GENERAL DESCRIPTION

The SGM2057 is a negative output charge pump which has an inside adjustable regulator. The input voltage range is from 2.3V to 5.5V and the unregulated output equals to $-V_{IN}$. For the regulated output of the SGM2057, it equals to $-V_{CTL}$ and the range is from 0V to $-V_{IN}$.

The inrush current of the SGM2057 can be decreased by the internal soft-start circuit. For application case, four ceramic capacitors and no inductor are required, and it can be used for supplying optical modules, bias of RF amplifiers and sensors.

The SGM2057 is available in a Green TQFN-1.8×1.4-10L package. It operates over an operating temperature range of -40℃ to +125℃.

FEATURES

- **Input Voltage Range: 2.3V to 5.5V**
- **Dual Outputs:**
  - ◆ **V_{OUT1}: $-V_{IN}$**
    (Unregulated Negative Charge Pump Output)
  - ◆ **V_{OUT2}: $-V_{CTL}$ between 0V and $-V_{IN}$**
    (Regulated Output)
- **Output Current Limit: 175mA (TYP)**
- **Stable with Small Case Size Ceramic Capacitors**
- **Thermal Shutdown Protection**
- **No Inrush Current during Start-Up**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in a Green TQFN-1.8×1.4-10L Package**

APPLICATIONS

Optical Applications
Biasing of the Amplifier for RF
Supplying Sensors in Portable Devices
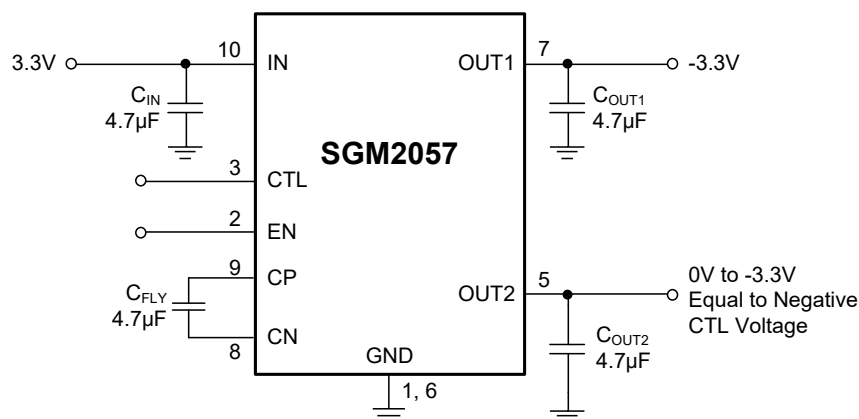
TYPICAL APPLICATION

Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM2057	TQFN-1.8×1.4-10L	-40℃ to +125℃	SGM2057XWQ10G/TR	S3H XXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XXX = Date Code and Trace Code.

Y Y Y —— Serial Number

X X X

┌──── Trace Code

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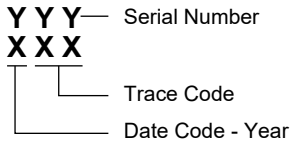
Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS

IN to GND .... -0.3V to 6V

CP to GND.. -0.3V to (V_{IN} + 0.3V)

CN, OUT2 to GND .... (V_{OUT1} - 0.3V) to 0.3V

OUT1 to GND .... -6V to 0.3V

All Other Pins to GND......................... -0.3V to 6V

Package Thermal Resistance

TQFN-1.8×1.4-10L, θ_{JA} .... 166℃/W

Junction Temperature.................................+150℃

Storage Temperature Range ....-65℃ to +150℃

Lead Temperature (Soldering, 10s)............................+260℃

ESD Susceptibility

HBM..4000V

CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Supply Voltage Range ....2.3V to 5.5V

Input Effective Capacitance, C_{IN} .... 1µF to 10µF

Fly Effective Capacitance, C_{FLY}...........................4.7µF (TYP)

OUT1 Effective Capacitance, C_{OUT1}....................... 1µF (MIN)

OUT2 Effective Capacitance, C_{OUT2}....................1µF to 10µF

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.
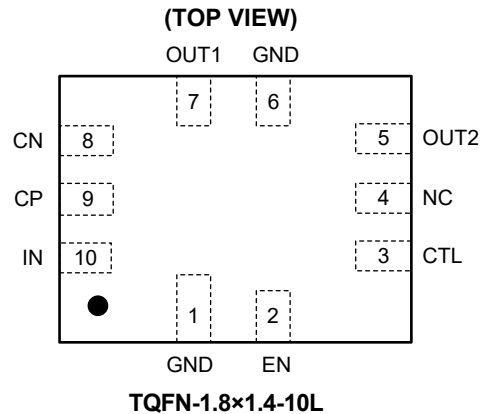
ESD SENSITIVITY CAUTION

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

(TOP VIEW)

TQFN-1.8×1.4-10L

PIN DESCRIPTION

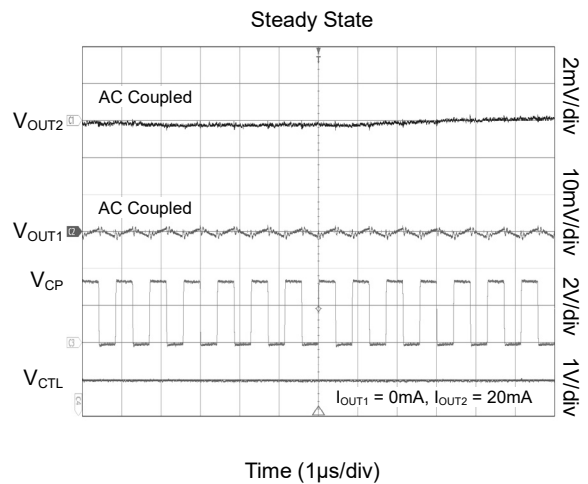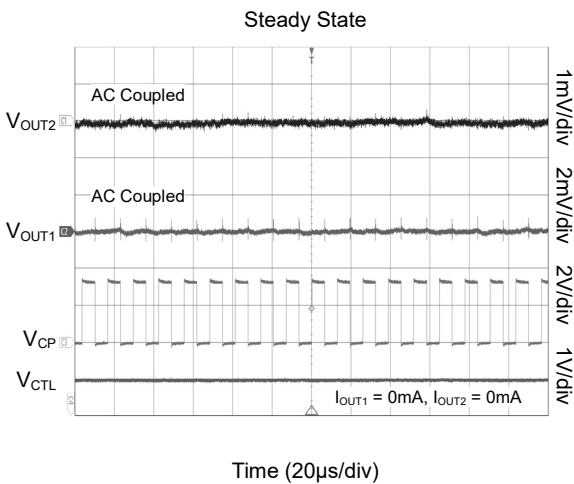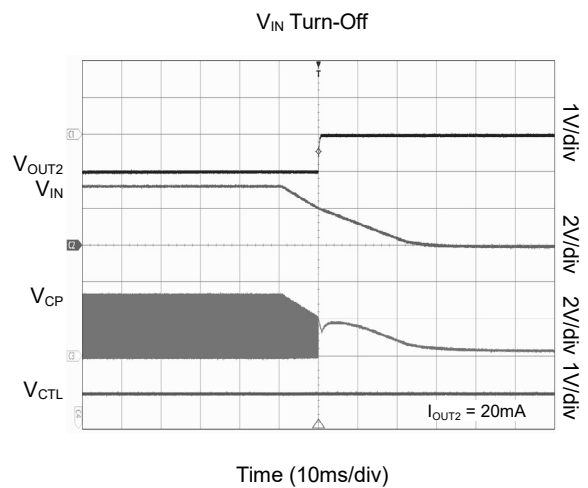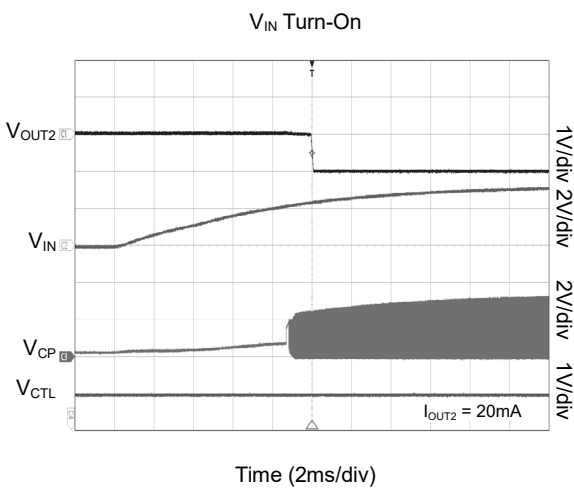| PIN	NAME	FUNCTION
1, 6	GND	Ground.
2	EN	Enable Pin. Drive EN high to turn on the device. Drive EN low to turn off the device. The EN pin has an internal pull-down resistance to ensure that the device is turned off when the EN pin is floating.
3	CTL	Analog Input Voltage Pin. $V_{OUT2} = -V_{CTL}$.
4	NC	Recommend connecting this pin to GND.
5	OUT2	Regulator Output Pin. It is recommended to use an output capacitor (C_{OUT2}) with effective capacitance in the range of 1µF to 10µF.
7	OUT1	Negative Charge Pump Output Pin. It is recommended to use an output capacitor (C_{OUT1}) with effective capacitance in the range of 1µF to 10µF.
8	CN	Negative Connection for the Charge Pump Flying Capacitor.
9	CP	Positive Connection for the Charge Pump Flying Capacitor.
10	IN	Input Voltage Supply Pin. Decoupling capacitor should be added for this power supply.

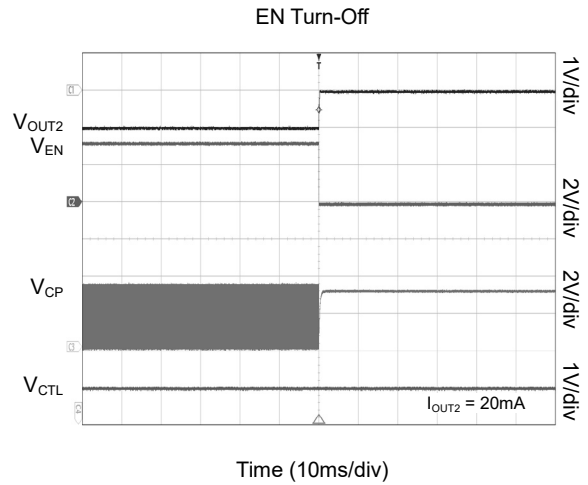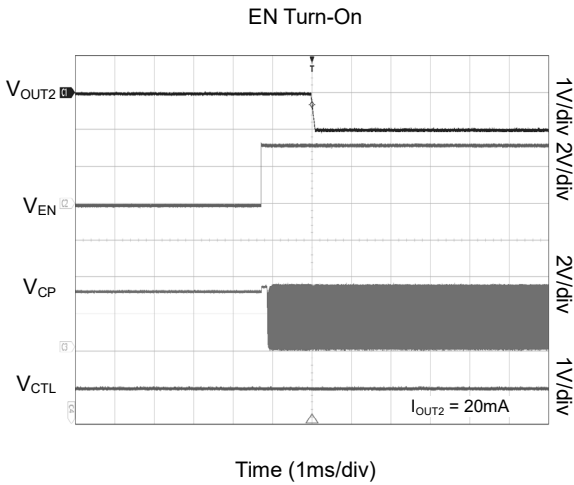# ELECTRICAL CHARACTERISTICS

(V_{IN} = 3.3V, C_{IN} = C_{FLY} = C_{OUT1} = C_{OUT2} = 4.7µF, T_J = -40℃ to +125℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}			2.3		5.5	V
Input Under-Voltage Lockout Threshold	V_{IN_UVLO}	V_{IN} rising			2.2	2.3	V
UVLO Threshold Hysteresis	V_{IN_HYS}			60	90	120	mV
Shutdown Current	I_{SHDN}	V_{EN} = 0V			0.1	1	µA
Quiescent Current	I_Q	V_{EN} = 2V, force V_{OUT1} = -3.4V, no switching	T_J = +25℃		170	210	µA
			T_J = -40℃ to +125℃		170	230	
Charge Pump MOSFET On-Resistance	R_{ON}				0.28		Ω
Negative Linear Regulator							
Output Current Limit	I_{LIMIT}	V_{IN} = 3.3V, V_{OUT2} = -2.5V			175	240	mA
Output Voltage		V_{CTL} = 2.5V, I_{OUT2} = 10mA	T_J = +25℃	-2.532	-2.507	-2.482	V
			T_J = -40℃ to +125℃	-2.544	-2.507	-2.47	
Output Offset Voltage		I_{OUT2} = 10mA		-22		22	mV
Dropout Voltage	V_{DROP}	V_{IN} = 2.5V, I_{OUT2} = 60mA		15		66	mV
		V_{IN} = 3.3V, I_{OUT2} = 60mA		5		58	
Load Regulation	ΔV_{OUT}	V_{OUT1} = -3.3V, V_{CTL} = 1V, I_{OUT2} = 0 to 150mA			0.004	0.015	%/mA
Power Supply Rejection Ratio	PSRR	C_{OUT1} = 1µF, C_{OUT2} = 1µF, I_{OUT2} = 10mA	f = 100Hz		70		dB
			f = 50kHz		30		
Soft-Start Slew Rate					10		V/ms
EN Turn-On Delay				80		255	µs
EN Input Threshold	V_{IL}	Logic low				0.4	V
	V_{IH}	Logic high		1.2			
Output Discharge Resistance	R_{DIS1}	V_{EN} = 0V, OUT1 rail			130		Ω
	R_{DIS2}	V_{EN} = 0V, OUT2 rail			125		
EN Input Current	I_{EN}	V_{EN} = 2V		1.2	1.8	2.4	µA
		V_{EN} = 0V			0		
Thermal Shutdown Temperature	T_{SHDN}				160		℃
Thermal Shutdown Hysteresis	ΔT_{SHDN}				20		℃
System Level							
OUT1 Pin Voltage					-1×		V_{IN}
Output Ripple	V_{RIPPLE_OUT1}	V_{IN} = 3.3V, V_{OUT1} = -3.3V, C_{FLY} = C_{OUT1} = 4.7µF, I_{OUT1} = 60mA			7		mV
	V_{RIPPLE_OUT2}	V_{IN} = 3.3V, V_{OUT2} = 2.5V, C_{OUT2} = 1µF, I_{OUT2} = 60mA			2		
	V_{RIPPLE_OUT2}	V_{IN} = 3.3V, V_{OUT2} = 2.5V, C_{OUT2} = 4.7µF, I_{OUT2} = 60mA			2		

TYPICAL PERFORMANCE CHARACTERISTICS

T_J = +25℃, V_{IN} = 3.3V, V_{OUT1} = -3.3V, V_{OUT2} = -1V, C_{IN} = C_{FLY} = C_{OUT1} = C_{OUT2} = 4.7µF, unless otherwise noted.

EN Turn-On

Time (1ms/div)

EN Turn-Off

Time (10ms/div)

V_{IN} Turn-On

Time (2ms/div)

V_{IN} Turn-Off

Time (10ms/div)

Steady State

Time (20µs/div)

Steady State

Time (1µs/div)

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_J = +25℃, V_{IN} = 3.3V, V_{OUT1} = -3.3V, V_{OUT2} = -1V, C_{IN} = C_{FLY} = C_{OUT1} = C_{OUT2} = 4.7µF, unless otherwise noted.
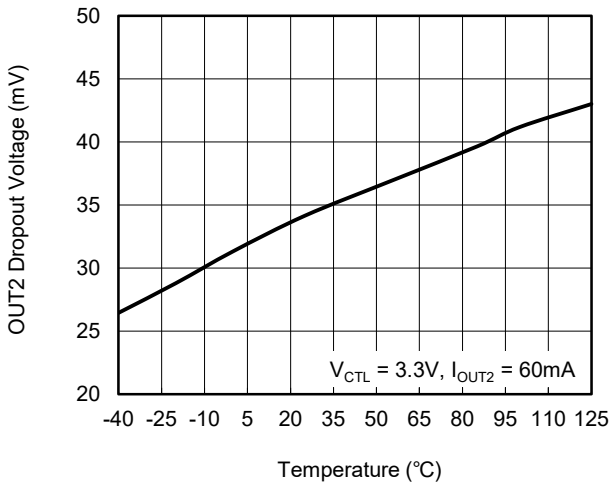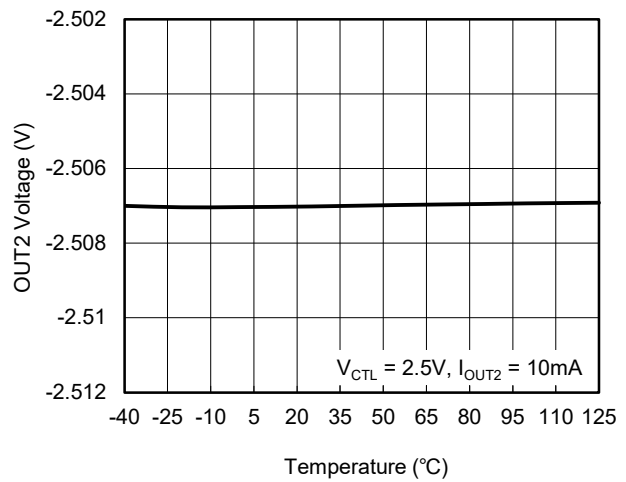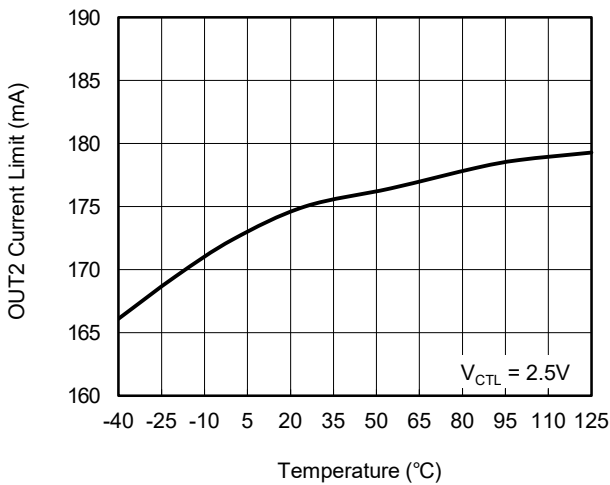
Steady State
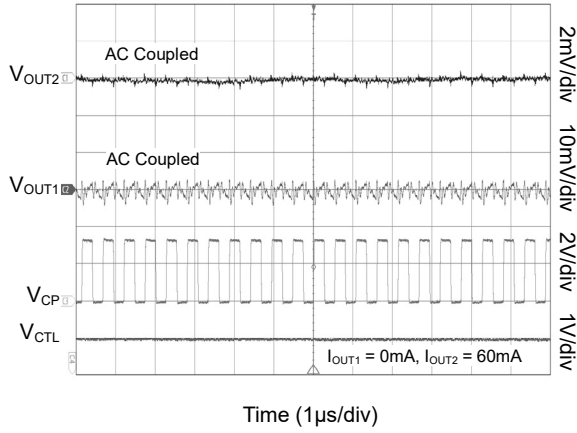
Load Capability
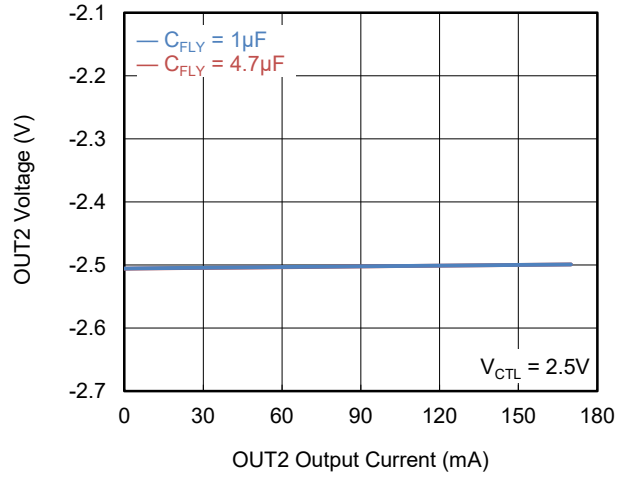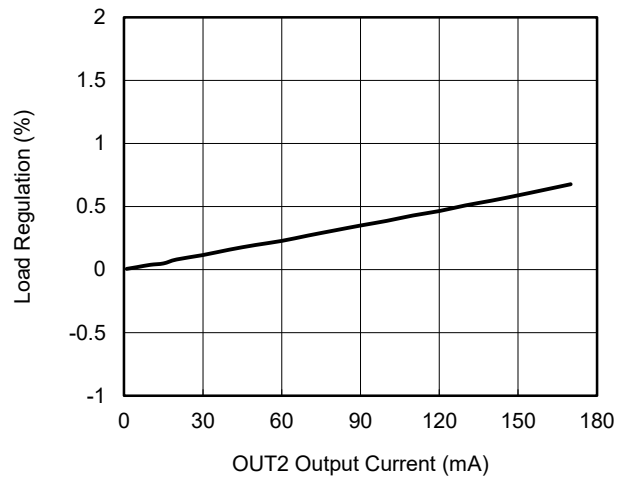

OUT2 Dropout Voltage vs. Temperature

OUT2 Voltage vs. Temperature

OUT2 Current Limit vs. Temperature

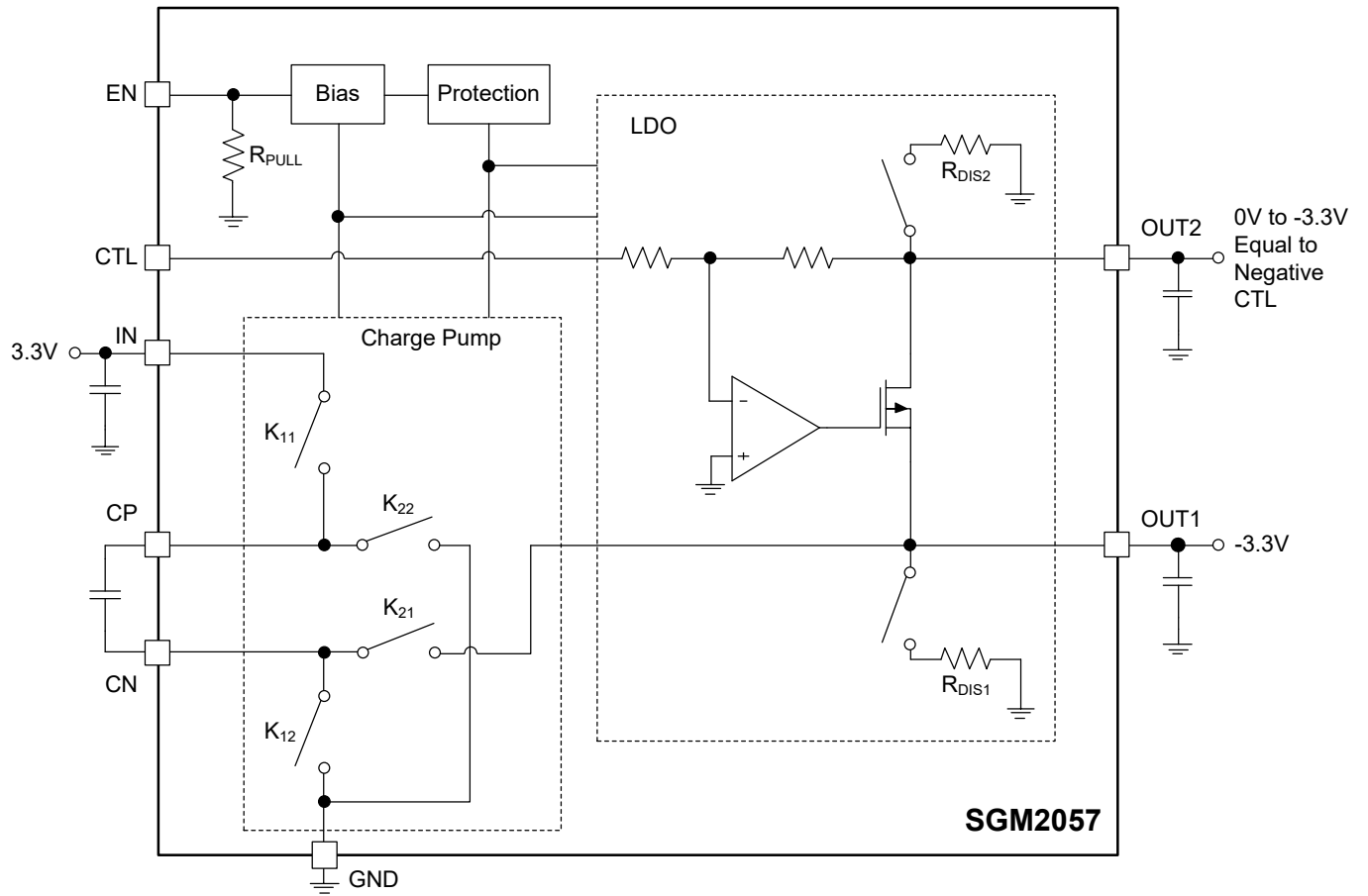Negative Linear Regulator Load Regulation

FUNCTIONAL BLOCK DIAGRAM

Figure 2. Functional Block Diagram

APPLICATION INFORMATION

The SGM2057 is a negative output charge pump which has an inside adjustable regulator. The input voltage range is from 2.3V to 5.5V and the unregulated output equals to -V_{IN}. For the regulated output of the SGM2057, it equals to -V_{CTL} and the range is from 0V to -V_{IN}.

The inrush current of the SGM2057 can be decreased by the internal soft-start circuit.

Negative Charge Pump

The technology of getting -V_{IN} (unregulated output) is by using the switched capacitors. Use an integrated oscillator to create a switching signal for driving the charge pump. The switching frequency of the oscillator is from 80kHz to 1875kHz (TYP). Also, the switching frequency can be changed with the dropout voltage between V_{IN} and V_{OUT1}. When heavy load occurs, this frequency will increase to compensate the output ripple.

The SGM2057 will assume that there is an over-current condition if V_{OUT1} < V_{IN}/2, so that the switching frequency of oscillator will be forced at 80kHz for fold-back.

Negative Linear Regulator

The negative linear regulator V_{OUT2} is integrated with the charge pump which powers it. For the properties of the internal regulator, the dropout voltage, quiescent supply and the output noise are extremely low. Also, the range is from 0V to V_{OUT1}.

V_{OUT2} is controlled by the feedback loop of the linear regulator and the relationship between V_{CTL} and V_{OUT2} is V_{CTL} = -V_{OUT2}. Also, the regulator provides a convenient interface for DAC, and the output of the SGM2057 can be driven by the input of DAC directly.

The output ripple of the negative linear regulator is extremely low because of the special design of Power Supply Rejection Ratio for its charge pump.

Output Voltage Setting

The absolute output voltage of the internal regulator is equal to V_{CTL}, which means that V_{OUT2} = -V_{CTL}. The analog input pin (CTL) can be connected directly to the output of DAC. The application circuit is shown as below:
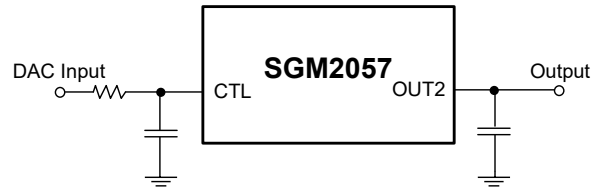

Figure 3. Output Voltage Setting

Enable Operation

The SGM2057 uses the EN pin to enable/disable the device and to deactivate/activate the output automatic discharge function.

When the EN pin voltage is lower than 0.4V, the device is in shutdown state. There is no current flowing from IN to OUT pins. In this state, the automatic discharge transistor is active to discharge the output voltage through R_{DIS1} (typically 130Ω) and R_{DIS2} (typically 125Ω).

When the EN pin voltage is higher than 1.2V, the device is in active state. The output voltage is regulated to the expected value and the automatic discharge transistor is turned off.

Equivalent Output Resistance

The charge pump frequency and fly capacitor determine the output resistance of the SGM2057 as shown in the following equation:

$$R_O = \frac{1}{f \times C_{FLY}} + 8 \times R_{ON} \qquad (1)$$

where:
R_{ON} is the on-resistance of each charge pump MOSFET.

The output current (I_O) and resistance (R_O) determine the charge pump output V_{OUT1} as shown in the following equation:

$$V_{OUT1} = - (V_{IN} - I_O \times R_O) \qquad (2)$$

Soft-Start

Soft-start circuitry is integrated into the IC, which supplies the controlled slew rate for the output voltage of the linear regulator to prevent the SGM2057 from overshoot at the instant of start-up. The typical ramp-up time is within 500µs (TYP). For the typically value of slew-rate, it can reach 10V/ms (TYP).

APPLICATION INFORMATION (continued)

Load Capability

The summation of I_{OUT1} and I_{OUT2} should be less than 175mA (TYP) because of the limitation of the load capability. Also, the changes of load capability are associated with output and fly capacitors. If the selected capacitors are smaller, the load capability will be decreased.

Input Capacitor Selection (C_{IN})

The input decoupling capacitor is necessary to be connected as close as possible to the IN pin. A 1µF to 10µF dielectric X7R or X5R ceramic capacitor is selected to get good dynamic performance.

Output Capacitor Selection (C_{OUT1}, C_{OUT2})

The output decoupling capacitors should be located as close as possible to the OUT pins. A 1µF capacitor for C_{OUT1} and a 1µF to 10µF capacitor for C_{OUT2} are selected to get good dynamic performance. For ceramic capacitor, temperature, DC bias and package size will change the effective capacitance, so enough margins of C_{OUT1} and C_{OUT2} must be considered in design.

Fly Capacitor Selection (C_{FLY})

According to Equation 1, the output voltage and resistance will be affected by the capacitance of the C_{FLY}. If the users prepare to use the charge pump in heavy load condition, it is recommended to set a larger capacitor than normal to handle this situation. For application, the C_{FLY} should be closed to both C_{IN} and C_{OUT1}, and it is a good choice to set the capacitance of these three capacitors equally.

Thermal Shutdown Protection

The SGM2057 can detect the temperature of die. When the die temperature exceeds the threshold value of thermal shutdown, the SGM2057 will be in shutdown state and it will remain in this state until the die temperature decreases to +140℃ (TYP).

Under-Voltage Lockout (UVLO)

The UVLO circuit monitors the input voltage to prevent the device from turning on before V_{IN} rises above the V_{UVLO} threshold. The UVLO circuit responds quickly to glitches on the IN pin and attempts to disable the output of the device if either of these rails collapses. The local input capacitance prevents severe brownouts in most applications.

PCB Layout

To obtain better performance of the SGM2057, the input and output bypass capacitors must be placed as close as possible to the IN pin and OUTx pins separately. There are four high-current paths which are GND, IN, CP and CN. The short and wide traces must be used to connect these pins.

REVISION HISTORY

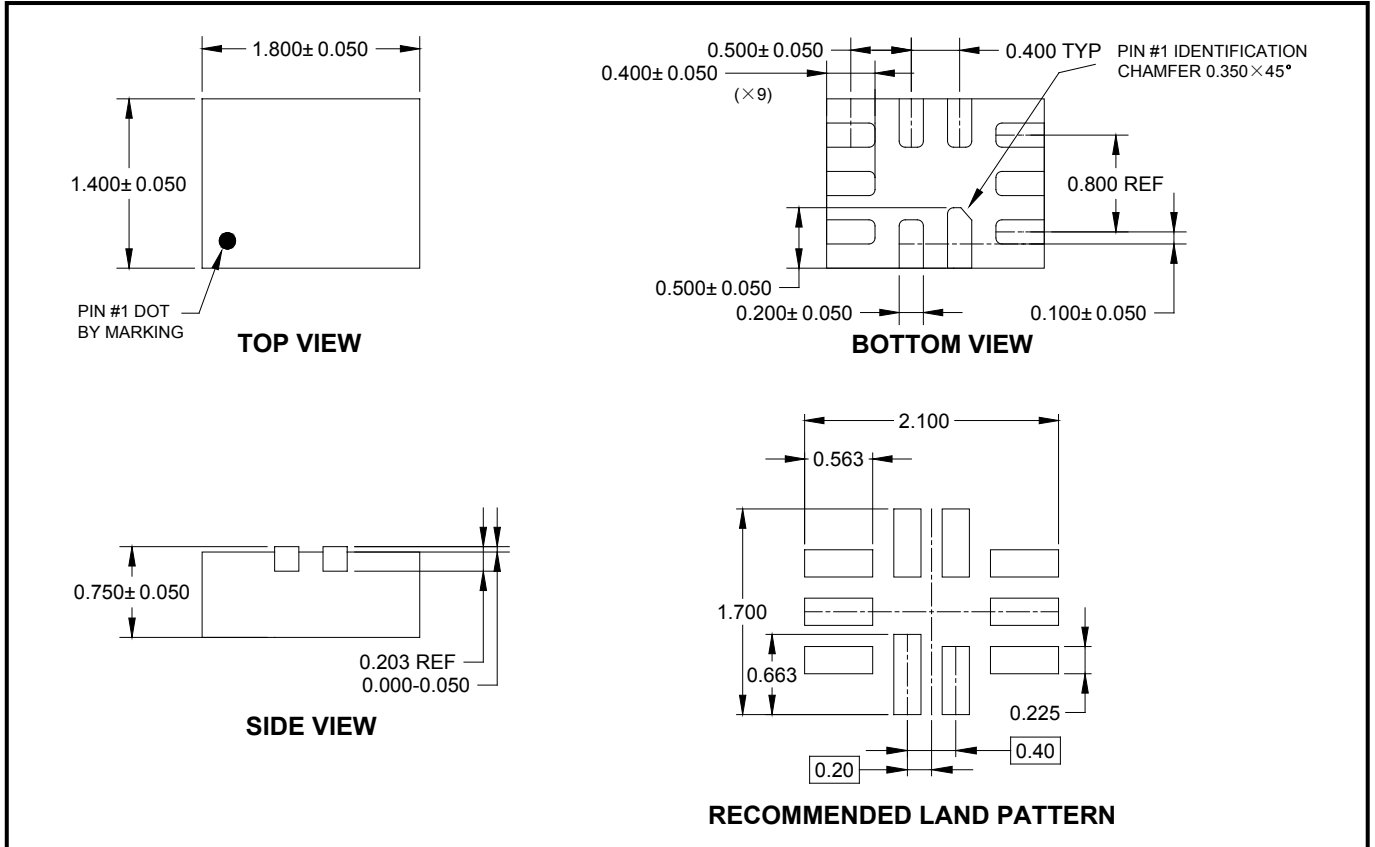NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

PACKAGE OUTLINE DIMENSIONS

TQFN-1.8×1.4-10L

1.800± 0.050

1.400± 0.050

PIN #1 DOT
BY MARKING

TOP VIEW

0.500± 0.050

0.400± 0.050

(×9)

0.400 TYP

PIN #1 IDENTIFICATION
CHAMFER 0.350×45°

0.800 REF

0.500± 0.050

0.200± 0.050

0.100± 0.050

BOTTOM VIEW

0.750± 0.050

0.203 REF
0.000-0.050

SIDE VIEW

2.100

0.563

1.700

0.663

0.225

0.20

0.40

RECOMMENDED LAND PATTERN

NOTE: All linear dimensions are in millimeters.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

TAPE DIMENSIONS
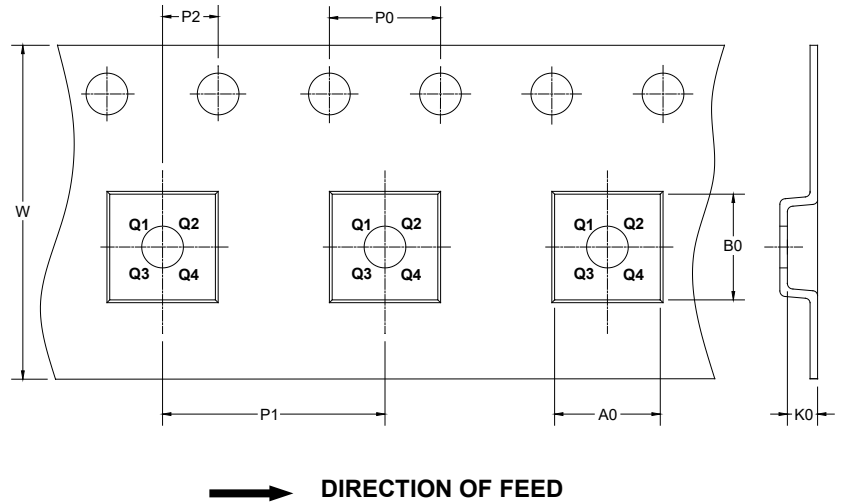
DIRECTION OF FEED

NOTE: The picture is only for reference. Please make the object as the standard.
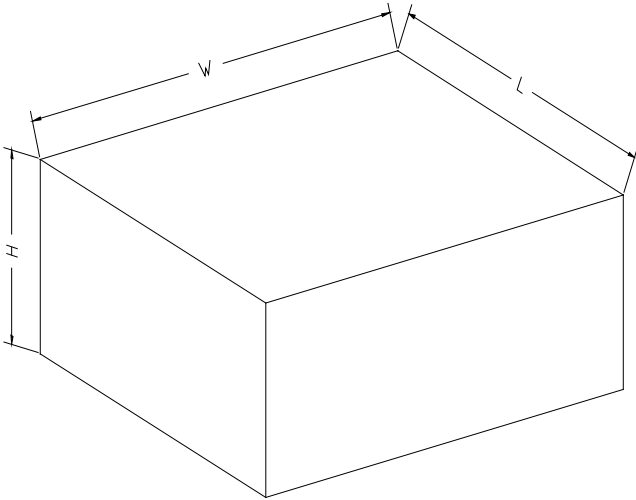
KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
TQFN-1.8×1.4-10L	7"	9.0	1.75	2.10	1.00	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