# 3A Synchronous Rectified Step Down Converter

## ■ General Description

The LN2430 is a monolithic synchronous high-efficiency DC/DC buck converter delivers up to 3A of output current. The device operates from an input voltage of 2.5V to 8 V and provides an output voltage from 0.8V to VIN, making the LN2430 ideal for on-board post-regulation applications. The LN2430 operate at a wide switching frequency range from 300KHz to 1.5MHz with an efficiency of up to 94%. The high operating frequency minimizes the size of external components.

Internal soft-start control circuitry reduces inrush current. Thermal-overload protections improve design reliability.

The LN2430 are available in a space-saving 8-pin SO/PP package.

## ■ Features

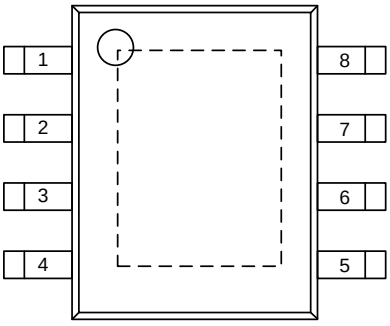
- Ceramic Input and Output Capacitors
- Efficiency Up to 94%
- Guaranteed 3A Output Current
- Operate from 2.5V to 8V Supply
- Adjustable Output from 0.8V to VIN
- Internal Soft-Start
- Thermal-Overload Protection
- ROHS Compliant

## ■ Applications

- FPGA,ASIC,DSP POWER SUPPLICES
- LCD TV
- Green Electronics/Appliances
- Notebook Computers
- Set-Top box
- Cellular Base Stations
- Networking and Telecommunications

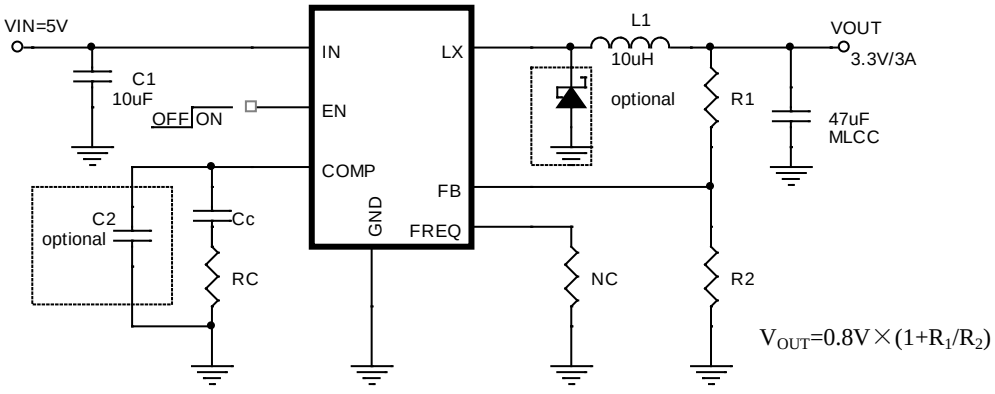
## ■ Package

- SOP-8/PP




SOP-8/PP
(Top View)

## ■ Typical Application Circuit




**NOTE:** FREQ pin is not connected :fosc=340KHz，$R_C$=1K、$C_C$=2.2nF ;If choose C2,C2=100PF

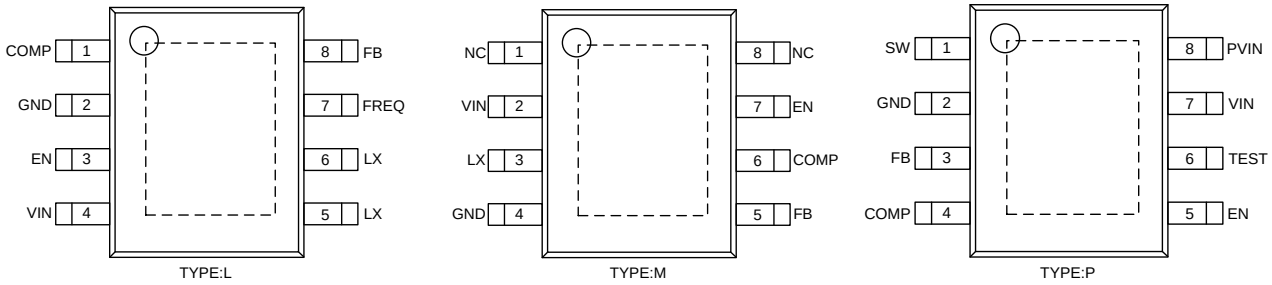
FREQ pin connect to a resistor=27KΩ :fosc=1.5MHz,$R_C$=10K、$C_C$=470PF;If choose C2,C2=22PF

## ■ Ordering Rule

**LN2430 AB C D E XXXX**

| Designator | Represents | Symbol | Description |
|---|---|---|---|
| AB | Output Voltage | AD | Adjustable |
| | | 12 | 1.2V |
| | | 18 | 1.8V |
| | | 33 | 3.3V |
| C | Frequency | F | Adjustable Frequency |
| | | K | 340k |
| | | M | 1.5MHZ |
| D | Package | S | SOP-8/PP |
| E | Pin assignment | L | |
| | | M | |
| | | P | |
| XXXX | Lot Number | Integer | |

## ■ Pin Configuration

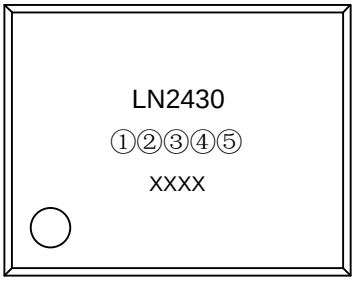



| | L | M | P |
|---|---|---|---|
| Pin1 | COMP | NC | SW |
| Pin2 | GND | VIN | GND |
| Pin3 | EN | LX | FB |
| Pin4 | VIN | GND | COMP |
| Pin5 | LX | FB | EN |
| Pin6 | LX | COMP | TEST |
| Pin7 | FREQ | EN | VIN |
| Pin8 | FB | NC | PVIN |

## ■ Functional Pin Description

| Name | Function |
|---|---|
| COMP | Loop Compensation Pin. Add R/C network to stabilize the loop. |
| GND | Ground Pin. |
| EN | Chip Enable pin. Active high. Internal pull high for auto start up. |
| IN | Input Power Supply Pin. |
| LX | Switch Pin. |
| FREQ | Frequency Adjust Pin. Add a resistor from this pin to ground determines the switching frequency. |
| FB | Feedback Pin. VOUT=0.8V×(1+R1/R2). |
| NC | Not connect. |

## ■ Marking Rule




SOP-8/PP

**①② Represents the output voltage**

| Designator | Symbol | Description |
|---|---|---|
| ① ② | AD | Adjustable |
| | 12 | 1.2V |
| | 18 | 1.8V |
| | 33 | 3.3V |

**③ Represents the frequency**

| Designator | Description |
|---|---|
| F | Adjustable |
| K | 340K |
| M | 1.5MHz |

**④ Represents the package type**

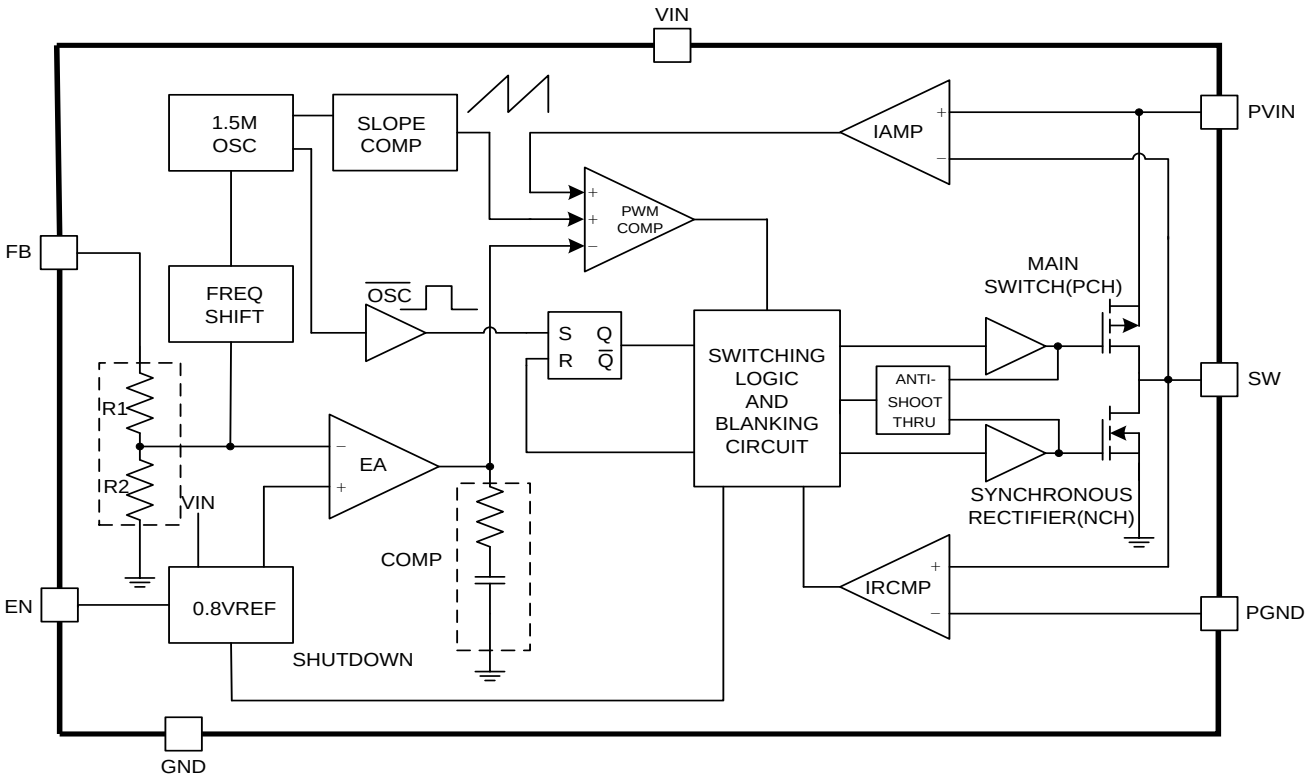
| Designator | Description |
|---|---|
| M | SOP-8/PP |

**⑤ Represents the pin assignment**

| 标号 | 代表 |
|---|---|
| L | LType |
| M | M Type |
| P | P Type |

**XXXX Represents the lot number**

## ■ Function Block Diagram



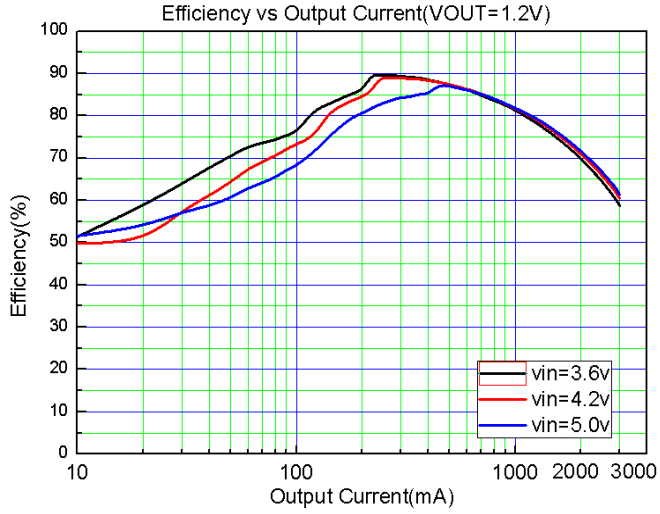

## ■ Absolute Maximum Ratings

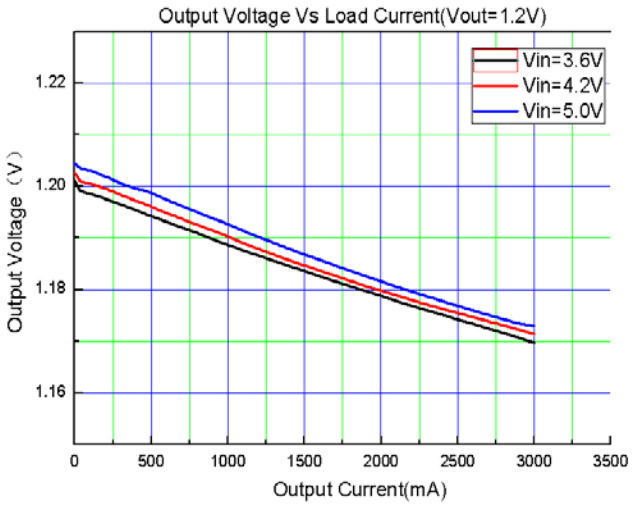
| Parameter | Symbol | Maximum Rating | | Unit |
|---|---|---|---|---|
| Input Voltage | $V_{IN}$ | $V_{SS}$-0.3～$V_{SS}$+8 | | V |
| | $V_{LX}$ | Vss-0.3~$V_{IN}$+0.7 | | |
| | $V_{EN.FREQ,FB,COMP}$ | $V_{SS}$-0.3～$V_{IN}$+0.3 | | |
| Power Dissipation | $P_D$ | SOP8/PP | 1400 | mW |
| Operating Ambient Temperature | Topr | -40～+85 | | °C |
| Storage Temperature | Tstg | -40～+125 | | |
| Reflow Temperature(soldeing,10s) | Trefl | 250 | | |

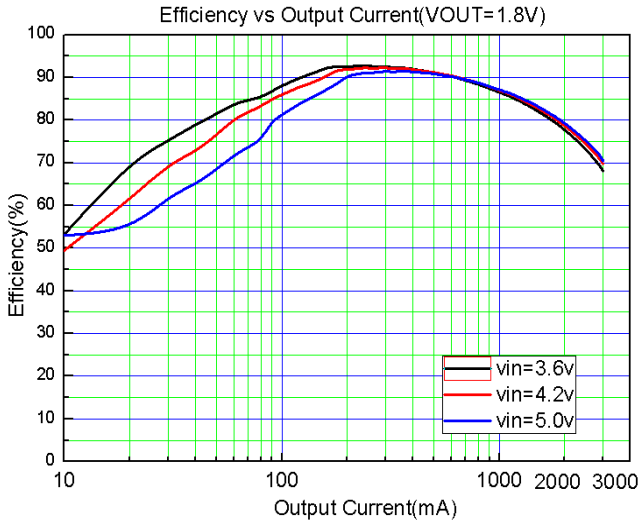
## ■ Electrical Characteristics

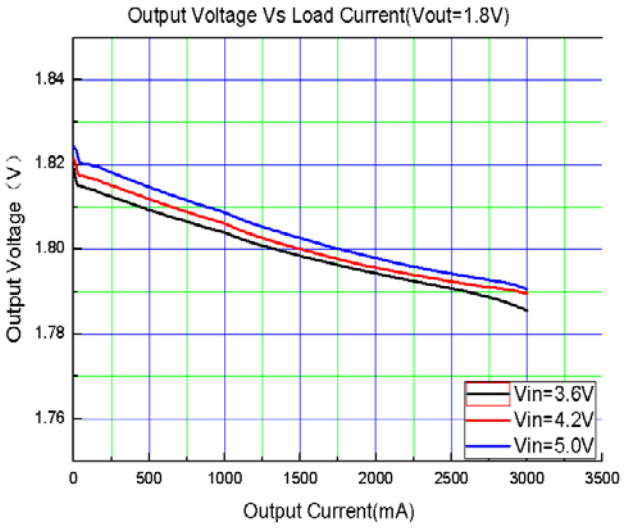
| Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| Input Voltage Range | | 3 | | 8 | V |
| Input UVLO | | 2 | 2.3 | 2.6 | V |
| Quiescent Current | $V_{FB}$ = 1V (no switching) | — | 460 | 550 | μA |
| | $V_{EN}$ = 0V | — | 0 | +1 | μA |
| FB Pin Voltage | | 0.784 | 0.8 | 0.816 | V |
| FB Pin Current | | -50 | 0 | +50 | nA |
| Load Regulation | 0A < IOUT < 3A | | 0.3 | | % |
| Line Regulation | 3.3V < VIN < 5V | | 0.17 | | % |
| EN Pin Voltage High | | 0.9 | | | V |
| EN Pin Voltage Low | | | | 0.75 | V |
| EN Pin Leakage Current | VEN=3V | | 0.1 | 1 | μA |
| Switching Frequency | RFREQ=NC | 300 | 340 | 380 | KHz |
| | RFREQ=120kΩ | 540 | 600 | 660 | |
| | RFREQ=47kΩ | 900 | 1000 | 1100 | |
| | RFREQ=27kΩ | 1275 | 1500 | 1725 | |
| Short-Circuit Frequency | | | 1/4 | | FSW |
| Current Limit | | 3.5 | 4.0 | 4.5 | A |
| Maximum Duty | | | | 100 | % |
| Minimum Duty | | 0 | | | % |
| Minimum On Time | | | 180 | | nS |
| Error Amp Transconductance | | 300 | 400 | 500 | μmho |
| P-Switch Leakage Current | VLX = 0V, VEN = 0V | | 0.1 | 20 | uA |
| P-Switch RDS(ON) | ILX = 150mA | | 130 | 200 | mΩ |
| N-Switch RDS(ON) | ILX = 150mA | | 110 | 180 | mΩ |
| Thermal Shutdown Protection | Rising | | 160 | | ℃ |
| | Hysteresis | | -20 | | ℃ |

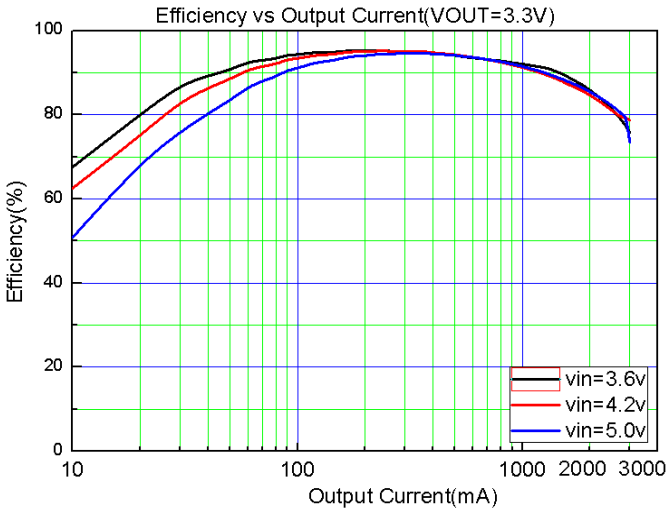
## ■ Typical Performance Characteristic

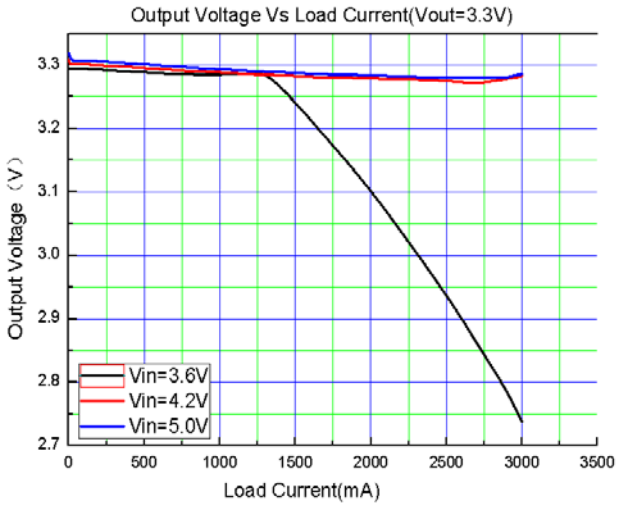


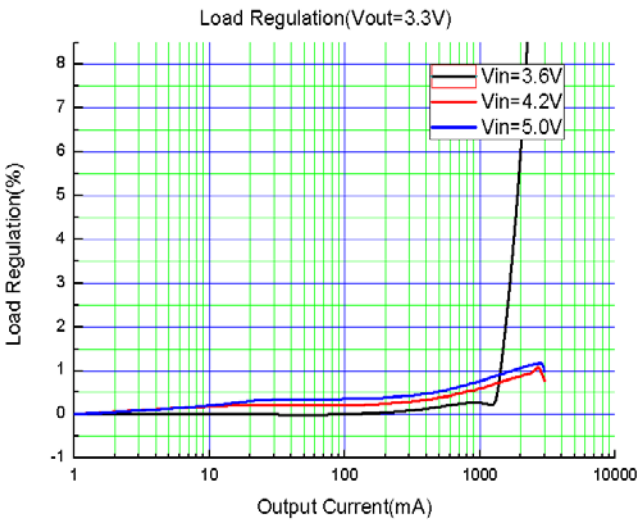



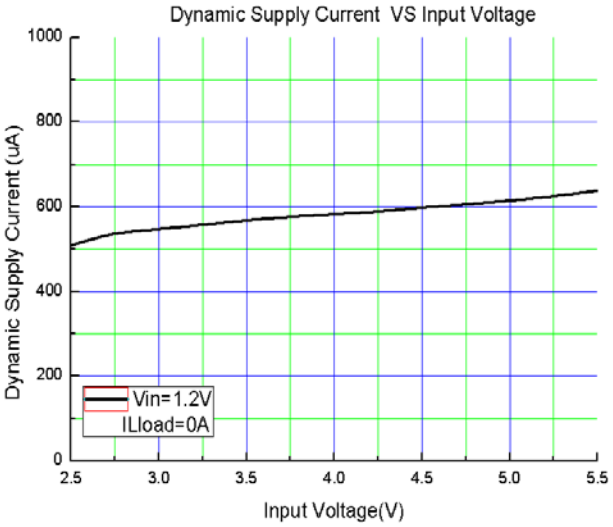



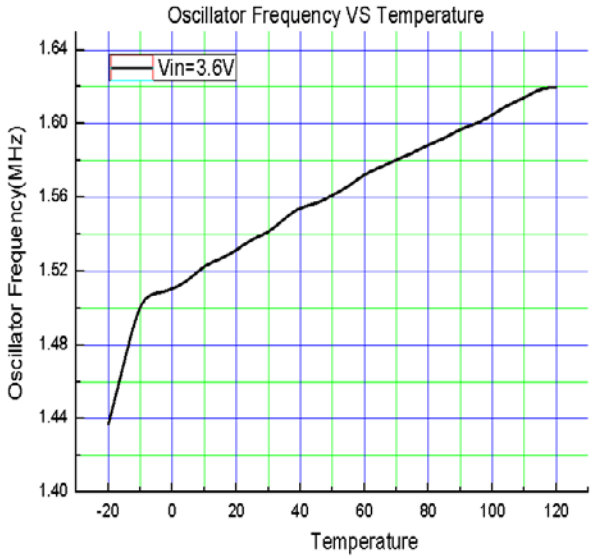



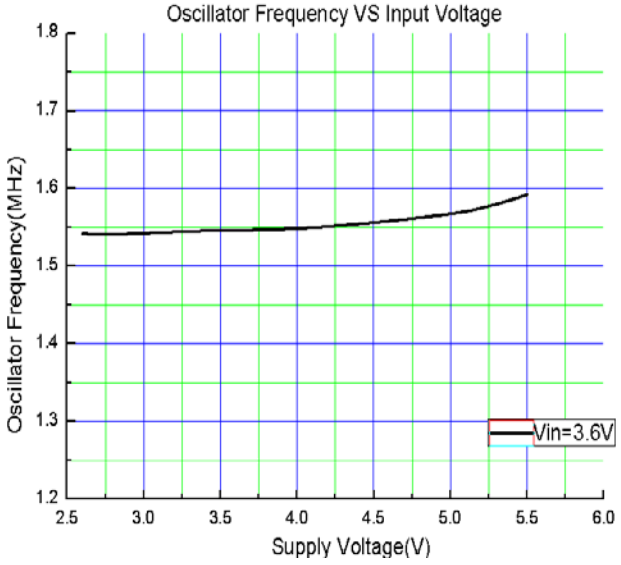




Load Regulation(Vout=3.3V)
Vin=3.6V
Vin=4.2V
Vin=5.0V
Load Regulation(%)
Output Current(mA)
8
7
6
5
4
3
2
1
0
-1
1
10
100
1000
10000


Dynamic Supply Current VS Input Voltage
Vin=1.2V
ILload=0A
Dynamic Supply Current (uA)
Input Voltage(V)
1000
800
600
400
200
0
2.5
3.0
3.5
4.0
4.5
5.0
5.5


Oscillator Frequency VS Temperature
Vin=3.6V
Oscillator Frequency(MHz)
Temperature
1.64
1.60
1.56
1.52
1.48
1.44
1.40
-20
0
20
40
60
80
100
120


Oscillator Frequency VS Input Voltage
Vin=3.6V
Oscillator Frequency(MHz)
Supply Voltage(V)
1.8
1.7
1.6
1.5
1.4
1.3
1.2
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0

## ■ Application Information

### Inductor Selection

For most applications, the value of the inductor will fall in the range of 4.7μH to 22μH. Its value is chosen based on the desired ripple current. Large value inductors lower ripple current and small value inductors result in higher ripple currents. Higher VIN or VOUT also increase the ripple current ΔIL:

$$\Delta I_L = \frac{1}{f \times L} V_{OUT}\left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

$$C_{IN} \text{requires} I_{RMS} \cong I_{QMAX} \frac{\sqrt{V_{OUT}(V_{IN} - V_{OUT})}}{V_{IN}}$$

$$\Delta V_{OUT} \cong \Delta I_L \left(ESR + \frac{1}{8fC_{OUT}}\right)$$

$$V_{OUT} = 0.8 \times \left[1 + \frac{R1}{R2}\right] Volt$$

where f=switching frequency, L=inductance. A reasonable inductor current ripple is usually set as 1/3 to 1/10 of maximum out current.

The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation. For better efficiency, choose a low DCR inductor.

### Capacitor Selection

In continuous mode, the source current of the top MOSFET is a square wave of duty cycle VOUT/VIN. To prevent large voltage transients, a low ESR input capacitor sized for maximum RMS current must be used. The maximum RMS capacitor current is given by:

$$C_{IN} \text{requires} I_{RMS} \cong I_{QMAX} \frac{\sqrt{V_{OUT}(V_{IN} - V_{OUT})}}{V_{IN}}$$

$$\Delta I_L = \frac{1}{f \times L} V_{OUT}\left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

This formula has a maximum at VIN=2VOUT, where IRMS=IOUT/2. This simple worst case condition is commonly used for design because even significant deviations do not offer much relief.

The selection of COUT is driven by the required effective series resistance (ESR). Typically, once the ESR requirement for COUT has been met, the RMS current rating generally far exceeds the IRIPPLE(P-P) requirement.

The output ripple ΔVOUT is determined by:

$$\Delta V_{OUT} \cong \Delta I_L \left(ESR + \frac{1}{8fC_{OUT}}\right)$$

$$\Delta I_L = \frac{1}{f \times L} V_{OUT}\left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

For a fixed output voltage, the output ripple is highest at maximum input voltage since ΔIL increases with input voltage.

Nowadays, higher value, lower cost ceramic capacitors are becoming available in smaller case sizes. Their high ripple current, high voltage rating and low ESR make them ideal for switching regulator applications. Because the LN2430's control loop does not depend on the output capacitor's ESR for stable operation, ceramic capacitors can be used freely to achieve very low output ripple and small circuit size.

When choosing the input and output ceramic capacitors, choose the X5R or X7R dielectric formulations. These dielectrics have the best temperature and voltage characteristics of all the ceramics for given value and size.

### Output Voltage Programming

The output voltage of the LN2430 is set by a resistive divider according to the following formula:

$$V_{OUT} = 0.8 \times \left[1 + \frac{R1}{R2}\right] Volt$$

Some standard value of R1, R2 for most commonly used output voltage values are listed in Table 1.

| $V_{OUT}$(V) | $R_1$(kΩ) | $R_2$(kΩ) |
|---|---|---|
| 1.1 | 7.5 | 20 |
| 1.2 | 10 | 20 |
| 1.5 | 13 | 15 |
| 1.8 | 30 | 24 |
| 2.5 | 51 | 24 |
| 3.3 | 75 | 24 |

### Loop Compensation

The LN2430 employs peak current mode control for easy use and fast transient response. Peak current mode control eliminates the double pole effect of the output L-C filter. It greatly simplifies the compensation loop design.

With peak current mode control, the buck power stage can be simplified to be a one-pole and one-zero system in frequency domain. The pole can be calculated by:

$$f_{p1} = \frac{1}{2\pi \times C_{OUT} \times R_L}$$

$$f_{Z1} = \frac{1}{2\pi \times C_{OUT} \times ESR_{COUT}}$$

$$f_{p2} = \frac{1}{2\pi \times C_C \times (R_C + \frac{A_{EA}}{G_{EA}})} \cong \frac{G_{EA}}{2\pi \times C_C \times A_{EA}}$$

$$f_{Z2} = \frac{1}{2\pi \times C_C \times R_C}$$

$$R_C = f_C \times \frac{V_{OUT}}{V_{FB}} \times \frac{2\pi \times C_{OUT}}{G_{EA} \times G_{CS}}$$

$$C_C = \frac{C_{OUT} \times R_L}{R_C}$$

$$R_{LX} = (R_{DS}(ON))D + (R_D(F)(1-D)$$

The zero is a ESR zero due to output capacitor and its ESR. It can be calculated by:

$$f_{Z1} = \frac{1}{2\pi \times C_{OUT} \times ESR_{COUT}}$$

Where COUT is the output capacitor; RL is load resistance; ESRCOUT is the equivalent series resistance of output capacitor.

The compensation design is to shape the converter close loop transfer function to get desired gain and phase. For most cases, a series capacitor and resistor network connected to the COMP pin sets the pole-zero and is adequate for a stable high-bandwidth control loop.

In the LN2430, FB pin and COMP pin are the inverting input and the output of internal transconductance error amplifier (EA). A series RC and CC compensation network connected to COMP pin provides one pole and one zero:

for RC <<AEA/GEA

$$f_{p2} = \frac{1}{2\pi \times C_C \times (R_C + \frac{A_{EA}}{G_{EA}})} \cong \frac{G_{EA}}{2\pi \times C_C \times A_{EA}}$$

$$f_{Z2} = \frac{1}{2\pi \times C_C \times R_C}$$

where GEA is the error amplifier transconductance

AEA is the error amplifier voltage gain

RC is the compensation resistor

CC is the compensation capacitor

The desired crossover frequency fC of the system is defined to be the frequency where the control loop has unity gain. It is also called the bandwidth of the converter. In general, a higher bandwidth means faster response to load transient. However, the bandwidth should not be too high because of system stability concern. When designing the compensation loop, converter stability under all line and load condition must be considered. Usually, it is recommended to set the bandwidth to be less than 1/10 of switching frequency.

Using selected crossover frequency, fC, to calculate RC:

$$R_C = f_C \times \frac{V_{OUT}}{V_{FB}} \times \frac{2\pi \times C_{OUT}}{G_{EA} \times G_{CS}}$$

where GCS = 2 A/V is the current sense circuit transconductance.

The compensation capacitor CC and resistor RC together make zero. This zero is put somewhere close to the pole fP1 of selected frequency. CC is selected by:

$$C_C = \frac{C_{OUT} \times R_L}{R_C}$$

**Checking Transient Response**

The regulator loop response can be checked by looking at the load transient response. Switching regulators take several cycles to respond to a step in load current. When a load step occurs, VOUT immediately shifts by an amount equal to (ΔILOAD×ESR), where ESR is the effective series resistance of COUT. ΔILOAD also begins to charge or discharge COUT, which generates a feedback error signal. The regulator loop then acts to return VOUT to its steady-state value. During this recovery time VOUT can be monitored for overshoot or ringing that would indicate a stability problem.

**Efficiency Considerations**

Although all dissipative elements in the circuit produce losses, one major source usually account for most of the losses in LN2430 circuits: $I^2R$ losses. The $I^2R$ loss dominates the efficiency loss at medium to high load currents. The $I^2R$ losses are calculated from the resistances of the internal switches, RLX, and external inductor RL. In continuous mode, the average output current flowing through inductor L is "chopped" between the main switch and the external diode. Thus the series resistance looking into the LX pin is a function of internal high-side switch's RDS(ON), external low-side diode's forward resistance RD(F) and the duty cycle (D) as follows:

$$R_{LX} = (R_{DS}(ON))D + (R_D(F)(1-D)$$

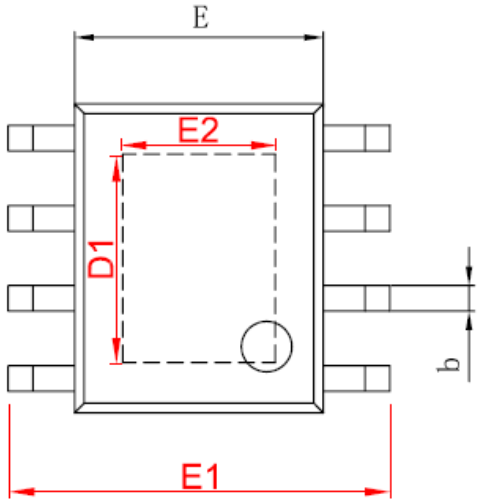
Thus, to obtained $I^2R$ losses, simply add RLX to RL and multiply the result by the square of the average output current. Other losses including CIN and COUT ESR dissipative losses and inductor core losses generally account for less than 2% total additional loss.

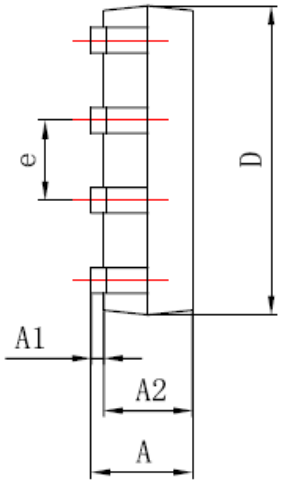
**Thermal considerations**

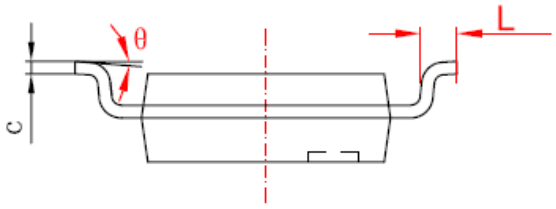
In most application the LN2430 does not dissipate much heat due to its high efficiency. But, in applications where the LN2430 is running at high ambient temperature with low supply voltage and high duty cycles, such as in dropout, the heat dissipated may exceed the maximum junction temperature of the part. If the junction temperature reaches approximately 140°C, both power switches will be turned off and the LX node will become high impedance.

## ■ Package Information

- **SOP-8/PP**




| 字符 | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.050 | 0.150 | 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 |
| D1 | 3.202 | 3.402 | 0.126 | 0.134 |
| E | 3.800 | 4.000 | 0.150 | 0.157 |
| E1 | 5.800 | 6.200 | 0.228 | 0.244 |
| E2 | 2.313 | 2.513 | 0.091 | 0.099 |
| e | 1.270(BSC) | | 0.050(BSC) | |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0° | 8° | 0° | 8° |