Low Noise, DC/DC Charge Pump Regulator

Description

The FP6770 is a low noise DC/DC charge pump regulator that produces a regulated output voltage from 2.7V to 5V input voltage. Low external parts count (one flying capacitor and two small bypass capacitors at V_{IN} and V_{OUT}) make the FP6770 ideal for small, battery-powered applications.

The FP6770 operates as a constant frequency mode switched capacitor voltage doubler to produce a regulated output and reduces both output and input ripple. The FP6770 has both short circuit protection and thermal shutdown capability.

The FP6770 is available in space-saving SOT-23-6 TSOT-23-6 and TDFN-6 packages.

Features

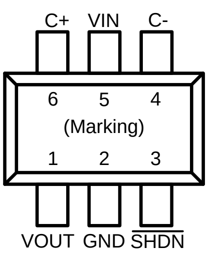
- Low Noise Constant Frequency Operation
- Output Current: Minimum 170mA at V_{IN}=3.2V
- Available in SOT-23-6 、TSOT-23-6 and TDFN-6
- 2MHz Switching Frequency
- Fixed 5V ± 4% Output
- V_{IN} Range: 2.7V to 5V
- No Inductors
- Low Shutdown Current: <1μA

Applications

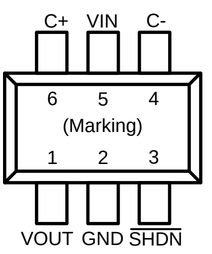
- White LEDs Backlighting
- Li-Ion Battery Backup Supply
- Smart Card Reader
- Local 3V to 5V Conversion
- PCMCIA Local 5V Supply

Pin Assignments

S6 Package (SOT-23-6)



S9 Package (TSOT-23-6)



WD Package (TDFN- 6) (1.6x1.6mm)

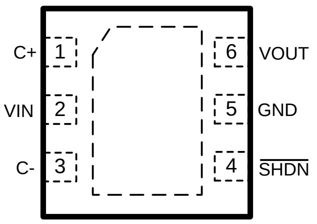
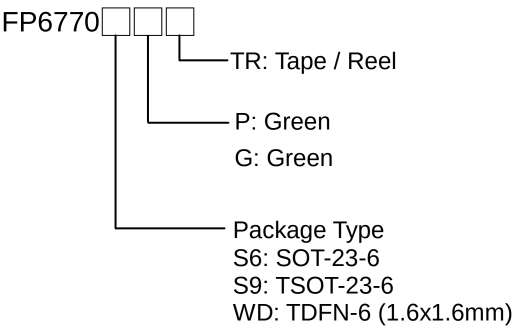


Figure 1. Pin Assignment of FP6770

Ordering Information



SOT-23-6 Marking

Part Number	Product Code
FP6770S6P	**C2**

TSOT-23-6 Marking

Part Number	Product Code
FP6770S9P	**C0**

TDFN-6(1.6x1.6mm) Marking

Part Number	Product Code
FP6770WDG	**P.**

Typical Application Circuit

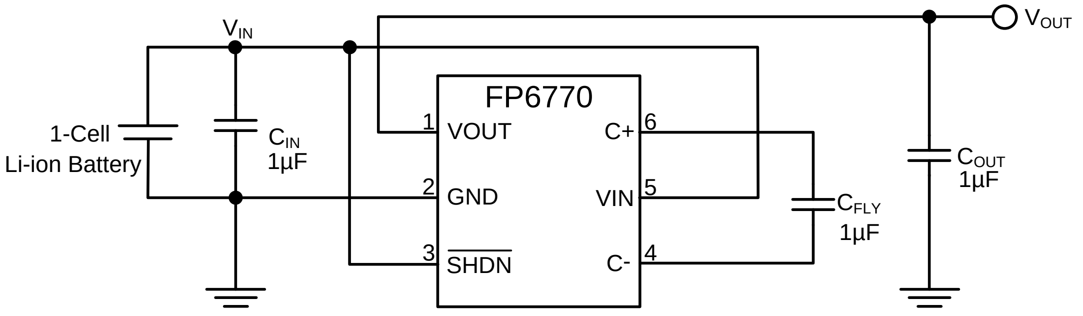


Figure 2. Typical Application Circuit of FP6770

Functional Pin Description

Pin Name	Pin Function
VOUT	Regulated output voltage. For best performance, V_{OUT} should be bypassed with a 1µF (min.) low ESR capacitor as close as possible to the pin.
GND	Ground. Should be tied to a ground plane for best performance.
$\overline{SHDN}$	Active low shutdown input. A low voltage on $\overline{SHDN}$ disables the FP6770. $\overline{SHDN}$ is not allowed to float.
C-	Flying capacitor negative terminal.
VIN	Input supply voltage. V_{IN} should be bypassed with a 1µF (min.) low ESR capacitor.
C+	Flying capacitor positive terminal.

Block Diagram

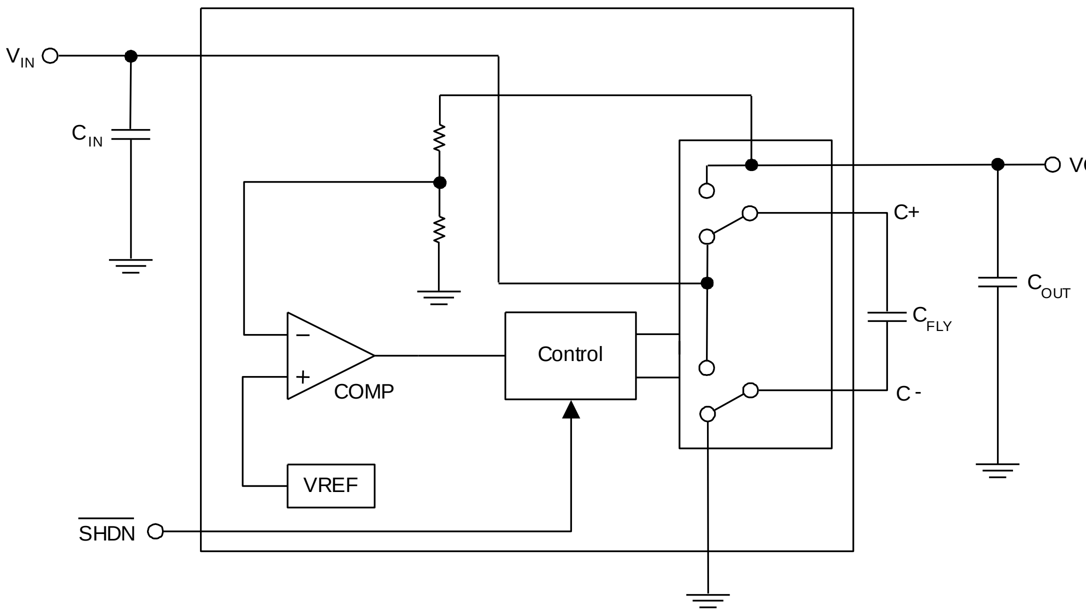


Figure 3. Block Diagram of FP6770

Absolute Maximum Ratings

- V_{IN} to GND -- +6V
- V_{OUT} to GND -- +6V
- All Other Pins to GND -- +6V
- Power Dissipation (P_D) @ T_A=25℃:
  - SOT-23-6 / TSOT-23-6 -- 0.4W
  - TDFN-6 (1.6mX1.6m)(P_D) -- 1.25W
- Package Thermal Resistance:
  - SOT-23-6 / TSOT-23-6 (θ_{JA}) -- 250°C/W
  - TDFN-6 (1.6mX1.6m) -- 80℃/W
- Junction Temperature -- +150°C
- Storage Temperature Range -- -65°C to +150°C
- Lead Temperature (Soldering, 10 sec.) -- +260°C

Note：Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device.

Recommended Operating Conditions

- Supply Voltage (V_{IN}) -- +2.7V to +5V
- Operation Temperature Range -- -40°C to +85°C

Electrical Characteristics

(T_A=25°C, C_{FLY}=1μF, C_{IN}=1μF, C_{OUT}=1μF, unless otherwise specified.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Voltage	V_{IN}		2.7		5	V
Output Voltage	V_{OUT}	2.7V≤ V_{IN}< 5V, I_{OUT}≤ 60mA	4.8	5	5.2	V
		3.0V≤ V_{IN}≤ 5V, I_{OUT}≤ 120mA	4.8	5	5.2	V
Continuous Output Current	I_{OUT}	V_{IN}=3.0V, V_{OUT}=5.0V, $\overline{SHDN}$=V_{IN}	100			mA
Supply Current	I_{CC}	2.7V≤ V_{IN}≤ 5.0V, I_{OUT}=0, $\overline{SHDN}$=V_{IN}		3	4.5	mA
Shutdown Current	$I_{\overline{SHDN}}$	2.7V≤ V_{IN}≤ 5.0V, I_{OUT}=0, $\overline{SHDN}$=0V		0.01	1.0	μA
Efficiency	η	V_{IN} =2.7V, I_{OUT}=60mA		90		%
Switching Frequency	f_{OSC}	Oscillator Free Running		2		MHz
$\overline{SHDN}$ Input Threshold	V_{IH}	V_{IN}=3.0V, output on	1.4			V
	V_{IL}	V_{IN}=3.0V, output off			0.3	V
$\overline{SHDN}$ Leakage Current	I_{IH}	$\overline{SHDN}$=V_{IN}	-1		1	μA
	I_{IL}	$\overline{SHDN}$= 0V	-1		1	μA
V_{OUT} Turn On Time	t_{ON}	V_{IN} =3V, I_{OUT} = 1mA		200		μS
Output Short Circuit Current	I_{SC}	V_{IN}=3V, V_{OUT}= 0V, $\overline{SHDN}$=V_{IN}		300		mA

Typical Performance Curves

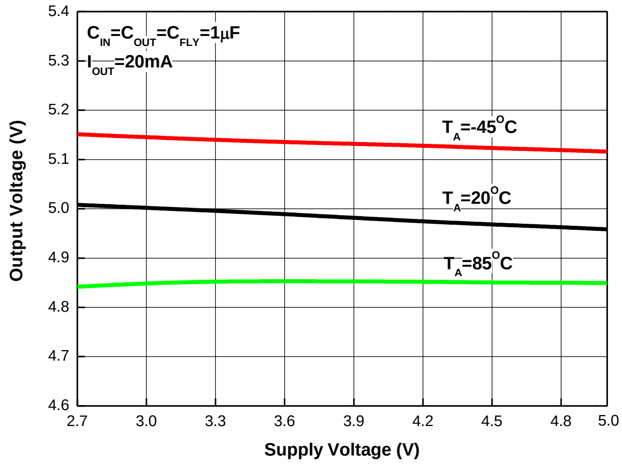


Figure 4. Output Voltage vs. Supply Voltage

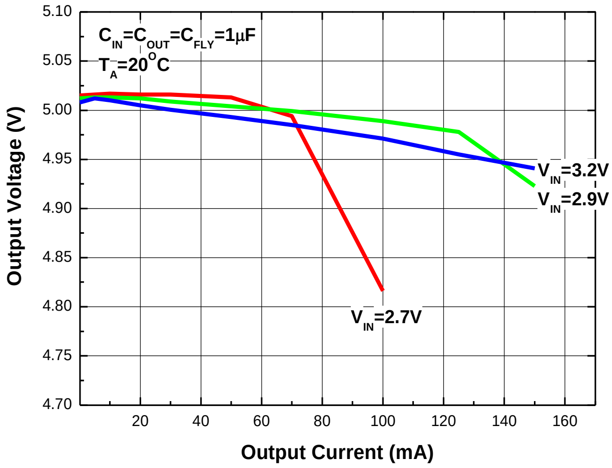


Figure 5. Output Voltage vs. Load Current

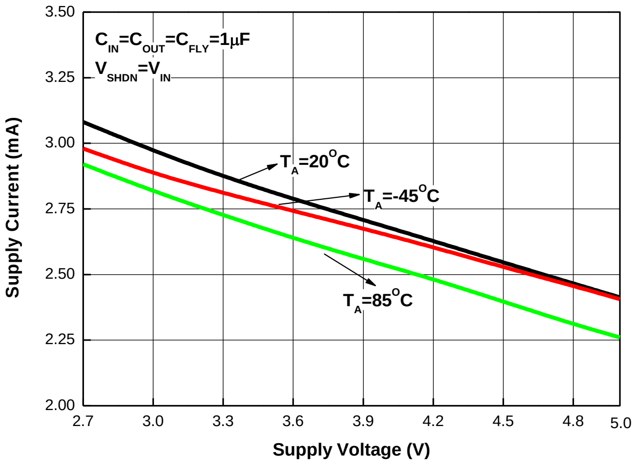


Figure 6. No Load Supply Current vs. Supply Voltage

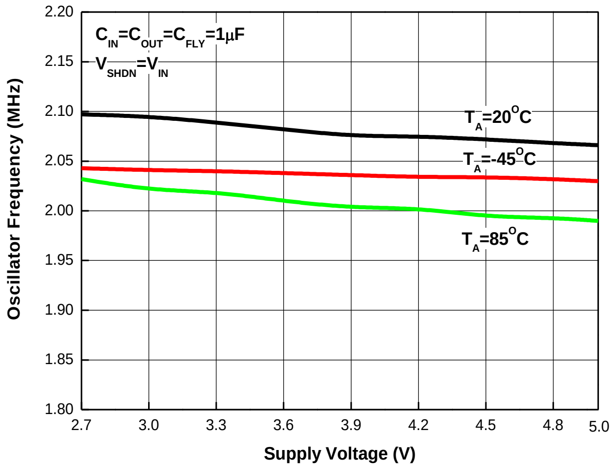


Figure 7. Oscillator Frequency vs. Supply Voltage

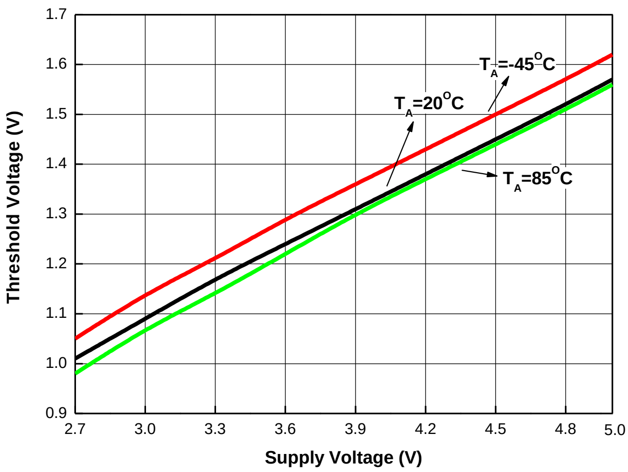


Figure 8. VSHDN Threshold Voltage vs. Supply Voltage

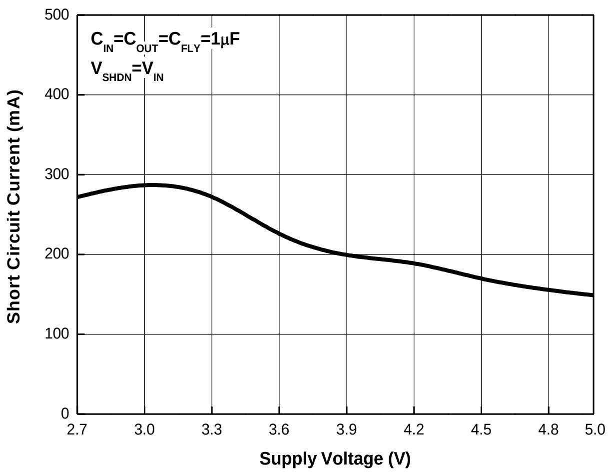


Figure 9. Short Circuit Current vs. Supply Voltage

Typical Performance Curves (Continued)

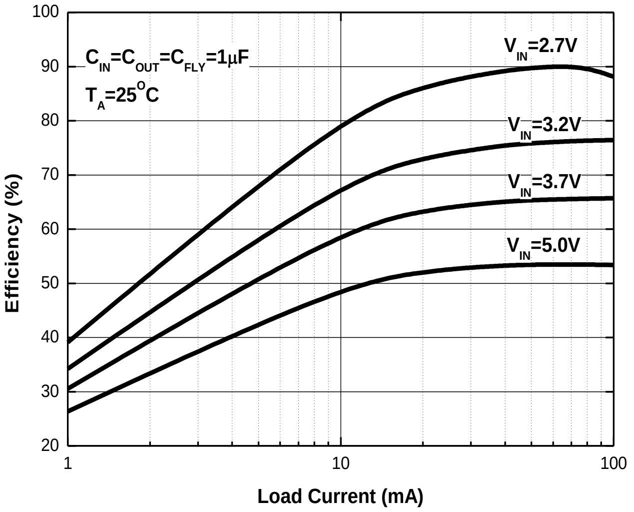


Figure 10. Efficiency vs. Load Current

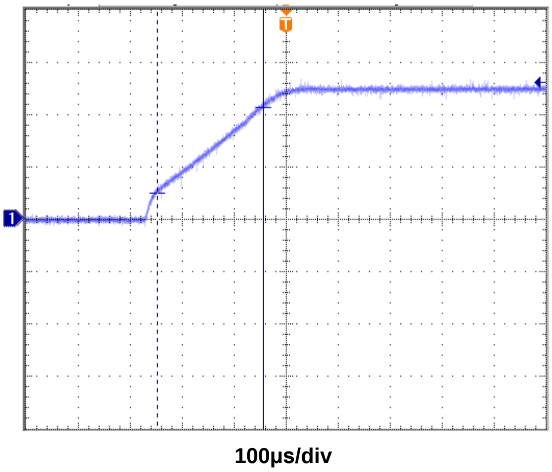


Figure 11. Output Voltage Start Up

Application Information

Introduction

The FP6770 is a DC/DC charge pump converter that produces a regulated 5V output with an input voltage that range from 2.7V to 5V. It boosts V_{IN} to get a regulated output voltage using the charge pump topology. Sensing the output voltage through an internal resistor divider. When the output voltage is lower, the internal comparator will increase charge pump ability, and vice versa. When the charge pump is enabled, a two-phase non-overlapping clock activates the charge pump switches.

Efficiency

Let's take advantage of conversation of charge for flying capacitor. Assume that the flying capacitor has reached its steady state.

$$I_{ON\text{-}AVE} = I_{OFF\text{-}AVE} \quad \text{.......................................(1)}$$

According to the equation (1), the input current is twice the output current.

$$\begin{aligned} I_{IN} &= I_{ON-AVE} + I_{OFF-AVE} \\ &= 2I_{OFF-AVE} \\ &= 2I_{OUT} \end{aligned}$$

The efficiency of charge pump is given below:

$$\eta = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times I_{IN}} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times 2I_{OUT}} = \frac{V_{OUT}}{2V_{IN}}$$

Short Circuit/Thermal Protection

FP6770 have a built-in short circuit current limiting and an over temperature protection. During the short circuit condition, the output current is automatically limited at approximately 300mA on V_{IN}=3V. When the die temperature exceeds 160°C, the thermal protection will shut the charge pump switching operation down and the die temperature will reduce afterwards. When the die temperature drops below 135°C, the charge pump switching circuit will restart. If the fault doesn't eliminate, the above protecting operation will repeat again and again. It allows FP6770 to continuously work at short circuit condition without damaging the device.

Shutdown

The output is disconnected from input when $\overline{SHDN}$ pin is tied to GND. In shutdown mode, most circuit is turned off and the input current gets extremely low. Due to high impedance, $\overline{SHDN}$ pin can't be floated.

External Capacitor Selection

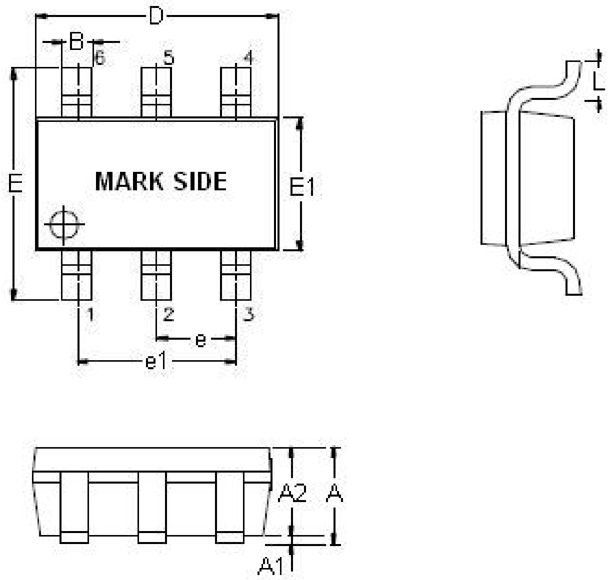
Three external capacitors determine FP6770 performances, in the aspects of output ripple voltage, charge pump strength and transient. Optimum performance can be obtained by the use of ceramic capacitors with low ESR.
Because a low ESR ceramic capacitor can reduce noise and ripple, ceramic capacitor is recommended for C_{IN} and C_{OUT}. The value of C_{OUT} determines the amount of output ripple voltage. An output capacitor with larger value results in smaller ripple.
C_{FLY} determine the strength of charge pump. The larger C_{FLY} means that the larger output current and larger ripple voltage on V_{OUT} pin. However, large C_{IN} and C_{OUT} are expected when a large C_{FLY} applies. The value of capacitors, which is used under operation condition, determines the performance of a charge pump converter. And two factors, as follows, affect the capacitance of capacitor.
There are many kinds of Ceramic capacitors materials, such as X7R, X5R, Z5U and Y5V. There have different ESR, tolerance in temperature and differnet cpacitance loss
For example, a X7R or X5R type of capacitor can retain most of the capacitance at temperature from -40°C to 85°C, but a Z5U or Y5V type will lose most of the capacitance at that temperature range.

Layout Considerations

Because the high frequency and high transient current of FP6770, careful consideration of PCB layout. Minimize the distance between every component, C_{FLY} and C_{OUT} especially. It also minimizes every connection length with a maximum trace width to achieve the best performance of FP6770. Make sure each device connects to immediate ground plane.

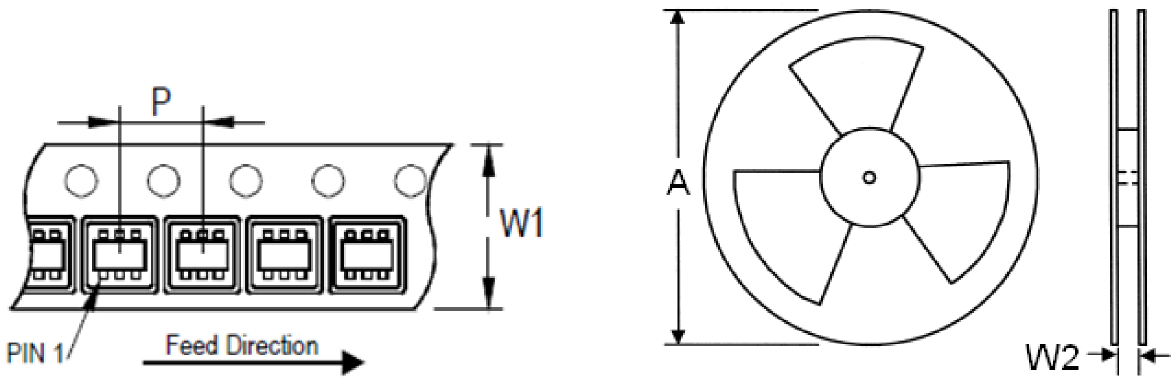
Outline Information

TSOT-23-6 Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER	
	MIN	MAX
A	0.70	1.10
A1	0.00	0.10
A2	0.70	1.00
B	0.30	0.50
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.90	1.00
e1	1.80	2.00
L	0.30	0.60

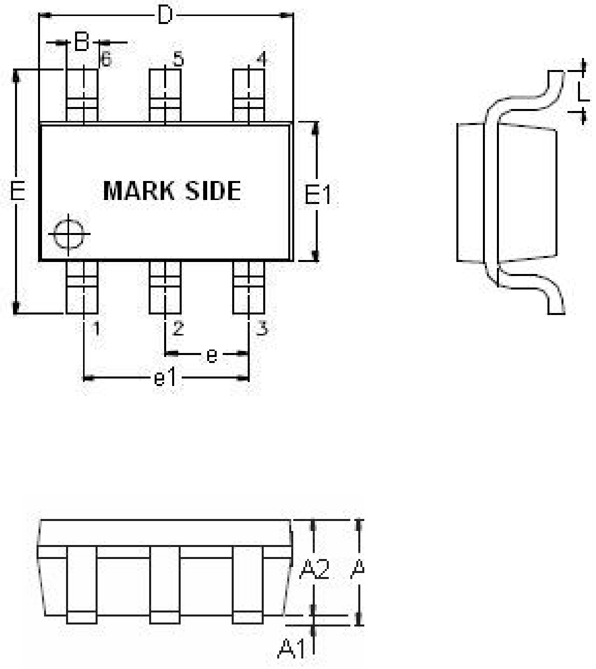
Carrier dimensions



Tape Size (W1) mm	Pocket Pitch (P) mm	Reel Size (A)		Reel Width (W2) mm	Empty Cavity Length mm	Units per Reel
		in	mm			
8	4	7	180	8.4	300~1000	3,000

Outline Information (Continued)

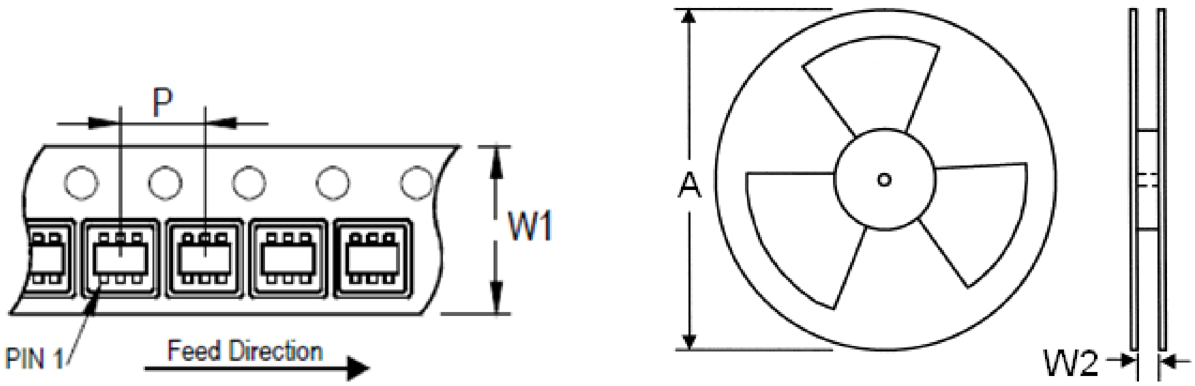
SOT-23-6 Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER	
	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
B	0.30	0.50
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.90	1.00
e1	1.80	2.00
L	0.30	0.60

Note：Followed From JEDEC MO-178-C.

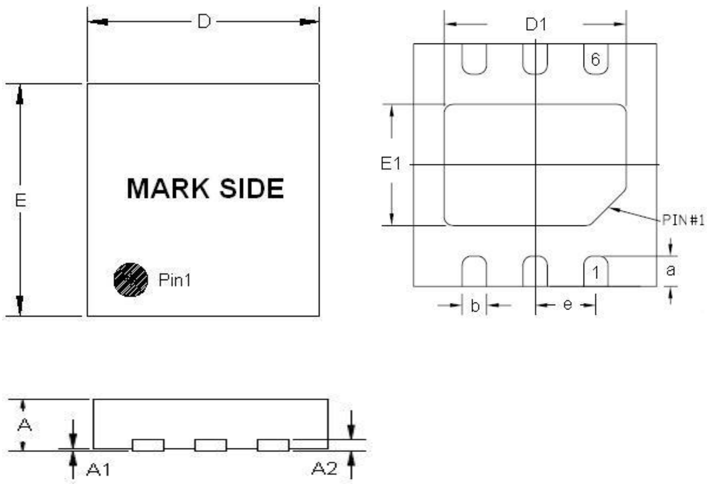
Carrier dimensions



Tape Size (W1) mm	Pocket Pitch (P) mm	Reel Size (A)		Reel Width (W2) mm	Empty Cavity Length mm	Units per Reel
		in	mm			
8	4	7	180	8.4	300~1000	3,000

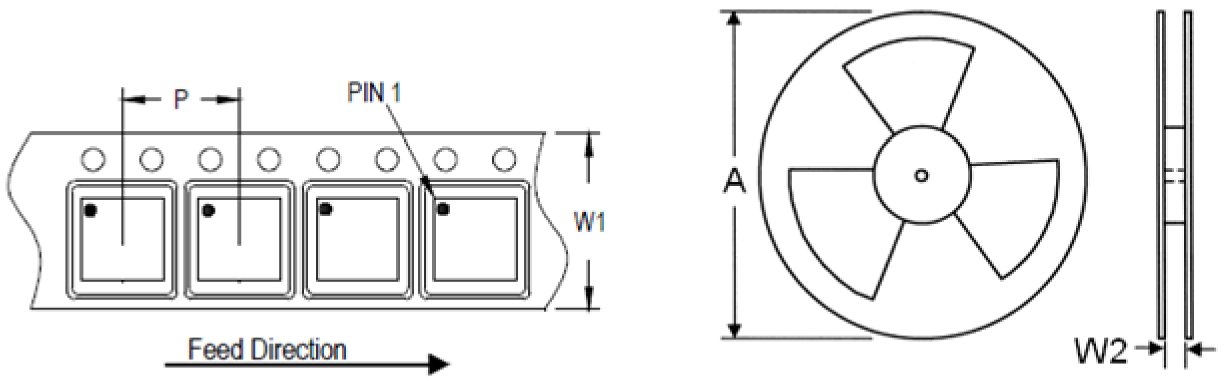
Outline Information (Continued)

TDFN-6 1.6mm×1.6mm (pitch 0.5mm) Package (Unit: mm)



SYMBOLS UNIT	DIMENSION IN MILLIMETER	
	MIN	MAX
A	0.70	0.80
A1	0.00	0.05
A2	0.18	0.25
D	1.55	1.65
E	1.55	1.65
a	0.18	0.30
b	0.18	0.30
e	0.45	0.55
D1	0.95	1.05
E1	0.55	0.65

Carrier dimensions



Tape Size (W1) mm	Pocket Pitch (P) mm	Reel Size (A)		Reel Width (W2) mm	Empty Cavity Length mm	Units per Reel
		in	mm			
8	4	7	180	8.4	400~1000	3,000

Life Support Policy
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