Dual Bidirectional I²C-Bus and SMBus Voltage-Level Translator

1 FEATURES

- **Qualified for Automotive Applications**
- **AEC-Q100 Qualified with the Grade 1**
- **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 I²C Applications**
- **Compatible with I²C and SMBus**
- **Less Than 1.5ns Maximum Propagation Delay to Accommodate Standard-Mode and Fast-Mode I²C 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 I²C 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 I²C I/O Ports to Support Mixed-Mode Signal Operation**
- **Extended Temperature: -40°C to 125°C**

2 APPLICATIONS

- **Automotive Infotainment**
- **Automotive Cluster**
- **Automotive ADAS**
- **Automotive Body Electronics**

3 DESCRIPTIONS

This dual bidirectional I²C 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-Q1 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 I²C applications, the bus capacitance limit of 400 pF restricts the number of devices and bus length. Using the RS0302-Q1 enables the system designer to isolate two halves of a bus; thus, more I²C devices or longer trace length can be accommodated.

The RS0302-Q1 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-Q1 are available in green VSSOP8 packages. It operates over an ambient temperature range of -40°C to 125°C.

Device Information [1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
RS0302-Q1	VSSOP8	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	2024/04/19	Preliminary version completed
A.1	2024/10/09	Initial version completed

5 PACKAGE/ORDERING INFORMATION [1]

PRODUCT	ORDERING NUMBER	TEMPERATURE RANGE	PACKAGE LEAD	Lead finish/Ball material [2]	MSL Peak Temp [3]	PACKAGE MARKING [4]	PACKAGE OPTION
RS0302-Q1	RS0302XVS8-Q1	-40°C ~125°C	VSSOP8	NIPDAUAG	MSL1-260°-Unlimited	0302	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) Lead finish/Ball material. Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.
(3) RUNIC classify the MSL level with using the common preconditioning setting in our assembly factory conforming to the JEDEC industrial standard J-STD-20F, Please align with RUNIC if your end application is quite critical to the preconditioning setting or if you have special requirement.
(4) 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.

6 FUNCTIONAL BLOCK DIAGRAM
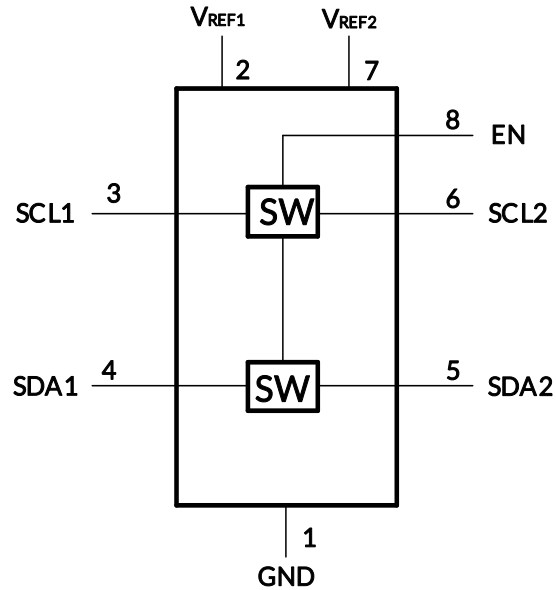
Figure 1. Function Block Diagram

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 ≥ 0.6 V higher than SCL1 or SCL2. The same is true of SDA.

7 PIN CONFIGURATIONS AND FUNCTIONS

TOP VIEW

GND [1 ... 8] EN
V_{REF1} [2 ... 7] V_{REF2}
SCL1 [3   RS0302-Q1   6] SCL2
SDA1 [4 ... 5] SDA2
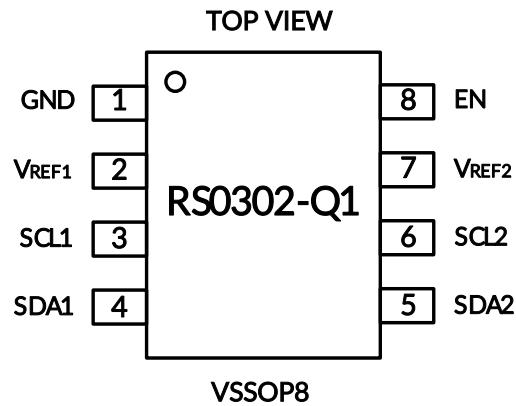
VSSOP8

PIN DESCRIPTION

PIN VSSOP8	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
θ_{JA}	Package thermal impedance [3]	VSSOP8		199	°C/W
$T_{j(max)}$	Maximum junction temperature [4]			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.

(3) The package thermal impedance is calculated in accordance with JESD-51.

(4) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$. All numbers apply for packages soldered directly onto a PCB.

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), per AEC Q100-002 [1]	±2000	V
		Charged-Device Model (CDM), per AEC Q100-011	±1000	V
		Latch-Up (LU), per AEC Q100-004	±200	mA

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

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		125	°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	5	Ω
				EN=3V		2.3	6	
				EN=2.3V		2.9	7	
			V_I=0V, I_O=15mA	EN=1.5V		3.9	12	
			V_I=2.4V[3], I_O=15mA	EN=4.5V		4	15	
				EN=3V		56	100	
			V_I=1.7V[3], I_O=15mA	EN=2.3V		49	80	

(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.
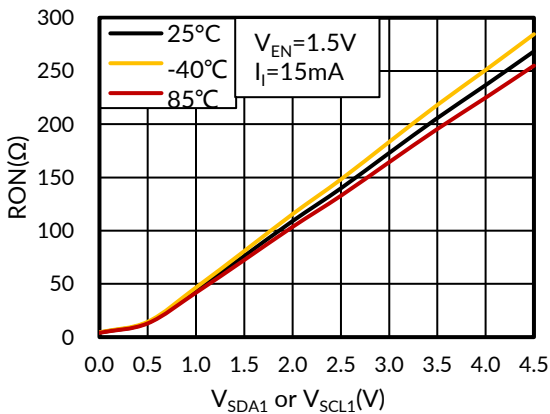
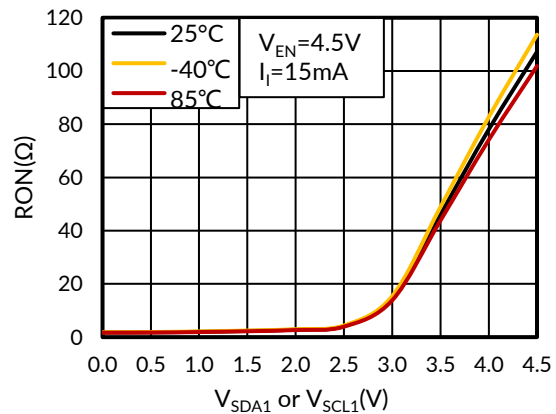**Figure 1. On-Resistance (R_{ON}) vs Input Voltage (V_{SDA1} or V_{SCL1})**

Figure 2. On-Resistance (R_{ON}) vs Input Voltage (V_{SDA1} or V_{SCL1})
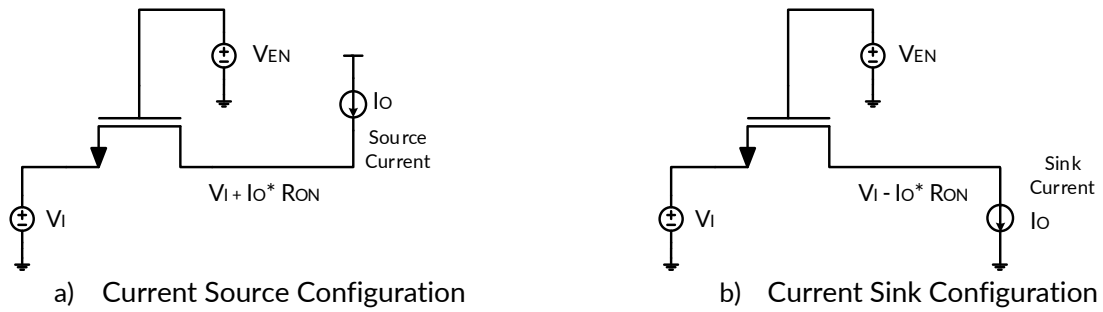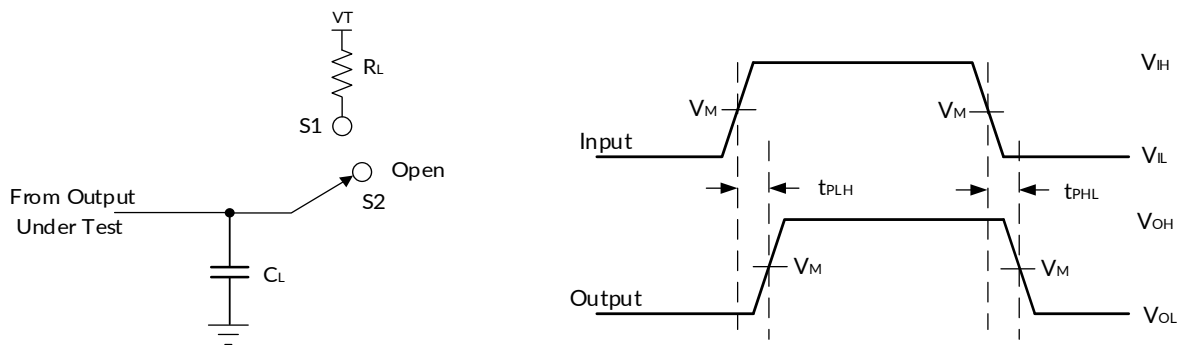
9 PARAMETER MEASUREMENT INFORMATION

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.

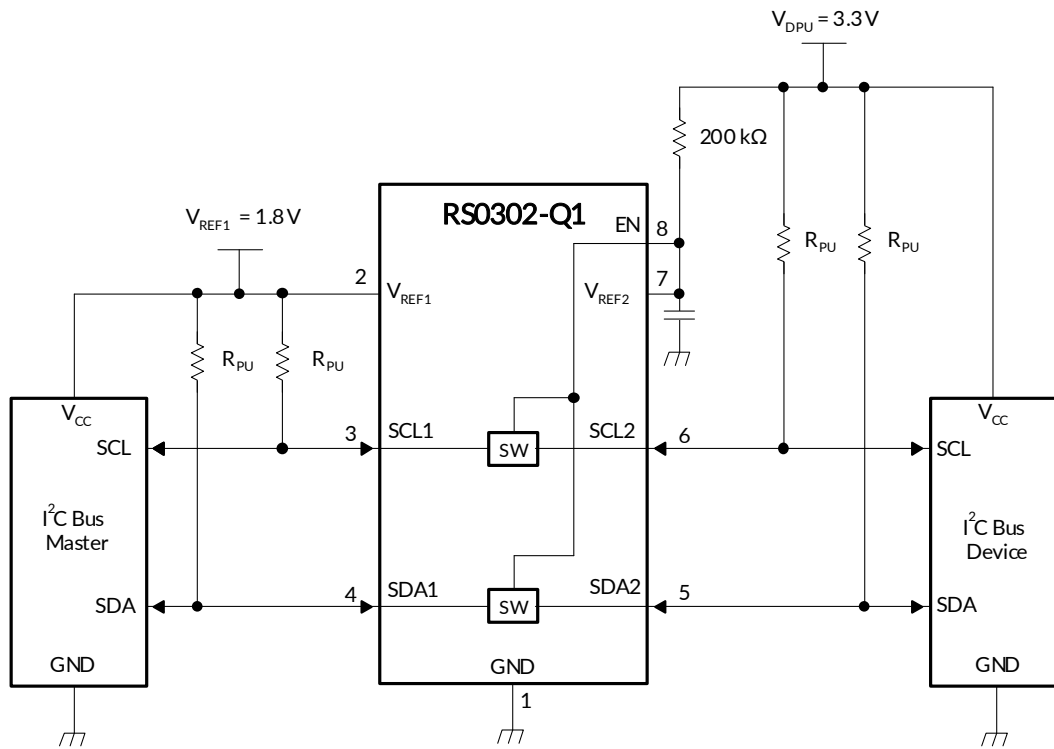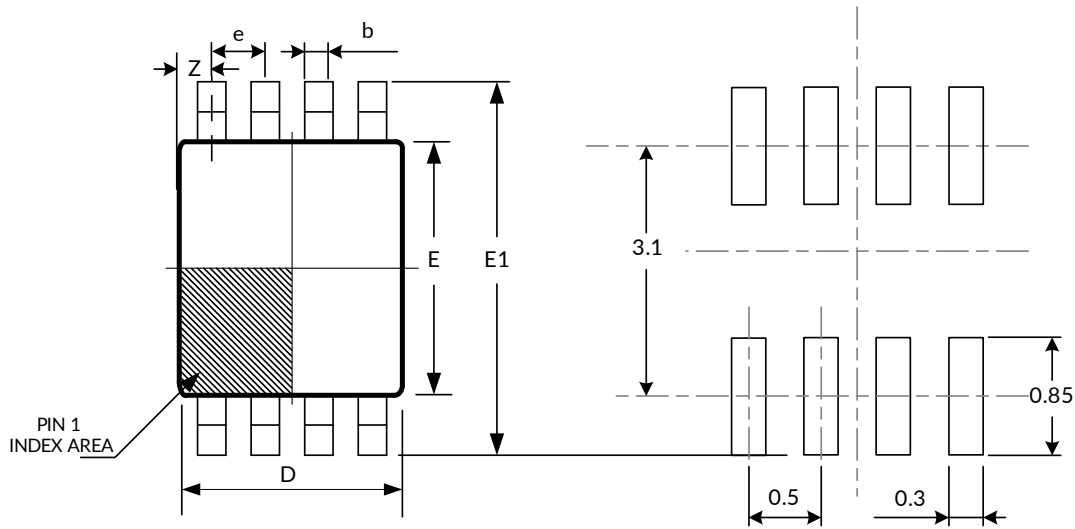**Figure 4. Load Circuit for Outputs**
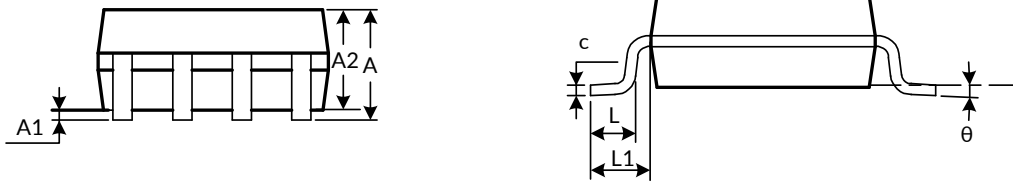
10 TYPICAL APPLICATION

Figure 5. Typical Application Circuit (Switch Always Enabled)

11 PACKAGE OUTLINE DIMENSIONS
VSSOP8 [(3)]

RECOMMENDED LAND PATTERN (Unit: mm)

| Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A [(1)]		1.000		0.039
A1	0.000	0.150	0.000	0.006
A2	0.600	0.850	0.023	0.034
b	0.170	0.270	0.007	0.010
c	0.080	0.230	0.003	0.009
D [(1)]	1.900	2.100	0.075	0.083
e	0.500 (BSC) [(2)]		0.020 (BSC) [(2)]	
E [(1)]	2.200	2.400	0.087	0.095
E1	3.000	3.200	0.118	0.126
L	0.150	0.400	0.006	0.016
L1	0.400 (BSC) [(2)]		0.016 (BSC) [(2)]	
Z	0.100	0.400	0.004	0.016
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.

12 TAPE AND REEL INFORMATION

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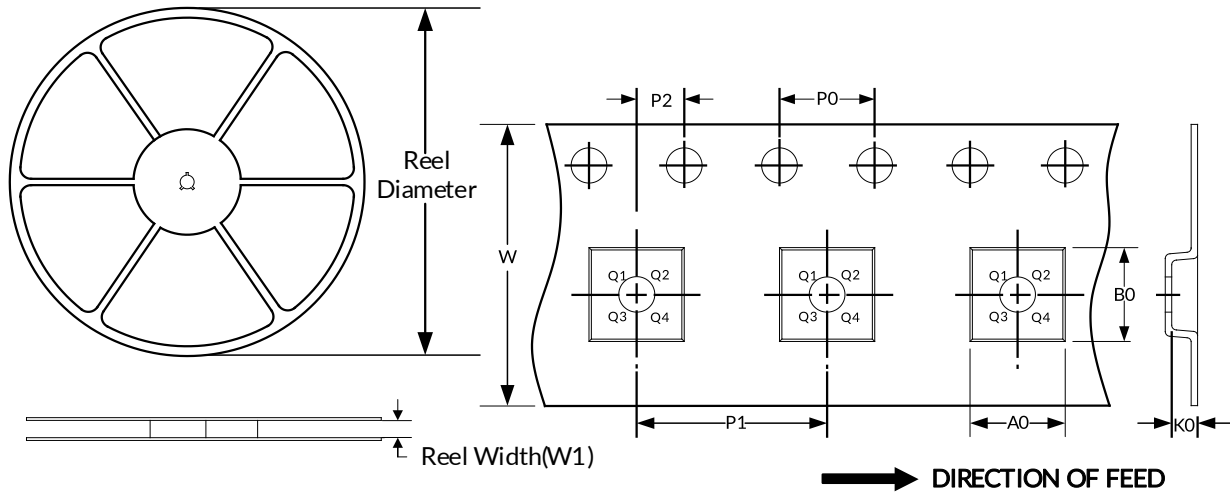
NOTE: The picture is only for reference. Please make the object as the standard.

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
VSSOP8	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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