Step-Up Converters

Boost Converter (LT1073)

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).

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.

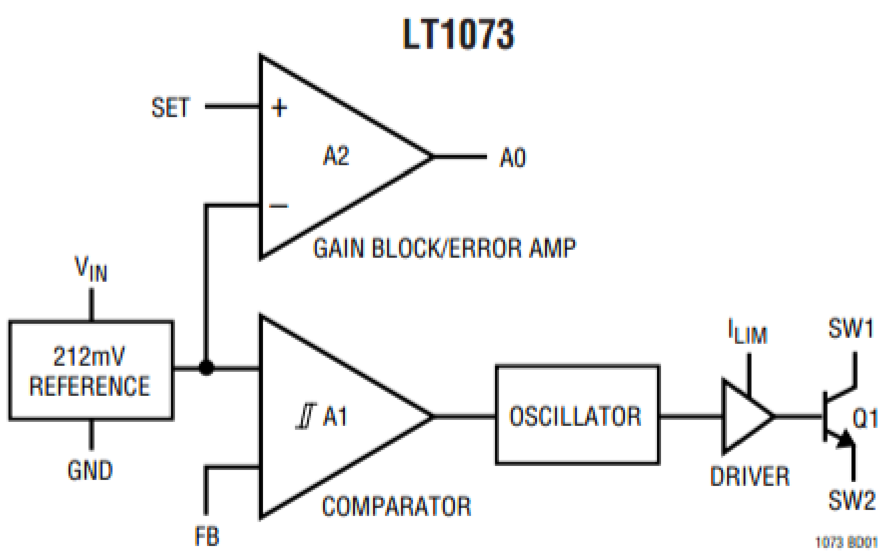
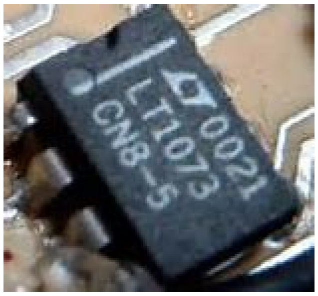


Figure1: LT1073 Block Diagram

LT1073-5



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 µA 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.

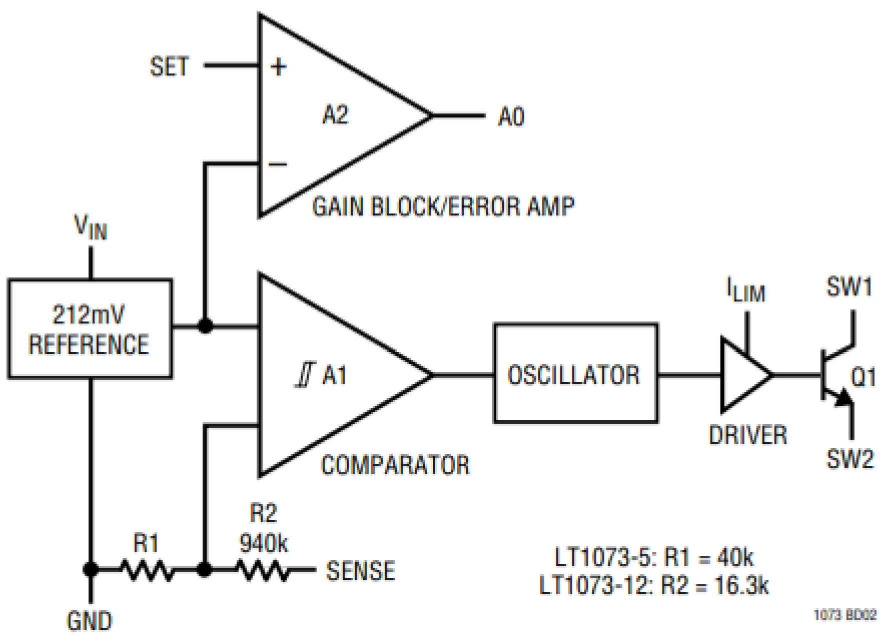


Figure2: Block Diagram of LT1073-5

DESIGNING A STEP UP CONVERTER USING LT1073

INPUT VOLTAGE (V)	BATTERY TYPE	OUTPUT VOLTAGE (V)	OUTPUT CURRENT (MIN)	INDUCTOR VALUE (µH)	INDUCTOR PART NUMBER	CAPACITOR VALUE (µF)	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 = CADDELL-BURNS *Add 68Ω 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.

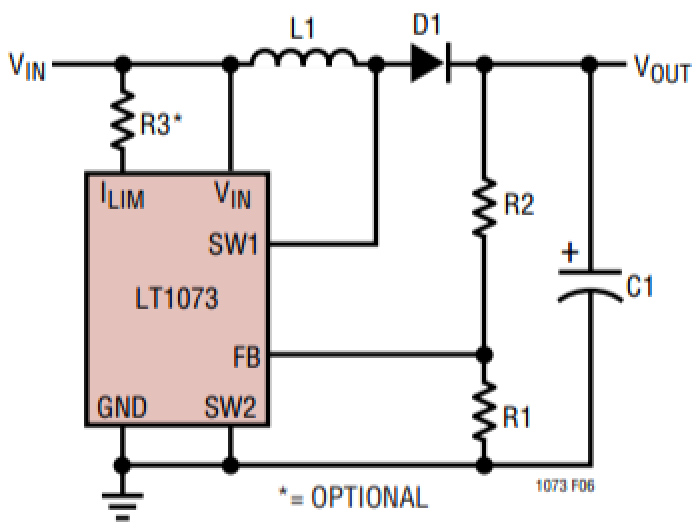


Figure3: LT1073 Step-Up Mode Hookup

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.

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 VD 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.

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

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 StepUp 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.

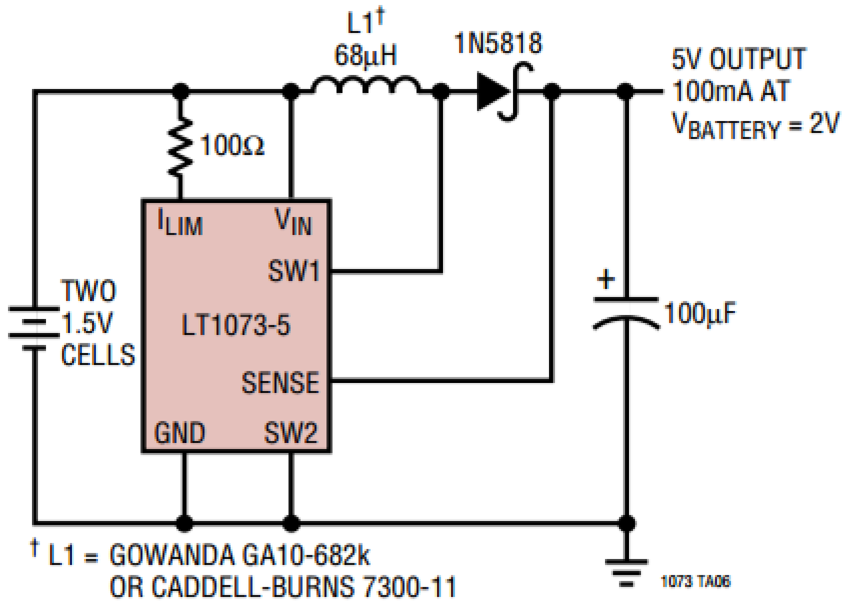


Figure4: 3V to 5V Step-Up

STEP DOWN CONVERTERS

Buck Converter (using LM2576)

A dc-dc regulator/converter or another name known as buck regulator or switching regulator, provides stable regulated output voltage to supply electronic circuits. Schematic, PCB layout and component list are available on this page.

Why do we need buck converters?

LM2576 circuits perform same function as the commonly known voltage regulator LM7805 from National Semiconductor. The 7805 voltage regulator dissipates a lot heat. The higher input voltage, the more heat is generated. The extra input energy is converted to heat, keeping the output voltage regulated at 5V.

LM7805 IC requires input voltage to be higher than output in order to regulate the output voltage. Input voltage needs to be at least 7V (up to a maximum of 20V) in order for LM7805 to regulate at an output of 5V. It is advisable to supply a voltage input range from 7.5V to 10V. Any higher input voltage is consider inefficiency, generating a lot of heat.

A switching mode power supply such as LM2576 dc-dc converter uses switching control to reduce the input dc voltage on average. This is equivalent to a lower input voltage resulting in minimum heat dissipated. The control results in better regulated output, less energy wasted through heat and the use for high current application.

DATA SHEET LM2576

TEXAS INSTRUMENTS

SNVS107D – JUNE 1999 – REVISED MAY 2016

LM2576xx Series SIMPLE SWITCHER® 3-A Step-Down Voltage Regulator

1 Features

- 3.3-V, 5-V, 12-V, 15-V, and Adjustable Output Versions
- Adjustable Version Output Voltage Range,1.23 V to 37 V (57 V for HV Version) ±4% Maximum Over Line and Load Conditions
- Specified 3-A Output Current
- Wide Input Voltage Range: 40 V Up to 60 V for HV Version
- Requires Only 4 External Components
- 52-kHz Fixed-Frequency Internal Oscillator
- TTL-Shutdown Capability, Low-Power Standby Mode
- High Efficiency
- Uses Readily Available Standard Inductors
- Thermal Shutdown and Current Limit Protection

2 Applications

- Simple High-Efficiency Step-Down (Buck) Regulator
- Efficient Preregulator for Linear Regulators
- On-Card Switching Regulators
- Positive-to-Negative Converter (Buck-Boost)

3 Description

The LM2576 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving 3-A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, 15 V, and an adjustable output version.

Requiring a minimum number of external components, these regulators are simple to use and include fault protection and a fixed-frequency oscillator.

The LM2576 series offers a high-efficiency replacement for popular three-terminal linear regulators. It substantially reduces the size of the heat sink, and in some cases no heat sink is required.

A standard series of inductors optimized for use with the LM2576 are available from several different manufacturers. This feature greatly simplifies the design of switch-mode power supplies.

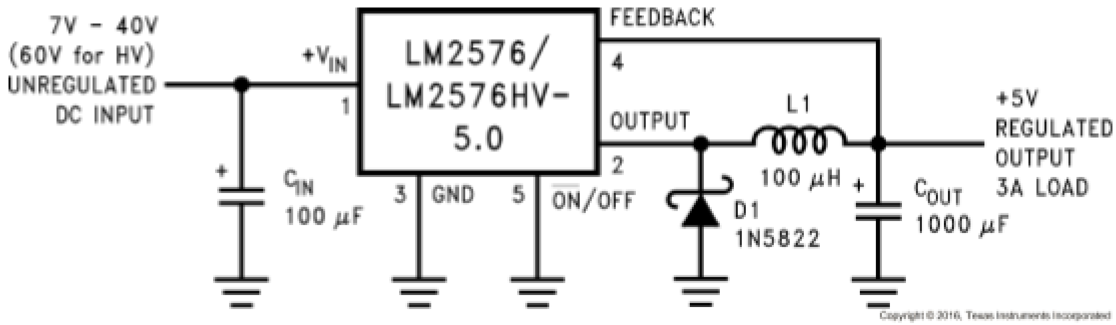
Other features include a ±4% tolerance on output voltage within specified input voltages and output load conditions, and ±10% on the oscillator frequency. External shutdown is included, featuring 50-µA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM2576 LM2576HV	TO-220 (5)	10.16 mm × 8.51 mm
	DDPAK/TO-263 (5)	10.16 mm × 8.42 mm

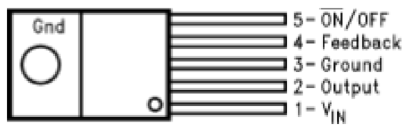
(1) For all available packages, see the orderable addendum at the end of the data sheet.

Fixed Output Voltage Version Typical Application Diagram

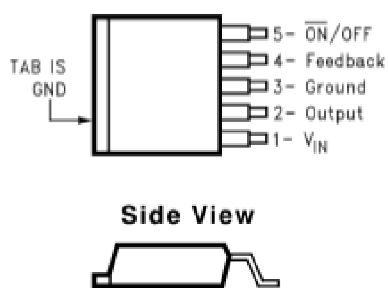


5 Pin Configuration and Functions

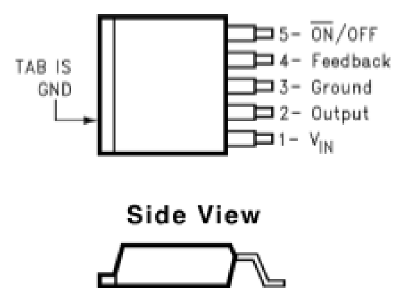
KC Package
5-Pin TO-220
Top View



KTT Package
5-PIN DDPAK/TO-263
Top View



DDPAK/TO-263 (S) Package
5-Lead Surface-Mount Package
Top View



Pin Functions

PIN		I/O[1]	DESCRIPTION
NO.	NAME		
1	V_{IN}	I	Supply input pin to collector pin of high-side transistor. Connect to power supply and input bypass capacitors CIN. Path from V_{IN} pin to high frequency bypass C_{IN} and GND must be as short as possible.
2	OUTPUT	O	Emitter pin of the power transistor. This is a switching node. Attached this pin to an inductor and the cathode of the external diode.
3	GROUND	—	Ground pin. Path to C_{IN} must be as short as possible.
4	FEEDBACK	I	Feedback sense input pin. Connect to the midpoint of feedback divider to set VOUT for ADJ version or connect this pin directly to the output capacitor for a fixed output version.
5	$\overline{ON}$/OFF	I	Enable input to the voltage regulator. High = OFF and low = ON. Connect to GND to enable the voltage regulator. Do not leave this pin float.
—	TAB	—	Connected to GND. Attached to heatsink for thermal relief for TO-220 package or put a copper plane connected to this pin as a thermal relief for DDPAK package.

(1) I = INPUT, O = OUTPUT

6 Specifications

6.1 Absolute Maximum Ratings

over the recommended operating junction temperature range of -40°C to 125°C (unless otherwise noted)[(1)(2)]

		MIN	MAX	UNIT
Maximum supply voltage	LM2576		45	V
	LM2576HV		63	
ON /OFF pin input voltage		$-0.3V \le V \le +V_{IN}$		V
Output voltage to ground	(Steady-state)	−1		V
Power dissipation		Internally Limited		
Maximum junction temperature, T_J			150	°C
Storage temperature, T_{stg}		−65	150	°C

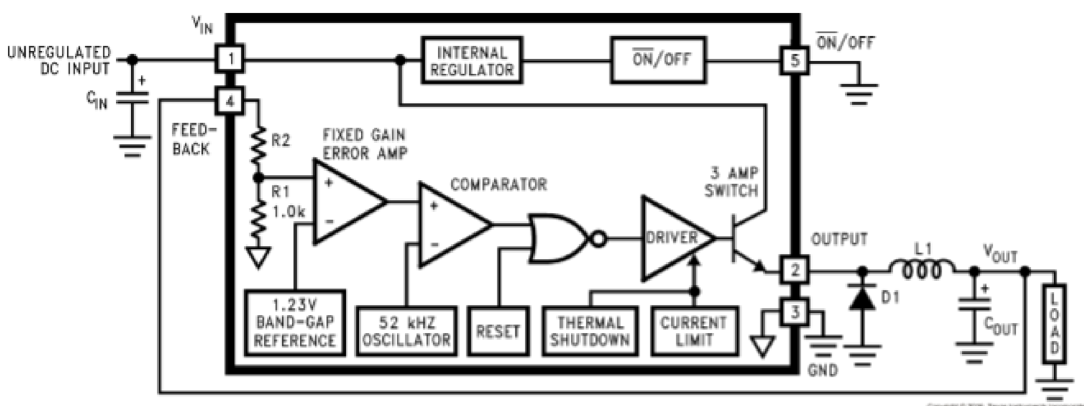
(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.

7 Detailed Description

7.1 Overview

The LM2576 SIMPLE SWITCHER® regulator is an easy-to-use, non-synchronous step-down DC-DC converter with a wide input voltage range from 40 V to up to 60 V for a HV version. It is capable of delivering up to 3-A DC load current with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, 15 V, and an adjustable output version. The family requires few external components, and the pin arrangement was designed for simple, optimum PCB layout.

7.2 Functional Block Diagram



3.3 V R2 = 1.7 k
5 V, R2 = 3.1 k
12 V, R2 = 8.84 k
15 V, R2 = 11.3 k
For ADJ. Version
R1 = Open, R2 = 0 Ω
Patent Pending

7.3 Feature Description

7.3.1 Undervoltage Lockout

In some applications it is desirable to keep the regulator off until the input voltage reaches a certain threshold. Figure 20 shows an undervoltage lockout circuit that accomplishes this task, while Figure 21 shows the same circuit applied to a buck-boost configuration. These circuits keep the regulator off until the input voltage reaches a predetermined level.

$$V_{TH} \approx V_{Z1} + 2V_{BE}(Q1) \quad (1)$$