ABSOLUTE MAXIMUM RATINGS

IN to GND ....+6.0V, -0.3V
OUT to GND ....-6.0V, +0.3V
OUT Output Current 50mA
OUT Short-Circuit to GND ....Indefinite
Continuous Power Dissipation (T_A = +70°C)
SOT23-5 (derate 7.1mW/°C above +70°C)....................571mW

Operating Temperature Range
MAX828EUK/MAX829EUK ....-40°C to +85°C
Storage Temperature Range ....-65°C to +160°C
Lead Temperature (soldering, 10s) ....+300°C

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} = +5V, C1 = C2 = 10µF (MAX828), C1 = C2 = 3.3µF (MAX829), T_A = 0°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Current	T_A = +25°C	MAX828		60	90	µA
		MAX829		150	260	
Minimum Supply Voltage	R_{LOAD} = 10kΩ	T_A = +25°C	1.25	1.0		V
		T_A = 0°C to + 85°C	1.5			
Maximum Supply Voltage	R_{LOAD} = 10kΩ				5.5	V
Oscillator Frequency	T_A = +25°C	MAX828	8.4	12	15.6	kHz
		MAX829	24.5	35	45.5	
Power Efficiency	R_{LOAD} = 1kΩ, T_A = +25°C			94		%
Voltage Conversion Efficiency	R_{LOAD} = ∞		95	99.9		%
Output Resistance	I_{OUT} = 5mA	T_A = +25°C		20	50	Ω
		T_A = 0°C to + 85°C			65	

Note 1: Capacitor contribution is approximately 20% of the output impedance [ESR + 1 / (pump frequency x capacitance)].

ELECTRICAL CHARACTERISTICS

(V_{IN} = +5V, C1 = C2 = 10µF (MAX828), C1 = C2 = 3.3µF (MAX829), T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

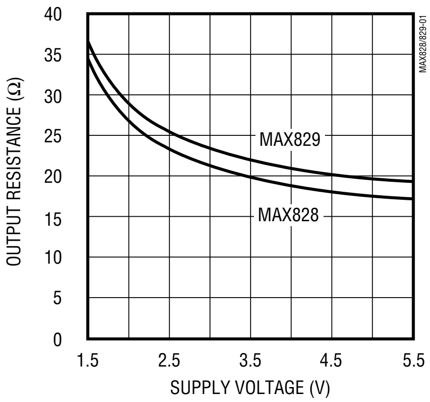
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Current	MAX828			115	µA
	MAX829			325	
Supply Voltage Range	R_{LOAD} = 10kΩ	1.5		5.5	V
Oscillator Frequency	MAX828	6		20	kHz
	MAX829	19		54.3	
Output Resistance	I_{OUT} = 5mA			65	Ω

Note 2: All -40°C to +85°C specifications above are guaranteed by design.

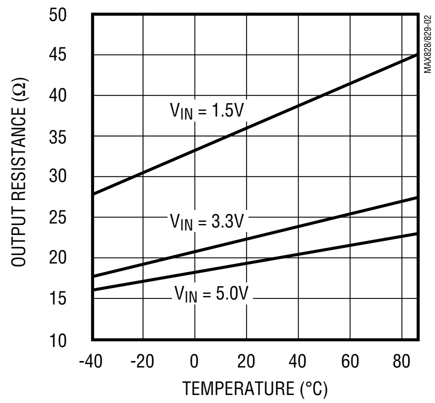
Typical Operating Characteristics

(Circuit of Figure 1, V_{IN} = +5V, C1 = C2 = C3, T_A = +25°C, unless otherwise noted.)

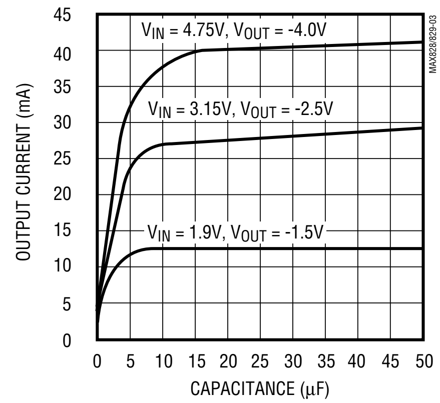
OUTPUT RESISTANCE vs. SUPPLY VOLTAGE



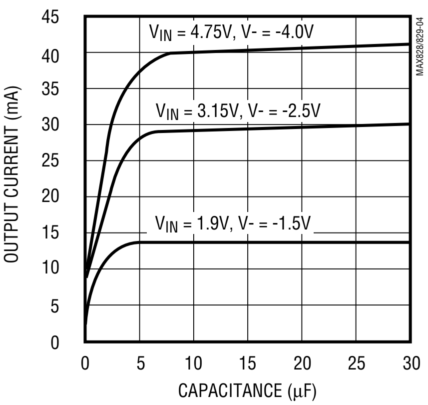
OUTPUT RESISTANCE vs. TEMPERATURE



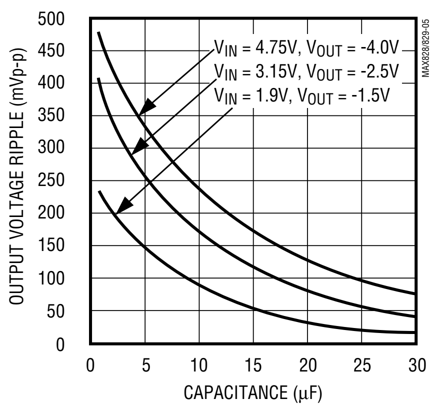
MAX828 OUTPUT CURRENT vs. CAPACITANCE



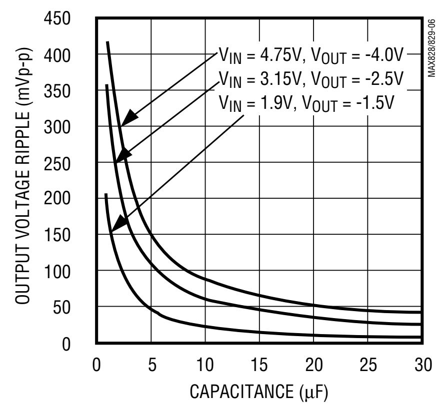
MAX829 OUTPUT CURRENT vs. CAPACITANCE



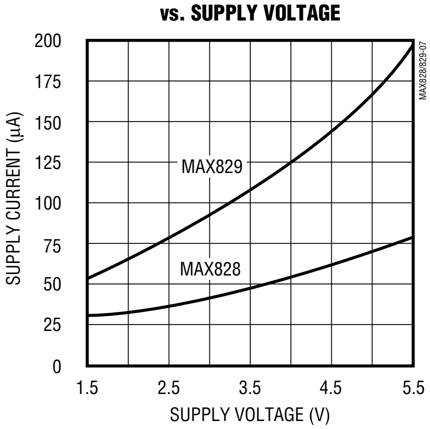
MAX828 OUTPUT VOLTAGE RIPPLE vs. CAPACITANCE



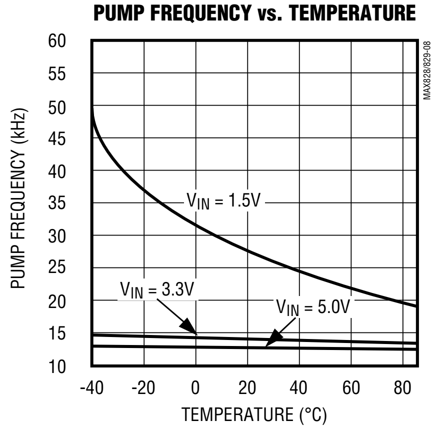
MAX829 OUTPUT VOLTAGE RIPPLE vs. CAPACITANCE



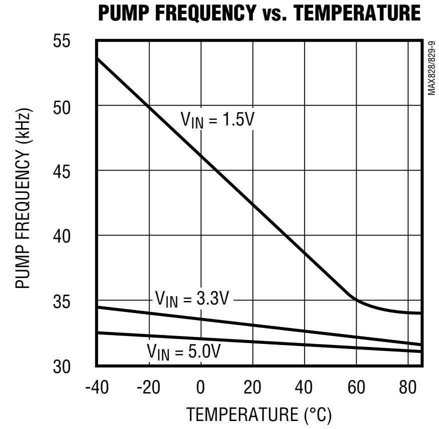
SUPPLY CURRENT vs. SUPPLY VOLTAGE



MAX828 PUMP FREQUENCY vs. TEMPERATURE



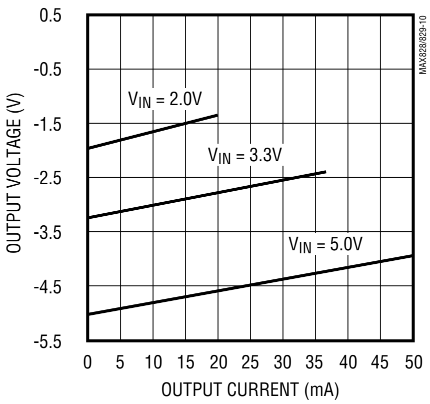
MAX829 PUMP FREQUENCY vs. TEMPERATURE



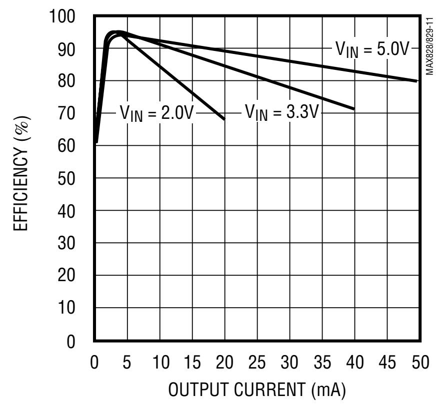
Typical Operating Characteristics (continued)

(Circuit of Figure 1, V_{IN} = +5V, C1 = C2 = C3, T_A = +25°C, unless otherwise noted.)

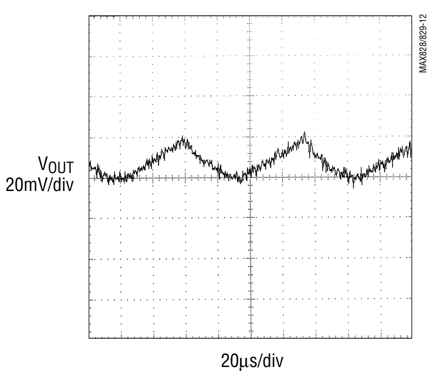
OUTPUT VOLTAGE vs. OUTPUT CURRENT



EFFICIENCY vs. OUTPUT CURRENT

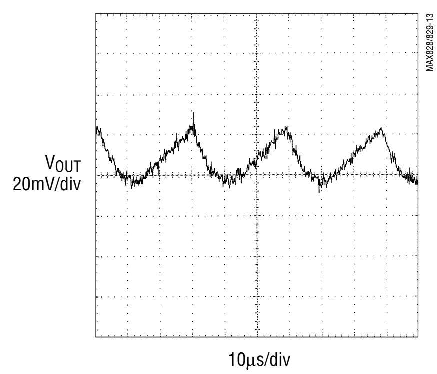


MAX828 OUTPUT NOISE AND RIPPLE



V_{IN} = 3.3V, V_{OUT} = -3.2V, I_{OUT} = 5mA, AC COUPLED

MAX829 OUTPUT NOISE AND RIPPLE



V_{IN} = 3.3V, V_{OUT} = -3.2V, I_{OUT} = 5mA, AC COUPLED

Pin Description

PIN	NAME	FUNCTION
1	OUT	Inverting Charge-Pump Output
2	IN	Positive Power-Supply Input
3	C1-	Flying Capacitor's Negative Terminal
4	GND	Ground
5	C1+	Flying Capacitor's Positive Terminal

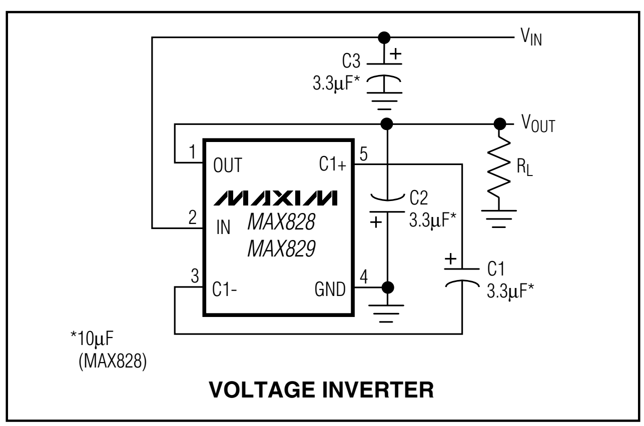


Figure 1. Test Circuit

Detailed Description

The MAX828/MAX829 capacitive charge pumps invert the voltage applied to their input. For highest performance, use low equivalent series resistance (ESR) capacitors.

During the first half-cycle, switches S2 and S4 open, switches S1 and S3 close, and capacitor C1 charges to the voltage at IN (Figure 2). During the second half-cycle, S1 and S3 open, S2 and S4 close, and C1 is level shifted downward by V_{IN} volts. This connects C1 in parallel with the reservoir capacitor C2. If the voltage across C2 is smaller than the voltage across C1, then charge flows from C1 to C2 until the voltage across C2 reaches $-V_{IN}$. The actual voltage at the output is more positive than $-V_{IN}$, since switches S1–S4 have resistance and the load drains charge from C2.

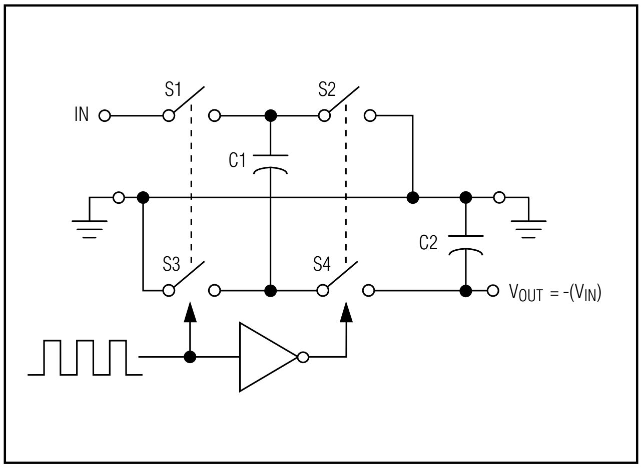


Figure 2. Ideal Voltage Inverter

Charge-Pump Output

The MAX828/MAX829 are not voltage regulators: the charge pump's output source resistance is approximately 20Ω at room temperature (with V_{IN} = +5V), and V_{OUT} approaches -5V when lightly loaded. V_{OUT} will droop toward GND as load current increases. The droop of the negative supply (V_{DROOP-}) equals the current draw from OUT (I_{OUT}) times the negative converter's source resistance (RS-):

$$V_{DROOP-} = I_{OUT} \times RS-$$

The negative output voltage will be:

$$V_{OUT} = -(V_{IN} - V_{DROOP-})$$

Efficiency Considerations

The efficiency of the MAX828/MAX829 is dominated by its quiescent supply current (I_Q) at low output current and by its output impedance (R_{OUT}) at higher output current; it is given by:

$$\eta \cong \frac{I_{OUT}}{I_{OUT} + I_Q}\left(1 - \frac{I_{OUT} \times R_{OUT}}{V_{IN}}\right)$$

where the output impedance is roughly approximated by:

$$R_{OUT} \cong \frac{1}{(f_{OSC}) \times C1} + 2R_{SW} + 4ESR_{C1} + ESR_{C2}$$

The first term is the effective resistance of an ideal switched-capacitor circuit (Figures 3a and 3b), and R_{SW} is the sum of the charge pump's internal switch resistances (typically 8Ω to 9Ω at V_{IN} = +5V). The typical output impedance is more accurately determined from the *Typical Operating Characteristics*.

Applications Information

Capacitor Selection

To maintain the lowest output resistance, use capacitors with low ESR (Table 1). The charge-pump output resistance is a function of C1's and C2's ESR. Therefore, minimizing the charge-pump capacitor's ESR minimizes the total output resistance.

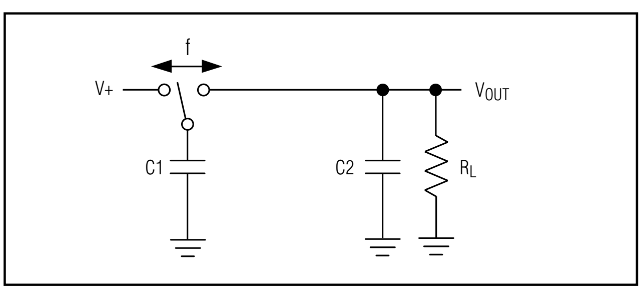


Figure 3a. Switched-Capacitor Model

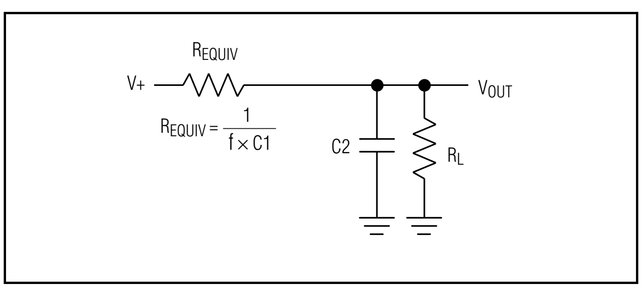


Figure 3b. Equivalent Circuit

Switched-Capacitor Voltage Inverters

Flying Capacitor (C1)

Increasing the flying capacitor's size reduces the output resistance. Small C1 values increase the output resistance. Above a certain point, increasing C1's capacitance has a negligible effect, because the output resistance becomes dominated by the internal switch resistance and capacitor ESR.

Output Capacitor (C2)

Increasing the output capacitor's size reduces the output ripple voltage. Decreasing its ESR reduces both output resistance and ripple. Smaller capacitance values can be used with light loads if higher output ripple can be tolerated. Use the following equation to calculate the peak-to-peak ripple:

$$V_{RIPPLE} = \frac{I_{OUT}}{f_{OSC} \times C2} + 2 \times I_{OUT} \times ESR_{C2}$$

Input Bypass Capacitor

Bypass the incoming supply to reduce its AC impedance and the impact of the MAX828/MAX829's switching noise. The recommended bypassing depends on the circuit configuration and on where the load is connected.

When the inverter is loaded from OUT to GND, current from the supply switches between 2 x I_{OUT} and zero. Therefore, use a large bypass capacitor (e.g., equal to the value of C1) if the supply has a high AC impedance.

When the inverter is loaded from IN to OUT, the circuit draws 2 x I_{OUT} constantly, except for short switching spikes. A 0.1µF bypass capacitor is sufficient.

Voltage Inverter

The most common application for these devices is a charge-pump voltage inverter (Figure 1). This application requires only two external components—capacitors C1 and C2—plus a bypass capacitor, if necessary. Refer to the *Capacitor Selection* section for suggested capacitor types and values.

Cascading Devices

Two devices can be cascaded to produce an even larger negative voltage (Figure 4). The unloaded output voltage is normally -2 x V_{IN}, but this is reduced slightly by the output resistance of the first device multiplied by the quiescent current of the second. When cascading more than two devices, the output resistance rises dramatically. For applications requiring larger negative voltages, see the MAX864 and MAX865 data sheets.

Paralleling Devices

Paralleling multiple MAX828s or MAX829s reduces the output resistance. Each device requires its own pump capacitor (C1), but the reservoir capacitor (C2) serves all devices (Figure 5). Increase C2's value by a factor of n, where n is the number of parallel devices. The equation for calculating output resistance is also shown in Figure 5.

Combined Doubler/Inverter

In the circuit of Figure 6, capacitors C1 and C2 form the inverter, while C3 and C4 form the doubler. C1 and C3 are the pump capacitors; C2 and C4 are the reservoir capacitors. Because both the inverter and doubler use part of the charge-pump circuit, loading either output causes both outputs to decline toward GND. Make sure the sum of the currents drawn from the two outputs does not exceed 40mA.

Table 1. Low-ESR Capacitor Manufacturers

MANUFACTURER		PHONE	FAX	DEVICE TYPE
AVX		(803) 946-0690 (800) 282-4975	(803) 626-3123	Surface-mount, TPS series
Matsuo		(714) 969-2491	(714) 960-6492	Surface-mount, 267 series
Sanyo	USA	(619) 661-6835	(619) 661-1055	Through-hole, OS-CON series
	Japan	81-7-2070-6306	81-7-2070-1174	
Sprague		(603) 224-1961	(603) 224-1430	Surface-mount, 595D series

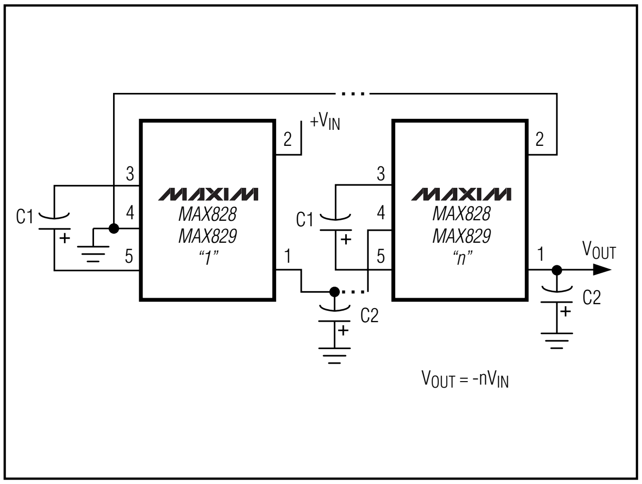


Figure 4. Cascading MAX828s or MAX829s to Increase Output Voltage

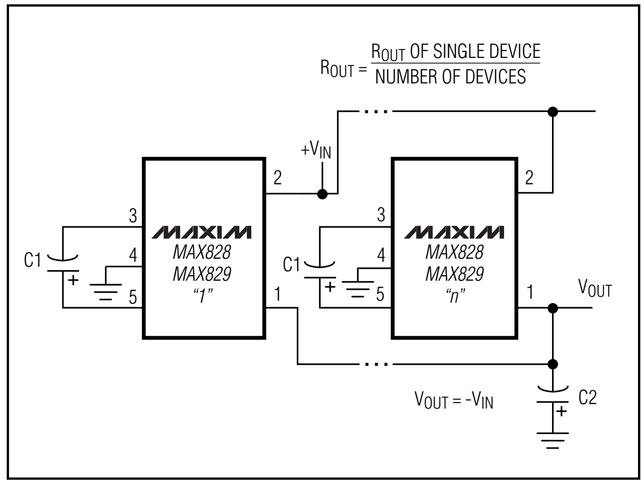


Figure 5. Paralleling MAX828s or MAX829s to Reduce Output Resistance

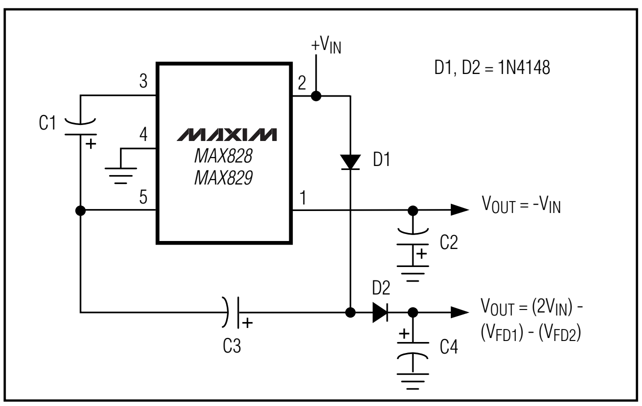


Figure 6. Combined Doubler and Inverter

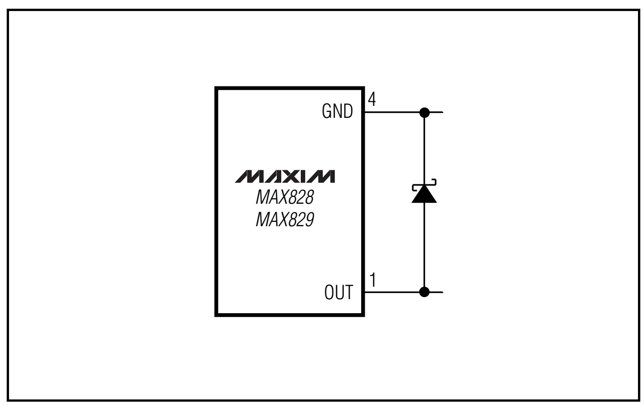


Figure 7. High V- Load Current

Heavy Output Current Loads

When under heavy loads, where higher supply is sourcing current into OUT, the OUT supply must not be pulled above ground. Applications that sink heavy current into OUT require a Schottky diode (1N5817) between GND and OUT, with the anode connected to OUT (Figure 7).

Layout and Grounding

Good layout is important, primarily for good noise performance. To ensure good layout, mount all components as close together as possible, keep traces short to minimize parasitic inductance and capacitance, and use a ground plane.

Shutting Down the MAX828/MAX829

For a similar device with logic-controlled shutdown, please refer to the MAX1719/MAX1720/MAX1721. To add manual shutdown control to the MAX828/MAX829, use the circuit in Figure 8. The output resistance of the MAX828/MAX829 will typically be 20Ω plus two times the output resistance of the buffer driving IN. The 0.1µF capacitor at the IN pin absorbs the transient input currents of the MAX828/MAX829.

The output resistance of the buffer driving the IN pin can be reduced by connecting multiple buffers in parallel. The polarity of the SHUTDOWN signal can also be changed by using a noninverting buffer to drive IN.

Switched-Capacitor Voltage Inverters

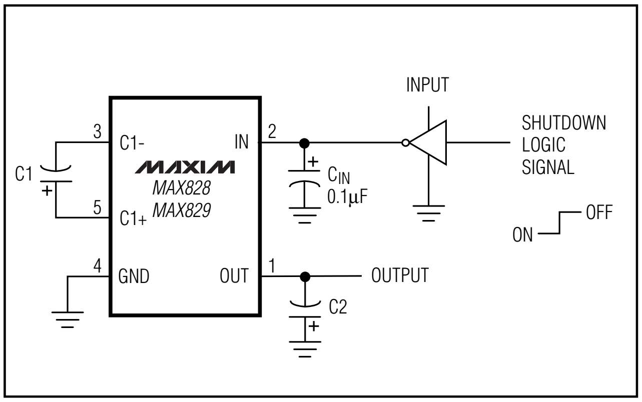


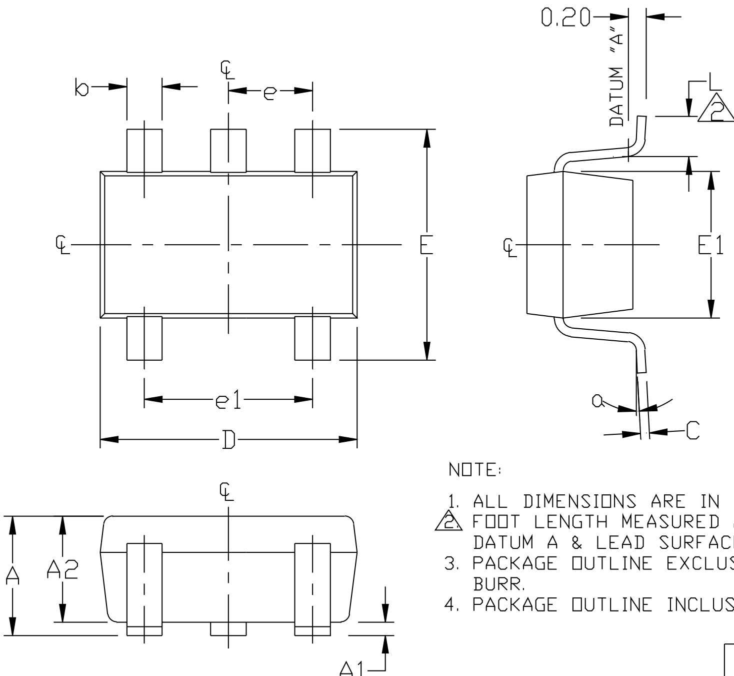
Figure 8. Shutdown Control

Chip Information

TRANSISTOR COUNT: 58

SUBSTRATE CONNECTED TO IN

Package Information



SYMBOL	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.35	0.50
C	0.08	0.20
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.75
L	0.35	0.55
e	0.95 REF	
e1	1.90 REF	
α	0°	10°

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.

MAXIM
PROPRIETARY INFORMATION
TITLE:
PACKAGE OUTLINE, SOT23, 5L
APPROVAL | DOCUMENT CONTROL NO. 21-0057 | REV B | 1/1

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