MAX828 MAX829

Switched Capacitor Voltage Converters

ON Semiconductor
Formerly a Division of Motorola
http://onsemi.com

The MAX828/829 are CMOS "charge–pump" voltage converters in ultra–small SOT–23 5 lead packages. They invert and/or double an input voltage which can range from +1.5V to +5.5V. Conversion efficiency is typically >95%. Switching frequency is 12kHz for the MAX828 and 35kHz for the MAX829.

External component requirement is only two capacitors (3.3μF nominal) for standard voltage inverter applications. With a few additional components a positive doubler can also be built. All other circuitry, including control, oscillator, power MOSFETs are integrated on–chip. Supply current is 50 μA (MAX828) and 115 μA (MAX829).

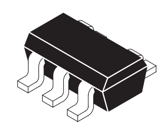
The MAX828 and MAX829 are available in a SOT–23 5 lead surface mount package.

Features

- Charge Pump in SOT–23 5 Lead Package
- >95% Voltage Conversion Efficiency
- Voltage Inversion and/or Doubling
- Low 50 μA (MAX828) Quiescent Current
- Operates from +1.5V to +5.5V
- Up to 25 mA Output Current
- Only Two External Capacitors Required
- Tested Operating Temperature Range: –40°C to +85°C

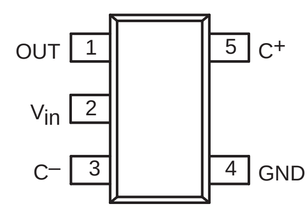
Typical Applications

- LCD Panel Bias
- Cellular Phones
- Pagers
- PDAs, Portable Dataloggers
- Battery–Powered Devices



SOT–23–5
SN SUFFIX
CASE TBD
PRELIMINARY INFORMATION

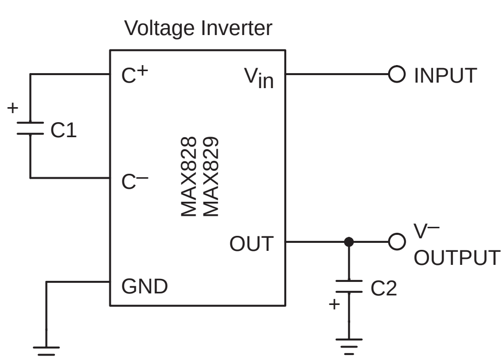
PIN CONFIGURATION
(Top View)



SOT–23–5*

NOTE: *SOT–23–5 is equivalent to EIAJ–SC74A

TYPICAL OPERATING CIRCUIT



ORDERING INFORMATION

Device	Package	Shipping
MAX828SNTR	SOT–23–5	3000 Tape/Reel
MAX829SNTR	SOT–23–5	3000 Tape/Reel

PIN DESCRIPTION

Pin No.	Symbol	Description
1	OUT	Inverting charge pump output
2	V_{IN}	Positive power supply input
3	C^{-}	Commutation capacitor negative terminal
4	GND	Ground
4	C^{+}	Commutation capacitor positive terminal

ABSOLUTE MAXIMUM RATINGS*

Symbol	Parameter	Value	Unit
	Input Voltage (V_{IN} to GND)	+6.0, – 0.3	V
	Output Voltage (OUT to GND)	–6.0, +0.3	V
	Current at OUT Pin	50	mA
	Short–Circuit Duration – OUT to GND	Indefinite	
T_A	Operating Temperature Range	–40 to +85	°C
P_D	Power Dissipation ($T_A \leq 70°C$) SOT–23–5 Derate by 4mW/°C for $T_A > 70°C$	240	mW
T_{stg}	Storage Temperature Range	–65 to +150	°C
T_{sol}	Lead Temperature (Soldering, 10 Seconds)	+300	°C

* Maximum Ratings are those values beyond which damage to the device may occur.

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

Symbol	Characteristic	Min	Typ	Max	Unit
I_{DD}	Supply Current (T_A = 25°C) MAX828 MAX829	 — —	 50 115	 90 260	µA
V^{+}	Supply Voltage Range (R_{LOAD} = 10kΩ)	—	—	5.5	V
F_{OSC}	Oscillator Frequency (T_A = 25°C) MAX828 MAX829	 8.4 24.5	 12 35	 15.6 45.5	kHz
P_{EFF}	Power Efficiency I_{LOAD} = 3mA, T_A = 25°C	 —	 96	 —	%
V_{EFF}	Voltage Conversion Efficiency ($R_{LOAD} = \infty$)	95	99.9		%
R_{OUT}	Output Resistance (Note 1.) I_{OUT} = 5mA, T_A = 25°C T_A = 0°C to +85°C	 — —	 25 —	 50 65	Ω

1. Capacitors C1 and C2 contribution is approximately 20% of the output impedance. For additional information, refer to Equation 1 in the Applications Information section.

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

Symbol	Characteristic	Min	Typ	Max	Unit
I_{DD}	Supply Current MAX828 MAX829	 — —	 — —	 115 325	µA
V_{in}	Supply Voltage Range (R_{LOAD} = 10kΩ)	1.5	—	5.5	V
F_{OSC}	Oscillator Frequency MAX828 MAX829	 6.0 19	 — —	 20 54.3	kHz
R_{OUT}	Output Resistance (I_{OUT} = 5mA)	—	—	65	Ω

2. All –40°C to +85°C specifications are guaranteed by design.

DETAILED OPERATING DESCRIPTION

The MAX828/829 charge pump converters invert the voltage applied to the V_{IN} pin. Conversion consists of a two–phase operation (Figure 1). During the first phase, switches S2 and S4 are open and S1 and S3 are closed. During this time, C1 charges to the voltage on V_{IN} and load current is supplied from C2. During the second phase, S2 and S4 are closed, and S1 and S3 are open. This action connects C1 across C2, restoring charge to C2.

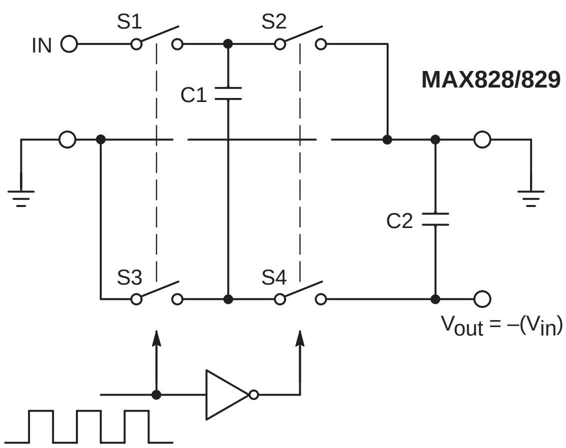


Figure 1. Ideal Switched Capacitor Charge Pump

APPLICATIONS INFORMATION

Output Voltage Considerations

The MAX828/829 perform voltage conversion but do not provide *regulation*. The output voltage will drop in a linear manner with respect to load current. The value of this equivalent output resistance is approximately 25Ω nominal at +25°C and V_{IN} = +5V. V_{OUT} is approximately - 5V at light loads, and droops according to the equation below:

$$V_{DROP} = I_{OUT} \text{ x } R_{OUT}$$
$$V_{OUT} = -(V_{IN} - V_{DROP})$$

Charge Pump Efficiency

The overall power efficiency of the charge pump is affected by four factors:

(1) Losses from power consumed by the internal oscillator, switch drive, etc. (which vary with input voltage, temperature and oscillator frequency).

(2) I^2R losses due to the on–resistance of the MOSFET switches on–board the charge pump.

(3) Charge pump capacitor losses due to effective series resistance (ESR).

(4) Losses that occur during charge transfer (from the commutation capacitor to the output capacitor) when a voltage difference between the two capacitors exists.

Most of the conversion losses are due to factors (2), (3) and (4) above. These losses are given by Equation 1.

$$P_{LOSS(2,3,4)} = I_{OUT}{}^2 \times R_{OUT} \cong I_{OUT}{}^2 \times \left[\frac{1}{(f_{OSC})C1} + 8R_{SWITCH} + 4ESR_{C1} + ESR_{C2}\right]$$

Equation 1.

The $1/(f_{OSC})(C1)$ term in Equation 1 is the effective output resistance of an ideal switched capacitor circuit (Figures 2a, 2b).

The losses in the circuit due to factor (4) above are also shown in Equation 2. The output voltage ripple is given by Equation 3.

$$P_{LOSS(4)} = \left[(0.5)(C1)(V_{IN}{}^2 - V_{OUT}{}^2) + (0.5)(C2)(V_{RIPPLE}{}^2 - 2V_{OUT}V_{RIPPLE})\right] \times f_{OSC}$$

Equation 2.

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

Equation 3.

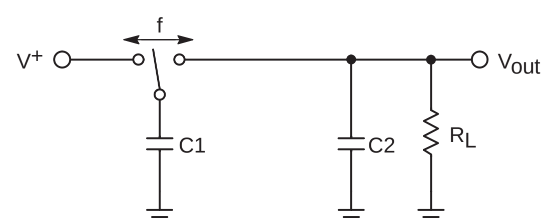


Figure 2a. Ideal Switched Capacitor Model

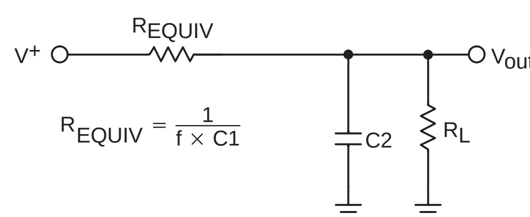


Figure 2b. Equivalent Output Resistance

Capacitor Selection

In order to maintain the lowest output resistance and output ripple voltage, it is recommended that low ESR capacitors be used. Additionally, larger values of C1 will lower the output resistance and larger values of C2 will reduce output ripple. (See Equation 3).

Table 1 shows various values of C1 and the corresponding output resistance values at +25°C. It assumes a 0.1Ω ESR_{C1} and 0.5Ω R_{SW}. Table 2 shows the output voltage ripple for various values of C2. The V_{RIPPLE} values assume 10mA output load current and 0.1Ω ESR_{C2}.

Table 1. Output Resistance vs. C1 (ESR = 0.1Ω)

C1(µF)	MAX828 R_{OUT} (Ω)	MAX829 R_{OUT} (Ω)
0.1	1.7k	580
1	170	61
3.3	55	21
10	21	10
47	8.0	5.7
100	6.2	5.1

Table 2. Output Voltage Ripple vs. C2 (ESR = 0.1Ω) I_{OUT} = 10mA

C2(µF)	MAX828 V_{RIPPLE} (mV)	MAX829 V_{RIPPLE} (mV)
1	830	290
3.3	250	87
10	83	28
47	17	6.1
100	8.3	2.9

Input Supply Bypassing

The V_{IN} input should be capacitively bypassed to reduce AC impedance and minimize noise effects due to the switching internal to the device. The recommended capacitor depends on the configuration of the MAX828/829.

If the device is loaded from OUT to GND it is recommended that a large value capacitor (at least equal to C1) be connected from the input to GND. If the device is loaded from IN to OUT a small (0.1µF) capacitor from IN to OUT is sufficient.

Voltage Inverter

The most common application for charge pump devices is the inverter (Figure 3). This application uses two external capacitors - C1 and C2 (plus a power supply bypass capacitor, if necessary). The output is equal to $-V_{IN}$ plus any voltage drops due to loading. Refer to Table 1 and Table 2 for capacitor selection.

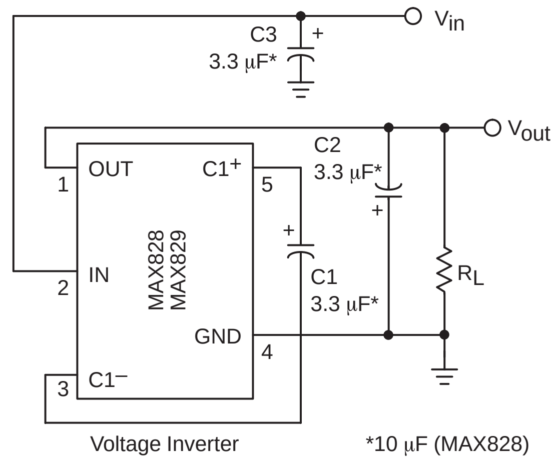


Figure 3. Test Circuit

Cascading Devices

Two or more MAX828/829's can be cascaded to increase output voltage (Figure 4). If the output is lightly loaded, it will be close to (- 2 x V_{IN}) but will droop at least by R_{OUT} of the first device multiplied by the I_Q of the second. It can be seen that the output resistance rises rapidly for multiple cascaded devices.

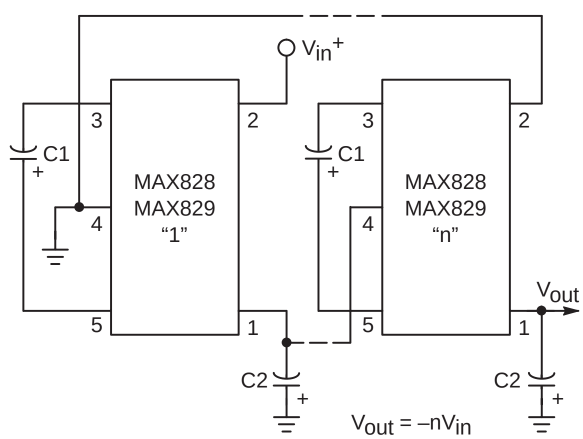


Figure 4. Cascading MAX828s or MAX829s to Increase Output Voltage

Paralleling Devices

To reduce the value of R_{OUT}, multiple MAX828/829s can be connected in parallel (Figure 5). The output resistance will be reduced by a factor of N where N is the number of MAX828/829's. Each device will require it's own pump capacitor (C1), but all devices may share one reservoir capacitor (C2). However, to preserve ripple performance the value of C2 should be scaled according to the number of paralleled MAX828/829's.

$$R_{out} = \frac{R_{out} \text{ OF SINGLE DEVICE}}{\text{NUMBER OF DEVICES}}$$

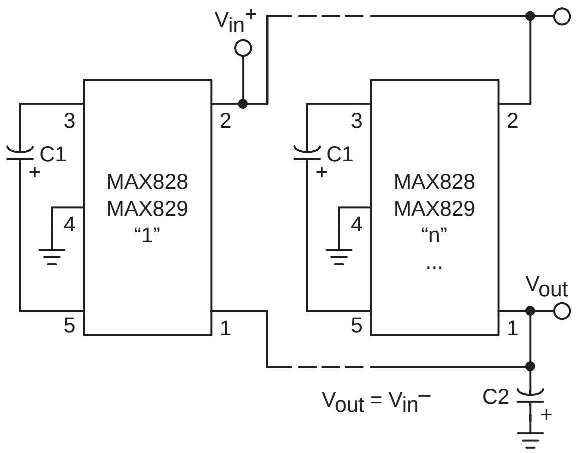


Figure 5. Paralleling MAX828s or MAX829s to Reduce Output Resistance

Voltage Doubler/Inverter

Another common application of the MAX828/829 is shown in Figure 6. This circuit performs two functions in combination. C1 and C2 form the standard inverter circuit described above. C3 and C4 plus the two diodes form the voltage doubler circuit. C1 and C3 are the pump capacitors and C2 and C4 are the reservoir capacitors. Because both sub–circuits rely on the same switches if either output is loaded, both will droop toward GND. Make sure that the total current drawn from both the outputs does not total more than 40mA.

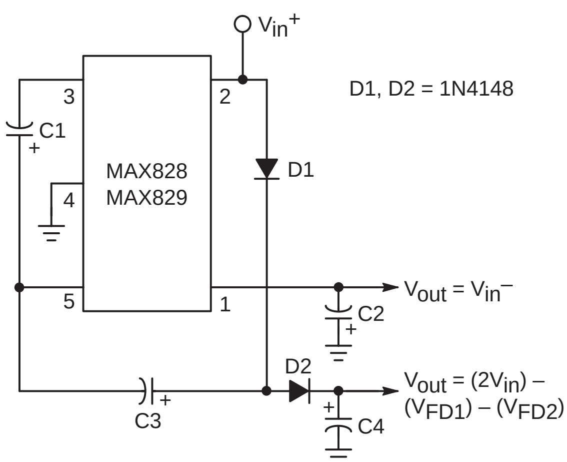


Figure 6. Combined Doubler and Inverter

Diode Protection for Heavy Loads

When heavy loads require the OUT pin to sink large currents being delivered by a positive source, diode protection may be needed. The OUT pin should not be allowed to be pulled above ground. This is accomplished by connecting a Schottky diode (1N5817) as shown in Figure 7.

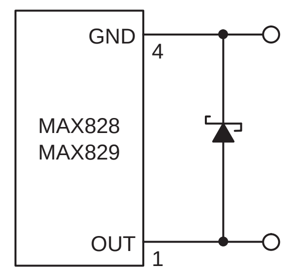


Figure 7. High V– Load Current

Layout Considerations

As with any switching power supply circuit good layout practice is recommended. Mount components as close together as possible to minimize stray inductance and capacitance. Also use a large ground plane to minimize noise leakage into other circuitry.

TYPICAL CHARACTERISTICS

Circuit of Figure 3, V_{in} = +5 V, C1 = C2 = C3, T_A = +25°C, unless otherwise noted.

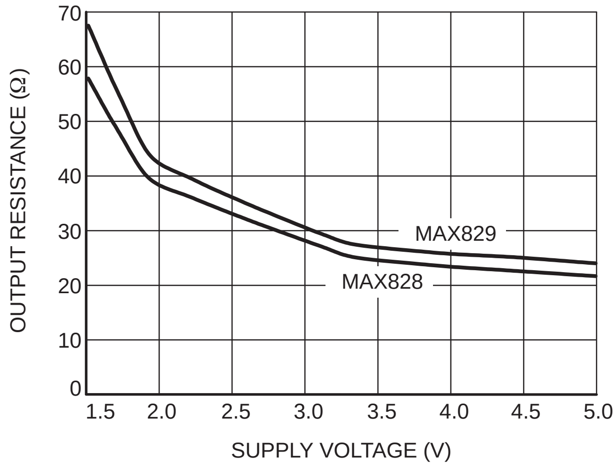


Figure 8. Output Resistance versus Supply Voltage

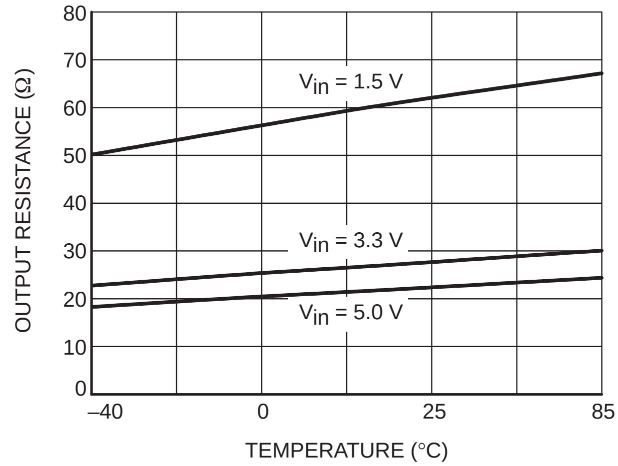


Figure 9. Output Resistance versus Temperature

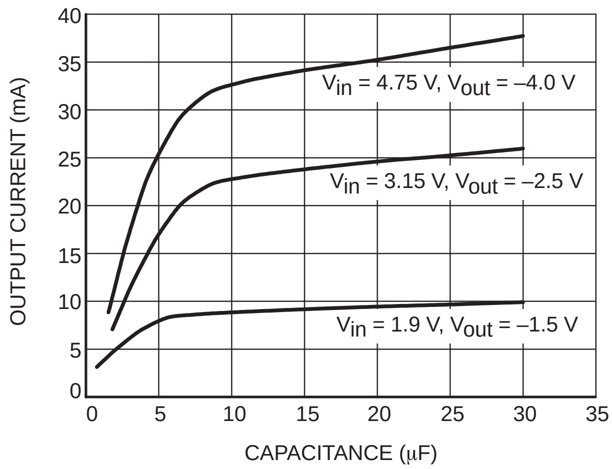


Figure 10. Output Current versus Capacitance (MAX828)

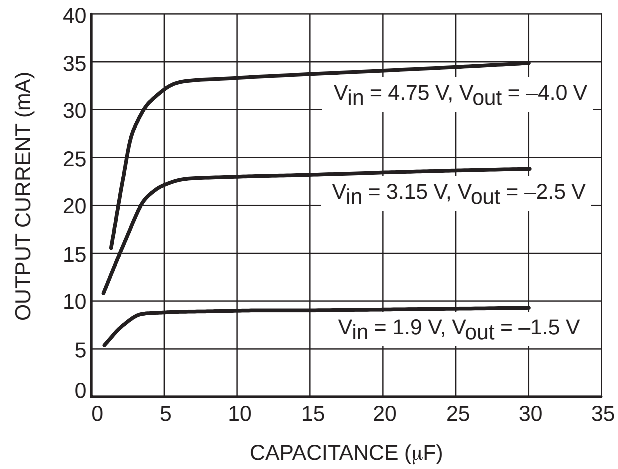


Figure 11. Output Current versus Capacitance (MAX829)

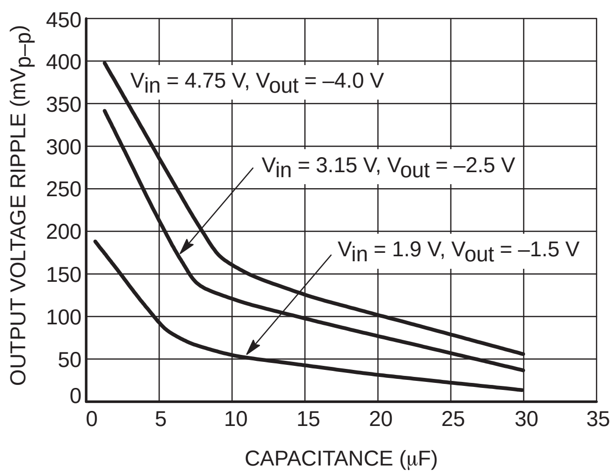


Figure 12. Output Voltage Ripple versus Capacitance (MAX828)

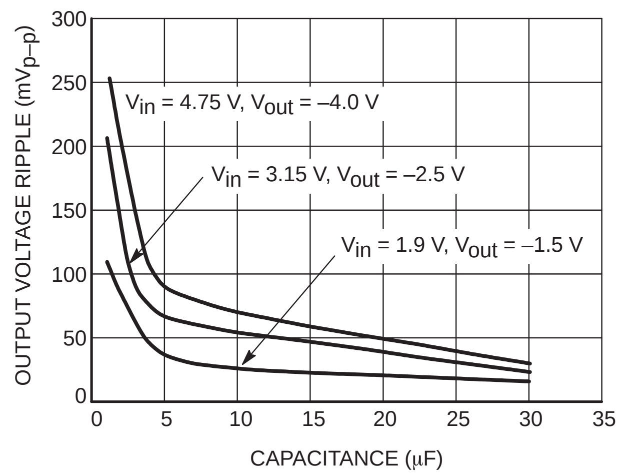


Figure 13. Output Voltage Ripple versus Capacitance (MAX829)

TYPICAL CHARACTERISTICS

Circuit of Figure 3, V_{in} = +5 V, C1 = C2 = C3, T_A = +25°C, unless otherwise noted.

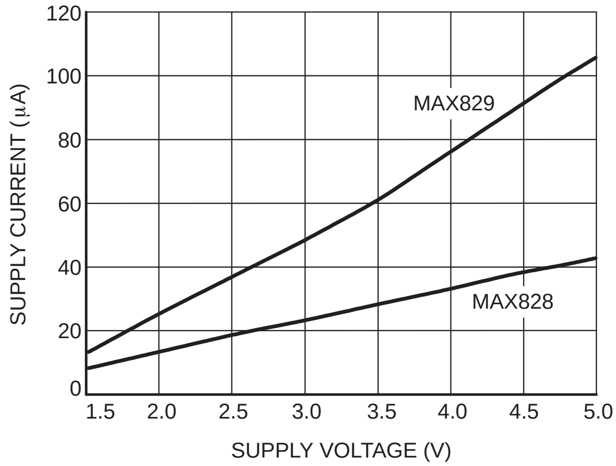


Figure 14. Supply Current versus Supply Voltage

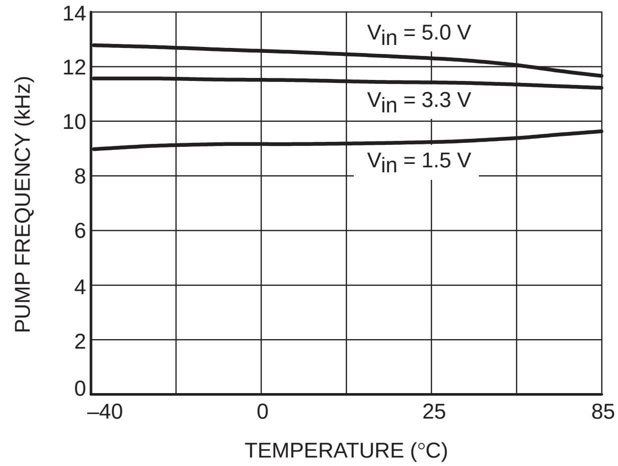


Figure 15. Pump Frequency versus Temperature (MAX828)

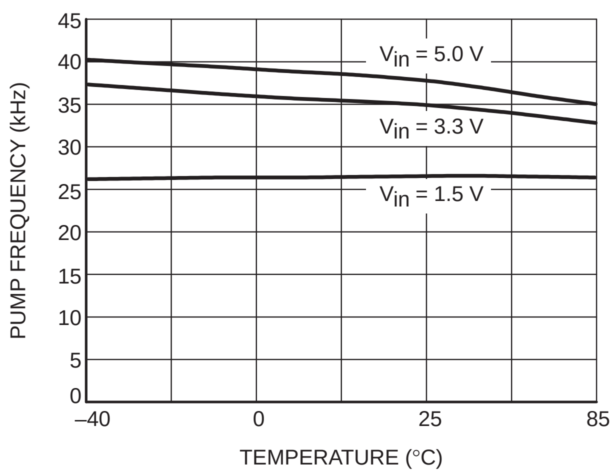


Figure 16. Pump Frequency versus Temperature (MAX829)

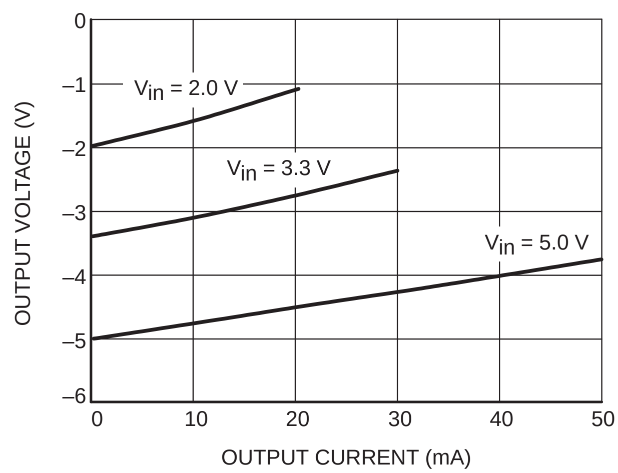


Figure 17. Output Voltage versus Output Current

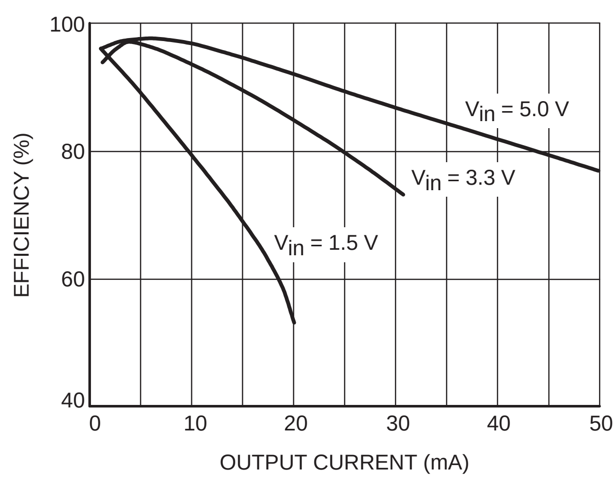
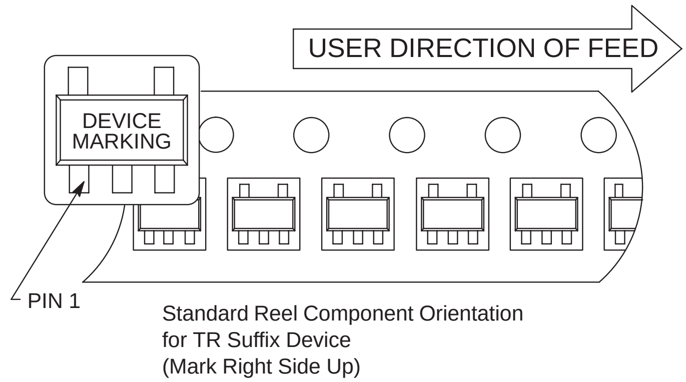


Figure 18. Efficiency versus Output Current

TAPING FORM

Component Taping Orientation for 5L SOT–23 Devices

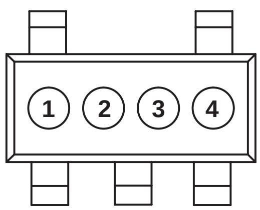


Tape & Reel Specifications Table

Package	Tape Width (W)	Pitch (P)	Part Per Full Reel	Diameter
5L SOT–23	8 mm	4 mm	3000	7 inches

MARKING

SOT–23–5

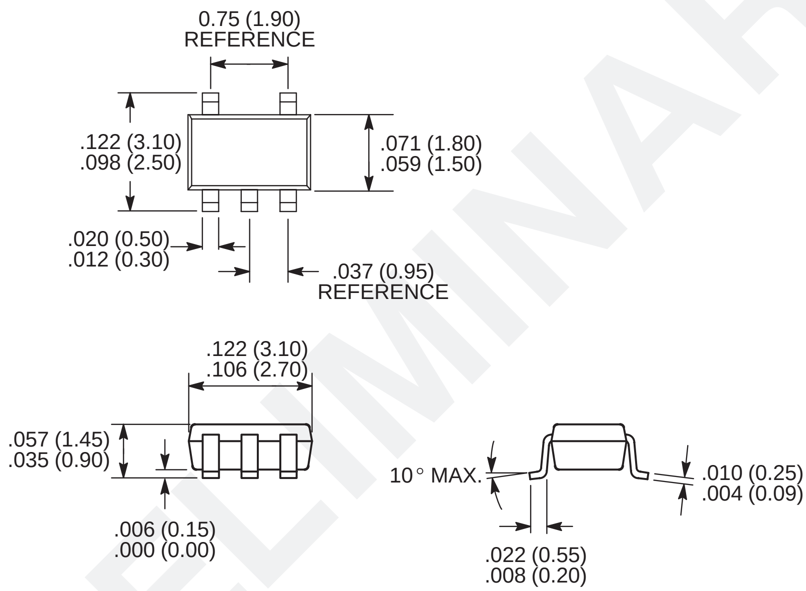


MAX828/829	Marking 1 + 2
MAX828SNTR	CA
MAX829SNTR	CB

3 + 4 Date Code

PACKAGE DIMENSIONS

SOT–23–5
PLASTIC PACKAGE
CASE TBD
ISSUE TBD



NOTE: SOT–23–5 is equivalent to EIAJ–SC74A

Dimensions: inches (mm)

Notes

Notes

PUBLICATION ORDERING INFORMATION

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