SGM2058
Negative Charge Pump and Adjustable Regulator

GENERAL DESCRIPTION

The SGM2058 is a negative charge pump with a built-in adjustable negative regulator. The input voltage range is from 2.3V to 5.5V and provides an unregulated output which equals to the $-V_{IN}$. The SGM2058 also provides a regulated output which equals to -1× CTL voltage and with the range between 0V and $-V_{IN}$.

An internal soft-start circuit effectively reduces the inrush current during start-up. The SGM2058 requires only 4 ceramic capacitors and no external inductor for a compact solution size. It is ideal for a wide range of applications, including optical modules, RF amplifiers and sensor supplies.

The SGM2058 is available in a Green TQFN-1.8×1.4-10L package. It operates over an operating temperature range of -40℃ to +125℃.

FEATURES

- **Input Voltage Range: 2.3V to 5.5V**
- **Up to 265mA Output Current**
- **Only 4 × 4.7μF Capacitors Needed for 60mA**
- **Auto Power-Save Mode**
- **No Inrush Current during Start-Up**
- **Short-Current and Over-Temperature Protections**
- **Dual Outputs:**
  - **V_{OUT1}: Negative Charge Pump Output ($-V_{IN}$)**
  - **V_{OUT2}: Regulated Output (-1× CTL Voltage between 0V and $-V_{IN}$)**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in a Green TQFN-1.8×1.4-10L Package**

APPLICATIONS

Optical Module
Bias for RF Amplifier
Sensor Supply in Portable Instruments

TYPICAL APPLICATION

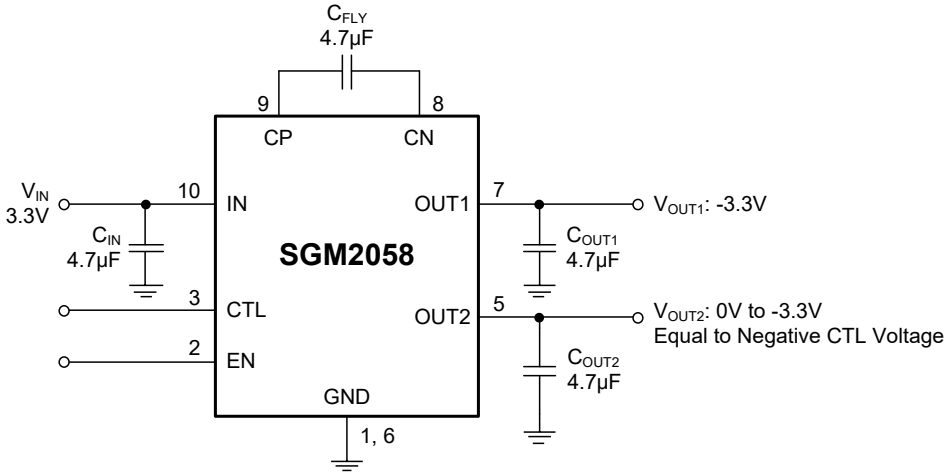


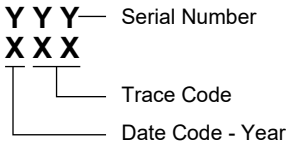
Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM2058	TQFN-1.8×1.4-10L	-40℃ to +125℃	SGM2058XWQ10G/TR	S3I 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

Supply Voltage Range, V_{IN} ..... -0.3V to 6V
V_{CP} ..... -0.3V to (V_{IN} + 0.3V)
V_{CN} ..... (V_{OUT1} - 0.3V) to 0.3V
V_{OUT1} ..... -6V to 0.3V
V_{OUT2} ..... (V_{OUT1} - 0.3V) to 0.3V
All Other Pins ..... -0.3V to 6V
Package Thermal Resistance
TQFN-1.8×1.4-10L, θ_{JA} ..... 166℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃

RECOMMENDED OPERATING CONDITIONS

Supply Voltage Range ..... 2.3V to 5.5V
Input Capacitance, C_{IN} 4.7μF
Fly Capacitor, C_{FLY} 4.7μF
OUT1 Capacitor, C_{OUT1} 4.7μF
OUT2 Capacitor, C_{OUT2} 4.7μF
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.

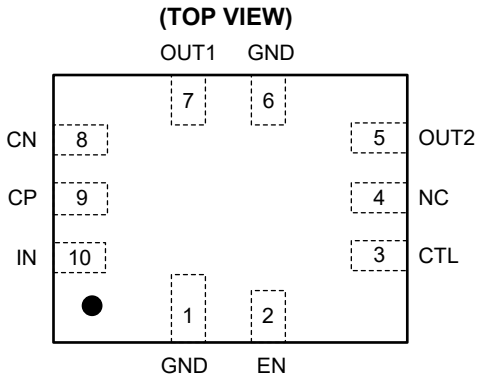
ESD SENSITIVITY CAUTION

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



TQFN-1.8×1.4-10L

PIN DESCRIPTION

PIN	NAME	FUNCTION
1, 6	GND	Power Ground.
2	EN	Enable/Disable Control.
3	CTL	Analog Input Voltage. V_{OUT2} equals to negative CTL voltage.
4	NC	Recommend to connect this pin to ground.
5	OUT2	Negative Linear Regulator Output. A decoupling capacitor is needed.
7	OUT1	Negative Charge Pump Output. A decoupling capacitor is needed.
8	CN	Fly Capacitor Negative Connection.
9	CP	Fly Capacitor Positive Connection.
10	IN	Supply Voltage. A decoupling capacitor is needed.

ELECTRICAL CHARACTERISTICS

(V_{IN} = 3.3V, C_{IN} = C_{FLY} = C_{OUT1} = C_{OUT2} = 4.7μF, typical values are at T_J = +25℃, 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		V
UVLO Threshold Hysteresis	V_{IN_HYS}			100		mV
Shutdown Current	I_{SHDN}	V_{EN} = 0V		0.1		μA
Quiescent Current	I_Q	V_{EN} = 2V, force V_{OUT1} = -3.4V, no switching		170		μA
Charge Pump MOSFET On-Resistance	R_{ON}			0.28		Ω
Negative Linear Regulator						
Load Current Limit	I_{LIMIT}			265		mA
Output Voltage Accuracy		Compared with V_{CTL} = 2.5V, I_{OUT2} = 10mA		0.07		%
Output Offset Voltage		I_{OUT2} = 10mA		2		mV
Dropout Voltage	V_{DROP}	V_{IN} = 2.5V, I_{OUT2} = 60mA		40		mV
		V_{IN} = 3.3V, I_{OUT2} = 60mA		32		
Load Regulation	ΔV_{OUT}	V_{OUT1} = -3.3V, V_{CTL} = 1V, I_{OUT2} = 0 to 150mA		0.003		%/mA
Power Supply Rejection Ratio	PSRR	C_{OUT1} = 1μF, C_{OUT2} = 1μF, I_{OUT2} = 10mA		70		dB
				30		
Soft-Start Slew Rate				10		V/ms
EN Turn-On Delay				150		μs
EN Input Threshold	V_{IL}	Logic low		0.78		V
	V_{IH}	Logic high		0.82		
Output Discharge Resistance	R_{DIS1}	V_{EN} = 0V, OUT1 rail		130		Ω
	R_{DIS2}	V_{EN} = 0V, OUT2 rail		130		
EN Input Current	I_{EN}	V_{EN} = 2V		1.8		μA
		V_{EN} = 0V		0		
Thermal Shutdown Temperature	T_{SHDN}			160		℃
Thermal Shutdown Hysteresis	ΔT_{SHDN}			20		℃
System Level						
OUT1 Pin Voltage				-1×		V_{IN}
Output Ripple	V_{RIPPLE_OUT1}	V_{IN} = 3.3V, V_{OUT1} = -3.3V, C_{FLY} = C_{OUT1} = 4.7μF, I_{OUT1} = 60mA		7		mV
	V_{RIPPLE_OUT2}	V_{IN} = 3.3V, V_{OUT2} = 2.5V, C_{OUT2} = 1μF, I_{OUT2} = 60mA		2		
	V_{RIPPLE_OUT2}	V_{IN} = 3.3V, V_{OUT2} = 2.5V, C_{OUT2} = 4.7μF, I_{OUT2} = 60mA		2		

FUNCTIONAL BLOCK DIAGRAM

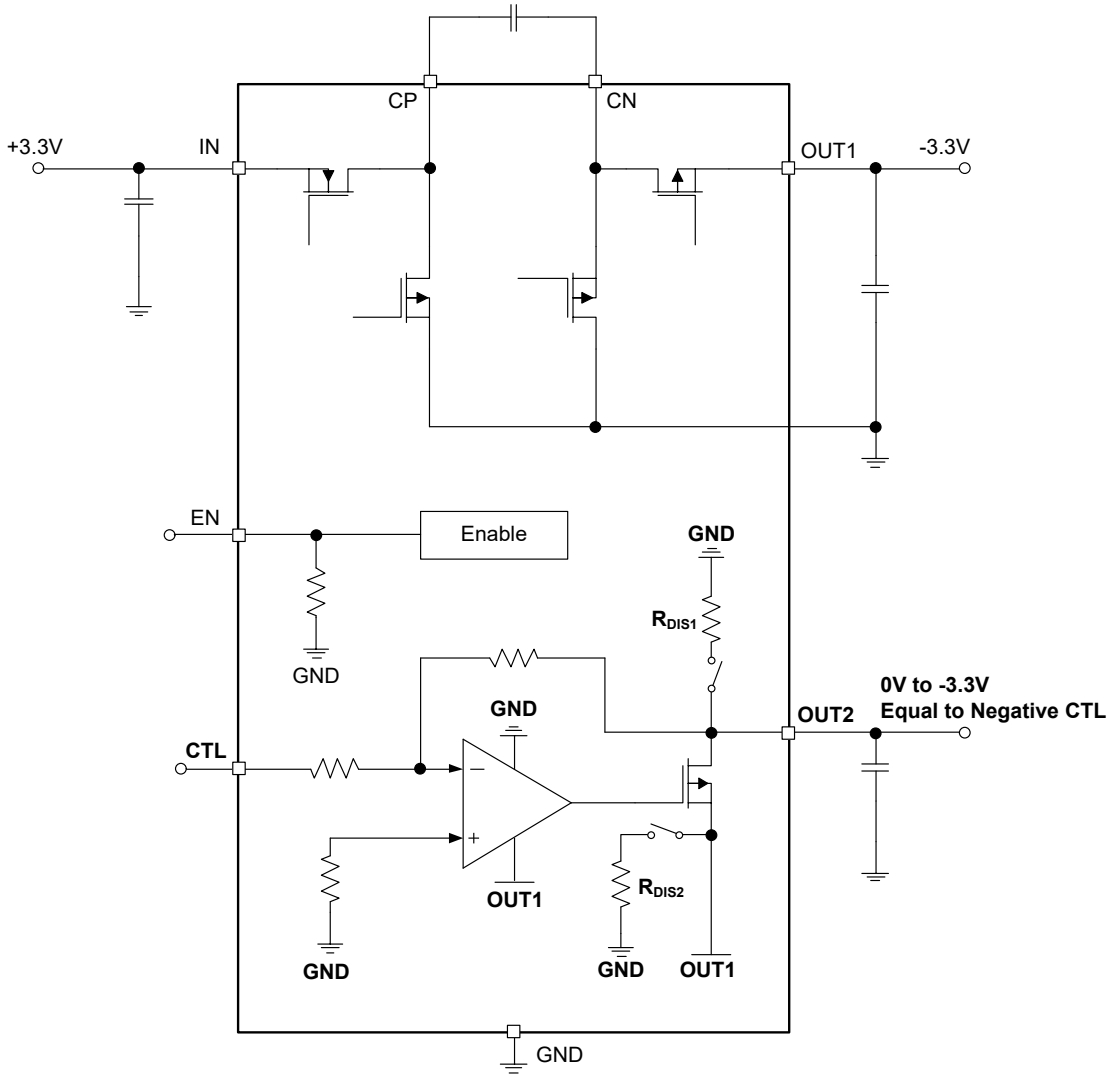


Figure 2. Functional Block Diagram

DETAILED DESCRIPTION

The SGM2058 is a negative charge pump with a built-in adjustable negative regulator. The input voltage range is from 2.3V to 5.5V and provides an unregulated output which equals to the $-V_{IN}$. The SGM2058 also provides a regulated output which equals to -1× CTL voltage and with the range between 0V and $-V_{IN}$.

An internal soft-start circuit effectively reduces the inrush current during start-up.

Negative Charge Pump

The SGM2058 uses a switched capacitor charge pump to get an unregulated negative voltage with the absolute value V_{IN}. Use an integrated oscillator to create a switching signal for driving the charge pump. The oscillator charge pump switching frequency is from 80kHz to 1850kHz. The device will auto adjust the frequency according to V_{IN} and V_{OUT1} voltage gap. In theory, the oscillator frequency will increase with load increase. The higher frequency will compensate the output ripple when heavy load.

When the absolute value of V_{OUT1} is less than $V_{IN}/2$, the charge pump treats it as an over-current condition. The SGM2058 will force the oscillator frequency to 80kHz for fold-back.

Negative Linear Regulator

The SGM2058 integrates a negative linear regulator, which is powered from the negative charge pump output. The regulator has a low dropout voltage, low quiescent supply and low output noise. Its output range is from 0V to V_{OUT1}.

The regulator uses an internal feedback loop to control the output voltage, which equals -1× CTL voltage. This is an easy interface for DAC. Using efficient DAC, its output voltage can be set by an external signal.

The PSRR of the linear regulator is specially designed for its charge pump. The negative linear regulator will have a low output ripple.

Load Capability

The SGM2058 load capability is 265mA; the sum of I_{OUT1} and I_{OUT2} is less than 265mA. This load capability is related to the fly and output capacitors. The smaller the capacitor is, the smaller the load capability is.

Over-Temperature Protection (OTP)

If the typical junction temperature of +160℃ is exceeded, an internal thermal shutdown turns off the device. The device is released from shutdown automatically when the junction temperature decreases by 20℃.

The maximum power output current is a function of the package's maximum power dissipation for a given temperature.

Under-Voltage Lockout (UVLO)

The device has a built-in under-voltage lockout function that disables the device when the input supply voltage is too low for normal operation. When the input supply voltage is higher than UVLO threshold (typically 2.2V), the device is enabled.

Enable (EN)

When the input voltage is greater than UVLO threshold, the SGM2058 can be enabled by pulling EN higher than 0.82V. There is an internal 1MΩ resistor from EN to ground. Floating EN or pulling it down to ground will disable the device.

When the SGM2058 is shutdown, the device goes into output discharge mode automatically, and its internal discharge MOSFET provides a resistive discharge path from the output capacitor to ground.

Equivalent Output Resistance

The equivalent output resistance of the SGM2058 is determined by the charge pump frequency and fly capacitor. The relationship is given by Equation 1:

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

where:

R_{ON} is the on-resistance of each switch MOSFET in the charge pump.

The charge pump output V_{OUT1} is determined by I_O and R_O. The relationship is given by Equation 2:

$$V_{OUT1} = -(V_{IN} - I_O \times R_O) \quad (2)$$

Soft-Start

Soft-start circuitry is integrated into the IC, which supply a controlled slew rate for the output voltage of the linear regulator to avoid overshoot during start-up. The typical ramp-up time is within 500μs. The soft-start slew rate is set internally to 10V/ms (TYP).

APPLICATION INFORMATION

Typical Application Circuit

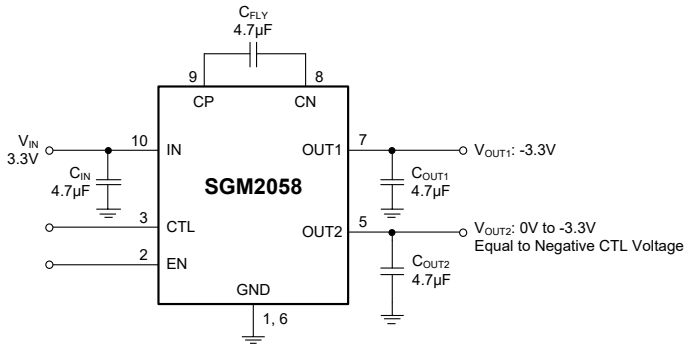


Figure 3. Typical Application Circuit

Design Example

Table 1 is a design example following the application guidelines for the specifications below:

Table 1. Design Example

SYMBOL	VALUE
V_{IN}	3.3V
V_{OUT1}	-3.3V
V_{CTL}	1V
V_{OUT2}	-1V

The detailed application schematic is shown in Figure 3.

Output Capacitors Selection (C_{OUT1}, C_{OUT2})

The output capacitors are mainly selected to meet the requirement for the output ripple and loop stability. For stable operation, use X5R or X7R ceramic capacitors.

A 1μF capacitor for C_{OUT1} and a 1μF to 10μF capacitor for C_{OUT2} are recommended. Output capacitors of other dielectric types may be used but are not recommended, as their capacitance can deviate greatly from their rated value over temperature.

Input Capacitor Selection (C_{IN})

A 1μF to 10μF ceramic, dielectric X5R or X7R capacitor is recommended.

The Fly Capacitor Selection (C_{FLY})

According to Equation 1, the fly capacitor will affect the output resistance, as well the output voltage of OUT1. The higher the output current is, the larger the fly capacitor is recommended. Placing the fly capacitor close to C_{IN} and C_{OUT1} is recommended. It is ideal to use the same capacitor for C_{IN}, C_{OUT1} and C_{FLY}.

Setting the Output Voltage

The linear regulator will follow CTL voltage. The output value is regulated to -1× the CTL voltage. The CTL pin is an analog input and can be directly connected to the DAC output. Figure 4 shows the application circuit.

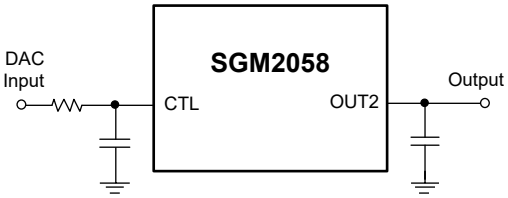


Figure 4. Output Voltage Setting

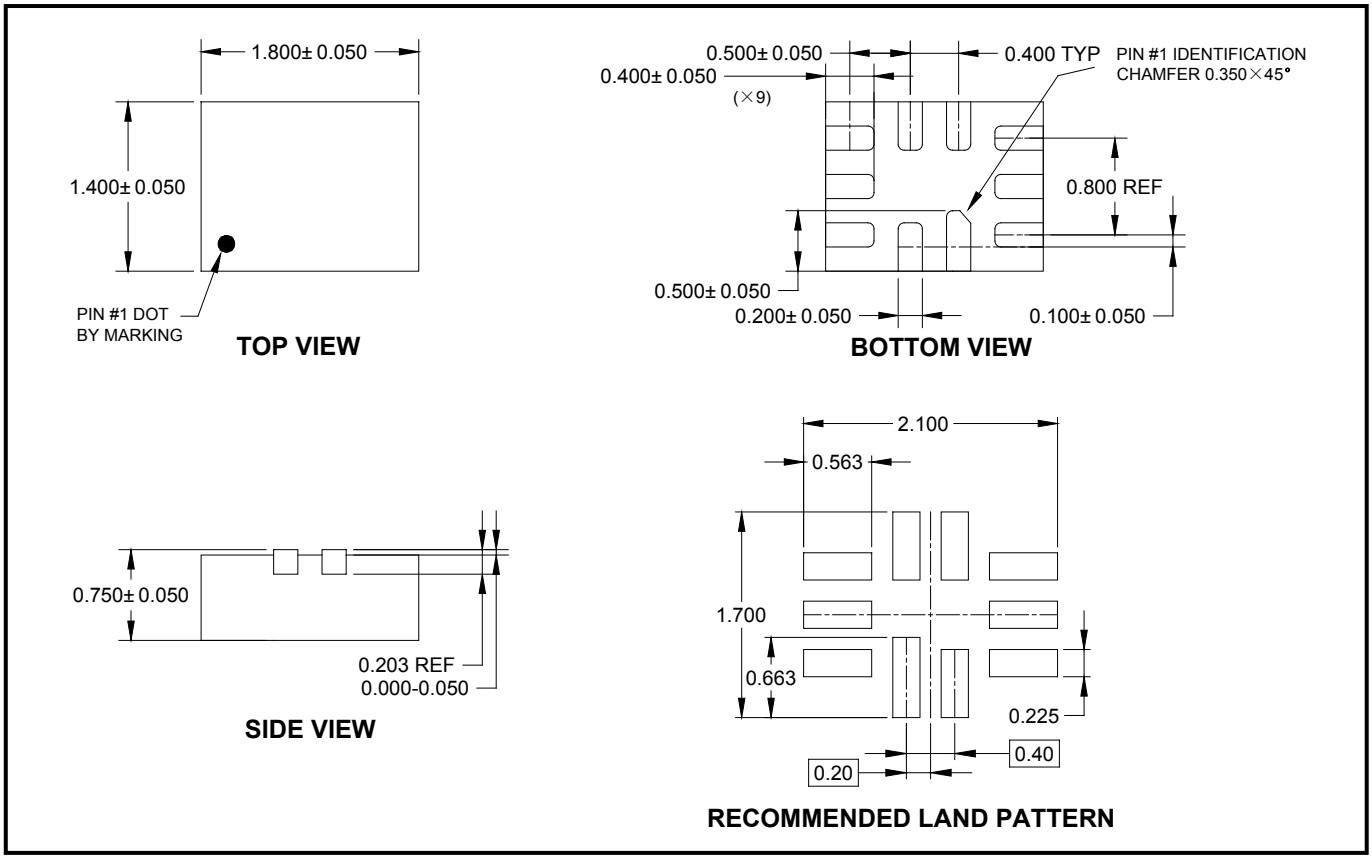
PCB Layout

To achieve the best performance of the SGM2058, the following layout guidelines must be followed:

- Place the high-current paths (GND, IN, CP and CN) very close to the device with short, direct and wide traces.
- Place the input capacitor as close as possible to IN and GND pins.
- Place the output capacitors as close as possible to the OUTx and GND pins.

PACKAGE OUTLINE DIMENSIONS

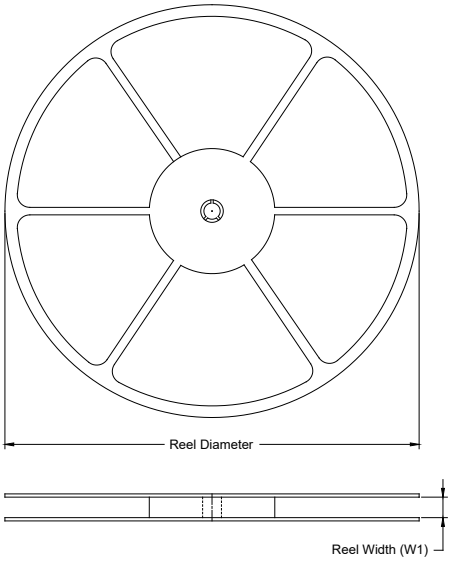
TQFN-1.8×1.4-10L



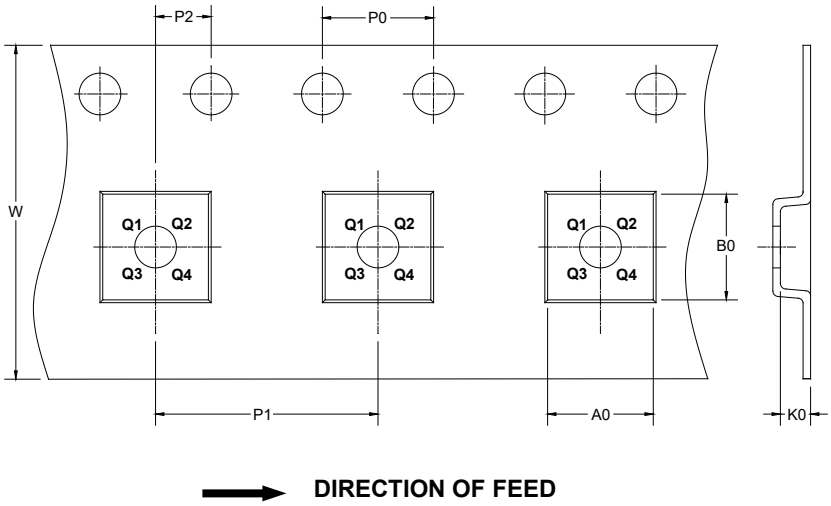
NOTE: All linear dimensions are in millimeters.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



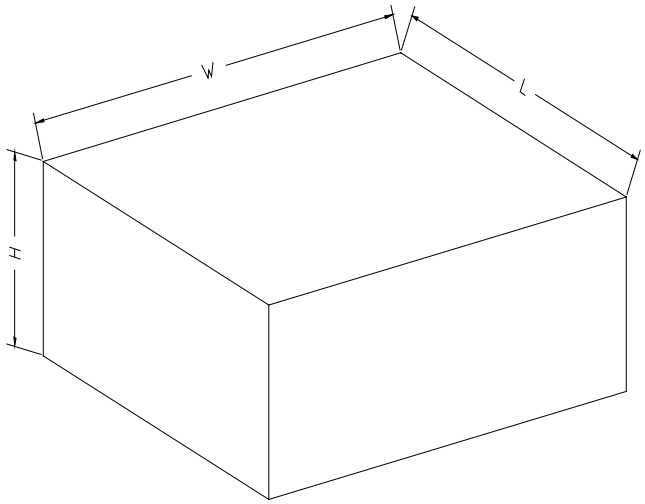
NOTE: The picture is only for reference. Please make the object as the standard.

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

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