Micropower DC-DC Converter Adjustable and Fixed 5V, 12V

FEATURES

- No Design Required
- Operates at Supply Voltages From 1.0V to 30V
- Consumes Only 95μA Supply Current
- Works in Step-Up or Step-Down Mode
- Only Three External Off-the-Shelf Components Required
- Low-Battery Detector Comparator On-Chip
- User-Adjustable Current Limit
- Internal 1A Power Switch
- Fixed or Adjustable Output Voltage Versions
- Space-Saving 8-Pin MiniDIP or SO8 Package

APPLICATIONS

- Pagers
- Cameras
- Single-Cell to 5V Converters
- Battery Backup Supplies
- Laptop and Palmtop Computers
- Cellular Telephones
- Portable Instruments
- 4mA-20mA Loop Powered Instruments
- Hand-Held Inventory Computers
- Battery-Powered α, β, γ Particle Detectors

DESCRIPTION

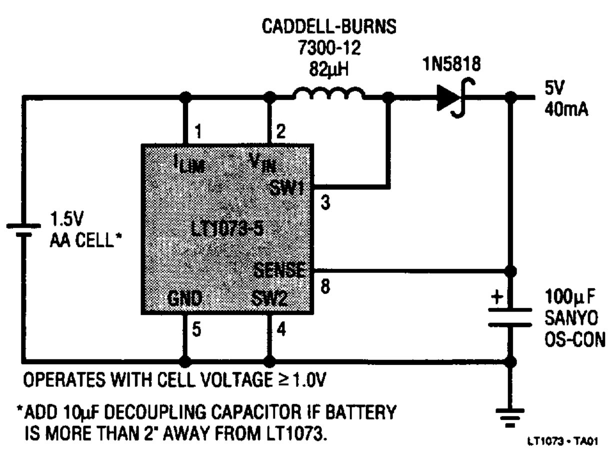
The LT1073 is a versatile micropower DC-DC converter. The device requires only three external components to deliver a fixed output of 5V or 12V. The very low minimum supply voltage of 1.0V allows the use of the LT1073 in applications where the primary power source is a single cell. An on-chip auxiliary gain block can function as a low-battery detector or linear post-regulator.

Average current drain of the LT1073-5 used as shown in the Typical Application circuit below is just 135μA unloaded, making it ideal for applications where long battery life is important. The circuit shown can deliver 5V at 40mA from an input as low as 1.25V, and 5V at 10mA from a 1.00V input.

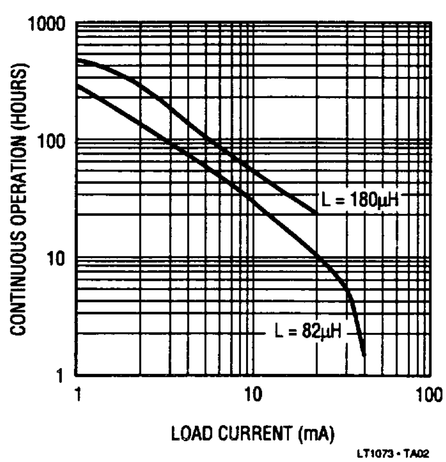
The device can easily be configured as a step-up or step-down converter, although for most step-down applications or input sources greater than 3V, the LT1173 is recommended. Switch current limiting is user-adjustable by adding a single external resistor. Unique reverse-battery protection circuitry limits reverse current to safe, non-destructive levels at reverse supply voltages up to 1.6V.

TYPICAL APPLICATION

Single-Cell to 5V Converter



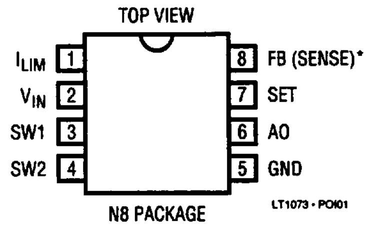
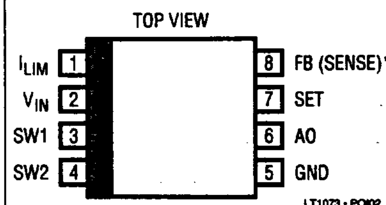
Single Alkaline "AA" Cell Operating Hours vs DC Load Current



ABSOLUTE MAXIMUM RATINGS

Supply Voltage, Step-Up Mode 15V
Supply Voltage, Step-Down Mode 36V
SW1 Pin Voltage 50V
SW2 Pin Voltage .... −0.4V to V_{IN}
Feedback Pin Voltage (LT1073) 5V
Switch Current 1.5A
Maximum Power Dissipation 500mW
Operating Temperature Range (LT1073C) ... 0°C to 70°C
Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec.) .... 300°C

PACKAGE/ORDER INFORMATION

	ORDER PART NUMBER
 N8 PACKAGE 8-LEAD PLASTIC DIP *FIXED VERSIONS	LT1073CN8 LT1073CN8-5 LT1073CN8-12
 S8 PACKAGE 8-LEAD PLASTIC SOIC *FIXED VERSIONS	LT1073CS8 LT1073CS8-5 LT1073CS8-12 **S8 PART MARKING** 1073 07305 07312

ELECTRICAL CHARACTERISTICS $T_A = 25°C$, $V_{IN} = 1.5V$ unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS			MIN	TYP	MAX	UNITS
I_Q	Quiescent Current	Switch Off		●		95	130	μA
I_Q	Quiescent Current, Step-Up Mode Configuration	No Load	LT1073-5			135		μA
			LT1073-12			250		
V_{IN}	Input Voltage	Step-Up Mode		●	1.15		12.6	V
					1.0		12.6	
		Step-Down Mode		●			30	
	Comparator Trip Point Voltage	LT1073 (Note 1)		●	202	212	222	mV
V_{OUT}	Output Sense Voltage	LT1073-5 (Note 2)		●	4.75	5.00	5.25	V
		LT1073-12 (Note 2)		●	11.4	12.00	12.6	
	Comparator Hysteresis	LT1073		●		5	10	mV
	Output Hysteresis	LT1073-5		●		125	250	mV
		LT1073-12		●		300	600	
f_{OSC}	Oscillator Frequency			●	15	19	23	kHz
DC	Duty Cycle	Full Load ($V_{FB} < V_{REF}$)		●	65	72	80	%
t_{ON}	Switch ON Time			●	30	38	50	μs
I_{FB}	Feedback Pin Bias Current	LT1073, $V_{FB} = 0V$		●		10	50	nA
I_{SET}	Set Pin Bias Current	$V_{SET} = V_{REF}$		●		60	120	nA
V_{AO}	AO Output Low	$I_{AO} = -100mA$		●		0.15	0.4	V
	Reference Line Regulation	$1.0V \le V_{IN} \le 1.5V$		●		0.35	1.0	%/V
		$1.5V \le V_{IN} \le 12V$		●		0.05	0.1	

ELECTRICAL CHARACTERISTICS $T_A = 25°C$, $V_{IN} = 1.5V$ unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{CESAT}	Switch Saturation Voltage Step-Up Mode	$V_{IN} = 1.5V$, $I_{SW} = 400mA$			300	400	mV
			●			600	
		$V_{IN} = 1.5V$, $I_{SW} = 500mA$			400	550	
			●			750	
		$V_{IN} = 5V$, $I_{SW} = 1A$			700	1000	
			●			1500	
A_V	A2 Error Amp Gain	$R_L = 100k\Omega$ (Note 3)	●	400	1000		V/V
I_{REV}	Reverse Battery Current	(Note 4)			750		mA
I_{LIM}	Current Limit	220Ω Between I_{LIM} and V_{IN}			400		mA
	Current Limit Temperature Coefficient				−0.3		%/°C
I_{LEAK}	Switch OFF Leakage Current	Measured at SW1 Pin			1	10	μA
V_{SW2}	Maximum Excursion Below GND	$I_{SW1} \le 10\mu A$, Switch Off			−400	−350	mV

The ● denotes the specifications which apply over the full operating temperature range.

Note 1: This specification guarantees that both the high and low trip point of the comparator fall within the 202mV to 222mV range.

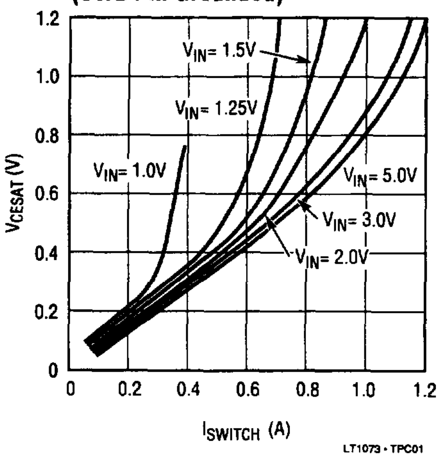
Note 2: This specification guarantees that the output voltage of the fixed versions will always fall within the specified range. The waveform at the sense pin will exhibit a sawtooth shape due to the comparator hysteresis.

Note 3: 100kΩ resistor connected between a 5V source and the AO pin.

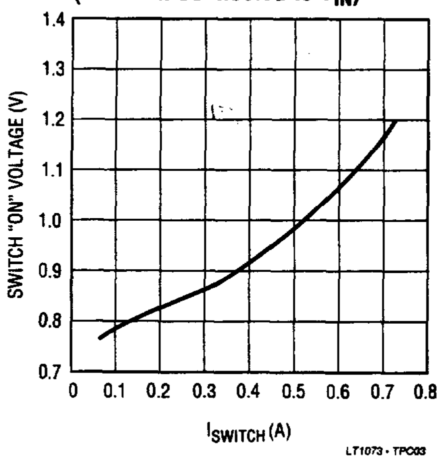
Note 4: The LT1073 is guaranteed to withstand continuous application of +1.6V applied to the GND and SW2 pins while V_{IN}, I_{LIM}, and SW1 pins are grounded.

TYPICAL PERFORMANCE CHARACTERISTICS

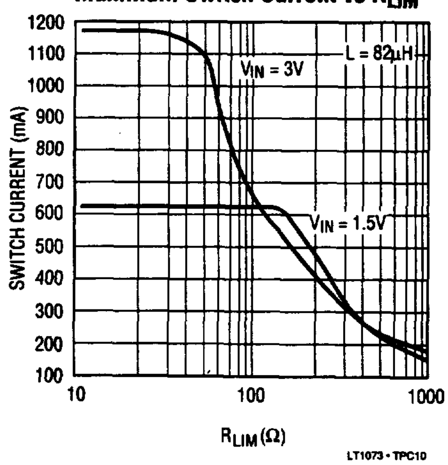
Saturation Voltage Step-Up Mode (SW2 Pin Grounded)



Switch ON Voltage Step-Down Mode (SW1 Pin Connected to V_{IN})

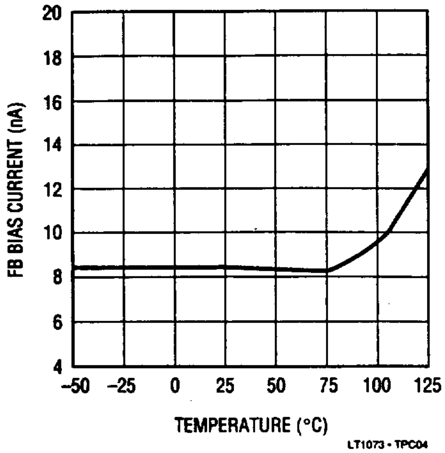


Maximum Switch Current vs R_{LIM}

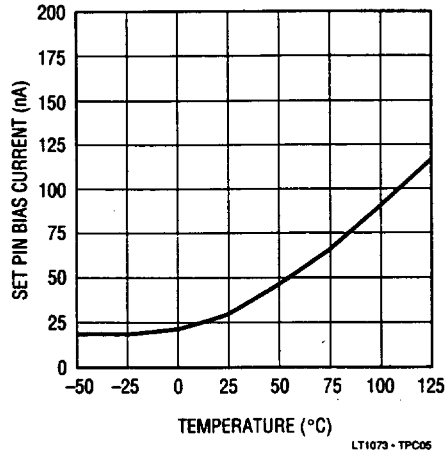


TYPICAL PERFORMANCE CHARACTERISTICS

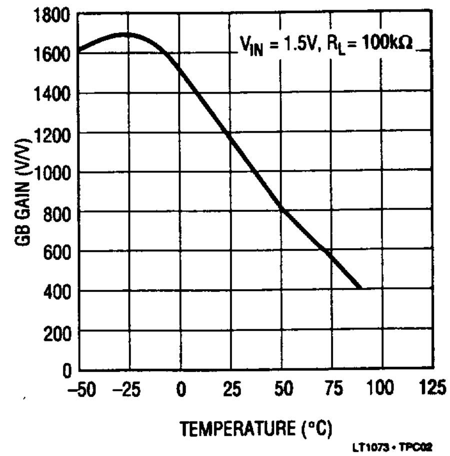
Feedback Pin Bias Current vs Temperature



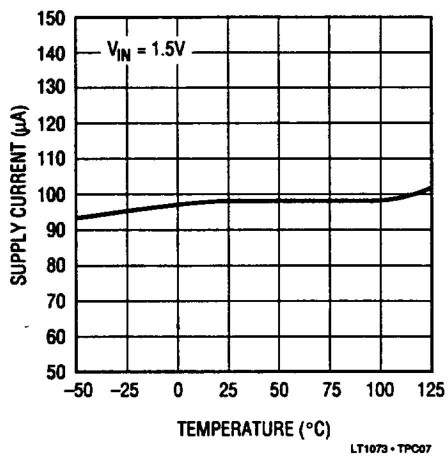
Set Pin Bias Current vs Temperature



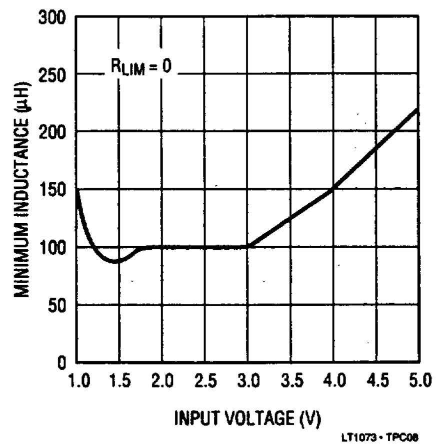
"Gain Block" Gain



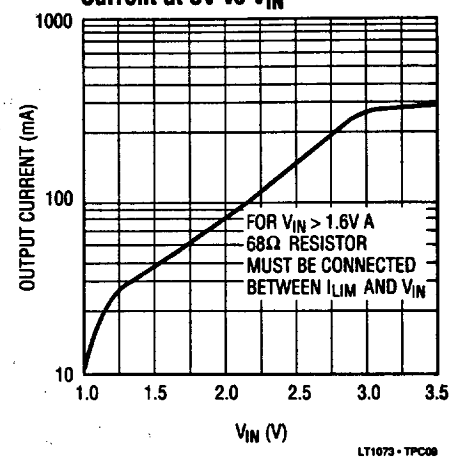
Supply Current vs Temperature



Recommended Minimum Inductance Value



Guaranteed Minimum Output Current at 5V vs V_{IN}



PIN FUNCTIONS

I_{LIM} (Pin 1): Connect this pin to V_{IN} for normal use. Where lower current limit is desired, connect a resistor between I_{LIM} and V_{IN}. A 220Ω resistor will limit the switch current to approximately 400mA.

V_{IN} (Pin 2): Input supply voltage.

SW1 (Pin 3): Collector of power transistor. For step-up mode connect to inductor/diode. For step-down mode connect to V_{IN}.

SW2 (Pin 4): Emitter of power transistor. For step-up mode connect to ground. For step-down mode connect to inductor/diode. This pin must never be allowed to go more than a Schottky diode drop below ground.

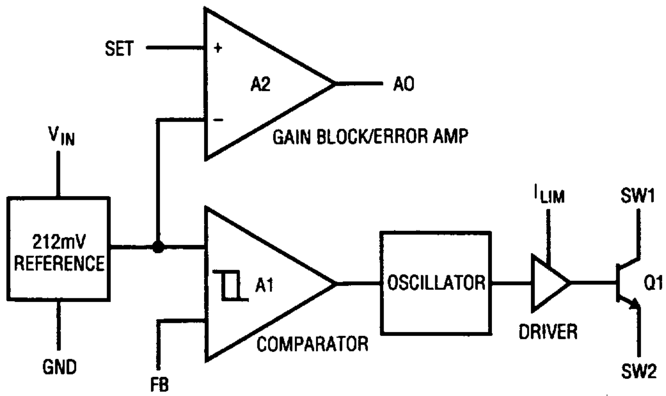
GND (Pin 5): Ground.

AO (Pin 6): Auxiliary Gain Block (GB) output. Open collector, can sink 100µA.

SET (Pin 7): GB input. GB is an op amp with positive input connected to SET pin and negative input connected to 212mV reference.

FB/SENSE (Pin 8): On the LT1073 (adjustable) this pin goes to the comparator input. On the LT1073-5 and LT1073-12, this pin goes to the internal application resistor that sets output voltage.

LT1073 BLOCK DIAGRAM



LT1073 OPERATION

The LT1073 is a gated oscillator switcher. This type architecture has very low supply current because the switch is cycled only when the feedback pin voltage drops below the reference voltage. Circuit operation can best be understood by referring to the LT1073 block diagram above. Comparator A1 compares the FB pin voltage with the 212mV reference signal. When FB drops below 212mV, A1 switches on the 19kHz oscillator. The driver amplifier boosts the signal level to drive the output NPN power switch Q1. An adaptive base drive circuit senses switch current and provides just enough base drive to ensure switch saturation without overdriving the switch, resulting in higher efficiency. The switch cycling action raises the output voltage and FB pin voltage. When the FB voltage is sufficient to trip A1, the oscillator is gated off. A small amount of hysteresis built into A1 ensures loop stability without external frequency compensation. When the comparator is low the oscillator and all high current circuitry is turned off, lowering device quiescent current to just 95μA for the reference, A1 and A2.

The oscillator is set internally for 38μs ON time and 15μs OFF time, optimizing the device for step-up circuits where $V_{OUT} \approx 3V_{IN}$, e.g., 1.5V to 5V. Other step-up ratios as well as step-down (buck) converters are possible at slight losses in maximum achievable power output.

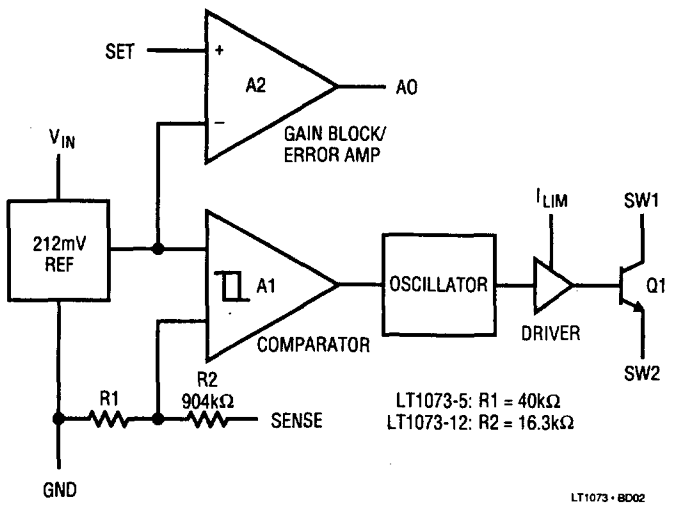
A2 is a versatile gain block that can serve as a low-battery detector, a linear post-regulator, or drive an undervoltage lockout circuit. The negative input of A2 is internally connected to the 212mV reference. An external resistor divider from V_{IN} to GND provides the trip point for A2. The AO output can sink 100μA (use a 56k resistor pull-up to +5V). This line can signal a microcontroller that the battery voltage has dropped below the preset level.

A resistor connected between the I_{LIM} pin and V_{IN} adjusts maximum switch current. When the switch current exceeds the set value, the switch is turned off. This feature is especially useful when small inductance values are used with high input voltages. If the internal current limit of 1.5A is desired, I_{LIM} should be tied directly to V_{IN}. Propagation delay through the current-limit circuitry is about 2μs.

In step-up mode, SW2 is connected to ground and SW1 drives the inductor. In step-down mode, SW1 is connected to V_{IN} and SW2 drives the inductor. Output voltage is set by the following equation in either step-up or step-down modes where R1 is connected from FB to GND and R2 is connected from V_{OUT} to FB.

$$V_{OUT} = (212\text{mV})\left(\frac{R2}{R1} + 1\right) \qquad (01)$$

LT1073-5, -12 BLOCK DIAGRAM



LT1073-5, -12 OPERATION

The LT1073-5 and LT1073-12 fixed output voltage versions have the gain-setting resistors on-chip. Only three external components are required to construct a fixed-output converter. 5μA flows through R1 and R2 in the LT1073-5, and 12.3μA flows in the LT1073-12. This current represents a load and the converter must cycle from time to time to maintain the proper output voltage. Output ripple, inherently present in gated-oscillator designs, will typically run around 150mV for the LT1073-5 and 350mV for the LT1073-12 with the proper inductor/capacitor selection. This output ripple can be reduced considerably by using the gain block amp as a pre-amplifier in front of the FB pin. See the applications section for details.

APPLICATIONS INFORMATION

Measuring Input Current at Zero or Light Load

Obtaining meaningful numbers for quiescent current and efficiency at low output current involves understanding how the LT1073 operates. At very low or zero load current, the device is idling for seconds at a time. When the output voltage falls enough to trip the comparator, the power switch comes on for a few cycles until the output voltage rises sufficiently to overcome the comparator hysteresis. When the power switch is on, inductor current builds up to hundreds of milliamperes. Ordinary digital multimeters are not capable of measuring average current because of bandwidth and dynamic range limitations. A different approach is required to measure the 100μA off-state and 500mA on-state currents of the circuit.

Quiescent current can be accurately measured using the circuit in Figure 1. V_{SET} is set to the input voltage of the LT1073. The circuit must be "booted" by shorting V2 to V_{SET}. After the LT1073 output voltage has settled, disconnect the short. Input voltage is V2, and average input current can be calculated by this formula:

$$I_{IN} = \frac{V2 - V1}{100\Omega} \qquad (02)$$

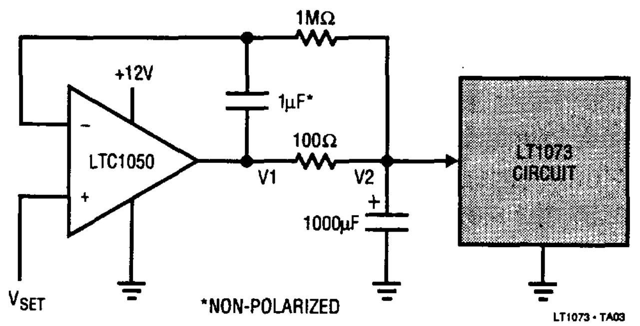


Figure 1. Test Circuit Measures No-Load Quiescent Current of LT1073 Converter