SGM3138
6-Channel Charge Pump White LED Driver with Low Dropout Current Source

GENERAL DESCRIPTION

The SGM3138 is a high performance white LED driver. It integrates current sources and automatic mode selection charge pump. The part maintains the high efficiency by utilizing a 1×/1.5× fractional charge pump and low dropout current sources. The small equivalent 1× mode open loop resistance and ultra-low dropout voltage of current source extend the operating time of 1× mode and optimize the efficiency of Li-ion battery in white LED applications.

The SGM3138 supports up to 6 white LEDs and regulates a constant current which the initial value can be set by an internal resistor. The part implements a 4-bit DAC for brightness control. Users can easily configure the LED current from 1.25mA to 20mA by a serial pulse. The dimming of white LEDs current can be achieved by applying a pulse signal to the EN/SET pin. There are totally 16 steps of current could be set by users. The operating voltage range is 2.7V to 5.5V. Internal soft-start circuitry effectively reduces the in-rush current while both start-up and mode transition.

The SGM3138 is available in Green TQFN-3×3-16L package and is rated over the -40℃ to +85℃ temperature range.

FEATURES

- **Input Voltage Range: 2.7V to 5.5V**
- **Drives Up to 6 LEDs at 20mA Each**
- **One Single Wire Interface**
- **16-Step Brightness Control**
- **High Efficiency by Fractional Conversion with 1× and 1.5× Modes**
- **Switching Frequency: 1MHz**
- **Regulated Output Current with ±5% Matching**
- **Internal Soft-Start Limits Inrush Current**
- **Low Input Ripple and Low EMI**
- **Over-Current and Over-Temperature Protection**
- **Under-Voltage Lockout with Hysteresis**
- **Available in Green TQFN-3×3-16L Package**

APPLICATIONS

Mobile Phone, DSC, MP3
White LED Backlighting
LCD Display Supply

PACKAGE/ORDERING INFORMATION

MODEL	ORDER NUMBER	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	PACKAGE OPTION	MARKING INFORMATION
SGM3138	SGM3138YTQ16G/TR	TQFN-3×3-16L	-40℃ to +85℃	Tape and Reel, 3000	3138TQ

ABSOLUTE MAXIMUM RATINGS

V_{IN} to GND……………………..………..…….…....…….… -0.3V to 6.0V

The Other Pins to GND………………..………....…….. -0.3V to V_{IN}

Power Dissipation, P_D @ T_A = 25℃

TQFN-3×3-16L…………………………….…………....…1.47W

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

Junction Temperature……………………….…………….…..150℃

Operating Temperature Range...…………...…….-40℃ to +85℃

Lead Temperature (Soldering 10 sec)

………………………………………………...…………….. 260℃

ESD Susceptibility

HBM……………………………………….……………....2000V

MM…………………………………………...………..……200V

NOTE:

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

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.

SGMICRO reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time. Please contact SGMICRO sales office to get the latest datasheet.

PIN CONFIGURATION (TOP VIEW)

TQFN-3×3-16L
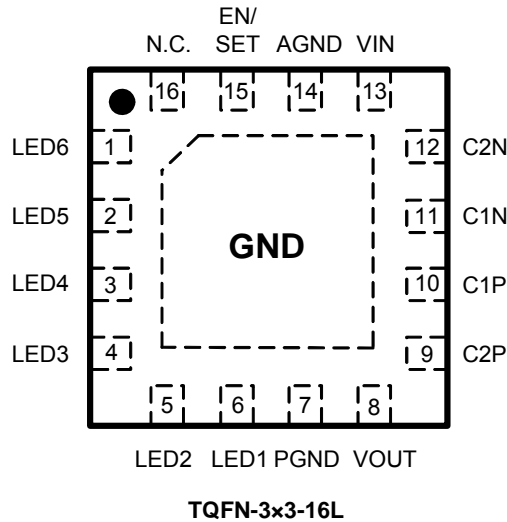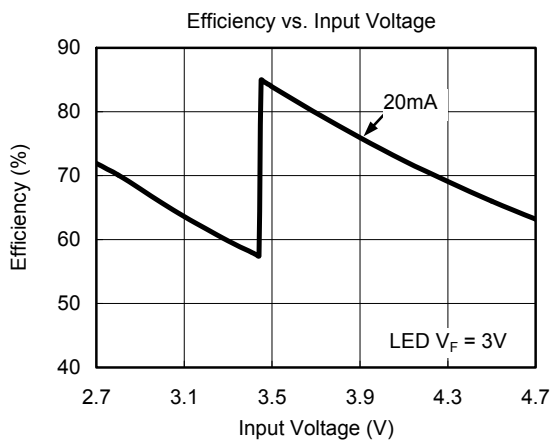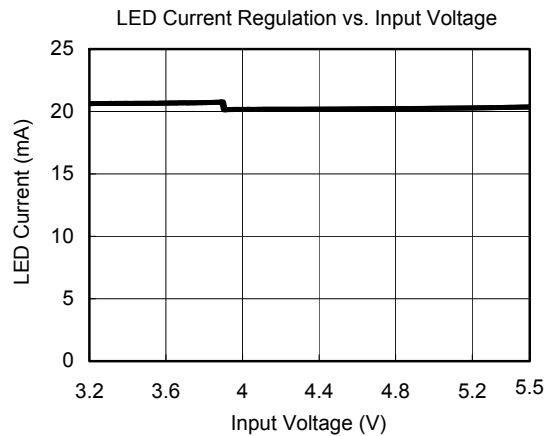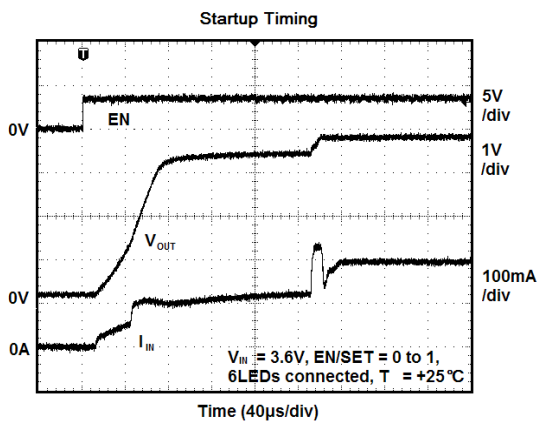
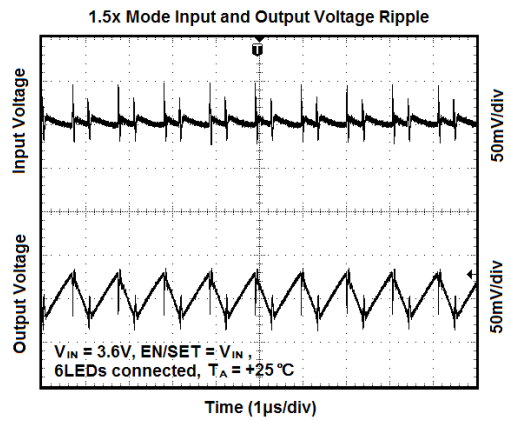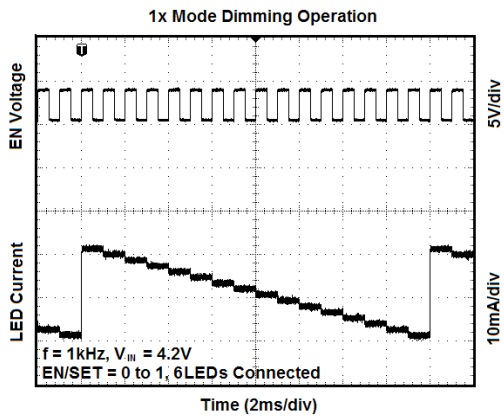# PIN DESCRIPTION

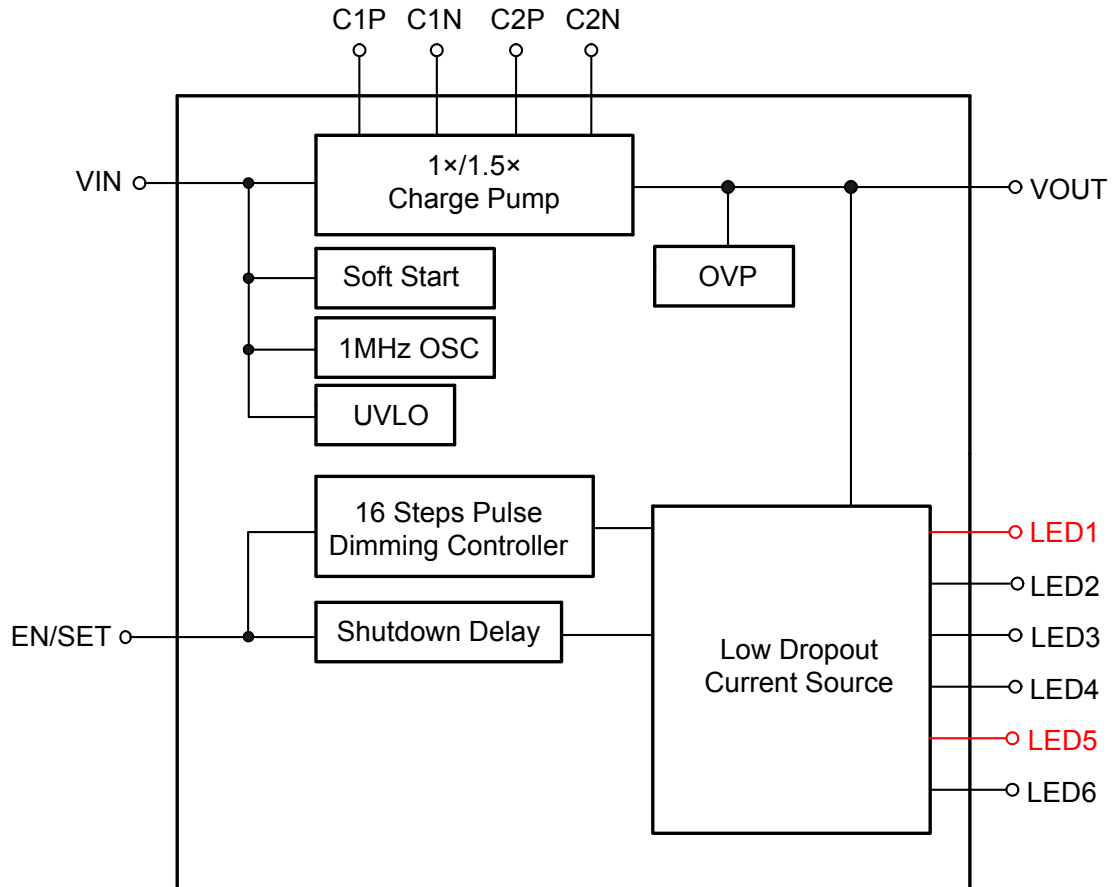| PIN	NAME	I/O	FUNCTION
1, 2, 3, 4, 5, 6	LED6－LED1	I	Current Sink Input. Connect the cathode of the white LEDs to these inputs.
7	PGND	-	Power Ground.
8	VOUT	O	Connect the output capacitor and the anode of the LEDs to this pin.
9	C2P	-	Positive Terminal of Bucket Capacitor 2.
10	C1P	-	Positive Terminal of Bucket Capacitor 1.
11	C1N	-	Negative Terminal of Bucket Capacitor 1.
12	C2N	-	Negative Terminal of Bucket Capacitor 2.
13	VIN	I	Supply Voltage Input.
14	AGND	-	Analog Ground.
15	EN/SET	I	LED1 to LED6 Enable (Active High) and Dimming Control. Connect to GPIO pin of MCU.
16	N.C.	-	No Internal Connection.
Exposed Pad	GND	-	Exposed pad should be soldered to PCB board and connected to GND.

ELECTRICAL CHARACTERISTICS

(V_{IN} = 3.6V, EN/SET = V_{IN}, T_A = +25℃, unless otherwise noted.)

PARAMETER		SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SUPPLY VOULTAGE AND CURRENT							
Input Voltage Range		V_{IN}		2.7		5.5	V
Quiescent Power Supply Current		I_Q	V_{IN} = 4.2V, 1× Mode, I_{LEDx} = 1.25mA		210		µA
		I_Q	I_{OUT} = 0mA, 1.5× Mode		2		mA
Shutdown Supply Current		I_{SHDN}	EN/SET = GND		0.1	1	µA
CHARGE PUMP STAGE							
Over-Voltage Limit		V_{OUT}	LEDx unconnected, V_{IN} = 4.2V		5.8		V
Start-Up Time			C_{OUT} = 1µF, I_{LEDx} ≥ 0.9 × $I_{LEDx-set}$		235		µs
Soft-Start Duration					190		µs
Switching Frequency		f		0.6	1	1.4	MHz
Efficiency		η	V_{IN} = 3.45V, V_{LEDx} = 3V		85		%
Shutdown Temperature			Temperature rising		150		℃
Shutdown Temperature Hysteresis					15		℃
Input Current Limit			EN/SET = 1		300		mA
CURRENT SINKS							
Recommended Maximum Current per Current Sink		I_{LEDx}	3.2V ≤ V_{IN} ≤ 5.5V	18	20	22.5	mA
Current Matching between Any Two Outputs			V_{LEDx} = 3.2V, I_{LEDx} = 20mA	-5	1	5	%
Line Regulation			3.3V < V_{IN} < 5.5V, V_{LEDx} = 3.2V, EN/SET = 1		3		%
Voltage at LED_X to GND		V_{SOURCE}	V_{IN} = 4.2V, EN/SET = 1		400		mV
EN/SET LOGIC							
Low Time for Shutdown		t_{SHDN}		3			ms
Low Time for Dimming		t_{LO}		0.5		500	µs
High Time for Dimming		t_{HI}		0.5			µs
Threshold	Logic-High Voltage	V_{IH}		1.2			V
	Logic-Low Voltage	V_{IL}				0.6	V

TYPICAL PERFORMANCE CHARACTERISTICS

1x Mode Dimming Operation

f = 1kHz, V$_{IN}$ = 4.2V
EN/SET = 0 to 1, 6LEDs Connected

Time (2ms/div)

1.5x Mode Input and Output Voltage Ripple

V$_{IN}$ = 3.6V, EN/SET = V$_{IN}$,
6LEDs connected, T$_A$ = +25°C

Time (1µs/div)

Startup Timing

V$_{IN}$ = 3.6V, EN/SET = 0 to 1,
6LEDs connected, T = +25°C

Time (40µs/div)

LED Current Regulation vs. Input Voltage

Efficiency vs. Input Voltage

20mA

LED V$_F$ = 3V

FUNCTION BLOCK DIAGRAM

TYPICAL APPLICATION
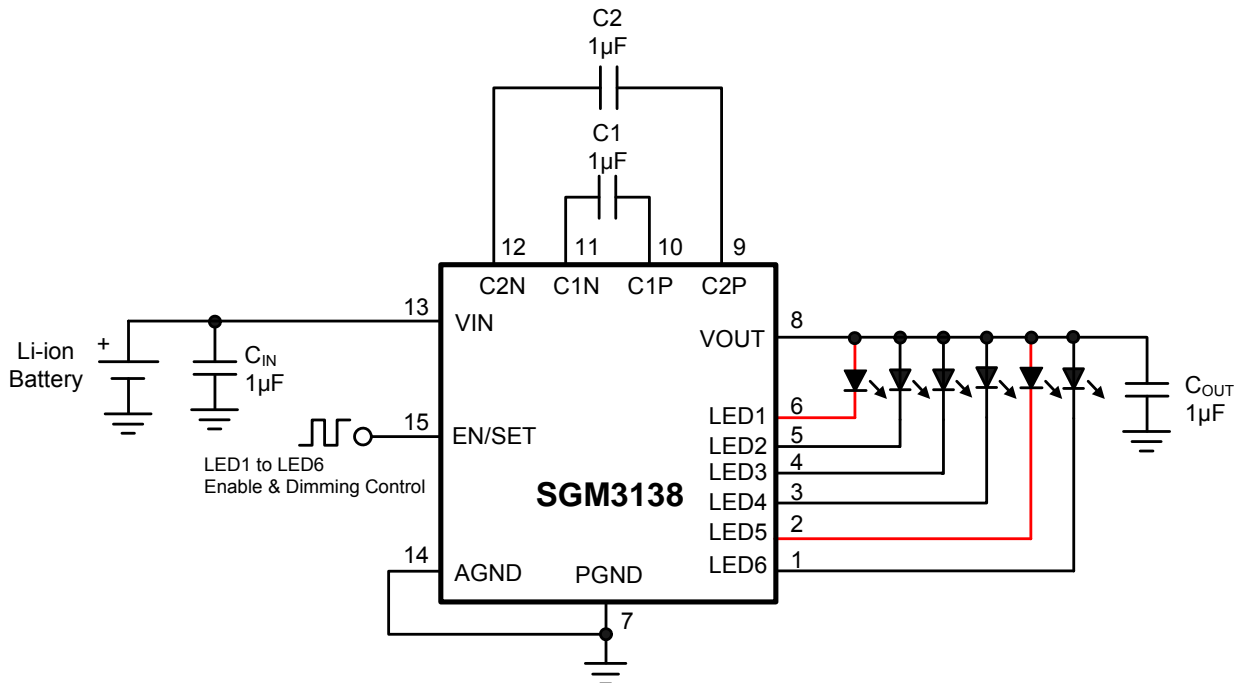
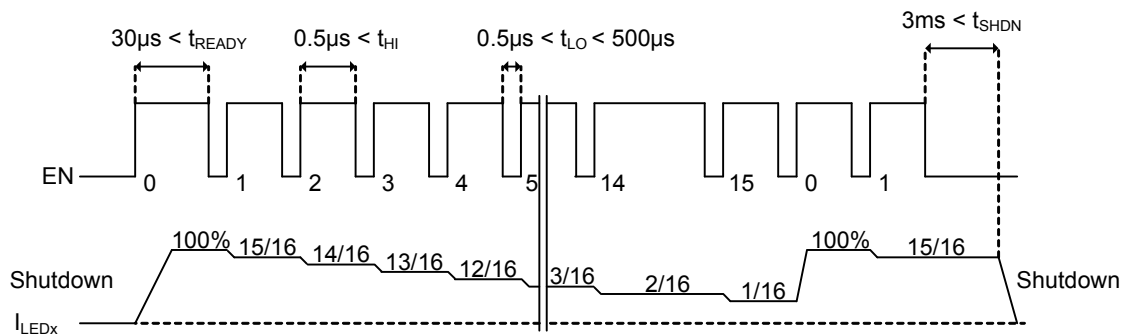**Figure 1. For 6-WLEDs Application Circuit**

Figure 2. Brightness Control by Pulse Dimming

APPLICATION INFORMATION

The SGM3138 uses a fractional switched capacitor charge pump to power up to 6 white LEDs with a programmable current for uniform intensity. The part integrates current sources and automatic mode selection charge pump. It maintains the high efficiency by utilizing a 1×/1.5× fractional charge pump and current sources. The small equivalent 1× mode open loop resistance and ultra-low dropout voltage of current source extend the operating time of 1× mode and optimize the efficiency in white LED applications.

Input UVLO

The input operating voltage range of the SGM3138 is 2.7V to 5.5V. An input capacitor at the VIN pin could reduce ripple voltage. It is recommended to use a ceramic 1µF or larger capacitance as the input capacitor. This IC provides an under-voltage lockout (UVLO) function to prevent it from unstable issue when start-up. The UVLO threshold of input rising voltage is set at 2.15V typically with a hysteresis 50mV.

Soft-Start

The SGM3138 employs a soft start feature to limit the inrush current. The soft-start circuit prevents the excessive inrush current and input voltage droop. The soft-start clamps the input current over a typical period of 190µs.

Mode Decision

The SGM3138 uses a smart mode selection method to decide the working mode for optimizing the efficiency. Mode decision circuit senses the output and LED voltage for up/down selection. The SGM3138 automatically switches to 1.5× mode whenever the dropout condition is detected from the current source and returns to 1× mode whenever the dropout condition releases.

Chip Enable and Shutdown

When EN/SET is in "High" status, SGM3138 will enter into active status, When EN/SET is in "Low" status for 3ms, and SGM3138 will enter into shutdown status.

LED Dimming Control Interface

An internal resistor sets the maximum LED current to be 20mA. EN/SET one wire interface is used to adjust the current of LED1 to LED6, this is 16 steps pulse dimming. The programming pulse is shown in Figure 2.

Brightness Control

The SGM3138 implements a pulse dimming method to control the brightness of white LEDs. Users can easily configure the LED current from 1.25mA to 20mA by a serial pulse. The dimming of white LEDs' current can be achieved by applying a pulse signal to the EN/SET pin. There are totally 16 steps of current could be set by users. The detail operation of brightness dimming is showed in the Figure 2.

LED Connection

The SGM3138 supports up to 6 white LEDs. The 6 LEDs are connected from VOUT to pin 1, 2, 3, 4, 5 and 6 respectively. Figure 1 shows the connection for 6-WLEDs application. LED1 to LED6 are controlled by EN/SET. The SGM3138 internal current source reference circuit bases feedback from current sensed on the LED1 and LED5 outputs. For best operation, the only requirement for this type of application is the output LED1 and LED5 should always be connected to the load circuit. The other LED pins (LED2, 3, 4,&6) can be left floating if those white LEDs are not used.

Over-Voltage Protection

The SGM3138 equips over-voltage protection function. When LED is open, the voltage between input and output will be clamped at a certain voltage level.

Selecting Capacitors

To get the better performance of SGM3138, the selection of peripherally appropriate capacitor and value is very important. These capacitors determine some parameters such as input/output ripple voltage, power efficiency, and maximum supply current by charge pump. To reduce the input and output ripple effectively, the low ESR ceramic capacitors are recommended. For LED driver applications, the input voltage ripple is more important than output ripple. Input ripple is controlled by input capacitor C_{IN}, increasing the value of input capacitance can further reduce the ripple. Practically, the input voltage ripple depends on the power supply impedance. The flying capacitor C1 and C2 determine the supply current capability of the charge pump and to influence the overall efficiency of system. The lower value will improve efficiency, but it will limit the LED's current at low input voltage. For 6 × 20mA load over the entire input range of 2.7V to 5.5V, it is recommended to use a 1µF ceramic capacitor on the flying capacitor C1 and C2.
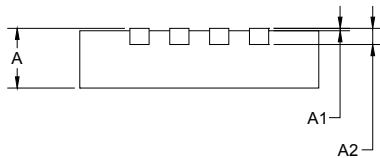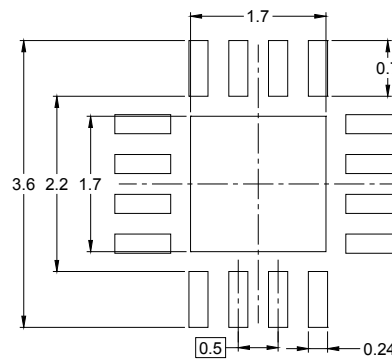
PACKAGE OUTLINE DIMENSIONS
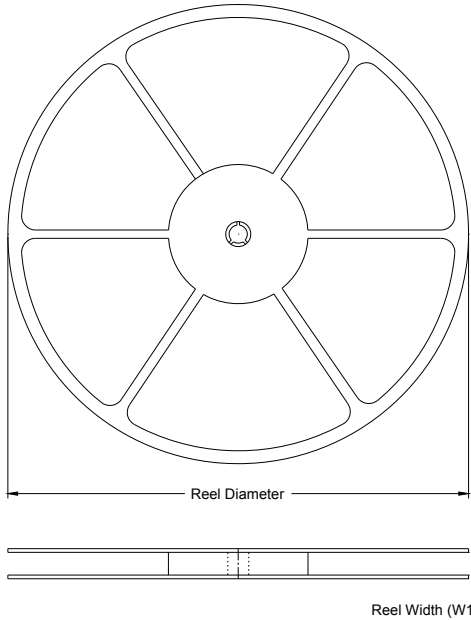
TQFN-3×3-16L
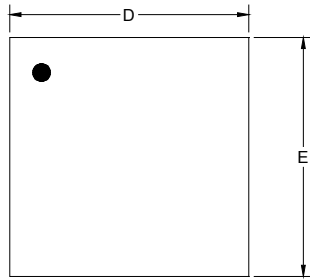
TOP VIEW
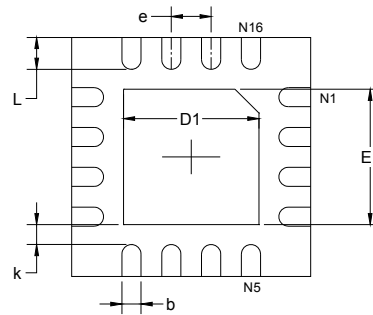
BOTTOM VIEW

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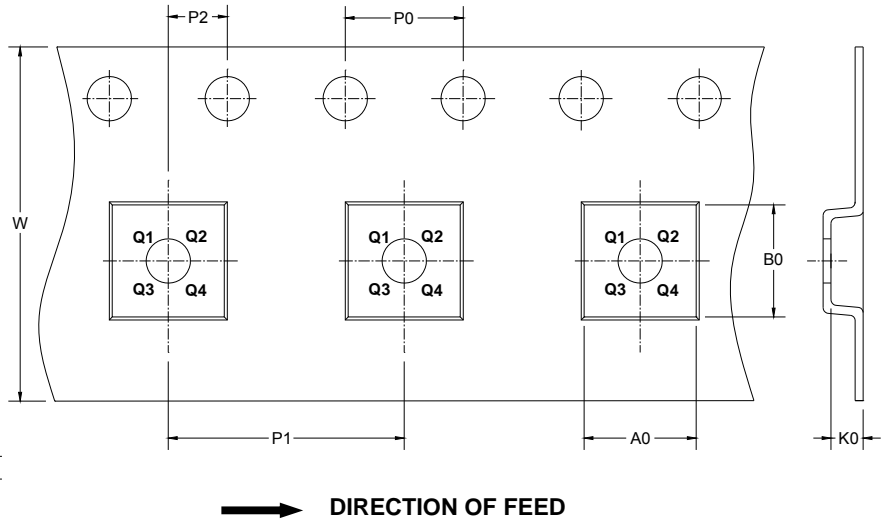
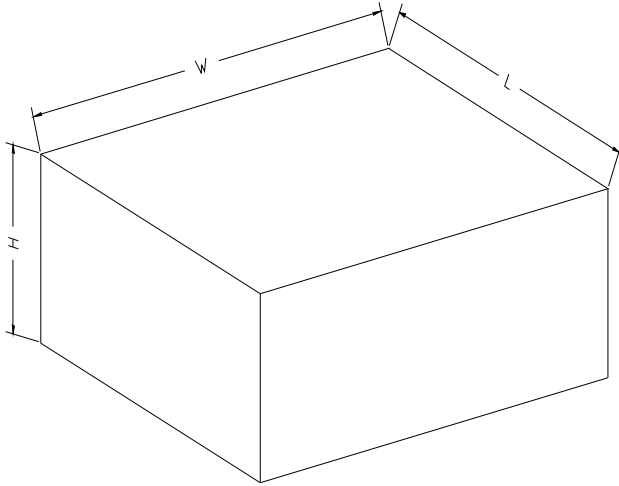NOTE: The picture is only for reference. Please make the object as the standard.

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″	12.40	3.35	3.35	1.13	4.00	4.00	2.00	12.00	Q1

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