

Step-Up Converters (LT1073)

Application and Design

Timothy Patrick Carroll

4/5/2013

Step-Up converters are used in many applications such as cell phones, cameras and laptops. Most students learn a little bit about Step-Up converters in class but do not have the hands-on experience of building a Step-Up converter. This application note should give the reader an easy guide on how to create a Step-Up converter using the LT1073 and LT1073-5 integrated circuits.

Table of contents

Introduction	Page 2
Objective	Page 2
Key Words	Page 2
LT1073 Basics	Page 3
LT1073-5 Basics	Page 4
LT1073 Applications/Design	Page 6-7
LT1073-5 Applications	Page 7-8
Conclusion	Page 8
References	Page 9

Introduction

Step-Up converters are DC to DC power converters that have a greater output voltage than input voltage. Step-Up converters are a type of switch mode power supply that contains a diode and a transistor that are used as semiconductor switches with a capacitor and inductor that are used to store energy. The input power can come from any type of DC source. In most cases the source of input power will come from a battery but it can also come from a solar cell or a DC generator. Since the Step-Up converter has a higher output voltage than input voltage the output current must be less than the input current because of the concept of power conservation ($P = IV$).

Objective

The objective of this paper is to provide some basic knowledge on how design and build a step up converter using the LT1073 Step-Up converter from Linear Technology. Uses and applications of the LT1073-5 will also be covered in this document. After reading this document, the reader should be able to design a Step-Up converter using the LT1073 or LT1073-5 and be able to pick out the correct components to be used in the application that is desired.

Key Words

Electromagnetic interference (EMI), Equivalent Series Resistance (ESR), Step-Up converter

LT1073 Basics

The LT1073 is a gated oscillator switcher that has very low supply current because the switch is only cycled when the feedback pin voltage drops below the reference voltage. The operation of the circuit can be seen in Figure1. The comparator (A1) compares the voltage at the FB pin with the reference signal voltage (212 mV). When the voltage at pin FB drops below 212 mV, the comparator switches on the 19 kHz oscillator. The driver amplifier drives the output of the NPN power switch (Q1) by boosting the signal level.

The oscillator is set internally for 38 μ s ON time and 15 μ s OFF time. These ON and OFF times are ideal for optimizing step-up circuits where the desired output voltage is three times the input voltage ($V_{OUT} \approx 3V_{IN}$).

A2 in Figure1 is a gain block that can be used as a low-battery detector, a linear post-regulator, or it can drive an under voltage lockout circuit.

While in Step-up mode, the SW2 pin is connected to ground and the SW1 pin drives the inductor. The output can be calculated using Equation1. Equation1 can also be used as a design tool if the desired output voltage is known and the resistors R1 and R2 are yet to be known.

$$V_{OUT} = (212mV)\left(\frac{R2}{R1} + 1\right)$$

Equation1

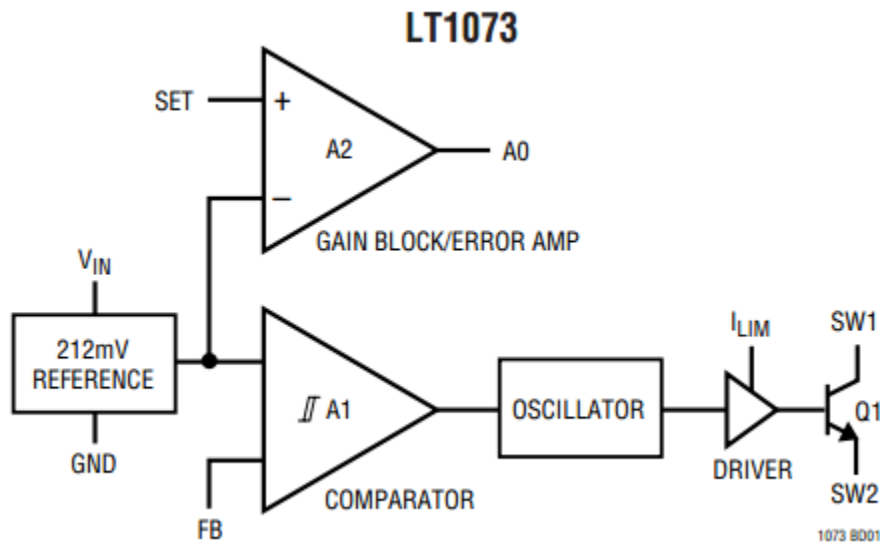


Figure1: LT1073 Block Diagram

LT1073-5 Basics

The LT1073-5 is a fixed output voltage version of the LT1073. The LT1073-5 has a gain setting resistor on the chip while the LT1073 does not. The LT1073-5 only requires three external components to construct a fixed output converter. During operation, $5\ \mu\text{A}$ flows through R1 and R2 (Figure2). This current acts as a load and the converter cycles from time to time to maintain the desired output voltage.

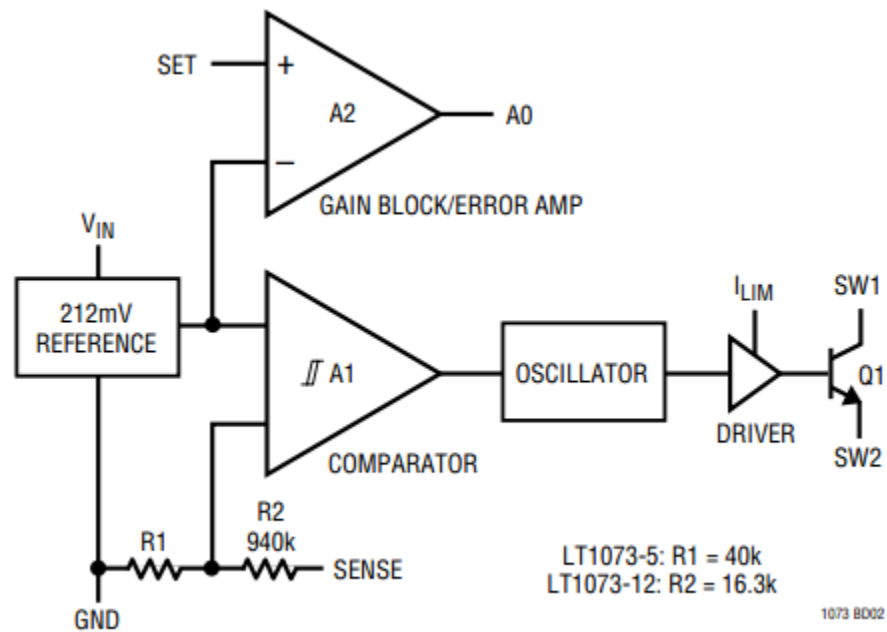


Figure2: Block Diagram of LT1073-5

LT1073 Applications/Design

INPUT VOLTAGE (V)	BATTERY TYPE	OUTPUT VOLTAGE (V)	OUTPUT CURRENT (MIN)	INDUCTOR VALUE (μ H)	INDUCTOR PART NUMBER	CAPACITOR VALUE (μ F)	NOTES
1.55-1.25	Single Alkaline	3	60mA	82	G GA10-822K, CB 7300-12	150	
1.30-1.05	Single Ni-Cad	3	20mA	180	G GA10-183K, CB 7300-16	47	
1.55-1.25	Single Alkaline	5	30mA	82	G GA10-822K, CB 7300-12	100	
1.30-1.05	Single Ni-Cad	5	10mA	180	G GA10-183K, CB 7300-16	22	
3.1-2.1	Two Alkaline	5	80mA	120	G GA10-123K, CB 7300-14	470	*
3.1-2.1	Two Alkaline	5	25mA	470	G GA10-473K, CB 7300-21	150	*
3.3-2.5	Lithium	5	100mA	150	G GA40-153K, CB 6860-15	470	*
3.1-2.1	Two Alkaline	12	25mA	120	G GA10-123K, CB 7300-14	220	
3.1-2.1	Two Alkaline	12	5mA	470	G GA10-473K, CB 7300-21	100	
3.3-2.5	Lithium	12	30mA	150	G GA10-153K, CB 7300-15	220	
4.5-5.5	TTL Supply	12	90mA	220	G GA40-223K, CB 6860-17	470	*
4.5-5.5	TTL Supply	12	22mA	1000	G GA10-104K, CB 7300-25	100	*
4.5-5.5	TTL Supply	24	35mA	220	G GA40-223K, CB 6860-17	150	*

G = GOWANDA

CB = CADELLE-BURNS

*Add 68 Ω from I_{LIM} to V_{IN}

Table1: Step-Up Component Selection

As can be seen in Table1 there are many different Step-Up converters that can be designed using the LT1073. The hookup that must be used when building a Step-Up converter using the LT1073 can be seen in Figure3.

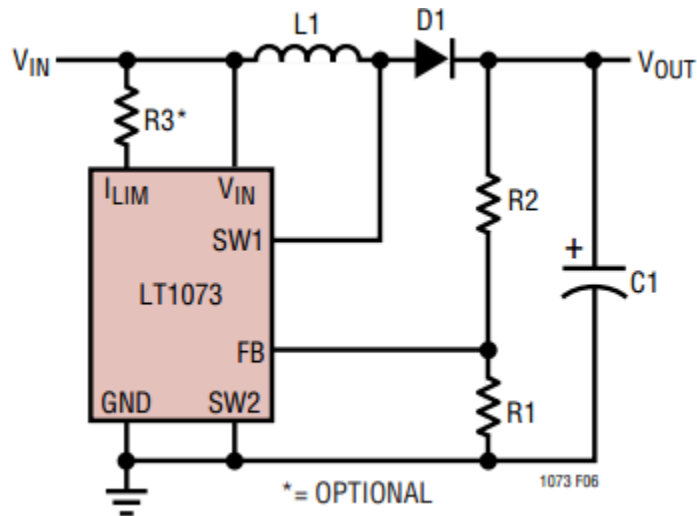


Figure3: LT1073 Step-Up Mode Hookup

Inductor Selection

It is very important to have the correct inductor when designing a Step-Up converter. It is important because a DC to DC converter operates by storing energy as magnetic flux in the inductor core. After storing energy in the inductor core the converter then switches the stored energy to the load. In order to have an efficient energy transfer the inductor must fulfill three requirements.

1. The inductance must be low enough for the inductor to store energy when the input voltage is at its minimum. The inductance must also be high enough that the maximum current ratings of the LT1073 and the inductor are not exceeded when the input voltage is at its maximum.
2. The inductor core must be able to store the required flux. In order to be sure that the inductor can store the required flux, the inductor cannot saturate. Most LT1073 designs are able to use inductors with saturation current ratings in the range of 300 mA to 1 A.
3. The inductor must have a low DC resistance. A low DC resistance is important because excessive power will not be lost as heat in the inductor windings.

It may also be important in some designs to consider possible electro-magnetic interference (EMI). If the design has a requirement where EMI must be kept to a minimum it is best to use Toroid and pot core inductor.

In a Step-Up converter inductive events add to the input voltage to create the output voltage. The required power from the inductor can be determined by Equation2 where V_D is the diode drop. There are two companies that make inductors that work great with the LT1073 and are used in all of the applications that are in Table, Caddell-Burns and Gowanda.

$$P_L = (V_{OUT} + V_D - V_{IN})(I_{OUT})$$

Equation2

Capacitor Selection

When selecting a capacitor for a Step-Up converter it is best to use a low-ESR (equivalent series resistance) aluminum capacitor. The required operation can be done using most types of capacitors but if a low-ESR capacitor is not used the circuit may be less efficient. If the circuit is less efficient there will be a loss of energy that could drain the power source faster.

Diode Selection

There are three main considerations when selecting a diode for the LT1073, speed, forward drop and leakage current. General purpose rectifiers such as the 1N4001 will not work for the Step-Up application of the LT1073 because the switching time is too slow. For most applications that the LT1073 is used for the 1N5818 Schottky diode will work just fine.

LT1073-5 Applications

Typical applications of the LT1073-5 are for designs that have a size constraint because the LT1073-5 requires less external components than the LT1073. The LT1073-5 also has many applications that are easy to assemble and are used in many products that are used every day. Some application examples can be seen below.

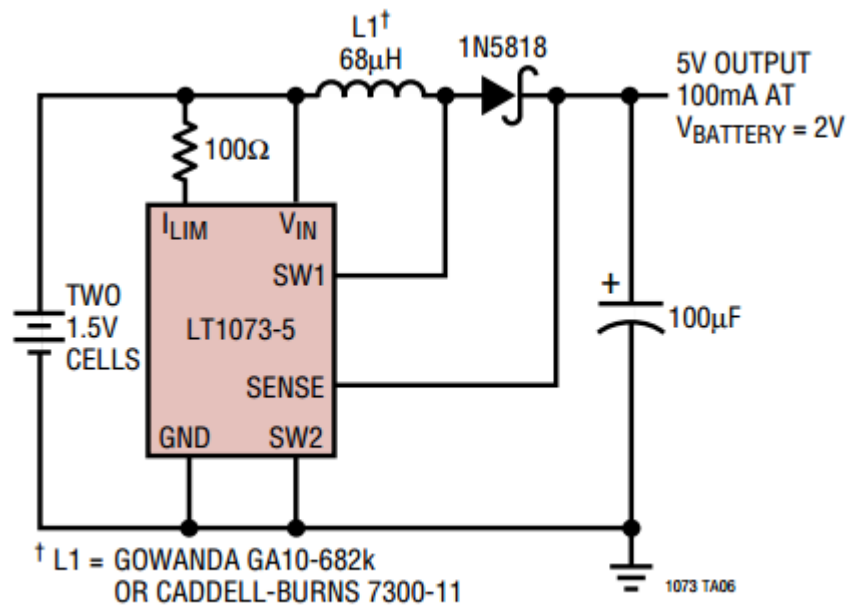
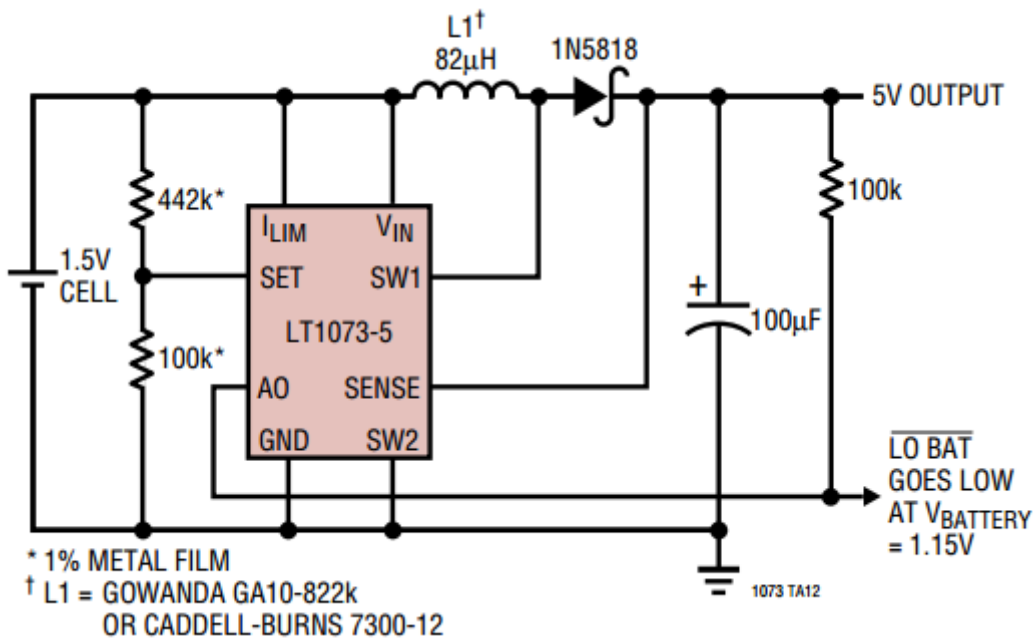


Figure4: 3V to 5V Step-Up



Conclusion

The circuits and applications that were discussed in this document are used in many products and designs that are used today. Stepping up the voltage of a voltage source is very important in designing a device that needs a higher voltage to operate than that that is given. Using the LT1073 is a good option for a Step-Up converter and there are many built in applications that can make a designer's life easier. To be a great designer, one must understand how to create a Step-Up converter and the LT1073 is a great building block for designing converters.

References

"Boost Converter." *Wikipedia*. Wikimedia Foundation, 29 Mar. 2013. Web. 03 Apr. 2013.
<http://en.wikipedia.org/wiki/Boost_converter>.

"Definition of a Boost Controller/converter." *Technology for Inovators*. Texas Instruments, 2006.
Web. 4 Apr. 2013.

"LT1073 Datasheet Pdf." *LT1073 Datasheet Pdf - Micropower DC-DC Converter Adjustable and Fixed 5V, 12V - Linear Technology*. Linear Technology Corporation, n.d. Web. 1 Apr. 2013.