

### 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  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

### 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**
- **$-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  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

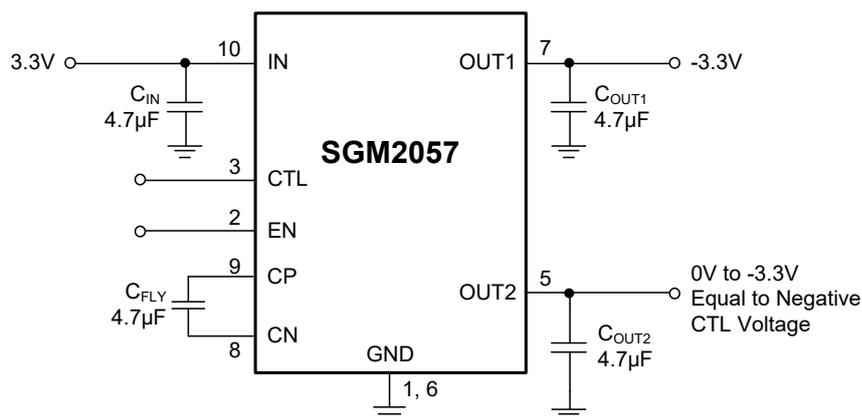


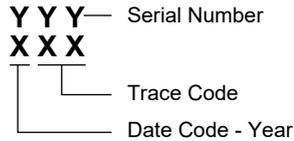
Figure 1. Typical Application Circuit

**PACKAGE/ORDERING INFORMATION**

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

**MARKING INFORMATION**

NOTE: XXX = Date Code and Trace Code.



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 <sub>IN</sub> + 0.3V)  |
| CN, OUT2 to GND .....                   | (V <sub>OUT1</sub> - 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 <sub>JA</sub> ..... | 166°C/W                            |
| Junction Temperature .....              | +150°C                             |
| Storage Temperature Range .....         | -65°C to +150°C                    |
| Lead Temperature (Soldering, 10s) ..... | +260°C                             |
| ESD Susceptibility                      |                                    |
| HBM .....                               | 4000V                              |
| CDM .....                               | 1000V                              |

**RECOMMENDED OPERATING CONDITIONS**

|   |                 |
|---|-----------------|
| Supply Voltage Range .....                          | 2.3V to 5.5V    |
| Input Effective Capacitance, C <sub>IN</sub> .....  | 1µF to 10µF     |
| Fly Effective Capacitance, C <sub>FLY</sub> .....   | 4.7µF (TYP)     |
| OUT1 Effective Capacitance, C <sub>OUT1</sub> ..... | 1µF (MIN)       |
| OUT2 Effective Capacitance, C <sub>OUT2</sub> ..... | 1µF to 10µF     |
| Operating Junction Temperature Range .....          | -40°C to +125°C |

**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.

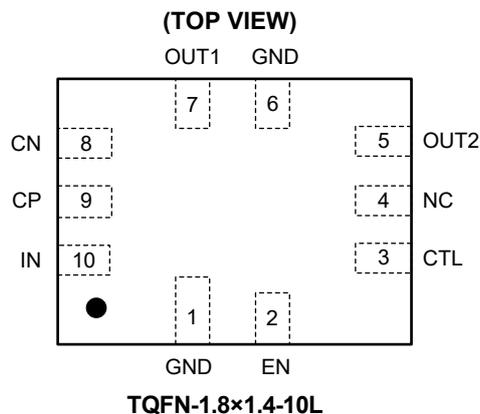
**ESD SENSITIVITY CAUTION**

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   |
|------|------|--|
| 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 $1\mu\text{F}$ to $10\mu\text{F}$ .   |
| 7    | OUT1 | Negative Charge Pump Output Pin. It is recommended to use an output capacitor ( $C_{OUT1}$ ) with effective capacitance in the range of $1\mu\text{F}$ to $10\mu\text{F}$ .                                |
| 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.  |

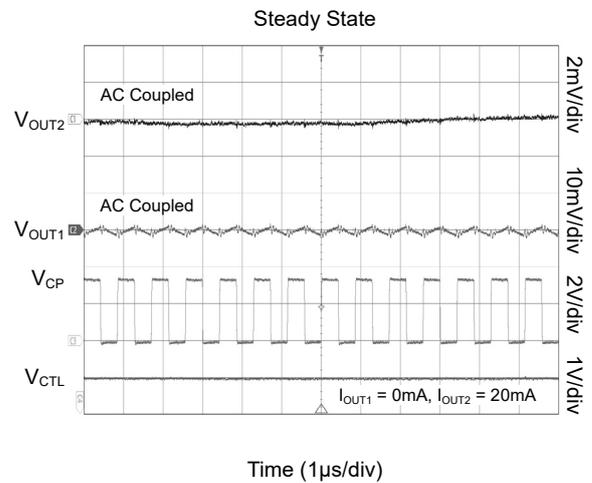
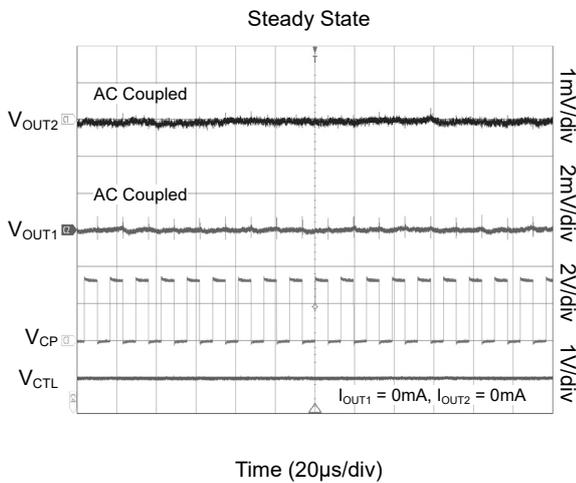
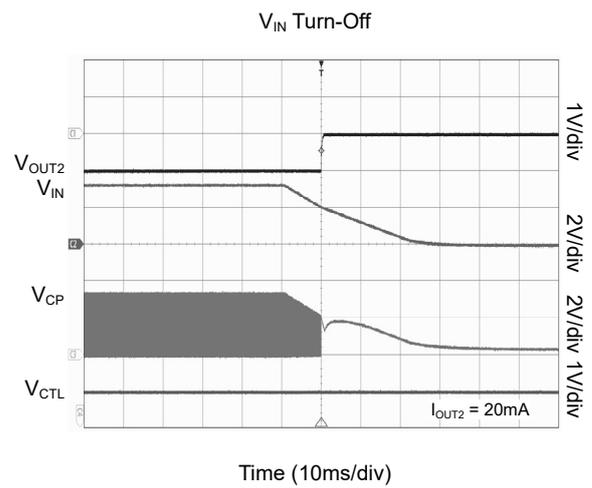
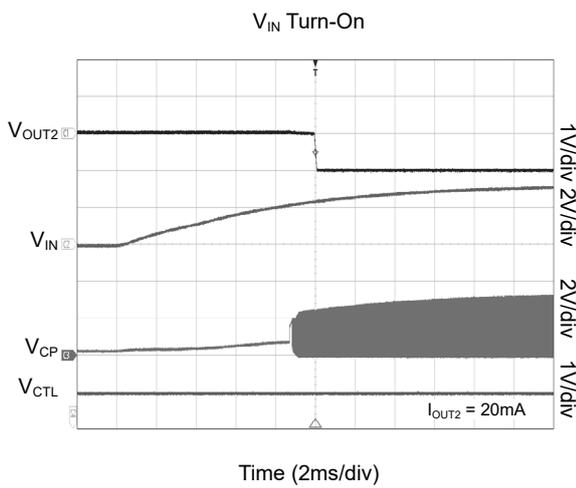
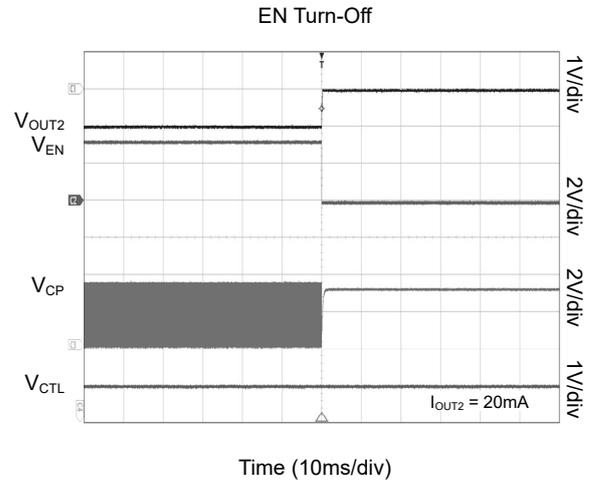
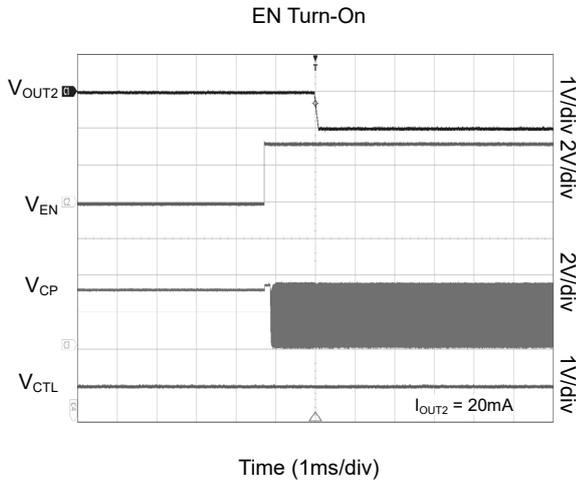
### ELECTRICAL CHARACTERISTICS

( $V_{IN} = 3.3V$ ,  $C_{IN} = C_{FLY} = C_{OUT1} = C_{OUT2} = 4.7\mu F$ ,  $T_J = -40^\circ C$  to  $+125^\circ C$ , typical values are at  $T_J = +25^\circ C$ , 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      | $\mu A$    |   |
| Quiescent Current                     | $I_Q$              | $V_{EN} = 2V$ , force $V_{OUT1} = -3.4V$ , no switching                                       | $T_J = +25^\circ C$                   | 170    | 210    | $\mu A$    |   |
|                                       |                    |   | $T_J = -40^\circ C$ to $+125^\circ C$ | 170    | 230    |            |   |
| Charge Pump MOSFET On-Resistance      | $R_{ON}$           |   |                                       | 0.28   |        | $\Omega$   |   |
| <b>Negative Linear Regulator</b>      |                    |   |                                       |        |        |            |   |
| Output Current Limit                  | $I_{LIMIT}$        | $V_{IN} = 3.3V$ , $V_{OUT2} = -2.5V$  |                                       | 175    | 240    | mA         |   |
| Output Voltage                        |                    | $V_{CTL} = 2.5V$ ,<br>$I_{OUT2} = 10mA$   | $T_J = +25^\circ C$                   | -2.532 | -2.507 | -2.482     | V |
|                                       |                    |   | $T_J = -40^\circ C$ to $+125^\circ C$ | -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                       | $\Delta V_{OUT}$   | $V_{OUT1} = -3.3V$ , $V_{CTL} = 1V$ , $I_{OUT2} = 0$ to $150mA$                               |                                       | 0.004  | 0.015  | %/mA       |   |
| Power Supply Rejection Ratio          | PSRR               | $C_{OUT1} = 1\mu F$ , $C_{OUT2} = 1\mu F$ ,<br>$I_{OUT2} = 10mA$                              | $f = 100Hz$                           | 70     |        | dB         |   |
|                                       |                    |   | $f = 50kHz$                           | 30     |        |            |   |
| Soft-Start Slew Rate                  |                    |   |                                       | 10     |        | V/ms       |   |
| EN Turn-On Delay                      |                    |   | 80                                    |        | 255    | $\mu s$    |   |
| 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    |        | $\Omega$   |   |
|                                       | $R_{DIS2}$         | $V_{EN} = 0V$ , OUT2 rail   |                                       | 125    |        |            |   |
| EN Input Current                      | $I_{EN}$           | $V_{EN} = 2V$   | 1.2                                   | 1.8    | 2.4    | $\mu A$    |   |
|                                       |                    | $V_{EN} = 0V$   |                                       | 0      |        |            |   |
| Thermal Shutdown Temperature          | $T_{SHDN}$         |   |                                       | 160    |        | $^\circ C$ |   |
| Thermal Shutdown Hysteresis           | $\Delta T_{SHDN}$  |   |                                       | 20     |        | $^\circ C$ |   |
| <b>System Level</b>                   |                    |   |                                       |        |        |            |   |
| OUT1 Pin Voltage                      |                    |   |                                       | -1x    |        | $V_{IN}$   |   |
| Output Ripple                         | $V_{RIPPLE\_OUT1}$ | $V_{IN} = 3.3V$ , $V_{OUT1} = -3.3V$ , $C_{FLY} = C_{OUT1} = 4.7\mu F$ ,<br>$I_{OUT1} = 60mA$ |                                       | 7      |        | mV         |   |
|                                       | $V_{RIPPLE\_OUT2}$ | $V_{IN} = 3.3V$ , $V_{OUT2} = 2.5V$ , $C_{OUT2} = 1\mu F$ ,<br>$I_{OUT2} = 60mA$              |                                       | 2      |        |            |   |
|                                       | $V_{RIPPLE\_OUT2}$ | $V_{IN} = 3.3V$ , $V_{OUT2} = 2.5V$ , $C_{OUT2} = 4.7\mu F$ ,<br>$I_{OUT2} = 60mA$            |                                       | 2      |        |            |   |

TYPICAL PERFORMANCE CHARACTERISTICS

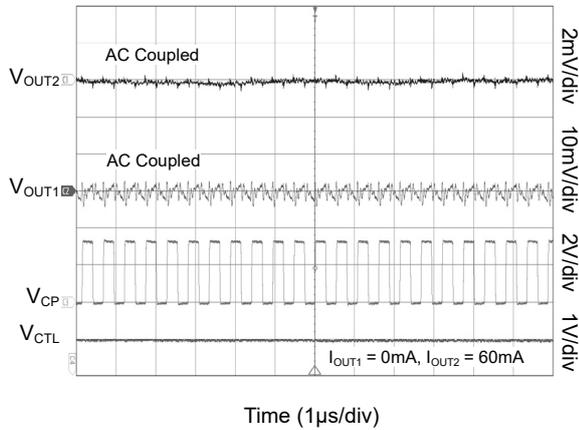
$T_J = +25^\circ\text{C}$ ,  $V_{IN} = 3.3\text{V}$ ,  $V_{OUT1} = -3.3\text{V}$ ,  $V_{OUT2} = -1\text{V}$ ,  $C_{IN} = C_{FLY} = C_{OUT1} = C_{OUT2} = 4.7\mu\text{F}$ , unless otherwise noted.



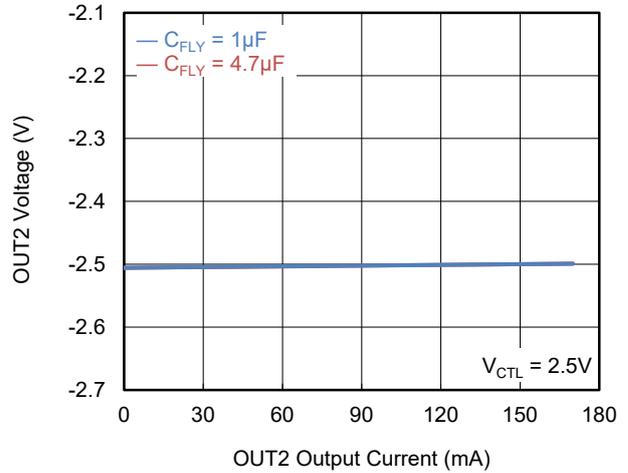
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$T_J = +25^\circ\text{C}$ ,  $V_{IN} = 3.3\text{V}$ ,  $V_{OUT1} = -3.3\text{V}$ ,  $V_{OUT2} = -1\text{V}$ ,  $C_{IN} = C_{FLY} = C_{OUT1} = C_{OUT2} = 4.7\mu\text{F}$ , unless otherwise noted.

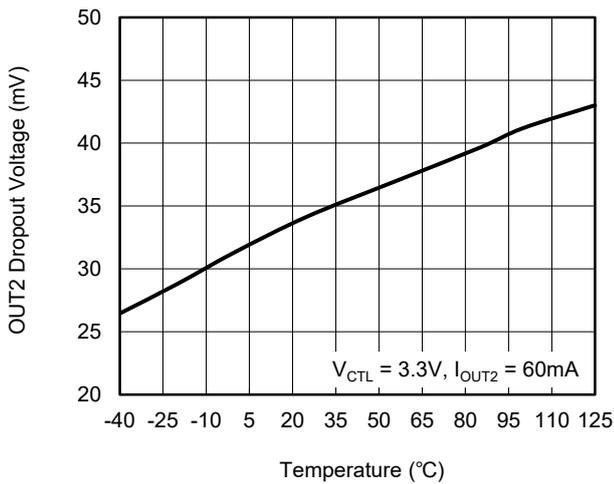
Steady State



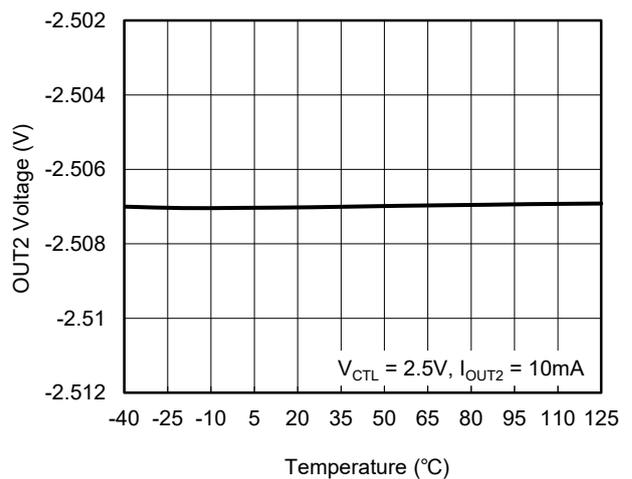
Load Capability



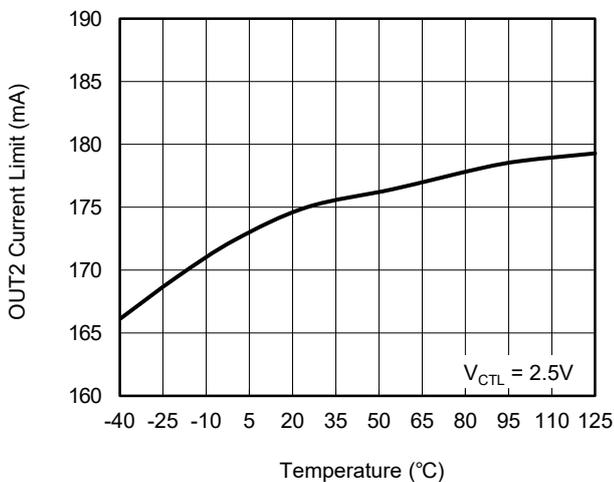
OUT2 Dropout Voltage vs. Temperature



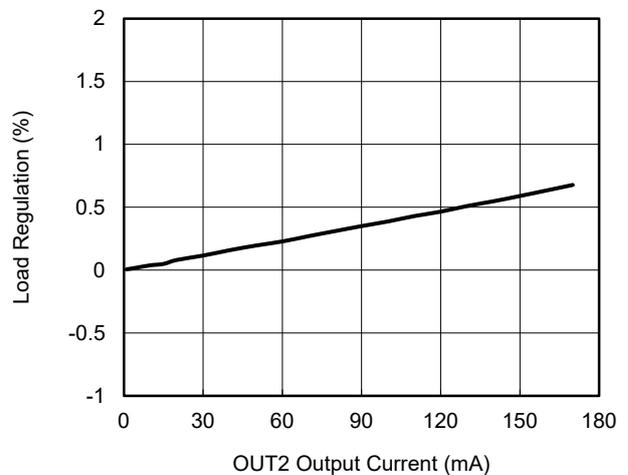
OUT2 Voltage vs. Temperature



OUT2 Current Limit vs. Temperature



Negative Linear Regulator Load Regulation



FUNCTIONAL BLOCK DIAGRAM

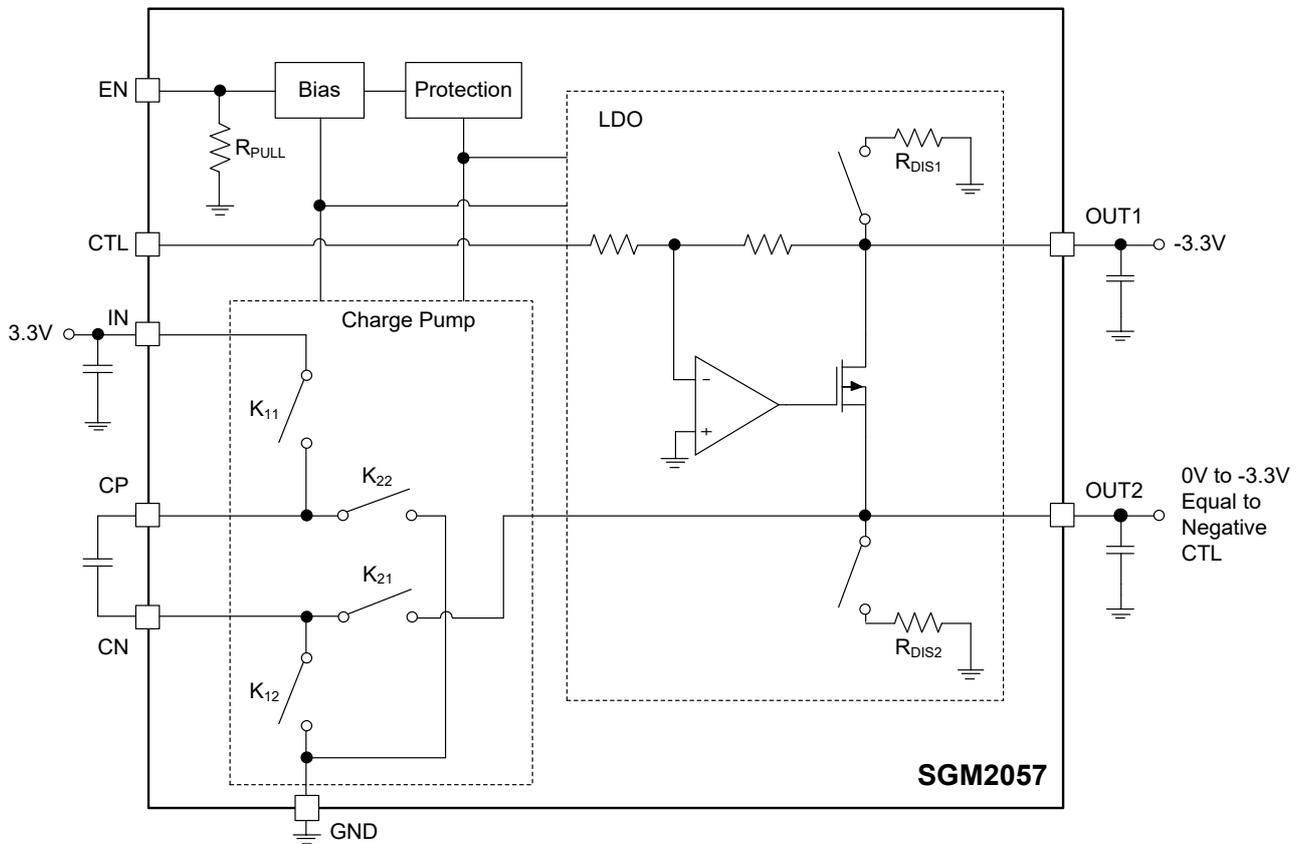


Figure 2. Functional Block Diagram

## 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:

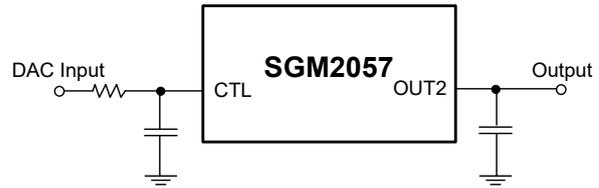


Figure 3. Output Voltage Setting

### 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 130 $\Omega$ ) and  $R_{DIS2}$  (typically 125 $\Omega$ ).

When the EN pin voltage is higher than 1.2V, the device is in active state, the input voltage is regulated to the output voltage 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:

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

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:

$$V_{OUT1} = -(V_{IN} - I_o \times R_o) \quad (2)$$

### 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 500 $\mu$ s (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 1 $\mu$ F to 10 $\mu$ F 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 1 $\mu$ F capacitor for  $C_{OUT1}$  and a 1 $\mu$ F to 10 $\mu$ F 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°C (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.

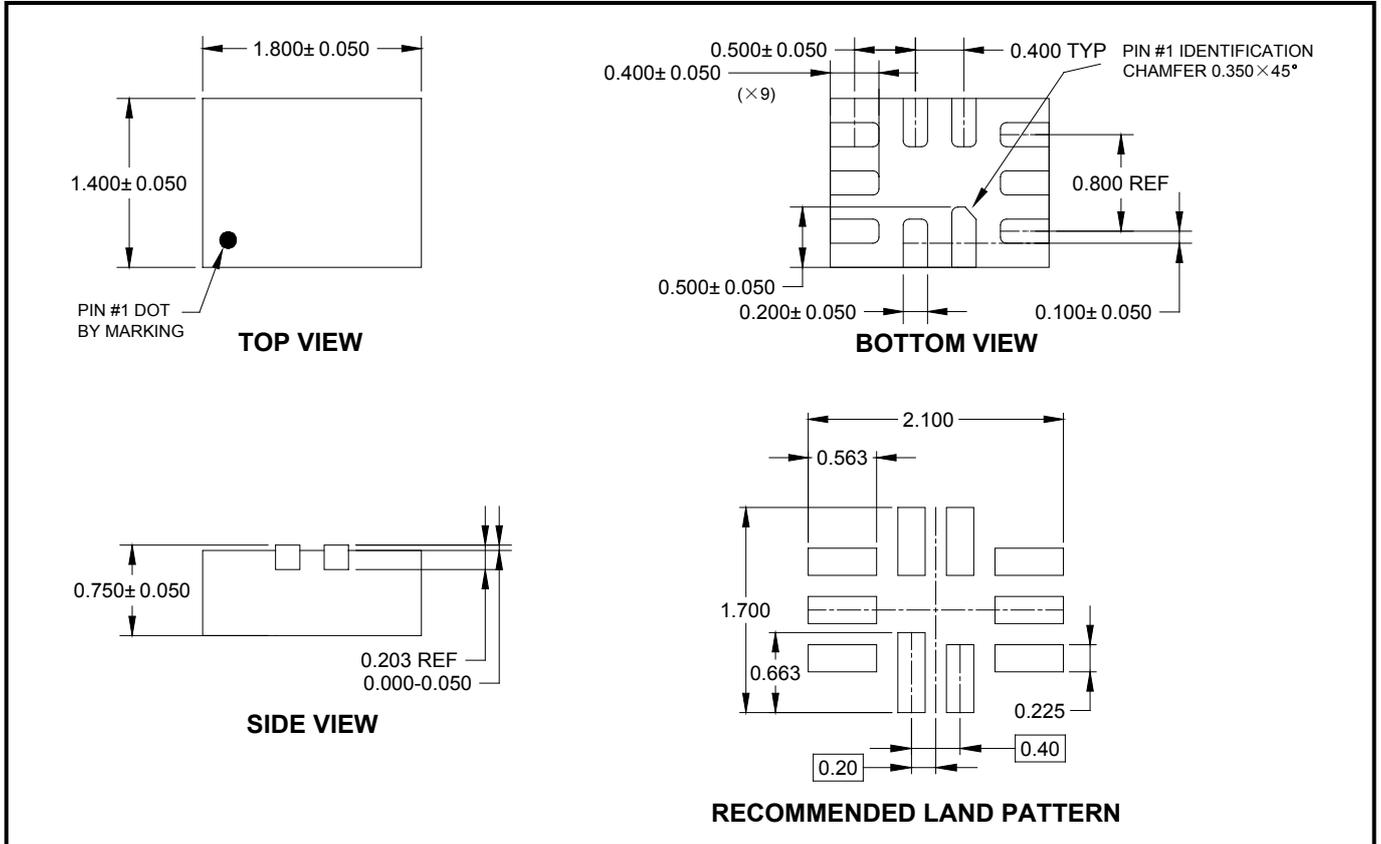
**Changes from Original (MARCH 2022) to REV.A**

Page

|   |     |
|---|-----|
| Changed from product preview to production data ..... | All |
|---|-----|

PACKAGE OUTLINE DIMENSIONS

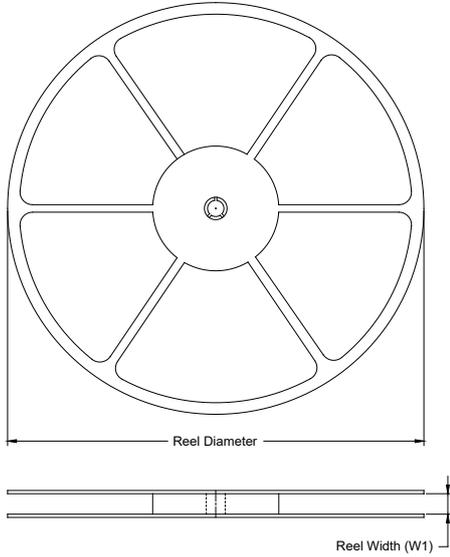
TQFN-1.8×1.4-10L



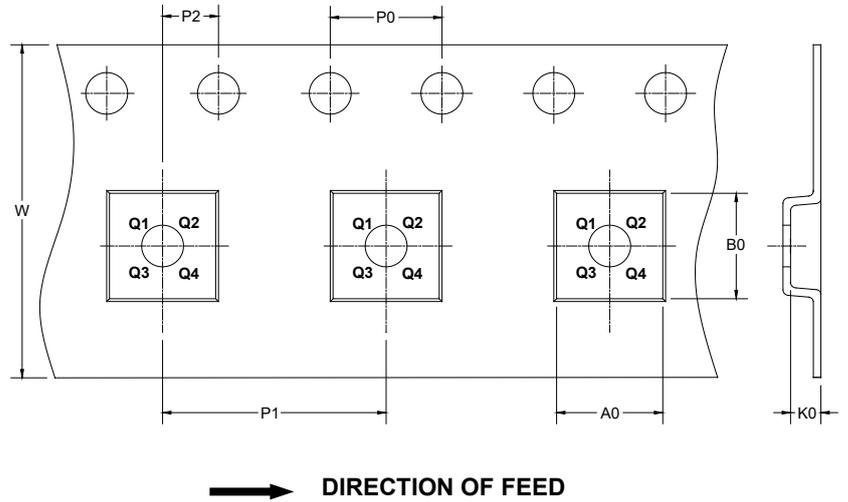
NOTE: All linear dimensions are in millimeters.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



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

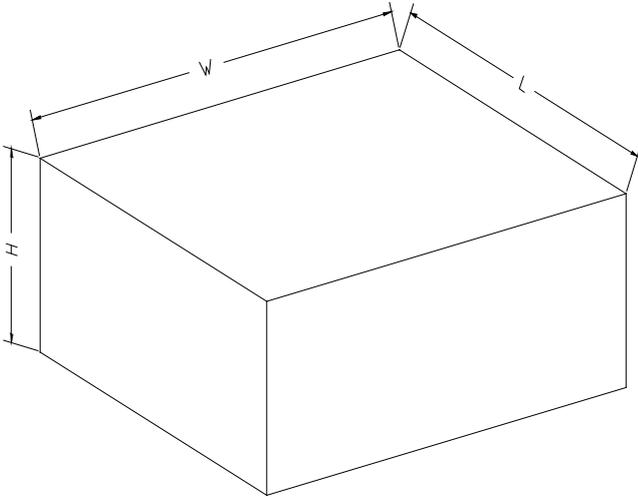
KEY PARAMETER LIST OF TAPE AND REEL

| Package Type     | Reel Diameter | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P0 (mm) | P1 (mm) | P2 (mm) | W (mm) | Pin1 Quadrant |
|------------------|---------------|--------------------|---------|---------|---------|---------|---------|---------|--------|---------------|
| TQFN-1.8×1.4-10L | 7"            | 9.0                | 1.75    | 2.10    | 1.00    | 4.0     | 4.0     | 2.0     | 8.0    | Q1            |

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# PACKAGE INFORMATION

## 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           |

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