



# 50mA Regulated Step-Down Charge Pump for 1.8V or 1.9V Logic

## General Description

The MAX1730 regulated step-down charge pump generates up to 50mA at fixed output voltages of 1.8V or 1.9V from an input voltage in the 2.7V to 5.5V range. Specifically designed to provide high-efficiency logic supplies in applications that demand a compact design, the MAX1730 employs fractional conversion techniques to provide efficiency exceeding that of a linear regulator.

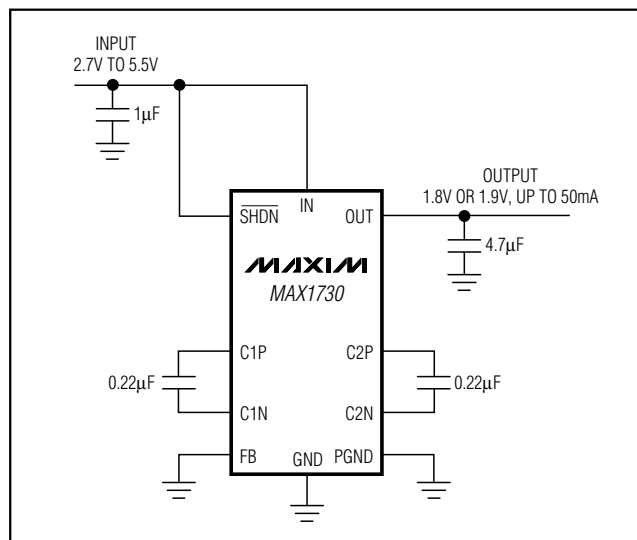
The MAX1730 operates at up to 2MHz, permitting the use of small 0.22μF flying capacitors while maintaining low 75μA quiescent supply current. Proprietary soft-start circuitry prevents excessive current from being drawn from the supply during startup, making the MAX1730 compatible with higher impedance sources such as alkaline and lithium-ion cells.

The MAX1730 is available in a space-saving 10-pin μMAX package that is only 1.09mm high and occupies one-half the area of an 8-pin SO.

## Applications

Low-Voltage Logic Supplies  
Wireless Handsets  
PDAs  
PC Cards  
Hand-Held Instruments

## Typical Operating Circuit



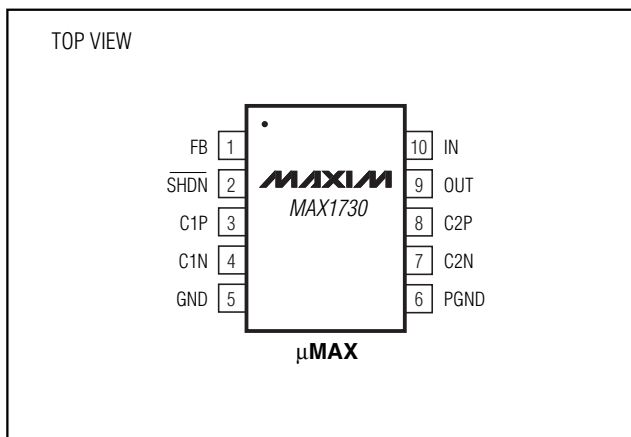
## Features

- ◆ > 85% Peak Efficiency
- ◆ 50mA Guaranteed Output Current
- ◆ Dual-Mode 1.8V or 1.9V Output
- ◆ ±3% Output Voltage Accuracy
- ◆ Up to 2MHz Operating Frequency
- ◆ Small 0.22μF Capacitors
- ◆ No Inductor Required
- ◆ 2.7V to 5.5V Input Voltage Range
- ◆ Output Disconnects from Input in Shutdown Mode
- ◆ Small 10-Pin μMAX Package (1.09mm max height)

## Ordering Information

| PART       | TEMP. RANGE    | PIN-PACKAGE |
|------------|----------------|-------------|
| MAX1730EUB | -40°C to +85°C | 10 μMAX     |

## Pin Configuration



# 50mA Regulated Step-Down Charge Pump for 1.8V or 1.9V Logic

## ABSOLUTE MAXIMUM RATINGS

IN, OUT,  $\overline{\text{SHDN}}$ , FB to GND ..... -0.3V to +6V  
 C1P, C1N, C2P, C2N to GND ..... -0.3V to ( $V_{\text{IN}} + 0.3\text{V}$ )  
 GND to PGND .....  $\pm 0.3\text{V}$   
 Output Short-Circuit Duration ..... Indefinite  
 Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )  
 10-Pin  $\mu\text{MAX}$  (derate 5.6mW/ $^\circ\text{C}$  above  $+70^\circ\text{C}$ ) ..... 444mW

Junction Temperature .....  $+150^\circ\text{C}$   
 Operating Temperature Range .....  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$   
 Storage Temperature Range .....  $-65^\circ\text{C}$  to  $+150^\circ\text{C}$   
 Lead Temperature Range (soldering, 10s) .....  $+300^\circ\text{C}$

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

( $V_{\text{IN}} = +3.6\text{V}$ , FB = GND,  $\overline{\text{SHDN}} = \text{IN}$ ,  $T_A = 0^\circ\text{C}$  to  $+85^\circ\text{C}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ\text{C}$ .)

| PARAMETER                                                       | SYMBOL                       | CONDITIONS                                                                                                    |                 | MIN   | TYP  | MAX   | UNITS            |
|-----------------------------------------------------------------|------------------------------|---------------------------------------------------------------------------------------------------------------|-----------------|-------|------|-------|------------------|
| Input Voltage Range                                             | $V_{\text{IN}}$              |                                                                                                               |                 | 2.7   |      | 5.5   | V                |
| Input Undervoltage Lockout                                      |                              | Falling edge (100mV hysteresis)                                                                               |                 | 2.3   |      | 2.6   | V                |
| Output Voltage                                                  | $V_{\text{OUT}}$             | $V_{\text{IN}} = 2.7\text{V}$ to $5.5\text{V}$ ,<br>$I_{\text{OUT}} = 0$ to $50\text{mA}$                     | FB = GND        | 1.746 | 1.80 | 1.854 | V                |
|                                                                 |                              |                                                                                                               | FB = IN         | 1.843 | 1.90 | 1.957 |                  |
| Output Leakage Current                                          |                              | OUT forced to 1.8V, $V_{\text{IN}} = 1.8\text{V}$ to $5.5\text{V}$ ,<br>$\overline{\text{SHDN}} = \text{GND}$ |                 |       | 1    | 5     | $\mu\text{A}$    |
| No-Load Supply Current                                          |                              | $\overline{\text{SHDN}} = \text{IN}$                                                                          |                 |       | 75   | 150   | $\mu\text{A}$    |
| Shutdown Supply Current                                         |                              | $V_{\text{IN}} = 4.2\text{V}$ , $\overline{\text{SHDN}} = \text{GND}$ , $V_{\text{OUT}} = 1.8\text{V}$ or GND |                 |       | 1    | 5     | $\mu\text{A}$    |
| Output Short-Circuit Current                                    |                              | $V_{\text{OUT}} = \text{GND}$                                                                                 |                 |       | 45   | 125   | mA               |
| Oscillator Frequency                                            |                              |                                                                                                               |                 | 1.5   | 2.0  | 2.5   | MHz              |
| Thermal Shutdown Threshold                                      |                              |                                                                                                               |                 |       | 150  |       | $^\circ\text{C}$ |
| Thermal Shutdown Threshold Hysteresis                           |                              |                                                                                                               |                 |       | 15   |       | $^\circ\text{C}$ |
| $V_{\text{IN}}$ Transition Voltage<br>( $V_{\text{IN}}$ Rising) |                              | FB = GND                                                                                                      | From 1:1 to 2:3 | 3.1   | 3.2  | 3.35  | V                |
|                                                                 |                              |                                                                                                               | From 2:3 to 1:2 | 4.00  | 4.12 | 4.30  |                  |
| Startup Timer                                                   |                              |                                                                                                               |                 |       | 4.1  |       | ms               |
| $\overline{\text{SHDN}}$ Logic Input High Voltage               | $V_{\text{IH}}$              | $V_{\text{IN}} = 2.7\text{V}$ to $5.5\text{V}$                                                                |                 | 1.4   |      |       | V                |
| $\overline{\text{SHDN}}$ Logic Input Low Voltage                | $V_{\text{IL}}$              | $V_{\text{IN}} = 2.7\text{V}$ to $5.5\text{V}$                                                                |                 |       |      | 0.6   | V                |
| Shutdown Logic Input Current                                    | $I_{\overline{\text{SHDN}}}$ | $\overline{\text{SHDN}} = \text{IN}$ or GND                                                                   |                 | -1    |      | 1     | $\mu\text{A}$    |

# 50mA Regulated Step-Down Charge Pump for 1.8V or 1.9V Logic

MAX1730

## ELECTRICAL CHARACTERISTICS

( $V_{IN} = +3.6V$ ,  $FB = GND$ ,  $\overline{SHDN} = IN$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , unless otherwise noted.) (Note 1)

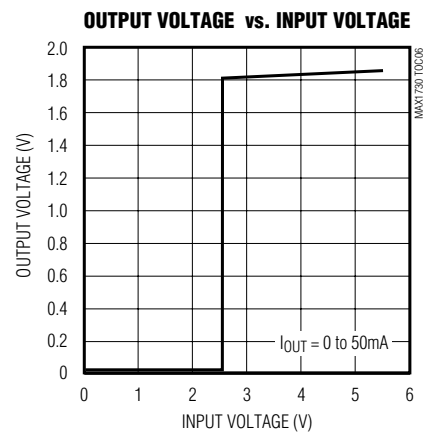
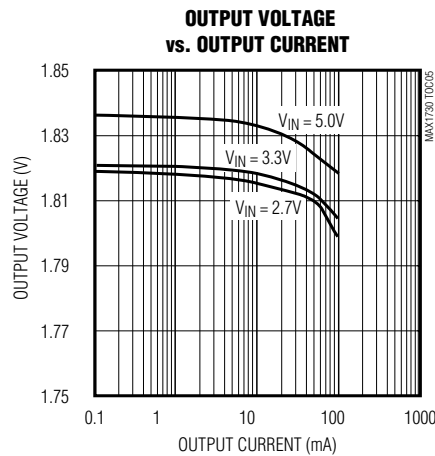
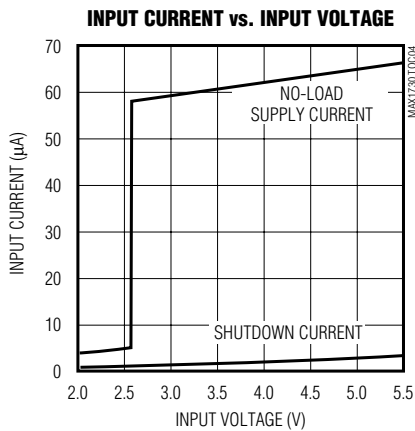
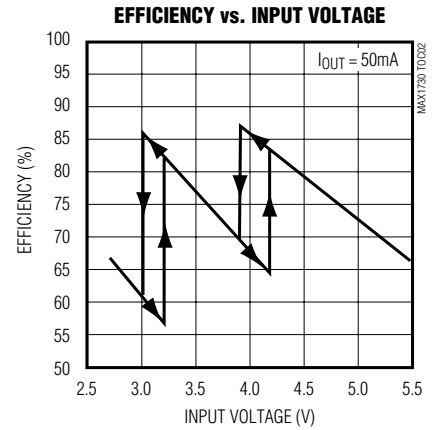
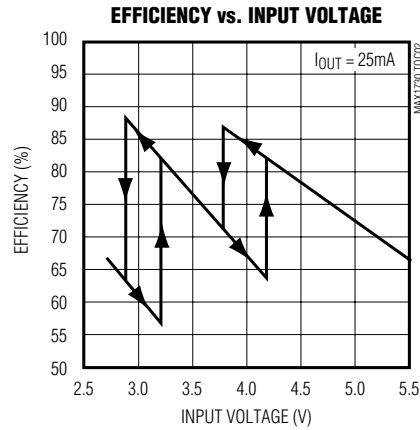
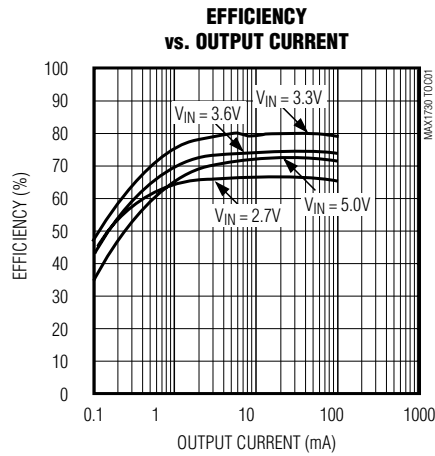
| PARAMETER                                         | SYMBOL                | CONDITIONS                                                                 |                 | MIN   | MAX   | UNITS   |
|---------------------------------------------------|-----------------------|----------------------------------------------------------------------------|-----------------|-------|-------|---------|
| Input Voltage Range                               | $V_{IN}$              |                                                                            |                 | 2.7   | 5.5   | V       |
| Input Undervoltage Lockout                        |                       | Falling edge (100mV hysteresis)                                            |                 | 2.3   | 2.6   | V       |
| Output Voltage                                    | $V_{OUT}$             | $V_{IN} = 2.7V$ to $5.5V$ ,<br>$I_{OUT} = 0$ to $50mA$                     | $FB = GND$      | 1.746 | 1.854 | V       |
|                                                   |                       |                                                                            | $FB = IN$       | 1.843 | 1.957 |         |
| Output Leakage Current                            |                       | OUT forced to 1.8V, $V_{IN} = 1.8V$ to $5.5V$ ,<br>$\overline{SHDN} = GND$ |                 |       | 5     | $\mu A$ |
| No-Load Supply Current                            |                       | $\overline{SHDN} = IN$                                                     |                 |       | 150   | $\mu A$ |
| Shutdown Supply Current                           |                       | $V_{IN} = 4.2V$ , $\overline{SHDN} = GND$                                  |                 |       | 5     | $\mu A$ |
| Output Short-Circuit Current                      |                       | $V_{OUT} = GND$                                                            |                 |       | 125   | mA      |
| Oscillator Frequency                              | f                     |                                                                            |                 | 1.5   | 2.5   | MHz     |
| $V_{IN}$ Transition Voltage<br>( $V_{IN}$ Rising) |                       | $FB = GND$                                                                 | From 1:1 to 2:3 | 3.1   | 3.35  | V       |
|                                                   |                       |                                                                            | From 2:3 to 1:2 | 4.00  | 4.30  |         |
| $\overline{SHDN}$ Logic Input High Voltage        | $V_{IH}$              | $V_{IN} = 2.7V$ to $5.5V$                                                  |                 | 1.4   |       | V       |
| $\overline{SHDN}$ Logic Input Low Voltage         | $V_{IL}$              | $V_{IN} = 2.7V$ to $5.5V$                                                  |                 |       | 0.6   | V       |
| Shutdown Logic Input Current                      | $I_{\overline{SHDN}}$ | $\overline{SHDN} = IN$ or $GND$                                            |                 | -1    | 1     | $\mu A$ |

**Note 1:** Specifications to  $-40^{\circ}C$  are guaranteed by design, not production tested.

# 50mA Regulated Step-Down Charge Pump for 1.8V or 1.9V Logic

## Typical Operating Characteristics

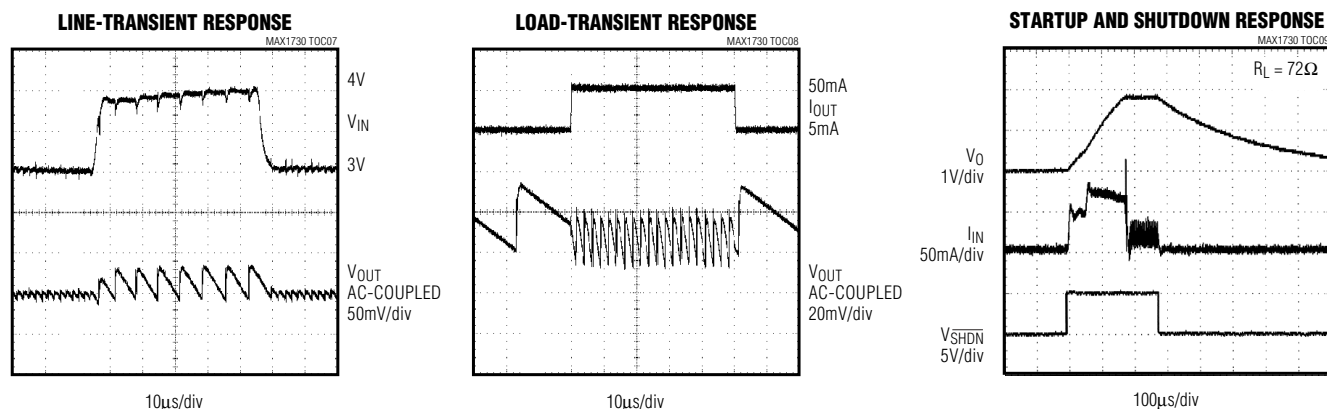
( $V_{IN} = +3.6V$ ,  $FB = GND$ ,  $\overline{SHDN} = IN$ ,  $C_{IN} = 1\mu F$ ,  $C_1 = C_2 = 0.22\mu F$ ,  $C_{OUT} = 4.7\mu F$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# 50mA Regulated Step-Down Charge Pump for 1.8V or 1.9V Logic

## Typical Operating Characteristics (continued)

( $V_{IN} = +3.6V$ ,  $FB = GND$ ,  $\overline{SHDN} = IN$ ,  $C_{IN} = 1\mu F$ ,  $C_1 = C_2 = 0.22\mu F$ ,  $C_{OUT} = 4.7\mu F$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



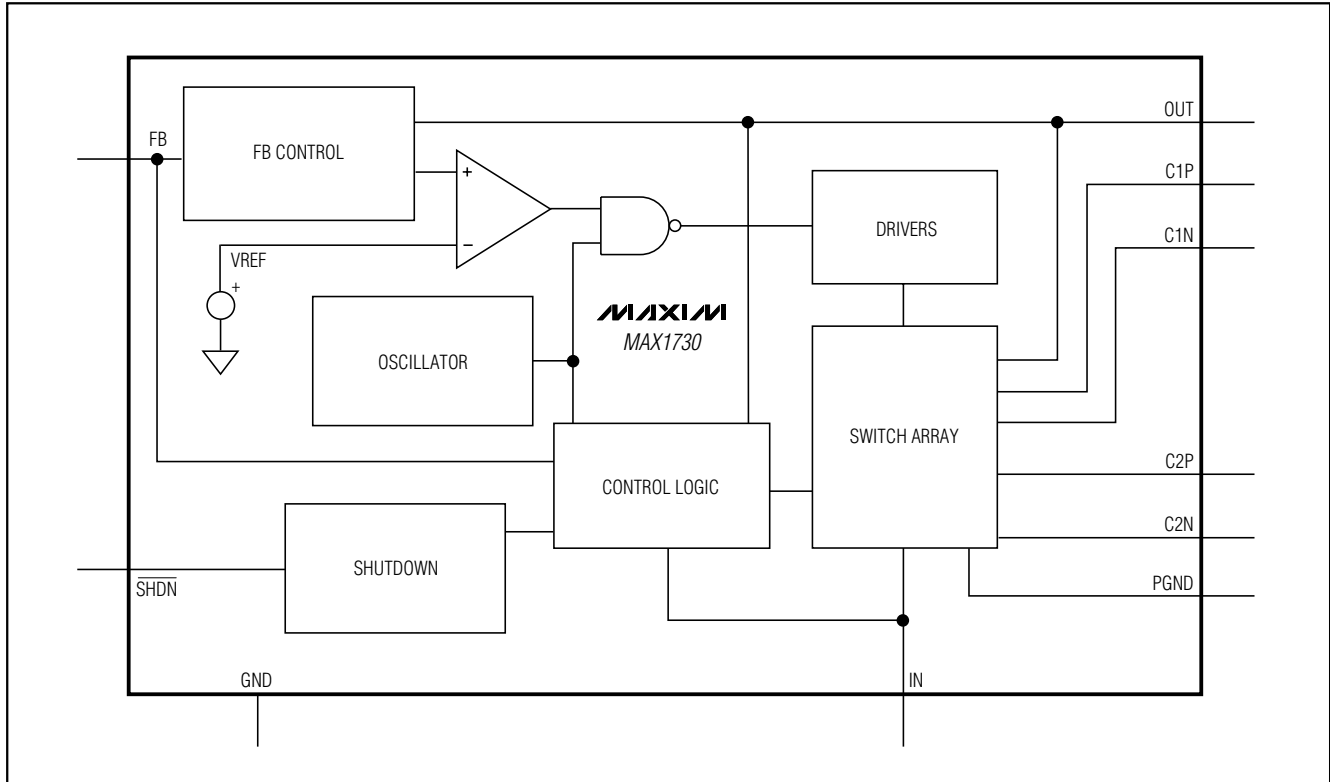
**MAX1730**

## Pin Description

| PIN | NAME              | FUNCTION                                                                                                                                                  |
|-----|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | FB                | Feedback Input. Connect FB to GND for a 1.8V output. Connect FB to IN for a 1.9V output. Do not leave FB unconnected.                                     |
| 2   | $\overline{SHDN}$ | Active-Low Shutdown Input. Connect to logic control or to IN for normal operation. OUT disconnects from the input in shutdown and goes to high impedance. |
| 3   | C1P               | C1 Flying Capacitor Positive Connection                                                                                                                   |
| 4   | C1N               | C1 Flying Capacitor Negative Connection                                                                                                                   |
| 5   | GND               | Ground                                                                                                                                                    |
| 6   | PGND              | Power Ground                                                                                                                                              |
| 7   | C2N               | C2 Flying Capacitor Negative Connection                                                                                                                   |
| 8   | C2P               | C2 Flying Capacitor Positive Connection                                                                                                                   |
| 9   | OUT               | Output. Bypass to GND with a 4.7μF or greater capacitor.                                                                                                  |
| 10  | IN                | Input Supply. Connect to a +2.7V to +5.5V supply. Bypass to GND with a 1μF ceramic capacitor as close to the IC as possible.                              |

# 50mA Regulated Step-Down Charge Pump for 1.8V or 1.9V Logic

## Functional Diagram



## Detailed Description

The MAX1730 step-down charge pump automatically switches between charge pump configurations (Figures 1, 2, and 3) and utilizes pulse-skipping pulse-frequency modulation (PFM) to provide a regulated output voltage with high efficiency. The output voltage is pin-selectable to 1.8V or 1.9V. The MAX1730 accepts inputs between 2.7V and 5.5V and guarantees up to 50mA output current.

### Charge-Pump Configurations

Charge pumps work by passing energy through capacitors. They generally work in two phases. In the first phase, the input source charges the flying capacitors. The input capacitor helps reduce the source's input impedance. In the second phase, the switching capacitors transfer their charge to the output as needed.

Figure 1 shows the 1:1 charge-pump configuration. C1 and C2 charge in parallel between IN and GND during the first phase. In the second phase, C1 and C2 connect in parallel between OUT and GND.

Figure 2 shows the 3:2 charge-pump configuration. C1 and C2 charge in parallel between IN and OUT during the first phase. In the second phase, C1 and C2 connect in series between OUT and GND.

Figure 3 shows the 2:1 charge-pump configuration. C1 and C2 charge in parallel between IN and OUT during the first phase. In the second phase, C1 and C2 connect in parallel between OUT and GND.

### Pulse-Skipping PFM and Mode Transitions

In the MAX1730, pulse-skipping PFM mode pauses the oscillator when the output is in regulation. Using the 2:1 charge-pump configuration as an example, when the output is set to half the input, the switching frequency is near the oscillator frequency. However, for outputs below half the input, switching pauses once the desired output level is achieved. With no output current, the device switches occasionally. With higher levels of current, the switching frequency increases to supply the load.

## 50mA Regulated Step-Down Charge Pump for 1.8V or 1.9V Logic

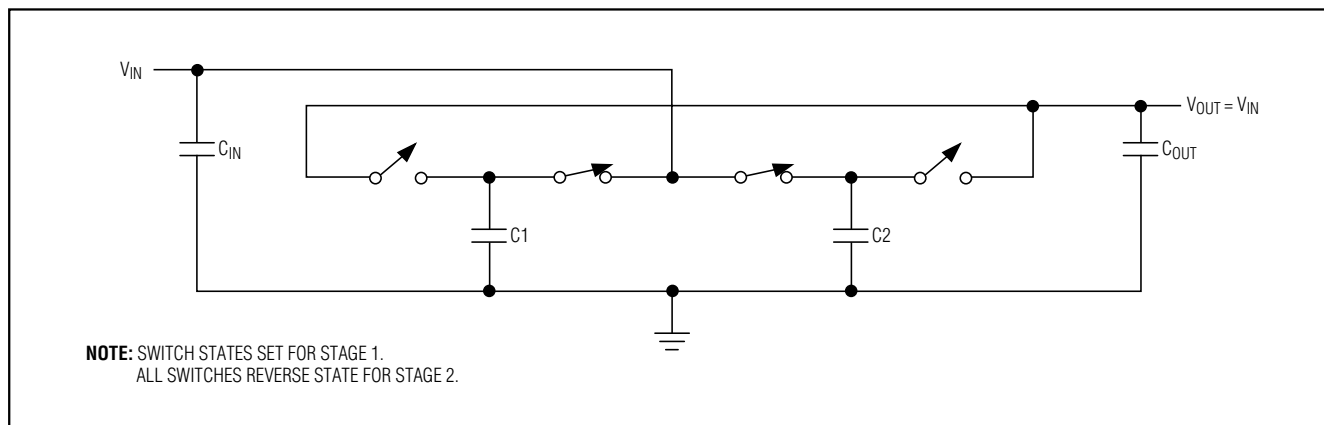


Figure 1. 1:1 Capacitor Configuration

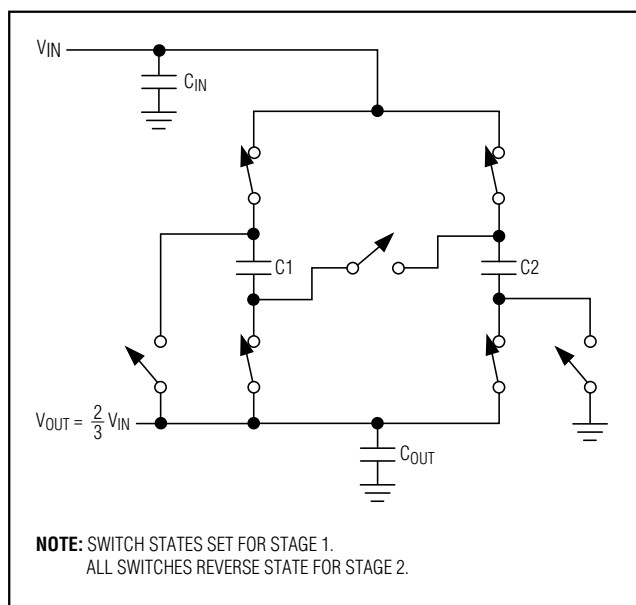


Figure 2. 3:2 Capacitor Configuration

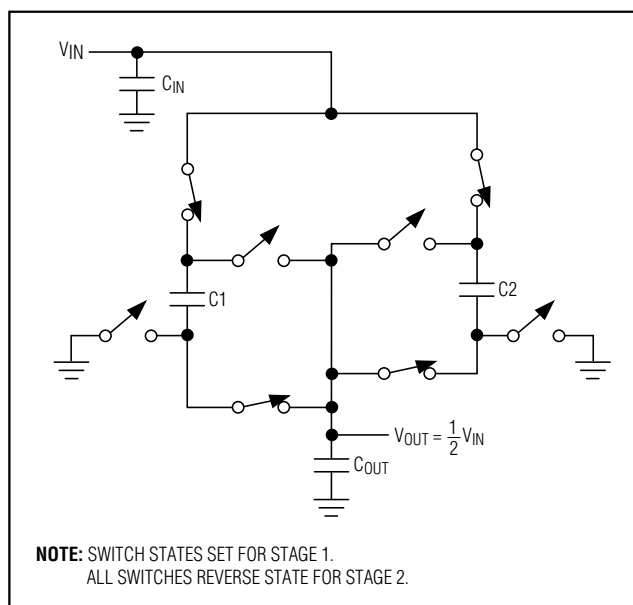


Figure 3. 2:1 Capacitor Configuration

To maximize efficiency, the MAX1730 automatically switches between charge-pump configurations (Figures 1, 2, and 3). Efficiency is greatest when the IN/OUT voltage ratio is close to the voltage ratio of the selected capacitor configuration and decreases for output voltages lower than the divider ratio. To choose between configurations, the MAX1730 senses the input voltage and the output voltage. The MAX1730 uses a control scheme with hysteresis to prevent oscillation between capacitor configurations.

### Applications Information

#### Setting the Output Voltage

For an output voltage of 1.8V, connect FB to GND. For an output voltage of 1.9V, connect FB to IN.

# 50mA Regulated Step-Down Charge Pump for 1.8V or 1.9V Logic

## Shutdown

The MAX1730 features an active-low shutdown pin (SHDN) to decrease supply current to below 5 $\mu$ A. When in shutdown, the output disconnects from the input and OUT goes to high impedance.

## Capacitor Selection

The input capacitor provides the charge pump with a low-impedance supply. For most applications, a 1 $\mu$ F ceramic capacitor is adequate. Lower-value capacitors and those with higher ESR may be inadequate for proper operation and may result in lower output current capability and higher output ripple.

To reduce the output voltage ripple, the value of the output capacitor should exceed that of the flying capacitors (C1 + C2) by 10:1 or more. Values for C1 and C2 between 0.22 $\mu$ F and 0.47 $\mu$ F are recommended for most applications. Use ceramic capacitors to increase maximum output current and improve efficiency.

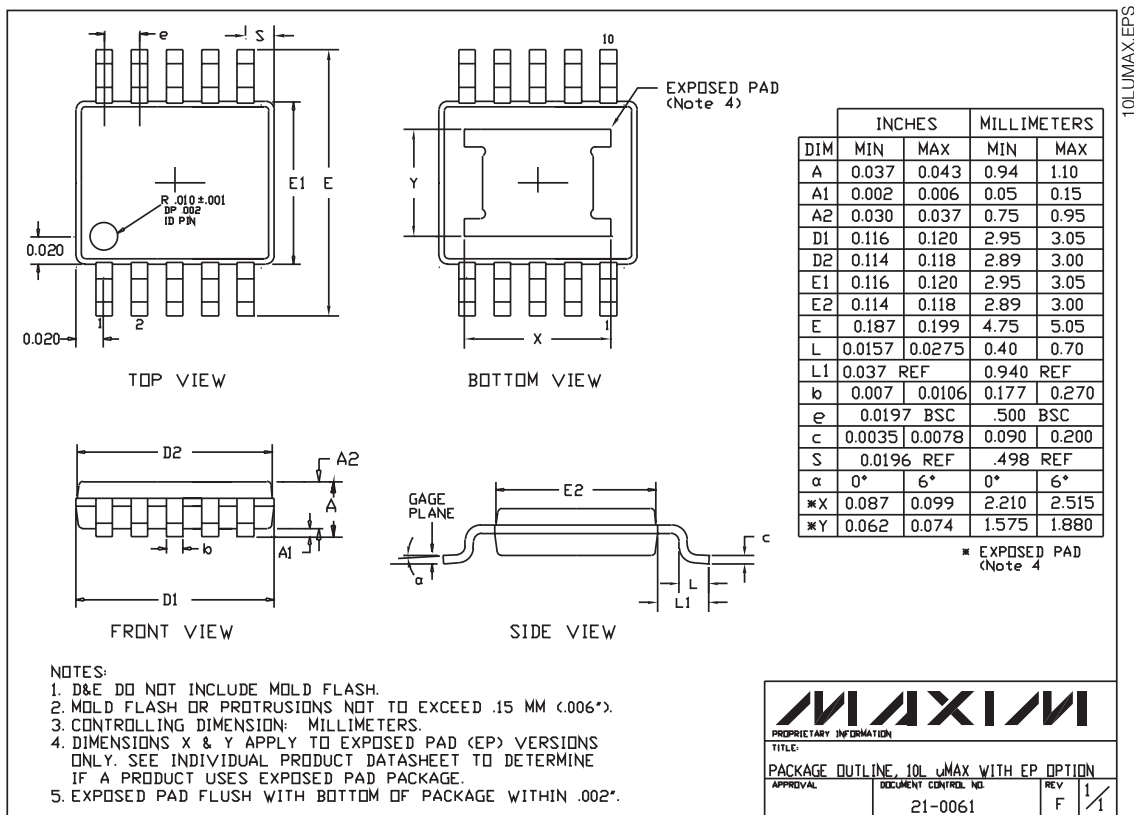
## Layout Considerations

The MAX1730's high-frequency operation demands careful layout. All components should be placed as close to the IC as possible, with priority going to CIN, C1, and C2. Traces should be kept short, wide, and as straight as possible. Connect PGND and GND together with a low-impedance ground plane.

## Chip Information

TRANSISTOR COUNT: 2295

## Package Information



**Note:** The MAX1730 does not have an exposed pad.

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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