4.2V, 1.5A, 105mΩ Self-Protected Load Switch with Controlled Rise Time

1 FEATURES

- **Input operating voltage range (V_{IN}): 1.6 V to 4.2 V**
- **Maximum continuous current (I_{MAX}): 1.5 A**
- **On-Resistance (R_{ON}):**
  - **4.2V V_{IN}: 105mΩ (typical)**
  - **3.6V V_{IN}: 105mΩ (typical)**
  - **1.8V V_{IN}: 120mΩ (typical)**
- **Reverse-Current Blocking**
- **Output short protection (I_{SC}): 3.8A (typical)**
- **Low power consumption:**
  - **ON state (I_Q): 11µA (typical)**
  - **OFF state (I_{SD}): 0.01µA (typical)**
- **Smart ON pin pull down (R_{PD}):**
  - **ON ≥ V_{IH} (I_{ON}): 0.1µA (maximum)**
  - **ON ≤ V_{IL} (R_{PD}): 550kΩ (typical)**
- **Slow Turn ON timing to limit inrush current (t_{ON}):**
  - **4.2V Turn ON time (t_{ON}): 1.2ms at 4.4mV/µs**
  - **3.6 V Turn ON time (t_{ON}): 1.2ms at 4mV/µs**
  - **1.8 V Turn ON time (t_{ON}): 1.12ms at 2.5mV/µs**
- **Adjustable output discharge and fall time (QOD Version: RS2587B):**
  - **Internal QOD resistance = 11Ω (typical)**
- **Micro SIZE PACKAGES: SC70-6**

2 APPLICATIONS

- **Personal Electronics**
- **Set Top Box**
- **HDTV**
- **Multi Function Printer**

3 DESCRIPTIONS

The RS2587 device is a small, single channel load switch with controlled slew rate. The device contains an N-channel MOSFET that can operate over an input voltage range of 1.6V to 4.2V and can support a maximum continuous current of 1.5A.

The switch ON state is controlled by a digital input that is capable of interfacing directly with low-voltage control signals. When power is first applied, a Smart Pull Down is used to keep the ON pin from floating until system sequencing is complete. Once the pin is deliberately driven High (>V_{IH}), the Smart Pull Down will be disconnected to prevent unnecessary power loss.

The RS2587 load switch is also self-protected, meaning that it protects against short circuit events on the output of the device. RS2587 has a reverse-current blocking function to block unwanted reverse current from output to input during V_{IN} floating/V_{IN}=0 states. Otherwise, the RS2587 has thermal shutdown protection to prevent any damage from overheating.

Furthermore, the RS2587 offers QOD Version, RS2587B, which features a QOD pin. The RS2587B allows the configuration of the discharge rate of OUT once the switch is disabled.

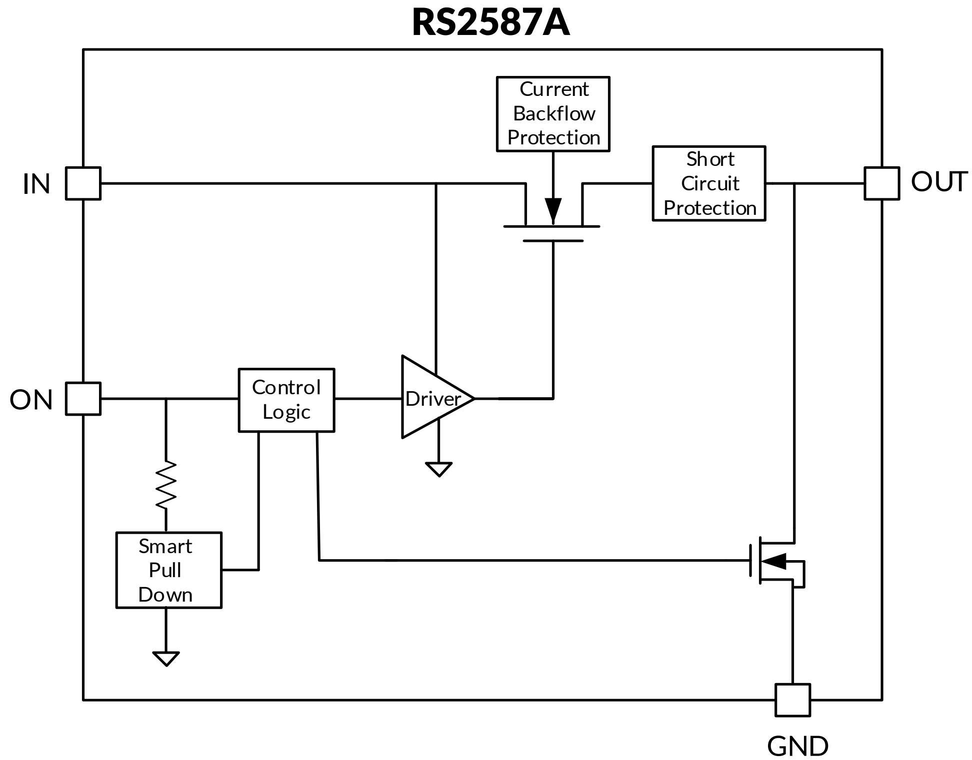
RS2587 is available in a standard SC70-6 package characterized for operation over a junction temperature range of –40°C to 125°C.

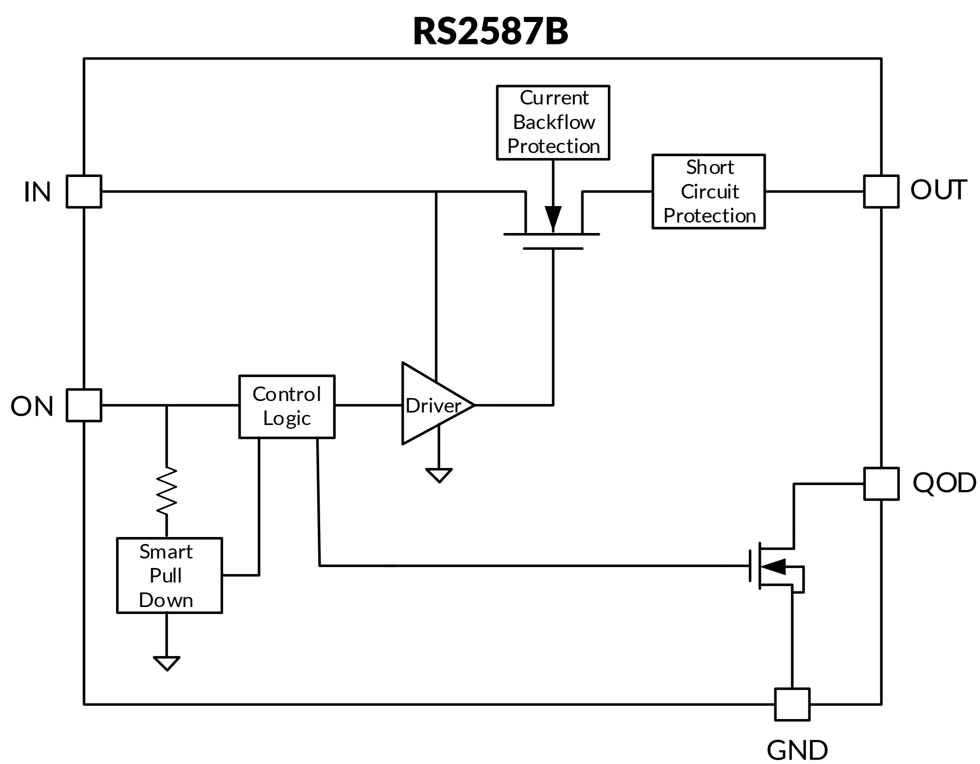
Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
RS2587	SC70-6	2.10mm×1.25mm

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

4 Functional Block Diagram





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5 Revision History

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

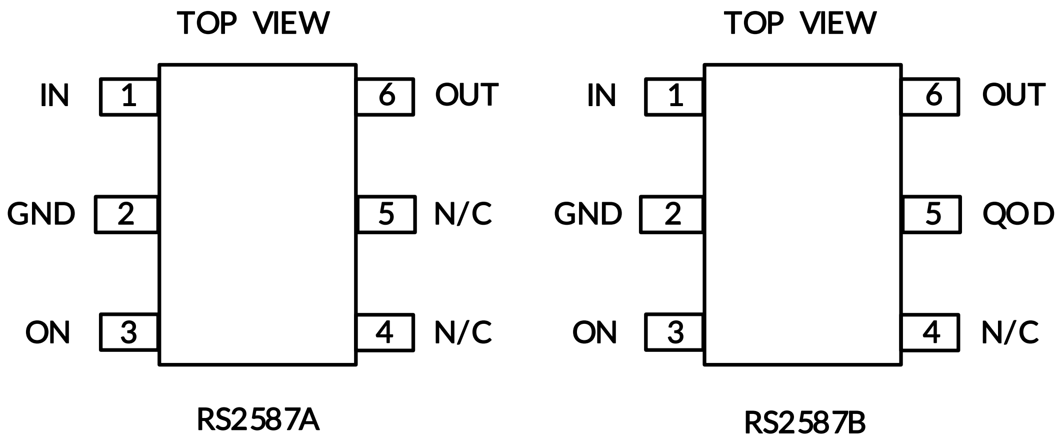
VERSION	Change Date	Change Item
A.0	2023/09/14	Preliminary version completed
A.0.1	2024/02/23	Modify packaging naming
A.1	2024/03/11	Initial version completed

6 PACKAGE/ORDERING INFORMATION (1)

PRODUCT	ORDERING NUMBER	TEMPERATURE RANGE	PACKAGE LEAD	PACKAGE MARKING (2)	MSL (3)	PACKAGE OPTION
RS2587	RS2587AXC6	-40°C ~+125°C	SC70-6 (4)	2587A	MSL3	Tape and Reel,3000
	RS2587BXC6	-40°C ~+125°C	SC70-6 (4)	2587B	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.
(4) Equivalent to SOT363.

7 PIN CONFIGURATIONS



PIN DESCRIPTION

PIN		NAME	I/O TYPE (1)	FUNCTION
SC70-6				
RS2587A	RS2587B			
1	1	IN	I	Input.
2	2	GND	-	Ground.
3	3	ON	I	Active high switch control input. Do not leave floating.
4, 5	4	N/C	-	No connect pin, leave floating.
-	5	QOD	O	Quick Output Discharge pin. This functionality can be enabled in one of three ways. • Placing an external resistor between VOUT and QOD • Tying QOD directly to VOUT and using the internal resistor value (R_{PD}) • Disabling QOD by leaving pin floating See the Fall Time (t_{FALL}) and Quick Output Discharge (QOD) section for more information.
6	6	OUT	O	Output.

(1) I=input, O=output.

8 SPECIFICATIONS

8.1 Absolute Maximum Ratings

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

SYMBOL	PARAMETER		MIN	MAX	UNIT
V_{IN}	Maximum Input Voltage Range		-0.3	4.5	V
V_{OUT}	Maximum Output Voltage Range		-0.3	4.5	V
V_{ON}	Maximum ON Pin Voltage Range		-0.3	4.5	V
V_{QOD}	Maximum QOD Pin Voltage Range		-0.3	4.5	V
I_{MAX}	Maximum Continuous Current			1.5	A
I_{PLS}	Maximum Pulsed Current (2ms, 2% Duty Cycle)			2.5	A
θ_{JA}	Package thermal impedance (2)	SC70-6		265	°C/W
T_J	Junction Temperature (3)		Internally Limited		°C
T_{stg}	Storage temperature		-65	150	°C
T_{LEAD}	Maximum Lead Temperature (10 s soldering time)			300	°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 package thermal impedance is calculated in accordance with JESD-51.

(3) 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), MIL-STD-883K METHOD 3015.9	±5000	V
		Charged-device model (CDM), ANSI/ESDA/JEDEC JS-002-2018	±1500	V

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

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Input Voltage Range	V_{IN}	1.6		4.2	V
Output Voltage Range	V_{OUT}	0		4.2	V
Ambient Temperature	T_A	-40		125	°C

8.4 Electrical Characteristics

Typical values at V_{IN} = 3.6V, T_A=25°C unless otherwise specified.

PARAMETER		TEST CONDITIONS		TEMP	MIN(1)	TYP(2)	MAX(1)	UNIT
Input Supply (VIN)								
$I_{Q, VIN}$	VIN Quiescent Current	V_{ON} ≥ V_{IH}, V_{OUT} = Open		25°C		11	14	µA
				-40°C to 125°C			20	
$I_{SD, VIN}$	VIN Shutdown Current	V_{ON} ≤ V_{IL}, V_{OUT} = GND		25°C		0.01	0.1	µA
				-40°C to 125°C			1	
$I_{OUT-LKG}$	VOUT Pin sink current	V_{IN} floating, V_{OUT}=4.5V		25°C		3	4	µA
				-40°C to 125°C			5	
		V_{IN} =GND，V_{OUT}=4.5V		25°C		3	4	µA
				-40°C to 125°C			8	
ON-Resistance (RON)								
R_{ON}	ON-State Resistance	I_{OUT} = -200 mA	V_{IN}=4.2V	25°C		105		mΩ
				-40°C to 85°C			140	mΩ
				-40°C to 105°C			155	mΩ
				-40°C to 125°C			175	mΩ
			V_{IN}=3.6V	25°C		105		mΩ
				-40°C to 85°C			140	mΩ
				-40°C to 105°C			155	mΩ
				-40°C to 125°C			175	mΩ
			V_{IN}=1.8V	25°C		120		mΩ
				-40°C to 85°C			155	mΩ
				-40°C to 105°C			165	mΩ
				-40°C to 125°C			200	mΩ
Output Short Protection (ISC)								
I_{SC}	Short Circuit Current Limit	V_{OUT}≤V_{IN}-1.5V		25°C		3.8		A
		V_{OUT} ≤ V_{SC}		25°C		0.75		A
V_{SC}	Output Short Detection Threshold	V_{IN} - V_{OUT}		25°C	0.28	0.37	0.46	V
				-40°C to 125°C	0.2		0.62	V
t_{SC}	Output Short Reponse Time	V_{IN}=1.6V to 4.2V		-40°C to 125°C		5		µs
T_{SD}	Thermal Shutdown	Rising				175		°C
		Falling				140		°C
Enable Pin (ON)								
V_{IH}	Enable Input Threshold	V_{IN}=1.6V to 4.2V		25°C	1.0			V
V_{IL}		V_{IN}=1.6V to 4.2V		25°C			0.4	V
I_{ON}	ON Pin Leakage	V_{ON} ≥ V_{IH}		-40°C to 125°C			0.1	µA
$R_{PD, ON}$	Smart Pull Down Resistance	V_{ON} ≤ V_{IL}		-40°C to 125°C	430	550	670	kΩ
Quick-output Discharge (QOD)								
$R_{PD, QOD}$	QOD Pin Internal Discharge Resistance	V_{ON} ≤ V_{IL}		-40°C to 125°C	10	11	13	Ω

(1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.

(2) 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 Switching Characteristics

Unless otherwise noted, the typical characteristics in the following table apply to an input voltage of 3.6V, an ambient temperature of 25°C, and a load of C_L=0.1µF, R_L=100Ω.

PARAMETER		TEST CONDITIONS	MIN(1)	TYP(2)	MAX(1)	UNIT
t_{ON}	Turn ON Time	V_{IN}=4.2V		1200		µs
		V_{IN}=3.6V		1200		µs
		V_{IN}=1.8V		1120		µs
t_R	Output Rise Time	V_{IN}=4.2V		760		µs
		V_{IN}=3.6V		720		µs
		V_{IN}=1.8V		580		µs
SR_{ON}	Turn ON Slew Rate	V_{IN}=4.2V		4.4		mV/µs
		V_{IN}=3.6V		4		mV/µs
		V_{IN}=1.8V		2.5		mV/µs
t_{OFF}	Turn OFF Time	V_{IN} = 4.2V, R_L = 100Ω, C_L = 0.1uF		3		µs
t_{FALL}	Output Fall Time (3)	R_L = 100Ω, C_L = 0.1uF, R_{QOD} = Short		4		µs
		R_L = Open (4), C_L = 10uF, R_{QOD} = Short		0.5		ms

(1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.
(2) 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.
(3) Output may not discharge completely if QOD is not connected to VOUT.
(4) See the Timing Application section for information on how R_L and C_L affect Fall Time.

8.6 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.

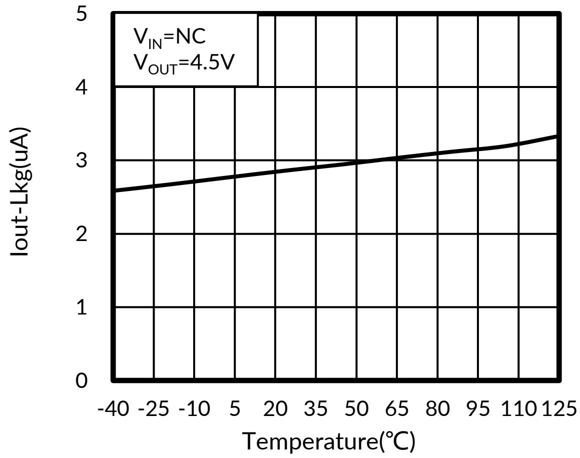


Figure 1. VOUT Pin Leakage Current vs Temperature

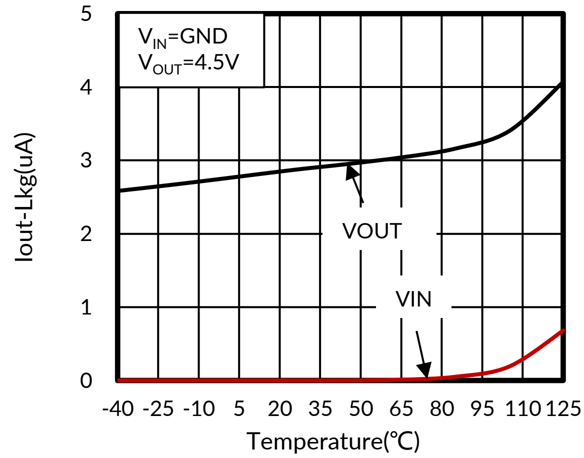


Figure 2. VOUT/VIN Pin Leakage Current vs Temperature

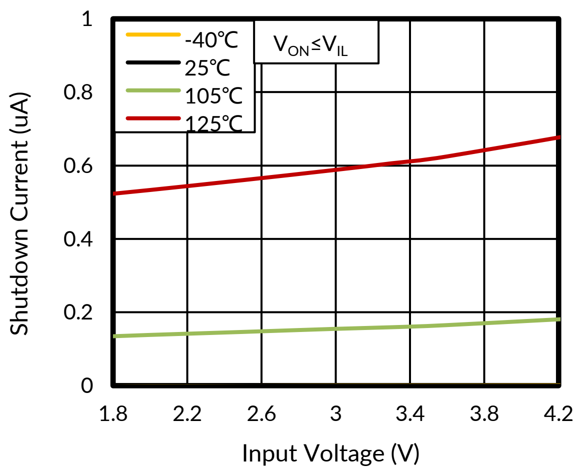


Figure 3. Shutdown Current vs Input Voltage

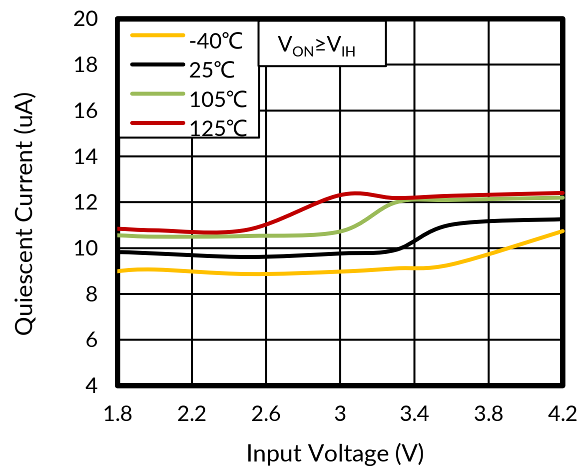


Figure 4. Quiescent Current vs Input Voltage

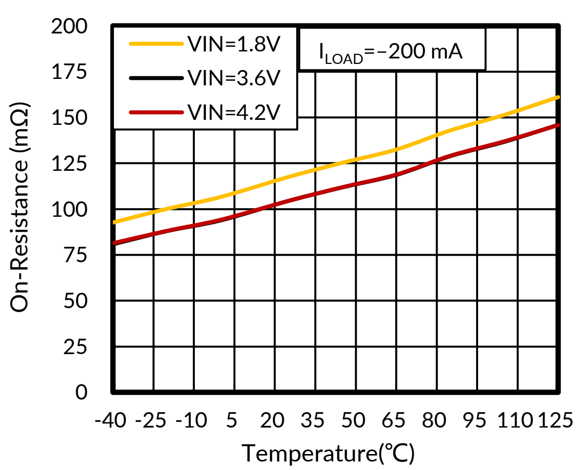


Figure 5. On-Resistance vs Temperature

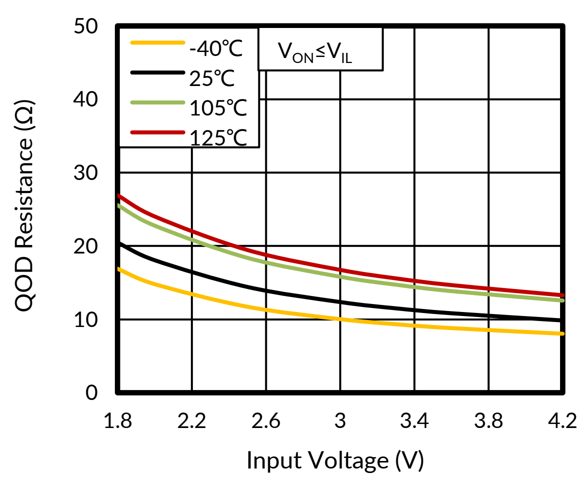


Figure 6. QOD Resistance vs Input Voltage

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.

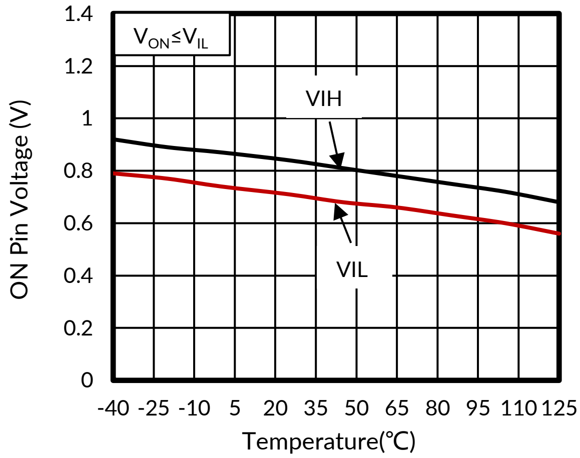


Figure 7. V_{IH}/V_{IL} vs Temperature

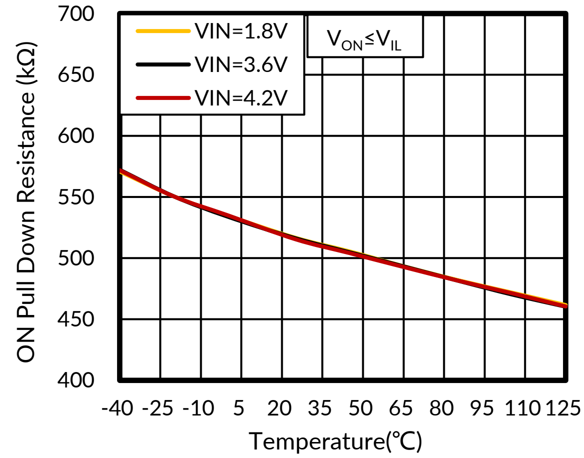


Figure 8. ON Pull Down Resistance vs Temperature

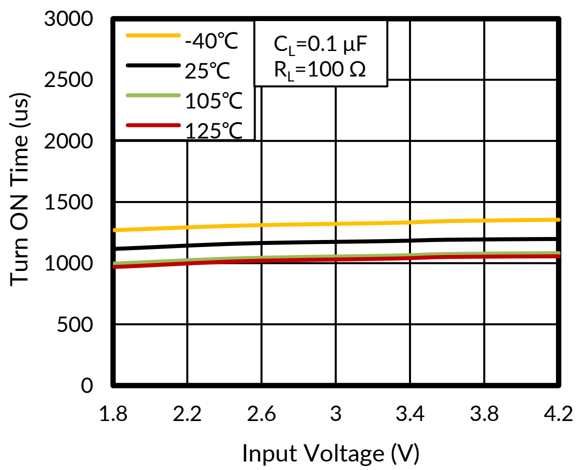


Figure 9. Turn ON Time vs Input Voltage

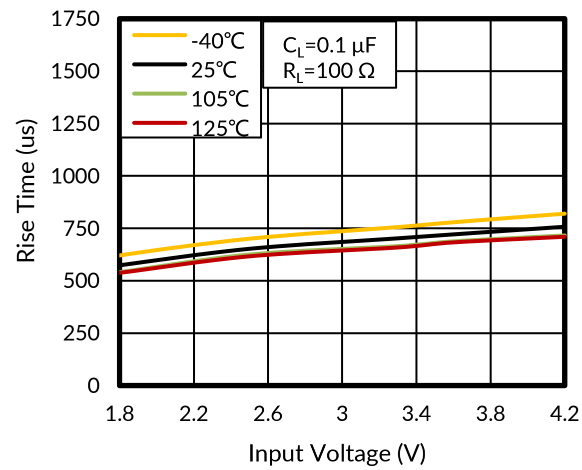


Figure 10. Rise Time vs Input Voltage

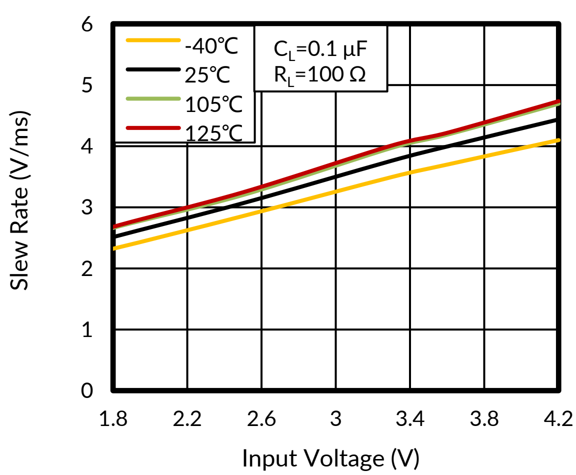


Figure 11. Output Slew Rate vs Input Voltage

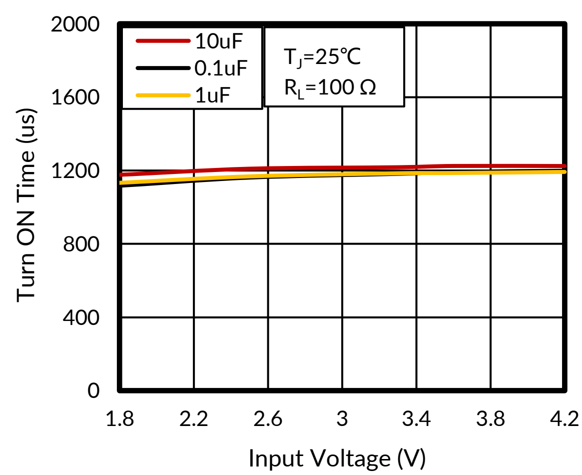


Figure 12. Turn ON Time vs Input Voltage Across Load Capacitance

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.

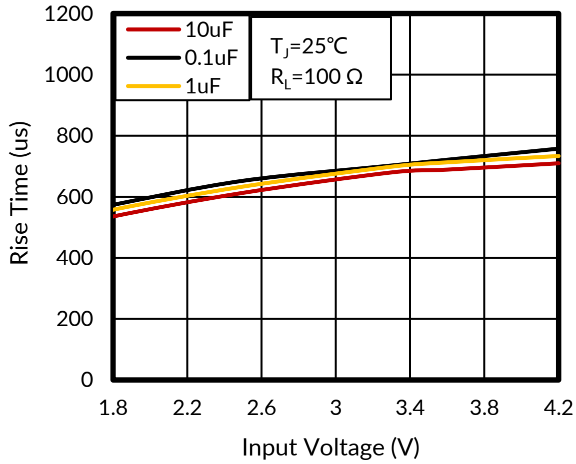


Figure 13. Rise Time vs Input Voltage Across Load Capacitance

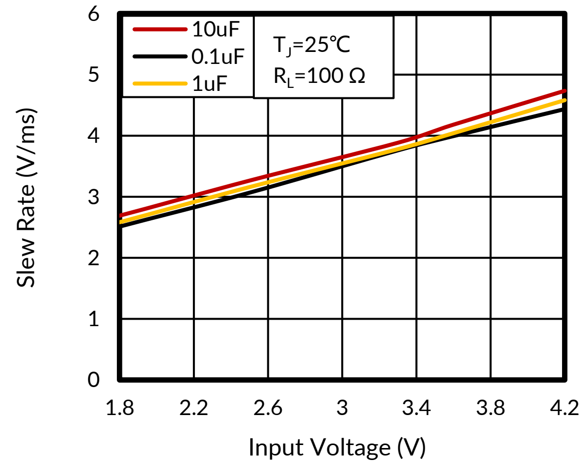


Figure 14. Slew Rate vs Input Voltage Across Load Capacitance

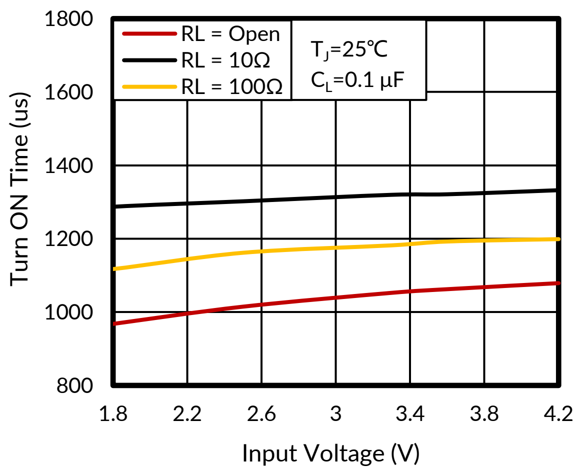


Figure 15. Turn ON Time vs Input Voltage Across Load Resistance

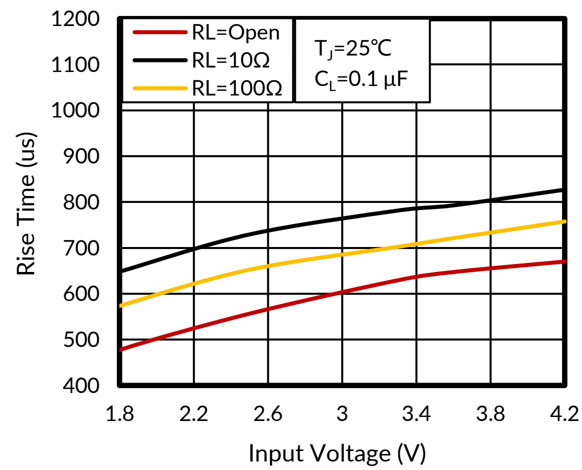


Figure 16. Rise Time vs Input Voltage Across Load Resistance

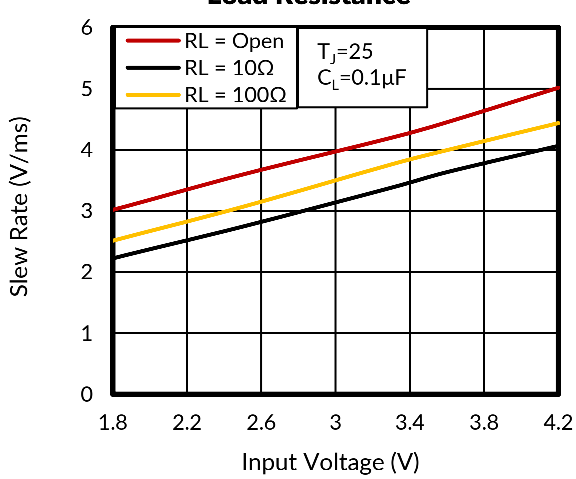


Figure 17. Output Slew Rate vs Input Voltage Across Load Resistance

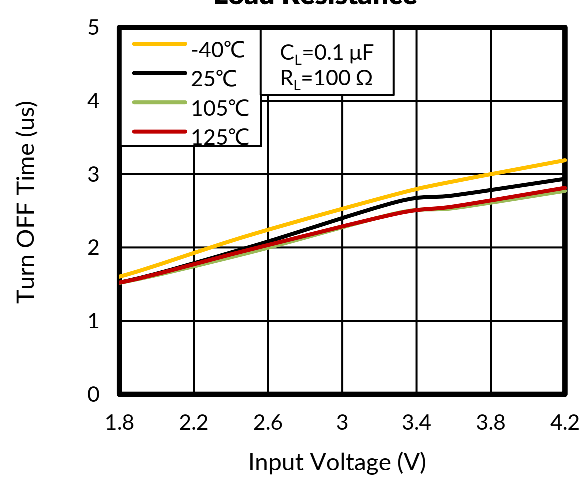


Figure 18. Turn OFF Time vs Input Voltage

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.

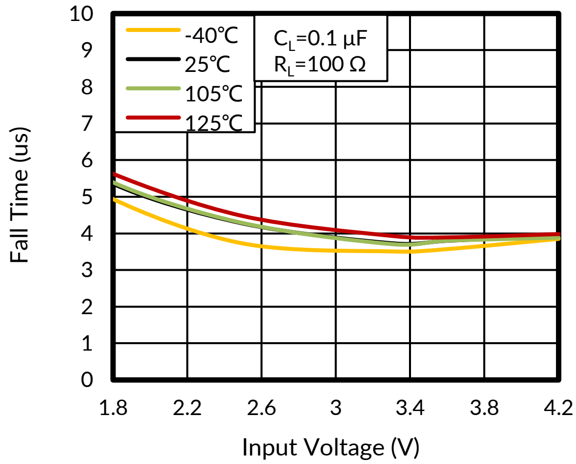


Figure 19. Fall Time vs Input Voltage

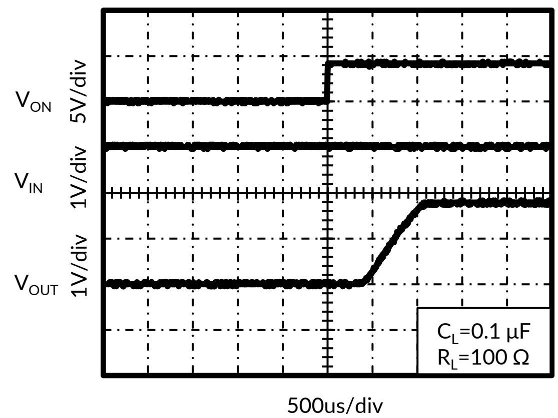


Figure 20. Rise Time with VIN = 1.8 V

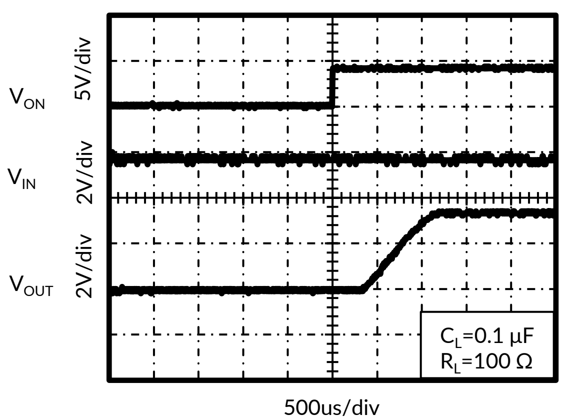


Figure 21. Rise Time with VIN = 3.3 V

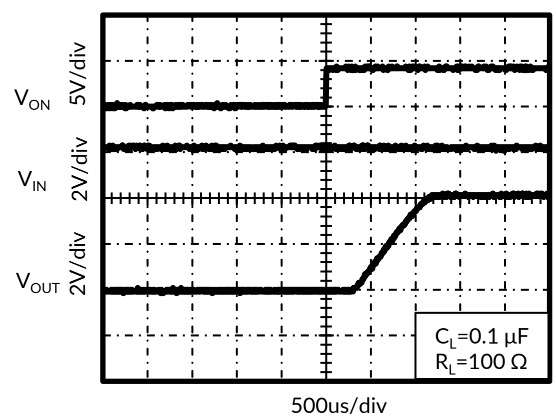


Figure 22. Rise Time with VIN = 4.2 V

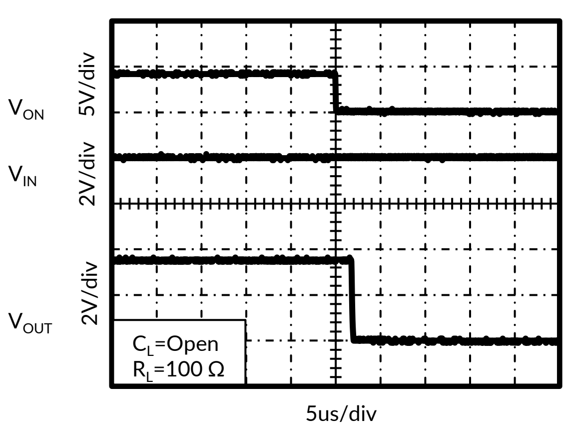


Figure 23. Turn off with a small load capacitance

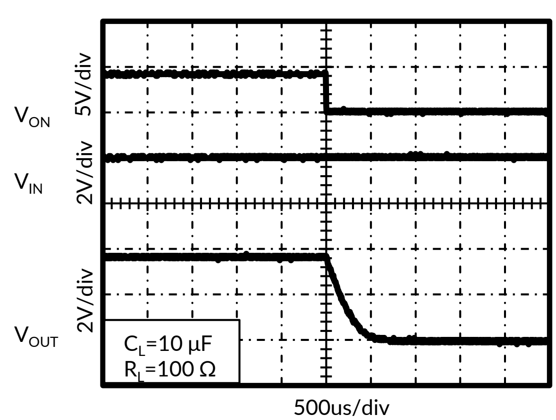


Figure 24. Turn off with a large load capacitance

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.

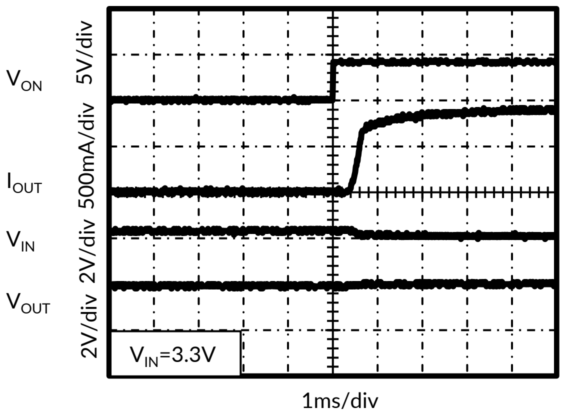


Figure 25. Turn on into an output short

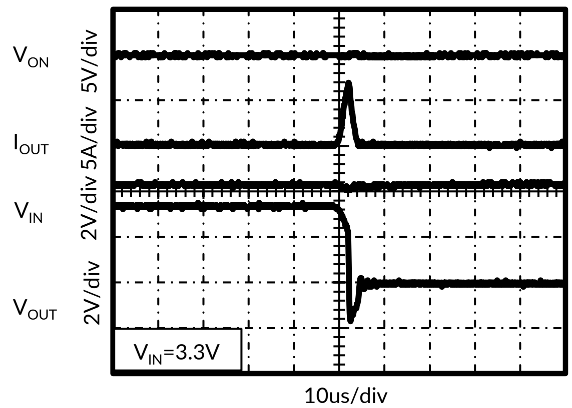


Figure 26. Hot short event when ON

9 Parameter Measurement Information

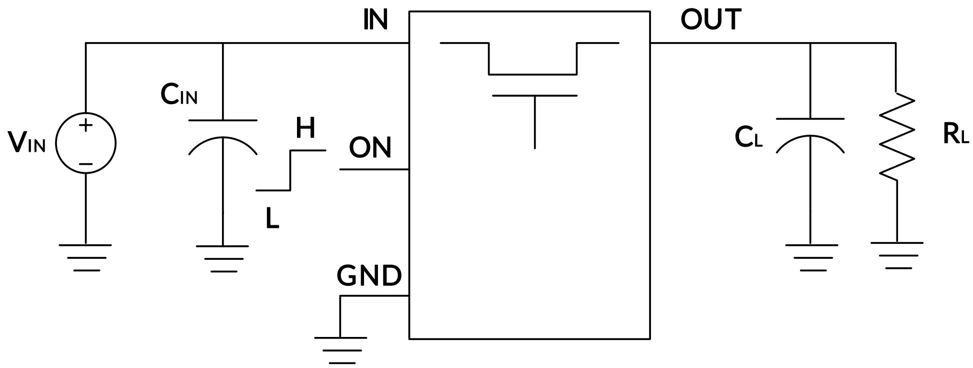


Figure 27. RS2587A Test Circuit

NOTE:
(1) Turn-off times and fall times are dependent on the time constant at the load. For the RS2587 devices, the internal pull-down resistance is enabled when the switch is disabled. The time constant for RS2587A is (R_{QOD} || R_L) × C_L.

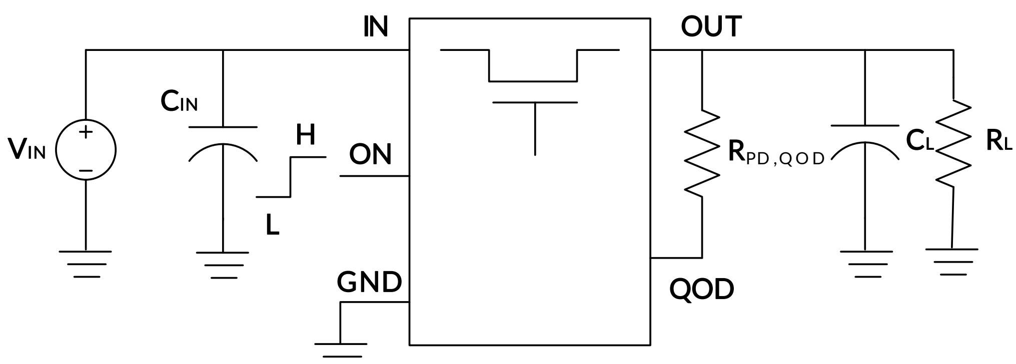


Figure 28. RS2587B Test Circuit

NOTE:
(1) Turn-off times and fall times are dependent on the time constant at the load. For the RS2587 devices, the internal pull-down resistance is enabled when the switch is disabled. The time constant for RS2587B is (R_{QOD} + $R_{PD, QOD}$ || R_L) × C_L.

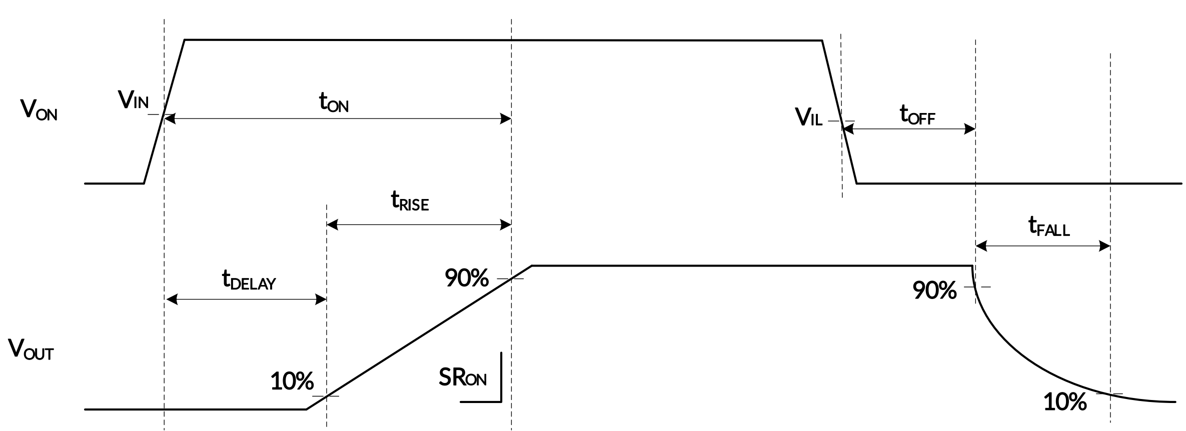


Figure 29. Timing Waveforms

10 Feature Description

10.1 Overview

The RS2587 device is a small, single channel load switch with controlled slew rate. The device contains an N-channel MOSFET that can operate over an input voltage range of 1.6V to 4.2V and can support a maximum continuous current of 1.5A.

The switch ON state is controlled by a digital input that is capable of interfacing directly with low-voltage control signals. When power is first applied, a Smart Pull Down is used to keep the ON pin from floating until system sequencing is complete. Once the pin is deliberately driven High (>V_{IH}), the Smart Pull Down will be disconnected to prevent unnecessary power loss.

The RS2587 load switch is also self-protected, meaning that it protects against short circuit events on the output of the device. RS2587 has a reverse-current blocking function to block unwanted reverse current from output to input during V_{IN} floating/V_{IN}=0 states. Otherwise, the RS2587 has thermal shutdown protection to prevent any damage from overheating.

Furthermore, the RS2587 offers QOD Version, RS2587B, which features a QOD pin. The RS2587B allows the configuration of the discharge rate of OUT once the switch is disabled.

10.2 Current Backflow Protection

Reverse-current blocking functionality block unwanted reverse current during both V_{IN} floating and V_{IN}=0 states when the higher V_{OUT} than V_{IN} is applied.

10.3 On and Off Control

The ON pin controls the state of the switch. The ON pin is compatible with standard GPIO logic threshold so it can be used in a wide variety of applications. When power is first applied to V_{IN}, a Smart Pull Down is used to keep the ON pin from floating until the system sequencing is complete. Once the ON pin is deliberately driven high (≥V_{IH}), the Smart Pull Down is disconnected to prevent unnecessary power loss. See Table 1 when the ON Pin Smart Pull Down is active.

Table 1. Smart-ON Pull Down

VON	Pull Down
≤ V_{IL}	Connected
≥ V_{IH}	Disconnected

10.4 Fall Time (t_{FALL}) and Quick Output Discharge (QOD)

The RS2587 device includes a QOD pin that can be configured in one of three ways:

- QOD pin shorted to V_{OUT} pin. Using this method, the discharge rate after the switch becomes disabled is controlled with the value of the internal resistance QOD ($R_{PD, QOD}$).
- QOD pin connected to V_{OUT} pin using an external resistor R_{QOD}. After the switch becomes disabled, the discharge rate is controlled by the value of the total discharge resistance. To adjust the total discharge resistance, Equation 1 can be used:

  $R_{DIS} = R_{PD, QOD} + R_{QOD}$

  Where:
  - R_{DIS} = Total output discharge resistance (Ω)
  - $R_{PD, QOD}$ = Internal pulldown resistance (Ω)
  - R_{QOD} = External resistance placed between the VOUT and QOD pins (Ω) (1)
- QOD pin is unused and left floating. Using this method, there will be no quick output discharge functionality, and the output will remain floating after the switch is disabled.

The fall times of the device depend on many factors including the total discharge resistance (R_{DIS}) and the output capacitance (C_L). To calculate the approximate fall time of V_{OUT} use Equation 2.

$t_{FALL} = 2.2 \times (R_{DIS} \| R_L) \times C_L$

Where:
- t_{FALL} = Output Fall Time from 90% to 10% (µs)
- R_{DIS} = Total QOD + R_{QOD} Resistance (Ω)
- R_L = Output Load Resistance (Ω)
- C_L = Output Load Capacitance (µF) (2)

11 Application and Implementation

Information in the following applications sections is not part of the RUNIC component specification, and RUNIC does not warrant its accuracy or completeness. RUNIC's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

11.1 Detailed Design Procedure

11.1.1 Limiting Inrush Current

Use Equation 3 to find the maximum slew rate value to limit inrush current for a given capacitance:

(Slew Rate) = $I_{RUSH} \div C_L$

where

- I_{INRUSH} = maximum acceptable inrush current (mA)
- C_L = capacitance on V_{OUT} (µF)
- Slew Rate = Output Slew Rate during turn on (mV/µs) (3)

The RS2587 has a slew rate of 4mV/µs @ VIN=3.6V.

12 Power Supply Recommendations

The device is designed to operate with a VIN range of 1.6V to 4.2V. The V_{IN} power supply must be well regulated and placed as close to the device terminal as possible. The power supply must be able to withstand all transient load current steps. In most situations, using an input capacitance (C_{IN}) of 1µF is sufficient to prevent the supply voltage from dipping when the switch is turned on. In cases where the power supply is slow to respond to a large transient current or large load current step, additional bulk capacitance may be required on the input.

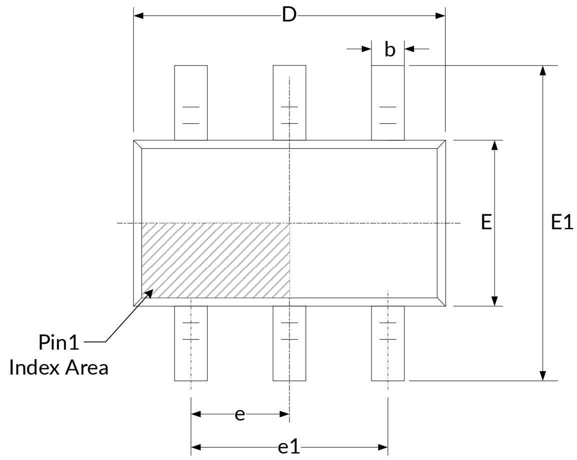
13 Layout

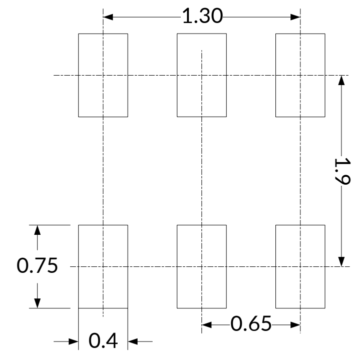
13.1 Layout Guidelines

For best performance, all traces must be as short as possible. To be most effective, the input and output capacitors must be placed close to the device to minimize the effects that parasitic trace inductances may have on normal operation. Using wide traces for V_{IN}, V_{OUT}, and GND helps minimize the parasitic electrical effects.

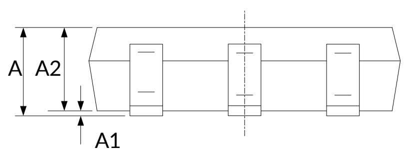
14 PACKAGE OUTLINE DIMENSIONS

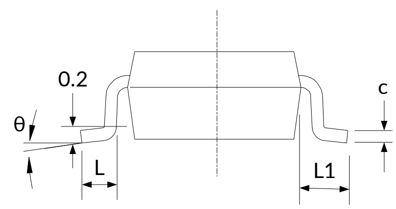
SC70-6 (3)





RECOMMENDED LAND PATTERN (Unit: mm)





Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.080	0.150	0.003	0.006
D (1)	2.000	2.200	0.079	0.087
E (1)	1.150	1.350	0.045	0.053
E1	2.150	2.450	0.085	0.096
e	0.650(BSC) (2)		0.026(BSC) (2)	
e1	1.300(BSC) (2)		0.051(BSC) (2)	
L	0.260	0.460	0.010	0.018
L1	0.525		0.021	
θ	0°	8°	0°	8°

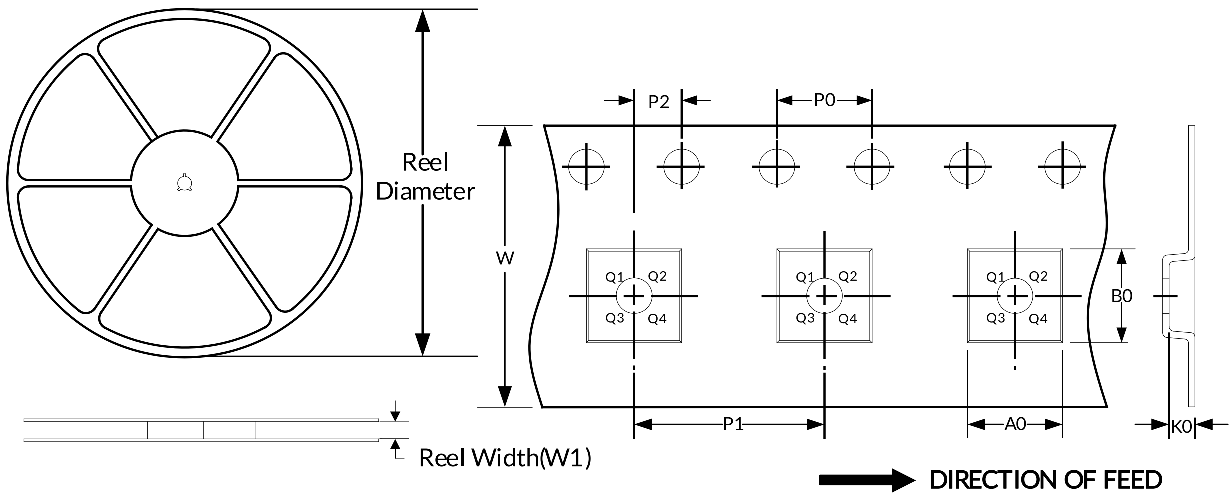
NOTE:

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.

15 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
SC70-6	7’’	9.5	2.40	2.50	1.20	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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