Dual Bidirectional I^{2}C-Bus and SMBus Voltage-Level Translator

1 FEATURES

- **1.0V to 5.5V V$_{REF1}$ and 1.8V to 5.5V V$_{REF2}$ (V$_{REF1}$<V$_{REF2}$)**
- **2-Bit Bidirectional Translator for SDA and SCL Lines in Mixed-Mode I^{2}C Applications**
- **Compatible with I^{2}C and SMBus**
- **Less Than 1.5ns Maximum Propagation Delay to Accommodate Standard-Mode and Fast-Mode I^{2}C Devices and Multiple Masters**
- **Provides bidirectional voltage translation with no direction pin**
- **Allows Voltage-Level Translation Between**
  –1.0V V$_{REF1}$ and 1.8V, 2.5V, 3.3V or 5V V$_{REF2}$
  –1.2V V$_{REF1}$ and 1.8V, 2.5V, 3.3V or 5V V$_{REF2}$
  –1.8V V$_{REF1}$ and 2.5V, 3.3V or 5V V$_{REF2}$
  –2.5V V$_{REF1}$ and 3.3V or 5V V$_{REF2}$
  –3.3V V$_{REF1}$ and 5V V$_{REF2}$
- **Low 3.5Ω ON-State Connection Between Input and Output Ports Provides Less Signal Distortion**
- **Open-Drain I^{2}C I/O Ports (SCL1, SDA1, SCL2 and SDA2)**
- **High-Impedance SCL1, SDA1, SCL2 and SDA2 Pins for EN = Low**
- **Lock-Up-Free Operation for Isolation When EN = Low**
- **5V Tolerant I^{2}C I/O Ports to Support Mixed-Mode Signal Operation**
- **Extended Temperature: -40°C to +85°C**

2 APPLICATIONS

- **I^{2}C, SMBus, PMBus, MDIO, UART, Low-Speed SDIO, GPIO, and Other Two-Signal Interfaces**
- **Automotive Head Units**
- **Automotive Instrument Clusters**
- **Automotive Driver Assistance Cameras**

3 DESCRIPTIONS

This dual bidirectional I^{2}C and SMBus voltage-level translator, with an enable (EN) input, is operational from 1.0V to 5.5V V$_{REF1}$ and 1.8V to 5.5V V$_{REF2}$.

The RS0302 allows bidirectional voltage translations between 1.0V and 5V without the use of a direction pin. The low ON-state resistance (R$_{ON}$) of the switch allows connections to be made with minimal propagation delay. When EN is HIGH, the translator switch is ON, and the SCL1 and SDA1 I/O are connected to the SCL2 and SDA2 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.

In I^{2}C applications, the bus capacitance limit of 400 pF restricts the number of devices and bus length. Using the RS0302 enables the system designer to isolate two halves of a bus; thus, more I^{2}C devices or longer trace length can be accommodated.

The RS0302 also can be used to run two buses, one at 400kHz operating frequency and the other at 100kHz operating frequency. If the two buses are operating at different frequencies, the 100kHz bus must be isolated when the 400kHz operation of the other bus is required. If the master is running at 400kHz, the maximum system operating frequency may be less than 400kHz because of the delays added by the repeater.

The RS0302 are available in green SOT23-8, DFN1.4x1.0-8L and VSSOP-8 packages. It operates over an ambient temperature range of -40°C to +85°C.

Device Information [1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
RS0302	SOT23-8	1.60mm×2.92mm
	DFN1.4x1.0-8L	1.00mm×1.40mm
	VSSOP-8	2.00mm×2.30mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

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4 Revision History

Note: Page numbers for previous revisions may different from page numbers in the current version.

VERSION	Change Date	Change Item
A.0	2021/01/20	initial version completed
A.1	2021/09/15	Added DFN1.4x1.0-8L package
A.2	2022/01/13	Update the Minimum operating voltage of V_{REF1}
A.3	2023/07/13	Added VSSOP-8 package

5 PACKAGE/ORDERING INFORMATION [(1)]

PRODUCT	ORDERING NUMBER	TEMPERATURE RANGE	PACKAGE LEAD	PACKAGE MARKING [(2)]	MSL [(3)]	PACKAGE OPTION
RS0302	RS0302YH8	-40°C ~+85°C	SOT23-8	0302	MSL3	Tape and Reel,3000
	RS0302YUTDS8	-40°C ~+85°C	DFN1.4x1.0-8L	0302	MSL3	Tape and Reel,5000
	RS0302YVS8	-40°C ~+85°C	VSSOP-8	0302	MSL3	Tape and Reel,3000

NOTE:

(1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.

(2) There may be additional marking, which relates to the lot trace code information(data code and vendor code)，the logo or the environmental category on the device.

(3)   MSL, The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications.
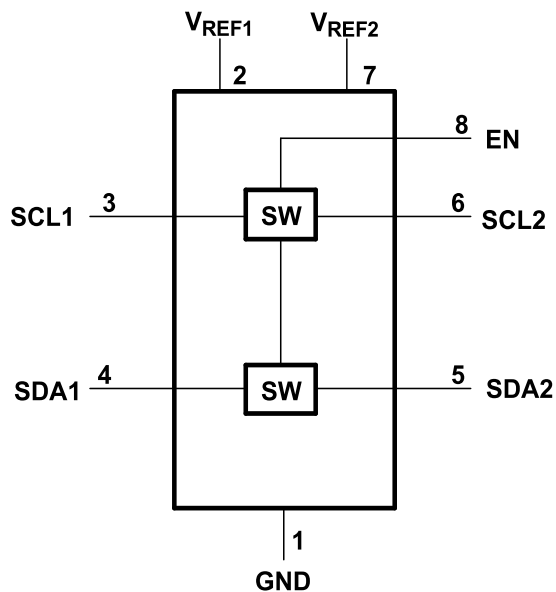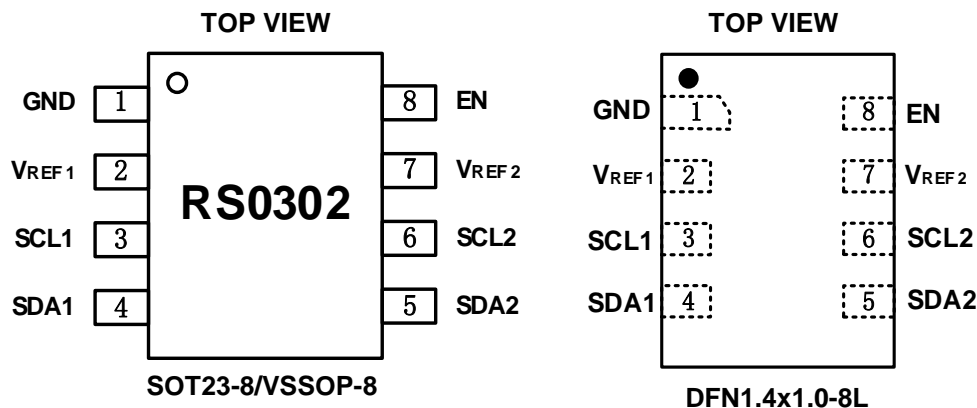
6 Functional Block Diagram

Figure 1. Function Block Diagram

Function table

INPUT EN [1]	FUNCTION
H	Logic Lows are propagated from one side to the other, Logic Highs blocked (independent pull up resistors passively drive the line high)
L	Disconnect

(1) The SCL switch conducts if EN is $\geq$ 0.6 V higher than SCL1 or SCL2. The same is true of SDA.

7 PIN CONFIGURATIONS AND FUNCTIONS

TOP VIEW

GND 1 — RS0302 — 8 EN
V_{REF1} 2 — 7 V_{REF2}
SCL1 3 — 6 SCL2
SDA1 4 — 5 SDA2

SOT23-8/VSSOP-8

TOP VIEW

GND 1 — 8 EN
V_{REF1} 2 — 7 V_{REF2}
SCL1 3 — 6 SCL2
SDA1 4 — 5 SDA2

DFN1.4x1.0-8L

PIN DESCRIPTION

PIN SOT23-8/DFN1.4x1.0-8L /VSSOP-8	NAME	TYPE (1)	FUNCTION
1	GND	–	Ground
2	V_{REF1}	I	Low-voltage-side reference supply voltage for SCL1 and SDA1
3	SCL1	I/O	Serial clock, low-voltage side
4	SDA1	I/O	Serial data, low-voltage side
5	SDA2	I/O	Serial data, high-voltage side
6	SCL2	I/O	Serial clock, high-voltage side
7	V_{REF2}	I	High-voltage-side reference supply voltage for SCL2 and SDA2
8	EN	I	Switch enable input

(1) I=input, O=output, I/O=input and output

8 SPECIFICATIONS

8.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted) [1]

SYMBOL	PARAMETER		MIN	MAX	UNIT
V_{REF1}	DC reference voltage		-0.5	7	V
V_{REF2}	DC reference voltage		-0.5	7	V
V_I [2]	Input Voltage		-0.5	7	V
$V_{I/O}$ [2]	Input/output		-0.5	7	V
I_{ch}	Continuous Channel current			128	mA
I_{IK}	Input clamp current	$V_I < 0$		-50	mA
$T_{j(max)}$	Maximum junction temperature			125	°C
T_{stg}	Storage temperature		-65	+150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) The input and output negative-voltage ratings may be exceeded if the input and output current ratings are observed.

8.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM)	±7000	V
		Machine model (MM)	±400	

ESD SENSITIVITY CAUTION

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.3 Recommended Operating Conditions

		MIN	TYP	MAX	UNIT
Input/output voltage ($V_{I/O}$)	SCL1, SDA1, SCL2, SDA2	0		5.5	V
Reference voltage (V_{REF1}) [1]		0		5.5	V
Reference voltage (V_{REF2}) [1]		0		5.5	V
Enable input voltage (EN)		0		5.5	V
Pass switch current (I_{PASS})				64	mA
Operating ambient temperature (T_A)		-40		85	°C

(1) To support translation, V_{REF1} supports 1.0 V to V_{REF2} - 0.6 V. V_{REF2} must be between V_{REF1} + 0.6 V to 5.5 V. See Typical Application for more information.

8.4 Electrical Characteristics

over recommended operating ambient temperature range (unless otherwise noted) [1]

PARAMETER		CONDITIONS		MIN	TYP	MAX	UNIT
V_{IK}	Input clamp voltage	I_I=-18mA	EN=0V			-1.2	V
I_I	Input leakage current	V_I=5V	EN=0V			5	μA
$C_{i(EN)}$	Input capacitance	V_I=3V or 0V			10		pF
$C_{i(off)}$	Off capacitance	SCLn, SDAn	V_o=3V or 0V, EN=0V		4	6	pF
$C_{i(on)}$	On capacitance	SCLn, SDAn	V_o=3V or 0V, EN=3V		10.3	12.5	pF
R_{ON} [2]	ON-state resistance	SCLn, SDAn	V_I=0V, I_O=64mA, EN=4.5V		1.8		Ω
			V_I=0V, I_O=64mA, EN=3V		2.3		
			V_I=0V, I_O=64mA, EN=2.3V		2.9		
			V_I=0V, I_O=15mA, EN=1.5V		3.9		
			V_I=2.4V [3], I_O=15mA, EN=4.5V		4		
			V_I=2.4V [3], I_O=15mA, EN=3V		56		
			V_I=1.7V [3], I_O=15mA, EN=2.3V		49		

(1) All typical values are at T_A = 25°C.
(2) Measured by the voltage drop between the SCL1 and SCL2, or SDA1 and SDA2 terminals, at the indicated current through the switch. ON-state resistance is determined by the lowest voltage of the two terminals.
(3) Measured in current sink configuration only

8.5 Switching Characteristics AC Performance: Translating Down [1], EN=3.3V

over recommended operating ambient temperature range, EN = 3.3 V, V_{IH} = 3.3 V, V_{IL} = 0, V_M = 1.15 V (unless otherwise noted)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	C_L=50pF		C_L=30pF		C_L=15pF		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t_{PLH}	SCL2 or SDA2	SCL1 or SDA1	0	0.8	0	0.6	0	0.4	ns
t_{PHL}			0	0.6	0	0.6	0	0.5	ns

(1) Translating down: the high-voltage side driving toward the low-voltage side

8.6 Switching Characteristics AC Performance: Translating Down [1], EN=2.5V

over recommended operating free-air temperature range, EN = 2.5 V, V_{IH} = 3.3 V, V_{IL} = 0, V_M = 0.75 V (unless otherwise noted)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	C_L=50pF		C_L=30pF		C_L=15pF		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t_{PLH}	SCL2 or SDA2	SCL1 or SDA1	0	1.0	0	0.7	0	0.6	ns
t_{PHL}			0	0.6	0	0.6	0	0.8	ns

(1) Translating down: the high-voltage side driving toward the low-voltage side

8.7 Switching Characteristics AC Performance: Translating Up [1], EN=3.3V

over recommended operating free-air temperature range, EN = 3.3 V, V_{IH} = 2.3 V, V_{IL} = 0, V_T = 3.3V, V_M = 1.15V, R_L=300Ω (unless otherwise noted)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	C_L=50pF		C_L=30pF		C_L=15pF		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t_{PLH}	SCL1 or SDA1	SCL2 or SDA2	0	0.8	0	0.6	0	0.5	ns
t_{PHL}			0	1.2	0	1.1	0	1.0	ns

(1) Translating up: the low-voltage side driving toward the high-voltage side

8.8 Switching Characteristics AC Performance: Translating Up [1], EN=2.5V

over recommended operating free-air temperature range, EN = 2.5 V, V_{IH} = 2.3 V, V_{IL} = 0, V_T = 3.3V, V_M = 0.75V, R_L=300Ω (unless otherwise noted)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	C_L=50pF		C_L=30pF		C_L=15pF		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t_{PLH}	SCL1 or SDA1	SCL2 or SDA2	0	0.8	0	0.6	0	0.4	ns
t_{PHL}			0	1.2	0	1.2	0	1.0	ns

(1) Translating up: the low-voltage side driving toward the high-voltage side

8.9 Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

V_{EN}=1.5V I_I=15mA
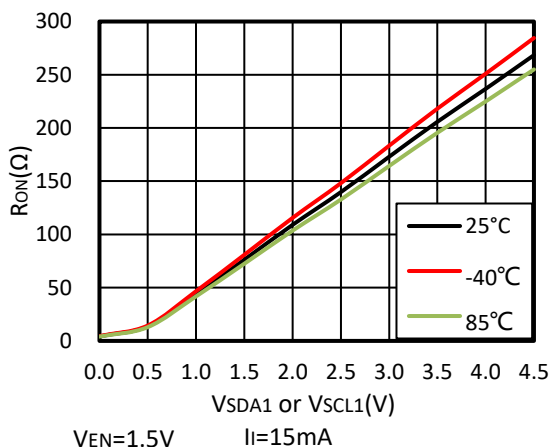
Figure 1. On-Resistance (R_{ON}) vs Input Voltage (V_{SDA1} or V_{SCL1})

V_{EN}=4.5V I_I=15mA
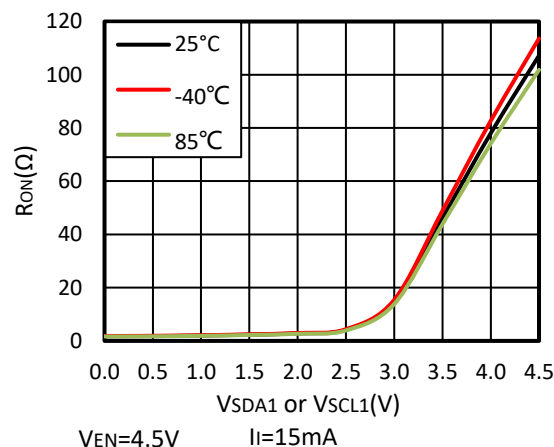
Figure 2. On-Resistance (R_{ON}) vs Input Voltage (V_{SDA1} or V_{SCL1})

9 Parameter Measurement Information

a) Current Source Configuration

b) Current Sink Configuration
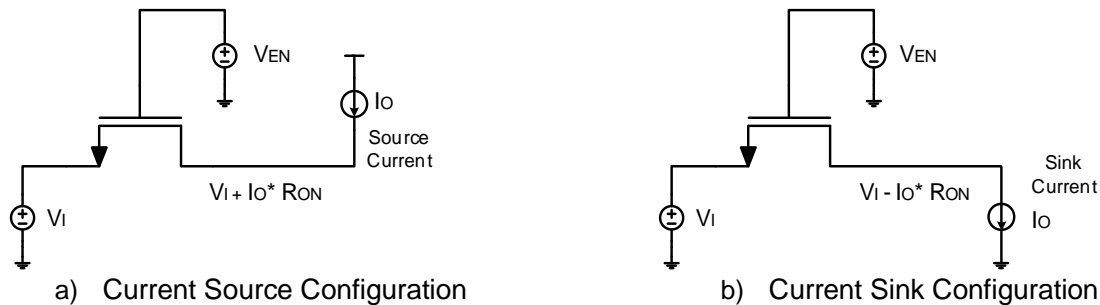
Figure 3. Current Source and Current Sink Configurations for R_{ON} Measurements

USAGE	SWITCH
Translating up	S1
Translating down	S2
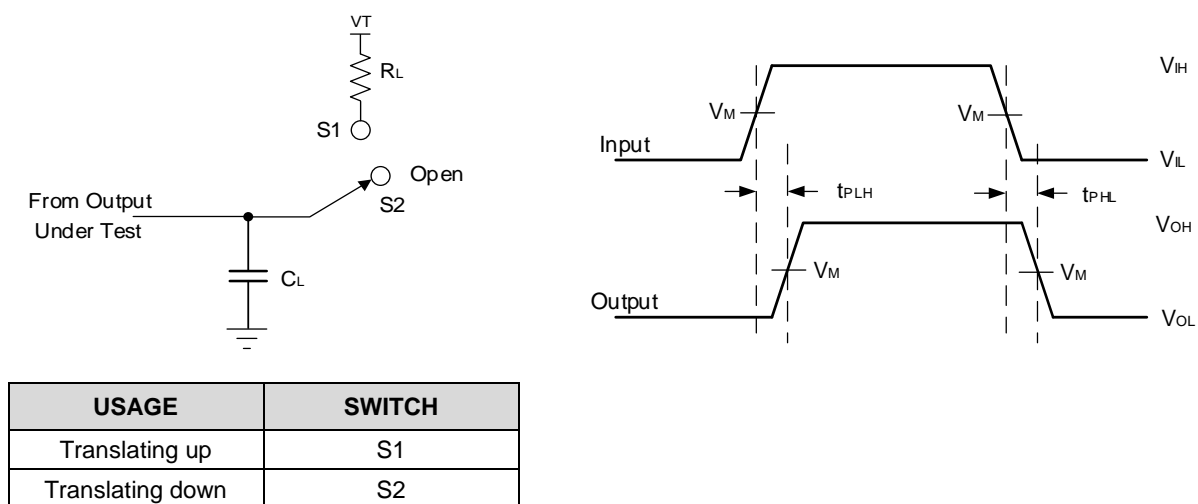
NOTES: A. CL includes probe and jig capacitance
      B. All input pulses are supplied by generators having the following characteristics: PRR≤10 MHz, Z_O = 50 Ω, tr≤ 2 ns, t_f≤2 ns.
      C. The outputs are measured one at a time, with one transition per measurement.

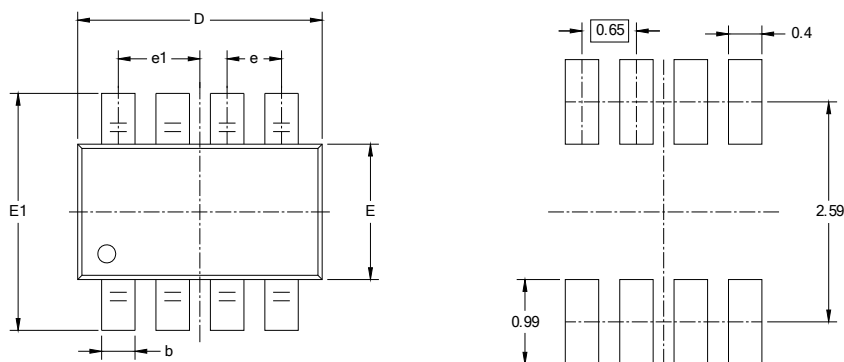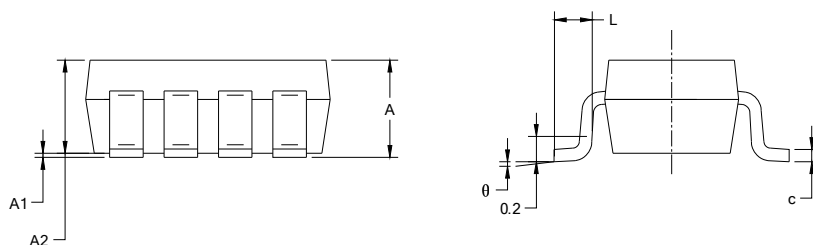**Figure 4. Load Circuit for Outputs**

10 Typical Application
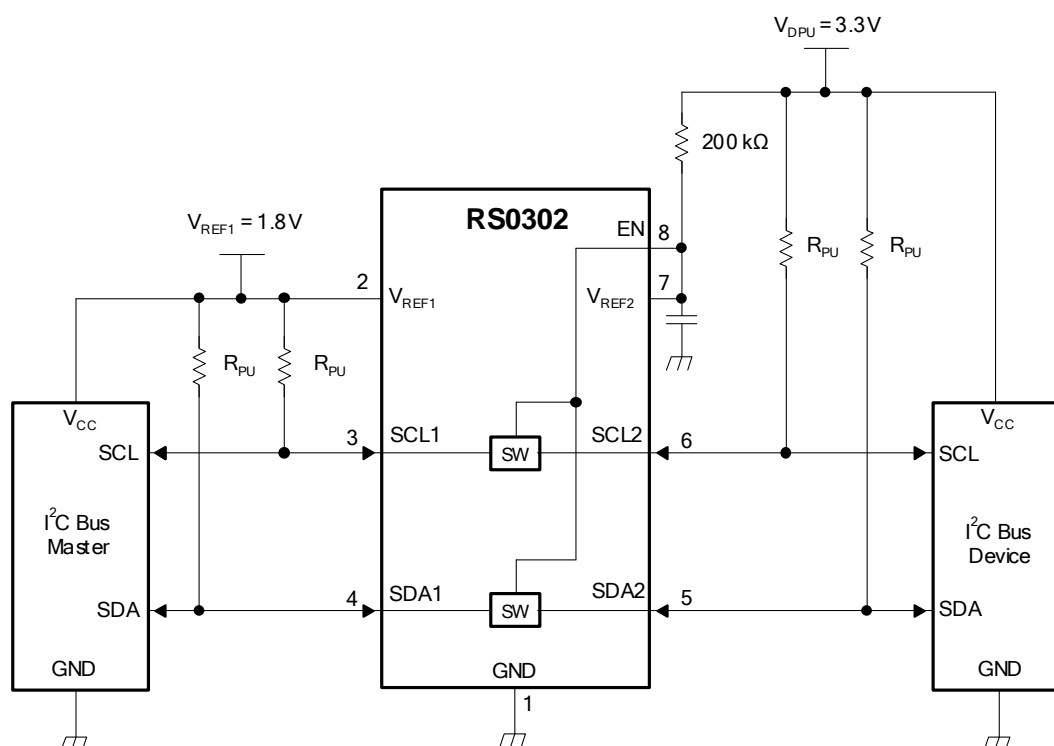
Figure 5. Typical Application Circuit (Switch Always Enabled)

11 PACKAGE OUTLINE DIMENSIONS
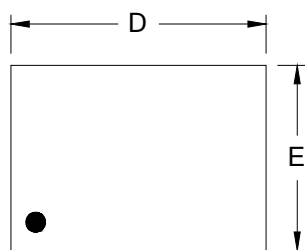## SOT23-8 [3]

RECOMMENDED LAND PATTERN (Unit: mm)

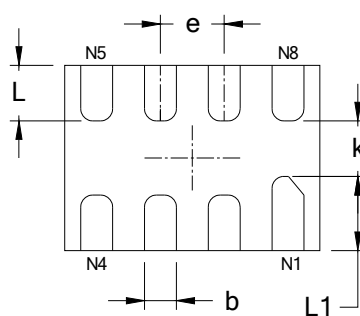| Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A [1]	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D [1]	2.820	3.020	0.111	0.119
E [1]	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.650(BSC) [2]		0.026(BSC) [2]	
e1	0.975(BSC) [2]		0.038(BSC) [2]	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

NOTE:
   1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
   2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
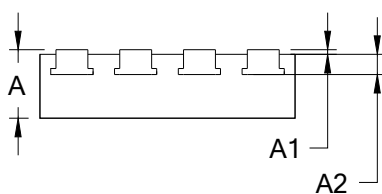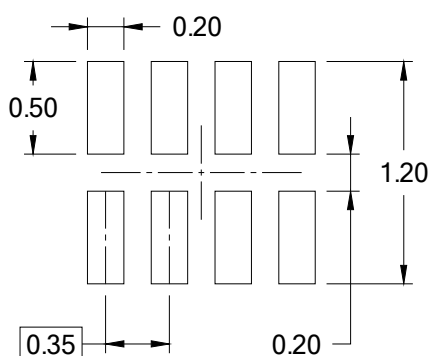   3. This drawing is subject to change without notice.

DFN1.4x1.0-8L [3]

D

E

TOP VIEW

e

N5　　　N8

L

k

N4　　　N1

b

L1

BOTTOM VIEW

A

A1

A2

SIDE VIEW

0.20

0.50

1.20

0.35

0.20

RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A [1]	0.340	0.400	0.013	0.016
A1	0.000	0.050	0.000	0.002
A2	0.110 REF [2]		0.004 REF [2]	
D [1]	1.350	1.450	0.053	0.057
E [1]	0.950	1.050	0.037	0.041
k	0.200 MIN		0.008 MIN	
b	0.150	0.200	0.006	0.008
e	0.350 TYP		0.014 TYP	
L	0.250	0.350	0.010	0.014
L1	0.350	0.450	0.014	0.018

NOTE:
1. Plastic or metal protrusions of 0.075mm maximum per side are not included.
2. REF is the abbreviation for Reference.
3. This drawing is subject to change without notice.

VSSOP-8 [3]
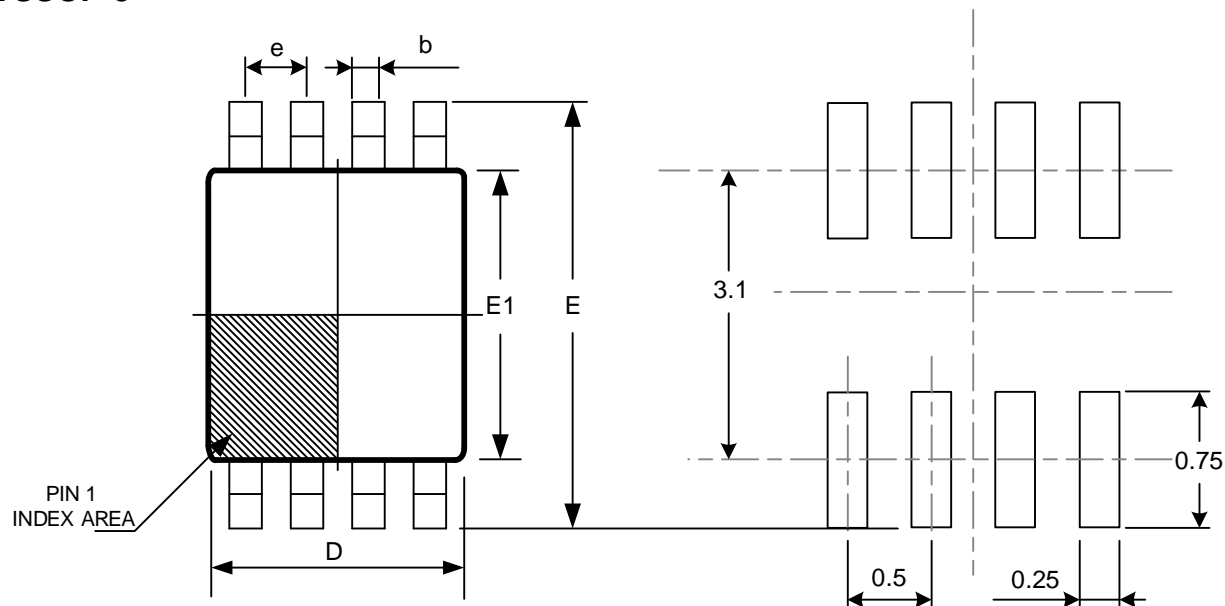
RECOMMENDED LAND PATTERN (Unit: mm)
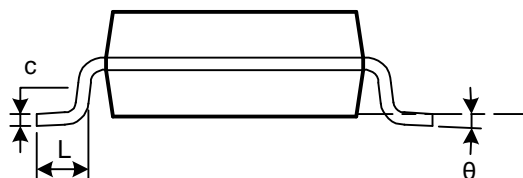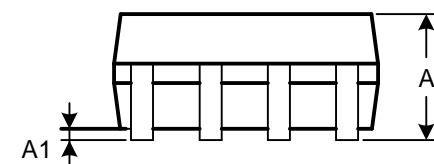
| Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A [1]	0.600	0.900	0.024	0.085
A1	0.000	0.100	0.000	0.004
b	0.170	0.250	0.007	0.010
c	0.100	0.200	0.004	0.008
D [1]	1.900	2.100	0.075	0.083
e	0.500 (BSC) [2]		0.020 (BSC) [2]	
E	3.000	3.200	0.118	0.126
E1 [1]	2.200	2.400	0.087	0.095
L	0.200	0.350	0.008	0.014
θ	0°	6°	0°	6°

NOTE:
   1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
   2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
   3. This drawing is subject to change without notice.

12 TAPE AND REEL INFORMATION

REEL DIMENSIONS   TAPE DIMENSION
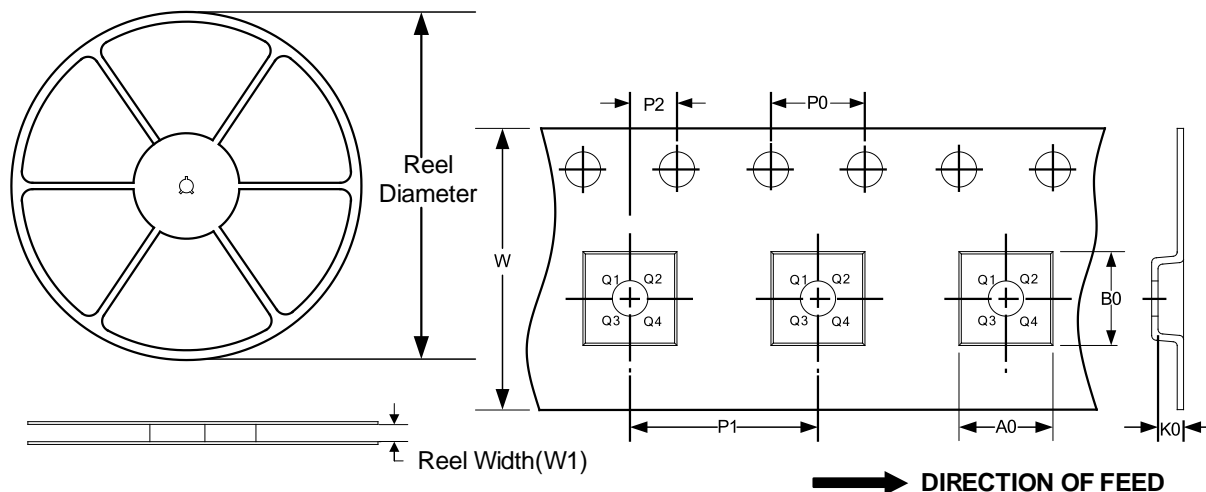
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT23-8	7"	9.5	3.17	3.23	1.37	4.0	4.0	2.0	8.0	Q3
DFN1.4x1.0-8L	7"	9.5	1.2	1.6	0.5	4.0	4.0	2.0	8.0	Q1
VSSOP-8	7"	9.5	2.25	3.35	1.40	4.0	4.0	2.0	8.0	Q3

NOTE:
1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

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