SGM41283
70V Step-Up Converter with APD Current Monitor

GENERAL DESCRIPTION

The SGM41283 is a monolithic step-up converter that integrates a power switch and a biased avalanche photodiode (APD) current monitor. The device can double the output voltage through the APD optical receivers. The SGM41283 can provide up to 70V output.

The SGM41283 uses a current-mode, fixed-frequency architecture to regulate the output voltage, which provides a fast transient response and cycle-by-cycle current limiting. The SGM41283 features two accurate APD current monitoring outputs with 10:1 and 2:1 ratios, respectively. Resistor-adjustable current limiting protects the APD from optical power transients.

The SGM41283 includes over-current and thermal-overload protection to prevent damage in the event of an output overload.

The SGM41283 is available in Green TQFN-3×3-16L package. It operates over an ambient temperature range of -40℃ to +85℃.

FEATURES

- **2.7V to 5.5V Input Voltage**
- **72V/0.6Ω NFET with 1.1A Limit**
- **Up to 70V Output Voltage**
- **50ns APD Current Monitoring Response Speed**
- **850kHz Fixed Switching Frequency**
- **Internal Compensation and Soft-Start**
- **High-side APD Current Monitor with Less than ±5% Tolerance**
- **High-side Current Monitor Ratio:10:1 and 2:1**
- **Thermal-Shutdown Protection**
- **Programmable APD Over-Current Limit and Protection**
- **-40℃ to +85℃ Operating Temperature Range**
- **Available in Green TQFN-3×3-16L Package**

APPLICATIONS

APD Biasing
PIN Diode Biasing
Optical Receivers and Modules
Fiber-Optic-Network Equipment

TYPICAL APPLICATION

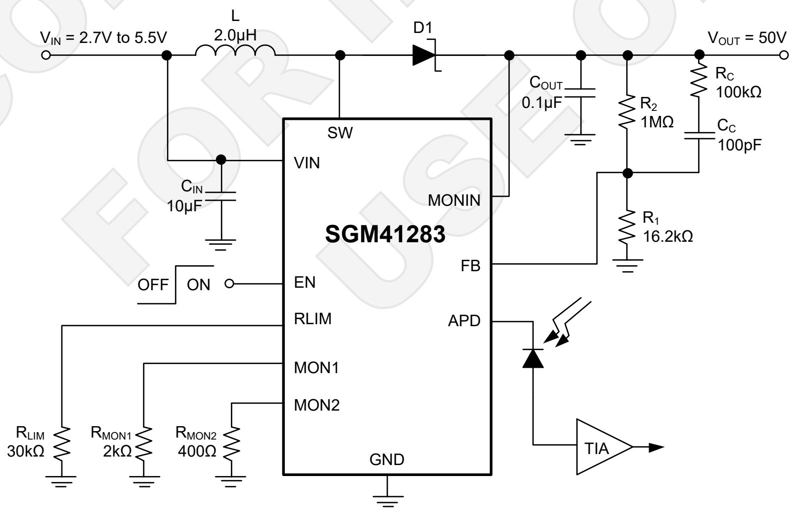


Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM41283	TQFN-3×3-16L	-40℃ to +85℃	SGM41283YTQ16G/TR	41283TQ XXXXX	Tape and Reel, 4000

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
Junction Temperature ....+150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s) ....+260℃

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range ....2.7V to 5.5V
MON1, MON2 ....2.2V
MONIN, SW, APD ....2.7V to 70V
Operating Ambient Temperature Range ....-40℃ to +85℃
Operating Junction Temperature Range ......-40℃ to +125℃

OVERSTRESS CAUTION

Stresses beyond those listed may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

ESD SENSITIVITY CAUTION

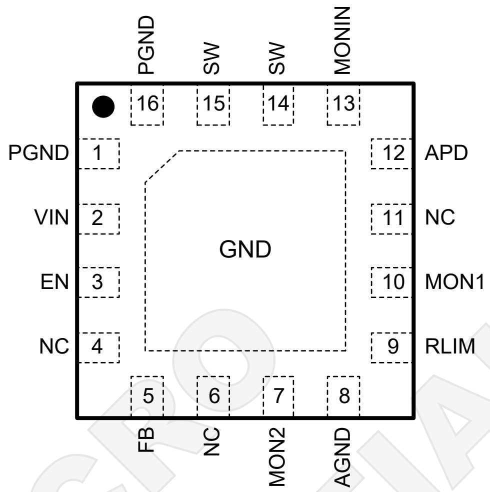
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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, specification or other related things if necessary without notice at any time.

PIN CONFIGURATION

(TOP VIEW)



TQFN-3×3-16L

PIN DESCRIPTION

PIN	NAME	FUNCTION
1, 16	PGND	Power Ground. Pins connected internally. For best performance, connect both pins to board ground.
2	VIN	Input Supply. Locally bypass this pin.
3	EN	Enable Pin. Tie to 1.6V or higher to enable device; 0.4V or less to disable device.
4, 6, 11	NC	Not Connected.
5	FB	Feedback. Connect to the output-resistor-divider tap.
7	MON2	Current-Monitor Output. It sources a current equal to 50% of the APD current and converts to a reference voltage through an external resistor.
8	AGND	Analog Ground.
9	RLIM	Current-Limit Resistor. Connect a resistor from RLIM to GND to program the APD current-limit threshold.
10	MON1	Current-Monitor Output. It sources a current equal to 10% of the APD current and converts to a reference voltage through an external resistor.
12	APD	Connect to APD Cathode.
13	MONIN	Current-Monitor Power Supply. Connect an external low-pass filter to further reduce supply voltage ripple.
14, 15	SW	Switch. Minimize the trace length on this pin to reduce EMI.
–	Exposed Pad	GND. Solder to a large copper plane on the PCB.

ELECTRICAL CHARACTERISTICS

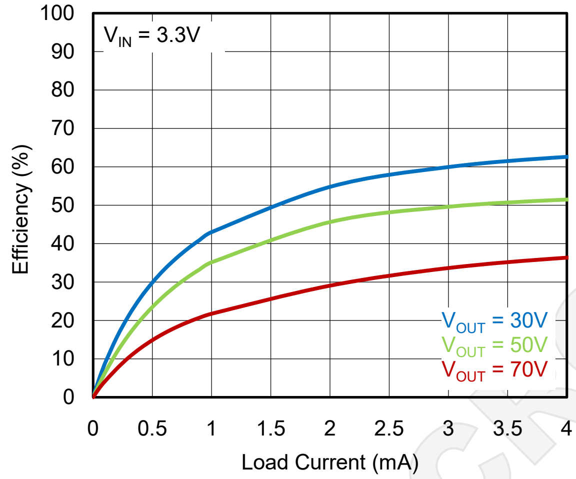
(V_{IN} = 3.3V, V_{EN} = 3.3V, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{IN}		2.7		5.5	V
Supply Current	I_{SUPPLY}	V_{FB} = 1V, not switching		0.2		mA
		V_{EN} = 0V		0.1		μA
Under-Voltage Lockout Threshold	V_{UVLO}			2.5		V
Under-Voltage Lockout Hysteresis	V_{UVLO_HYS}			200		mV
EN Logic High Threshold	V_{IH}		1.6			V
EN Logic Low Threshold	V_{IL}				0.4	V
Feedback Voltage	V_{FB}			0.795		V
Feedback Line Regulation				0.2		%/V
FB Input-Bias Current	I_{FB}	V_{FB} = 0.795V		30		nA
Switching Frequency	f_{SW}			850		kHz
Maximum Duty Cycle	D_{MAX}			91		%
Switch Current Limit	I_{LIM_SW}			1.1		A
Internal Switch On-Resistance	R_{ON}	I_{SW} = 150mA		0.6		Ω
Switch Leakage Current		V_{SW} = 75V, V_{EN} = 0V		0.01		μA
EN Pin Pull-Down Current	I_{ENP}	V_{EN} = 0V		0.001		μA
APD Current-Monitor Output1 Gain	G_{CM1}	I_{APD} = 250nA, 10V ≤ V_{MONIN} ≤70V		0.10		mA/mA
		I_{APD} = 2.5mA, 10V ≤ V_{MONIN} ≤70V		0.10		
APD Current-Monitor Output2 Gain	G_{CM2}	I_{APD} = 250nA, 10V ≤ V_{MONIN} ≤ 70V		0.495		mA/mA
		I_{APD} = 2.5mA, 10V ≤ V_{MONIN} ≤70V		0.5		
Monitor-Output1 Voltage Clamp	V_{MOC1}	250nA < I_{APD} < 2.5mA		4		V
Monitor-Output2 Voltage Clamp	V_{MOC2}	250nA < I_{APD} < 2.5mA		4		V
APD Monitor-Voltage Drop	V_{DROP}	V_{MONIN} - V_{APD} at I_{APD} = 1mA, V_{MONIN} = 40V		1.5		V
APD Monitor-Current Response Speed	t_{DELAY1}	10μA to 1mA step APD current input		50		ns
	t_{DELAY2}	250nA to 10μA step APD current input		7		μs
APD Input Current Limit	I_{LIM_APD}	V_{APD} = 0V, V_{MONIN} = 40V, R_{LIM} = 16.9kΩ		4.3		mA
APD Current Limit Adjustment Range		R_{LIM} = 27.2kΩ, V_{MONIN} = 10V		2.5		mA
		R_{LIM} = 137kΩ, V_{MONIN} = 10V		0.5		
		R_{LIM} = 27.2kΩ, V_{MONIN} = 70V		2.5		
		R_{LIM} = 137kΩ, V_{MONIN} = 70V		0.5		
Thermal Shutdown				160		℃
Thermal Shutdown Hysteresis				15		℃

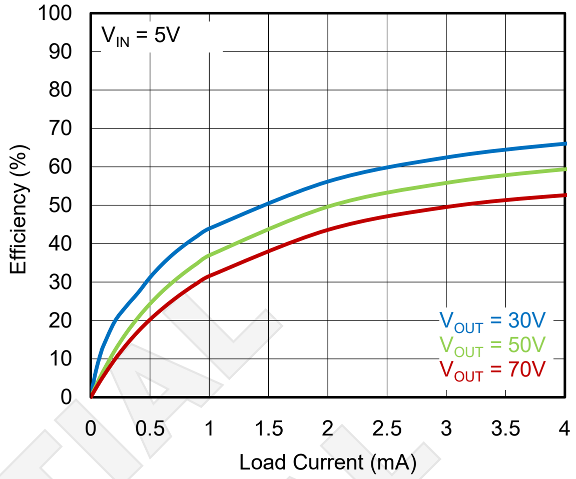
TYPICAL PERFORMANCE CHARACTERISTICS

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

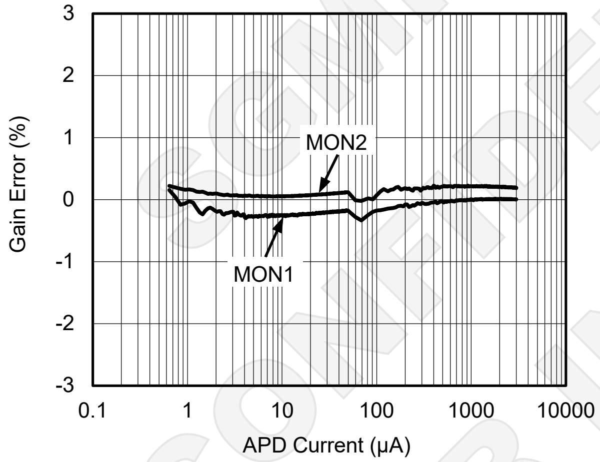
Efficiency vs. Load Current



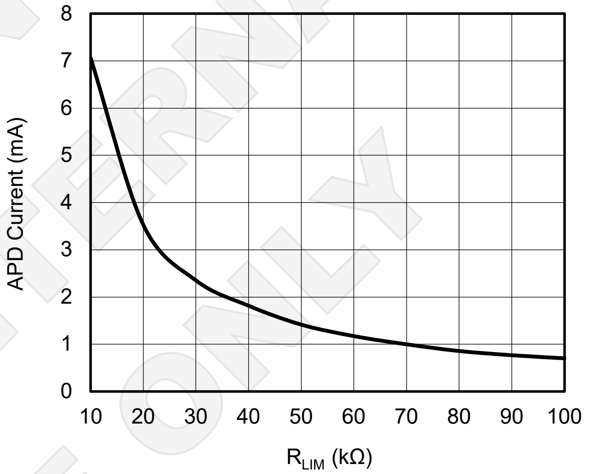
Efficiency vs. Load Current



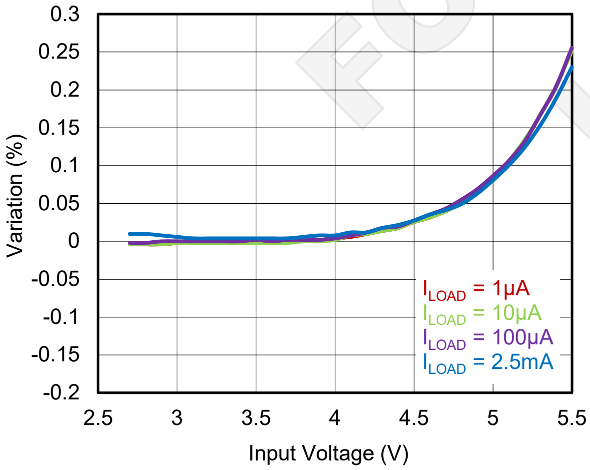
Gain Error vs. APD Current



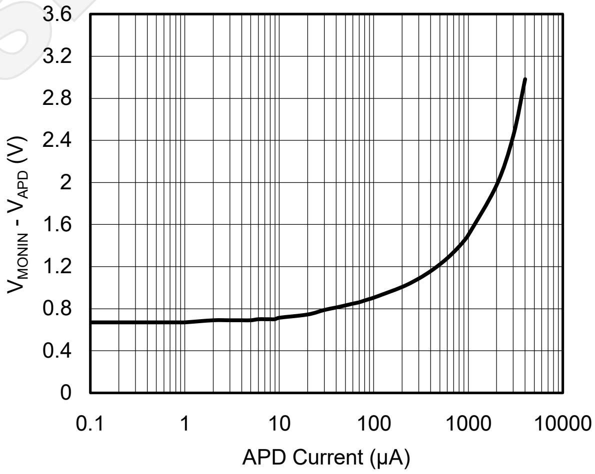
APD Current Limit vs. R_{LIM}



Line Regulation



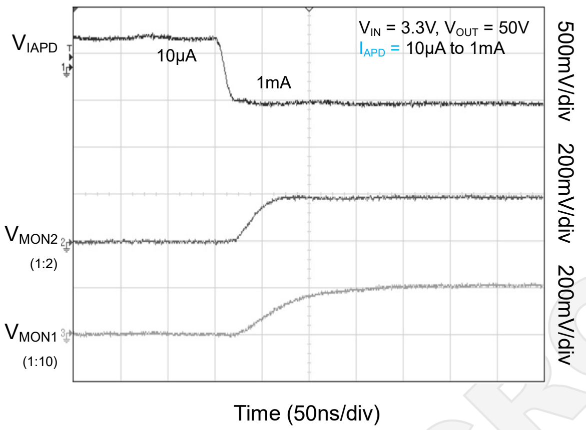
APD Monitor-Voltage Drop vs. APD Current



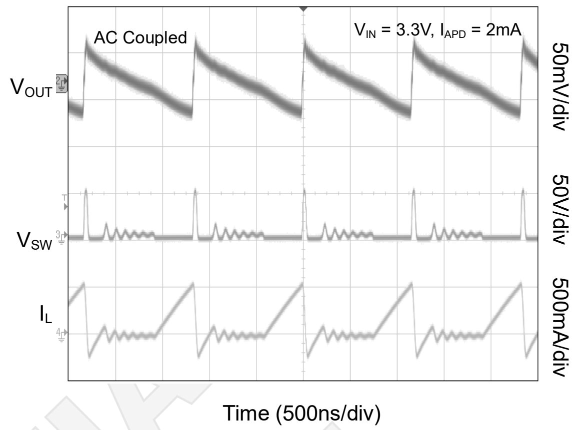
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

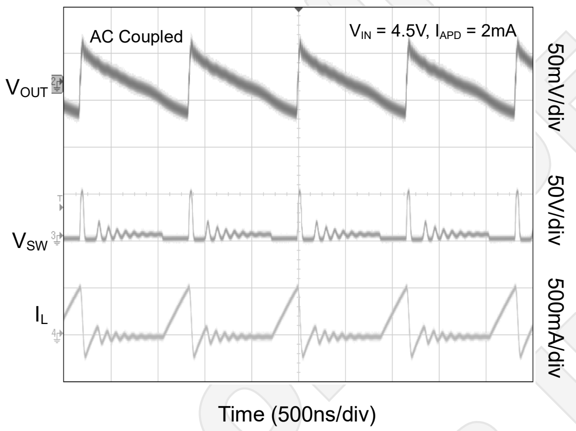
APD Monitor-Current Response



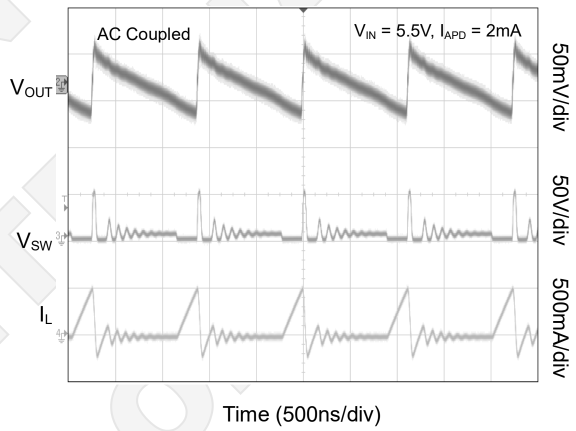
Steady State



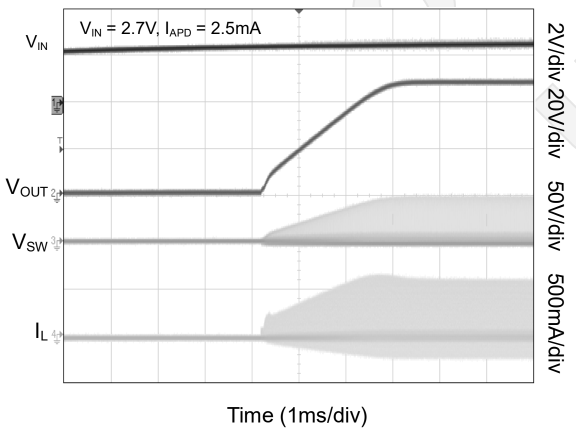
Steady State



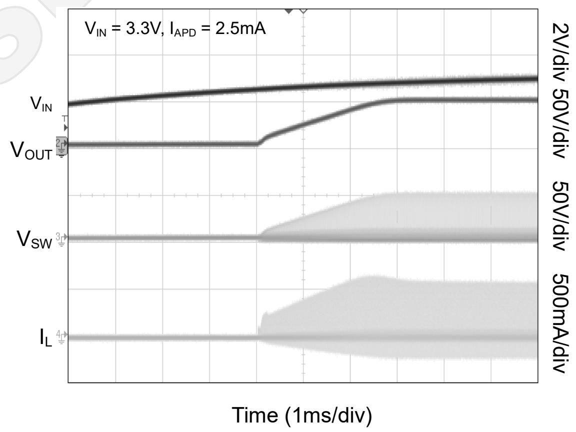
Steady State



Power Startup



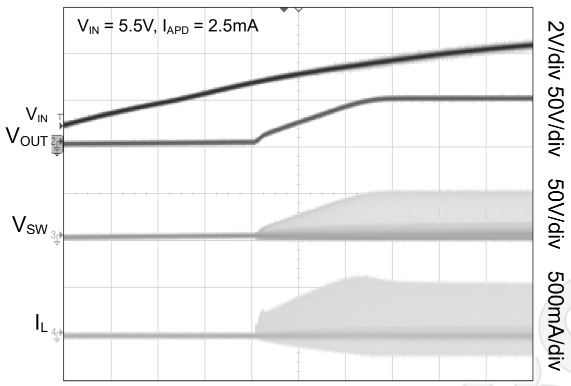
Power Startup



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

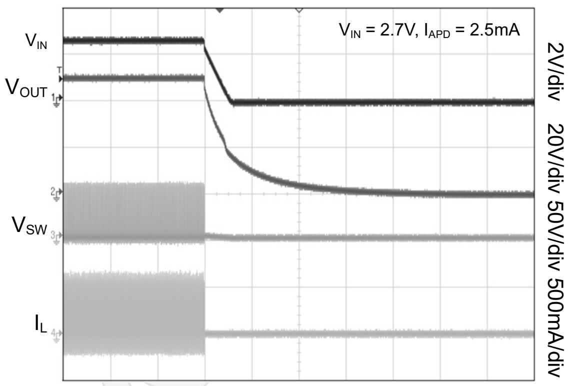
$V_{IN} = V_{EN} = 3.3V$, $V_{OUT} = 50V$, $T_A = +25°C$, unless otherwise noted.

Power Startup



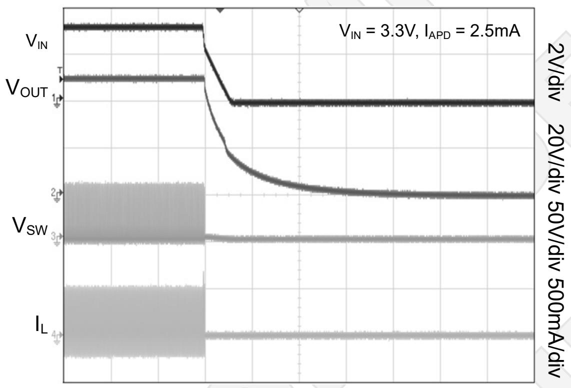
Time (1ms/div)

Power Shutdown



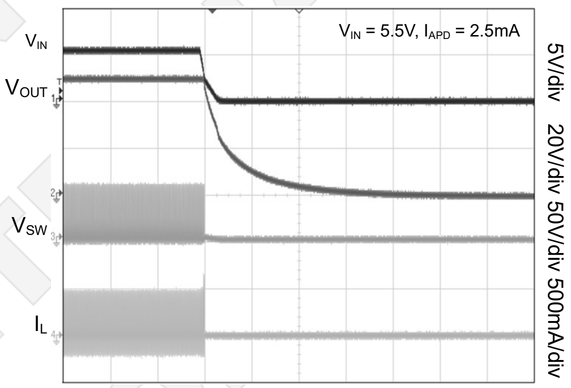
Time (100ms/div)

Power Shutdown



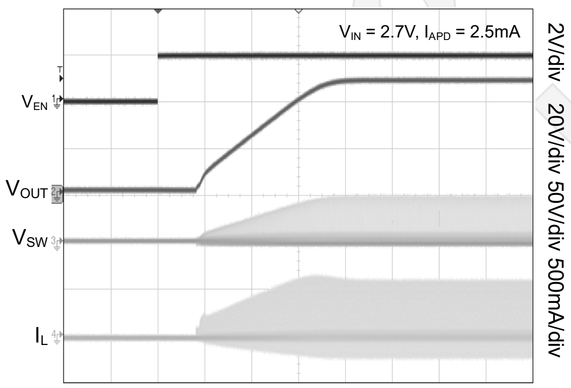
Time (100ms/div)

Power Shutdown



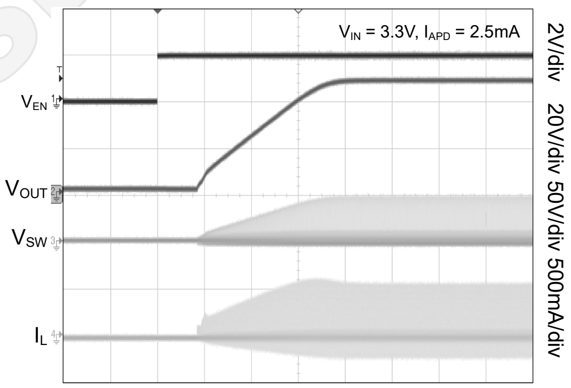
Time (100ms/div)

Enable Startup



Time (1ms/div)

Enable Startup

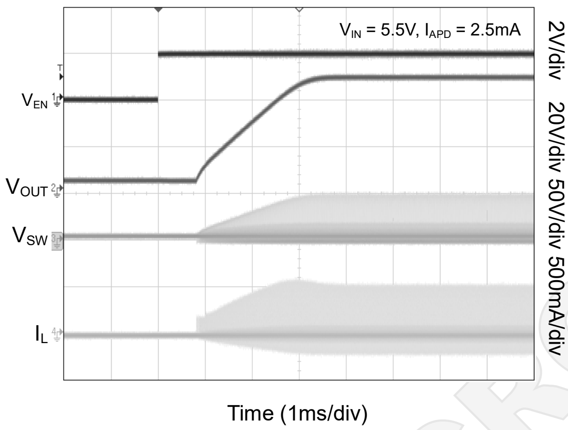


Time (1ms/div)

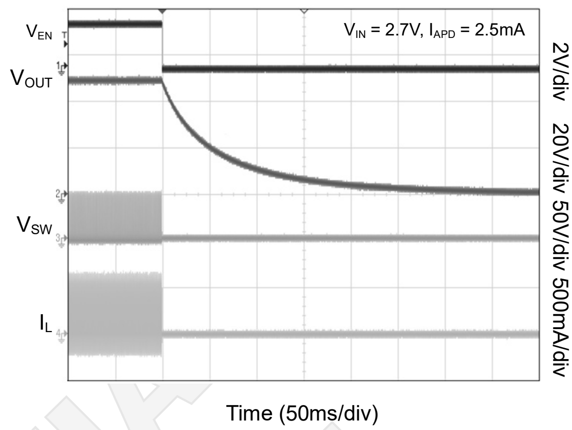
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

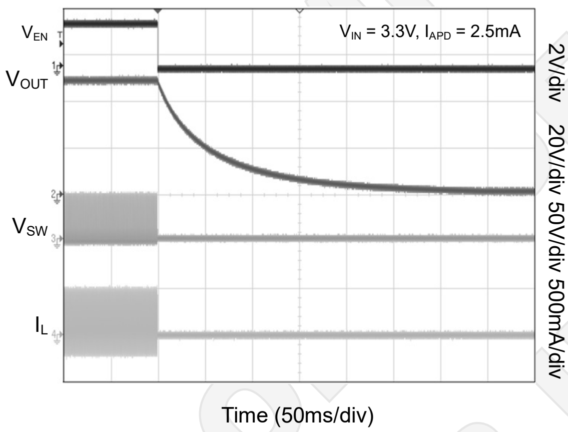
Enable Startup



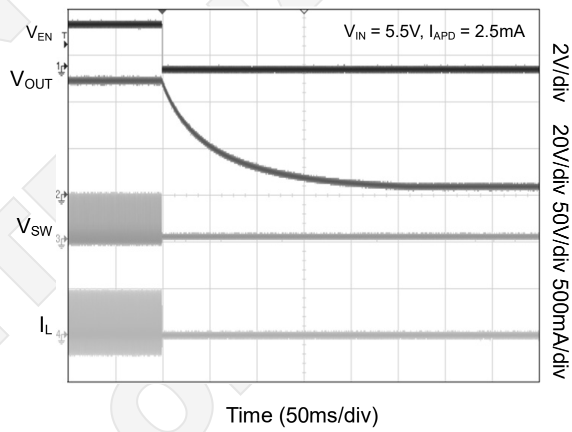
Enable Shutdown



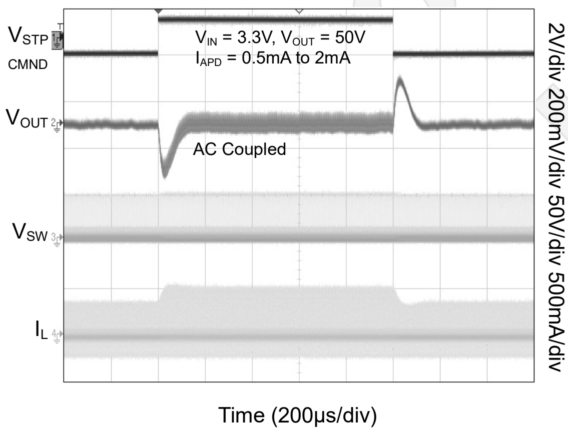
Enable Shutdown



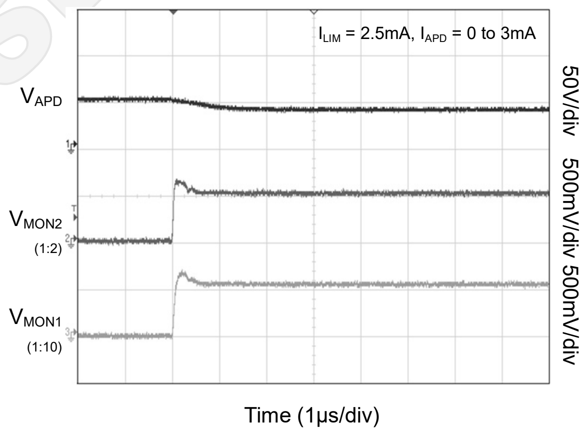
Enable Shutdown



APD Transient Response



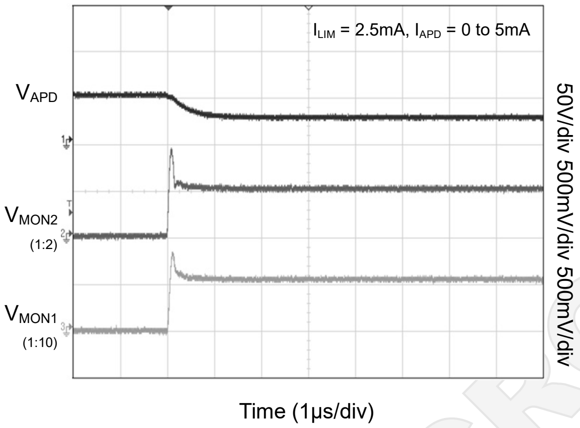
OCP Response



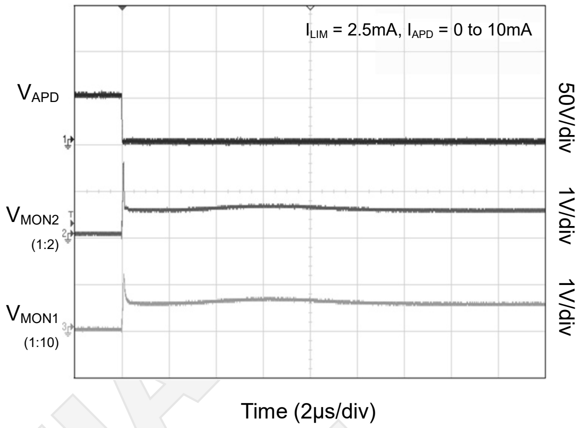
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

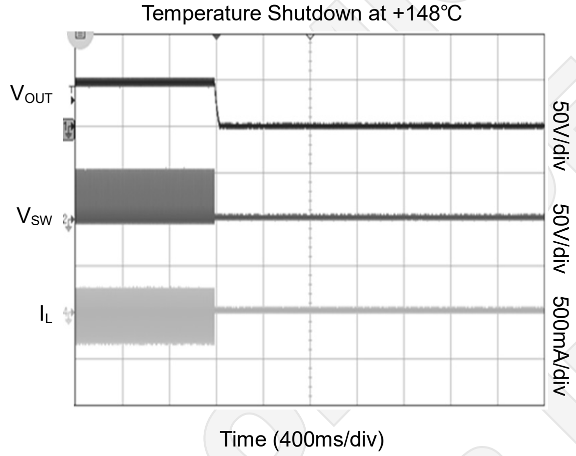
OCP Response



OCP Response



Temperature Shutdown at +148℃



FUNCTIONAL BLOCK DIAGRAM

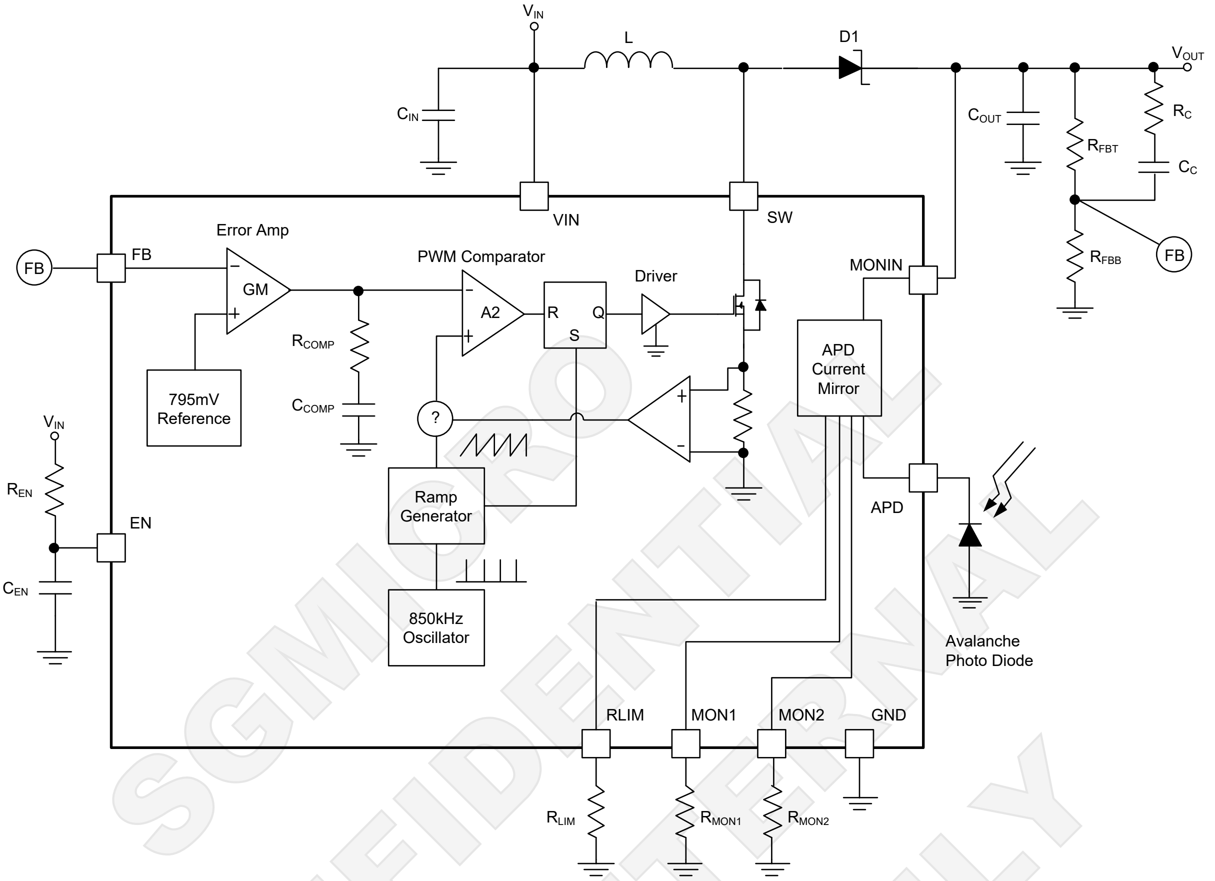


Figure 2. Block Diagram

APPLICATION INFORMATION

The SGM41283 step-up converter uses a constant-frequency, current-mode control scheme to provide excellent line and load regulation.

At the start of each oscillator cycle, the RS latch is set, which turns on the power switch. The output of current sense amplifier which is proportional to the switching current is added to a generated ramp. The resulting sum is fed into the positive terminal of the PWM comparator. The RS latch resets, turning off the power switch as soon as the positive terminal exceeds the level of negative input of PWM comparator which is proportional to the difference between the feedback voltage and the reference voltage. As the load varies, the error amplifier sets the switching peak current necessary to supply the load and regulate the output voltage.

SGM41283 has an integrated high-side APD current monitor. The MONx pin has an open-circuit protection feature and is internally clamped to 4V. MON1 and MON2 mirror the load current on the APD pin, and convert the currents to voltage signals through resistors R_{MON1} and R_{MON2}. The current mirror ratios are set to be 10:1 and 2:1. The APD output current has over-current protection with a threshold programmed by an external resistor at the RLIM pin.

APD Current-Limit Design

The current limit can be adjusted from 0mA to 2.5mA. Calculate the value of the external resistor, R_{LIM}, for a given current limit, I_{LIM}, using the following equation:

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

Soft-Start

There is no need for a soft-start because V_{OUT} rises very slowly on the order of ms. The portion of the inductor current that actually drives up the output voltage is small due to the high conversion ratio. The inductor current limit 1.1A (TYP), the output capacitor 0.1μF (TYP), and V_{IN} limit the V_{OUT} rise time.

V_{OUT} Programming

A resistor feedback network programs the output voltage. Typically, the top resistor from V_{OUT} to V_{FB} is 1MΩ. The bottom resistor from V_{FB} to GND is:

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

In addition, place a series resistor and capacitor of 100kΩ and 100pF, respectively, in parallel with R_{TOP}. This gives a phase boost for good phase margin as well as decreases the gain for good gain margin in the extreme cases of V_{IN} and V_{OUT}.

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

Due to the high-output voltage combined with the diode capacitive coupling, there is a significant reverse current through the inductor. Generally, a low reverse bias capacitance equates to a low reverse inductor current. However, this is not always true though; so test the diodes prior to final selection. Two recommended 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 maximum allowed voltage on either R_{MON1} or R_{MON2} is 2.5V (TYP). The maximum allowed current is 2.5mA (TYP). For faster response, chose the maximum output less than the maximum allowed voltage.

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

$$I_{MON2,MAX}(mA) = \frac{I_{APD,MAX}}{20} \quad (4)$$

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

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

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

C_{IN} Design

If the C_{IN} is not big enough, the initial current pulses will pull VIN down below UVLO during power start-up. This may cause false starts. Select a C_{IN} of at least 10μF.

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:

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

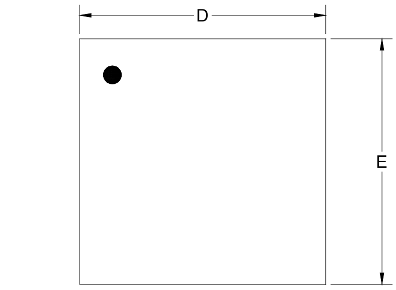
$$ESR\ (m\Omega) = \frac{0.5 \times \Delta V_{OUT}}{I_{OUT}} \quad (8)$$

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

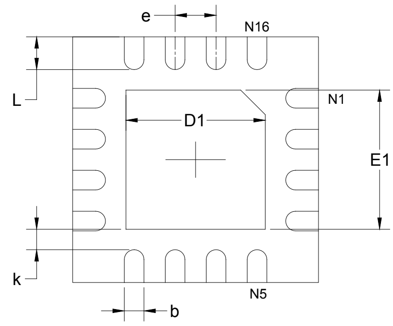
V_{OUT} (V)	$I_{OUT,MAX}$ (mA)	L (μH)	$R_{FB,TOP}$ (MΩ) (V_{OUT} to FB)	$R_{FB,BOTTOM}$ (kΩ) (FB to GND)	Diode (Schottky Small Signal)	C_{OUT} (μF 100V)	C_{IN} (μF)
30	2.5	3.3		27.4			
40	2.5	2.7		20.5			
50	2.5	2.0	1.0	16.2	BAT46W	0.1	10
60	2.0	1.5		13.3			
70	2.0	1.5		11.5			

PACKAGE OUTLINE DIMENSIONS

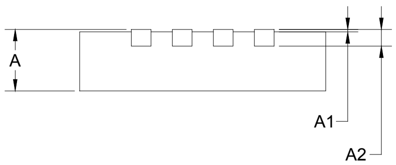
TQFN-3×3-16L



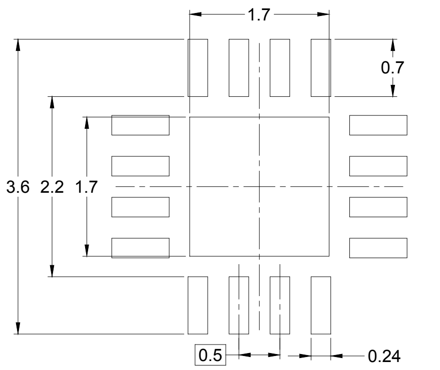
TOP VIEW



BOTTOM VIEW



SIDE VIEW

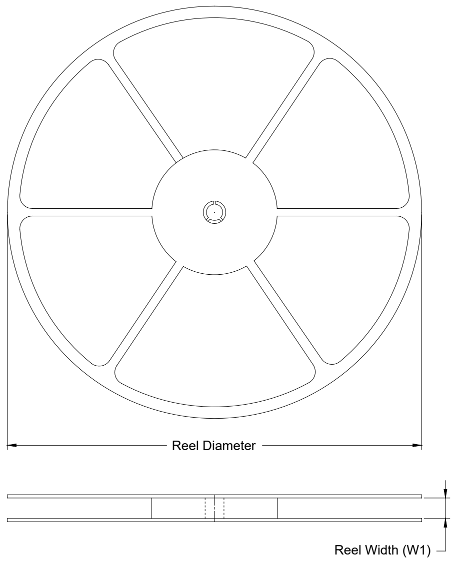


RECOMMENDED LAND PATTERN (Unit: mm)

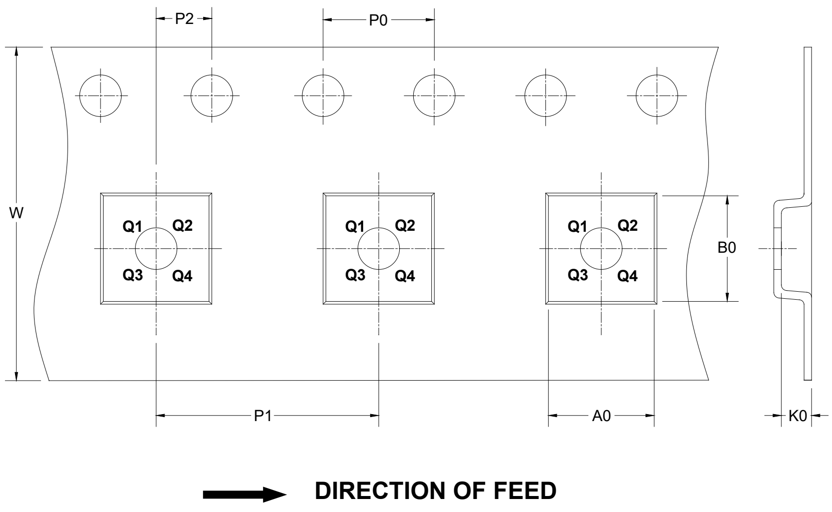
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	1.600	1.800	0.063	0.071
E	2.900	3.100	0.114	0.122
E1	1.600	1.800	0.063	0.071
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007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



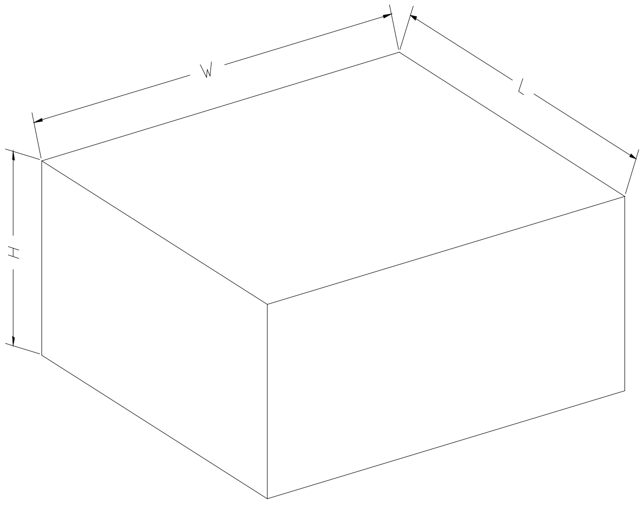
NOTE: The picture is only for reference. Please make the object as the standard.

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