AP2973

4.5V to 18V Input, 3A Synchronous Step-Down Converter

General Description

AP2973 is a High Efficiency Synchronous DC-DC Buck Converter with fast transient response, which can output up to 3A in a wide input range from 4.5V to 18V. The AP2973 integrates low $R_{DS\ (ON)}$ main switch and synchronous switch to minimize the conduction loss and eliminates the external Schottky diode.

AP2973 applies the Neo-COT technology to achieve the extremely fast transient responses for high step down applications and high efficiency at light loads. In addition, it keeps in constant frequency of 500kHz at heavy load conditions, also can minimize the size of inductor and capacitor.

Full protection features include OCP, OTP, SCP and UVLO. The AP2973 is available in a space saving 6-pin SOT23-6L package.

Applications

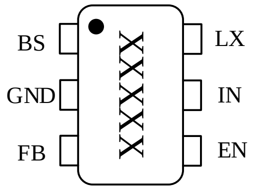
- Industrial Power Supply
- Communication Applications
- Access Point Router
- DSL Modem
- LCD TV

Features

- 4.5V-18V input voltage range
- Integrated 70mΩ and 50mΩ FETs
- Up to 3A Output Current
- The Neo-COT technology to achieve the extremely fast transient responses
- Internal soft-start circuitry limits the inrush current
- 1.5% 0.6V reference
- Input Under Voltage Lockout
- Cycle by Cycle Peak Current Limit
- Output Short Circuit Protection
- Thermal Shutdown
- The space saving package: SOT23-6L

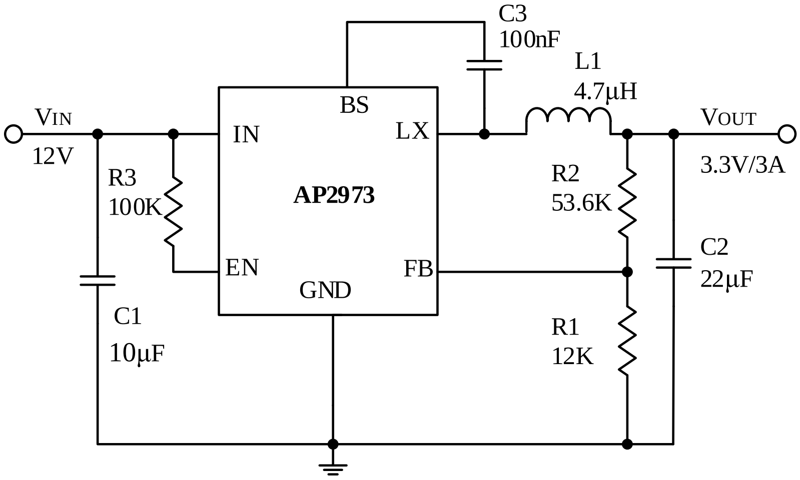
Package/Order Information

SOT23-6L



Order code	Package
AP2973TC-A1	SOT23-6L

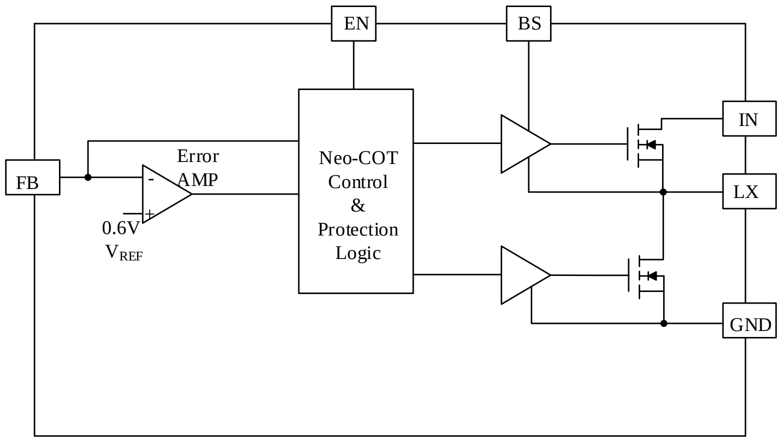
Typical Application Circuit



Pin Description

Pin No.	Pin Name	Pin Description
1	BS	Boot-Strap Pin. Supply input for the gate drive circuit of high-side NFET. Connect a 100nF capacitor between BS and LX pins.
2	GND	Ground pin.
3	FB	Converter Feedback Input. Connect to the center point of the output feedback resistors divider to program the output voltage. Keep away from LX noising node.
4	EN	Enable pin. Pull high to turn on chip, can not be floating.
5	IN	Input Voltage Supply. Connect a decoupling capacitor between IN and GND pins with least distance.
6	LX	Switch Node between High-side NFET and Low-side NFET. Connect this pin to the switching node of inductor.

Functional Block Diagram



Absolute Maximum Ratings (1)

Supply Voltage (V_{IN}).................................. -0.3V to 19V
Switch Voltage (V_{LX})......................... –1V to V_{IN} + 0.3V
Enable (V_{EN}).......................................–1V to V_{IN} + 0.3V
Bootstrap Voltage (V_{BS}) .... (Vsw-0.3) to (Vsw+5V)
Feedback Voltage (V_{FB}) .... –1V to V_{IN} + 0.3V

Thermal Resistance
θ_{JA}(2)...160°C/W
θ_{JC}(3)..40°C/W
Junction Temperature .... Internally Limited
Lead Temperature (Soldering, 10s)………...…..+260°C
Storage Temperature...........................–65°C to +150°C

Recommended Operating Conditions (4)

Input Voltage (V_{IN}) ....4.5V to 18V

Operating Temperature................ –40°C to +85°C

(1). All voltages refer to GND pin unless otherwise noted; Stresses exceed those ratings may damage the device.
(2). Soldered to 100 mm^2, 1oz copper clad.
(3). Measured on pin 6(LX) Close to plastic interface.
(4). The device is not guaranteed to function outside of its operating conditions.

Electrical Characteristics (1)

(V_{IN} = 12V, V_{OUT} = 3.3V, L = 4.7μH, T_A = 25 ℃, unless otherwise specified.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Voltage	V_{IN}		4.5		18	V
Input UVLO Threshold Rising	V_{UVLO}	V_{IN} Rising	3.8	4.2	4.5	V
Input UVLO Threshold Hysteresis	V_{UVLO_HYS}			50		mV
Supply Current	I_Q	I_{OUT}=0, V_{FB}=V_{REF}×105 %, no switching		410		μA
Shutdown Supply Current	I_{SD}	V_{EN} = 0V			1	μA
Feedback Voltage	V_{FB}	5V≤V_{IN} ≤18V	591	600	609	mV
FB Input Current	I_{FB}		-0.1		0.1	μA
High-Side Switch-On Resistance	$R_{DS(ON)H}$			70		mΩ
Low-Side Switch-On Resistance	$R_{DS(ON)L}$			50		mΩ
High-Side Switch Leakage	I_{LEAK_H}	V_{EN} = 0V, V_{LX} = 0V		0	10	μA
Low-Side Switch Leakage	I_{LEAK_L}	V_{EN} = 0V, V_{LX} = V_{IN}		0	10	μA
Internal Cycle-by-Cycle Current Limit	I_{LIM}			4.5		A
Oscillator Frequency	F_{SW}			500		kHz
EN Rising Threshold	V_{EN_H}	V_{EN} Rising	1.6			V
EN Falling Threshold	V_{EN_L}	V_{EN} Falling			0.4	V
Min On Time	t_{ON_MIN}			100		ns
Soft-start Time	t_{SS}			1		ms
Max Duty Cycle	D_{MAX}			90		%
Thermal Shutdown	T_{SDN}			160		℃

(1). Specifications over temperature range are guaranteed by design and characterization.

Functional Description

AP2973 is a High Efficiency Synchronous DC-DC Buck Converter, which can output up to 3A in a wide input range from 4.5V to 18V. AP2973 switching frequency is 500kHz.

The AP2973 integrates two N-Channel MOSFET switches to step-down the input voltage to the regulated output voltage with current-mode control architecture, and the Neo-COT technology can achieve the extremely fast transient responses for high step down applications.

Application Information

1. Setting the Output Voltage

The AP2973 feedback voltage is regulated at 0.6V and the output voltage is programed by the feedback divider R1 and R2, where R2 form the upper feedback resistor and R1 is the lower feedback resistor. The output voltage can be calculated using the following Equation 1.

$$V_{OUT}=V_{FB}\times\left(1+\frac{R2}{R1}\right)=0.6V\times\left(1+\frac{R2}{R1}\right) \quad (1)$$

2. Inductor

Since the selection of the inductor affects the power supply's steady state operation, transient behavior, loop stability, and overall efficiency, the inductor is the most important component in switch power regulator design. Three most important specifications to the performance of the inductor are the inductor value, DC resistance, and saturation current.

The AP2973 is designed to work with inductor values of 4.7μH. The tolerance of inductors can be ranging from 10% to 30%. The inductance will further decrease 20% to 35% from the value of zero bias current depending on the definition of saturation by inductor manufacturers. The basic requirements of selecting an inductor are the saturation current must be higher than the peak switching current and the DC rated current is higher than the average inductor current in normal operation. In buck converter, the average inductor current is equal to the output current. The inductor value can be derived from the Equation 2.

$$\Delta I_L=\frac{V_{OUT}\times(V_{IN}-V_{OUT})}{V_{IN}\times L\times f_{SW}} \quad (2)$$

Where

- ΔI_L is the inductor peak-to-peak ripple current.
- V_{OUT} is the output voltage.
- V_{IN} is the input voltage.
- f_{SW} is the switching frequency.
- L is the inductor value.

Table 1 lists the recommended inductor specifications.

Table 1. Recommended Inductors

Vendor	P/N	L (μH)	DCR (mΩ)	I_{SAT} (A)
Sunlord	MWSA050 3S-4R7MT	4.7	60	4.6

3. Input Capacitor

The input capacitor reduces the surge current drawn from the input and the switching noise from the converter. The input capacitor impedance at the switching frequency should be less than the input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Multilayer Ceramic Capacitor (MLCC) with X5R or X7R dielectric is highly recommended because of their low ESR, low temperature coefficients and compact size characteristics. A 10μF MLCC capacitor is sufficient for most applications.

In hot plug applications, the input needs to be connected in parallel with an electrolytic capacitor above 100 μF to prevent IC damage.

4. Output Capacitor

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. MLCC with X5R or X7R dielectric is recommended due to their low ESR, low temperature coefficients and compact size characteristics. The output ripple, ΔV_{OUT}, is determined by:

$$\Delta V_{OUT}\le\frac{V_{OUT}\times(V_{IN}-V_{OUT})}{V_{IN}\times f_{SW}\times L}\times\left(ESR+\frac{1}{8\times f_{SW}\times C_{OUT}}\right) \quad (3)$$

Where

- ΔV_{OUT} is the output ripple voltage.
- V_{OUT} is the output voltage.
- V_{IN} is the input voltage.
- f_{SW} is the switching frequency
- L is the inductor value.
- ESR is the output capacitor Equivalent Series Resistance.
- C_{OUT} is the output capacitor value.

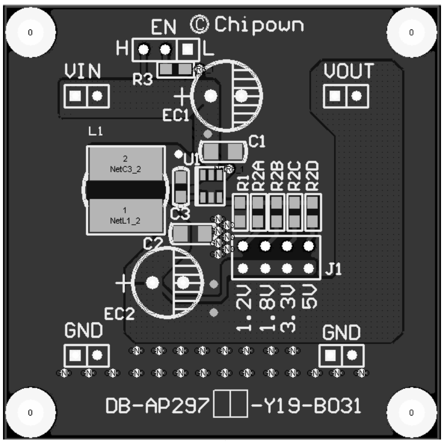
Table 2. Recommended Component Values for typical Output Voltage

Vout	R1 (kΩ)	R2 (kΩ)	L1 (μH)	C1 (μF)	C2 (μF)	C3 (nF)
5.0V	12	91	4.7	10	22	100
3.3V	12	53.6	4.7	10	22	100
2.5V	12	39	4.7	10	22	100
1.8V	12	24	4.7	10	22	100
1.5V	12	18	4.7	10	22	100
1.2V	12	12	4.7	10	22	100
1.0V	12	8.2	4.7	10	22	100

Layout Guidance

When doing the PCB layout, the following suggestions should be taken into consideration to ensure proper operation of the AP2973. These suggestions are also illustrated graphically in the below Figure.

1. The power path including the GND trace, the LX trace and the IN trace should be as short as possible, direct and wide.
2. The FB pin should be connected directly to the center point of the output feedback resistors divider.
3. The input decoupling MLCC should be placed as close to the IN and GND pins as possible and connected to input power plane and ground plane directly. This capacitor provides the AC current to the internal power MOSFETs.
4. The power path between the output MLCC, and the power inductor should be kept short and the other terminal of the capacitor should connect to the ground plane directly to reduce noise emission.
5. Keep the switching node, LX, away from the sensitive FB node.
6. Keep the negative terminals of input capacitor and output capacitor as close as possible.
7. Use large copper plane and thermal vias for GND for the best heat dissipation and noise immunity.



Typical Performance Characteristics

All curves taken at V_{IN} = 12V, V_{OUT} = 3.3V with configuration in Typical Application Circuit shown in this datasheet. T_A = 25 ℃, unless otherwise specified.

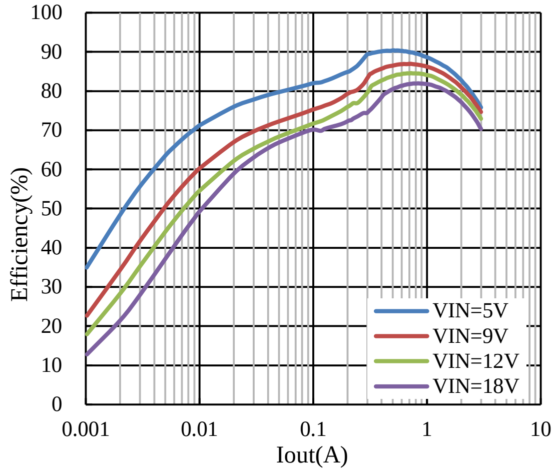


Figure 1. Efficiency vs. Load Current, V_{OUT} = 1.2V

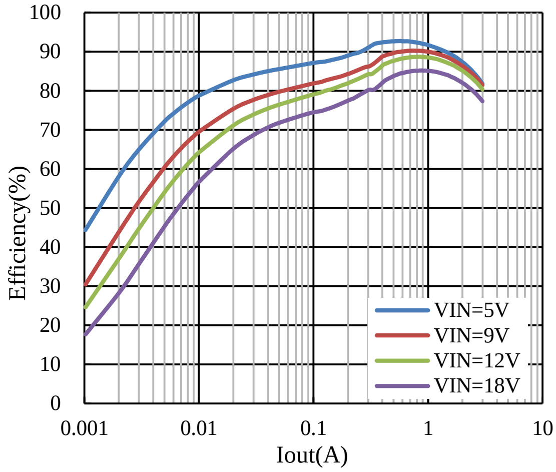


Figure 2. Efficiency vs. Load Current, V_{OUT} = 1.8V

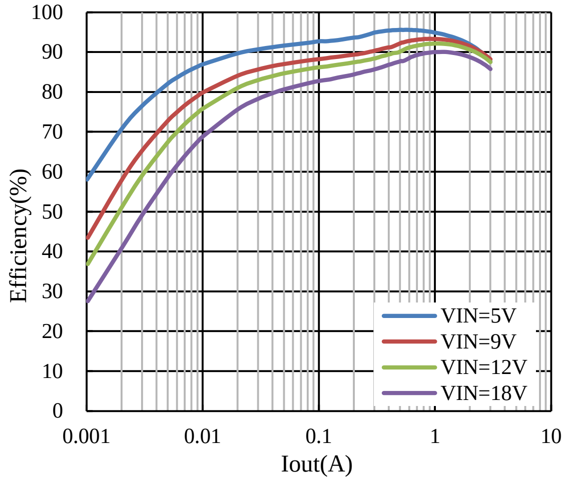


Figure 3. Efficiency vs. Load Current, V_{OUT} = 3.3V

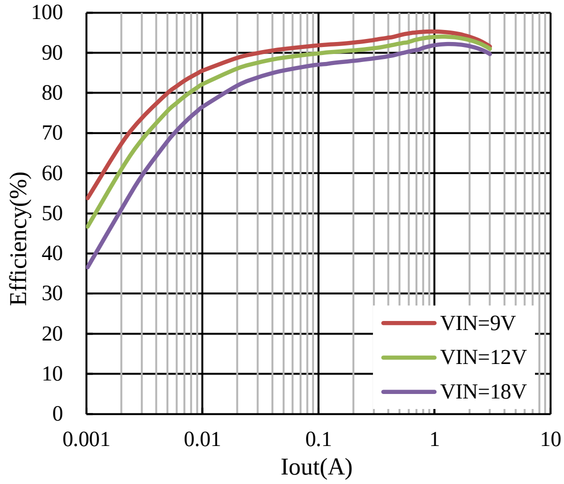


Figure 4. Efficiency vs. Load Current, V_{OUT} = 5V

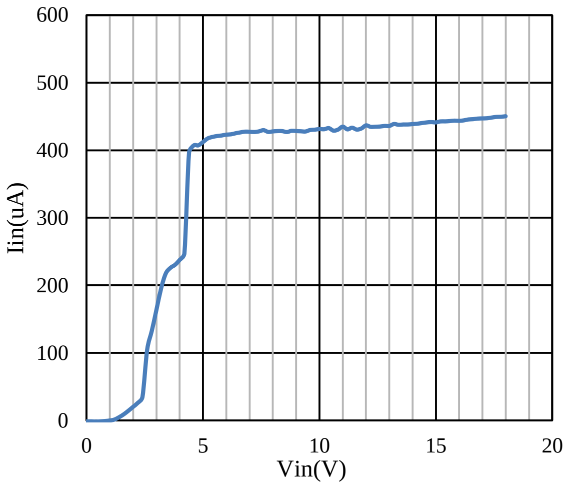


Figure 5. Input current vs. Input voltage

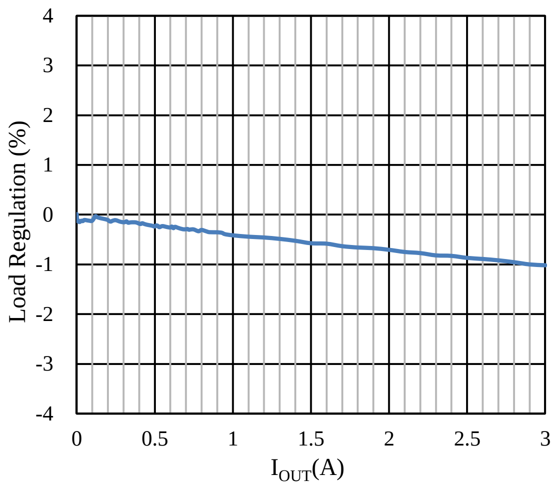


Figure 6. Load Regulation vs. Load Current

Typical Performance Characteristics(continued)

All curves taken at V_{IN} = 12V, V_{OUT} = 3.3V with configuration in Typical Application Circuit shown in this datasheet. T_A = 25 ℃, unless otherwise specified.

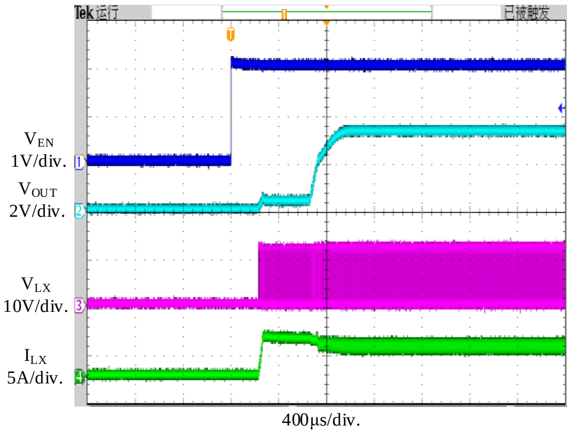


Figure 7. Startup Waveforms

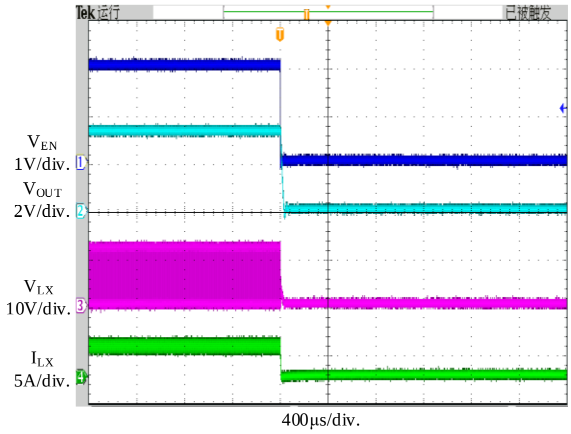


Figure 8. Shutdown Waveforms

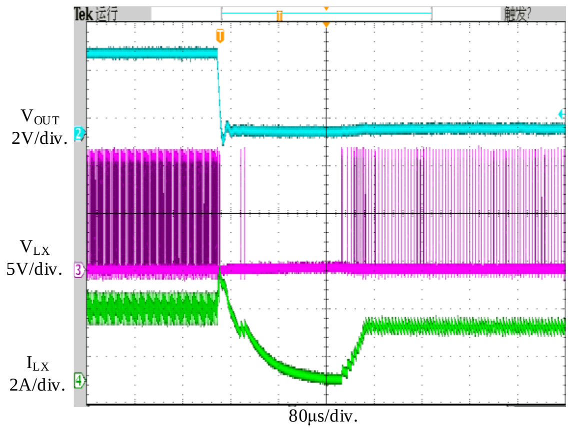


Figure 9. Short Circuit Protection

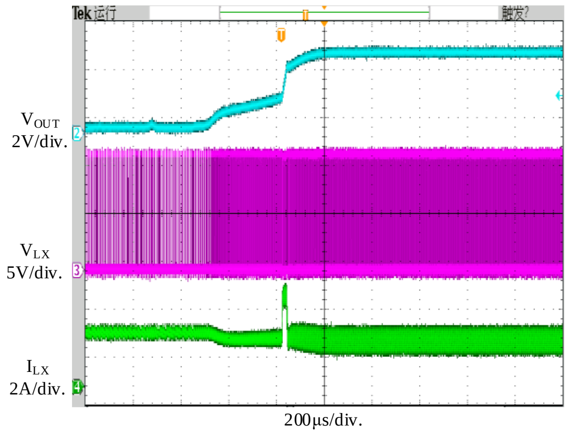


Figure 10. Short Circuit Recovery

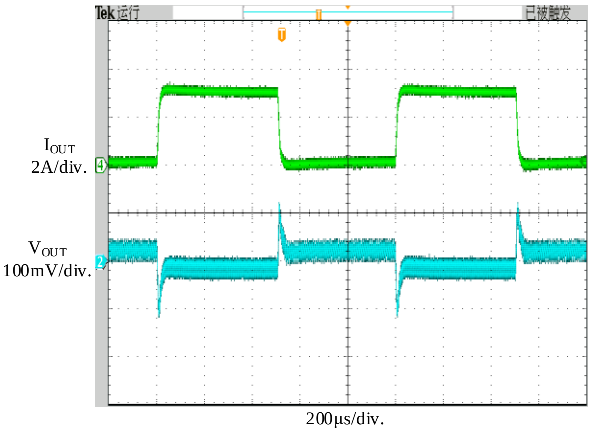


Figure 11. Load Transient,

V_{OUT}=3.3V, I_{OUT}=0.1A-3A

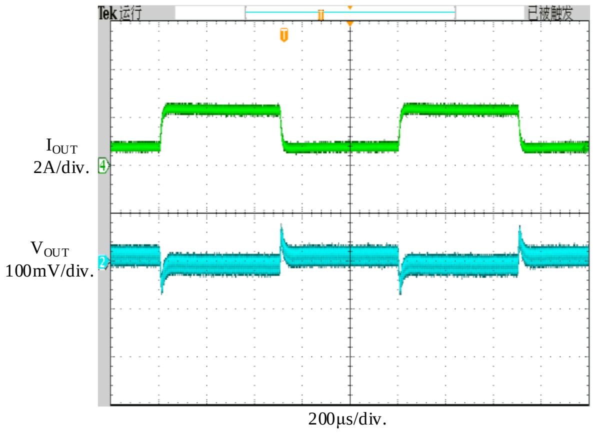
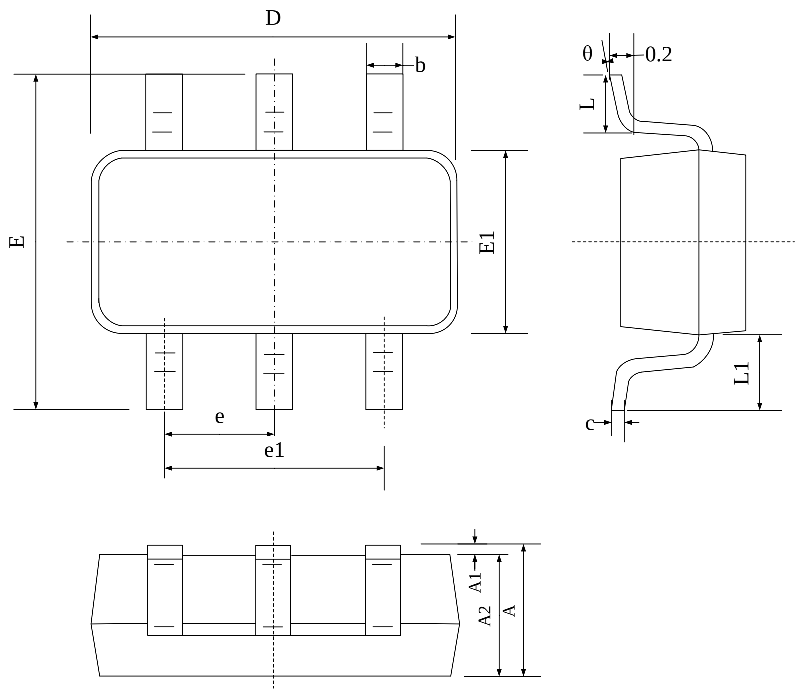


Figure 12. Load Transient,

V_{OUT}=3.3V, I_{OUT}=0.75A-2.25A

Package Information

Package Outline and Dimensions



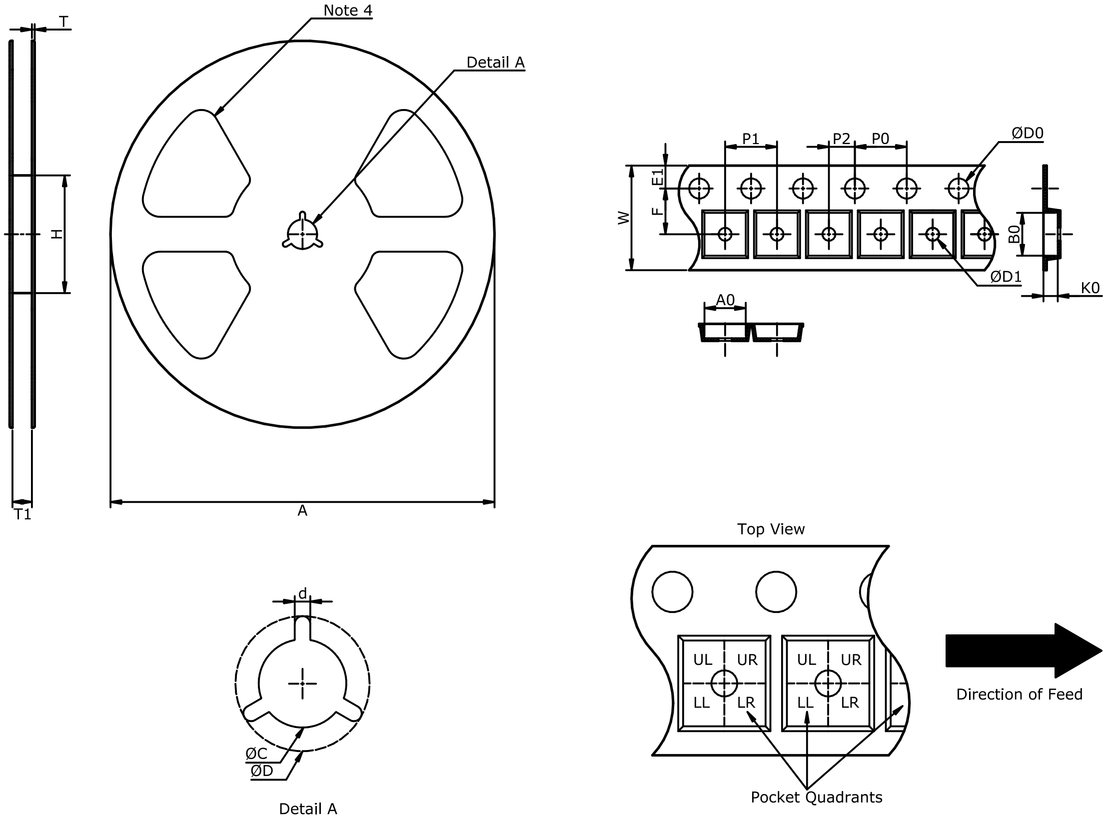
Size / Symbol	Min. (mm)	Max. (mm)	Size / Symbol	Min. (mm)	Max. (mm)
A	1.050	1.450	E	2.600	3.000
A1	0.000	0.150	e	0.95	
A2	0.900	1.300	e1	1.800	2.000
b	0.300	0.500	L	0.300	0.600
c	0.080	0.220	L1	0.6	
D	2.820	3.050	θ	0 °	8 °
E1	1.500	1.700			

Top mark	Package
V3XXX	SOT23-6L

Note: XXX = Internal Code

Notes:
1. This drawing is subjected to change without notice.
2. Body dimensions do not include mold flash or protrusion.

Tape and Reel Information



A (mm)	T (mm)	T1 (mm)	H (mm)	ØC (mm)	d (mm)	A0 (mm)	B0 (mm)	K0 (mm)
180 +1/−4	1.4 ±0.4	9.5 +1/−1.1	54 ±2	13.00 +2.2/−0.2	2.5 +0.7/−0.6	3.18 +0.2/−0.92	3.23 +0.17/−0.1	1.4 +0.1/−0.2
W (mm)	**F (mm)**	**E1 (mm)**	**P0 (mm)**	**P1 (mm)**	**P2 (mm)**	**ØD0 (mm)**	**ØD1 (mm)**	**Pin 1 Quadrant**
8.0 ±0.1	3.5 ±0.1	1.75 ±0.1	4.0 ±0.1	4.0 ±0.1	2.0 ±0.1	1.5 +0.15/−0.1	1.1 ±0.1	LL

Notes:
1. This drawing is subjected to change without notice.
2. All dimensions are nominal and in mm.
3. This drawing is not in scale and for reference only. Customer can contact Chipown sales representative for further details.
4. The number of flange openings depends on the reel size and assembly site. This drawing shows an example only.

Important Notice