.19	-	0.30	0.007	-	0.012
c	0.09	-	0.20	0.004	-	0.008
D	2.83	3.00	3.10	0.111	0.118	0.122
E	4.30	4.40	4.50	0.169	0.173	0.177
E1	6.20	6.40	6.60	0.244	0.252	0.260
e	0.65BSC			0.026BSC		
L	0.45	0.60	0.75	0.018	0.024	0.030
L1	1.00REF			0.039REF		
L2	0.25BSC			0.010BSC		
θ1	0°	-	8°	0°	-	8°
θ2	10°	12°	14°	10°	12°	14°
θ3	10°	12°	14°	10°	12°	14°

Land Pattern



NOTES:
1. Compound dimension: 3.0×4.40;
2. Unit: mm;
3. General tolerance ±0.05mm unless otherwise specified;
4. The layout is just for reference.

Tape and Reel Orientation

GREEN COMPLIANCE

Union Semiconductor is committed to environmental excellence in all aspects of its operations including meeting or exceeding regulatory requirements with respect to the use of hazardous substances. Numerous successful programs have been implemented to reduce the use of hazardous substances and/or emissions.
All Union components are compliant with the RoHS directive, which helps to support customers in their compliance with environmental directives. For more green compliance information, please visit:
http://www.union-ic.com/index.aspx?cat_code=RoHSDeclaration

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