300mA 40V Low-Dropout Voltage-Tracking LDO With 4mV Tracking Tolerance

1 FEATURES

- **RS3011-Q1 AEC-Q100 Qualification is Ongoing**
- **-40 to 45V Wide Input-Voltage Range (Maximum)**
- **Output Voltage Adjusts Down to: 1.5 to 40V**
- **300mA Output Current Capability**
- **Very-Low Output Tracking Tolerance, ±4 mV**
- **280mV Low Dropout Voltage when I_{OUT} = 200mA**
- **Low Quiescent Current (I_Q):**
  - **<8 µA when EN=LOW**
  - **80 µA (Typical) at Light Loads**
- **Reverse Polarity Protection**
- **Current-Limit and Thermal-Shutdown Protection**
- **Output Short-Circuit Proof to Ground and Supply**
- **Inductive Clamp at OUT Pin**
- **Available in ESOP8 Packages**

2 APPLICATIONS

- **Off-Board Sensor Supply**
- **High-Precision Voltage Tracking**
- **Power Switch for Off-Board Load**

3 DESCRIPTIONS

For automotive off-board sensors and small current off-board modules, the power supply is through a long cable from the main board. In such cases, protection is required in the power devices for the off-board loads to prevent the onboard components from damage during a short to GND or short to battery caused by a broken cable. Off-board sensors require consistent power supply as onboard components to secure high accuracy of data acquisition.

The RS3011-Q1 device is designed for automotive applications with a 45V load dump. The device can either be used as one tracking low-dropout (LDO) regulator or voltage tracker to build one closed power loop for off-board sensors with an onboard main supply. The output of the device is accurately regulated by a reference voltage at the ADJ pin.

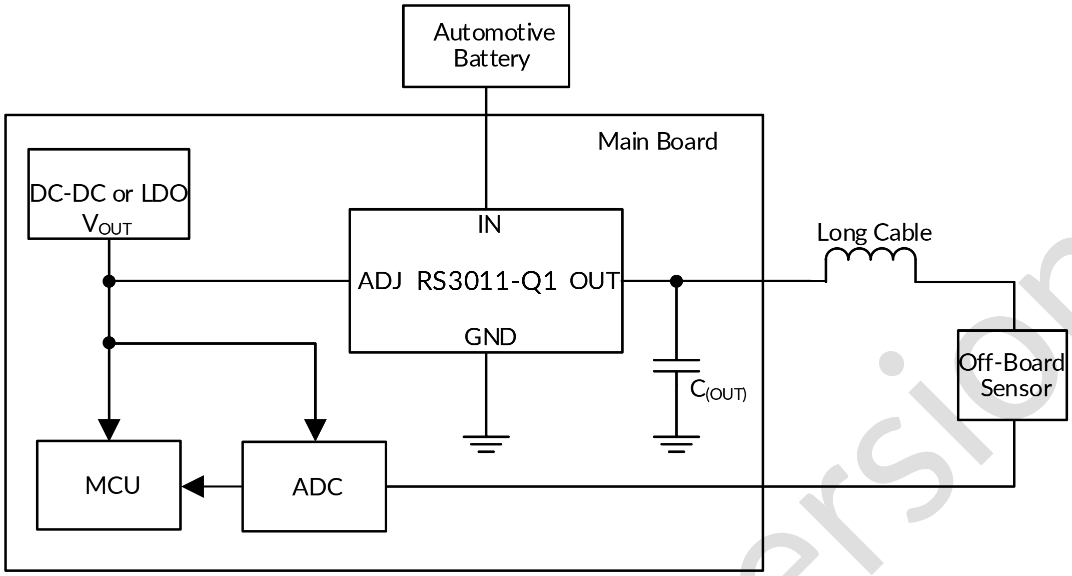
To provide an accurate power supply to the off-board modules, the device offers a 4mV ultralow tracking tolerance between the ADJ and FB pins across temperature. The back-to-back PMOS topology eliminates the need for an external diode under reverse polarity condition. The RS3011-Q1 device also includes thermal shutdown, inductive clamp, overload, and short-to-battery protection to prevent damage to onboard components during extreme conditions.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
RS3011-Q1	ESOP8	4.90mm×3.90mm

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

4 TYPICAL APPLICATION SCHEMATIC



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5 REVISION HISTORY

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

VERSION	Change Date	Change Item
A.0	2025/04/30	Preliminary version completed

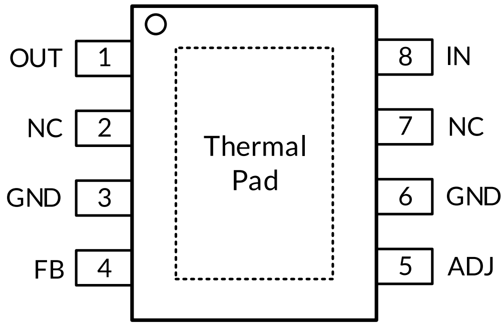
6 PACKAGE/ORDERING INFORMATION [1]

PRODUCT	ORDERING NUMBER	TEMPERATURE RANGE	PACKAGE LEAD	Lead finish/Ball material [2]	MSL Peak Temp [3]	PACKAGE MARKING [4]	PACKAGE OPTION
RS3011-Q1	RS3011AXEK-Q1	-40°C ~125°C	ESOP8	SN	TBD	RS3011A	Tape and Reel, 4000
	RS3011BXEK-Q1	-40°C ~125°C	ESOP8	SN	TBD	RS3011B	Tape and Reel, 4000

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.

7 PIN CONFIGURATION AND FUNCTIONS

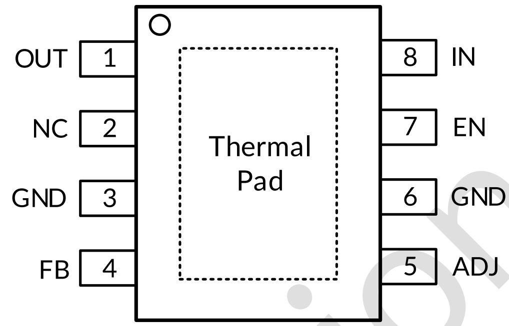
RS3011A-Q1



ESOP8

NC — No internal connection

RS3011B-Q1



ESOP8

NC — No internal connection

PIN FUNCTIONS

PIN		NAME	I/O TYPE (1)	DESCRIPTION
ESOP8				
RS3011A-Q1	RS3011B-Q1			
1	1	OUT	O	LDO output
2, 7	2	NC	-	No internal connection
3, 6	3, 6	GND	G	Ground reference
4	4	FB	I	This pin is the feedback pin which can connect to the external resistor divider to select the output voltage.
5	5	ADJ	I	Connect the reference to this pin. A low signal disables the device and a high signal enables the device. The reference voltage can be connected directly or by a voltage divider for lower output voltages. To compensate for line influences, connect a capacitor close to the device pins.
-	7	EN	I	This pin is the enable pin. The device goes to the STANDBY state when the enable pin goes lower than the threshold value.
8	8	IN	I	This pin is the device supply. To compensate for line influences, connect a capacitor close to the device pins.
-	-	Thermal Pad	-	Connect the thermal pad to the GND pin or leave it floating.

(1) I = Input, O = Output, G = Ground.

8 SPECIFICATIONS

8.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)

		MIN	MAX	UNIT
IN Voltage	IN (2) (3)	-40	45	V
Input Voltage (EN Pin)	EN (2) (3)	-40	45	V
Output Voltage	OUT (2) (4)	-1	45	V
Voltage difference between the input and output	IN-OUT	-40	45	V
Reference voltage	ADJ (2) (3)	-0.3	45	V
Feedback input voltage for the tracker	FB (2) (3)	-1	45	V
Reference voltage minus the input voltage	ADJ – IN (5)		18	V
Package thermal impedance (6), θ_{JA}	ESOP8		64	°C/W
Operating Junction Temperature (7)			150	°C
Storage Temperature Range		-65	150	°C
Lead Temperature (Soldering, 10 sec)			260	°C

(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.
(2) All voltage values are with respect to the GND pin.
(3) Absolute maximum voltage.
(4) An internal diode is connected between the OUT and GND pins with 600mA DC current capability for inductive clamp protection.
(5) When the (ADJ – IN) voltage is higher than 18 V, the (ADJ – OUT) voltage should maintain lower than 18 V, otherwise the device can be damaged.
(6) The package thermal impedance is calculated in accordance with JESD-51.
(7) 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	TBD	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

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

		MIN	MAX	UNIT
V_{IN}	Input Voltage Range on IN	4	40	V
V_{EN}	Input Voltage (EN Pin)	0	40	V
V_{OUT}	Output Voltage Range on OUT	1.5	40	V
V_{ADJ}	Adjust and enable input voltage	1.5	18	V
C_{OUT}	Output capacitor requirements	1	220	µF
T_J	Operating Junction Temperature Range	-40	150	°C

8.4 Electrical Characteristics

V_{IN} = 13.5 V, V_{EN} ≥ 2 V, T_J = −40°C to 150°C unless otherwise stated.

SYMBOL	PARAMETER	Test Conditions	MIN(3)	TYP(4)	MAX(3)	UNIT
$V_{I(UVLO)}$	IN Under Voltage Detection	V_{IN} rising			3.65	V
		V_{IN} falling	1.8		2.8	V
ΔV_O	Output Voltage Tracking Accuracy (1)	I_{OUT} = 100 µA to 300 mA, V_{IN} = 4 to 40 V, V_{ADJ} < V_{IN} − 1 V	-4		4	mV
$\Delta V_{O(\Delta IO)}$	Load Regulation Steady-State	I_{OUT} = 0.1 to 300 mA, V_{ADJ}= 5 V			4	mV
$\Delta V_{O(\Delta VI)}$	Line Regulation Steady-State	I_{OUT}= 10 mA, V_{IN} = 6 to 40 V, V_{ADJ} = 5 V			4	mV
PSRR	Power Supply Ripple Rejection	f_{rip} = 100 Hz, V_{rip} = 0.5 V_{PP}, $C_{(OUT)}$ = 10 µF, I_{OUT} = 100 mA		78		dB
$V_{(DROPOUT)}$	Dropout Voltage ($V_{(DROPOUT)}$ = V_{IN} − V_{OUT})	I_{OUT} = 200 mA, V_{IN} = V_{ADJ} ≥ 4 V (2)		280	500	mV
$I_{O(lim)}$	Output Current Limitation	V_{ADJ} = 5 V, OUT short to GND	301	470	500	mA
$I_{R(IN)}$	Reverse Current at IN	V_{IN} = 0 V, V_{OUT} = 40 V, V_{ADJ} = 5 V	-4		0	µA
$I_{R(-IN)}$	Reverse Current at Negative IN	V_{IN} = −40 V, V_{OUT} = 0 V, V_{ADJ} = 5 V	-12		0	µA
T_{SD}	Thermal Shutdown Temperature	T_J increases because of power dissipation generated by the IC		185		°C
T_{SD_hys}	Thermal Shutdown Hysteresis			15		°C
I_Q	Current Consumption	4 V ≤ V_{IN} ≤ 40 V, V_{ADJ} = 0 V; V_{EN} = 0 V		1	8	µA
		4 V ≤ V_{IN} ≤ 40 V, V_{EN} ≥ 2 V, V_{ADJ} < 0.8 V		8.5	20	µA
		4 V ≤ V_{IN} ≤ 40 V, I_{OUT} < 100 µA, V_{ADJ} = 5 V		80	110	µA
		4 V ≤ V_{IN} ≤ 40 V, I_{OUT} < 300 mA, V_{ADJ} = 5V		800	900	µA
$I_{Q(DROPOUT)}$	Current Consumption in Dropout Region	V_{IN} = V_{ADJ} = 5 V, I_{OUT} = 100 µA		80	100	µA
$I_{I(ADJ)}$	Adjust Input Current	V_{ADJ} = V_{FB} = 5 V, RS3011A-Q1			10	µA
		V_{ADJ} = V_{FB} = 5 V, RS3011B-Q1			200	nA
$V_{(ADJ\_LOW)}$	Adjust Low Signal Valid	V_{OUT} = 0 V	0		1.1	V
$V_{(ADJ\_HIGH)}$	Adjust High Signal Valid	|V_{OUT} − V_{ADJ}| < 5 mV	1.25		18	V
$V_{(EN\_LOW)}$	Enable Low Signal Valid	V_{OUT} = 0 V	0		0.7	V
$V_{(EN\_HIGH)}$	Enable High Signal Valid	OUT settled	2		40	V
I_{EN}	Enable Pulldown Current	2V < V_{EN} < 40 V			10	µA
I_{FB}	FB Bias Current	V_{ADJ} = V_{FB} = 5 V			0.5	µA

(1) The tracking accuracy is specified when the FB pin is directly connected to the OUT pin which means V_{ADJ} = V_{OUT}, external resistor divider variance is not included.
(2) Measured when the output voltage, V_{OUT} has dropped 10 mV from the nominal value.
(3) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.
(4) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.

8.5 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_{IN} = 14 V, V_{ADJ} = 5 V, V_{FB} = V_{OUT}, unless otherwise specified.

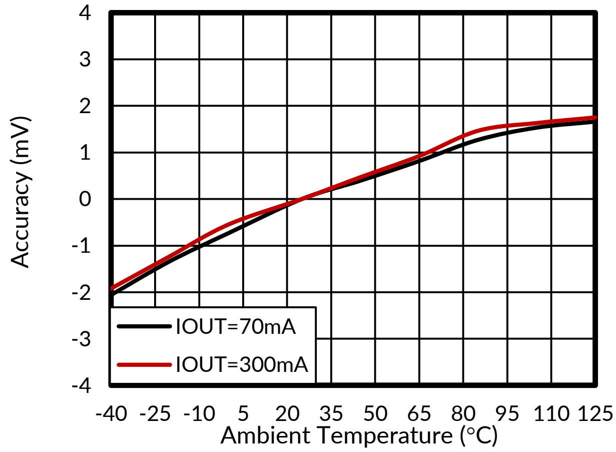


Figure 1. Tracking Accuracy vs Ambient Temperature

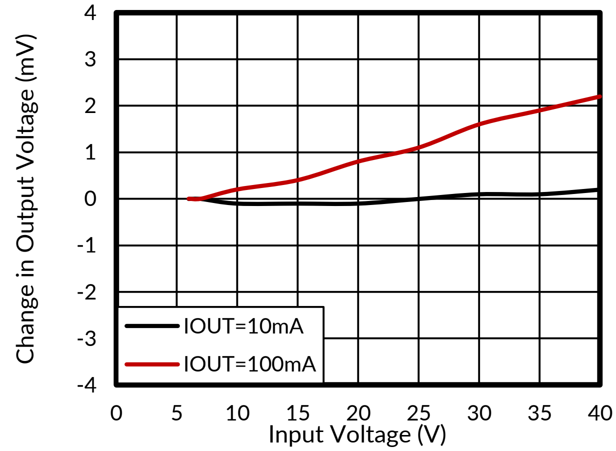


Figure 2. Line Regulation

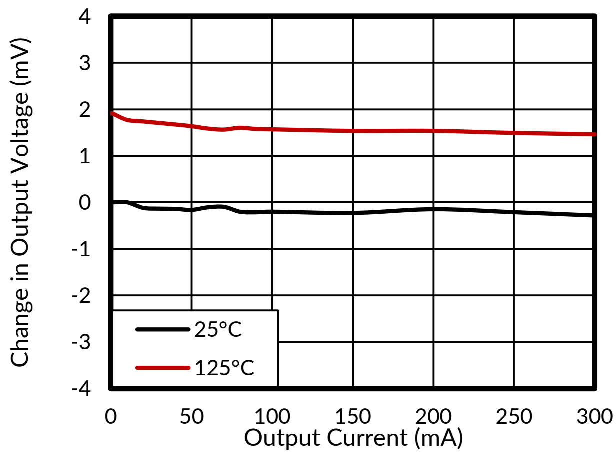


Figure 3. Load Regulation

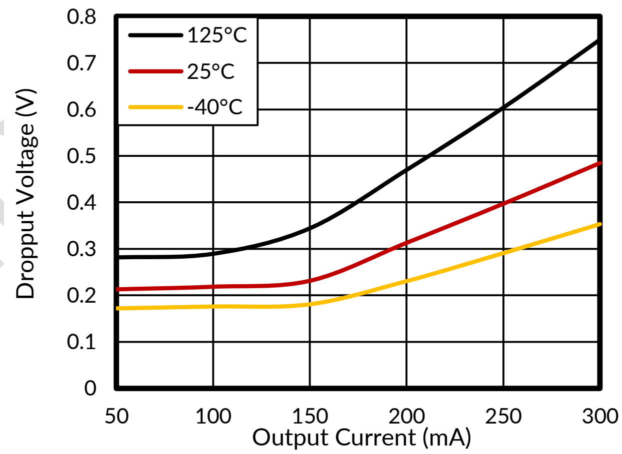


Figure 4. Dropout Voltage vs Output Current

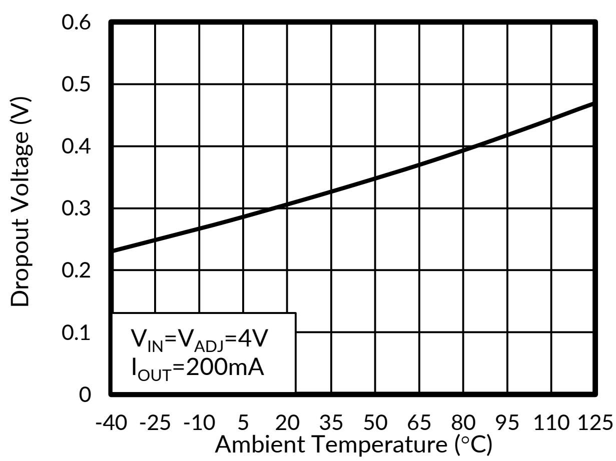


Figure 5. Dropout Voltage vs Ambient Temperature

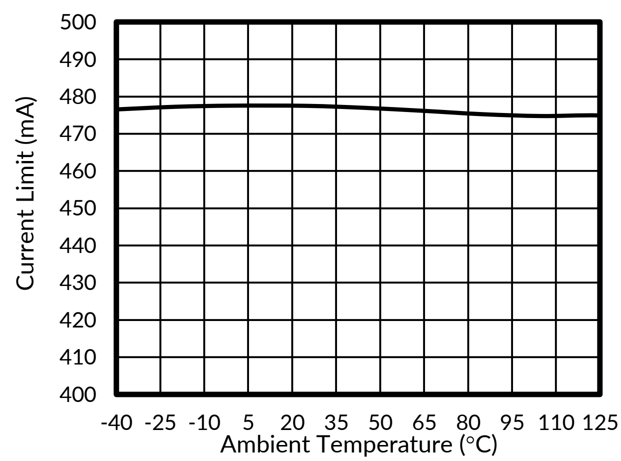


Figure 6. Current Limit ($I_{O(lim)}$) vs Ambient Temperature

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_{IN} = 14 V, V_{ADJ} = 5 V, V_{FB} = V_{OUT}, unless otherwise specified.

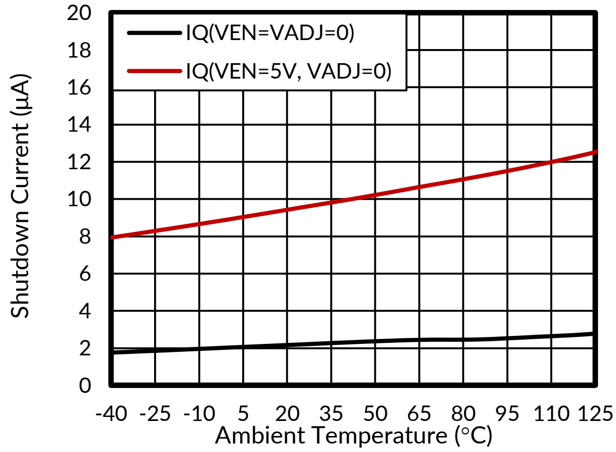


Figure 7. Shutdown Current vs Ambient Temperature

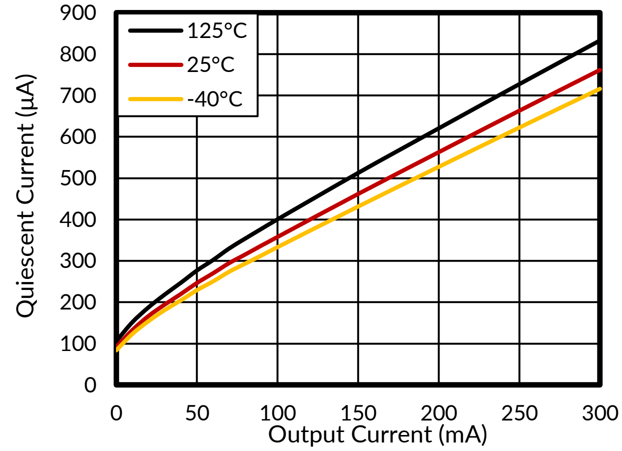


Figure 8. Quiescent Current vs Output Current

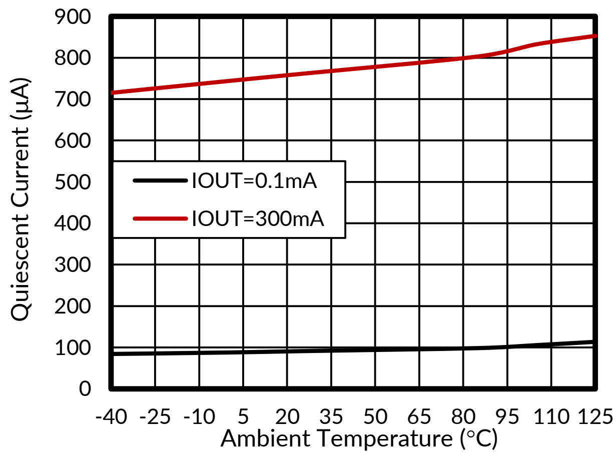


Figure 9. Quiescent Current vs Ambient Temperature

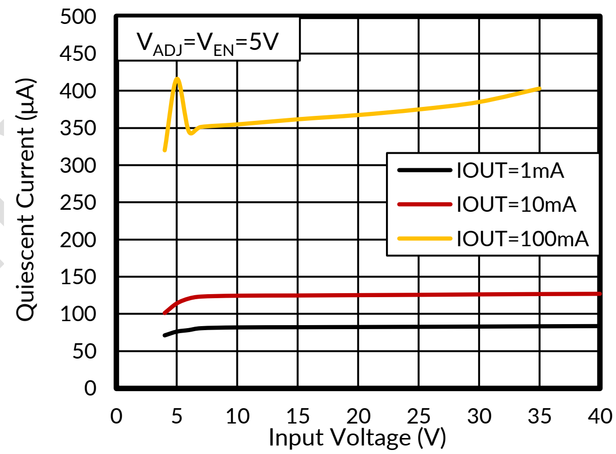


Figure 10. Quiescent Current vs Input Voltage

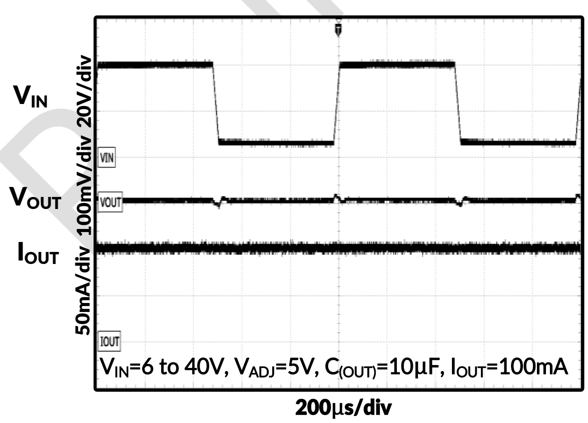


Figure 11. Line Transient

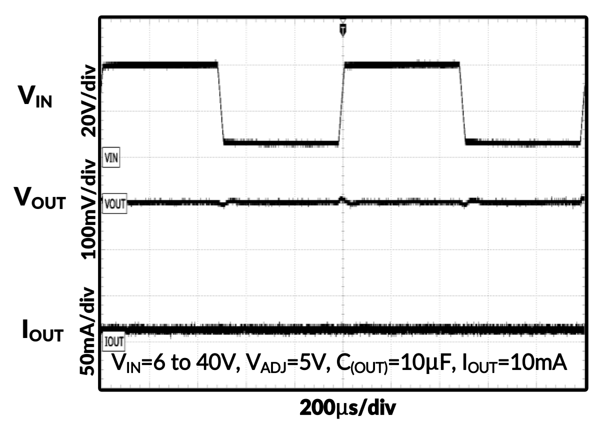


Figure 12. Line Transient

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_{IN} = 14 V, V_{ADJ} = 5 V, V_{FB} = V_{OUT}, unless otherwise specified.

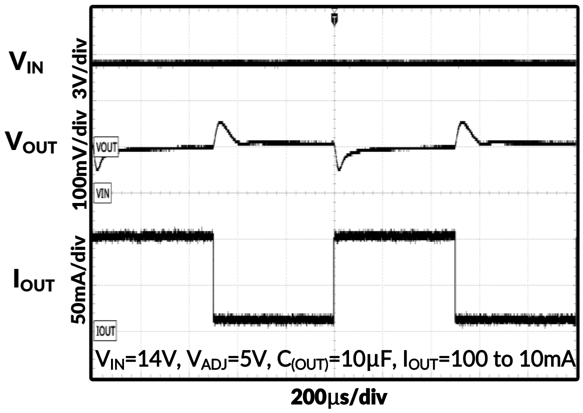


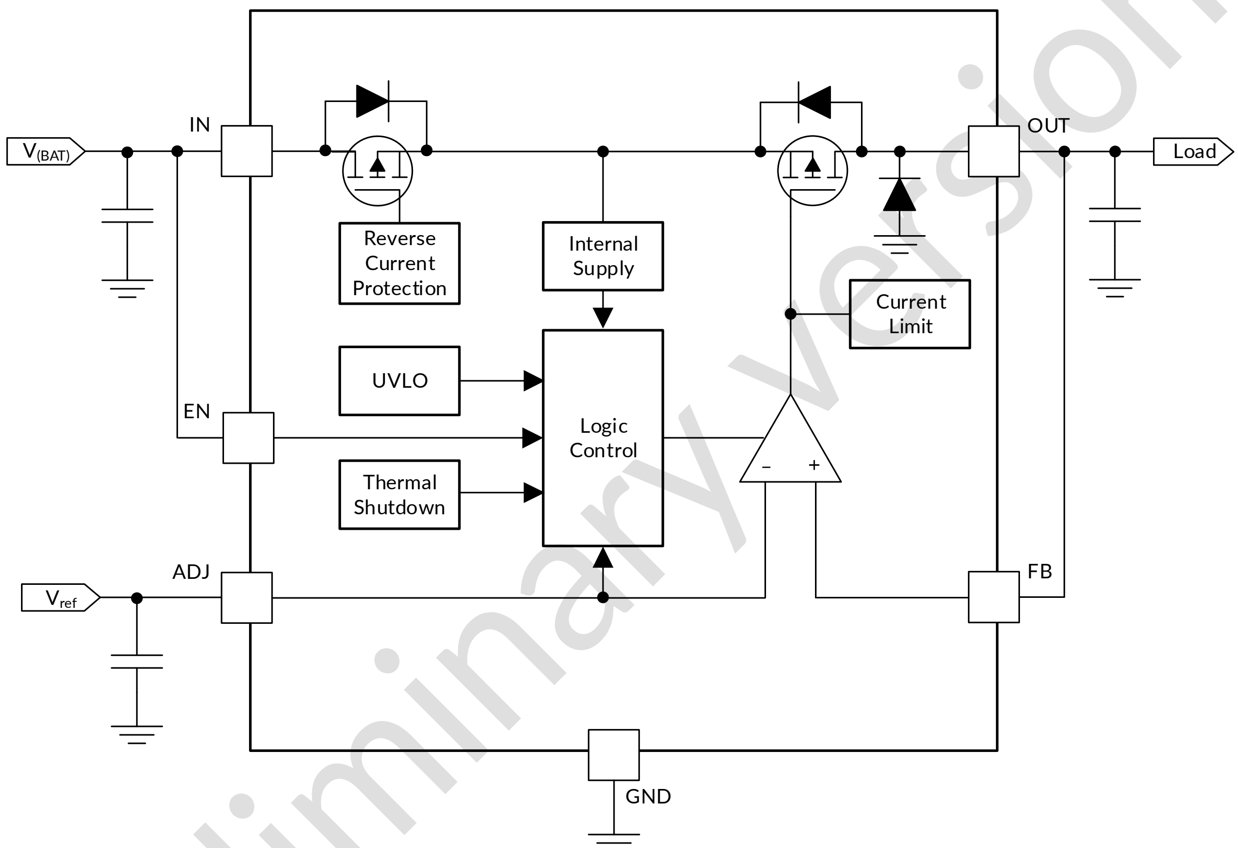
Figure 13. Load Transient

9 DETAILED DESCRIPTION

9.1 Overview

The RS3011-Q1 device is a monolithic integrated low-dropout voltage tracker with an ultralow tracking tolerance. Key protection circuits are integrated in the device, including output current limitation, reverse polarity protection, inductive load clamp, output short-to-battery protection, and thermal shutdown in case of an overtemperature event.

9.2 Functional Block Diagram



9.3 Feature Description

9.3.1 Short Circuit and Overcurrent Protection

The RS3011-Q1 device features integrated fault protection which makes the device ideal for automotive applications. To keep the device in a safe area of operation during certain fault conditions, internal current-limit protection is used to limit the maximum output current. This protection protects the device from excessive power dissipation. For example, during a short-circuit condition on the output, the current through the pass element is limited to $I_{O(lim)}$ to protect the device from excessive power dissipation.

9.3.2 Integrated Inductive Clamp Protection

During output turnoff, the cable inductance continues to source the current from the output of the device. The device integrates an inductive clamp at the OUT pin to help to dissipate the inductive energy stored in the cable. An internal diode is connected between the OUT and GND pins with a DC-current capability of 600 mA for inductive clamp protection.

9.3.3 OUT Short to Battery and Reverse Polarity Protection

The RS3011-Q1 device can withstand a short to battery when the output is shorted to the battery, as shown in Figure 14. Therefore, no damage to the device occurs.

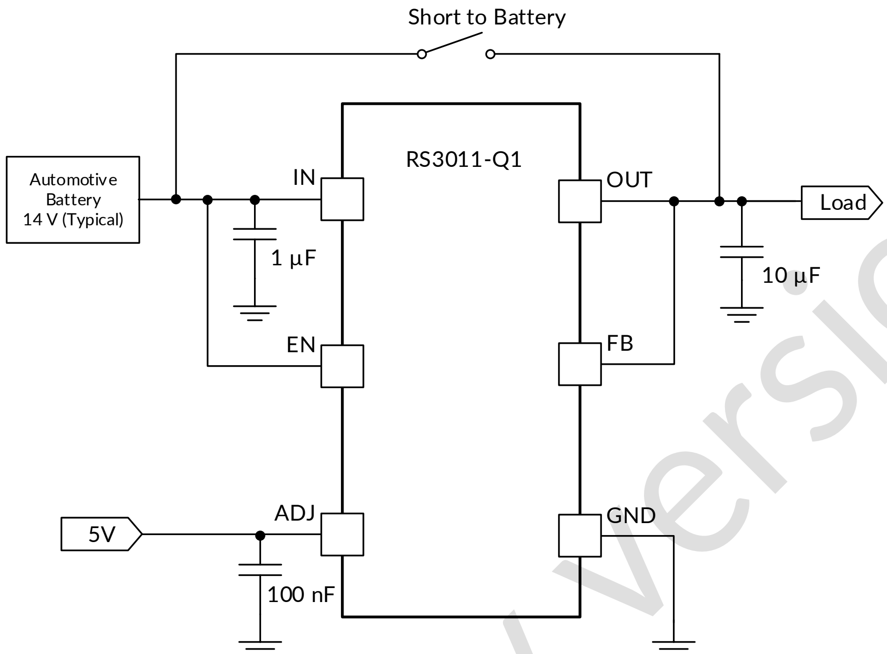


Figure 14. OUT Short to Battery, V_{IN} = $V_{(BAT)}$

A short to the battery can also occur when the device is powered by an isolated supply at lower voltage, as shown in Figure 15. In this case, the RS3011-Q1 supply-input voltage is set to 7 V when a short to battery (14 V typical) occurs on the OUT pin which operates at 5 V. The internal back-to-back PMOS remains on for 1 ms during which the input voltage of the RS3011-Q1 device charges up to the battery voltage. A diode connected between the output of the DC-DC converter and the input of the RS3011-Q1 device is required in case the other loads connected behind the DC-DC converter cannot withstand the voltage of an automotive battery. To achieve a lower dropout voltage, RUNIC recommends using a Schottky diode. This diode can be eliminated if the output of the DC-DC converter and the loads connect behind it withstand automotive battery voltage.

The internal back-to-back PMOS is switched to OFF when reverse polarity or short to battery occur for 1 ms. After that, the reverse current flows out through the IN pin with less than 10 µA. In the meanwhile, a special ESD structure implemented at the input ensures the device can withstand –40 V.

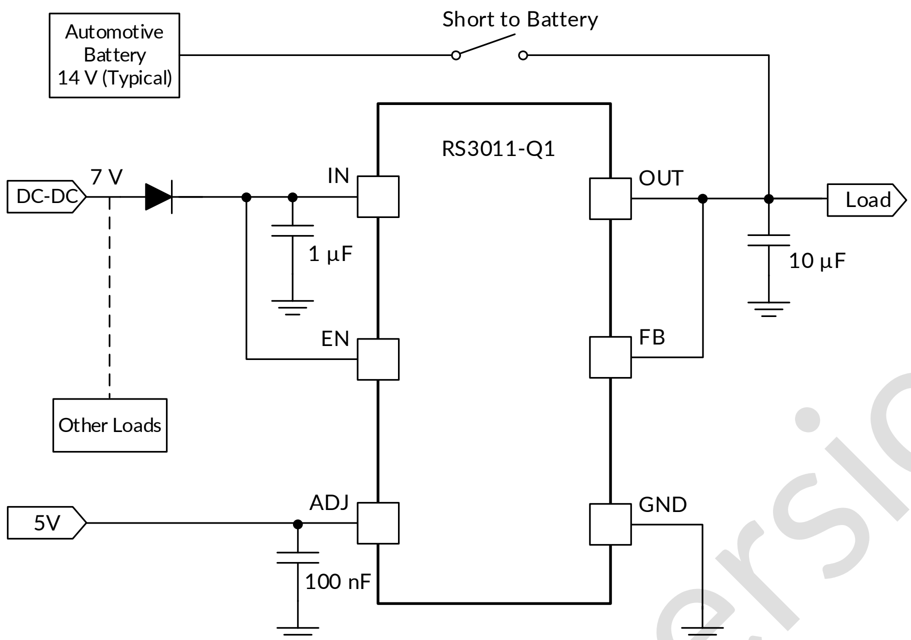


Figure 15. OUT Short to Battery, $V_{IN} < V_{(BAT)}$

In most cases, the output of the RS3011-Q1 device is shorted to the battery through an automotive cable. The parasitic inductance on the cable results in LC oscillation at the output of the RS3011-Q1 device when the short to battery occurs. Ideally, the peak voltage at the output of the RS3011-Q1 device should be lower than the absolute-maximum voltage rating (45 V) during LC oscillation.

9.3.4 Undervoltage Shutdown

The device has an internally fixed undervoltage-shutdown threshold. Undervoltage shutdown activates when the input voltage on IN drops below UVLO. This activation ensures the regulator is not latched into an unknown state during a low input-supply voltage. If the input voltage has a negative transient that drops below the UVLO threshold and then recovers, the regulator shuts down and then powers up with a standard power-up sequence when the input voltage is above the required levels.

9.3.5 Thermal Protection

The device incorporates a thermal shutdown (TSD) circuit as a protection from overheating. During continuous normal operation, the junction temperature should not exceed the TSD trip point. If the junction temperature exceeds the TSD trip point, the output turns off. When the junction temperature decreases to 15°C (typical) lower than the TSD trip point, the output turns on.

NOTE: The purpose of the design of the internal protection circuitry of the RS3011-Q1 device is to protect against overload conditions and is not intended as a replacement for proper heat-sinking. Continuously running the device into thermal shutdown degrades device reliability.

9.3.6 Regulated Output (OUT)

The OUT pin is the regulated output based on the required voltage. The output has current limitation. During initial power up, the regulator has an incorporated soft-start feature to control the initial current through the pass element.

9.3.7 Enable (EN)

The EN pin is a high-voltage-tolerant pin. A high input on the EN pin acitvates the device and turns on the regulator. The device consumes a maximum of shutdown current 8 µA when the EN pin is low. The EN pin has a maximum internal pulldown of 10 µA.

9.3.8 Adjustable Output Voltage (FB and ADJ)

9.3.8.1 OUT Voltage Equal to the Reference Voltage

With the reference voltage applied directly at the ADJ pin and the FB pin connected to the OUT pin, the voltage at the OUT pin equals to the reference voltage at the ADJ pin, as shown in Figure 16.

$$V_{OUT} = V_{ADJ} \quad (1)$$

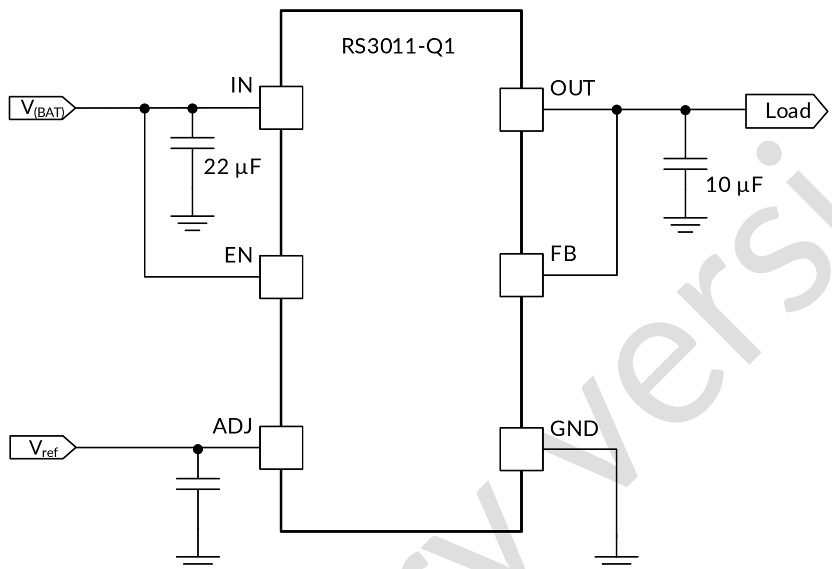


Figure 16. OUT Voltage Equal to the Reference Voltage

9.3.8.2 OUT Voltage Higher Than Reference Voltage

By using an external resistor divider connected between the OUT and FB pins, an output voltage higher than reference voltage can be generated as shown in Figure 17. Use Equation 2 to calculate the value of the output voltage. The recommended range for R1 and R2 is from 10 kΩ to 100 kΩ.

$$V_{OUT} = \frac{V_{ADJ} \times (R1 + R2)}{R2} \quad (2)$$

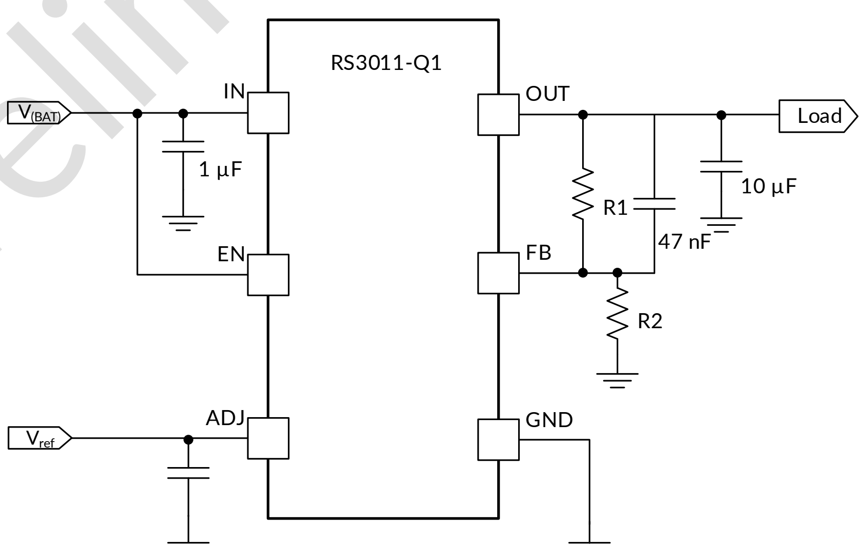


Figure 17. OUT Voltage Higher Than the Reference Voltage

9.3.8.3 Output Voltage Lower Than Reference Voltage

By using an external resistor divider connected at the ADJ pin, an output voltage lower than reference voltage can be generated as shown in Figure 18. Use Equation 3 to calculate the output voltage. The recommended value for both R1 and R2 is less than 100 kΩ.

$$V_{OUT} = \frac{V_{ref} \times R2}{R1 + R2} \quad (3)$$

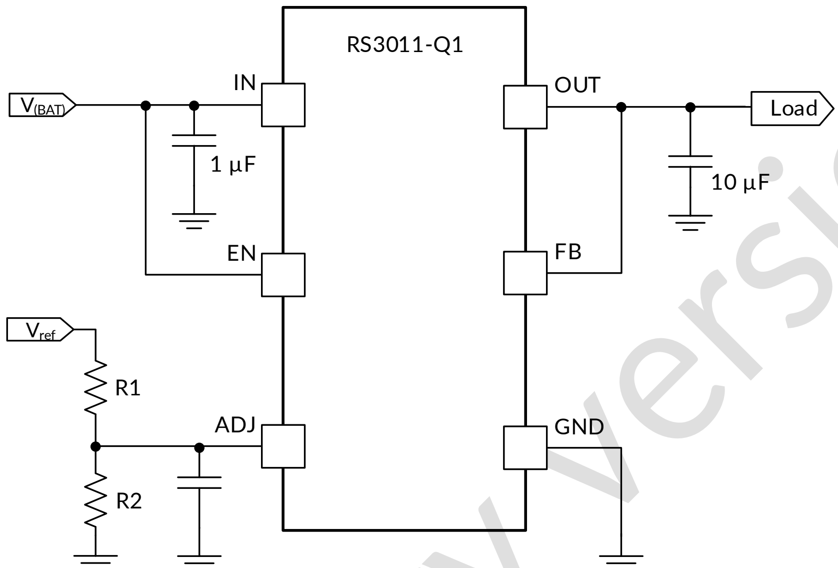


Figure 18. OUT Voltage Lower Than the Reference Voltage

9.4 Device Functional Modes

9.4.1 Operation With V_{IN} < 4 V

The maximum UVLO voltage is 3.65 V, and the device generally operates at an input voltage above 4 V. The device can also operate at a lower input voltage; no minimum UVLO voltage is specified. At an input voltage below the actual UVLO voltage, the device does not operate.

9.4.2 Operation With EN Control

The enable rising edge threshold is 2 V (maximum). With the EN pin held above that voltage and the input voltage above 4 V, the device becomes active. The falling edge of the EN pin is 0.7 V (minimum). Holding the EN pin below that voltage disables the device, thus reducing the quiescent current of the device.

10 POWER SUPPLY RECOMMENDATIONS

The device is designed to operate with an input voltage supply from 4 V to 40 V. This input supply must be well regulated. If the input supply is more than a few inches away from the RS3011-Q1 device, RUNIC recommends adding an electrolytic capacitor with a value of 2.2 µF and a ceramic bypass capacitor at the input.

11 LAYOUT

11.1 Layout Guidelines

For the layout of the RS3011-Q1 device, place the input and output capacitors close to the devices as shown in the Functional Block Diagram. To enhance the thermal performance, RUNIC recommends surrounding the device with some vias.

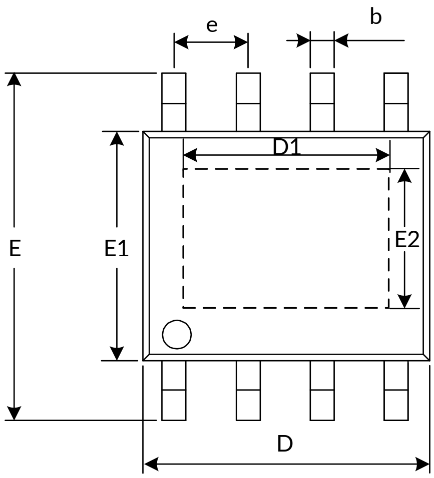
Minimize equivalent series inductance (ESL) and ESR to maximize performance and ensure stability. Place every capacitor as close as possible to the device and on the same side of the PCB as the regulator.

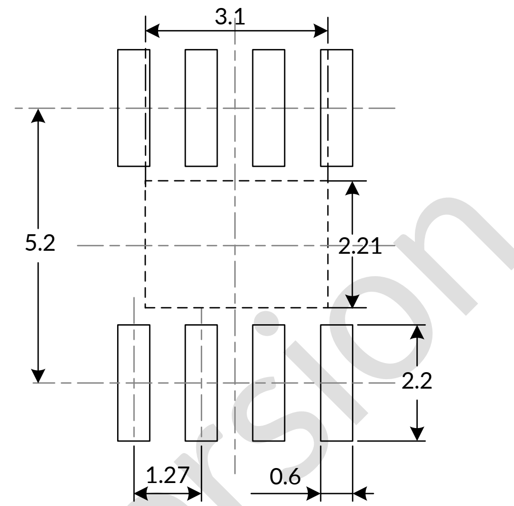
Do not place any of the capacitors on the opposite side of the PCB from where the regulator is installed. RUNIC strongly discourages the use of vias and long traces for the path between the output capacitor and the OUT pins because vias can negatively impact system performance and even cause instability.

If possible, and to ensure the maximum performance specified in this data sheet, use the same layout pattern used for the RS3011-Q1 evaluation board.

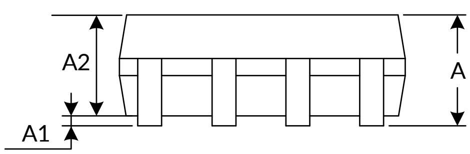
12 PACKAGE OUTLINE DIMENSIONS

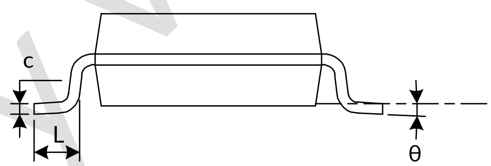
ESOP8 (4)





RECOMMENDED LAND PATTERN (Unit: mm)





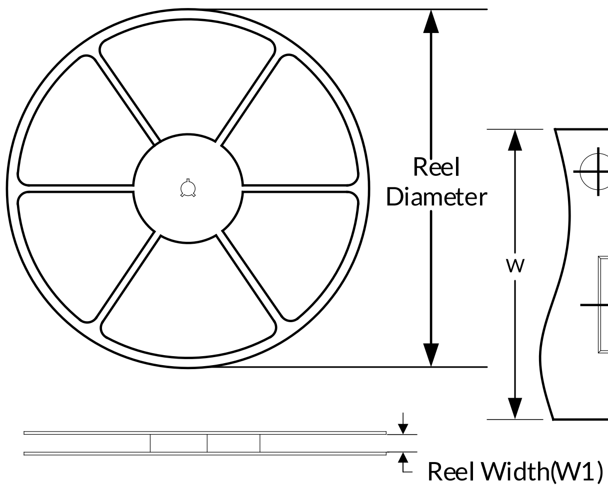
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)		1.650		0.065
A1	0.050	0.150	0.002	0.006
A2	1.300	1.500	0.051	0.059
b	0.390	0.470	0.015	0.019
c	0.200	0.240	0.007	0.010
D (1)	4.800	5.000	0.189	0.197
e	1.270 (BSC) (2)		0.050 (BSC) (2)	
D1	3.100 (REF) (3)		0.122 (REF) (3)	
E2	2.210 (REF) (3)		0.087 (REF) (3)	
E	5.800	6.200	0.228	0.244
E1 (1)	3.800	4.000	0.150	0.157
L	0.500	0.800	0.019	0.032
θ	0°	8°	0°	8°

NOTE:

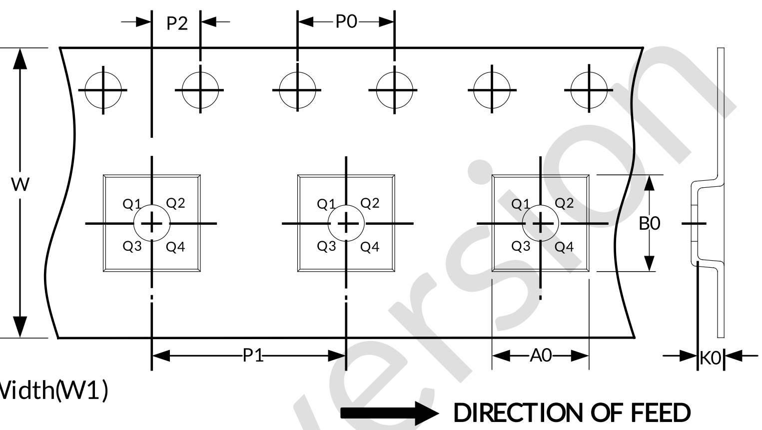
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. REF is the abbreviation for Reference.
4. This drawing is subject to change without notice.

13 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
ESOP8	13''	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1

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

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