SGM2564 5.5V, 4A, 16mΩ R_{ON}, Load Switch with Reverse Current Protection and Controlled Turn-On

GENERAL DESCRIPTION

The SGM2564 is a small, ultra-low on-resistance load switch with reverse current protection and controlled turn-on. The load switch contains an N-MOSFET that operates over an input voltage range of 1V to 5.5V and can support a maximum continuous current of 4A.

An integrated charge pump biases the N-MOSFET switch in order to achieve a low switch R_{ON}. The switch is controlled by ON pin, which is capable of interfacing directly with low voltage control signals. The rise time of the device is controlled internally to avoid inrush current.

The SGM2564 provides reverse current protection. When the power switch is disabled, the device will not allow the flow of current towards the input side of the switch. The reverse current protection feature is active only when the device is disabled so as to allow for intentional reverse current (when the switch is enabled) for some applications.

The SGM2564 is available in a Green WLCSP-1.45×0.95-6B package.

FEATURES

- **Integrated N-MOSFET Load Switch**
- **1V to 5.5V Input Voltage Range**
- **Ultra-Low On-Resistance**
  - **R_{ON} = 16mΩ at V_{IN} = 3.3V**
  - **R_{ON} = 16mΩ at V_{IN} = 1.8V**
- **Reverse Current Protection (When Disabled)**
- **4A Maximum Continuous Switch Current**
- **Low Shutdown Current: 180nA (TYP)**
- **Low Threshold 1.2V GPIO Control Input**
- **Controlled Slew Rate to Avoid Inrush Current**
- **Quick Output Discharge**
- **Bidirectional Power Supply for Power Zone Application**
- **Available in a Green WLCSP-1.45×0.95-6B Package**

APPLICATIONS

Smartphone
Notebook Computer and Ultrabook
Tablet PC Computer
Solid State Drive (SSD)
DTV/IP Set Top Box
POS Terminal and Media Gateway

TYPICAL APPLICATION

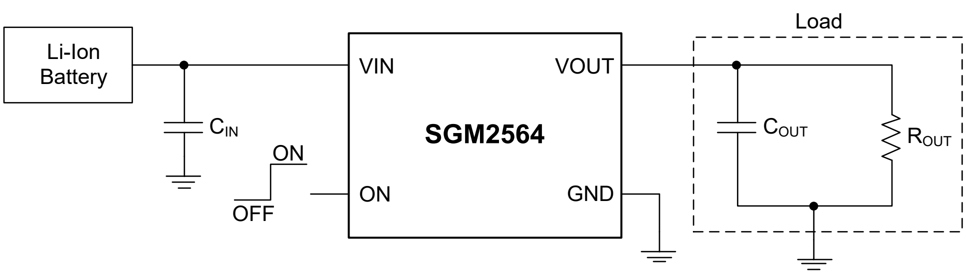


Figure 1. Simplified Schematic

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM2564	WLCSP-1.45×0.95-6B	-40℃ to +85℃	SGM2564YG/TR	XXX MZF	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XXX = Date Code and Trace Code.

Date Code - Year

Trace Code

XXX

YYY — Serial Number

Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS

Input Voltage Range, V_{IN} .... -0.3V to 6V
Output Voltage Range, V_{OUT} .... -0.3V to 6V
ON Pin Voltage Range, V_{ON} .... -0.3V to 6V
Maximum Continuous Switch Current, I_{MAX} .... 4A (MAX)
Junction Temperature .... +150℃
Storage Temperature Range .... -65℃ to +150℃
Lead Temperature (Soldering, 10s) .... +260℃
ESD Susceptibility
HBM 4000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range, V_{IN} .... 1V to 5.5V
Output Voltage Range, V_{OUT} .... 0V to 5.5V
ON Pin Input High Voltage, V_{IH} .... 1.1V to 5.5V
ON Pin Input Low Voltage, V_{IL} .... 0V to 0.4V
Operating Ambient Temperature Range .... -40℃ to +85℃
Operating Junction Temperature Range ...... -40℃ to +125℃

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

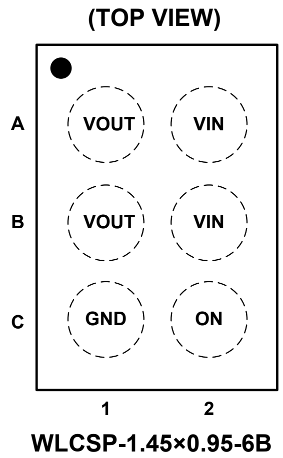
ESD SENSITIVITY CAUTION

This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

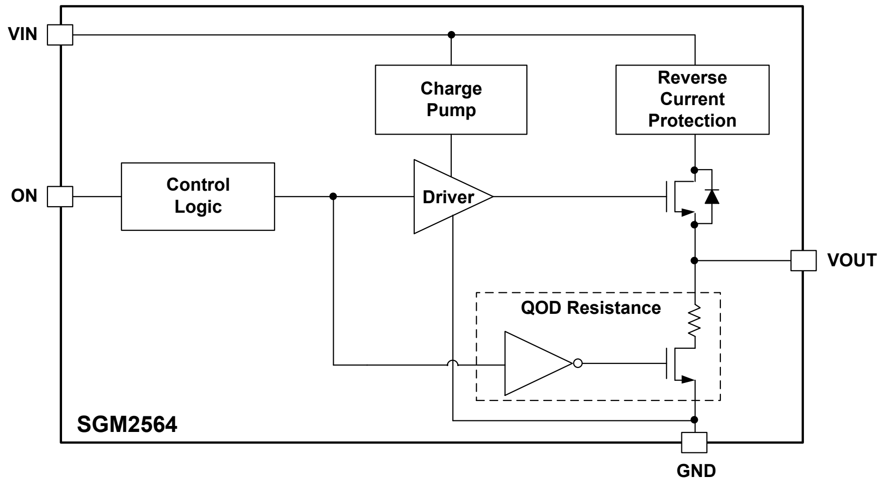
PIN CONFIGURATION



PIN DESCRIPTION

PIN	NAME	FUNCTION
A1, B1	VOUT	Switch Output.
A2, B2	VIN	Switch Input. Use a bypass capacitor (ceramic) to ground.
C1	GND	Ground.
C2	ON	Switch Control Input. Do not float this pin. Logic high turns on power switch.

FUNCTIONAL BLOCK DIAGRAM



FUNCTIONAL TABLE

ON	VIN to VOUT	Output Discharge (1)
L	Off	Active
H	On	Disabled

NOTE: 1. This feature discharges the output of the switch to ground through a 270Ω resistor, preventing the output from floating.

ELECTRICAL CHARACTERISTICS

(V_{IN} = 1V to 5.5V, C_{IN} = 1μF, C_{OUT} = 0.1μF, Full = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}		Full	1		5.5	V
Quiescent Current	I_Q	V_{IN} = 5.5V, V_{ON} = 1.2V, I_{OUT} = 0mA	Full		600	960	nA
		V_{IN} = 3.3V, V_{ON} = 1.2V, I_{OUT} = 0mA			440	700	
		V_{IN} = 1V, V_{ON} = 1.2V, I_{OUT} = 0mA			250	460	
Shutdown Current	I_{SD}	V_{IN} = 5.5V, V_{ON} = 0V	Full		180	550	nA
Supply Leakage Current in Shutdown Mode	$I_{LEAKAGE}$	V_{IN} = 5.5V, V_{ON} = 0V, V_{OUT} = 0V	Full			560	nA
On-Resistance	R_{ON}	V_{IN} = 3.3V, V_{ON} = 1.2V, I_{OUT} = -200mA	Full		16	35	mΩ
		V_{IN} = 1.8V, V_{ON} = 1.2V, I_{OUT} = -200mA			16	35	mΩ
ON Pin Hysteresis	V_{HYS}	V_{IN} = 5V	Full		56		mV
		V_{IN} = 3.3V			47		
		V_{IN} = 1.8V			37		
		V_{IN} = 1V			35		
ON Pin Leakage Current	I_{ON}	V_{ON} = 5.5V	Full			720	nA
Reverse Current When Disabled	I_{RC}	V_{IN} = V_{ON} = 0V, V_{OUT} = 5V	Full			1	μA
Output Pull-Down Resistance	R_{PD}	V_{IN} = 2.5V, V_{ON} = 0V, I_{OUT} = 2mA	Full		280	400	Ω
		V_{IN} = 5V, V_{ON} = 0V, I_{OUT} = 2mA			270	390	
ON Pin Input Low Voltage	V_{IL}		Full			0.4	V
ON Pin Input High Voltage	V_{IH}		Full	1.1			

SWITCHING CHARACTERISTICS

(C_{IN} = 1μF, C_{OUT} = 0.1μF, R_{OUT} = 10Ω, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN} = 5.0V, T_J = +25℃, unless otherwise noted.						
Turn-On Time	t_{ON}	Figure 2 and Figure 3		1200		μs
Turn-Off Time	t_{OFF}			30		
V_{OUT} Rise Time	t_R			1000		
V_{OUT} Fall Time	t_F			25		
Delay Time	t_D			920		
V_{IN} = 3.3V, T_J = +25℃, unless otherwise noted.						
Turn-On Time	t_{ON}	Figure 2 and Figure 3		1050		μs
Turn-Off Time	t_{OFF}			30		
V_{OUT} Rise Time	t_R			850		
V_{OUT} Fall Time	t_F			25		
Delay Time	t_D			850		

PARAMETER MEASUREMENT INFORMATION

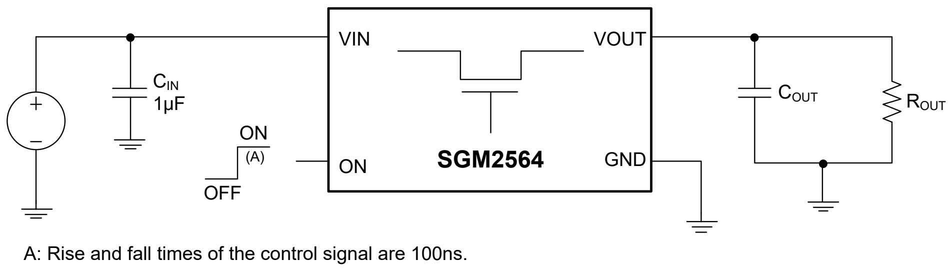


Figure 2. Test Circuit

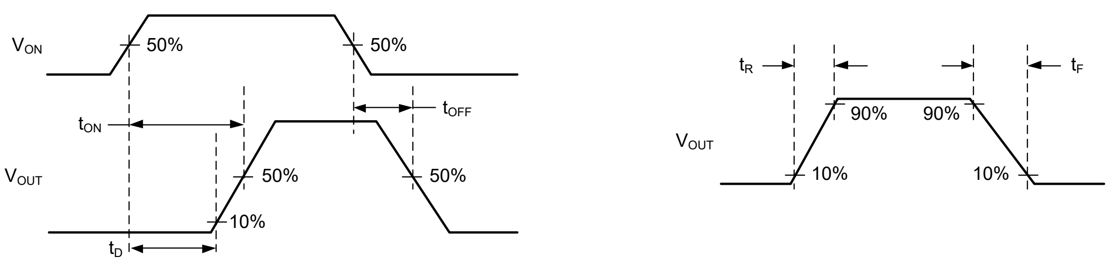
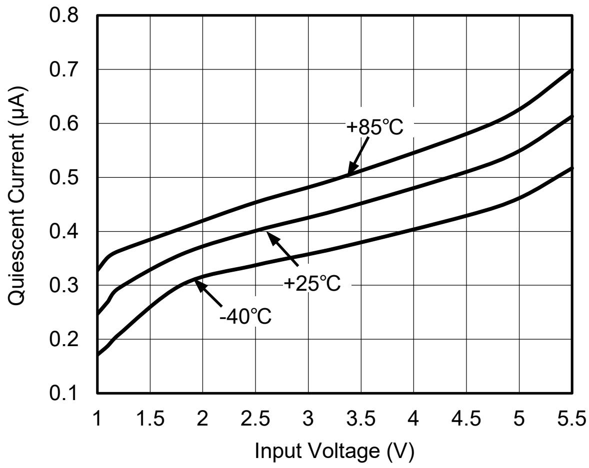


Figure 3. Timing Waveforms

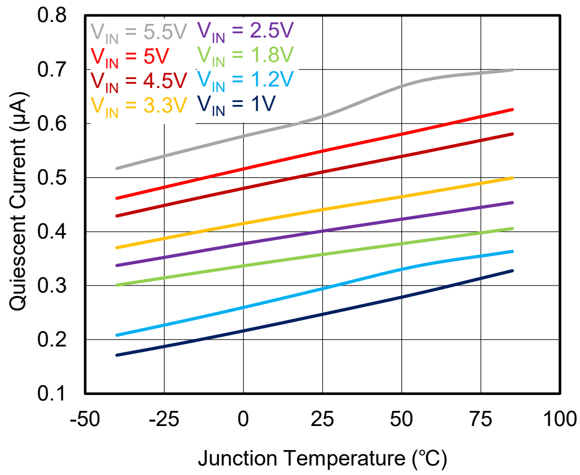
TYPICAL PERFORMANCE CHARACTERISTICS

C_{IN} = 1μF, C_{OUT} = 0.1μF, R_{OUT} = 10Ω, V_{IH} = 1.2V, V_{IL} = 0V, T_J = +25℃, unless otherwise noted.

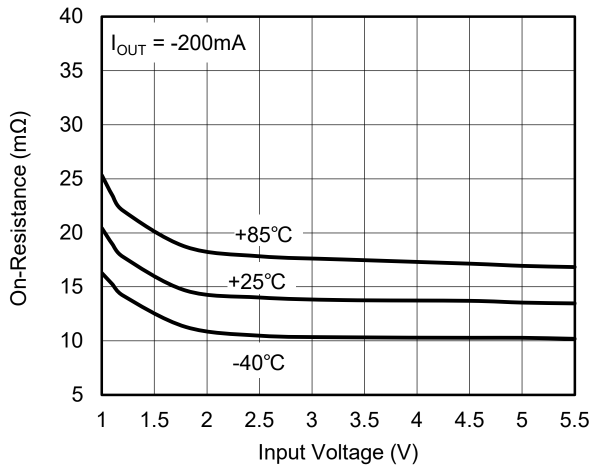
Quiescent Current vs. Input Voltage



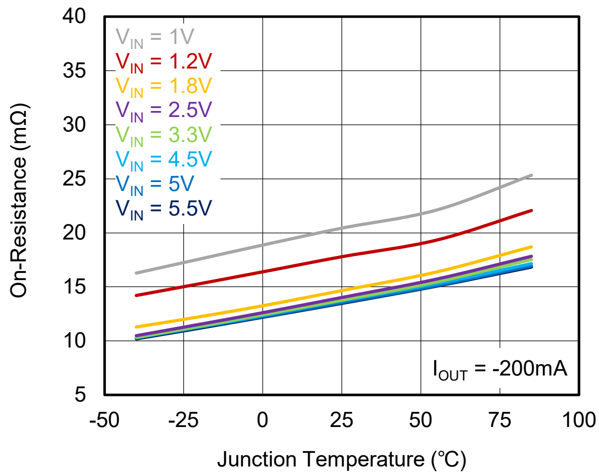
Quiescent Current vs. Junction Temperature



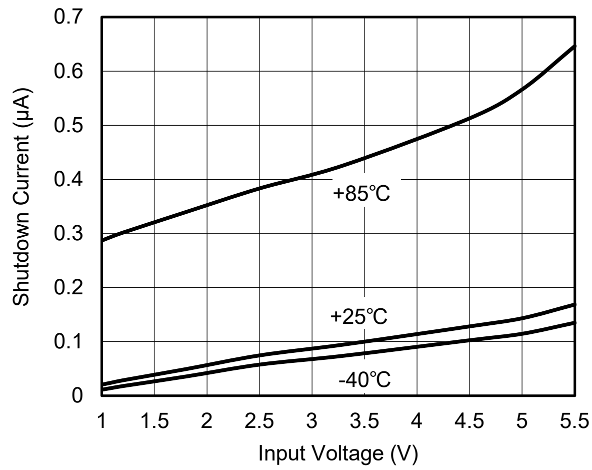
On-Resistance vs. Input Voltage



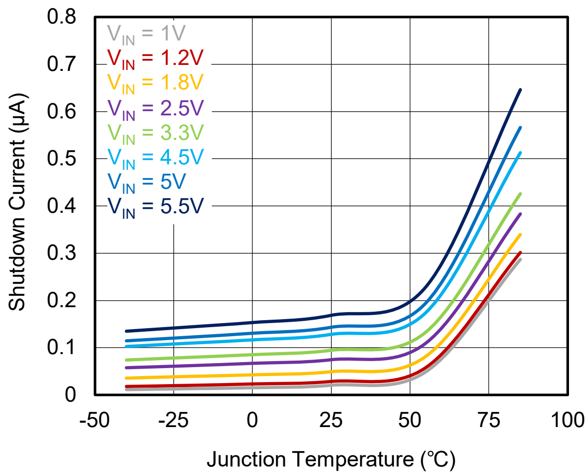
On-Resistance vs. Junction Temperature



Shutdown Current vs. Input Current

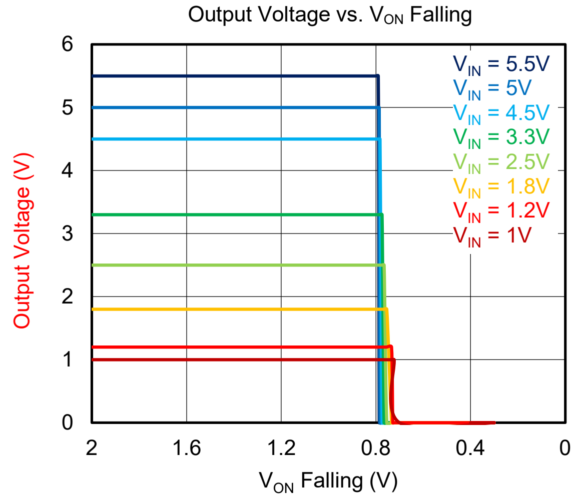


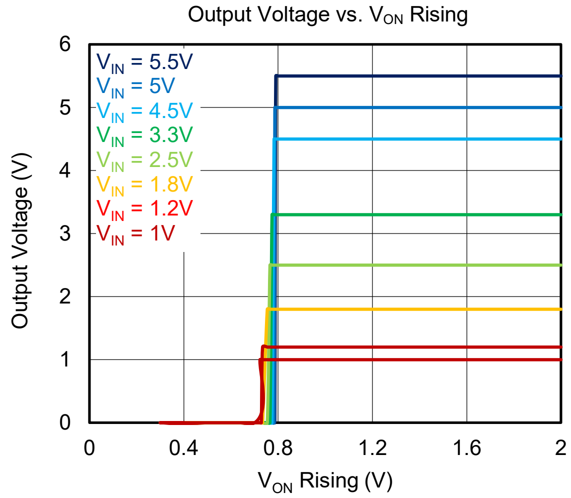
Shutdown Current vs. Junction Temperature

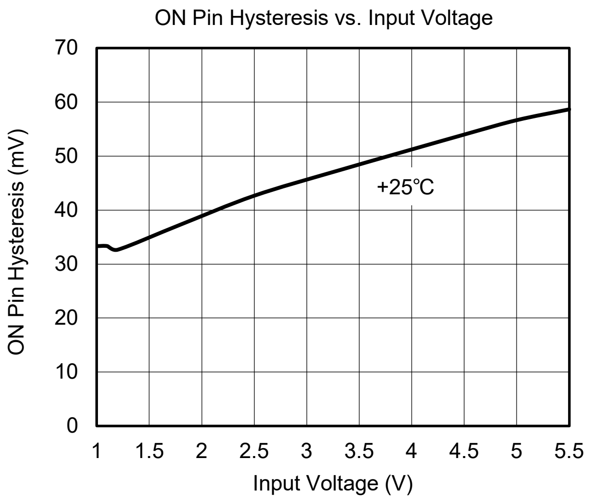


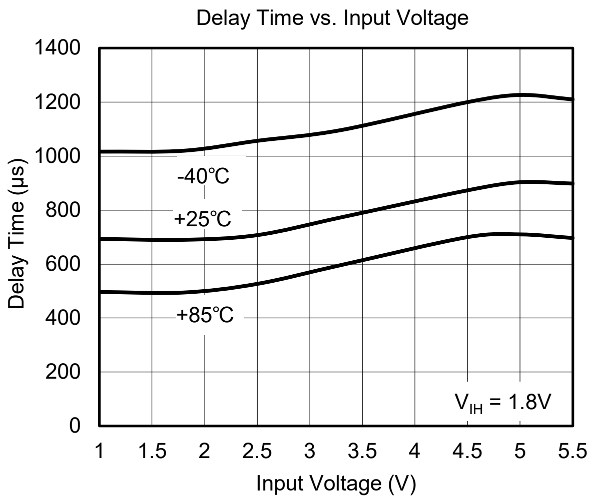
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

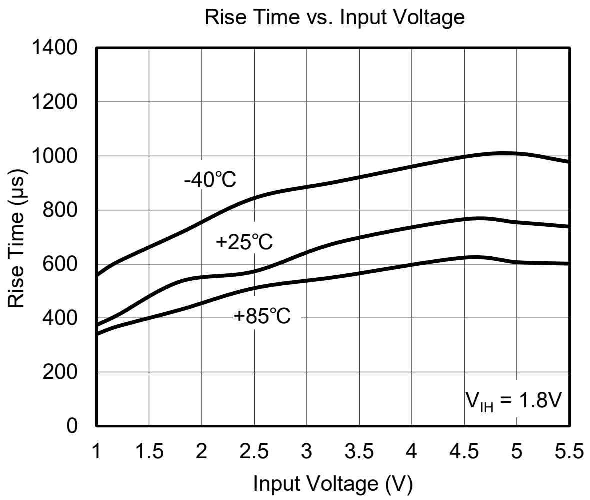
C_{IN} = 1μF, C_{OUT} = 0.1μF, R_{OUT} = 10Ω, V_{IH} = 1.2V, V_{IL} = 0V, T_J = +25℃, unless otherwise noted.

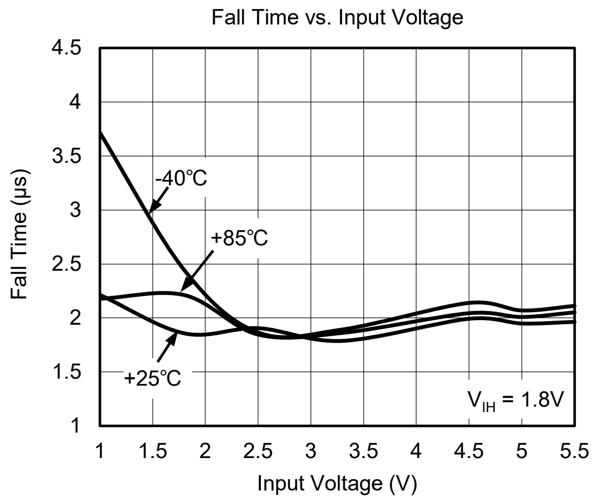






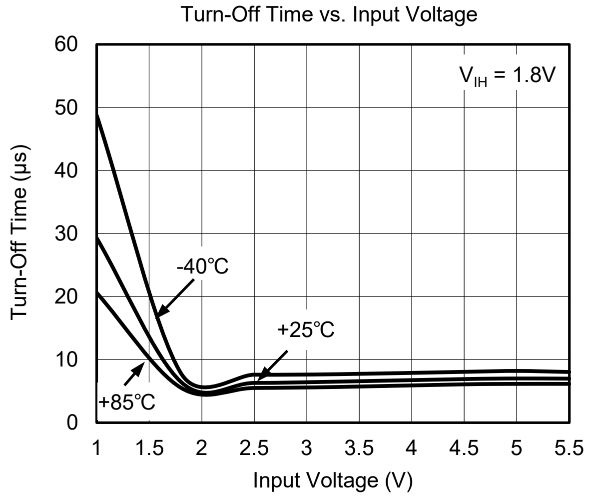


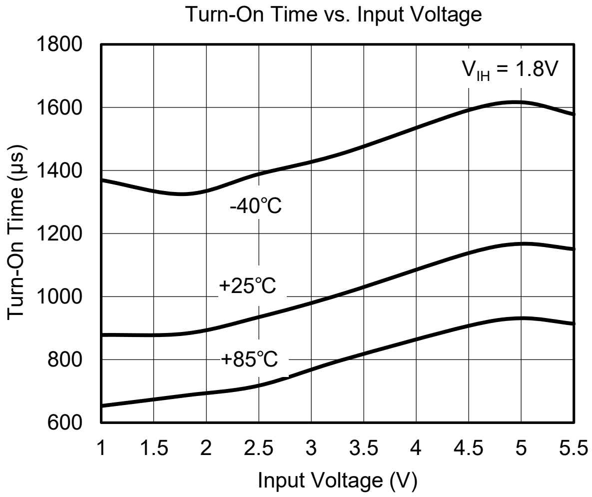


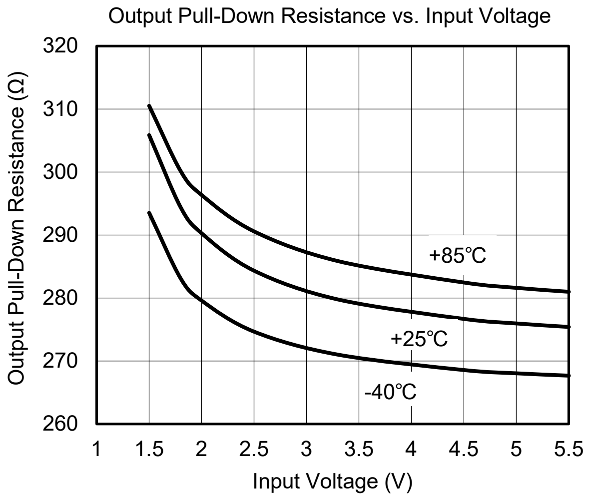


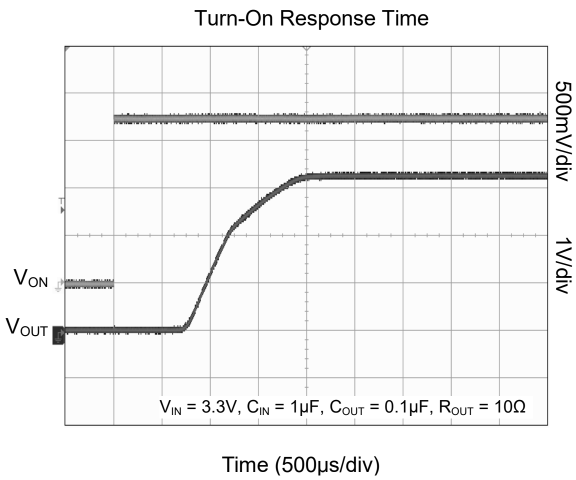
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

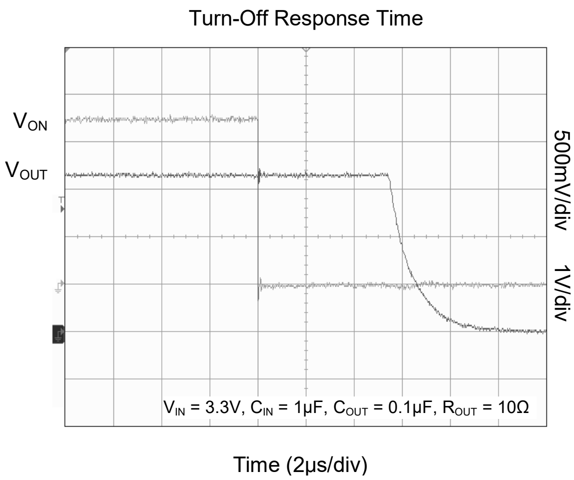
C_{IN} = 1μF, C_{OUT} = 0.1μF, R_{OUT} = 10Ω, V_{IH} = 1.2V, V_{IL} = 0V, T_J = +25℃, unless otherwise noted.











DETAILED DESCRIPTION

The SGM2564 is a single channel, up to 4A load switch in a small, space saving WLCSP package. This device implements an N-MOSFET to provide an ultra-low on-resistance for a low voltage drop across the device. A controlled rise time is used in applications to limit the inrush current.

On/Off Control

The ON pin controls the state of the switch. It is an active "high" pin and has a low threshold making it capable of interfacing with low voltage GPIO control signals. It can be used with any microcontroller with 1.2V GPIOs. Applying V_{IH} on the ON pin will put the switch in the on-state and V_{IL} will put the switch in the off-state.

Quick Output Discharge

The SGM2564 integrates the quick output discharge (QOD) feature. When the switch is disabled (below V_{IL}), a discharge resistance with a typical value of 270Ω is connected between the output and ground. This resistance pulls down the output and prevents it from floating when the device is disabled.

APPLICATION INFORMATION

Input Capacitor

To limit the voltage drop on the input supply caused by transient inrush currents when the switch turns on into a discharged load capacitor, a capacitor needs to be placed between VIN and GND pins. A 1μF ceramic capacitor (C_{IN}) must be placed close to the VIN pin. A higher value of C_{IN} can be used to further reduce the voltage drop experienced as the switch is turned on into a large capacitive load.

Output Capacitor

A 0.1μF output capacitor (C_{OUT}) should be placed between VOUT and GND pins. This capacitor will prevent parasitic board inductances from forcing V_{OUT} to be negative when the switch turns off. It is generally recommended to have C_{IN} greater than C_{OUT} so that once the switch is turned on, C_{OUT} can charge up to V_{IN} without V_{IN} dropping significantly. A 0.1μF ceramic capacitor that is placed close to the IC pins is usually sufficient.

Standby Power Reduction

Any end equipment that is being powered from the battery has a need to reduce current consumption in order to keep the battery charged for a longer time. SGM2564 helps to accomplish this by turning off the supply to the modules that is in standby state and hence significantly reduces the leakage current overhead of the standby modules.

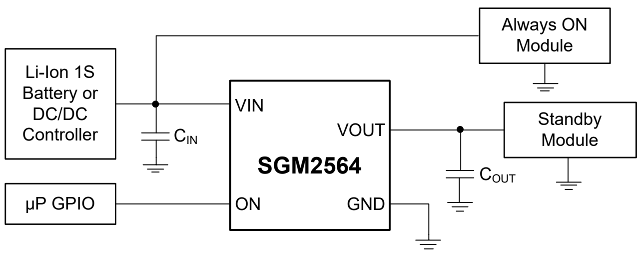


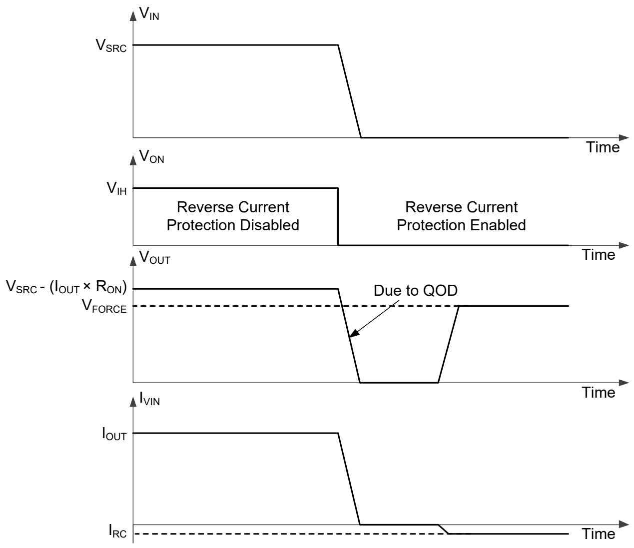
Figure 4. Standby Power Reduction

APPLICATION INFORMATION (continued)

Reverse Current Protection

The reverse current protection feature prevents the current to flow from VOUT to VIN when SGM2564 is disabled. This feature is particularly useful when the output of SGM2564 needs to be driven by another voltage source after SGM2564 is disabled (for example in a power multiplexer application). In order for this feature to work, SGM2564 has to be disabled and either of the following conditions shall be met: V_{IN} > 1V or V_{OUT} > 1V.

Figure 5 demonstrates the ideal behavior of reverse current protection circuit in SGM2564. After the device is disabled via the ON pin and VOUT pin is forced to an external voltage V_{FORCE}, a very small amount of current given by I_{RC}, V_{IN} will flow from V_{OUT} to V_{IN}. This will prevent any extra current loading on the voltage source supplying the V_{FORCE} voltage.



I_{VIN} = current through VIN pin.

V_{SRC} = input voltage applied to the device.

V_{FORCE} = external voltage source forced at VOUT pin of the device.

I_{OUT} = output load current.

Figure 5. Reverse Current Protection

Power Supply Sequencing without a GPIO Input

In many terminal devices, each module needs to be powered up in a pre-determined manner. SGM2564 can solve the power sequencing problem without increasing any complexity to the overall system. Figure 6 shows the configuration required to power up the two modules in a fixed sequence. The output of the first load switch is tied to the enable of the second load switch, so when module 1 is powered, the second load switch is enabled and module 2 is powered.

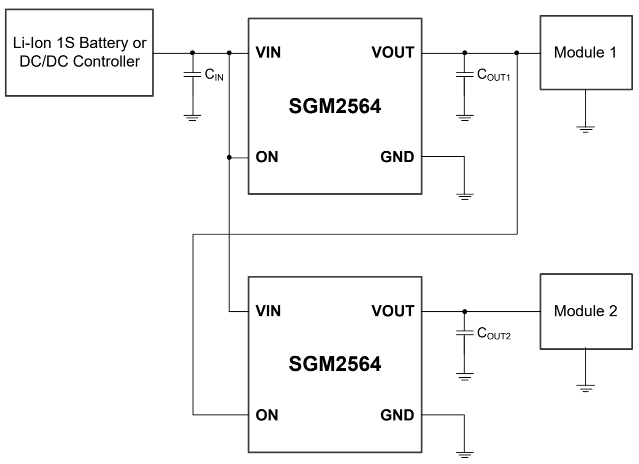


Figure 6. Power Supply Sequencing without a GPIO Input

Power Supply Recommendations

The device is designed to operate with a V_{IN} range of 1V to 5.5V. This supply must be well regulated and placed as close to the device terminal as possible with the recommended 1μF bypass capacitor. If the supply is located more than a few inches from the device terminals, additional bulk capacitance may be required in addition to the ceramic bypass capacitors. If additional bulk capacitance is required, an electrolytic, tantalum, or ceramic capacitor of 10μF may be sufficient.

TYPICAL APPLICATION

SGM2564 is a single channel, up to 4A load switch with ultra-low on-resistance, which can be directly connected to the 1S battery in portable consumer devices such as smartphones, NB-IoT, etc. Its wide input voltage range (from 1V to 5.5V) makes it suitable to be used for lower voltage rails as well inside different end equipment to accomplish power sequencing, inrush current control and reducing leakage current in sub-systems that are in standby mode. Figure 7 shows the typical application circuit of SGM2564.

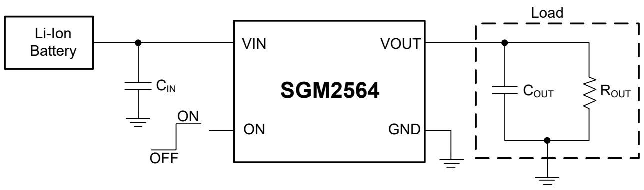


Figure 7. Typical Application Circuit

Design Requirements

Design Parameter	Example Value
V_{IN}	3.3V
C_L	4.7μF
Maximum Acceptable Inrush Current	30mA

Managing Inrush Current

When the switch is enabled, the output capacitors must be charged up from 0V to the set value (3.3V in this example). This charge arrives in the form of inrush current. Inrush current can be calculated using the following equation:

$$I_{INRUSH} = C_{OUT} \times \frac{dV_{OUT}}{dt}$$

where:

C_{OUT} is output capacitance.

dV_{OUT}/dt is desired output slew rate.

The SGM2564 offers controlled rise time for minimizing inrush current. This device can be selected based upon the minimum acceptable rise time which can be calculated using the design requirements and the inrush current equation. An output capacitance of 4.7μF will be used since the amound of inrush current increases with output capacitance:

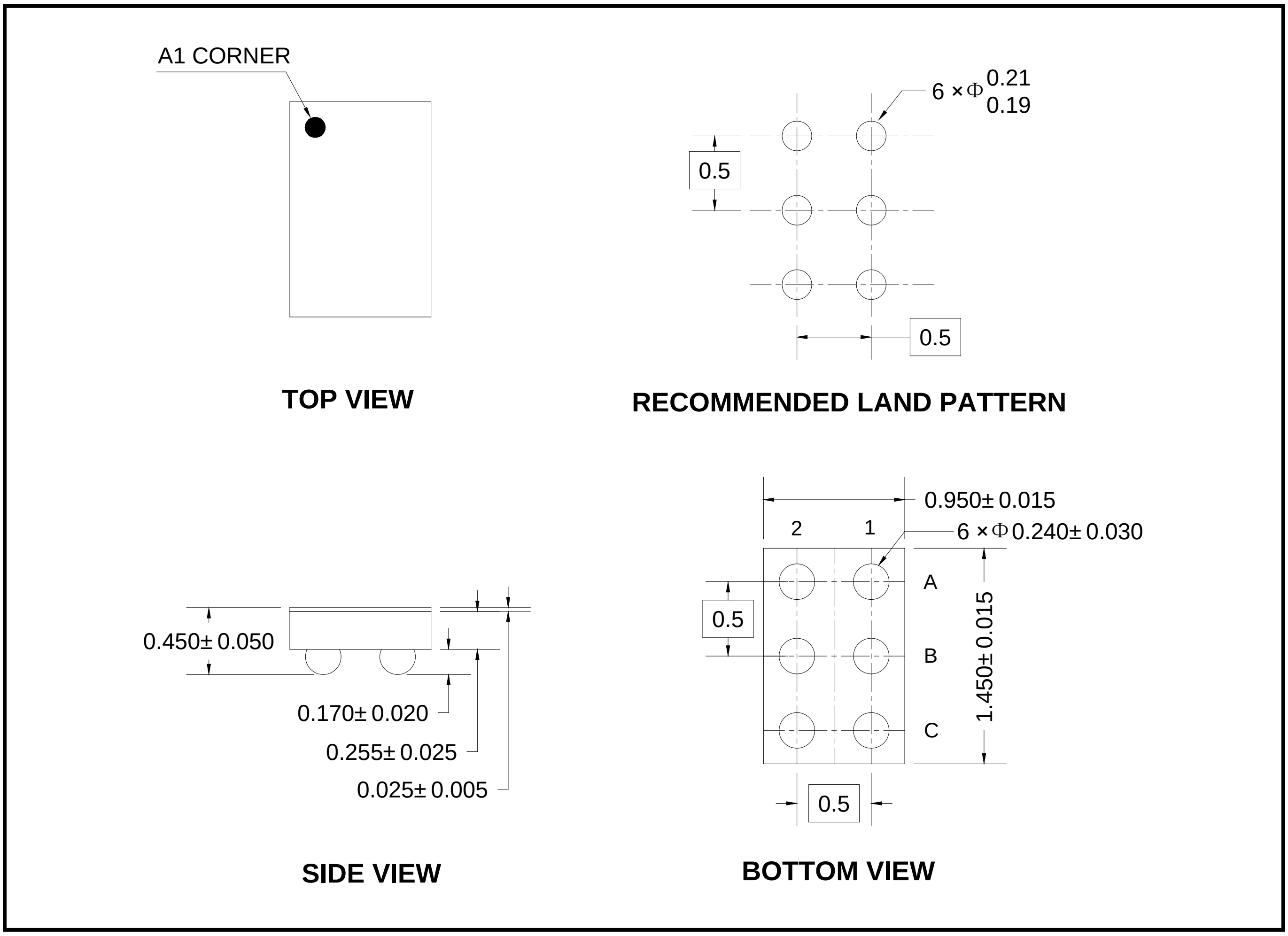
$$30mA = 4.7\mu F \times 3.3V/dt \quad (2)$$

$$dt = 517\mu s \quad (3)$$

To ensure an inrush current of less than 30mA, a device with a rise time greater than 517μs must be used. The SGM2564 has a typical rise time of 1000μs at 5V which meets the above design requirements.

PACKAGE OUTLINE DIMENSIONS

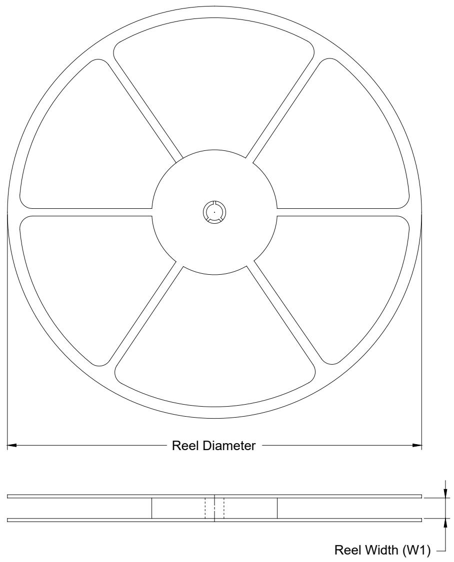
WLCSP-1.45×0.95-6B



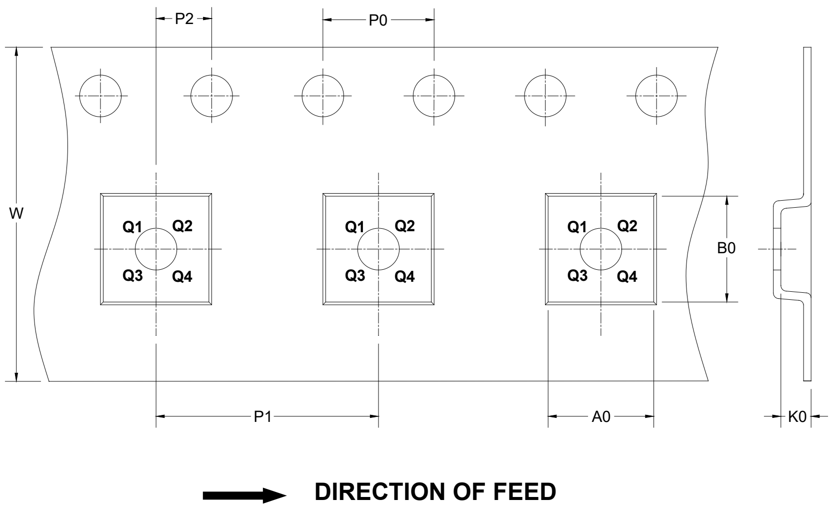
NOTE: All linear dimensions are in millimeters.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



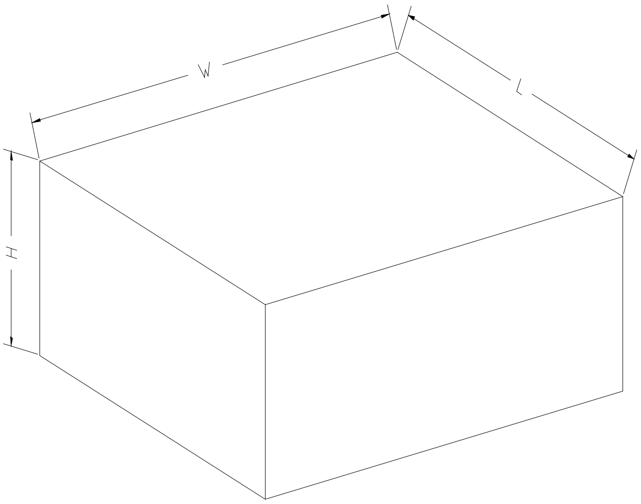
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
WLCSP-1.45×0.95-6B	7"	9.0	1.12	1.57	0.62	4.0	4.0	2.0	8.0	Q1

DD0001

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7″ (Option)	368	227	224	8
7″	442	410	224	18

DD0002