PR9853

Low Cost Green-Power PWM Controller With Low EMI Technique

Features

- Low Cost, PWM&PFM&hiccup mode
- Low Start-up Current (about 3μA)
- Low Operating Current (about 1.2mA)
- Current Mode Operation
- VDD Under Voltage Lockout (UVLO)
- Built-in Synchronized Slope Compensation
- Built-in Low EMI Technique
- Programmable PWM Frequency
- Audio Noise Free Operation
- Leading edge Blanking on SEN input
- Constant output power limiting in universal AC input Range
- SOT-23-6L, DIP-8 and SOP-8 Pb-Free Packaging
- Good Protection Coverage With Auto Self-Recovery

Complete Protection with

- Soft Clamped GATE output voltage 18.0V
- VDD over voltage Clamp 34.0V
- Cycle-by-cycle current limiting
- Output SCP (Short circuit Protection)
- Output OLP (Over Load Protection)
- High-Voltage CMOS Process with ESD

Applications

- Switching AC/DC Adapter
- Battery Charger
- Open Frame Switching Power Supply
- Standby Power Supplies
- Set-Top Box Power Supplies
- 384X Replacement

General Description

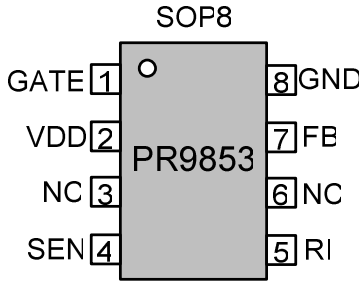
PR9853 is a highly integrated and low cost current mode PWM controller, which is ideal for low power current mode of offline AC-DC fly-back converter applications. By adjusting the external resistors to change the operating frequency, and then IC automatically enters PFM or hiccup mode in light-load or zero-load condition. Thereby reduce the standby power loss and achieve power-stored function. Because of the very low start-up current, a large value start-up resistor can be used in PR9853.

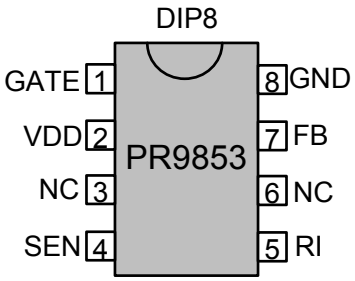
Built-in synchronized slope compensation enhances the stability of the system and avoids sub-harmonic oscillation. The dynamic peak current limiting circuit reduces the variation of output power which caused by system delay over a universal AC input range. Leading edge blanking circuit at current sense input could remove the signal glitch due to the reverse recovery of diode in snubber circuit, and thus greatly reduces the amount of external components and the system cost for this design. Cycle-by-Cycle current limiting ensures a safe operation even in the condition of short.

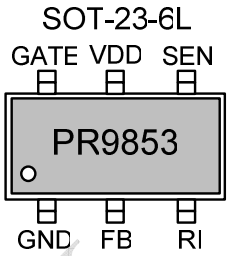
Excellent EMI performance is achieved by built-in soft driver and low EMI technique.

The PR9853 offers rich protection features such as VDD over voltage Clamp、OLP(Over Load Protection)、SCP(Short circuit protection)、Sense Fault Protection and OCP(Over current protection). The output voltage of PR9853 is softly clamped to maximum 18.0V to protect the power MOSFET. PR9853 is offered in SOT-23-6L, DIP-8 and SOP-8 packages.

Pin Assignment







Pin Descriptions

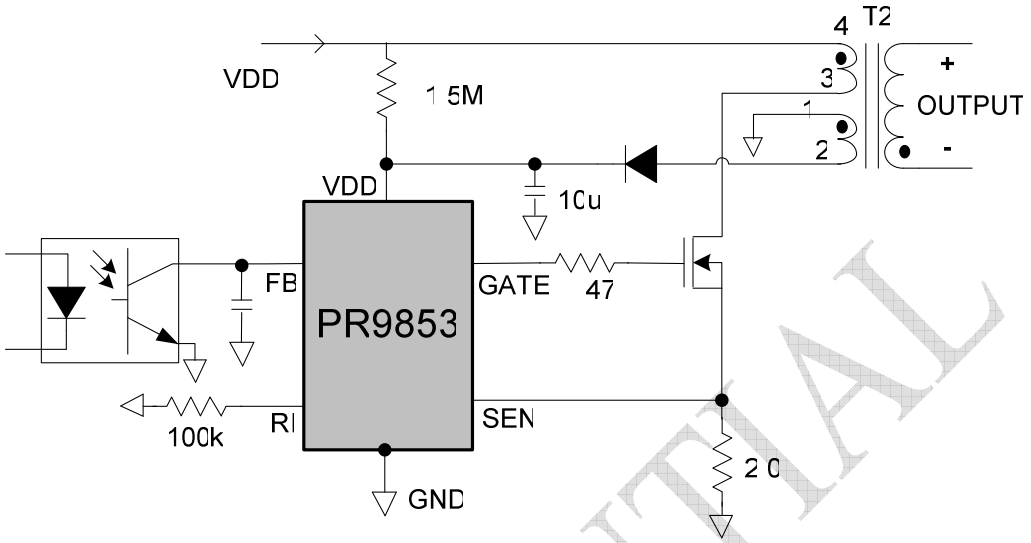
SOP8 / DIP8

PIN	Name	Description
1	GATE	Totem output, to drive the gate of external power MOSFET.
2	VDD	Supply voltage pin.
3	NC	
4	SEN	Current sense pin, a resistor connects, to sense the MOSFET current.
5	RI	This pin is to program the switching frequency. By connecting a resistor to ground to set the switching frequency.
6	NC	
7	FB	Voltage feedback pin. Output current of this pin could controls the PWM duty cycle、OLP and SCP.
8	GND	Ground Pin

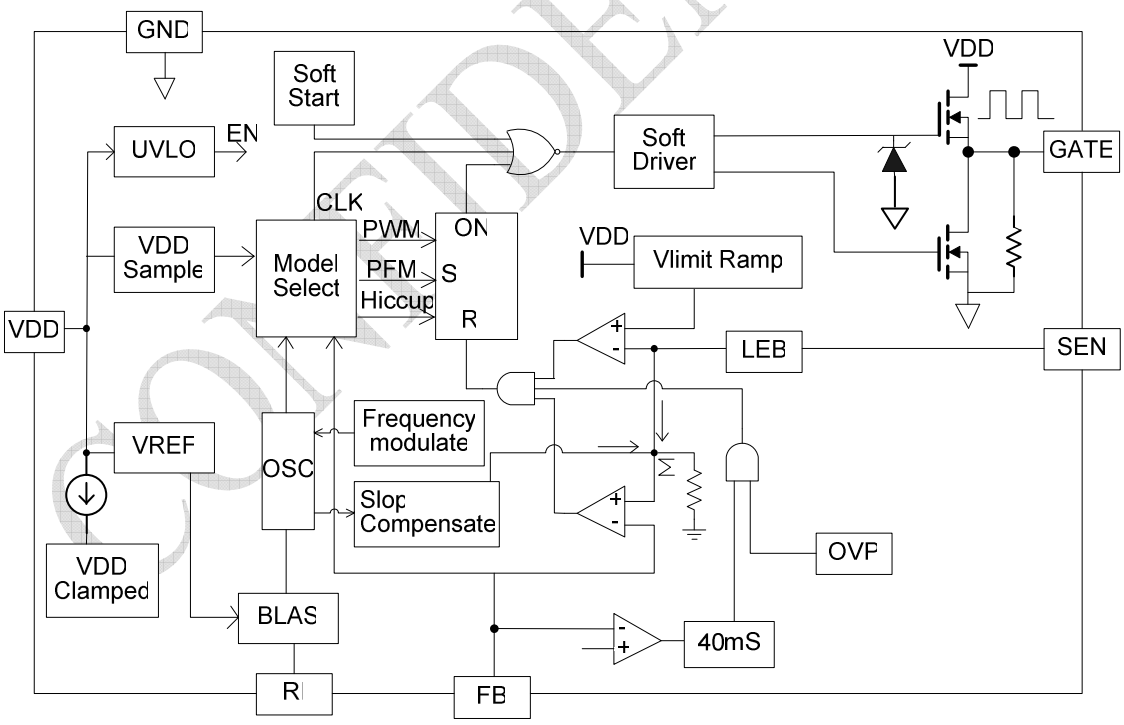
SOT23-6

PIN	Name	Description
1	GND	Ground Pin
2	FB	Voltage feedback pin. Output current of this pin could controls the PWM duty cycle、OLP and SCP.
3	RI	This pin is to program the switching frequency. By connecting a resistor to ground to set the switching frequency.
4	SEN	Current sense pin, a resistor connects, to sense the MOSFET current.
5	VDD	Supply voltage pin.
6	GATE	Totem output, to drive the gate of external power MOSFET.

Typical Application



Block Diagram



Simplified Internal Circuit Architecture

Absolute Maximum Ratings

Symbol	Parameter		Rating	Unit
V_{DD}	VDD DC Supply voltage		30	V
I_{OVP}	VDD Clamp maximal enter current		20	mA
V_{FB}	Input Voltage to FB Pin		-0.3 to 6V	V
V_{SEN}	Input Voltage to SEN Pin		-0.3 to 6V	V
V_{RI}	Input Voltage to RI Pin		-0.3 to 6V	V
$R_{\theta JA}$	Package Dissipation SOT-23-6		200	℃/W
	Package Dissipation DIP8		60	℃/W
	Package Dissipation SOP8		120	℃/W
	ESD Capability, HBM Model		2500	V
	ESD Capability, Machine Model		250	V
T_L	Lead Temperature (Soldering)	SOT-23-6L (20S)	220	℃
		DIP-8 (10S)	260	℃
		SOP-8 (10S)	230	℃
T_{STG}	Storage Temperature Range		-55 to + 150	℃
T_J	Operating Junction Temperature Range		-20 to + 150	℃

Electrical Characteristics

(Ta=25°C unless otherwise noted, V_{DD} = 16V)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage (V_{DD} Pin)						
I_{ST}	Startup Current			3.0	20.0	μA
I_{SS}	Operating Current	V_{FB}=0V		3.0	6	mA
		V_{FB}=3V		1.2	4	mA
		V_{FB}=Open		0.8	3.5	mA
VDD_{ON}	Turn-on Threshold Voltage		13.0	14.0	15.0	V
VDD_{OFF}	Turn-off Threshold Voltage		7.8	8.8	9.8	V
VDD_{CLAMP}	VDD Clamp Voltage	I_{VDD}=10mA	31		36	V
VDD_{AIS}	Anti Intermission Surge VDD Voltage			9.4		V
Voltage Feedback (FB Pin)						
I_{FB}	Short Circuit Current	V_{FB}=0V		0.65		mA
V_{FB}	Open Loop Voltage	V_{FB}=Open		4.8		V
I_{FB_0D}	Zero Duty Cycle FB current			0.59		mA
V_{PFM}	Enter PFM Threshold V_{FB}			1.80		V
V_{hiccup}	Enter hiccup mode Threshold V_{FB}			1.2		V
$V_{OLP\&SCP}$	Enter OLP&SCP FB voltage			3.7		V
$T_{OLP\&SCP}$	OLP&SCP min. delay Time	RI=100K	33	40	50	mS
Current Sensing (SEN Pin)						
V_{TH_L}	SEN Maximum Voltage Level （Dmin=0%）	RI=100K, FB=3.3V		0.80		V
V_{TH_H}	SEN Maximum Voltage Level(Dmax=78%)	RI=100K, FB=3.3V		1.05		V
T_{PD}	Delay to Output	FB=3.3V		75		ns
R_{CS}	Input Impedance			40		KΩ
T_{LEB}	Leading edge blanking time (LEB)	RI=100K		300		nS

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Oscillator (RI Pin)						
F_{OSC}	Normal Frequency	RI=100Kohm	60	65	70	KHz
F_{PFM}	PFM Frequency	RI=100Kohm		22		KHZ
DC_{MAX_W}	Maximum Duty Cycle PWM	RI=100Kohm		78		%
DC_{MAX_F}	Maximum Duty Cycle PFM	RI=100Kohm		78		%
ΔF_{TEMP}	Frequency Temp. Stability	-30-100℃		5		%
F_{swing}	Frequency swing	RI=100Kohm	-4		4	%
GATE Drive Output (GATE Pin)						
V_{OL}	Output Low Level	V_{DD}=16V, I_O=20mA			0.8	V
V_{OH}	Output High Level	V_{DD}=16V, I_O=20mA	10			V
T_R	Rising Time	C_L=1000pF		110		ns
T_F	Falling Time	C_L=1000pF		60		ns
VG_{CLAMP}	Output Clamp Voltage	VDD=20V		18.0		V

Operation Description

Current Mode

When the voltage of the sense resistor reaches the internal setting value V_{TH}, the register resets and the power MOSFET cuts off. So, to detect and modulate the peak current cycle-by-cycle could control the output power. The feedback current has a good linear modulation rate. It can increase the dynamic response of input or output, and avoid the pole brought by inductance of output filter ,thus the system descends from two-pole to one-pole. So it widens the frequency range and optimizes the overload protection and short circuit protection.

Startup Current and Under Voltage Lockout

The startup current of PR9853 is set to be very low so that a large value startup resistor can be used to minimize the power loss. For AC/DC Adapter application, a 2 MΩ and 1/8 W startup resistor and a 10uF/25V VDD hold capacitor could be used.

The turn-on and turn-off threshold of the PR9853 is designed to be 14V and 8.8V. During startup, the hold-up capacitor must be charged to 14.0V through the startup resistor. The hysteresis is to prevent the shutdown from the voltage drop during startup.

Internal Bias and OSC Operation

A resistor connected between RI pin and GND pin sets that the internal constant current source charge or discharge to the internal fixed capacitor. The charge time and discharge time decides the internal clock frequency. Increasing the resistance will reduce the input current and the switching frequency. The relationship between RI and PWM switching frequency follows the below equation within the RI allowed range.

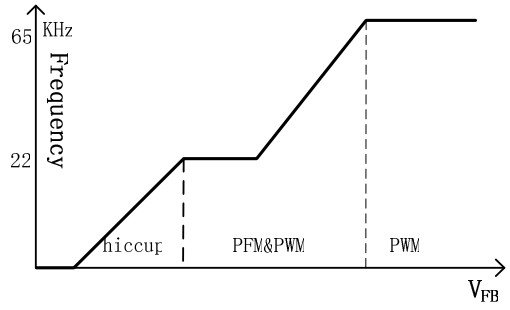
$$F_{OSC} = \frac{6500}{RI(K\Omega)}(kHz)$$

For example, a 100kΩ resistor RI could generate 20uA constant current and 65kHz PWM switching frequency. The suggested operating frequency range of PR9853 is from 50 KHz to 150 KHz.

Green Power Operation

The dissipation of switching mode power supply is highly concerned in zero load or light load condition. Different topologies have been applied in different chips, however, the basic operation theory of all these solutions tend to reduce the switching frequency under light-load or no-load condition.

The green power function of PR9853 adapts PWM、PFM and hiccup mode combining modulation. When RI resistor is 100kΩ, the PWM frequency is 65KHz at heavy load operation. T PR9853 control output voltage through modifying the pulse width. The voltage of FB pin decrease when the load is in light/medium condition, the switching mode controller enters PFM when the feedback voltage is below 1.8V. The operating frequency of oscillator descends gradually. When the feedback voltage is 1.2V, the frequency decreases to be 22kHz, and eliminates the audio noise.



PR9853 Green-Power Function

To decrease the standby dissipation, PR9853 enters the hiccup mode. If the feedback voltage is below 1.2V and active, MOSFET would have been cut off the until VDD voltage drops below preset level. Otherwise the MOSFET remains off state so that obtain minimized power dissipation.

Internal Synchronized Slop Compensation

Although there are many advantages in the current mode control than the conventional voltage mode control, there are still several drawbacks for peak-sensing current-mode converter, especially the instability of open loop when duty-cycle is higher than 50%. To solve this problem, PR9853 introduces an internal slope compensation, adding voltage ramp to the current sense input voltage for PWM generation. It improves the stability of close loop greatly at CCM, prevents the sub-harmonic oscillation, and thus reduces the output ripple voltage.

Current Sensing & Dynamic peak limiting

The current flowing by the power MOSFET is detected from SEN voltage V_{SEN} cycle-by-cycle, which would be compared to the internal reference voltage, and thereby controls the reverse of the internal register, limits the primary peak current I_{MAX} of the transformer. The transformer energy $E = \frac{1}{2} \times L \times I_{MAX}^{\ 2}$. So adjusting the R_{SEN} can set the maximal output power. The current flowing by the power MOSFET has an extra value ($\Delta I = \frac{V_{IN}}{L_P} \times T_D$) due to the system delay that is from detecting the current through the SEN pin to power MOSFET off in PR9853 (Among these, V_{IN} is the primary winding voltage of the transformer and L_P is the primary wind inductance). V_{IN} ranges from 85Vac to 264Vac. To guarantee the output power is a constant for universal input AC voltage, a dynamic peak limit circuit is designed to compensate the system delay time.

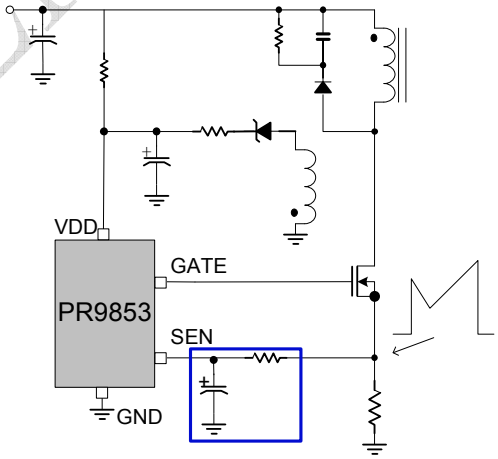
OLP&SCP

To protect the circuit from being damaged due to over load or short , a smart OLP&SCP function is added in PR9853. When short or over load occurs in the output end, the feedback cycle would enhance the voltage of FB pin. When the voltage is over 3.7V, the internal detective circuit would send a signal to shut down the GATE and pull down the VDD voltage, then the circuit is restart. To avoid the wrong operation when circuit starts, the delay time is set to be 40ms with the RI resistance is 100Kohm. The relationship between RI and $T_{OLP\&SCP}$ follows the below equation.

$$\frac{RI \times 2}{6 \times 10^3}(mS) < T_{OLP\&SCP} < \frac{RI \times 3}{6 \times 10^3}(mS)$$

Leading-edge Blanking (LEB)

Each time the power MOSFET is switched on, a turn-on spike will inevitably occur at the SEN pin, which would disturb the internal signal from the sampling of the R_{SEN}. There is a 300ns leading edge blanking time built in to avoid the effect of the turn-on spike, and the power MOSFET cannot be switched off during this moment, thus the external RC filter on SEN input is no longer required.



VDD over Clamp

There is a 34V VDD over-voltage clamp circuit in PR9853 to improve the credibility and extend the life of the chip. When the VDD voltage is over 34V, the GATE pin will be shutdown immediately and the VDD voltage descend rapidly.

GATE Driver

The output of PR9853 designs a totem pole to drive a external power MOSFET. The

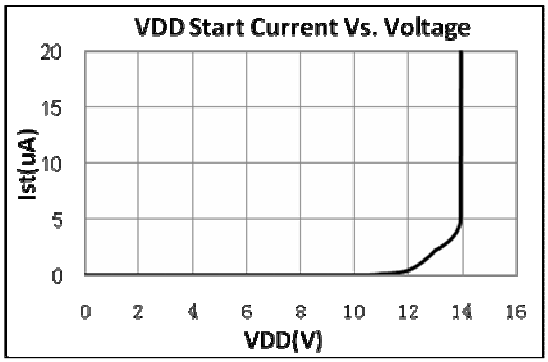
dead time is introduced to minimize the transfixion current during the output operating. The soft clamp technology is introduced to protect the external power MOSFET from breaking down .

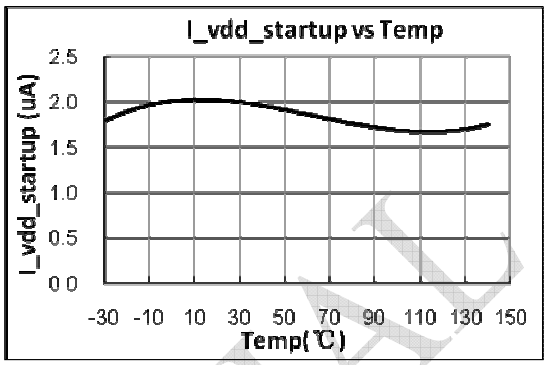
Low EMI technique

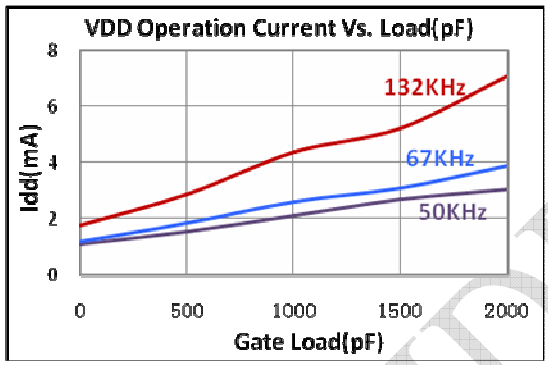
Low EMI technique is introduced in PR9853. As following figure shows, the internal oscillation frequency is modulated by itself. A whole surge cycle includes 128 pulses and the swing ranges from -4% to +4%. Thus, the function could minimize the electromagnetic interfere of the power supply module.

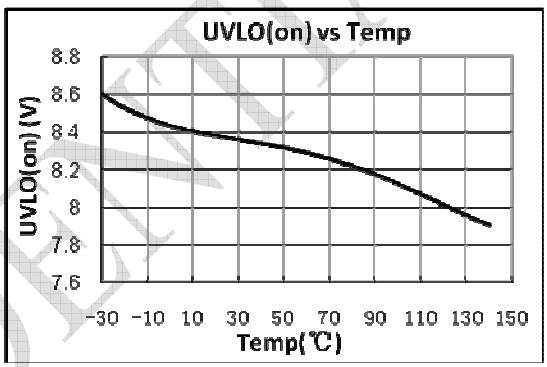
Characterization Plots

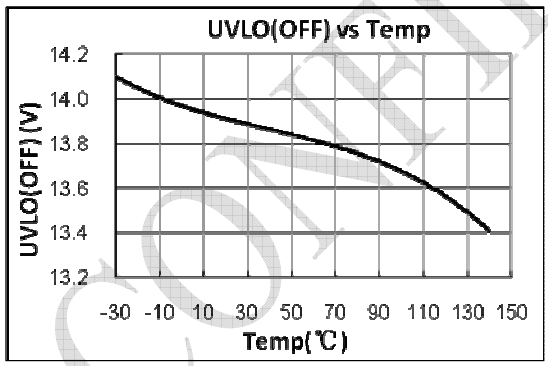
VDD=16V,RI=100Kohm,T_A=25℃ condition applies if not otherwise noted.

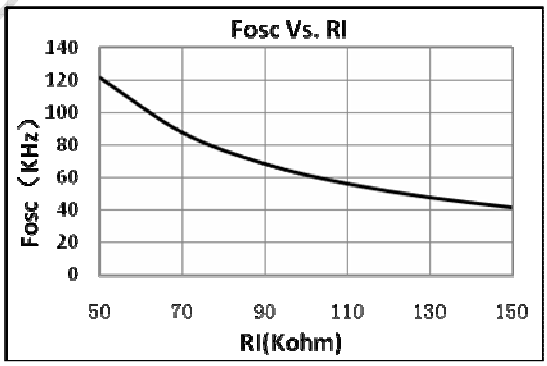


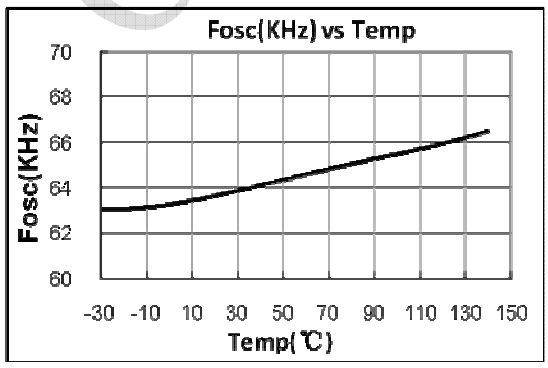


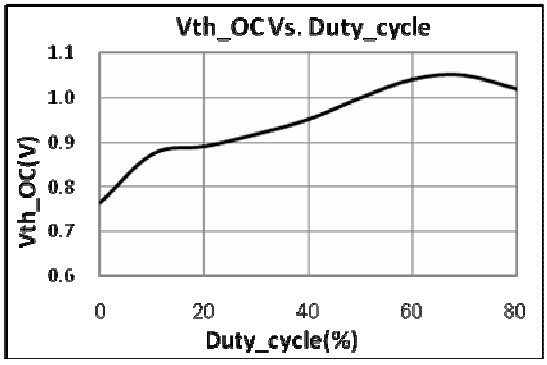






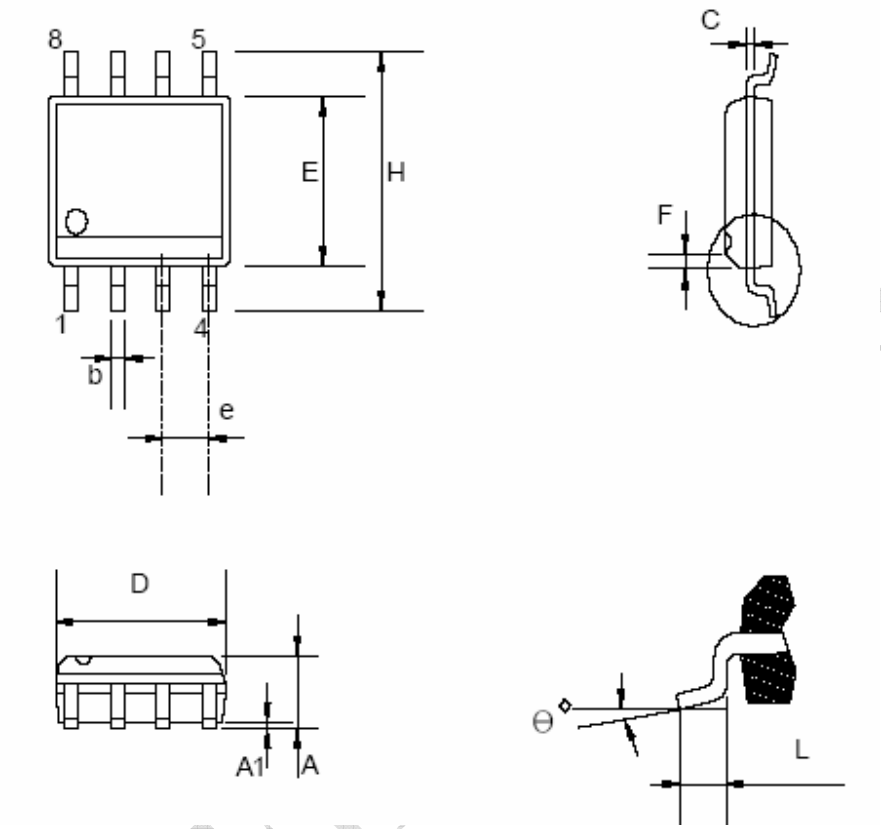






Package Dimensions

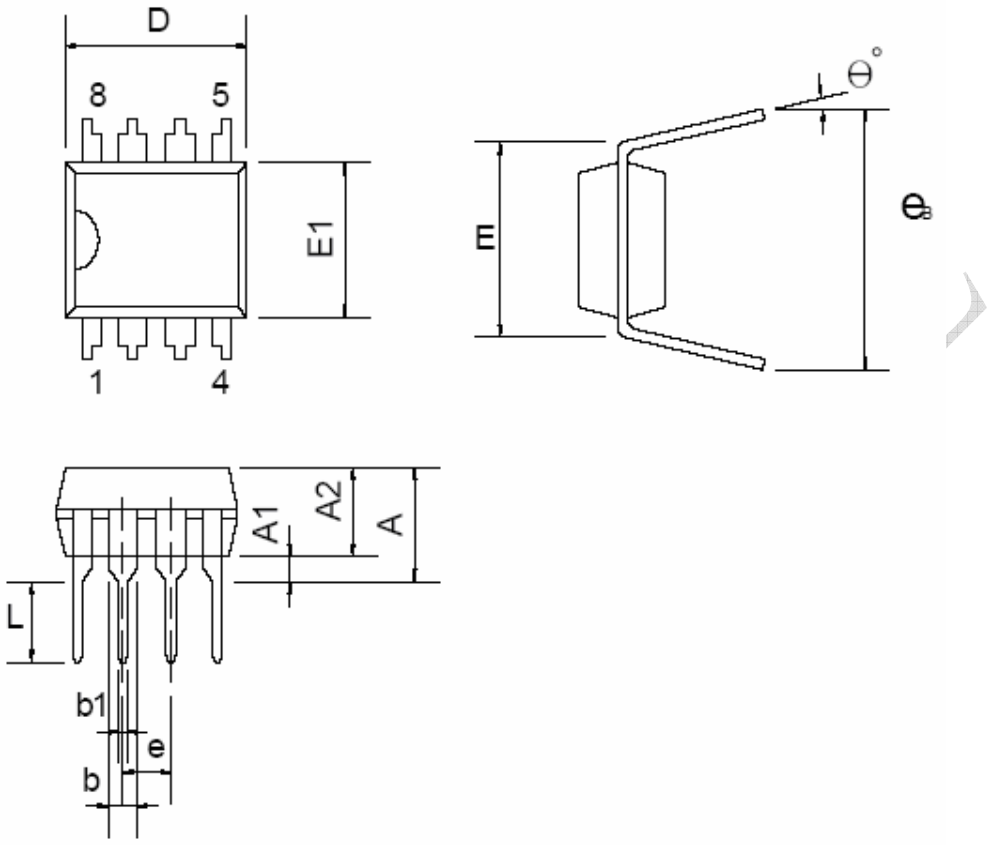
SOP-8L



Dimensions

Symbol	Millimeter			Inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.346		1.752	0.053		0.069
A1	0.101		0.254	0.004		0.010
b		0.406			0.016	
c		0.203			0.008	
D	4.648		4.978	0.183		0.196
E	3.810		3.987	0.150		0.157
e	1.016	1.270	1.524	0.040	0.050	0.060
F		0.381X45°			0.015X45°	
H	5.791		6.197	0.228		0.244
L	0.406		1.270	0.016		0.050
θ°	0°		8°	0°		8°

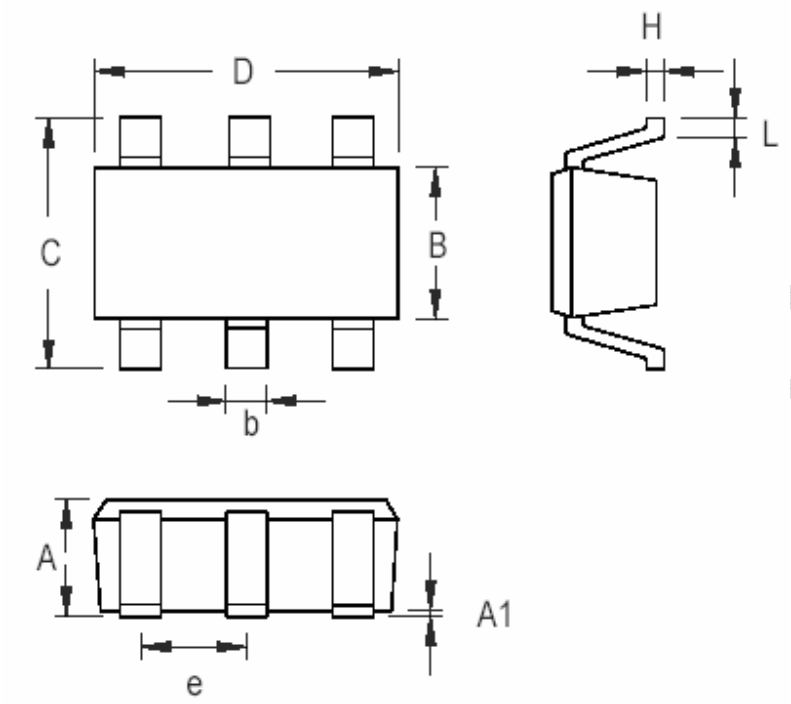
DIP-8L



Dimensions

Symbol	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			5.334			0.210
A1	0.381			0.015		
A2	3.175	3.302	3.429	0.125	0.130	0.135
b		1.524			0.060	
b1		0.457			0.018	
D	9.017	9.271	10.160	0.355	0.365	0.400
E		7.620			0.300	
E1	6.223	6.350	6.477	0.245	0.250	0.255
e		2.540			0.100	
L	2.921	3.302	3.810	0.115	0.130	0.150
eB	8.509	9.017	9.525	0.335	0.355	0.375
θ°	0°	7°	15°	0°	7°	15°

SOT-23-6L



Dimensions

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	1.000	0.028	0.039
A1	0.000	0.100	0.000	0.004
B	1.397	1.803	0.055	0.071
b	0.300	0.559	0.012	0.022
C	2.591	3.000	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024