SGM2066
Low-Noise Regulated, Switched-Capacitor Voltage Inverter

GENERAL DESCRIPTION

The SGM2066 is a negative output charge pump which has an inside adjustable regulator. The input voltage range is from 2.7V to 5.5V and the unregulated output equals to $-V_{IN}$. For the regulated output of the SGM2066, the range is from -1.5V to -5V.

The inrush current of the SGM2066 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 SGM2066 is available in a Green TDFN-2×2-8AL package. It operates over an operating temperature range of -40℃ to +125℃.

FEATURES

- **Operating Input Voltage Range: 2.7V to 5.5V**
- **Output Current Limit: 250mA (TYP)**
- **Inverter Output Impedance: 2.3Ω at V_{IN} = 5.5V**
- **Quiescent Current: 410μA (TYP)**
- **Low Dropout Voltage:**
  34mV (TYP) at I_{OUT} = 100mA, V_{OUT} = -5V
- **Low Noise: 28μV_{RMS} (TYP) at V_{IN} = 5V**
- **Current Limit and Thermal Protection**
- **Shutdown Supply Current: 0.1μA (TYP)**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in a Green TDFN-2×2-8AL Package**

APPLICATIONS

Optical Applications
Biasing of the Amplifier for RF
Supplying Sensors in Portable Devices
Cellular Telephones
Portable Equipment

TYPICAL APPLICATION

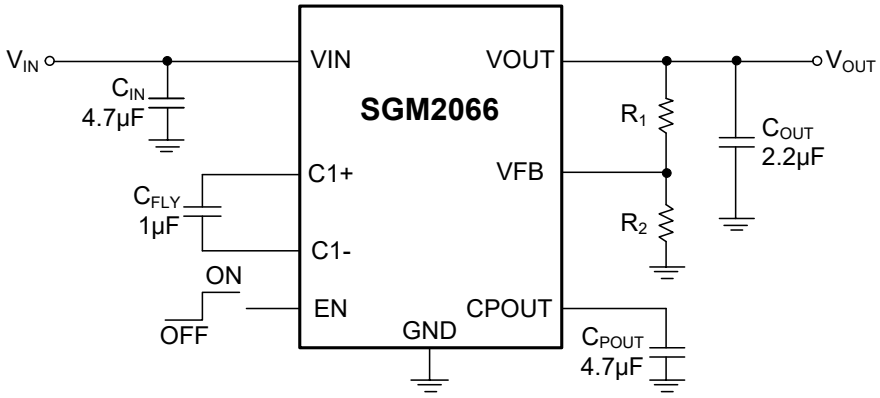


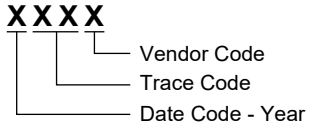
Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM2066	TDFN-2×2-8AL	-40℃ to +125℃	SGM2066XTDE8G/TR	2066 XXXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XXXX = Date Code, Trace Code and Vendor 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

GND to VOUT 6V
VIN to GND 6V
EN to GND ..... -0.3V to (V_{IN} + 0.3V)
Continuous Output Current, CPOUT and VOUT 300mA
Package Thermal Resistance
TDFN-2×2-8AL, θ_{JA} ..... 62℃/W
TDFN-2×2-8AL, θ_{JB} ..... 27℃/W
TDFN-2×2-8AL, $\theta_{JC\ (TOP)}$ ..... 79℃/W
TDFN-2×2-8AL, $\theta_{JC\ (BOT)}$ ..... 8.4℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -40℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 4000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range, V_{IN} ..... 2.7V to 5.5V
Operating Output Current, I_{OUT} ..... 0mA to 250mA
Input Effective Capacitance, C_{IN} ..... 2μF to 10μF
Fly Effective Capacitance, C_{FLY} ..... 1μF (TYP)
Output Effective Capacitance, C_{OUT} ..... 1μF (MIN)
Output Effective Capacitance, C_{POUT} ..... 2μF 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

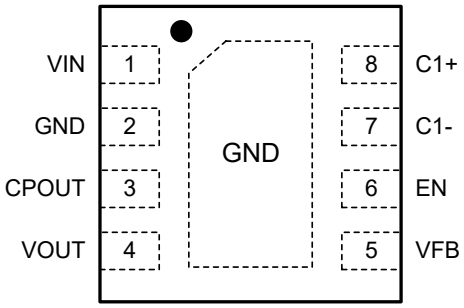
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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)



TDFN-2×2-8AL

PIN DESCRIPTION

PIN	NAME	DESCRIPTION
1	VIN	Input Supply Voltage Pin. It is recommended to use a 4.7μF or larger ceramic capacitor from IN pin to ground to get good power supply decoupling. This ceramic capacitor should be placed as close as possible to IN pin.
2	GND	Ground.
3	CPOUT	Unregulated Negative Output Pin. It is recommended to use an output capacitor (C_{POUT}) with effective capacitance in the range of 2μF to 10μF. This ceramic capacitor should be placed as close as possible to CPOUT pin.
4	VOUT	Regulator Negative Output Pin. It is recommended to use a 2.2μF or larger ceramic capacitor from VOUT pin to ground to ensure stability. This ceramic capacitor should be placed as close as possible to VOUT pin.
5	VFB	Feedback Voltage Input Pin. Connect this pin to the midpoint of an external resistor divider to adjust the output voltage. Place the resistors as close as possible to this pin.
6	EN	Enable Pin. Drive EN high to turn on the regulator. Drive EN low to turn off the regulator. The EN pin has an internal pull-down resistance to ensure that the device is turned off when the EN pin is floated.
7	C1-	Negative Connection for the Fly Capacitor (C_{FLY}).
8	C1+	Positive Connection for the Fly Capacitor (C_{FLY}).
Exposed Pad	GND	Exposed Pad. Connect the exposed pad at the bottom of the package to the internal GND for maximum thermal performance. In normal use, connect the exposed pad to the GND on the board.

FUNCTIONAL BLOCK DIAGRAM

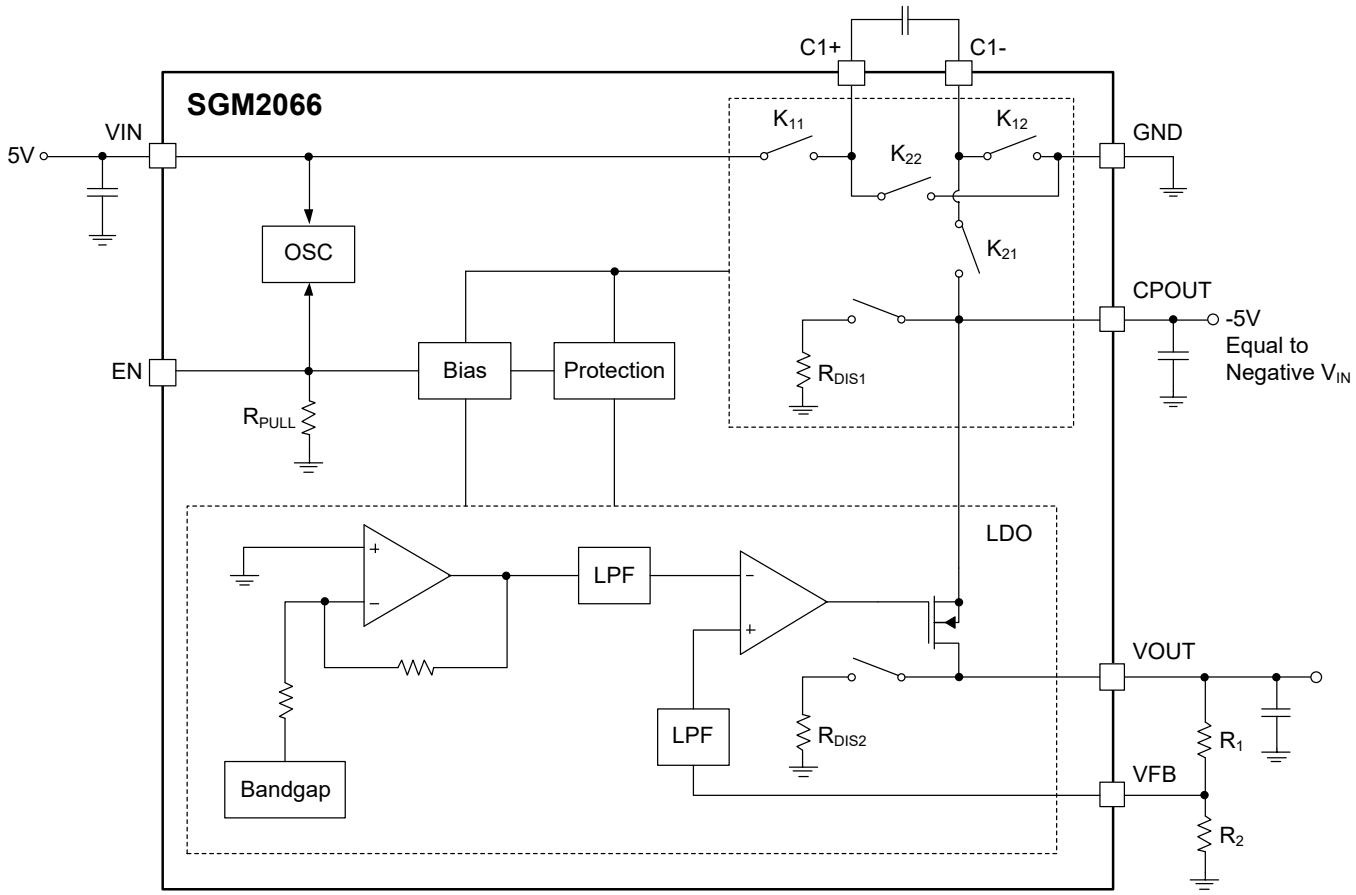


Figure 2. Block Diagram

ELECTRICAL CHARACTERISTICS

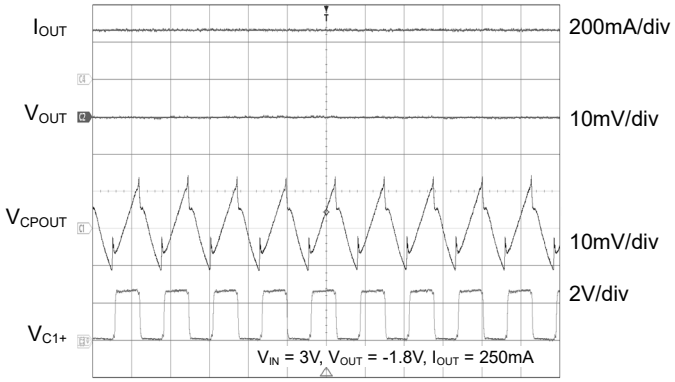
(T_A = -40℃ to +125℃, V_{IN} = 5V, C_{FLY} = 1μF, C_{OUT} = 2.2μF, C_{IN} = C_{POUT} = 4.7μF, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Adjustable Output Voltage	V_{OUT}	V_{IN} = 2.7V to 5.5V, T_A = +25℃		-5		-1.5	V
Feedback Pin Reference Voltage	V_{FB}	T_A = -40℃ to +125℃		-1.247	-1.225	-1.203	V
Under-Voltage Lockout Thresholds	UVLO	V_{IN} rising			2.5		V
		V_{IN} falling			1.6		
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	V_{IN} = 2.7V to 5.5V, I_{OUT} = 50mA			0.32		mV/V
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	I_{OUT} = 0mA to 250mA, V_{OUT} = -1.8V			3.04		μV/mA
Dropout Voltage	V_{DROP}	I_{OUT} = 100mA, V_{OUT} = -5V			34		mV
Quiescent Current	I_Q	Open circuit, no load, T_A = +25℃			410	480	μA
Shutdown Supply Current	I_{SHDN}	T_A = -40℃ to +125℃			0.1	0.7	μA
Enable Pin Input Voltage High	V_{IH}	V_{IN} = 2.7V to 5.5V, T_A = -40℃ to +125℃		1.1			V
Enable Pin Input Voltage Low	V_{IL}	V_{IN} = 2.7V to 5.5V, T_A = -40℃ to +125℃				0.4	V
Switching Frequency	f_{SW}	V_{IN} = 3.6V, T_A = -40℃ to +125℃		1.7	2	2.3	MHz
Output Resistance to CPOUT	R_{NEG}	V_{IN} = 5.5V			2.3		Ω
Power Supply Rejection Ratio	PSRR	I_{OUT} = 80mA, V_{CPOUT} = -5V	f = 100Hz		57		dB
			f = 50kHz		37		
Output Voltage Noise	e_n	I_{OUT} = 80mA, f = 10Hz to 100kHz			28		μV_{RMS}
Thermal Shutdown Temperature	T_{SHDN}				170		℃
Thermal Shutdown Hysteresis	ΔT_{SHDN}				25		℃

TYPICAL PERFORMANCE CHARACTERISTICS

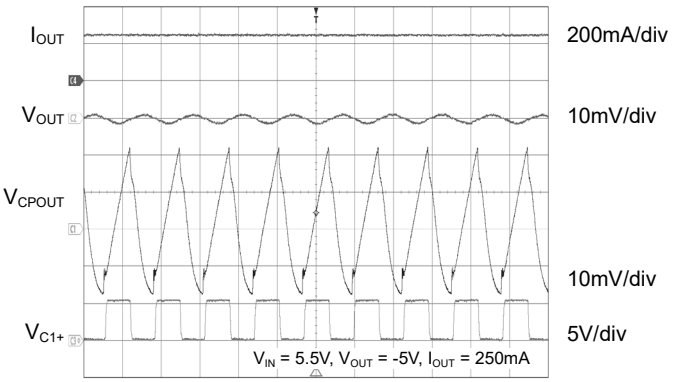
T_A = +25℃, V_{IN} = 5V, C_{FLY} = 1μF, C_{OUT} = 2.2μF, C_{IN} = C_{POUT} = 4.7μF, unless otherwise noted.

Output Voltage Ripple



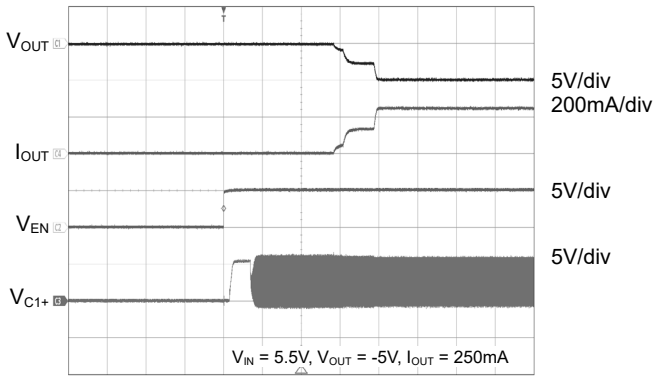
Time (400ns/div)

Output Voltage Ripple



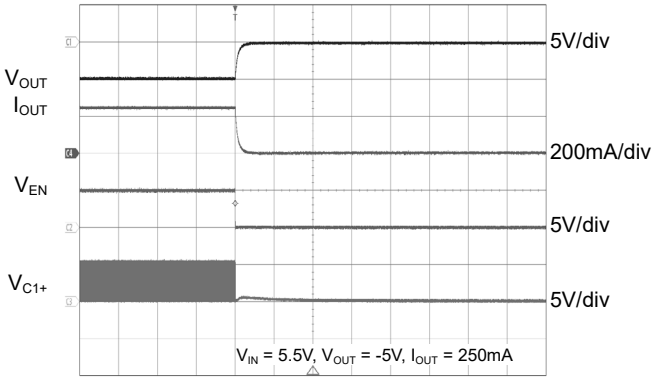
Time (400ns/div)

EN Turn-On



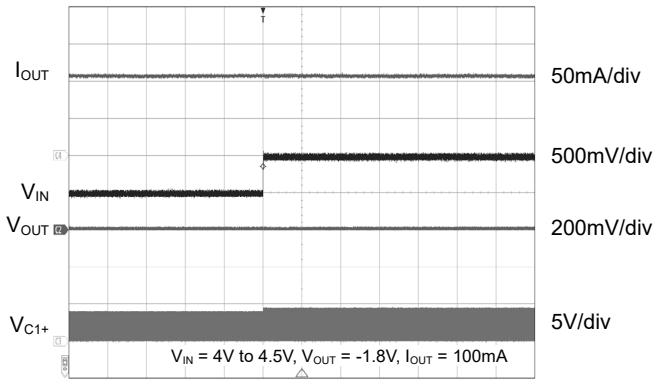
Time (500μs/div)

EN Turn-Off



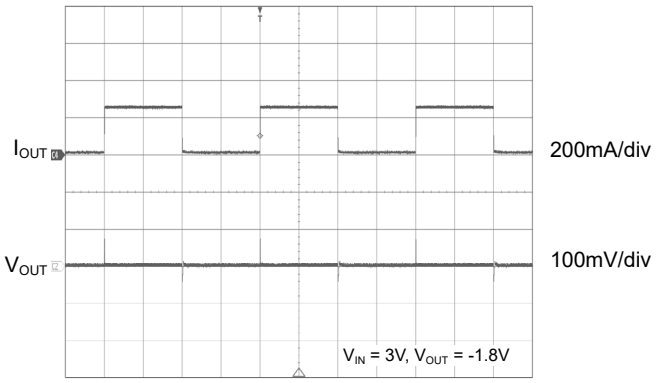
Time (500μs/div)

Line Transient Response



Time (2ms/div)

Load Transient Response

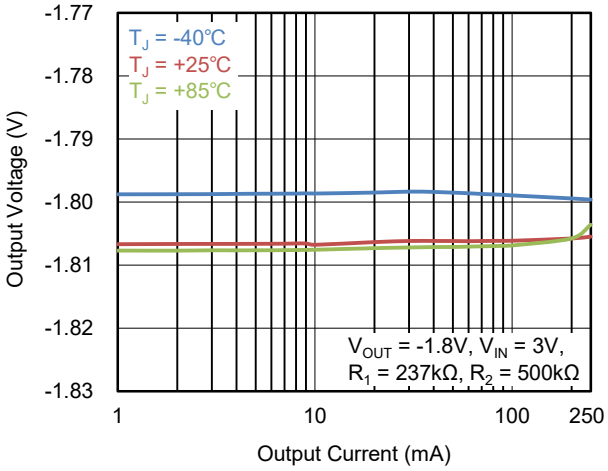


Time (500μs/div)

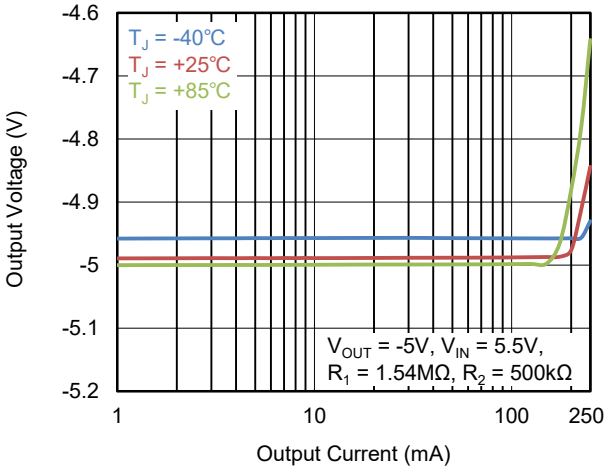
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_A = +25℃, V_{IN} = 5V, C_{FLY} = 1μF, C_{OUT} = 2.2μF, C_{IN} = C_{POUT} = 4.7μF, unless otherwise noted.

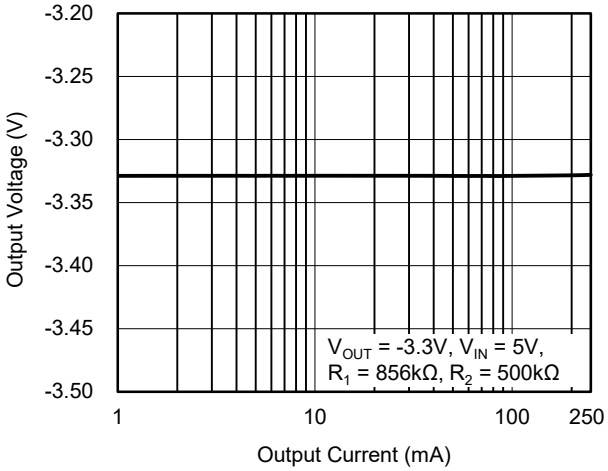
Load Regulation



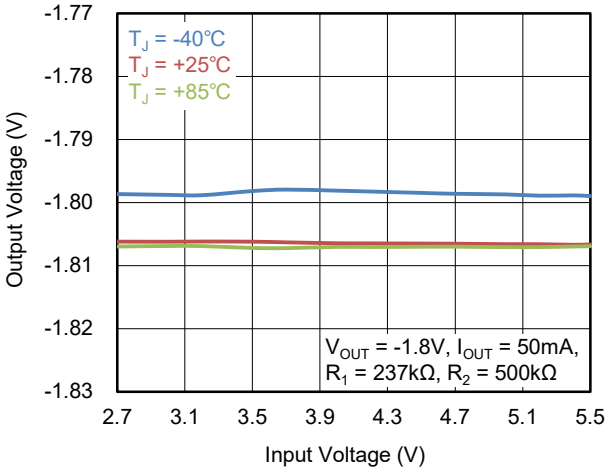
Load Regulation



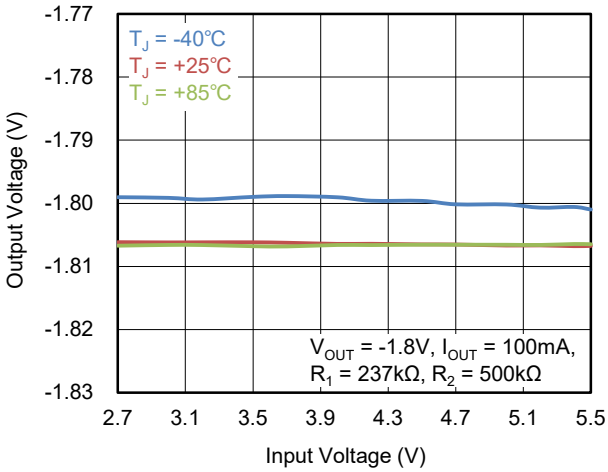
Load Regulation



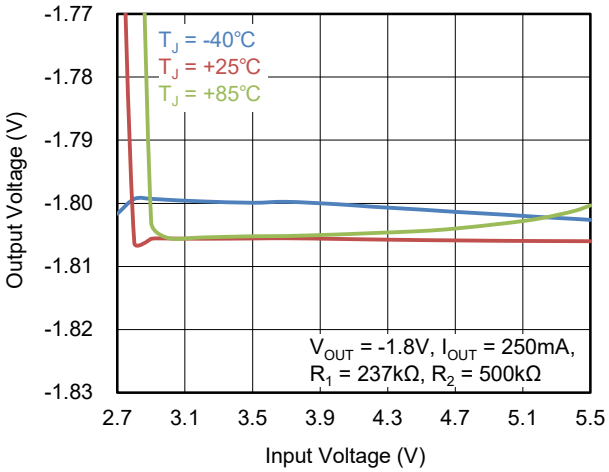
Line Regulation



Line Regulation



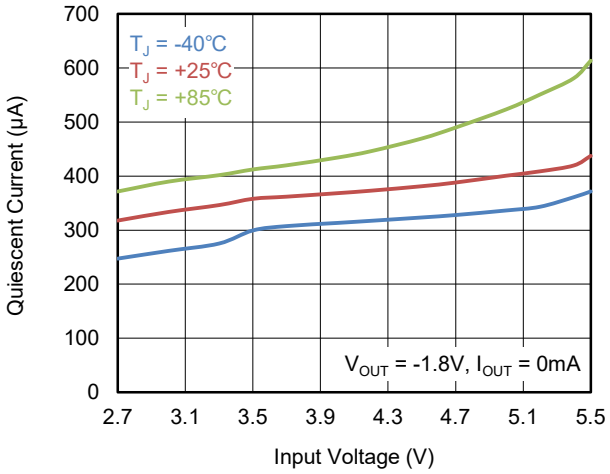
Line Regulation



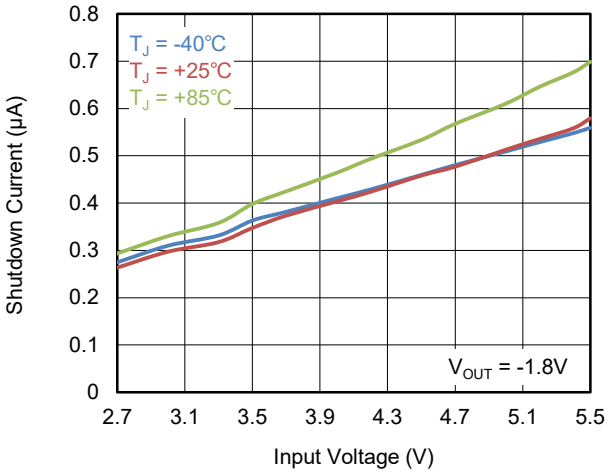
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_A = +25℃, V_{IN} = 5V, C_{FLY} = 1μF, C_{OUT} = 2.2μF, C_{IN} = C_{POUT} = 4.7μF, unless otherwise noted.

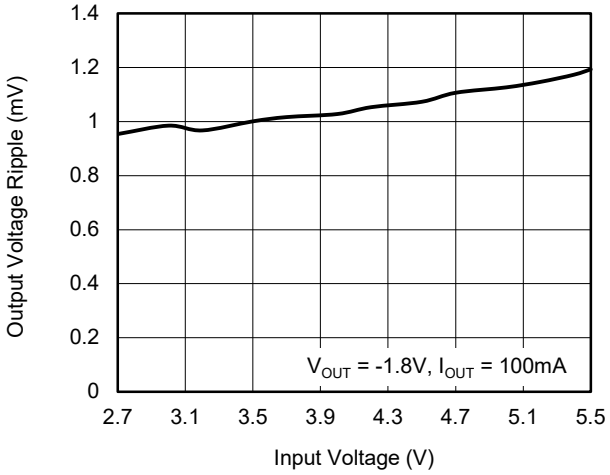
Quiescent Current vs. Input Voltage



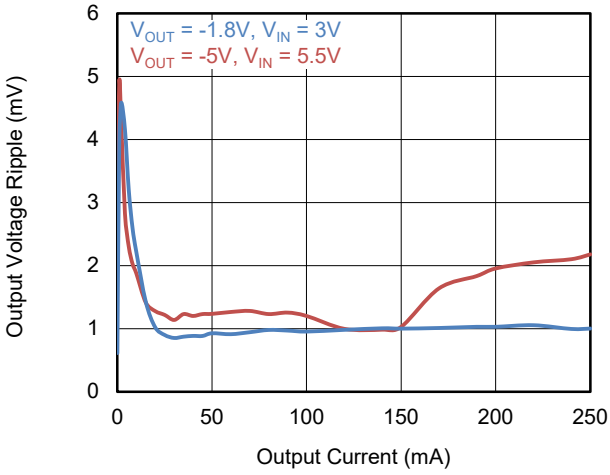
Shutdown Current vs. Input Voltage



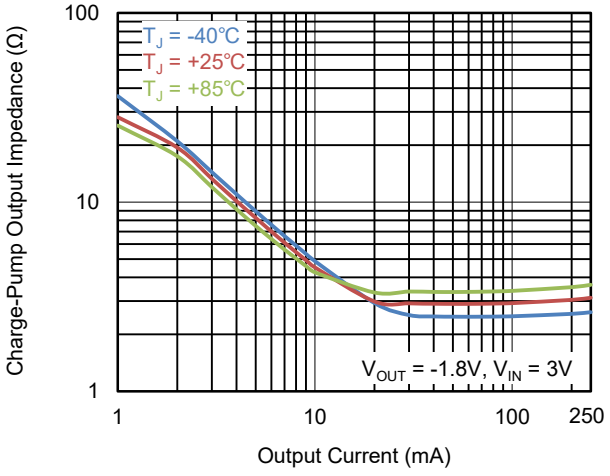
Output Voltage Ripple vs. Input Voltage



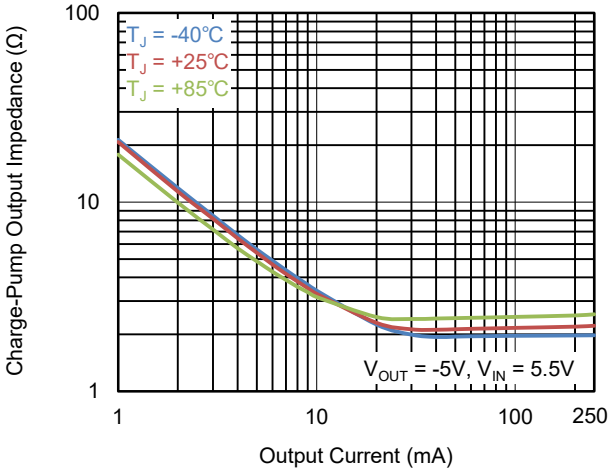
Output Voltage Ripple vs. Output Current



Charge-Pump Output Impedance vs.. Output Current



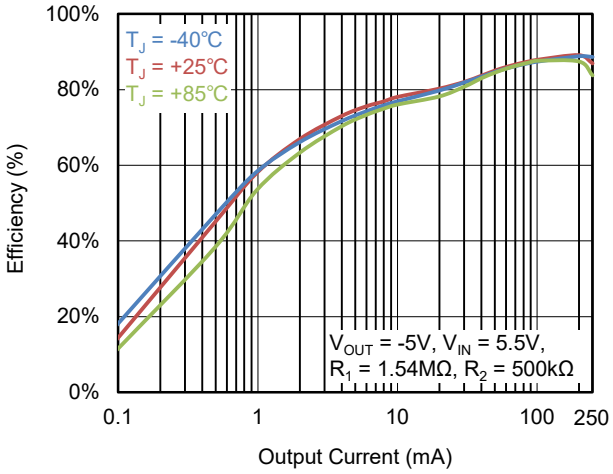
Charge-Pump Output Impedance vs.. Output Current



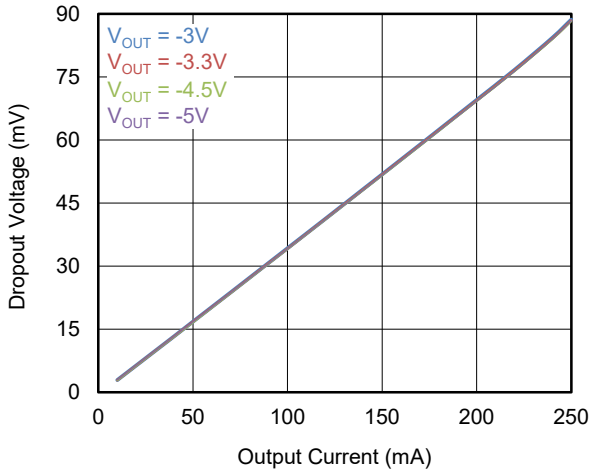
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_A = +25℃, V_{IN} = 5V, C_{FLY} = 1μF, C_{OUT} = 2.2μF, C_{IN} = C_{POUT} = 4.7μF, unless otherwise noted.

Efficiency vs. Output Current



Dropout Voltage vs. Output Current



APPLICATION INFORMATION

The SGM2066 is a negative output charge pump which has an inside adjustable regulator. The input voltage range is from 2.7V to 5.5V and the unregulated output equals to $-V_{IN}$. The regulated output voltage range is from -1.5V to -5V. The inrush current of the SGM2066 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 60kHz to 2MHz (TYP). Also, the switching frequency can be changed with the dropout voltage between V_{IN} and V_{CPOUT}. When heavy load occurs, this frequency will increase to compensate the output ripple.

The SGM2066 will assume that there is an over-current condition if $|V_{CPOUT}| < V_{IN}/2$, so that the resistance of charge/discharge switches are increased by a factor of 10.

Negative Linear Regulator

The negative linear regulator V_{OUT} 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 -1.5V to -5V.

V_{OUT} is controlled by the feedback loop of the linear regulator and the relationship between R_1, R_2 and V_{OUT} is $V_{OUT} = -1.225 \times (R_1 + R_2)/R_2$.

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.

Adjustable Regulator

The output voltage of the SGM2066 can be adjusted from -1.5V to -5V. The VFB pin will be connected to two external resistors as shown in Figure 3. The output voltage is determined by the following equation:

$$V_{OUT} = V_{FB} \times \left(1 + \frac{R_1}{R_2}\right) \quad (1)$$

where:

V_{OUT} is output voltage and V_{FB} is the internal voltage reference, V_{FB} = -1.225V. The value for R_2 must be no less than 50kΩ.

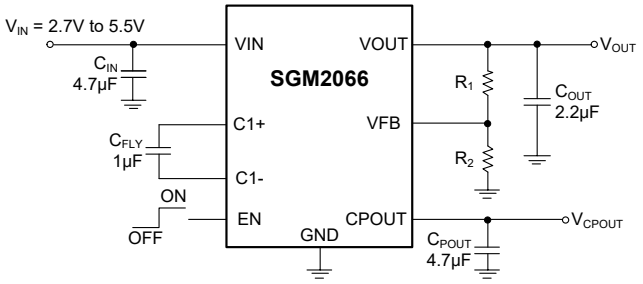


Figure 3. Adjustable Output Voltage Application

Enable Operation

The SGM2066 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 VIN to VOUT 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 1.1V, the device is in active state. The output voltage is regulated to the expect 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 SGM2066 as shown in the following equation:

$$R_O = \frac{1}{f \times C_{FLY}} + 8 \times R_{ON} \quad (2)$$

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_{CPOUT} as shown in the following equation:

$$V_{CPOUT} = -(V_{IN} - I_O \times R_O) \quad (3)$$

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 SGM2066 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 300mA (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 VIN pin. A 2μF to 10μF dielectric X7R or X5R ceramic capacitor is selected to get good dynamic performance.

Output Capacitor Selection (C_{POUT}, C_{OUT})

The output capacitors should be located as close as possible to the VOUT pin and CPOUT pin. A 2.2μF capacitor for C_{OUT} and a 2μF to 10μF capacitor for C_{POUT} 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_{POUT} and C_{OUT} must be considered in design.

Fly Capacitor Selection (C_{FLY})

According to equation 2, 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, a 1μF ceramic capacitor is recommended in application.

Thermal Shutdown

The SGM2066 can detect the temperature of die. When the die temperature exceeds the threshold value of thermal shutdown, the SGM2066 will be in shutdown state and it will remain in this state until the die temperature decreases to +145℃ (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 VIN 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 SGM2066, the input and output bypass capacitors must be placed as close as possible to the VIN, VOUT and CPOUT pins separately. There are four high-current paths which are GND, VIN, C1+ and C1-. The short and wide traces must be used to connect these pins. R_1 and R_2 should be placed as closed as possible to the VFB pin and the short traces must be used. Keep C_{FLY} away from the VFB pin and traces is helpful for better performance of the SGM2066.

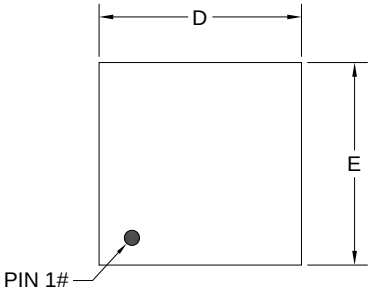
REVISION HISTORY

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

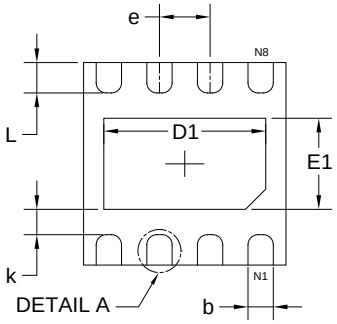
Changes from Original (APRIL 2023) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

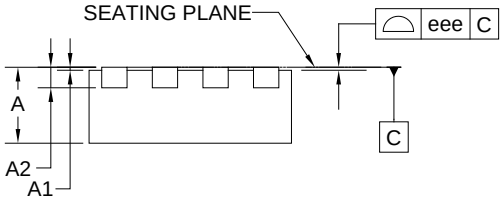
TDFN-2×2-8AL



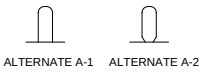
TOP VIEW



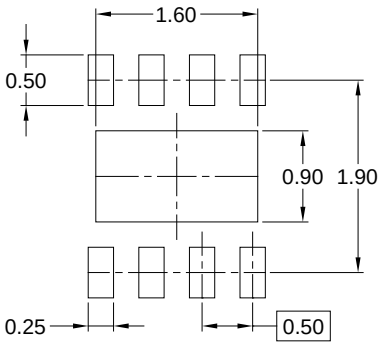
BOTTOM VIEW



SIDE VIEW



DETAIL A
ALTERNATE TERMINAL CONSTRUCTION



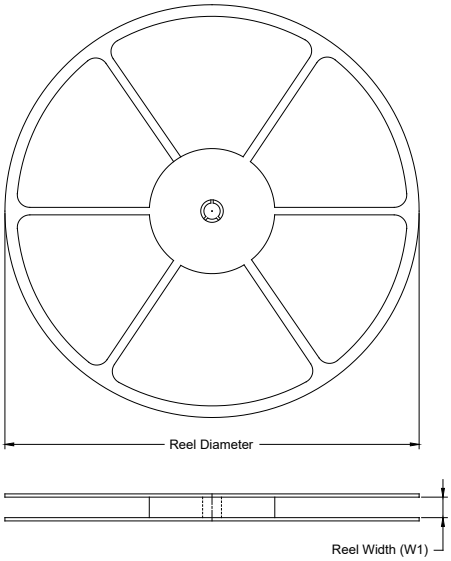
RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	0.700	0.750	0.800
A1	0.000	-	0.050
A2	0.203 REF		
b	0.200	0.250	0.300
D	1.900	2.000	2.100
D1	1.450	1.600	1.700
E	1.900	2.000	2.100
E1	0.750	0.900	1.000
k	0.150	0.250	0.350
e	0.450	0.500	0.550
L	0.200	0.300	0.400
eee	0.080		

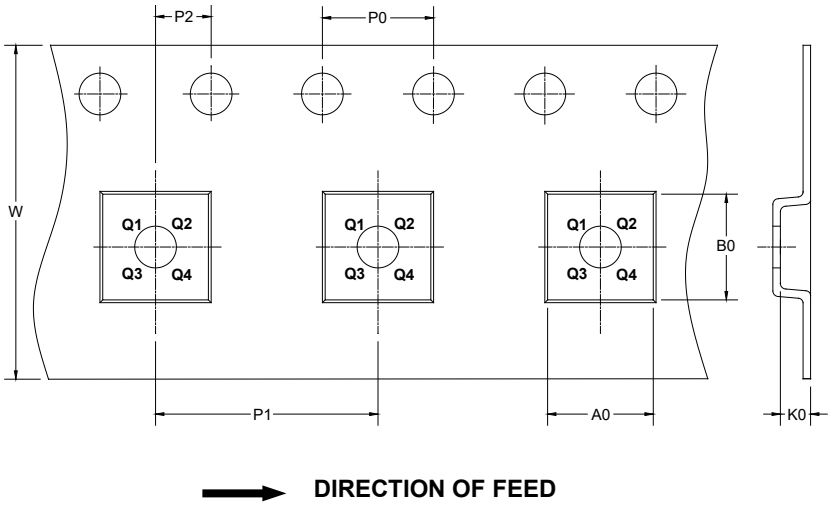
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



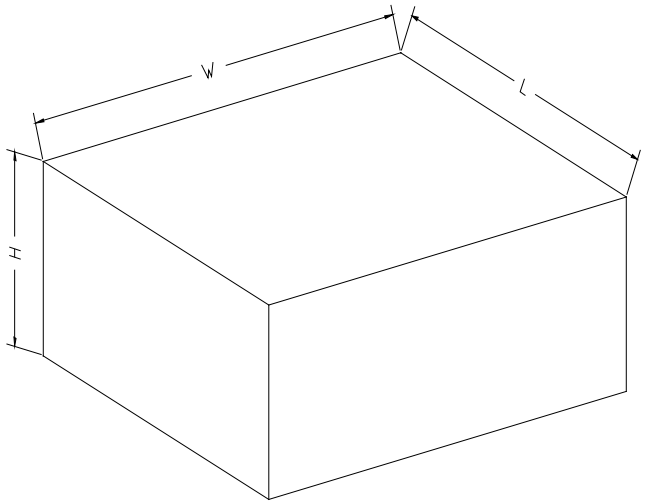
NOTE: The picture is only for reference. Please make the object as the standard.

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
TDFN-2×2-8AL	7″	9.5	2.30	2.30	1.10	4.0	4.0	2.0	8.0	Q2

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