1.4MHz, 1.5A / 16V Asynchronous Step-Down Converter

■ General Description

The LN8160 is a 1.4MHz fixed frequency PWM non-synchronous step-down regulator. The LN8160 is operated from 4.5V to 16V, the generated output is adjustable from 0.81V to 14V, and the output current can be up to 1.5A with excellent load and line regulation. Current mode operation provides fast transient response and eases loop stabilization. The turn on resistance of the power MOSFET switches is 0.35Ω. Shutdown current is 0.1μA typical. The LN8160 is with cycle-by-cycle over current protection and thermal shutdown. The LN8160 based solution is with minimum external components.

The LN8160 is available in the SOT-23-6L package, and it is ROHS compliant.

■ Applications

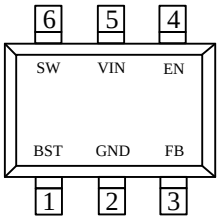
- Distributed power systems
- Battery charger
- Pre-regulator for linear regulators
- WLED driver

■ Features

- 4.5V to 16V input voltage
- Output current up to 1.5A
- Output adjustable from 0.81V to 14V
- Shutdown current 0.1μA typical
- Efficiency up to 92%
- 1.4MHz fixed frequency
- Over current protection
- Over temperature protection
- ROHS Compliant

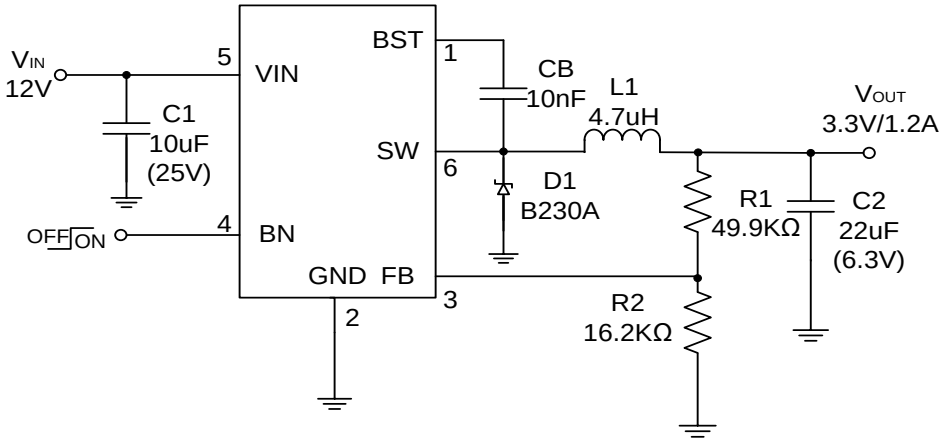
■ Package

- SOT-23-6L



SOT-23-6L
(Top View)

■ Typical Application Circuit



■ Ordering Information

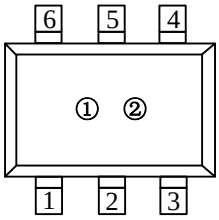
LN8160 ①②③

Designator	Symbol	Description
①	F	Oscillation Frequency 1.4MHz
②	M	Package Types: SOT-23-6L
③	S	Embossed Tape :Standard Feed
	R	Embossed Tape :Reverse Feed

■ Pin Assignment

Pin Number	Pin Name	Function Description
1	BST	Bootstrap pin
2	GND	Ground pin
3	FB	Feedback input
4	EN	On/Off control input
5	VIN	Supply voltage input
6	SW	Switch output

■ Marking Rule



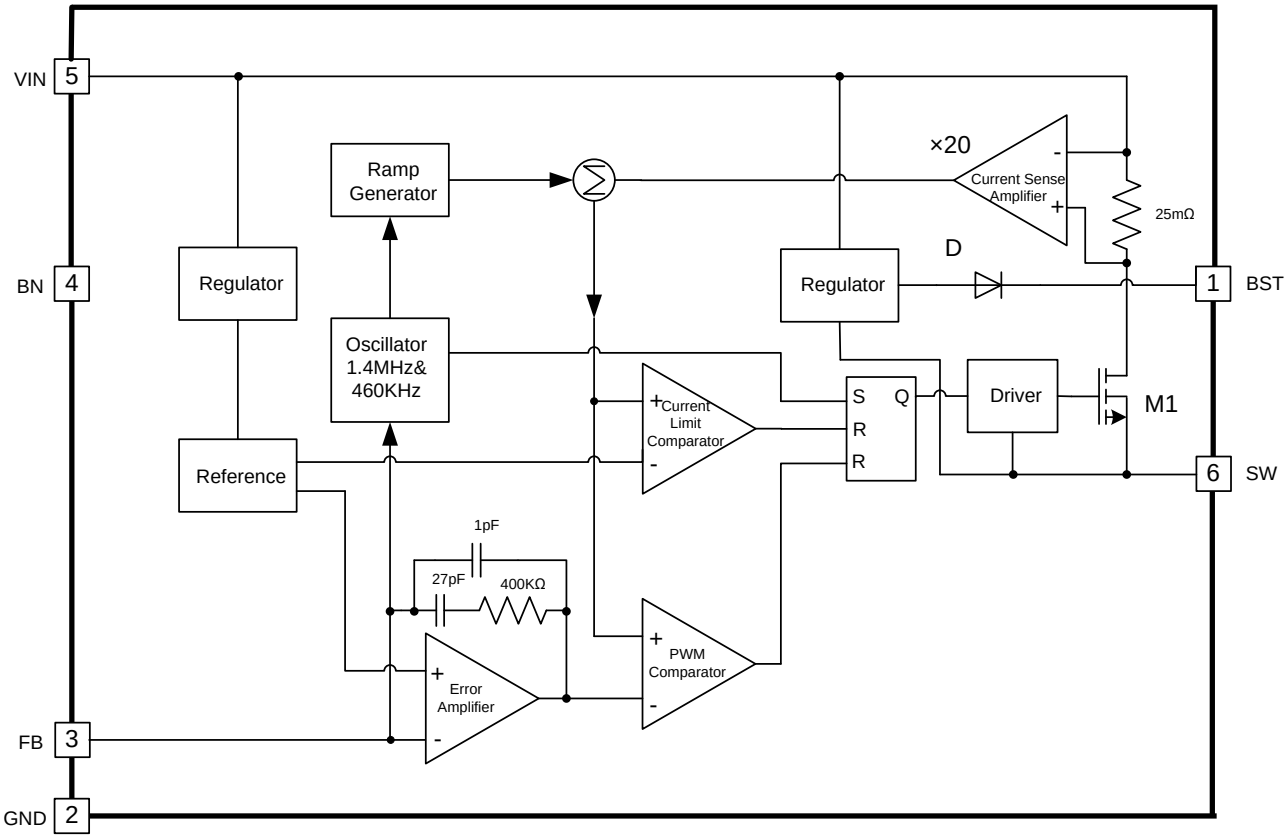
① Represents the product name

Symbol	Product Name
0	LN8160◆M◆

② Represents the assembly lot No.

0-9，A-Z; 0-9，A-Z mirror writing，repeated（G，I，J，O，Q，W exception）

■ Function Block Diagram



■ Absolute Maximum Ratings

The following ratings designate persistent limits beyond which damage to the device may occur.

Parameter	Symbol	Maximum Rating	Unit
Supply Voltage	V_{IN}	+17	V
Switch Voltage	V_{SW}	-0.3～V_{IN} +0.3	
Bootstrap Voltage	V_{BS}	V_{SW}+6.0	
All Other Pins	V_{ALL}	-0.3～+6.0	
Lead Temperature	L_T	260	℃
Junction Temperature	J_T	150	℃
Thermal Resistance	θ_{JA}	220	℃/W
Thermal Resistance	θ_{JC}	110	
Operating Temperature Range	T_{OPR}	-40~+85	℃
Storage Temperature Range	T_{STG}	-65~+150	℃

Caution: Stresses above those listed in “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational ections of this specification is not implied.

■ Electrical Characteristics

(Vcc=+12V,T_A=25℃, unless otherwise specified.)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply Voltage	V_{IN}		4.5		16	V
Output Voltage	V_{OUT}		0.81		14	V
Feedback Voltage	V_{FB}	4.5≤V_{IN}≤16V	0.790	0.810	0.830	V
Feedback Current	I_{FB}	V_{FB}=0.8V		0.1		μA
Switch-On Resistance	$R_{DS(ON)}$			0.35		Ω
Switch Leakage		V_{EN}=0V,V_{SW}=0V			10	μA
Current Limit				1.8		A
Oscilliator Frequency	f_{osc}	V_{FB}=0.6V	1.2	1.4	1.7	MHz
Fold-Back Frequency		V_{FB}=0.6V		460		KHz
Maximum Duty Cycle		V_{FB}=0.6V		87		%
Minimum On-Time	t_{ON}			100		ns
Under Voltage Lockout Threshold Rising			2.9	3.2	3.5	V
Under Voltage Lockout Threshold Hysteresis				150		mV
EN Input Low Voltage					0.4	V
EN Input High Voltage			1.5			V
EN Input Current		V_{EN}=2V		2.1		μA
		V_{EN}=0V		0.1		μA
Supply Current (Shutdown)	I_S	V_{EN}=0V		0.1	1.0	μA
Supply Current(Quiescent)	I_Q	V_{EN}=2V,V_{FB}=1V		0.8	1.0	mA
Thermal Shutdown				150		℃

■ Application Information

● Overview

Refer to the Functional Block Diagram in page 3. The LN8160 is a current mode buck regulator. That is, the Error Amplifier (EA) output voltage is proportional to the peak inductor current.

At the beginning of a cycle, M1 is off. The EA output voltage is higher than the current sense amplifier output, and the current comparator's output is low. The rising edge of the 1.4MHz CLK signal sets the RS Flip-Flop. Its output turns on M1 thus connecting the SW pin and inductor to the input supply.

The increasing inductor current is sensed and amplified by the Current Sense Amplifier. Ramp compensation is summed to the Current Sense Amplifier output and compared to the Error Amplifier output by the PWM Comparator. When the sum of the Current Sense Amplifier output and the Slope Compensation signal exceeds the EA output voltage, the RS Flip-Flop is reset and M1 is turned off. The external Schottky rectifier diode (D1) conducts the inductor current. (Refer to the Typical Application Circuit in page1.)

If the sum of the Current Sense Amplifier output and the Slope Compensation signal does not exceed the EA output for a whole cycle, then the falling edge of the CLK resets the Flip-Flop.

The output of the Error Amplifier integrates the voltage difference between the feedback and the 0.81V band-gap reference. The polarity is such that a FB pin voltage lower than 0.81V increases the EA output voltage. Since the EA output voltage is proportional to the peak inductor current, an increase in its voltage also increases current delivered to the output.

● Pins Description

BST: Bootstrap. A capacitor is connected between SW and BS pins to form a floating supply across the power switch driver. This capacitor is needed to drive the power switch's gate above the supply voltage.

GND: Ground. This pin is the voltage reference for the regulated output voltage. For this reason care must be taken in its layout. This node should be placed outside of the D1 to C1 ground path to prevent switching current spikes from inducing voltage noise into the part.

FB: Feedback. An external resistor divider from the output to GND, tapped to the FB pin sets the output voltage. To prevent current limit run away during a short circuit fault condition, the frequency fold-back comparator lowers the oscillator frequency when the FB voltage is below 250mV.

EN: On/Off Control Input. Pull EN above 1.5V to turn the device on.

VIN: Supply Voltage. The LN8160 operates from a +4.5V to +16V unregulated input. C1 is needed to prevent large voltage spikes from appearing at the input.

SW: Switch Output.

● Setting the Output Voltage

The external resistor divider is used to set the output voltage (refer to the Typical Application Circuit). The feedback resistor R1 also sets the feedback loop bandwidth with the internal compensation capacitor (refer to the Functional Block Diagram). Choose R1 to be around 50kΩ for optimal transient response. R2 can be determined by:

$$R2 = R1 / \left(\frac{V_{OUT}}{0.81V} - 1 \right)$$

Table 1 shows a list of resistor selection for common output voltages.

Table 1: Resistor selection for common output voltages.

OUT	R1(KΩ)	R2(KΩ)
1.8V	80.6(1%)	64.9(1%)
2.5V	49.9(1%)	23.7(1%)
3.3V	49.9(1%)	16.2(1%)
5V	49.9(1%)	9.53(1%)

● Selecting the Inductor

A 1μH to 10μH inductor with a DC current rating of at least 25% higher than the maximum load current is recommended for most applications. For highest efficiency, the inductor's DC resistance should be less than 200mΩ. Refer to Table 2 for suggested surface mount inductors. For most designs, the required inductance value can be derived from the following equation:

$$L = V_{OUT} \times (V_{IN} - V_{OUT}) / (V_{IN} \times \Delta I_L \times f_{OSC})$$

- **Application Inforamtion**

Where △IL is the inductor ripple current. Choose the inductor ripple current to be 30% of the maximum load current. The maximum inductor peak current is calculated from:

$$IL_{(MAX)} = I_{LOAD} + \Delta I_L / 2$$

Under light load conditions below 100mA, a larger inductance is recommended for improved efficiency. See Table 2 for suggested inductors.

Manufacturer	Part NO.	Inductance(μH)
Toko	A921CY-4R7M	4.7
Wurth Electronics	7440530047	4.7
Max DCR(Ω)	**Current Rating(A)**	**Dimensions L×W×H(mm^2)**
0.027	1.66	6×6.3×3
0.038	2.0	5.8×5.8×2.8

Table 2:Suggested surface mount inductors.

- **Selecting the Input Capacitor**

The input capacitor reduces the surge current drawn from the input supply and the switching noise from the device. The input capacitor impedance at the switching frequency should be less than the input source impedance to prevent high frequency switching current from passing through the input. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. For most applications, a 4.7μF capacitor is sufficient.

- **Selecting the Output Capacitor**

The output capacitor keeps the output voltage ripple small and ensures feedback loop stability. The output capacitor impedance should be low at the switching frequency.Ceramic capacitors with X5R or X7R dielectrics are recommended for their low ESR characteristics. For most applications, a 22μF ceramic capacitor will be sufficient.

- **PC Board Layout**

PCB layout is very important to achieve stable operation. Please follow the guidelines below.

1) Keep the path of switching current short and minimize the loop area formed by Input capacitor, high-side MOSFET and Schottky diode.
2) Keep the connection of Schottky diode between SW pin and input power ground as short and wide as possible.
3) Ensure all feedback connections are short and direct. Under light load conditions below 100mA, a larger inductance is recommended for improved efficiency. See Table 2 for suggested inductors. Also note that the maximum recommended load current is 1A if the duty cycle exceeds 35%.Place the feedback resistors and compensation components as close to the chip as possible.
4) Route SW away from sensitive analog areas such as FB.
5) Connect IN, SW, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability. For single layer PCB, exposed pad should not be soldered.

- **External Bootstrap Diode**

An external bootstrap diode may enhance the efficiency of the regulator, the applicable conditions of external BST diode are: VOUT = 5V or 3.3V;
and Duty cycle is high: D = VOUT/VIN > 65%
In these cases, an external BST diode is recommended from the output of the voltage regulator to BST pin, as shown in Figure 1.
The recommended external BST diode is IN4148, and the BST capacitor is 0.1~1μF.

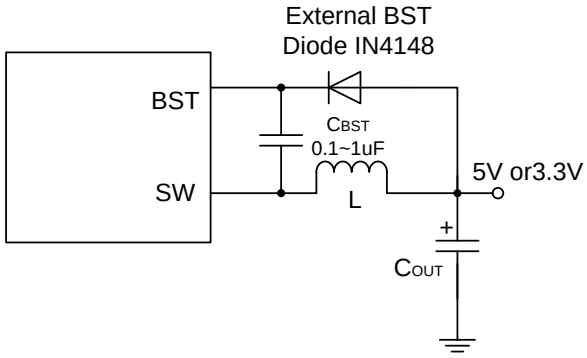
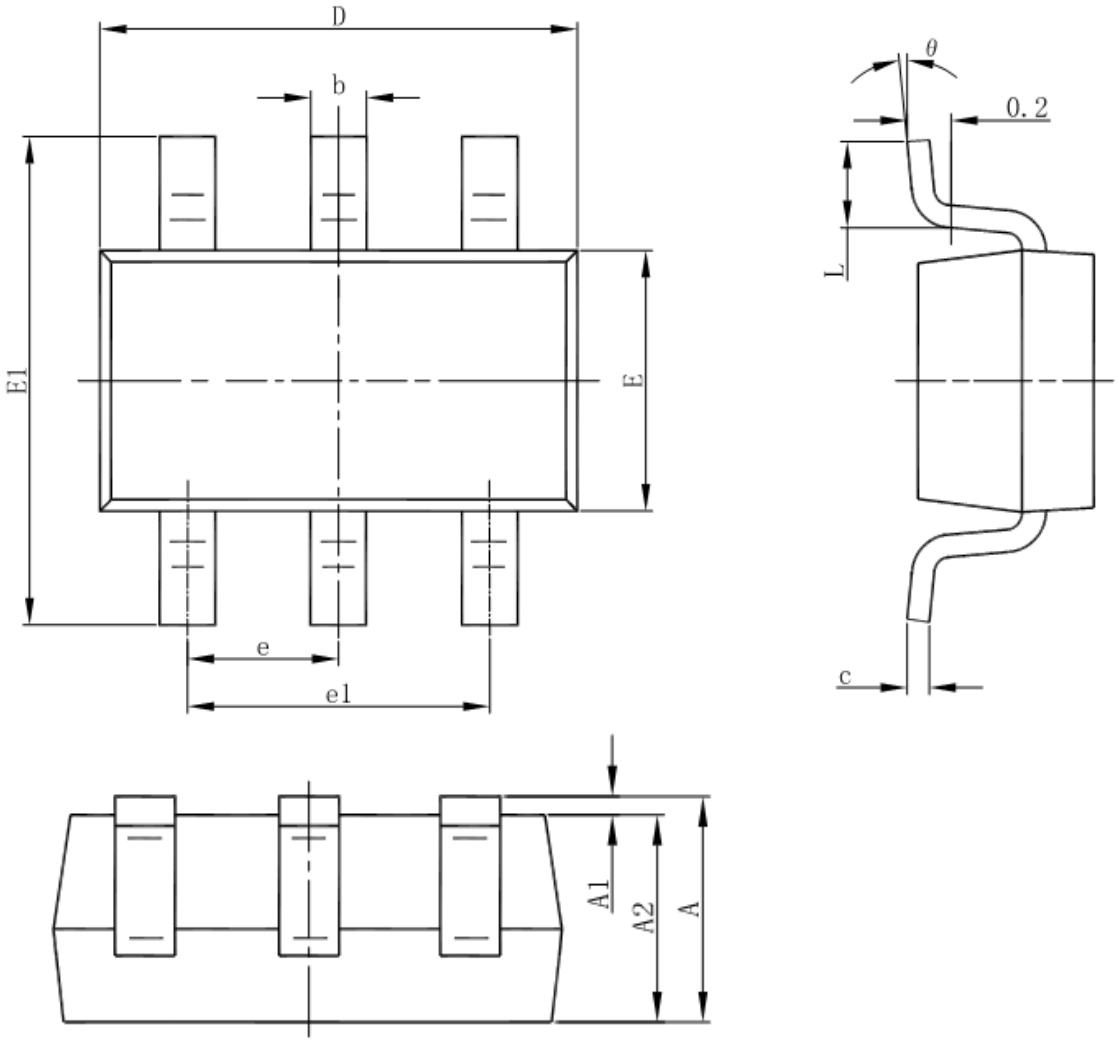


Figure 1: Add optional external bootstrap diode to enhance efficiency.

■ Package Information

- **SOT-23-6L**



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°