AAP6010A
7.5V to 40V Input Supply, Synchronous Buck Converter

GENERAL DESCRIPTION

The AAP6010A is a wide input voltage, high efficiency current mode synchronous buck converter that achieves excellent load and line regulation. The AAP6010A operates in either constant output current (CC) mode or constant output voltage (CV) mode. The CC current value is set by an external sense resistor. AAP6010A provides up to 3.5A output current at 125kHz switching frequency.

The AAP6010A is in a Green SOIC-8 package. It is rated over the -40℃ to +85℃ temperature range.

APPLICATIONS

Car Chargers/Adaptors
Rechargeable Portable Devices
Battery Chargers

FEATURES

- **Wide 7.5V to 40V Input Voltage Range**
- **Fixed 125kHz Switching Frequency**
- **Duty Cycle Range (0 ~ 100%)**
- **CC/CV Mode Control**
- **Up to 3.5A Output Current**
- **High Efficiency Up to 95%**
- **0.797V Reference Voltage**
- **Output Short Circuit Protection**
- **FB Resistance Short Protection**
- **Nearly Zero Input Current at Short Circuit Protection**
- **Internal Soft-Start**
- **Programmable Output Cable Compensation**
- **Thermal Shutdown Protection**
- **Available in a SOIC-8 Package**
- **RoHS Compliant and Halogen Free**

TYPICAL APPLICATION

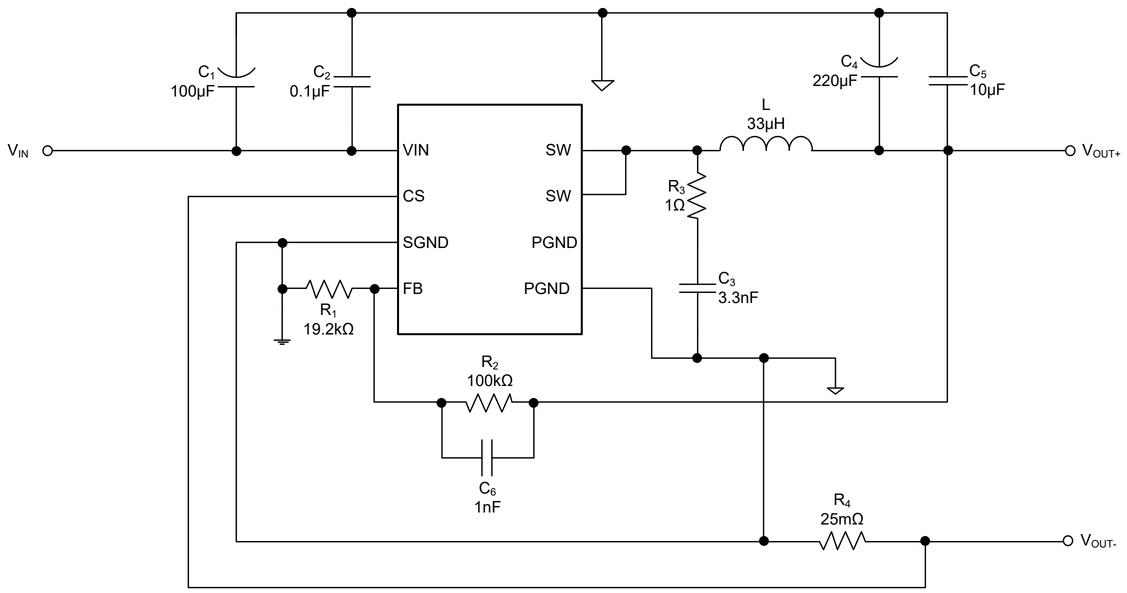


Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
AAP6010A	SOIC-8	-40℃ to +85℃	AAP6010ASA8	AAP6010A XXXXXX	Tape and Reel, 2500

ORDER INFORMATION

AAP6010 A SA 8

- A: Extension Code
- SA: Package Type
- 8: Pin Count

MARKING INFORMATION

AAP6010A Part Number

X X X X X X

- X: Production Code
- X: Assembly House Code
- X: Wafer Version Code
- X: Year
- X: Month
- X: Day

ABSOLUTE MAXIMUM RATINGS

PVIN to SGND .... -0.3V to 42V
SW (DC) to SGND .... -0.3V to V_{PVIN} + 0.3V
FB, CS to SGND .... -0.3V to 6V
Package Thermal Resistance
SOIC-8, θ_{JA} .... 106℃/W
Junction Temperature ....+150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s) ....+260℃
ESD Susceptibility
HBM..2000V
MM..200V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

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

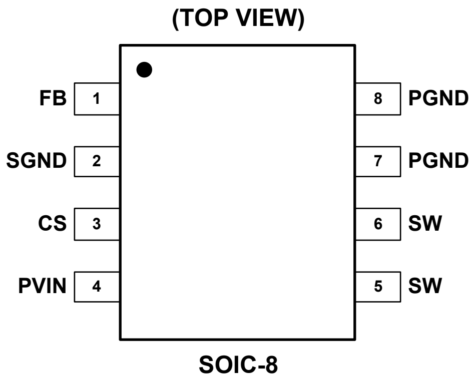
ESD SENSITIVITY CAUTION

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



PIN DESCRIPTION

PIN	NAME	DESCRIPTION
1	FB	Feedback Input.
2	SGND	Signal Ground and Output Current-Sense (-) Pin.
3	CS	Output Current-Sense (+) Pin.
4	PVIN	Power Supply.
5, 6	SW	Switching Node. Connect an inductor between SW and the regulator output.
7, 8	PGND	Power Ground.

ELECTRICAL CHARACTERISTICS

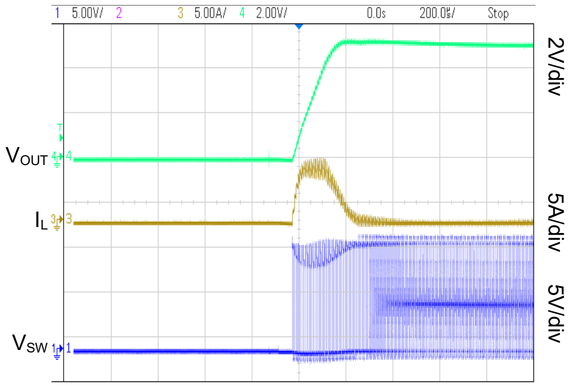
(V_{IN} = 12V, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		7.5		40	V
Input UVLO	V_{IN} rising		6.9		V
Input UVLO Hysteresis	V_{IN} falling		0.85		V
Input Supply Current	V_{FB} = 1V		1.56	2	mA
	V_{OUT} = 5V, no load		1.7		mA
FB Feedback Voltage		775	797	820	mV
Internal Soft-Start Time			0.2		ms
Switching Frequency			125		kHz
Maximum Duty Cycle				100	%
Current Limit	Duty = 62%		6		A
Current-Sense Voltage	V_{CS}	70	78	86	mV
SW Leakage Current	V_{SW} = 0V		2.5	4	μA
High-side R_{DSON}			47		mΩ
Low-side R_{DSON}			30		mΩ
FB UVP Voltage			385		mV
Fault Recycle Time	V_{FB} = 0V		550		ms
Over-Temperature Shutdown	Temperature rising		160		℃
Over-Temperature Shutdown Hysteresis	Temperature falling		20		℃

TYPICAL PERFORMANCE CHARACTERISTICS

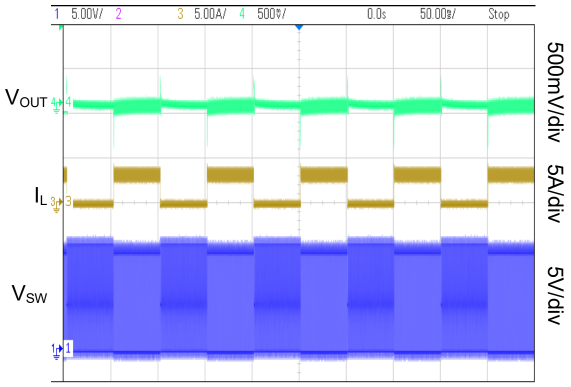
At T_A = +25℃, V_{IN} = 12V, V_{OUT} = 5V, unless otherwise noted.

Soft-Start



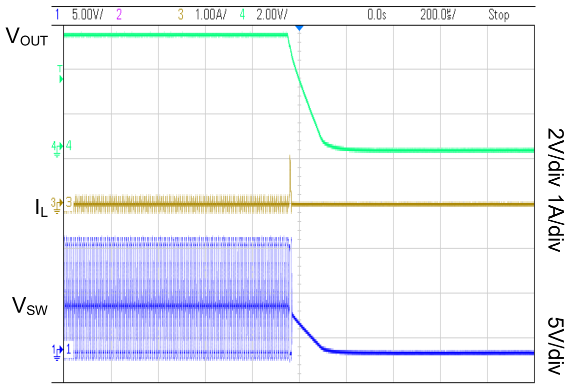
Time (200μs/div)

Transient (I_{OUT} = 0.1A ~ 3.4A)



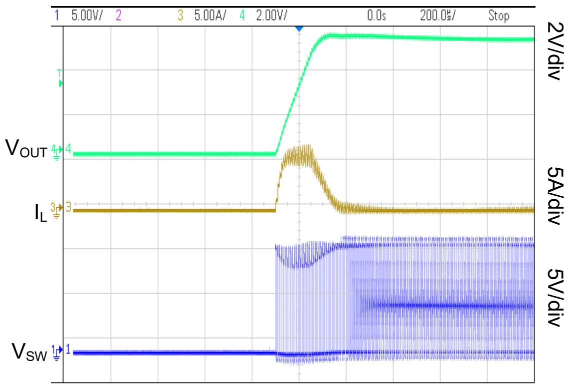
Time (50ms/div)

V_{OUT} Short Protection



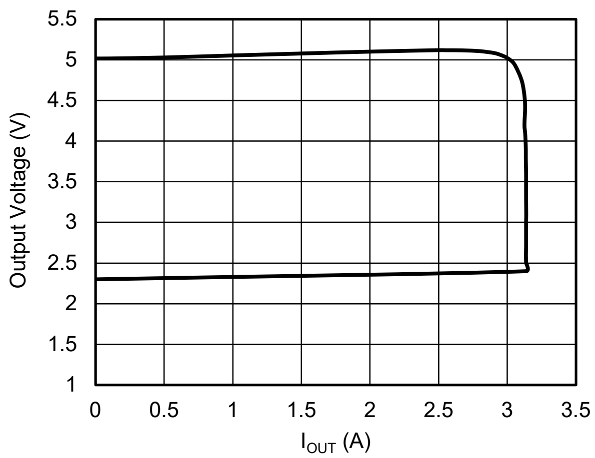
Time (200μs/div)

V_{OUT} Short Protection Recovery

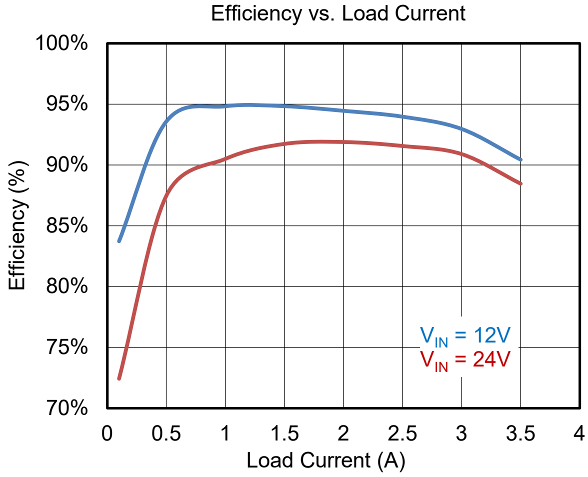


Time (200μs/div)

CC/CV Mode IV Curve



Efficiency vs. Load Current



FUNCTIONAL BLOCK DIAGRAM

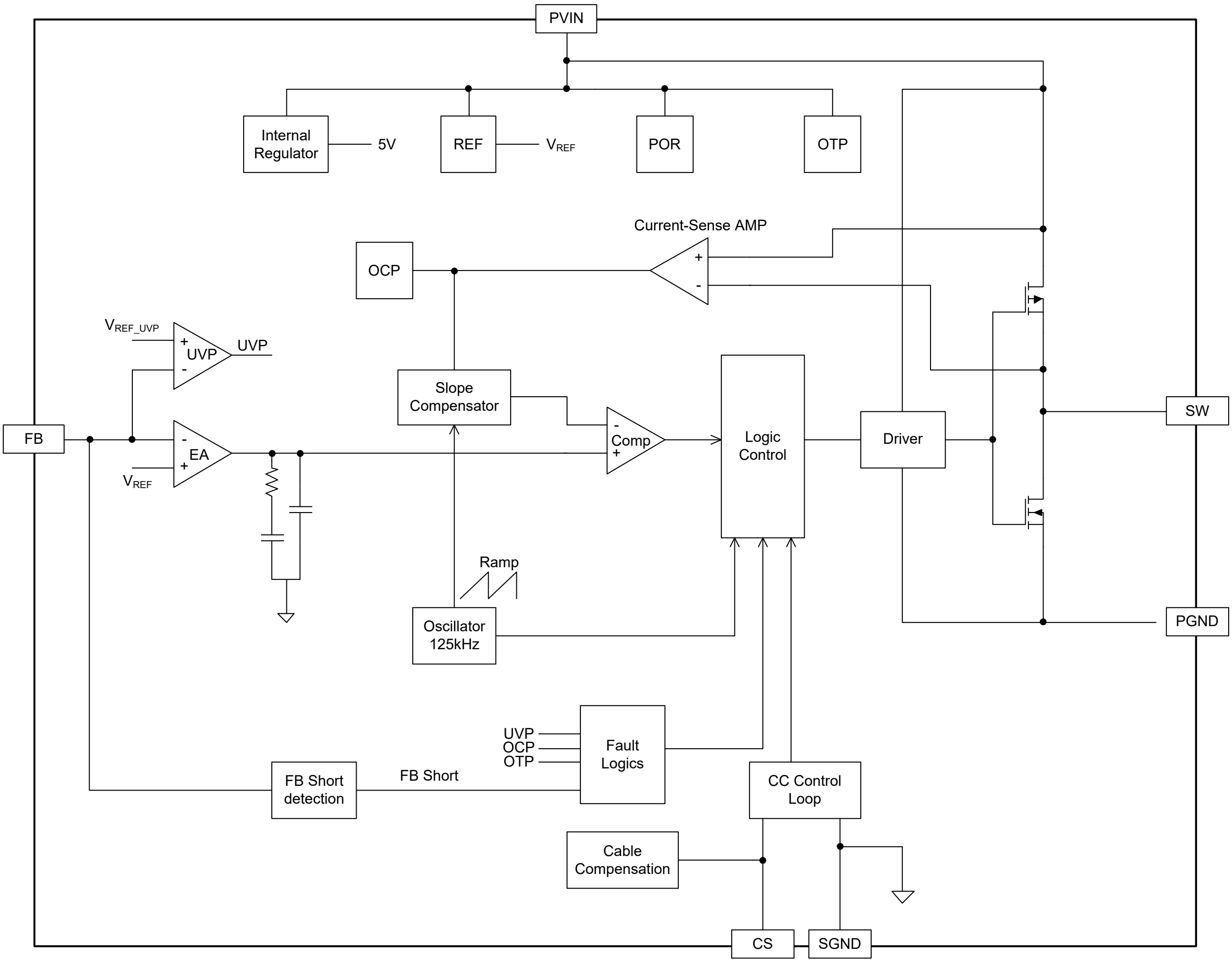


Figure 2. Block Diagram

DETAILED DESCRIPTION

The AAP6010A is a synchronous current mode buck PWM converter with programmable output CC/CV control.

Initialization

The AAP6010A creates its own internal supplies for use. The POR function continually monitors the input bias supply voltage at the PVIN pin. The POR function initiates soft-start operation after PVIN supply voltage exceeds its POR rising threshold voltage.

Soft-Start

The AAP6010A has an internal soft-start circuitry to reduce supply inrush current during startup conditions. The typical soft-start time is about 0.2ms. The power-on reset function initiates the soft-start process. Once the PVIN voltage falls below 6V, the controller will shut down until the voltage exceeds 6.9V again.

Switch Frequency

The internal oscillator frequency switches at 125kHz normally.

FB Resistance Short Protection

The AAP6010A detects FB resistance before startup. When the FB pin short circuit happens, the converter will not work until the FB short circuit condition is removed.

CC/CV Control and Output Short Protection

When the load current is less than the current-limit, the AAP6010A will regulate the output voltage and operate in the constant voltage mode. If the load current increases and reaches the current-limit point sensed by the CS pin, then the AAP6010A will enter the CC mode, and the output voltage will decrease. If the FB pin voltage is lower than 385mV, the AAP6010A will stop switching for a long time before initiating a new soft start. If the output over-current condition or output short condition is not removed, the converter will hiccup. By this long time sleeping at over-current or output under-voltage condition, the input current of the system is nearly zero.

Thermal Shutdown

Over-temperature protection limits total power dissipation in the device. When the junction temperature exceeds +160℃, a thermal sensor forces the device into shutdown, allowing the die to cool. The thermal sensor turns the device on again after the junction temperature cools by 20℃.

APPLICATION INFORMATION

Setting Output Voltages

The output voltage is set by external resistors. The V_{REF} is 0.797V. According to the typical application diagram:

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

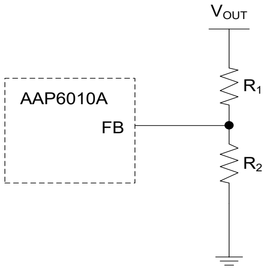


Figure 3. Setting V_{OUT} with a Resistor-Divider

Setting Constant-Current Threshold

The output constant-current value is set by a sense resistor between CS pin and GND, according to the following equation:

$$I_{CC} = \frac{78mV}{R_{CS}}$$

Output Cable Compensation

Output cable compensation voltage can be set by R_1 (Figure 3).

$$V_{CS} = I_{OUT} \times R_{SENSE}$$

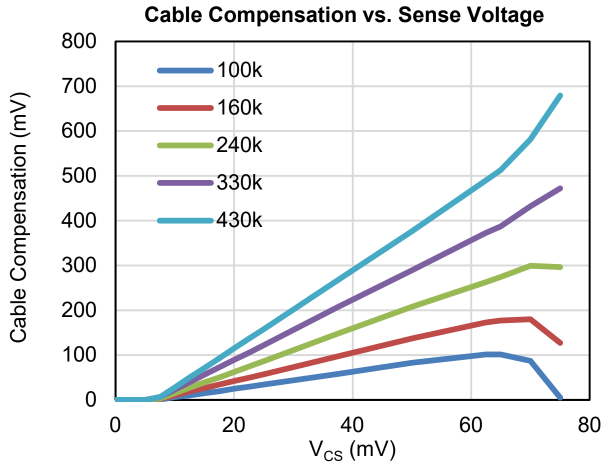


Figure 4. Setting Cable Compensation

Inductor Selection

The external components required for the step-down are an inductor, input and output filter capacitors, and compensation RC network. AAP6010A provides best efficiency with continuous inductor current. A reasonable inductor value (L_{IDEAL}) can be derived from the following:

$$L_{IDEAL} = \frac{V_{IN} \times D \times (1-D)}{f_{SW} \times I_{OUT} \times K_{RIPPLE}}$$

where K_{RIPPLE} is the ratio of the inductor peak-to-peak current to the inductor DC current. Usually, we set K_{RIPPLE} between 10% - 30%. D is the duty cycle:

$$D = \frac{V_{OUT}}{V_{IN}}$$

Given L_{IDEAL}, the peak-to-peak inductor current is $K_{RIPPLE} \times I_{OUT}$. The absolute-peak inductor current is $I_{OUT} \times (1 + 0.5K_{RIPPLE})$. Inductance values smaller than L_{IDEAL} can be used to reduce inductor size. However, if much smaller values are used, inductor current rises, and a larger output capacitance may be required to suppress output ripple. Larger values than L_{IDEAL} can be used to obtain higher output current, but typically with larger inductor size.

Output Capacitor Selection

The output capacitor is determined by the required ESR to minimize voltage ripple. Moreover, the amount of bulk capacitance is also a key for C_{OUT} selection to ensure that the control loop is stable. Loop stability can be checked by viewing the load transient response.

The output ripple is given by:

$$\Delta V_{OUT} \le \Delta I_L \times \left(R_{ESR} + \frac{1}{8f_{SW} \times C_{OUT}}\right)$$

The output ripple will be highest at maximum input voltage since ΔI_L increases with input voltage. Multiple capacitors placed in parallel may be needed to meet the ESR and RMS current handling requirement.

APPLICATION INFORMATION (continued)

Input Capacitor Selection

The input capacitor needs to be carefully selected to maintain sufficiently low ripple at the supply input of the converter. A low ESR capacitor is highly recommended. Since large current flows in and out of this capacitor during normal switching, its ESR also affects efficiency. Use small ceramic capacitors (CHF) for high frequency decoupling and bulk capacitors to supply the surge current needed each time high-side MOSFET turns on. Place the small ceramic capacitors (0.1μF) physically between the PVIN pin and the PGND pin.

The input buck capacitor should also be placed close to the PVIN and GND, with the shortest layout traces possible. The important parameters for the buck input capacitor are the voltage rating and the RMS current rating. For reliable operation, select the bulk capacitor with voltage and current ratings above the maximum input voltage and largest RMS current required by the circuit. The capacitor voltage rating should be at least 1.25 times greater than the maximum input voltage and a voltage rating of 1.5 times is a conservative guideline. The RMS current is given by:

$$I_{RMS} = I_{OUT}\frac{V_{OUT}}{V_{IN}}\sqrt{\frac{V_{IN}}{V_{OUT}} - 1}$$

I_{RMS} has a maximum at $V_{IN} = 2V_{OUT}$, where $I_{RMS} = I_{OUT}/2$. This simple worst-case condition is commonly used for design because even significant deviations do not offer much relief.

EMI Consideration

Since parasitic inductance and capacitance effects in PCB circuitry would cause a spike voltage on SW node when high-side MOSFET is turned on/off, this spike voltage on SW may impact on EMI performance in the system. In order to enhance EMI performance, place an RC snubber between SW and PGND. It is strongly recommended to reserve the RC snubber during PCB layout for EMI improvement. Moreover, reducing the SW trace area and keeping the main power in a small loop will be helpful on EMI performance.

Layout is critical to achieve clean and stable operation. The switching power stage requires particular attention. Follow these guidelines for good PC board layout:

1. Careful component selections, layout of the critical components, and use shorter and wider PCB traces help in minimizing the magnitude of voltage spikes.

2. There are two set of critical components in a DC-DC converter using the AAP6010A. The switching power components are most critical because they switch large amounts of energy, and as such, they tend to generate equally large amounts of noise. The critical small signal components are those connected to sensitive nodes or those supplying critical bypass current.

3. The converter should be placed firstly. Place the input capacitors, close to the power switches. Place the output inductor and output capacitors between the SW node and the load.

4. If possible, a multi-layer printed circuit board is recommended. The capacitor C_{IN} and C_{OUT} each of them represents numerous capacitors of input and output. Use a dedicated grounding plane and use vias to ground all critical components to this layer. Apply another solid layer as power plane and cut this plane into smaller islands of common voltage levels. The power plane should support the input power and output power nodes. Use copper filled polygons on the top and bottom circuit layers for the SW node is subjected to very high dv/dt voltages, the stray capacitance formed between these islands and the surrounding circuitry will tend to couple switching noise. Use the remaining printed circuit layers for small signal routing. The PCB traces of the SW pin should be sized to carry 6A peak currents.

REVISION HISTORY

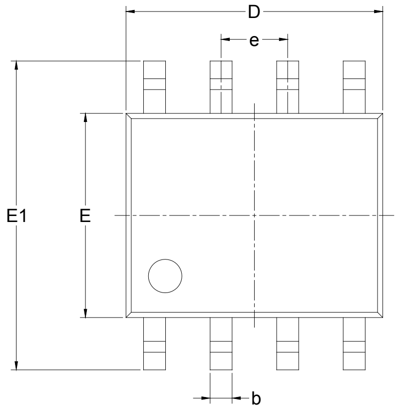
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

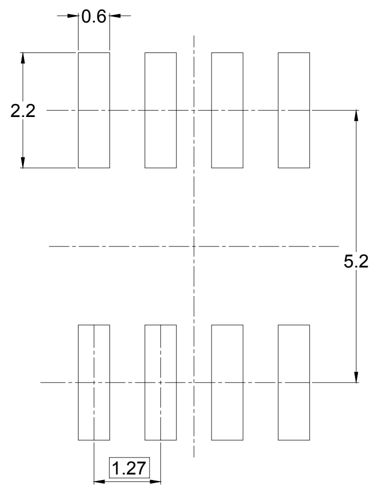
Changes from Original (DECEMBER 2018) to REV.A

Changed from product preview to production data.......................................All

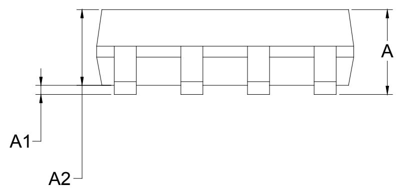
PACKAGE OUTLINE DIMENSIONS

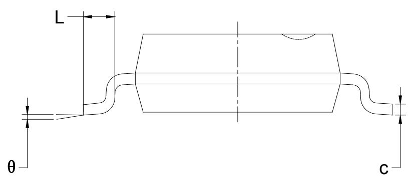
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)

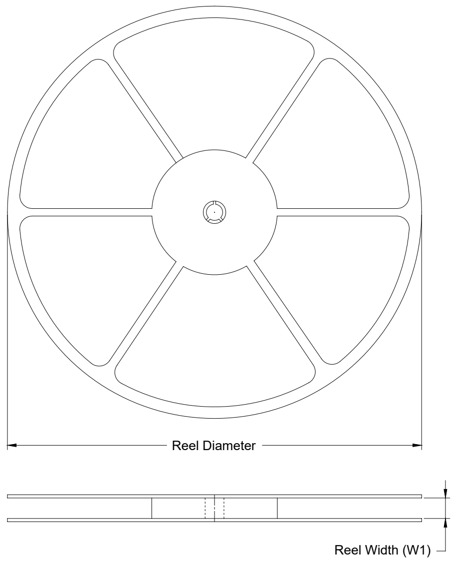




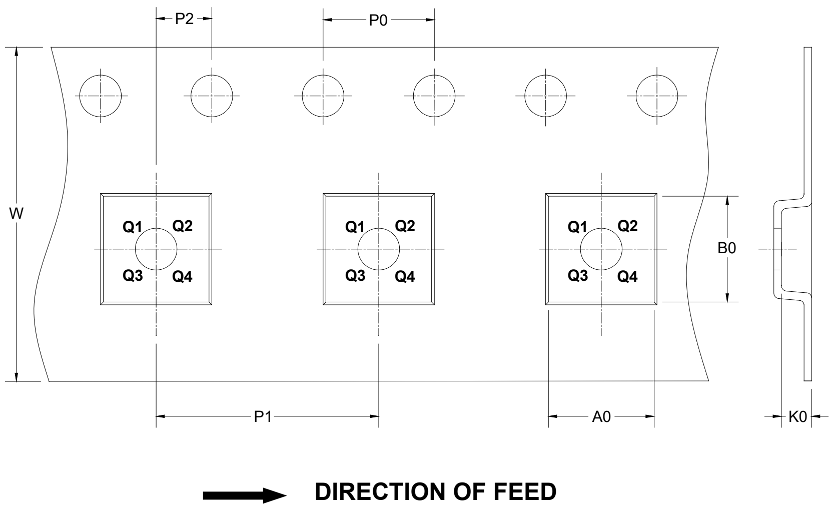
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



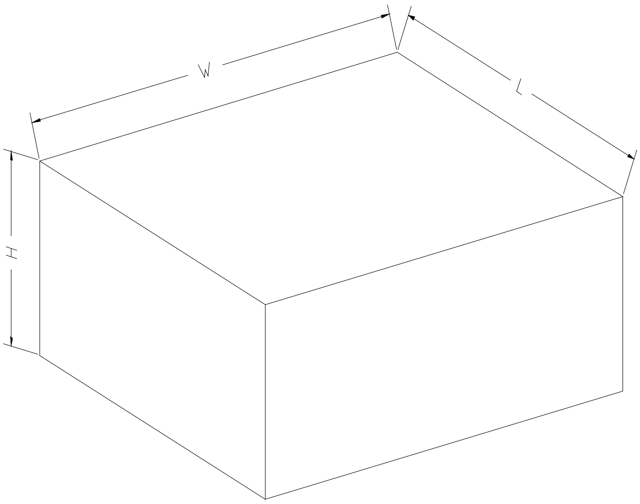
NOTE: The picture is only for reference. Please make the object as the standard.

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
SOIC-8	13″	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	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
13″	386	280	370	5

DD0002