LC2312

REV1.0-Revised DEC 2007

20V,2A Step Down Converter

DESCRIPTION

The LC2312 is a monolithic step-down DC to DC converter. The LC2312 works from a 4.75V to 20V input voltage range, and offers up to 2A of continuous output current in a compact SOIC 8 package.

The LC2312 operates in voltage mode. Lower quiescent current and wider operating input-voltage range are implemented by Belling's high-voltage BiCMOS-based technology. Alternative PWM/PFM control technique significantly improves the efficiency for both light load and heavy load.

The LC2312 also integrates soft-start, over load protection and under voltage lockout protection etc., which minimized external components and converter size.

FEATURES

- Built-in 90mΩ P-Channel MOSFET
- Wide 4.75~20V Input Voltage Range
- Adaptive PWM/PFM Operation Mode
- Up to 95% Efficiency
- Built-in Soft-Start Function
- Fault Protection (Auto Recovery Mode)
- <1µA Shutdown Current and 350µA Quiescent Current
- Low Temperature-Drift Coefficient of Bandgap Voltage
- Demo Board Available

APPLICATIONS

- Power Source for Battery-Powered Equipments.
- Distribute DC to DC Power Supply
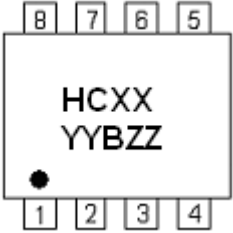- Pre-Regulator for Linear Regulator

TYPICAL APPLICATION
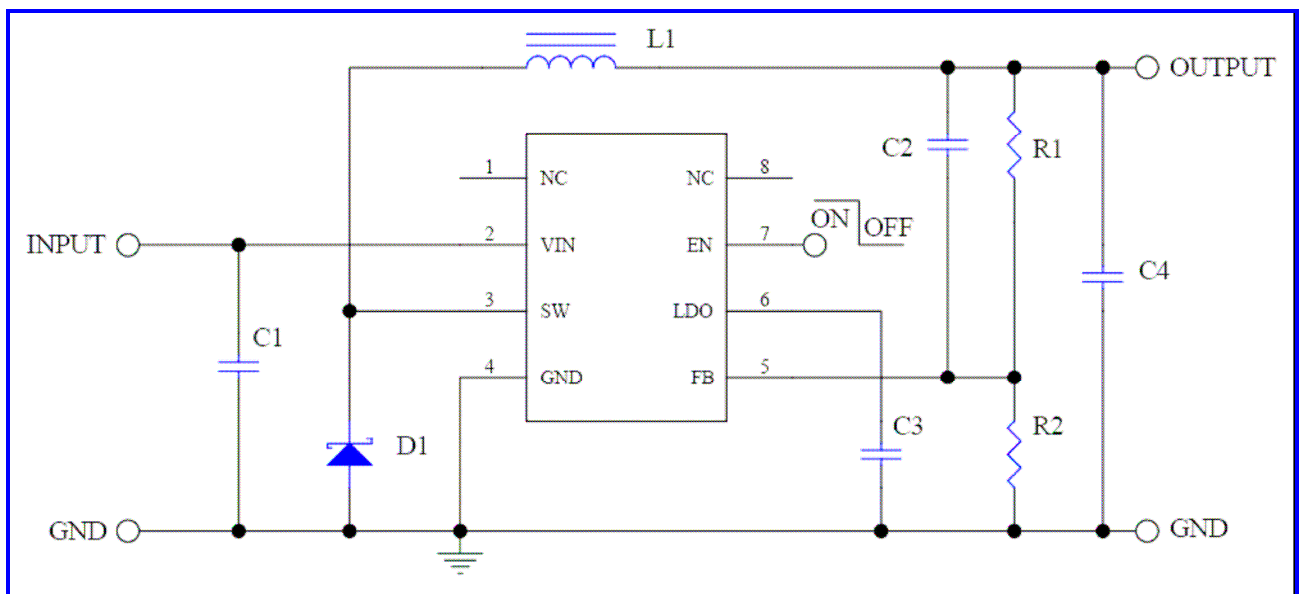
ORDERING INFORMATION

LC2312 ①②③

Code	Description
①	Temperature&Rohs: C:-40~85°C ,Pb Free Rohs Std.
②	Package type: D8:SOP8
③	Packing type: TR:Tape&Reel (Standard)

PIN CONFIGURATION

Product Classification	LC2312CD8TR
Marking	
HCXX YYBZZ	HC:Product Code
	XX:Output Voltage
	YY:LOT NO.
	B:FAB Code
	ZZ:Data Code

HCXX YYBZZ (pins 8 7 6 5 top, 1 2 3 4 bottom)

PIN DESCRIPTION

Pin No.	Name	Function Description
1	NC	Not connected
2	VIN	Power supply input pin.
3	SW	Switching node. PWM output connection to inductor.
4	GND	Ground
5	FB	Feedback pin. It is used to program the output voltage by adjusting the ratio of the external resistor divider from output to ground. A compensation capacitor paralleling with the upper resistor is recommended to improve system dynamic response.
6	LDO	LDO output pin. A 0.1uF capacitor is recommended in order to filter the switching noise.
7	EN	Chip enable pin. High level activates the chip. Connect the pin to Vin if not used, do not leave this pin floating.
8	NC	Not connected

ABSOLUTE MAXIMUM RATING

Supply voltage	–0.3V to 25V
Switch Node	– 0.3V to Vin + 0.3V
Chip Enabe	–0.3V to Vin+0.3V
Feedback input	–0.3V to 6V
LDO Output	–0.3V to 6V
PROG Pin Current	600µA
Maximum Junction Temperature	125℃
Operating Ambient Temperature Range	–40℃ to 85℃
Storage Temperature Range	–40℃ to 150℃
Lead Temperature (Soldering, 10 sec)	260℃
Thermal resistance :Θ$_{JA}$	105℃/W

Note: Exceed these limits to damage to the device.
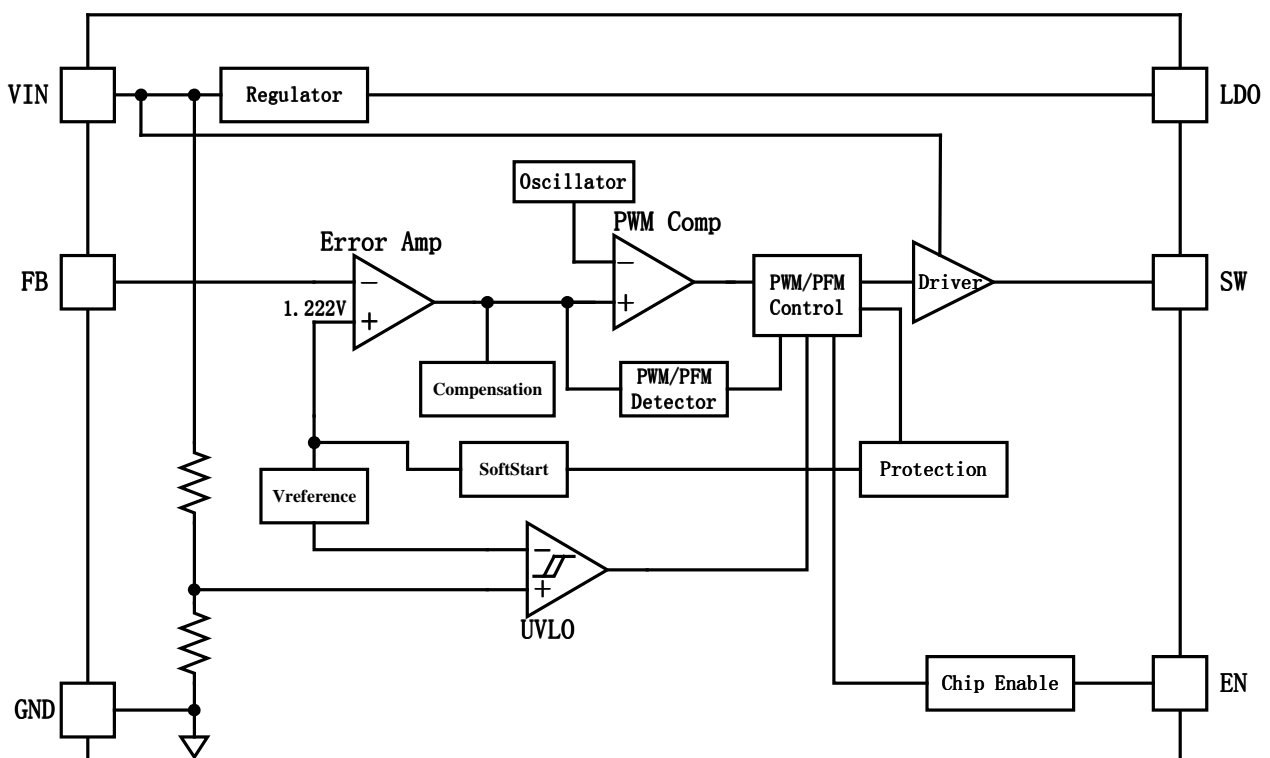Note: Exposure to absolute maximum rating conditions may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

ITEMS	MIN	NOM	MAX	UNIT
Input Voltage Range	4.75		20	V
Operating Temperature	-25		85	℃

Note: Measured on approximately 1" square of 1 oz copper.
Note: The device is not guaranteed to function outside its operating rating
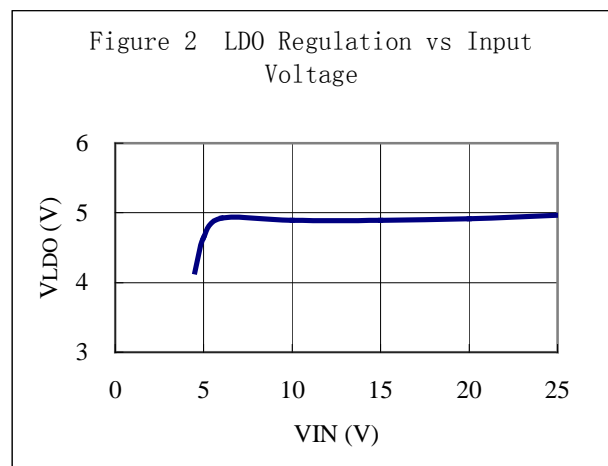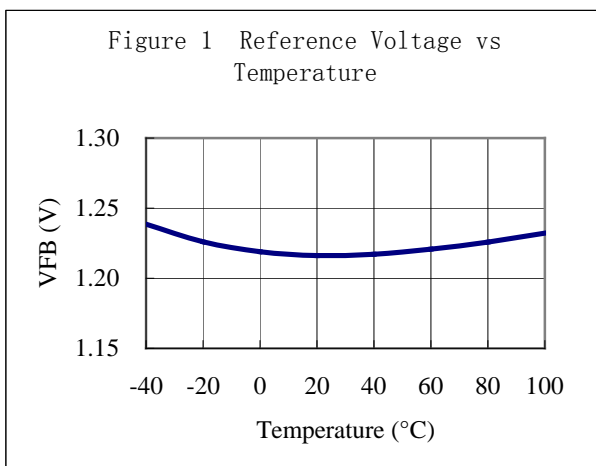
BLOCK DIGRAM

ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, VIN=12V, CLDO=0.1uF, Ta=25°C)

Symbols	Items	Conditions	Min.	Typ.	Max.	Units
VIN	Operation Input Voltage		4.75		20	V
Rds_on	Static P-Channel MOSFET On State Resistance	VCE=12V; IFB=0V		90*		mΩ
VFB	Feedback Voltage	VCE=12V; Iout=-100mA	1.198	1.222	1.246	V
Fosc	Oscillator Frequency	VCE=12V; Iout=-100mA	500	550	600	KHz
IDD	Quiescent Current (Operating)	VCE =12V; VFB =1.4V			350	μ A
Isd	Shutdown Current	VCE =0V			1	μ A
VCEH	CE "H" Threshold Voltage		1.5			V
VCEL	CE "L" Threshold Voltage				0.7	V
ICEH	CE "H" Input Current				0.3	μ A
ICEL	CE "L" Input Current		-0.3			μ A
V_{UVLO1}	UVLO Threshold Voltage	VIN=VCE=5 to 0V	1.5	1.9	2.3	V
V_{UVLO2}	UVLO Release Voltage	VIN=VCE=0 to 5V	1.6	2.0	2.4	V
Maxdty	Max. Duty Cycle		100			%
Tstart	Soft-Start Time	VCE = 0 to12V	5	10	15	ms
Tpro	Debounce Time for Fault Protection	VCE = 12V; VFB=0	500	700	1000	μ s
LDO	LDO Output Voltage	VIN>6V; VCE=VIN		5		V

*Ensured by design. Not 100% production tested.

TYPICAL PERFORMANCE CHARACTERISTICS

VCC=5V, Ta=25℃, unless otherwise noted .

Figure 1 Reference Voltage vs Temperature

Figure 2 LDO Regulation vs Input Voltage

Ibat=40mA

DETAILED DESCRIPTION

The LC2312 consists of a P-channel MOSFET, an oscillator, a PWM control circuit, a voltage reference unit, an error amplifier, a soft-start circuit, a fault protection circuit, a PWM/PFM alternative circuit, a chip enable circuit, and an input voltage detecting circuit.

PWM OPERATION

In normal operation, adjusting the width of pulses regulates the system output voltage. It is implemented by regulating the FB voltage at 1.222V. The LC2312's high-gain differential error amplifier and low temperature-drift coefficient reference guarantee the accuracy of output voltage with different input voltage and load conditions. In order to reduce the ripple voltage and improve the loop stability, a high bandwidth error amplifier is designed with a built-in zero. This zero, plus the ESR zero from the output electrolytic capacitor, balances the double poles of the output LC filter. Thus the step-down system is stable and external compensation network is not required. In practice, a low cost ceramic capacitor paralleling with the upper resistor on feedback resistors divider implements additional phase lead compensation function. This improves the dynamic response performance. In order to improve the efficiency, The LC2312 integrates a low on-resistance P-channel MOSFET and well designed driver circuits inside a SOIC 8 package, the power loss is limited at very low level.

PFM OPERATION

At light load, the error amplifier's output voltage becomes very low and the duty cycle becomes very small. The system switching losses dominate and conduction losses become less important. The LC2312 limits its minimum duty cycle. If the output current is low enough, the output voltage exceeds the desired value and the error amplifier output voltage decreases down to 0.6V, then the output pulses are disabled and the system output voltage decreases until the error amplifier output ramps up above the threshold of 0.6V. Thus the switching node waveform looks like a pulse-skipping mode. The number of pulses and switching losses are significantly reduced.

OSCILLATOR

The oscillator circuit provides a clock to set the converter operating frequency.

PROTECTION CIRCUIT
If the duration of maximum duty cycle is long enough, the embedded protection circuit shuts down internal power switch. Then the IC starts a soft start cycle. This procedure repeats until the cause of the protection condition is removed.

SOFT-START

A small current charges the soft-start capacitor and raises the internal soft start voltage. The reference voltage follows the soft-start voltage, and limits the speed of voltage rising on the error amplifier output, and hence reduces the speed of rising of output voltage during startup.

UVLO

If the input voltage is equal or less than UVLO threshold, the IC goes to standby mode. If the input voltage increases above the UVLO threshold with a hysteresis voltage, the IC starts another soft-start cycle and normal operation.

ENABLE (CE)

Logic low on CE puts the LC2312 in shutdown state. In shutdown mode, the output power switch, voltage reference, and other functions are shut off, the supply current is reduced to 1uA maximum.

NOTIFICATION

Be aware of the following issues while using the LC2312:

Set external components as close as possible to the IC and minimize the connection between the components and the IC. In particular, the power rails and SW connection should be short. In addition, a ceramic capacitor should be closely connected between LDO and GND pins. Make sufficient grounding and reinforce supplying.

If the difference between input and output voltage is too small, the maximum duty cycle may last long enough to trigger the maximum duty-cycle protection.

If input voltage is below 6V, the LDO output may drop below 5V, and the maximum duty cycle may be limited. The accuracy of load regulation may be limited by current capability if output voltage gets close to input voltage.

If the duty cycle in PWM mode needs to be less than the minimum duty cycle to go to PFM mode, the IC switches to PFM mode to reduce switching frequency and standby current. However, if the ratio of output voltage vs. input voltage is low enough (for example, Vin>12V and Vout=1.5V), even if the load current is large, the IC keeps in PFM mode, and the ripple of output voltage may increase.

COMPONENTS SELECTION

INDUCTOR

High inductance gives low inductor ripple current but requires larger size inductor to avoid saturation. Low ripple current reduces inductor core losses. It also reduces RMS current through inductor and switches, and hence reduces conduction loss. Usually, peak to peak current of inductor is designed to be 20% to 30% of output current

DIODE

Use a diode with low forward voltage drop and high switching speed. (Schottky type is recommended.)

Reverse voltage rating should be more than the input voltage, and current rating should be more than maximum load current.

CAPACITORS

The primary function of output capacitor is to smooth the inductor current. The actual output ripple voltage is a function of this capacitor's ESR (Equivalent Series Resistance). Normally, the ESR of this capacitor should not exceed the rated ripple voltage divided by the ripple current through the inductor.

As for input capacitor, use a capacitor with low ESR and a capacity of at least 10μF for stable operation.
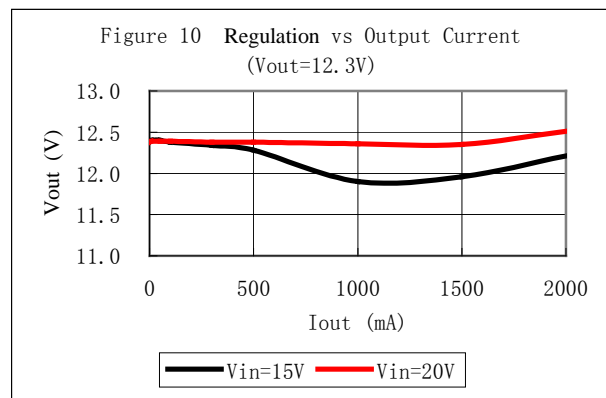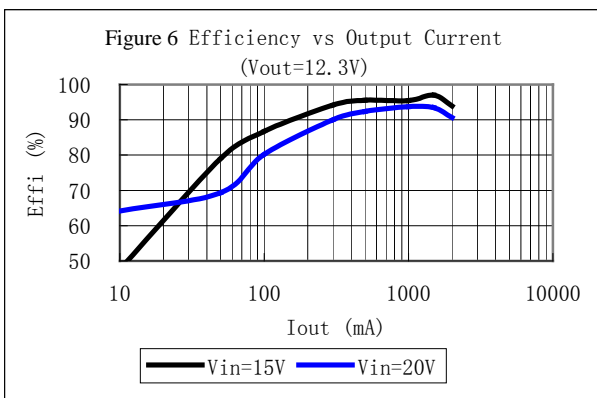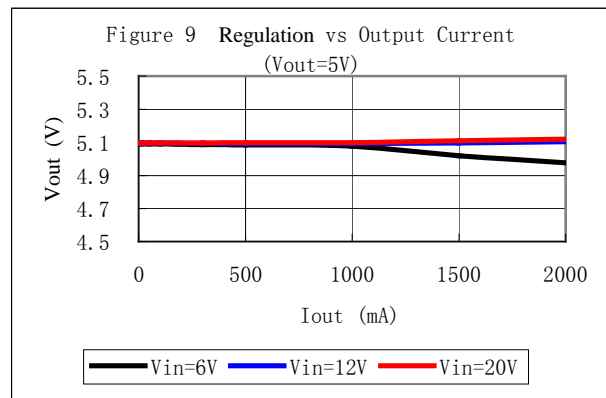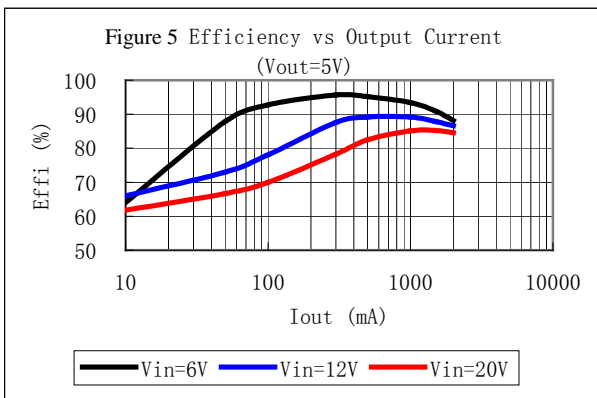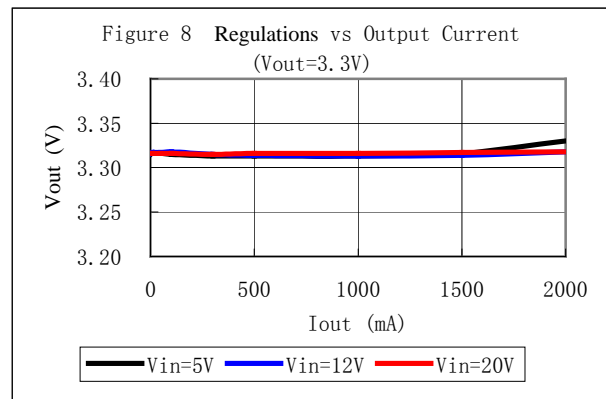
DEMO BOARD SCHEMATICS
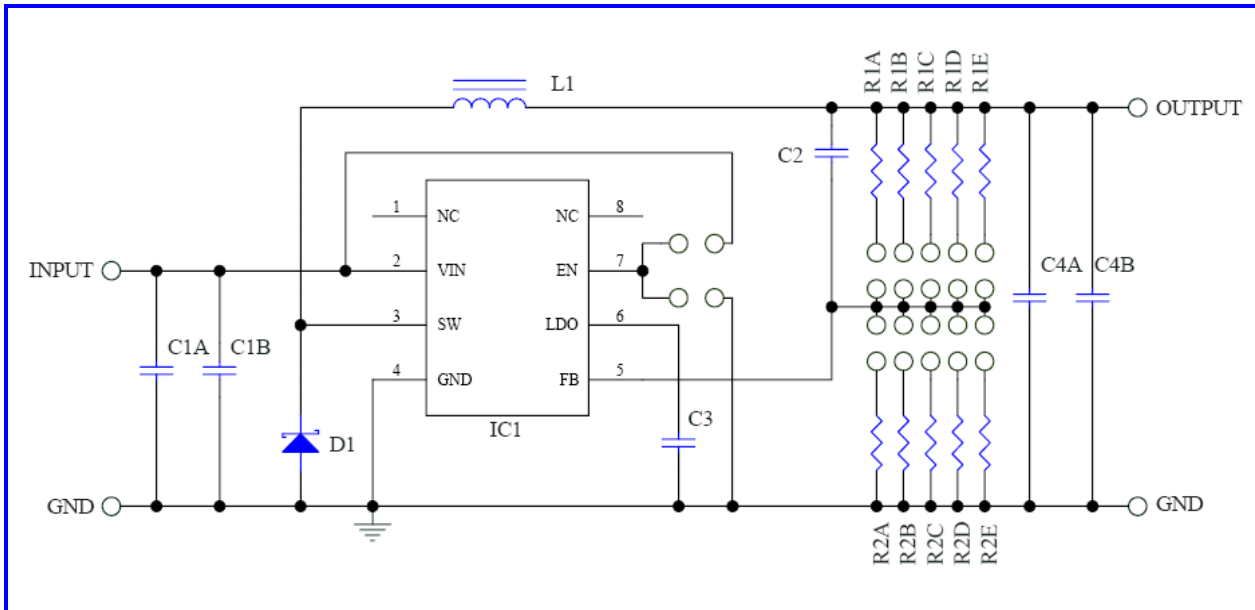
DEMO BOARD BOM

Table 1 Bill of Materials

No.	Reference	Type	Specification	Note
1	C1A	Capacitor	Tantalum Capacitor; 25V/10uF; SMD	
2	C1B	Capacitor	Open	
3	C2	Capacitor	MLCC 0.01uF; SMD 1206	
4	C3	Capacitor	MLCC 0.1uF; SMD 1206	
5	C4A	Capacitor	Tantalum 100uF; SMD 1206	
6	C4B	Capacitor	MLCC 0.1uF; SMD 1206	
7	D1	Diode	SS34; 40V, 3A; SMD	
8	L1	Inductor	22uH; 3A; SMD, Shielding	
9	IC1	IC	LC2312; SMD SOIC 8	
10	R1A~R1E	Resistor	SMD 1206; 1%	Refer to Table 2
11	R2A~R2E	Resistor	SMD 1206; 1%	Refer to Table 2

Table 2 Feedback Resistors Selection

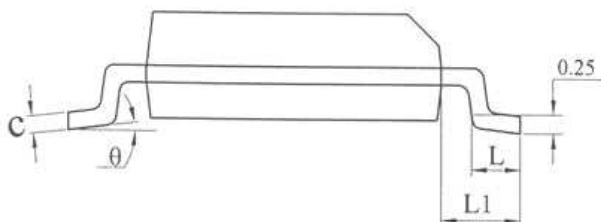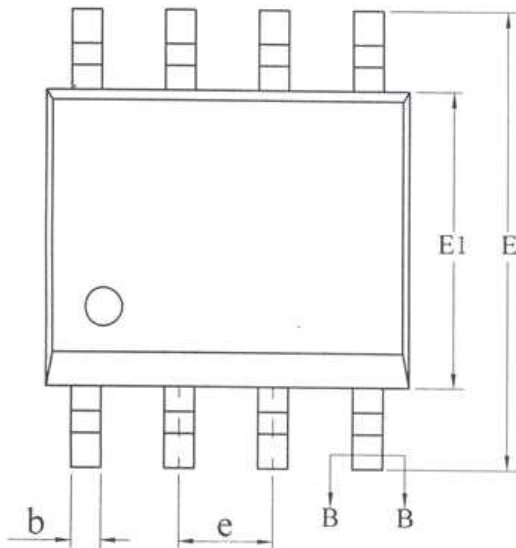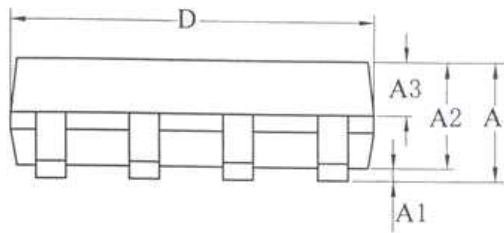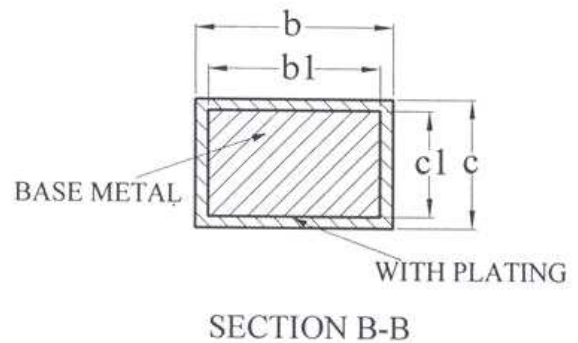| Vout	R1A	R1B	R1C	R1D	R1E	R2A	R2B	R2C	R2D	R2E
1.8V	30K					62K				
2.5V		51K					47K			
3.3V			27K					16K		
5.0V				56K					18K	
12.3V					39K					4.3K

DEMO BOARD MEASUREMENT

Figure 3 Efficiency vs Output Current (Vout=1.8V)

Figure 7 Regulation vs Output Current (Vout=1.8V)

Figure 4 Efficiency vs Output Current (Vout=3.3V)

Figure 8 Regulations vs Output Current (Vout=3.3V)

Figure 5 Efficiency vs Output Current (Vout=5V)

Figure 9 Regulation vs Output Current (Vout=5V)

Figure 6 Efficiency vs Output Current (Vout=12.3V)

Figure 10 Regulation vs Output Current (Vout=12.3V)

PACKAGE LINE

Package	SOP8	Devices per reel	2500Pcs	Unit	mm

Package specification：

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.77
A1	0.08	0.18	0.28
A2	1.20	1.40	1.60
A3	0.55	0.65	0.75
b	0.39	—	0.48
b1	0.38	0.41	0.43
c	0.21	—	0.26
c1	0.19	0.20	0.21
D	4.70	4.90	5.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
L	0.50	0.65	0.80
L1	1.05BSC		
θ	0	—	8°

BASE METAL

WITH PLATING

SECTION B-B