19-0227; Rev 2; 5/96

EVALUATION KIT MANUAL FOLLOWS DATA SHEET

MAXIM

Regulated 5V Charge-Pump DC-DC Converter

MAX619

General Description

The MAX619 step-up charge-pump DC-DC converter delivers a regulated 5V ±4% output at 50mA over temperature. The input voltage range is 2V to 3.6V (two battery cells).

The complete MAX619 circuit fits into less than 0.1in^2 of board space because it requires only four external capacitors: two 0.22µF flying capacitors, and 10µF capacitors at the input and output.

Low operating supply current (150µA max) and low shutdown supply current (1µA max) make this device ideal for small, portable, and battery-powered applications. When shut down, the load is disconnected from the input.

The MAX619 is available in 8-pin DIP and SO packages.

Applications

Two Battery Cells to 5V Conversion

Local 3V-to-5V Conversion

Portable Instruments & Handy-Terminals

Battery-Powered Microprocessor-Based Systems

5V Flash Memory Programmer

Minimum Component DC-DC Converters

Remote Data-Acquisition Systems

Compact 5V Op-Amp Supply

Regulated 5V Supply from Lithium Backup Battery

Switching Drive Voltage for MOSFETs in Low-Voltage Systems

Features

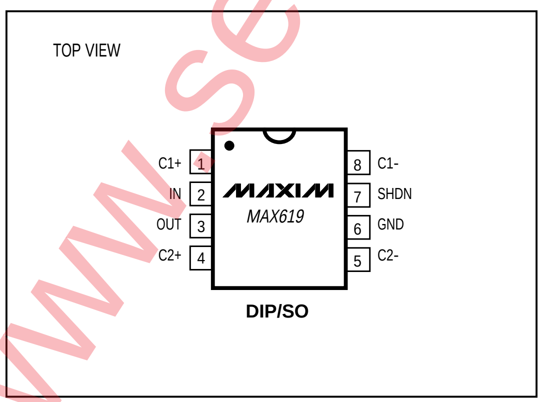
- **Regulated 5V ±4% Charge Pump**
- **Output Current Guaranteed over Temperature**
  20mA ($V_{IN} \geq 2V$)
  50mA ($V_{IN} \geq 3V$)
- **2V to 3.6V Input Range**
- **No Inductors; Very Low EMI Noise**
- **Ultra-Small Application Circuit (0.1in^2)**
- **Uses Small, Inexpensive Capacitors**
- **500kHz Internal Oscillator**
- **Logic-Controlled 1µA Max Shutdown Supply Current**
- **Shutdown Disconnects Load from Input**
- **8-Pin DIP and SO Packages**

Ordering Information

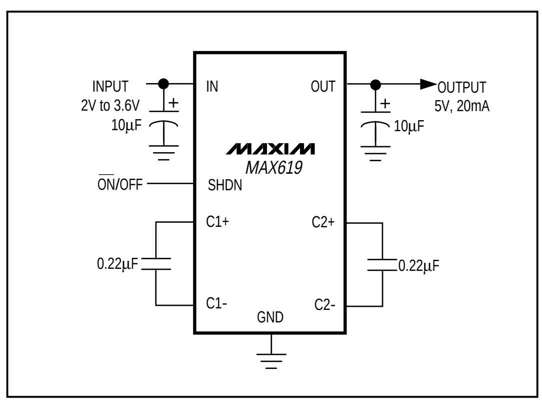
PART	TEMP. RANGE	PIN-PACKAGE
MAX619CPA	0°C to +70°C	8 Plastic DIP
MAX619CSA	0°C to +70°C	8 SO
MAX619C/D	0°C to +70°C	Dice*
MAX619EPA	-40°C to +85°C	8 Plastic DIP
MAX619ESA	-40°C to +85°C	8 SO
MAX619MJA	-55°C to +125°C	8 CERDIP

** Dice are specified at T_A = +25°C.*

Pin Configuration



Typical Operating Circuit



Regulated 5V Charge-Pump DC-DC Converter

ABSOLUTE MAXIMUM RATINGS

V_{IN} to GND ....-0.3V to +5.5V
V_{OUT} to GND ....-0.3V to +5.5V
SHDN to GND ....-0.3V to (V_{IN} + 0.3V)
I_{OUT} Continuous (Note 1)...120mA
Continuous Power Dissipation (T_A = +70°C)
Plastic DIP (derate 9.09mW/°C above +70°C) 727mW
SO (derate 5.88mW/°C above +70°C).........................471mW
CERDIP (derate 8.00mW/°C above +70°C).................640mW

Operating Temperature Ranges
MAX619C_ _ ....0°C to +70°C
MAX619E_ _ ....-40°C to +85°C
MAX619MJA ....-55°C to +125°C
Storage Temperature Range ....-65°C to +165°C
Lead Temperature (soldering, 10sec) ....+300°C

Note 1: The MAX619 is not short-circuit protected.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

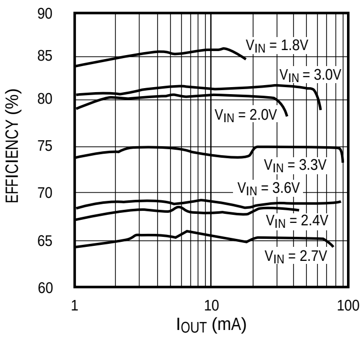
(V_{IN} = 2V to 3.6V, C1 = C2 = 0.22µF, C3 = C4 = 10µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage	V_{IN}			2		3.6	V
Output Voltage	V_{OUT}	2.0V ≤ V_{IN} ≤ 3.6V, 0mA ≤ I_{OUT} ≤ 20mA		4.8	5.0	5.2	V
		3.0V ≤ V_{IN} ≤ 3.6V, 0mA ≤ I_{OUT} ≤ 50mA, MAX619C					
		3.0V ≤ V_{IN} ≤ 3.6V, 0mA ≤ I_{OUT} ≤ 45mA, MAX619E					
		3.0V ≤ V_{IN} ≤ 3.6V, 0mA ≤ I_{OUT} ≤ 40mA, MAX619M					
Output Ripple	V_{RIPPLE}	No load to full load			100		mV
No-Load Supply Current	I_{IN}	2V ≤ V_{IN} ≤ 3.6V, I_{OUT} = 0mA			75	170	µA
Shutdown Supply Current		2V ≤ V_{IN} ≤ 3.6V, I_{OUT} = 0mA, V_{SHDN} = V_{IN}	MAX619C/E		0.02	1	µA
			MAX619M			10	
Efficiency	Eff	V_{IN} = 3V, I_{OUT} = 20mA			82		%
		V_{IN} = 3V, I_{OUT} = 30mA			82		
		V_{IN} = 2V, I_{OUT} = 20mA			80		
Switching Frequency		At full load			500		kHz
SHDN Input Threshold	V_{IH}			0.7 x V_{IN}			V
	V_{IL}					0.4	
SHDN Input Current	I_{IH}	V_{SHDN} = V_{IN}	MAX619C/E			±1	µA
			MAX619M			±10	

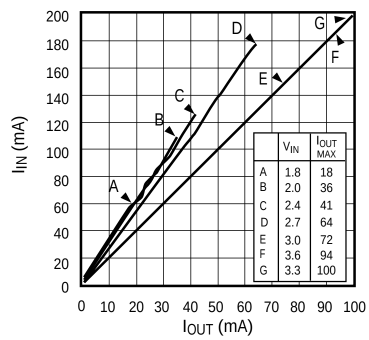
Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

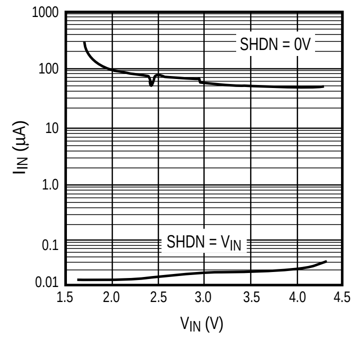
EFFICIENCY vs. OUTPUT CURRENT AND INPUT VOLTAGE



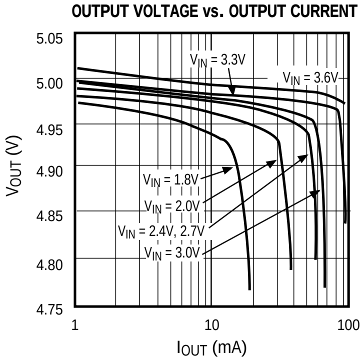
INPUT CURRENT vs. OUTPUT CURRENT



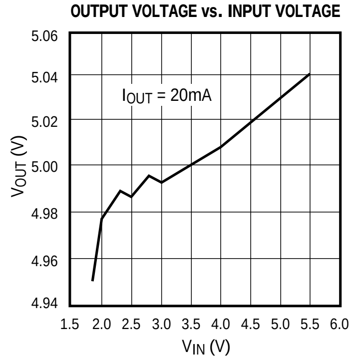
NO-LOAD INPUT CURRENT vs. INPUT VOLTAGE



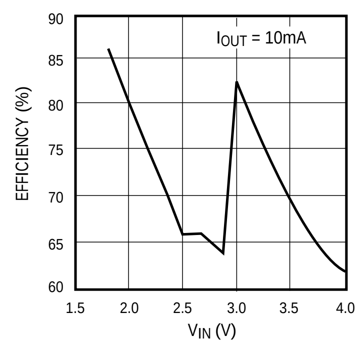
OUTPUT VOLTAGE vs. OUTPUT CURRENT



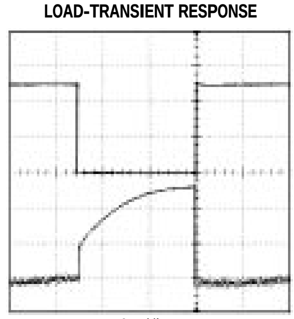
OUTPUT VOLTAGE vs. INPUT VOLTAGE



EFFICIENCY vs. INPUT VOLTAGE



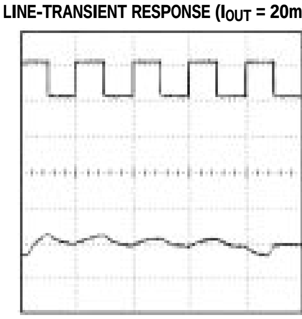
LOAD-TRANSIENT RESPONSE



2ms/div

TOP TRACE: OUTPUT CURRENT, 0mA to 25mA, 10mA/div
BOTTOM TRACE: OUTPUT VOLTAGE, 5mV/div, AC-COUPLED

LINE-TRANSIENT RESPONSE (I_{OUT} = 20mA)



2ms/div

R_{LOAD} = 250Ω, V_{OUT} = 5V, I_{OUT} = 20mA
TOP TRACE: V_{IN} = 2V to 3V, 1V/div
BOTTOM TRACE: OUTPUT VOLTAGE, 50mV/div, AC-COUPLED

Regulated 5V Charge-Pump DC-DC Converter

Pin Description

PIN	NAME	FUNCTION
1	C1+	Positive Terminal for C1
2	IN	Input Supply Voltage
3	OUT	+5V Output Voltage. V_{OUT} = 0V when in shutdown mode.
4	C2+	Positive Terminal for C2
5	C2-	Negative Terminal for C2
6	GND	Ground
7	SHDN	Active-High CMOS Logic-Level Shutdown Input
8	C1-	Negative Terminal for C1

Detailed Description

Operating Principle

The MAX619 provides a regulated 5V output from a 2V to 3.6V (two battery cells) input. Internal charge pumps and external capacitors generate the 5V output, eliminating the need for inductors. The output voltage is regulated to 5V ±4% by a pulse-skipping controller that turns on the charge pump when the output voltage begins to droop.

To maintain the greatest efficiency over the entire input voltage range, the MAX619's internal charge pump operates as a voltage doubler when V_{IN} ranges from 3.0V to 3.6V, and as a voltage tripler when V_{IN} ranges from 2.0V to 2.5V. When V_{IN} ranges from 2.5V to 3.0V, the MAX619 switches between doubler and tripler mode on alternating cycles, making a 2.5 x V_{IN} charge pump. To further enhance efficiency over the input range, an internal comparator selects the higher of V_{IN} or V_{OUT} to run the MAX619's internal circuitry. Efficiency with V_{IN} = 2V and I_{OUT} = 20mA is typically 80%.

Figure 1 shows a detailed block diagram of the MAX619. In tripler mode, when the S1 switches close, the S2 switches open and capacitors C1 and C2 charge up to V_{IN}. On the second half of the cycle, C1 and C2 are connected in series between IN and OUT when the S1 switches open and the S2 switches close, as shown in Figure 1. In doubler mode, only C2 is used.

During one oscillator cycle, energy is transferred from the input to the charge-pump capacitors, and then from the charge-pump capacitors to the output capacitor and load. The number of cycles within a given time frame increases as the load increases or as the input supply voltage decreases. In the limiting case, the charge pumps operate continuously, and the oscillator frequency is nominally 500kHz.

Shutdown Mode

The MAX619 enters low-power shutdown mode when SHDN is a logic high. SHDN is a CMOS-compatible input. In shutdown mode, the charge-pump switching action is halted, OUT is disconnected from IN, and V_{OUT} falls to 0V. Connect SHDN to ground for normal operation. When V_{IN} = 3.6V, V_{OUT} typically reaches 5V in 0.5ms under no-load conditions after SHDN goes low.

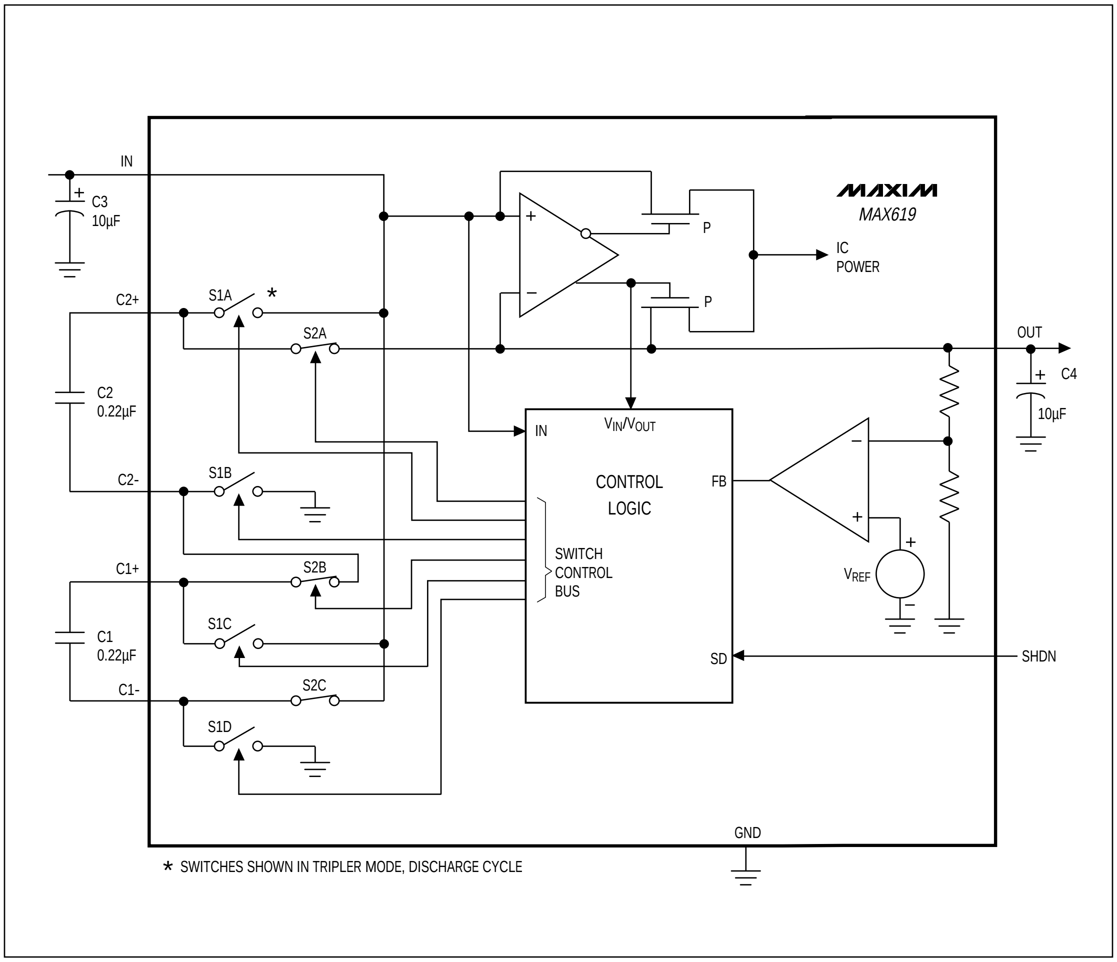


Figure 1. Block Diagram

Applications Information

Capacitor Selection

Charge-Pump Capacitors C1 and C2

The values of charge-pump capacitors C1 and C2 are critical to ensure adequate output current and avoid excessive peak currents. Use values in the range of 0.22µF to 1.0µF. Larger capacitors (up to 50µF) can be used, but larger capacitors will increase output ripple. Ceramic or tantalum capacitors are recommended.

Input and Output Capacitors, C3 and C4

The type of input bypass capacitor (C3) and output filter capacitor (C4) used is not critical, but it does affect performance. Tantalums, ceramics, or aluminum electrolytics are suggested. For smallest size, use Sprague 595D106X0010A2 surface-mount capacitors, which measure 3.7mm x 1.8mm (0.146in x 0.072in). For lowest ripple, use large, low effective-series-resistance (ESR) ceramic or tantalum capacitors. For lowest cost, use aluminum electrolytic or tantalum capacitors.

Figure 2 shows the component values for proper operation using minimal board space. The input bypass capacitor (C3) and output filter capacitor (C4) should both be at least 10µF when using aluminum electrolytics or Sprague's miniature 595D series of tantalum chip capacitors.

When using ceramic capacitors, the values of C3 and C4 can be reduced to 2µF and 1µF, respectively. If the input supply source impedance is very low, C3 may not be necessary.

Many capacitors exhibit 40% to 50% variation over temperature. Compensate for capacitor temperature coefficient by selecting a larger nominal value to ensure proper operation over temperature. Table 1 lists capacitor suppliers.

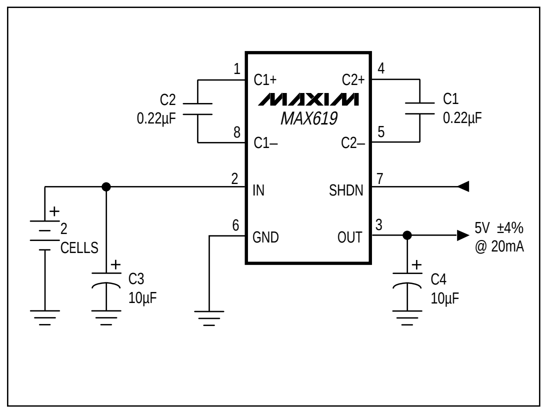


Figure 2. Two-Cell to 5V Application Circuit

Table 1. Capacitor Suppliers

SUPPLIER	PHONE NUMBER	FAX NUMBER	CAPACITOR	CAPACITOR TYPE*
Murata Erie	(814) 237-1431	(814) 238-0490	GRM42-6Z5U10M50	0.1µF ceramic (SM)
			GRM42-6Z5U22M50	0.22µF ceramic (SM)
			RPI123Z5U105M50V	1.0µF ceramic (TH)
			RPE121Z5U104M50V	0.1µF ceramic (TH)
Sprague Electric (smallest size)	(603) 224-1961 (207) 327-4140	(603) 224-1430 (207) 324-7223	595D106X0010A2	10µF tantalum (SM)

*** Note:** (SM) denotes surface-mount component, (TH) denotes through-hole component.

Layout Considerations

The MAX619's high oscillator frequency makes good layout important. A good layout ensures stability and helps maintain the output voltage under heavy loads. For best performance, use very short connections to the capacitors.

Paralleling Devices

Two MAX619s can be placed in parallel to increase output drive capability. The IN, OUT, and GND pins can be paralleled, but C1 and C2 pins cannot. The input bypass capacitor and output filter capacitor are, to some extent, shared when two circuits are paralleled. If the circuits are physically close together, it may be possible to use a single bypass and a single output capacitor, each with twice the value of the single circuit. If the MAX619s cannot be placed close together, use separate bypass and output capacitors. The amount of output ripple observed will determine whether single input bypass and output filter capacitors can be used.

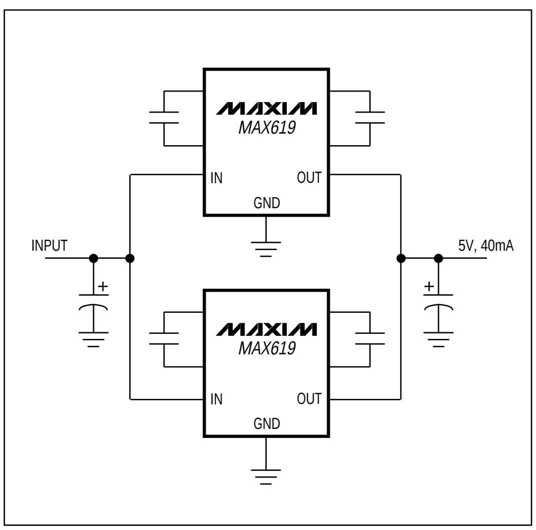
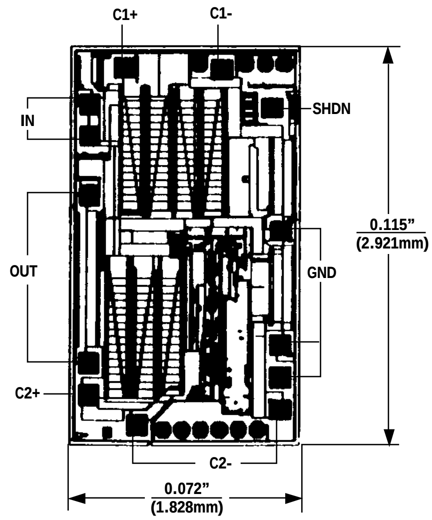


Figure 3. Paralleling Two MAX619s

Chip Topography



TRANSISTOR COUNT: 599;
SUBSTRATE CONNECTED TO GND.