



# Regulated 3.3V/5.0V Step-Up/Step-Down Charge Pump

MAX1595

## General Description

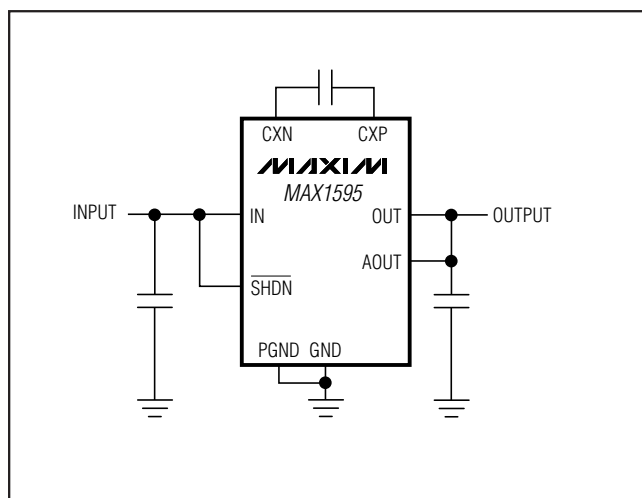
The MAX1595 charge-pump regulator generates either 3.3V or 5V from a 1.8V to 5.5V input. The unique control architecture allows the regulator to step up or step down the input voltage to maintain output regulation. The 1MHz switching frequency, combined with a unique control scheme, allows the use of a ceramic capacitor as small as 1 $\mu$ F for 125mA of output current. The complete regulator requires three external capacitors—no inductor is needed. The MAX1595 is specifically designed to serve as a high-power, high-efficiency auxiliary supply in applications that demand a compact design. The MAX1595 is offered in space-saving 8-pin  $\mu$ MAX® and high-power 12-pin TQFN packages.

## Applications

White LED Power  
Flash Memory Supplies  
Battery-Powered Applications  
Miniature Equipment  
PCMCIA Cards  
3.3V to 5V Local Conversion Applications  
Backup-Battery Boost Converters  
3V to 5V GSM SIMM Cards

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## Typical Operating Circuit



## Features

- ♦ Ultra-Small: Requires Only Three Ceramic Capacitors
- ♦ No Inductors Required
- ♦ Up to 125mA Output Current
- ♦ Regulated  $\pm 3\%$  Output Voltage
- ♦ 1MHz Switching Frequency
- ♦ 1.8V to 5.5V Input Voltage
- ♦ 220 $\mu$ A Quiescent Current
- ♦ 0.1 $\mu$ A Shutdown Current
- ♦ Load Disconnect in Shutdown

## Ordering Information

| PART          | TEMP RANGE     | PIN-PACKAGE |
|---------------|----------------|-------------|
| MAX1595EUA33+ | -40°C to +85°C | 8 $\mu$ MAX |
| MAX1595ETC33+ | -40°C to +85°C | 12 TQFN-EP* |
| MAX1595EUA50+ | -40°C to +85°C | 8 $\mu$ MAX |
| MAX1595ETC50+ | -40°C to +85°C | 12 TQFN-EP* |

+ Denotes a lead(Pb)-free/RoHS-compliant package.

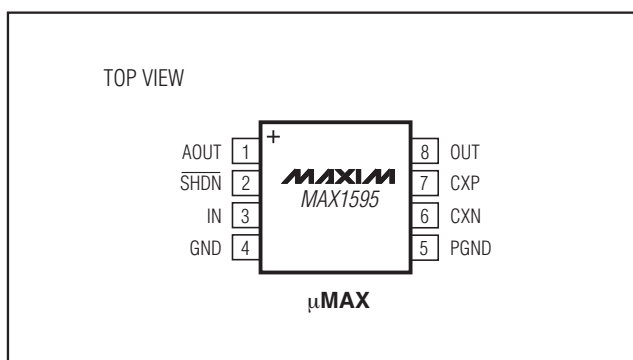
\*EP = Exposed pad.

## Selector Guide

| PART          | V <sub>OUT</sub> (V)** | TOP MARK |
|---------------|------------------------|----------|
| MAX1595EUA33+ | 3.3                    | —        |
| MAX1595ETC33+ | 3.3                    | AAEH     |
| MAX1595EUA50+ | 5.0                    | —        |
| MAX1595ETC50+ | 5.0                    | AAEI     |

\*\*Contact factory for other fixed-output voltages from 2.7V to 5.0V.

## Pin Configurations



Pin Configurations continued at end of data sheet.



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For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).

# Regulated 3.3V/5.0V Step-Up/ Step-Down Charge Pump

## ABSOLUTE MAXIMUM RATINGS

IN, OUT, AOUT to GND .....-0.3V to +6V  
 SHDN to PGND .....-0.3V to +6V  
 PGND to GND .....-0.3V to +0.3V  
 CXN to PGND .....-0.3V to (Lower of IN + 0.8V or 6.3V)  
 CXP to GND .....-0.8V to (Higher of OUT + 0.8V  
 or IN + 0.8V but not greater than 6V)  
 Continuous Output Current .....150mA

Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )  
 $\mu\text{MAX}$  (derate 4.8mW/ $^\circ\text{C}$  above  $+70^\circ\text{C}$ ) .....387.8mW  
 TQFN-EP (derate 24.4mW/ $^\circ\text{C}$  above  $+70^\circ\text{C}$ ) .....1951.2mW  
 Operating Temperature Range ..... $-40^\circ\text{C}$  to  $+85^\circ\text{C}$   
 Junction Temperature ..... $+150^\circ\text{C}$   
 Storage Temperature Range ..... $-65^\circ\text{C}$  to  $+150^\circ\text{C}$   
 Lead Temperature (soldering, 10s) ..... $+300^\circ\text{C}$   
 Soldering Temperature (reflow) ..... $+260^\circ\text{C}$

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.

## PACKAGE THERMAL CHARACTERISTICS (Note 1)

TQFN  $\mu\text{MAX}$   
 Junction-to-Ambient Thermal Resistance ( $\theta_{JA}$ ) ..... $41^\circ\text{C/W}$  Junction-to-Ambient Thermal Resistance ( $\theta_{JA}$ ) ..... $206.3^\circ\text{C/W}$   
 Junction-to-Case Thermal Resistance ( $\theta_{JC}$ ) ..... $6^\circ\text{C/W}$  Junction-to-Case Thermal Resistance ( $\theta_{JC}$ ) ..... $42^\circ\text{C/W}$

**Note 1:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maxim-ic.com/thermal-tutorial](http://www.maxim-ic.com/thermal-tutorial).

## ELECTRICAL CHARACTERISTICS

( $V_{IN} = 2\text{V}$  for MAX1595\_ \_33,  $V_{IN} = 3\text{V}$  for MAX1595\_ \_50,  $C_{IN} = 1\mu\text{F}$ ,  $C_X = 0.22\mu\text{F}$ ,  $C_{OUT} = 1\mu\text{F}$ ,  $T_A = -40^\circ$  to  $+85^\circ\text{C}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ\text{C}$ .) (Note 2)

| PARAMETER                             | SYMBOL            | CONDITIONS                                                             |                                 | MIN  | TYP  | MAX  | UNITS |
|---------------------------------------|-------------------|------------------------------------------------------------------------|---------------------------------|------|------|------|-------|
| Input Voltage Range                   | V <sub>IN</sub>   |                                                                        |                                 | 1.8  |      | 5.5  | V     |
| Input Undervoltage Lockout Threshold  |                   |                                                                        |                                 | 1.40 | 1.60 | 1.72 | V     |
| Input Undervoltage Lockout Hysteresis |                   |                                                                        |                                 | 40   |      |      | mV    |
| Output Voltage                        | V <sub>OUT</sub>  | 0 < I <sub>LOAD</sub> < 125mA, V <sub>IN</sub> = +3.0V                 | T <sub>A</sub> = 0°C to +85°C   | 4.85 | 5.05 | 5.15 | V     |
|                                       |                   |                                                                        | T <sub>A</sub> = -40°C to +85°C | 4.80 |      | 5.20 |       |
|                                       |                   | 0 < I <sub>LOAD</sub> < 75mA, V <sub>IN</sub> = +2.0V                  | T <sub>A</sub> = 0°C to +85°C   | 3.20 | 3.33 | 3.40 |       |
|                                       |                   |                                                                        | T <sub>A</sub> = -40°C to +85°C | 3.16 |      | 3.44 |       |
|                                       |                   | 0 < I <sub>LOAD</sub> < 30mA, V <sub>IN</sub> = +1.8V                  | T <sub>A</sub> = 0°C to +85°C   | 3.20 | 3.33 | 3.40 |       |
|                                       |                   |                                                                        | T <sub>A</sub> = -40°C to +85°C | 3.16 |      | 3.44 |       |
| No-Load Input Current                 | I <sub>Q</sub>    | V <sub>IN</sub> = +2.0V, MAX1595_ _ _33                                |                                 | 220  |      | 320  | μA    |
|                                       |                   | V <sub>IN</sub> = +3.0V, MAX1595_ _ _50                                |                                 | 240  |      | 350  |       |
| Switching Frequency                   | f <sub>OSC</sub>  | I <sub>LOAD</sub> > 20mA, V <sub>OUT</sub> > V <sub>IN</sub>           |                                 | 0.85 | 1.0  | 1.15 | MHz   |
| Shutdown Supply Current               | I <sub>SHDN</sub> | V <sub>SHDN</sub> = 0V, V <sub>IN</sub> = +5.5V, V <sub>OUT</sub> = 0V |                                 | 5    |      |      | μA    |
| SHDN Input Voltage Low                | V <sub>INL</sub>  | V <sub>IN</sub> = 2.0V to 5.5V                                         |                                 | 0.6  |      |      | V     |
| SHDN Input Voltage High               | V <sub>INH</sub>  | V <sub>IN</sub> = 2.0V to 5.5V                                         |                                 | 1.6  |      |      | V     |
| SHDN Input Leakage Current            |                   |                                                                        |                                 | 0.1  |      |      | μA    |

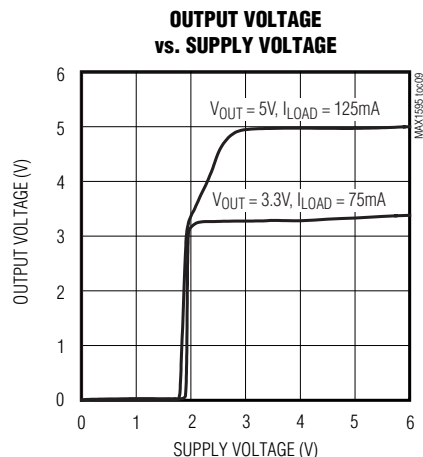
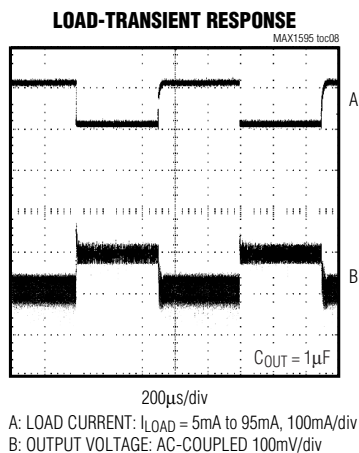
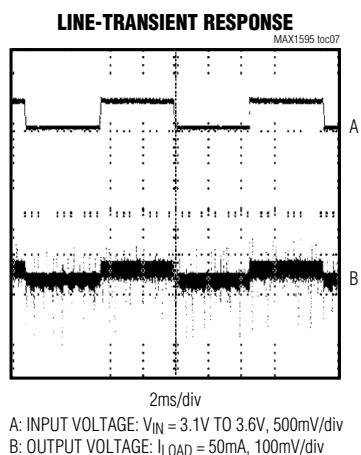
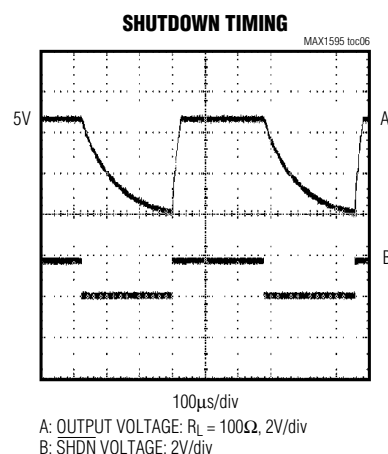
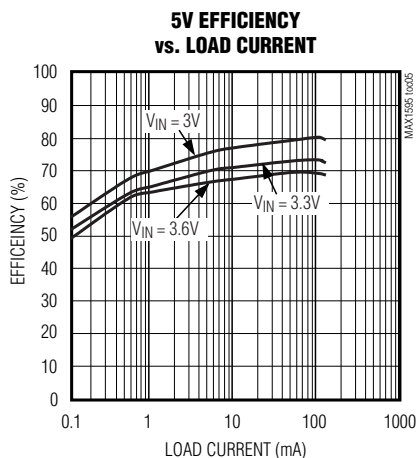
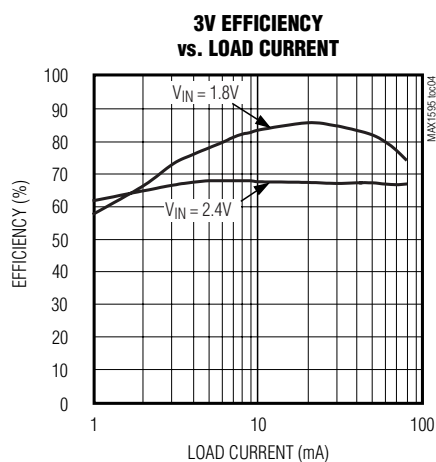
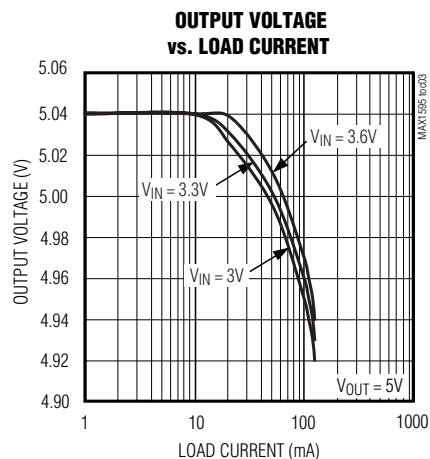
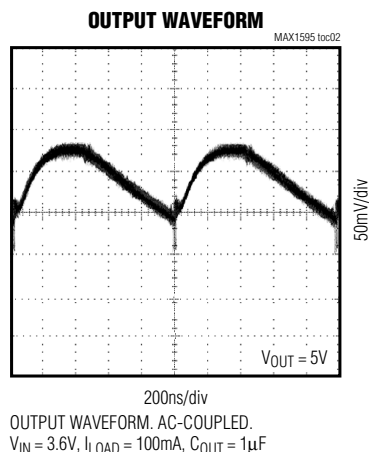
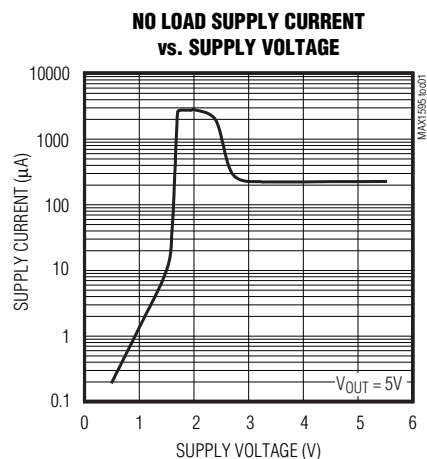
**Note 2:** Specifications to  $-40^\circ\text{C}$  are guaranteed by design, not production tested.

# Regulated 3.3V/5.0V Step-Up/Step-Down Charge Pump

## Typical Operating Characteristics

(Circuit of Figure 4,  $V_{IN} = 2V$  for MAX1595\_\_33,  $V_{IN} = 3V$  for MAX1595\_\_50,  $T_A = +25^\circ C$ , unless otherwise noted.)

MAX1595



# Regulated 3.3V/5.0V Step-Up/ Step-Down Charge Pump

## Pin Description

| PIN       |         | NAME                     | FUNCTION                                                                                                                                                                         |
|-----------|---------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\mu$ MAX | TQFN-EP |                          |                                                                                                                                                                                  |
| 1         | 12      | AOUT                     | Analog Power and Sense Input for Error Amplifier/Comparator. Connect to OUT at output filter capacitor.                                                                          |
| 2         | 1       | $\overline{\text{SHDN}}$ | Shutdown Input. When $\overline{\text{SHDN}}$ = low, the device turns off; when $\overline{\text{SHDN}}$ = high, the device activates. In shutdown, OUT is disconnected from IN. |
| 3         | 2, 3    | IN                       | Input Supply. Can range from 1.8V to 5.5V. Bypass to GND with a 1 $\mu$ F capacitor.                                                                                             |
| 4         | 4       | GND                      | Ground                                                                                                                                                                           |
| 5         | 5, 6    | PGND                     | Power Ground                                                                                                                                                                     |
| 6         | 7, 8    | CXN                      | Negative Terminal of the Charge-Pump Transfer Capacitor                                                                                                                          |
| 7         | 9       | CXP                      | Positive Terminal of the Charge-Pump Transfer Capacitor                                                                                                                          |
| 8         | 10, 11  | OUT                      | Output. Bypass to GND with output capacitor filter.                                                                                                                              |
| —         | —       | EP                       | Exposed Pad. Internally connected to GND. Connect to a large ground plane to maximize thermal performance. Not intended as an electrical connection point (TQFN package only).   |

## Detailed Description

The MAX1595 charge pump provides either a 3.3V or 5V regulated output. It delivers a maximum 125mA load current. In addition to boost regulating from a lower supply, it is also capable of buck regulating from supplies that exceed the regulated output by a diode drop or more. Designed specifically for compact applications, a complete regulator circuit requires only three small external capacitors. An innovative control scheme provides constant frequency operation from medium to heavy loads, while smoothly transitioning to low-power mode at light loads to maintain optimum efficiency. In buck mode, switch S1 (Figure 1) is switched continuously to IN, while switch S2 alternates between IN and OUT. An amount of charge proportional to the difference between the output voltage and the supply voltage is stored on  $C_X$ , which gets transferred to the output when the regulation point is reached. Maximum output ripple is proportional to the difference between the supply voltage and the output voltage, as well as to the ratio of the transfer capacitor ( $C_X$ ) to the output capacitor ( $C_{OUT}$ ).

The MAX1595 consists of an error amplifier, a 1.23V bandgap reference, internal resistive feedback network, oscillator, high-current MOSFET switches, and shutdown and control logic. Figure 1 shows an idealized unregulated charge-pump voltage doubler. The oscillator runs at a 50% duty cycle. During one half of the period, the transfer capacitor ( $C_X$ ) charges to the input voltage. During the other half, the doubler transfers the sum of  $C_X$  and input voltage to the output filter capacitor ( $C_{OUT}$ ). Rather

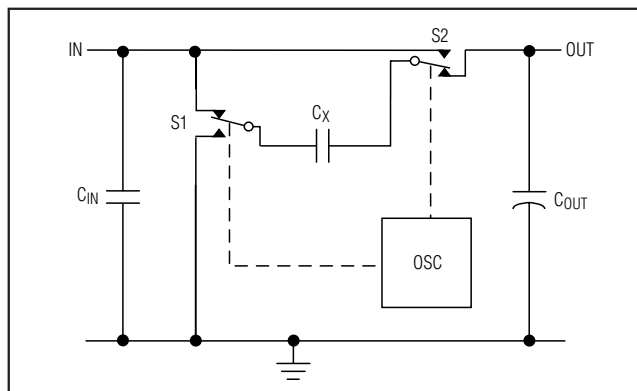


Figure 1. Unregulated Voltage Doubler

than doubling the input voltage, the MAX1595 provides a regulated output voltage of either 3.3V or 5.0V.

## Shutdown

Driving  $\overline{\text{SHDN}}$  low places the device in shutdown mode. The device draws 0.1 $\mu$ A of supply current in this mode. When driven high, the MAX1595 enters a soft-start mode. Soft-start mode terminates when the output voltage regulates, or after 2ms, whichever comes first. In shutdown, the output disconnects from the input.

## Undervoltage Lockout

The MAX1595 has an undervoltage-lockout that deactivates the devices when the input voltage falls below 1.6V. Below UVLO, hysteresis holds the device in shutdown until the input voltage rises 40mV above the lockout threshold.

# Regulated 3.3V/5.0V Step-Up/Step-Down Charge Pump

## Applications Information

Using white LEDs to backlight LCDs is an increasingly popular approach for portable information devices (Figure 2). Because the forward voltage of white LEDs exceeds the available battery voltage, the use of a charge pump such as the MAX1595 provides high efficiency, small size, and constant light output with changing battery voltages. If the output is used only to light LEDs, the output capacitor can be greatly reduced. The frequency modulation of the LED intensity is not discernible to the human eye, and the smaller capacitor saves both size and cost.

Adding two Schottky diodes and two capacitors implements a tripler and allows the MAX1595\_50 to regulate a current of 75mA with a supply voltage as low as 2.3V (Figure 3).

## Capacitor Selection

The MAX1595 requires only three external capacitors (Figure 4). Their values are closely linked to the output current capacity, oscillator frequency, output noise content, and mode of operation.

Generally, the transfer capacitor ( $C_X$ ) will be the smallest, and the input capacitor ( $C_{IN}$ ) is twice as large as  $C_X$ . Higher switching frequencies allow the use of the smaller  $C_X$  and  $C_{IN}$ . The output capacitor ( $C_{OUT}$ ) can be anywhere from 5-times to 50-times larger than  $C_X$ . Table 1 shows recommended capacitor values.

In addition, the following equation approximates output ripple:

$$V_{RIPPLE} \approx I_{OUT} / (2 \times f_{OSC} \times C_{OUT})$$

Table 2 lists the manufacturers of recommended capacitors. Ceramic capacitors will provide the lowest ripple due to their typically lower ESR.

## Power Dissipation

The power dissipated in the MAX1595 depends on output current and is accurately described by:

$$P_{DISS} = I_{OUT} (2V_{IN} - V_{OUT})$$

$P_{DISS}$  must be less than that allowed by the package rating.

## Layout Considerations

All capacitors should be soldered in close proximity to the IC. Connect ground and power ground through a short, low-impedance trace. The input supply trace should be as short as possible. Otherwise, an additional input supply filter capacitor (tantalum or electrolytic) may be required.

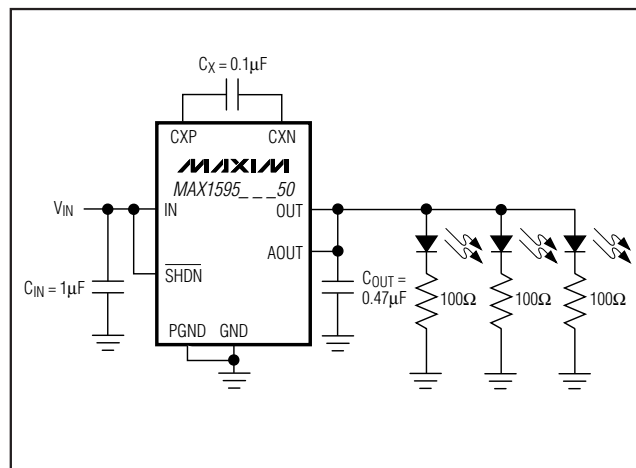


Figure 2. White LED Bias Supply

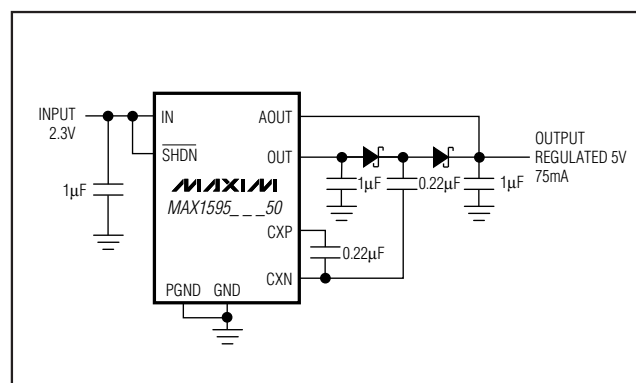


Figure 3. Regulated Voltage Tripler

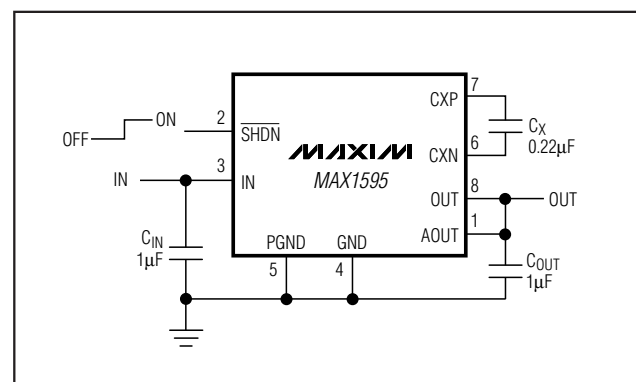


Figure 4. Standard Operating Circuit

MAX1595

# Regulated 3.3V/5.0V Step-Up/ Step-Down Charge Pump

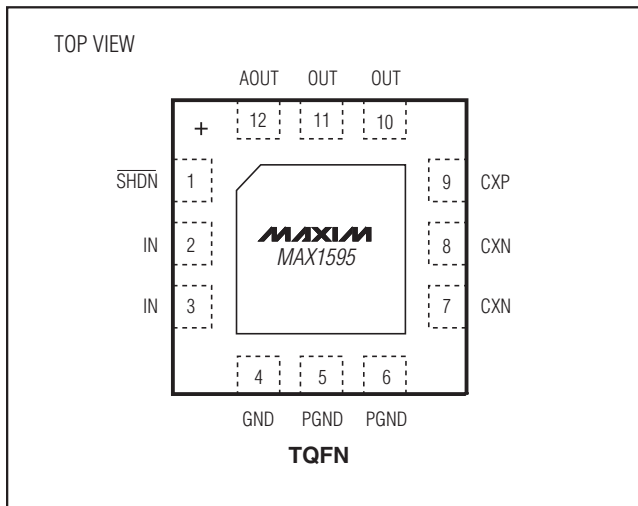
Table 1. Recommended Capacitor Values

| OUTPUT RIPPLE (mV) | C <sub>IN</sub> (μF) | C <sub>X</sub> (μF) | C <sub>OUT</sub> (μF) |
|--------------------|----------------------|---------------------|-----------------------|
| 70                 | 1                    | 0.22                | 1                     |
| 35                 | 2.2                  | 0.47                | 2.2                   |

Table 2. Recommended Capacitor Manufacturers

| VALUE (μF) | VOLTAGE (V) | TYPE | SIZE | MANUFACTURER | PART          |
|------------|-------------|------|------|--------------|---------------|
| 1          | 10          | X7R  | 0805 | Taiyo Yuden  | LMK212BJ105MG |
| 0.22       | 10          | X7R  | 0603 | Taiyo Yuden  | LMK107BJ224MA |
| 0.47       | 10          | X7R  | 0603 | Taiyo Yuden  | LMK107BJ474MA |
| 0.1        | 10          | X7R  | 0603 | Taiyo Yuden  | LMK107BJ104MA |

## Pin Configurations (continued)



## Chip Information

PROCESS: CMOS

## Package Information

For the latest package outline information and land patterns (footprints), go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO.             | LAND PATTERN NO.        |
|--------------|--------------|-------------------------|-------------------------|
| 8 μMAX       | U8+1         | <a href="#">21-0036</a> | <a href="#">90-0092</a> |
| 12 TQFN      | 1244+4       | <a href="#">21-0139</a> | <a href="#">90-0068</a> |

# Regulated 3.3V/5.0V Step-Up/Down Charge Pump

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION                                                                                              | PAGES CHANGED |
|-----------------|---------------|----------------------------------------------------------------------------------------------------------|---------------|
| 2               | 6/09          | Added EP (exposed pad) and top mark information                                                          | 1, 2, 4, 6    |
| 3               | 10/11         | Updated <i>Absolute Maximum Ratings</i> section and added <i>Package Thermal Characteristics</i> section | 2             |

MAX1595

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. The parametric values (min and max limits) shown in the Electrical Characteristics table are guaranteed. Other parametric values quoted in this data sheet are provided for guidance.

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