SGM41283
70V Boost Converter with APD Current Monitor

GENERAL DESCRIPTION

The SGM41283 is a high voltage non-synchronous Boost converter which integrates a 70V, 600mΩ, N-channel power FET and is capable of up to 1.1A switch current limit. The Boost converter adopts the fix frequency of 850kHz (TYP) peak current mode control for voltage regulation.

In addition, the SGM41283 integrates accurate current mirror with two selectable ratios of 10:1 and 2:1 for APD current monitoring.

The SGM41283 integrates various protection features such as Boost over-current protection, thermal shutdown, and APD current limit adjustment to protect the APD from optical power transients.

The SGM41283 is available in a Green TQFN-3×3-16L package. It operates over an ambient temperature range of -40℃ to +125℃.

FEATURES

- **Input Voltage Range: 2.7V to 5.5V**
- **R_{DSON} of Power FET: 0.6Ω**
- **Output Voltage Range: up to 70V**
- **Switch Current Limit: 1.1A**
- **Switching Frequency: 850kHz**
- **Internal Compensation and Soft-Start**
- **APD Current Monitoring Response Time: 50ns**
- **High-side APD Current Monitor with Less than ±5% Tolerance**
- **High-side Current Monitor Ratios: 10:1 and 2:1**
- **Thermal-Shutdown Protection**
- **Programmable APD Over-Current Limit and Protection**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in a Green TQFN-3×3-16L Package**

APPLICATIONS

APD Bias
Optical Line Terminal
High Voltage Sensor Bias

TYPICAL APPLICATION

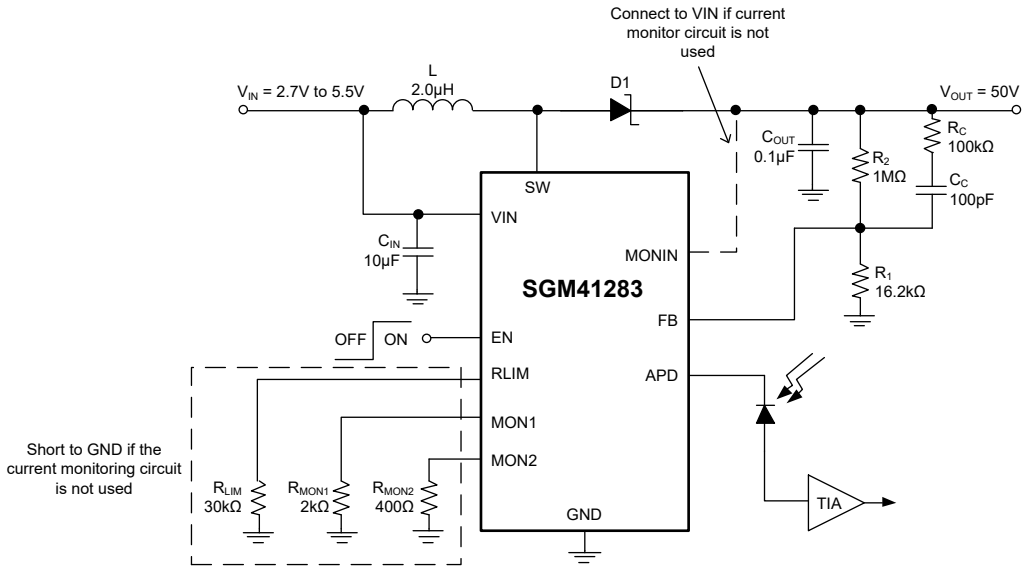


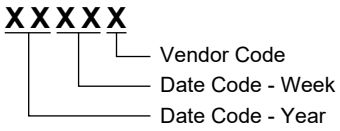
Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM41283	TQFN-3×3-16L	-40℃ to +125℃	SGM41283XTQ16G/TR	41283TQ XXXXX	Tape and Reel, 4000

MARKING INFORMATION

NOTE: XXXXX = Date 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

Input Voltage Range ..... -0.3V to 6.5V
MONIN, SW, APD..... -0.3V to 76V
EN, FB, RLIM..... -0.3V to 6.5V
MON1, MON2 ..... -0.3V to 4.5V
Package Thermal Resistance
TQFN-3×3-16L, θ_{JA}..... 45℃/W
Junction Temperature.....+150℃
Storage Temperature Range .....-65℃ to +150℃
Lead Temperature (Soldering, 10s).....+260℃
ESD Susceptibility
HBM.....4000V
MM.....300V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range .....2.7V to 5.5V
MON1, MON2 .....2.5V
MONIN, SW, APD.....2.7V to 70V
Operating Ambient Temperature Range.....-40℃ to +125℃
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

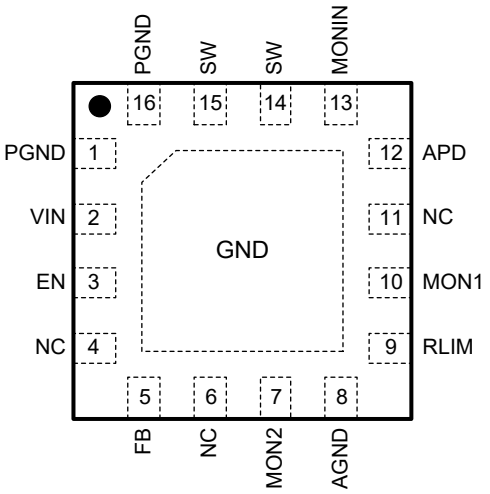
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its 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-3×3-16L

PIN DESCRIPTION

PIN	NAME	FUNCTION
1, 16	PGND	Power ground pin. Source connection of low-side power FET.
2	VIN	Input supply pin.
3	EN	Enable pin. Logic high enables the device; logic low disables the device.
4, 6, 11	NC	No connection.
5	FB	Feedback pin. A resistive divider connected on this pin to program the output voltage.
7	MON2	Current mirror output pin of 2:1 ratio. Tie to ground if not using the current monitoring circuit.
8	AGND	Analog ground.
9	RLIM	APD current-limit resistor. Connect a resistor from RLIM to GND to program the APD current-limit threshold. Tie to ground if not using the current monitoring circuit.
10	MON1	Current mirror output pin of 10:1 ratio. Tie to ground if not using the current monitoring circuit.
12	APD	The output of current monitor circuit, connect to the APD cathode if using monitor function. Leave it open if not used.
13	MONIN	Input to the current monitor circuit, connect to the Boost output if using the monitor circuit, or connect to VIN if not used.
14, 15	SW	Switch node pin, drain connection of the low-side power FET.
–	Exposed Pad	Connect to PGND on PCB for good thermal performance.

ELECTRICAL CHARACTERISTICS

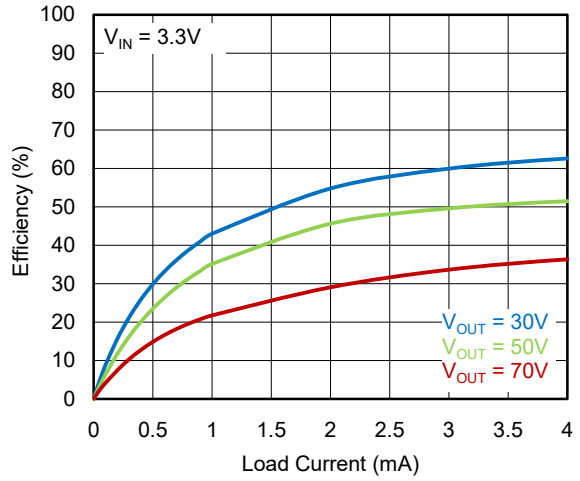
(V_{IN} = 3.3V, V_{EN} = 3.3V, Full = -40℃ to +125℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{IN}		Full	2.7		5.5	V
Supply Current	I_{SUPPLY}	V_{FB} = 1V, not switching	Full		0.2	0.28	mA
		V_{EN} = 0V	Full		0.01	1	μA
Under-Voltage Lockout Threshold	V_{UVLO}		Full	2.4	2.5	2.6	V
Under-Voltage Lockout Hysteresis	V_{UVLO_HYS}		+25℃		200		mV
EN Logic High Threshold	V_{IH}		Full	1.6			V
EN Logic Low Threshold	V_{IL}		Full			0.3	V
Feedback Voltage	V_{FB}		Full	0.775	0.795	0.815	V
Feedback Line Regulation			+25℃		0.15	0.42	%/V
FB Input-Bias Current	I_{FB}	V_{FB} = 0.795V	Full		10	400	nA
Switching Frequency	f_{SW}		Full	710	850	960	kHz
Maximum Duty Cycle	D_{MAX}		Full	85.5	90	92.0	%
Switch Current Limit	I_{LIM_SW}		+25℃	0.87	1.1	1.35	A
Internal Switch On-Resistance	R_{ON}	I_{SW} = 150mA	Full		0.6	1.1	Ω
Switch Leakage Current		V_{SW} = 72V, V_{EN} = 0V	Full		0.05	1	μA
EN Pin Pull-Down Current	I_{ENP}	V_{EN} = 0V	Full		0.1	0.4	μA
APD Current-Monitor Output1 Gain	G_{CM1}	I_{APD} = 250nA, 10V ≤ V_{MONIN} ≤ 70V	Full	0.08	0.10	0.12	mA/mA
		I_{APD} = 2.5mA, 10V ≤ V_{MONIN} ≤ 70V	Full	0.096	0.10	0.105	
APD Current-Monitor Output2 Gain	G_{CM2}	I_{APD} = 250nA, 10V ≤ V_{MONIN} ≤ 70V	Full	0.43	0.5	0.56	mA/mA
		I_{APD} = 2.5mA, 10V ≤ V_{MONIN} ≤ 70V	Full	0.489	0.5	0.522	
Monitor-Output1 Voltage Clamp	V_{MOC1}	250nA < I_{APD} < 2.5mA	Full	3.8	4.10	4.4	V
Monitor-Output2 Voltage Clamp	V_{MOC2}	250nA < I_{APD} < 2.5mA	Full	3.8	4.10	4.4	V
APD Monitor-Voltage Drop	V_{DROP}	V_{MONIN} - V_{APD} at I_{APD} = 1mA, V_{MONIN} = 40V	Full	1.3	1.5	1.7	V
APD Monitor-Current Response Speed	t_{DELAY1}	10μA to 1mA step APD current input	+25℃		50		ns
	t_{DELAY2}	250nA to 10μA step APD current input	+25℃		7		μs
APD Input Current Limit	I_{LIM_APD}	V_{APD} = 0V, V_{MONIN} = 40V, R_{LIM} = 16.9kΩ	Full	3.75		4.50	mA
APD Current Limit Adjustment Range		R_{LIM} = 27.2kΩ, V_{MONIN} = 10V	Full	2.29		2.80	mA
		R_{LIM} = 137kΩ, V_{MONIN} = 10V	Full	0.435		0.575	
		R_{LIM} = 27.2kΩ, V_{MONIN} = 70V	Full	2.25		2.95	
		R_{LIM} = 137kΩ, V_{MONIN} = 70V	Full	0.435		0.595	
Thermal Shutdown	T_{SHDN}				170		℃
Thermal Shutdown Hysteresis	T_{HYS}				20		℃

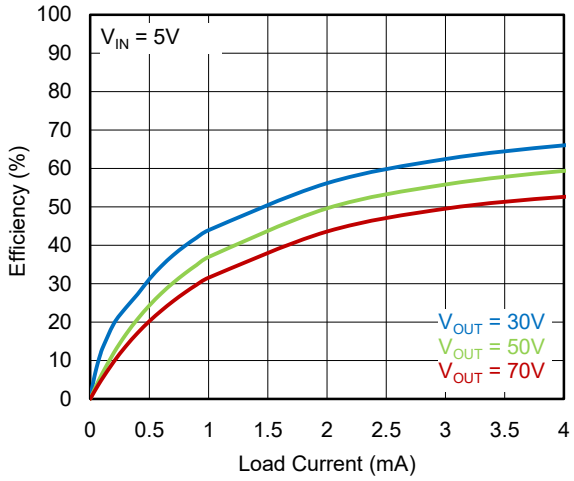
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = V_{EN} = 3.3V, V_{OUT} = 50V, T_A = +25℃, unless otherwise noted.

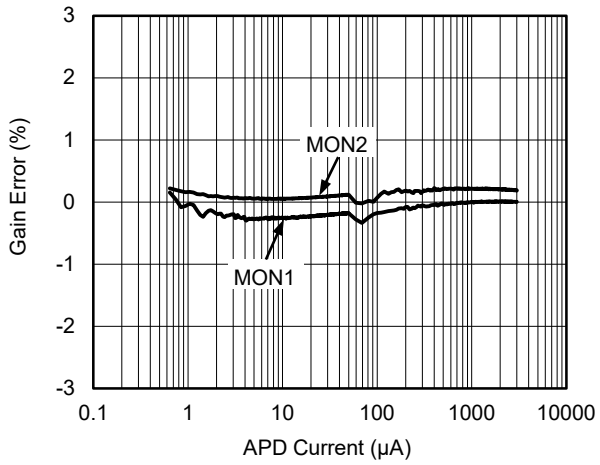
Efficiency vs. Load Current



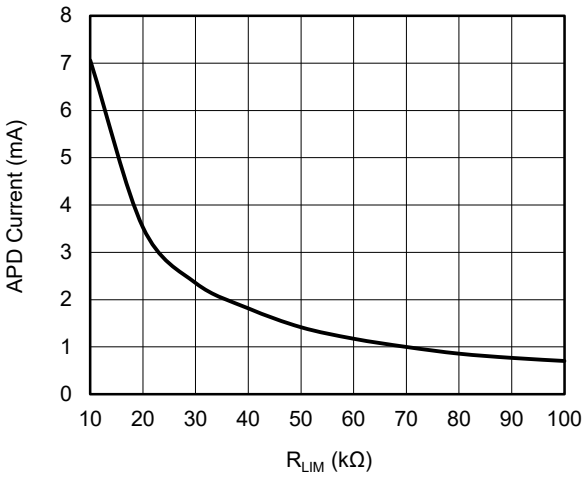
Efficiency vs. Load Current



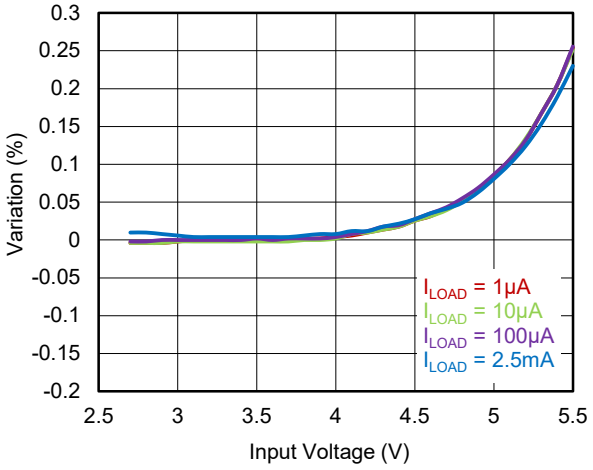
Gain Error vs. APD Current



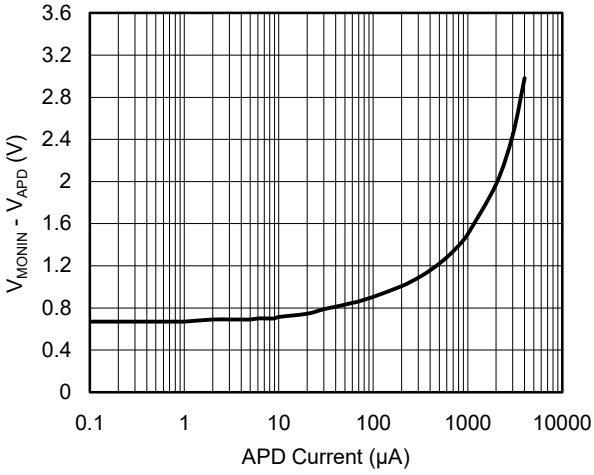
APD Current Limit vs. R_{LIM}



Line Regulation



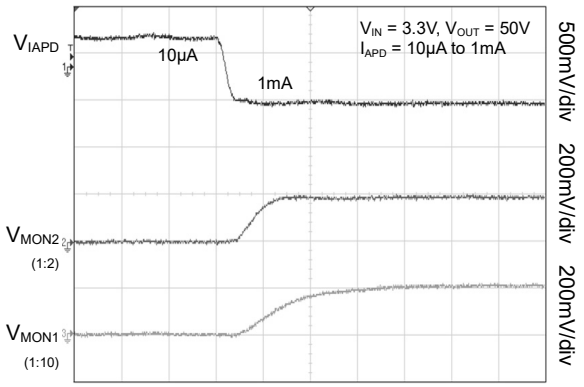
APD Monitor-Voltage Drop vs. APD Current



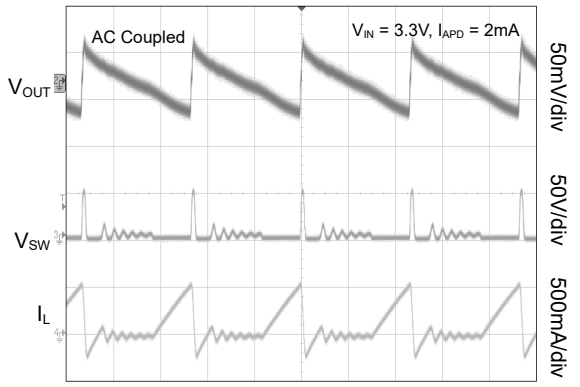
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

V_{IN} = V_{EN} = 3.3V, V_{OUT} = 50V, T_A = +25℃, unless otherwise noted.

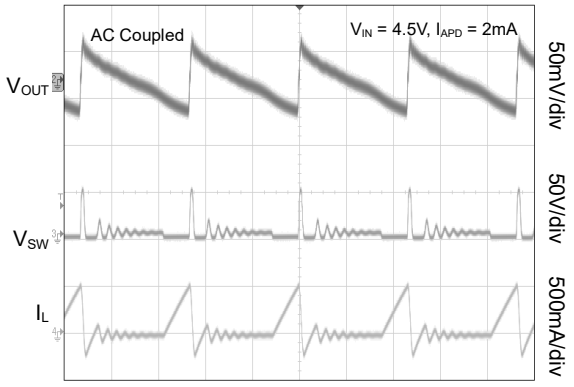
APD Monitor-Current Response



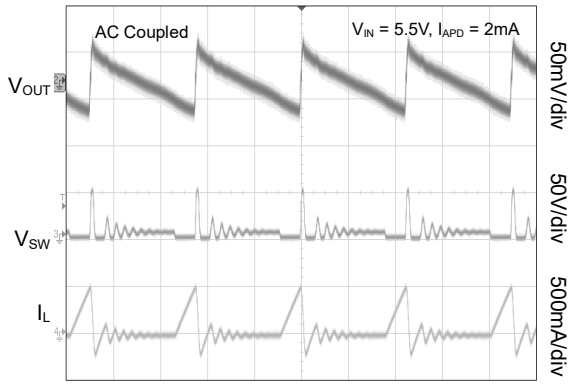
Steady State



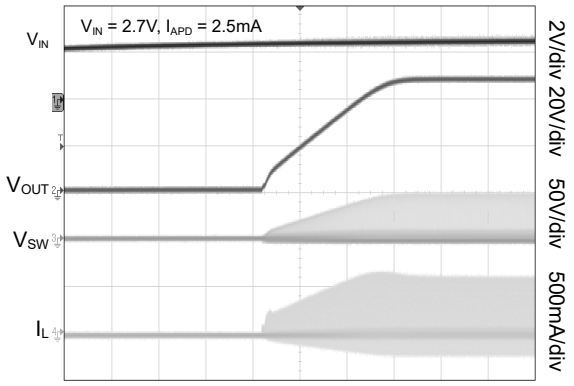
Steady State



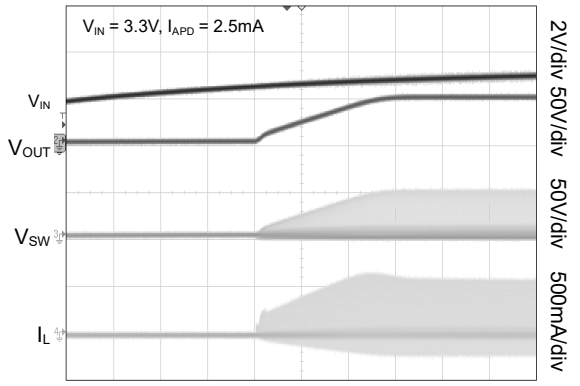
Steady State



Power Startup



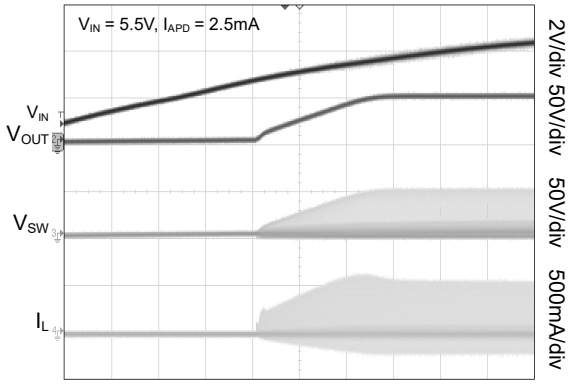
Power Startup



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

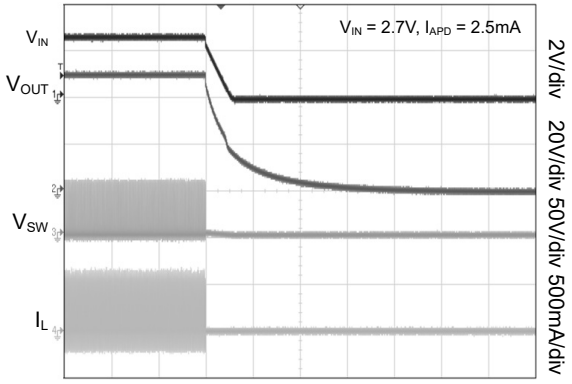
V_{IN} = V_{EN} = 3.3V, V_{OUT} = 50V, T_A = +25℃, unless otherwise noted.

Power Startup



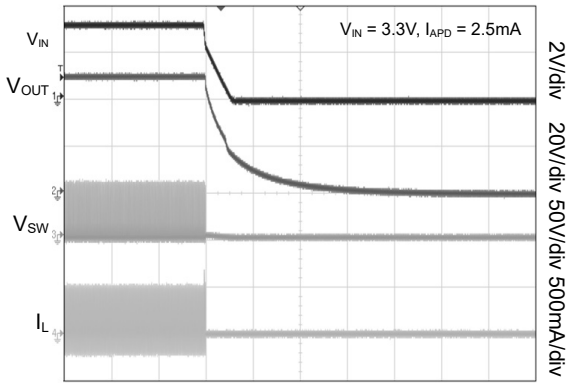
Time (1ms/div)

Power Shutdown



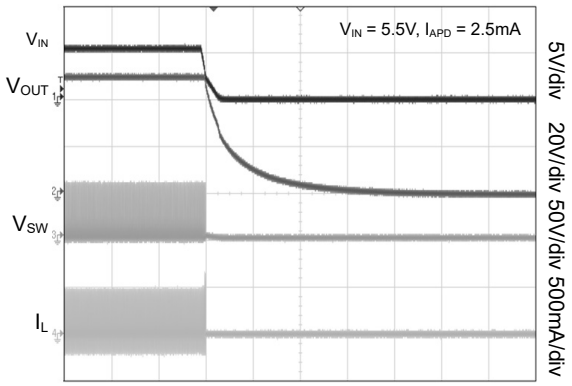
Time (100ms/div)

Power Shutdown



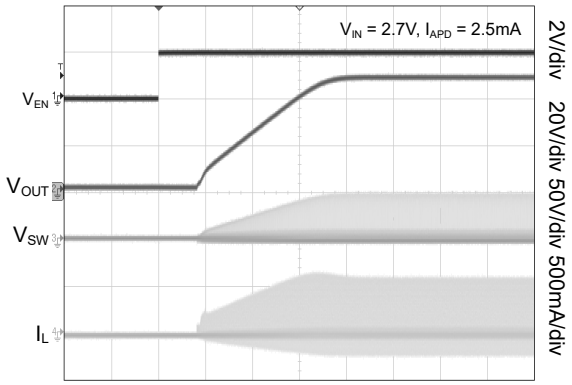
Time (100ms/div)

Power Shutdown



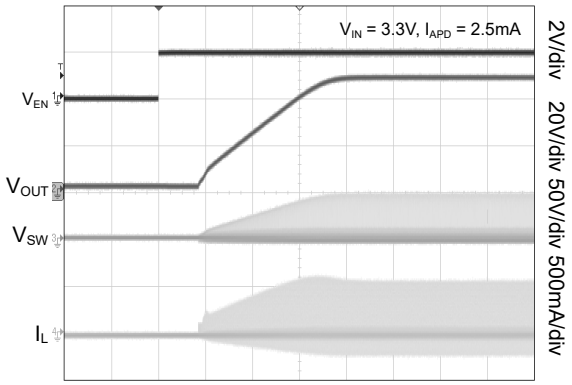
Time (100ms/div)

Enable Startup



Time (1ms/div)

Enable Startup

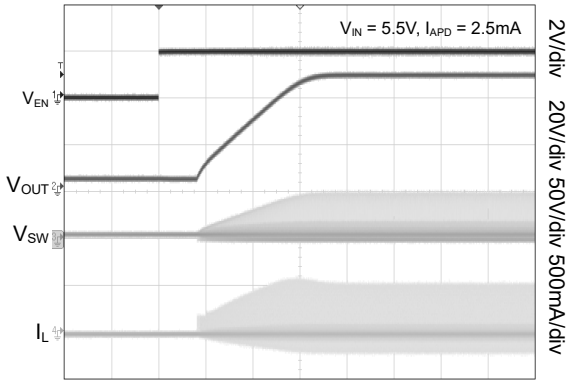


Time (1ms/div)

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

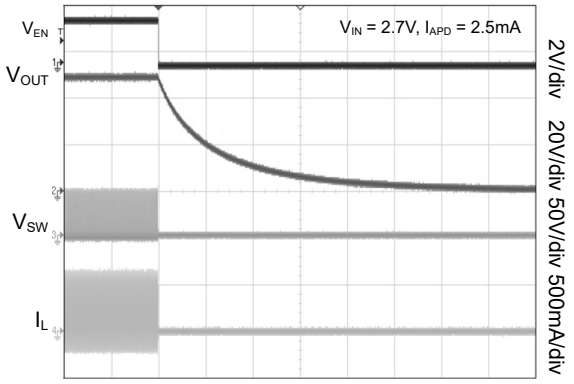
V_{IN} = V_{EN} = 3.3V, V_{OUT} = 50V, T_A = +25℃, unless otherwise noted.

Enable Startup



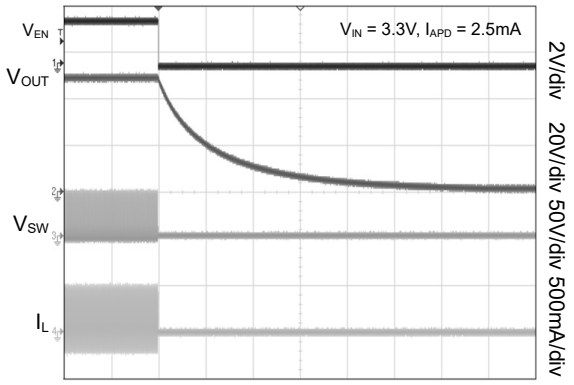
Time (1ms/div)

Enable Shutdown



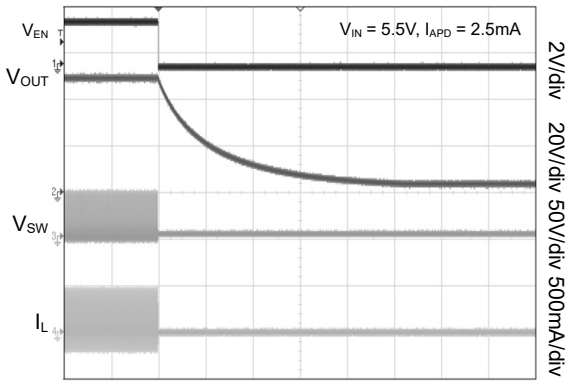
Time (50ms/div)

Enable Shutdown



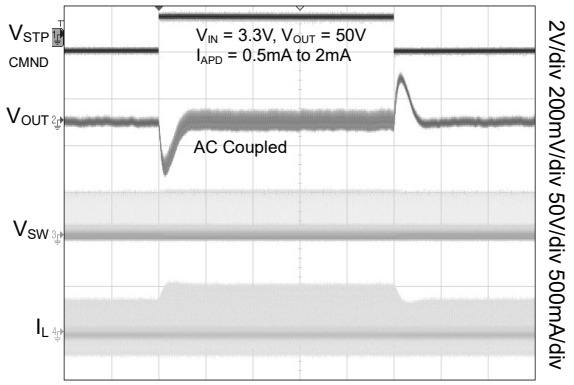
Time (50ms/div)

Enable Shutdown



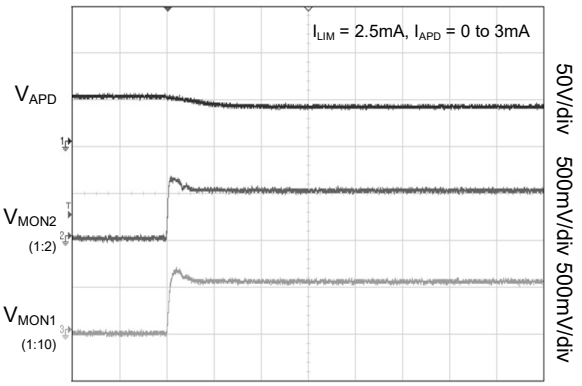
Time (50ms/div)

APD Transient Response



Time (200μs/div)

OCP Response

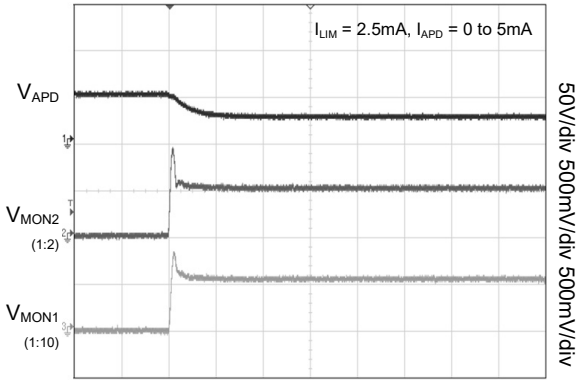


Time (1μs/div)

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

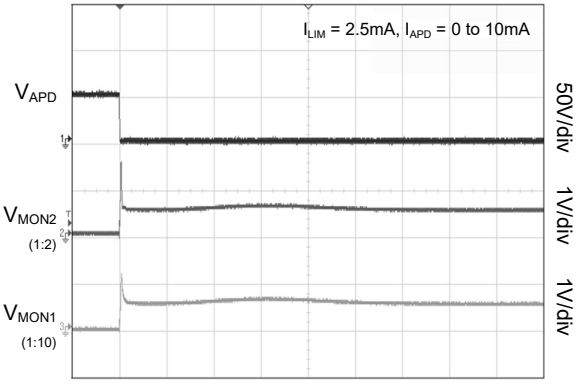
V_{IN} = V_{EN} = 3.3V, V_{OUT} = 50V, T_A = +25℃, unless otherwise noted.

OCP Response



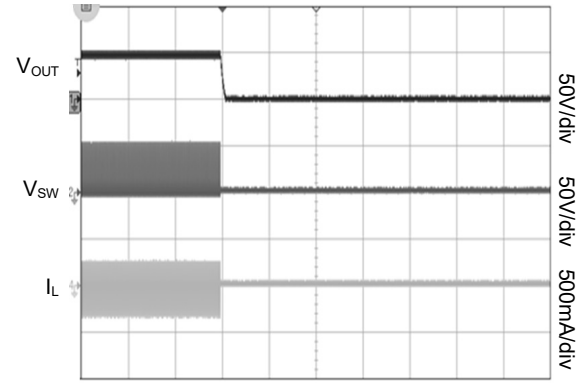
Time (1μs/div)

OCP Response



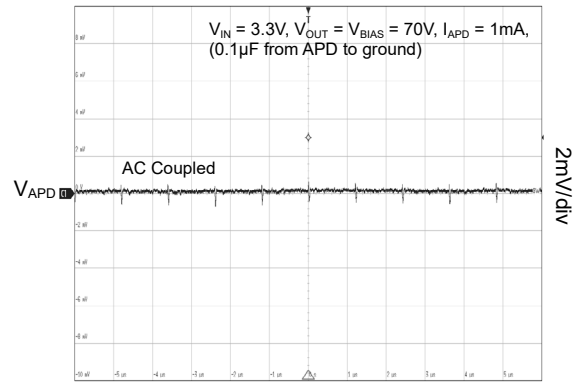
Time (2μs/div)

Temperature Shutdown at +148℃



Time (400ms/div)

APD Output Ripple Voltage



Time (1μs/div)

FUNCTIONAL BLOCK DIAGRAM

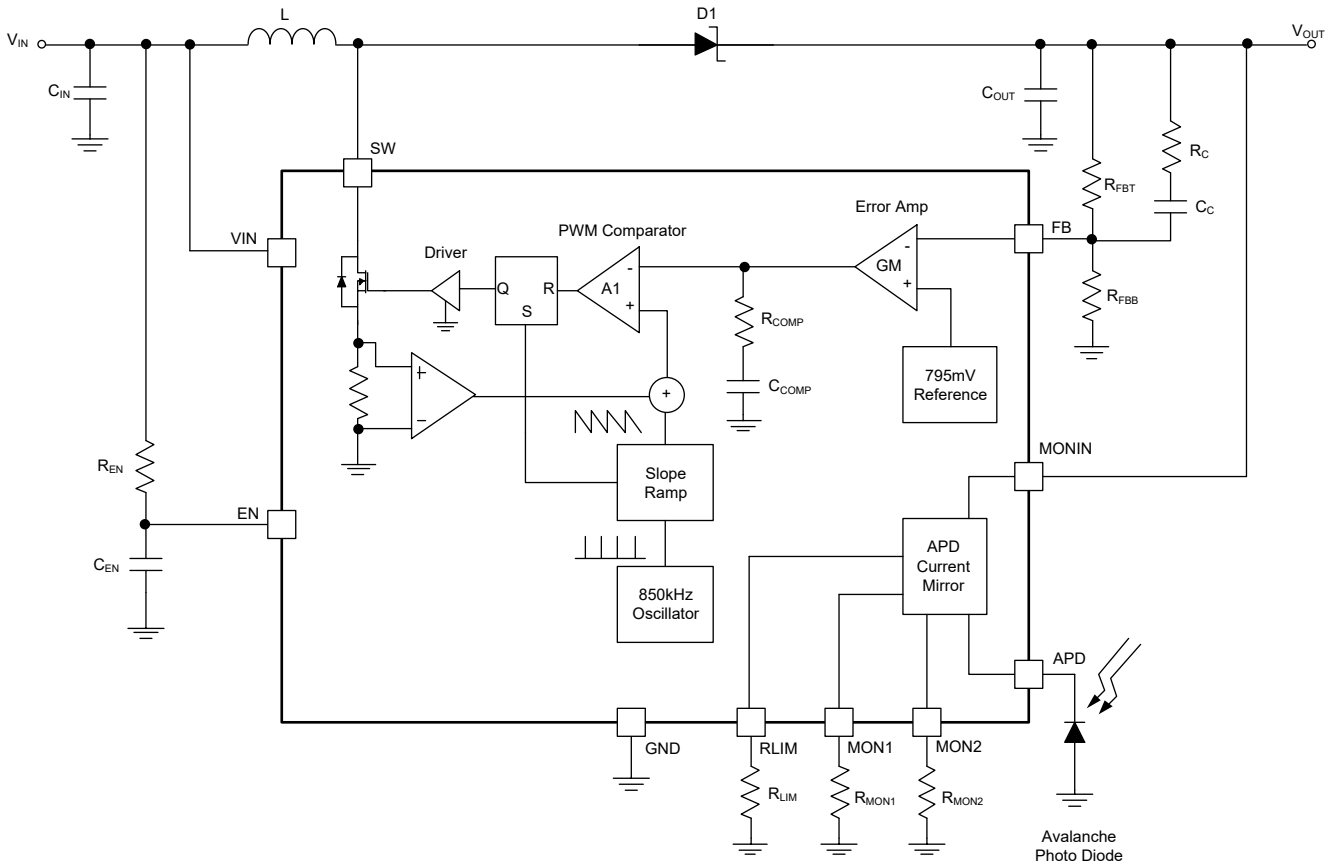


Figure 2. Block Diagram

APPLICATION INFORMATION

The SGM41283 is a high voltage Boost converter that adopts the fixed frequency current mode control to provide excellent line and load regulation.

The SGM41283 implements the negative feedback control to regulate the output voltage. The error amplifier output sets the peak switch current that's necessary to maintain the output voltage as well as load demands. The internal RS latch is set to turn on the LS power FET at the beginning of each switching cycle, when the current through the LS FET exceeds the level sets by the error amplifier output, the LS FET turns off, the inductor current flows through the rectifier diode to replenish the output capacitor as well as supplying the load, this cycle repeats itself during normal operation.

The SGM42183 integrates a high-side APD current monitor circuit to accurately monitor the current going through the APD. The device constantly monitors the current on the APD pin, and the monitored current is converted to a voltage signal via the resistor connected on the MONx pins. Where MON1 pin has a current mirror ratio of 10:1 and MON2 pin has a current mirror ratio of 2:1. The MONx pin is designed to have an internal clamp of 4V to protect the device against open-circuit. In addition, APD output over-current limit function is implemented via an external resistor connected on the RLIM pin.

APD Current-Limit Design

The APD current limit is adjustable 0mA to 2.5mA. Calculate the value of the external resistor, R_{LIM}, for a given current limit, I_{LIM}, using the following equation:

$$R_{RLIM}(k\Omega) = \frac{70}{I_{APD,MAX}}(mA) \quad (1)$$

Enable and Shutdown

When the EN pin is pulled to high voltage, the SGM41283 is enabled. When the EN pin is pulled to low voltage, the SGM41283 goes into shutdown mode. In shutdown mode, the device stops switching. Less than 1μA input current is consumed in shutdown mode when input voltage is lower than 5.0V, and the shutdown current may rise to about 50μA when input voltage is larger than 5.0V.

Soft-Start

The SGM41283 implements internal soft-start to reduce the inrush current during start-up.

Output Voltage Programming

Connect a resistor divider on the FB pin to program the output voltage of SGM41283. A 1MΩ top feedback resistor is recommended; use Equation 2 to calculate the bottom feedback resistor. A resistor feedback network programs the output voltage.

$$R_{BOTTM}(k\Omega) = R_{TOP}(k\Omega) \times \frac{V_{FB}}{V_{OUT} - V_{FB}} \quad (2)$$

A feed-forward capacitor of 100pF plus a series 100kΩ resistor in parallel with the top feedback resistor is also recommended to improve the loop stability. The addition of the series RC provides a phase Boost at the crossover as well as increasing the gain margin for wide Boost ratio.

Inductor Design

Three key inductor parameters must be specified for operation with the SGM41283: inductance value (L), inductor saturation current (I_{SAT}), and DC resistance (DCR). In general, the inductor should have a saturation current rating greater than the maximum peak switch current-limit value (I_{LIM_SW} = 1.1A). DCR should be be low for reasonable efficiency. The SGM41283 was designed for operation with inductors in the 1.5μH to 4μH range. Typically, 2.0μH inductor is recommended.

Diode Design

The SGM41283 supports output voltage up to 70V, the selected rectifier diode should have a voltage rating higher than the output voltage with margin. The reverse recovery time and junction capacitance of the selected diode should be as small as possible.

SGMICRO recommends two diodes with relatively small reverse currents are the DFLS1150-7 (Diodes Inc, Schottky, 1A (AVG), 150V) and the BAT46ZFILM (STMicroelectronics, Schottky, 150mA (AVG), 100V).

APPLICATION INFORMATION (continued)

R_{MON1}, R_{MON2} Design

The recommended voltage on the R_{MON1} or R_{MON2} is 2.5V, and recommended current is 2.5mA (TYP). To achieve fast response time, the selected output voltage should be lower than the maximum allowed voltage of 2.5V.

$$I_{MON1,MAX}(mA) = \frac{I_{APD,MAX}}{10} \quad (3)$$

$$I_{MON2,MAX}(mA) = \frac{I_{APD,MAX}}{2} \quad (4)$$

$$R_{MON1}(k\Omega) = \frac{V_{MON1,MAX}}{I_{MON1,MAX}} \quad (5)$$

$$R_{MON2}(k\Omega) = \frac{V_{MON2,MAX}}{I_{MON2,MAX}} \quad (6)$$

where: $V_{MON1,MAX}$, $V_{MON2,MAX}$ < 2.5V.

C_{IN} Design

For proper start-up, a 10μF ceramic cap is recommended to place on VIN pin to prevent the start-up current pulses to pull the VIN pin below the UVLO threshold.

C_{OUT} Design

For most applications, use a small output capacitor of 0.1μF or greater. To achieve low output ripple, a capacitor with low ESR, low ESL, and high capacitance value should be selected. If tantalum or electrolytic capacitors are used to achieve high capacitance values, always add a smaller ceramic capacitor in parallel to bypass the high-frequency components of the diode current. The higher ESR and ESL of electrolytic capacitors increase the output ripple and peak-to-peak transient voltage. Assuming the contribution from the ESR and capacitor discharge equals 50% (proportions may vary), calculate the output capacitance and ESR required for a specified ripple using the following equations:

$$C_{OUT}\ (\mu F) = \frac{I_{OUT}}{0.5 \times \Delta V_{OUT}} \left[t_S - \frac{I_{PEAK} \times L_{OPTIMUM}}{V_{OUT} - V_{IN\_MIN}} \right] \quad (7)$$

$$ESR\ (m\Omega) = \frac{0.5 \times \Delta V_{OUT}}{I_{OUT}} \quad (8)$$

Table 1. Recommended External Components (V_{IN}: 2.7V to 5.5V)

V_{OUT} (V)	$I_{OUT,MAX}$ (mA)	L (μH)	$R_{FB,TOP}$ (MΩ) (V_{OUT} to FB)	$R_{FB,BOTTOM}$ (kΩ) (FB to GND)	Diode (Schottky Small Signal)	C_{OUT} (μF 100V)	C_{IN} (μF)
30	2.5	3.3	1.0	27.4	BAT46W	0.1	10
40	2.5	2.7		20.5			
50	2.5	2.0		16.2			
60	2.0	1.5		13.3			
70	2.0	1.5		11.5			

REVISION HISTORY

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

JUNE 2023 – REV.A.2 to REV.A.3	Page
Updated General Description	1
Updated Pin Description	3
Updated Application Information	11-12

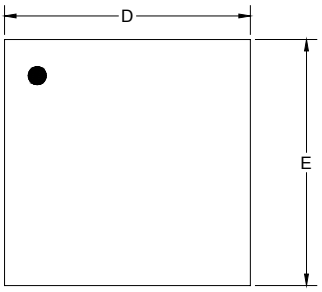
FEBRUARY 2019 – REV.A.1 to REV.A.2	Page
Updated Electrical Characteristics	4

JANUARY 2019 – REV.A to REV.A.1	Page
Updated operating temperature range and Electrical Characteristics	4
Added APD Output Ripple Voltage curve	9

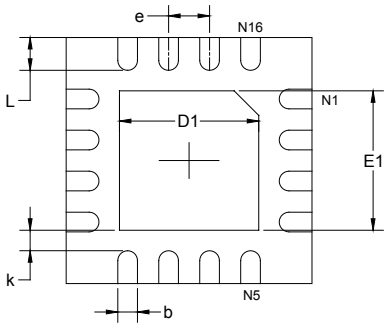
Changes from Original (DECEMBER 2018) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

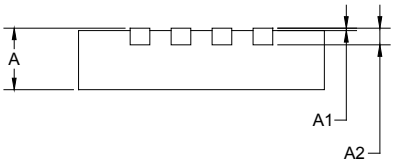
TQFN-3×3-16L



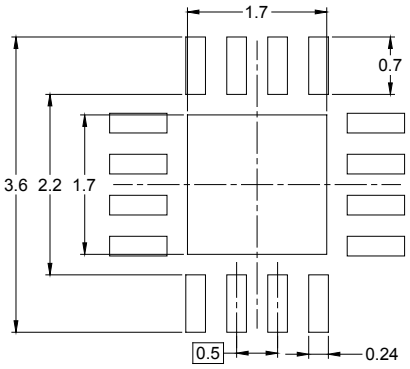
TOP VIEW



BOTTOM VIEW



SIDE VIEW

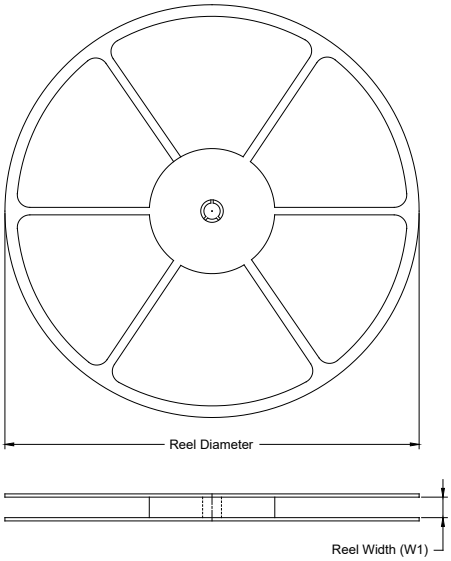


RECOMMENDED LAND PATTERN (Unit: mm)

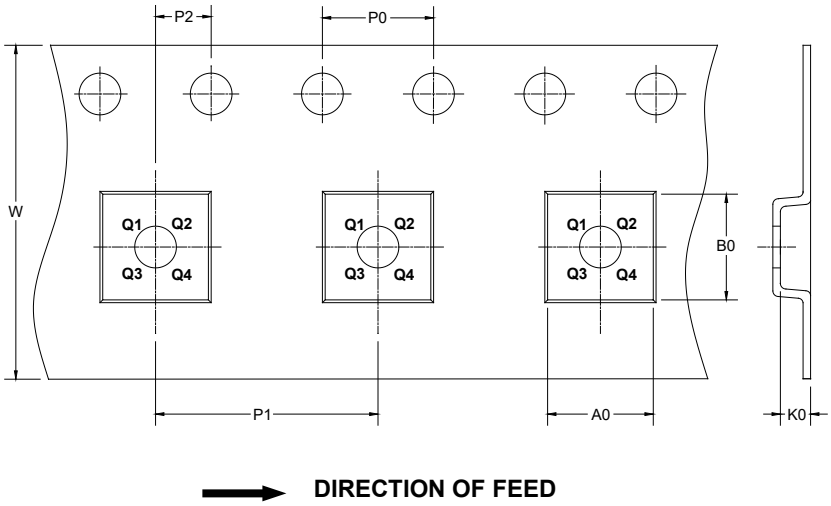
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	1.600	1.800	0.063	0.071
E	2.900	3.100	0.114	0.122
E1	1.600	1.800	0.063	0.071
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.300	0.500	0.012	0.020

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



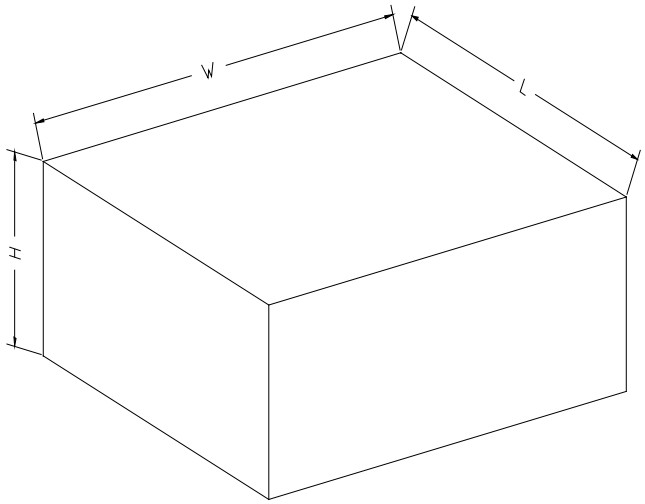
NOTE: The picture is only for reference. Please make the object as the standard.

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-3×3-16L	13″	12.4	3.35	3.35	1.13	4.0	8.0	2.0	12.0	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
13″	386	280	370	5

DD0002