19-1774; Rev 0; 7/00

EVALUATION KIT AVAILABLE

# High-Frequency, Regulated, 200mA, Inverting Charge Pump

MAX889

## General Description

The MAX889 inverting charge pump delivers a regulated negative output voltage at loads of up to 200mA. The device operates with inputs from 2.7V to 5.5V to produce an adjustable, regulated output from -2.5V to $-V_{IN}$.

The MAX889 is available with an operating frequency of 2MHz (T version), 1MHz (S version), or 0.5MHz (R version). The higher switching frequency devices allow the use of smaller capacitors for space-limited applications. The lower frequency devices have lower quiescent current.

The MAX889 also features a 0.1µA logic-controlled shutdown mode and is available in an 8-pin SO package. An evaluation kit, MAX889SEVKIT, is available.

## Features

- ♦ **200mA Output Current**
- ♦ **Up to 2MHz Switching Frequency**
- ♦ **Small Capacitors (1µF)**
- ♦ **+2.7V to +5.5V Input Voltage Range**
- ♦ **Adjustable Regulated Negative Output (-2.5V to $-V_{IN}$)**
- ♦ **0.1µA Logic-Controlled Shutdown**
- ♦ **Low 0.05Ω Output Resistance (in regulation)**
- ♦ **Soft-Start and Foldback Current Limited**
- ♦ **Short-Circuit and Thermal Shutdown Protected**
- ♦ **8-Pin SO Package**

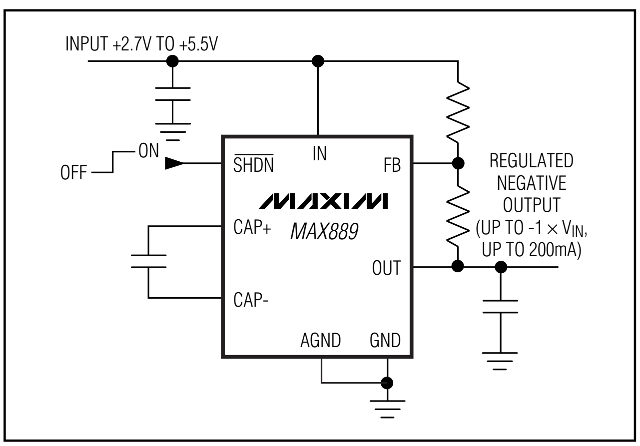
## Applications

TFT Panels
Hard Disk Drives
Camcorders
Digital Cameras
Measurement Instruments
Battery-Powered Applications

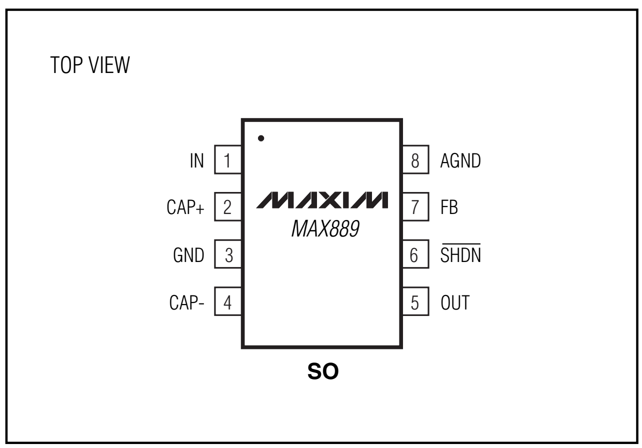
## Ordering Information

| PART | TEMP. RANGE | PIN-PACKAGE | SWITCHING FREQUENCY |
|---|---|---|---|
| MAX889TESA | -40°C to +85°C | 8 SO | 2MHz |
| MAX889SESA | -40°C to +85°C | 8 SO | 1MHz |
| MAX889RESA | -40°C to +85°C | 8 SO | 0.5MHz |

## Typical Operating Circuit




## Pin Configuration



# High-Frequency, Regulated, 200mA, Inverting Charge Pump

## ABSOLUTE MAXIMUM RATINGS

IN to GND ....................-0.3V to +6V
$\overline{SHDN}$, FB, CAP+ to GND ....................-0.3V to ($V_{IN}$ + 0.3V)
AGND to GND ....................-0.3V to +0.3V
OUT to GND ....................-6V to +0.3V
CAP- to GND ....................($V_{OUT}$ - 0.3V) to +0.3V
Continuous Output Current ....................250mA
Output Short-Circuit Duration ....................Indefinite

Continuous Power Dissipation ($T_A$ = +70°C)
8-Pin SO (derate 5.88mW/°C above +70°C)....................471mW
Operating Temperature Range....................-40°C to +85°C
Junction Temperature ....................+150°C
Storage Temperature Range ....................-65°C to +150°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

($V_{IN}$ = $V_{\overline{SHDN}}$ = +5V, capacitors from Table 1, **$T_A$ = 0°C to +85°C**, unless otherwise noted. Typical values are at $T_A$ = +25°C.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Supply Voltage Range | $V_{IN}$ | $R_{LOAD}$ = 100Ω | | 2.7 | | 5.5 | V |
| Output Voltage Range | $V_{OUT}$ | $R_{LOAD}$ = 100Ω | | -2.5 | | $-V_{IN}$ | V |
| Maximum Output Current | $I_{OUT(MAX)1}$ | $V_{IN}$ = 5V, $V_{OUT}$ = -3.3V | | 200 | | | mA |
| | $I_{OUT(MAX)2}$ | $V_{IN}$ = 3.3V, $V_{OUT}$ = -2.5V | | 145 | | | |
| Quiescent Supply Current (Free-Run Mode) | $I_{Q(FREE-RUN)}$ | No load, $V_{FB}$ = $V_{IN}$ | MAX889R | | 6 | 12 | mA |
| | | | MAX889S | | 12 | 24 | |
| | | | MAX889T | | 24 | 48 | |
| Quiescent Supply Current (Regulated Mode) | $I_{Q(REGULATED)}$ | No load, $V_{OUT}$ regulated to -3.3V | MAX889R | | 3.3 | 7 | mA |
| | | | MAX889S | | 5.5 | 12 | |
| | | | MAX889T | | 11 | 22 | |
| Shutdown Supply Current | $I_{\overline{SHDN}}$ | $V_{\overline{SHDN}}$ = 0 | | | 0.1 | 50 | µA |
| Open-Loop Output Resistance (Free-Run Mode) | $R_O$ | $V_{FB}$ = $V_{IN}$ | | | 2.0 | 4.5 | Ω |
| Output Resistance | $R_{O(REG1)}$ | $V_{OUT}$ regulated to -3.3V | | | 0.05 | | Ω |
| $\overline{SHDN}$, FB Input Bias Current | | | | | | ±1 | µA |
| FB Input Offset Voltage | | $I_{LOAD}$ = 0 | | | ±3 | ±35 | mV |
| Load Regulation | | $I_{OUT}$ = 0 to 200mA | | | 10 | | mV |
| IN Undervoltage Lockout Threshold | | $V_{IN}$ rising (30mV hysteresis) | | 2.3 | | 2.6 | V |
| $\overline{SHDN}$ Logic High | $V_{IH}$ | $V_{IN}$ = +2.7V to +5.5V | | 0.7 x $V_{IN}$ | | | V |
| $\overline{SHDN}$ Logic Low | $V_{IL}$ | | | | | 0.3 x $V_{IN}$ | |
| Switching Frequency | $f_{OSC}$ | MAX889R | | 0.375 | 0.5 | 0.62 | MHz |
| | | MAX889S | | 0.75 | 1 | 1.25 | |
| | | MAX889T | | 1.5 | 2 | 2.5 | |
| Thermal Shutdown Threshold | | Junction temperature rising (15°C hysteresis) | | | 160 | | °C |

## ELECTRICAL CHARACTERISTICS

($V_{IN}$ = $V_{\overline{SHDN}}$ = +5V, capacitors from Table 1, $T_A$ = **-40°C to +85°C**, unless otherwise noted.) (Note 1)

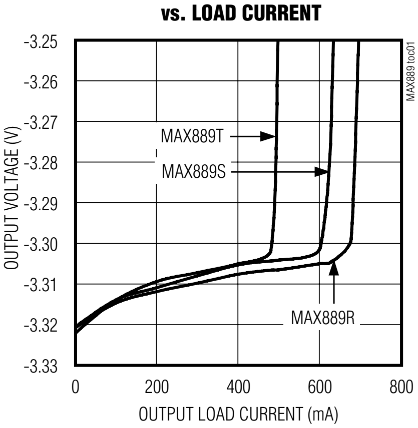
| PARAMETER | SYMBOL | CONDITIONS | | MIN | MAX | UNITS |
|---|---|---|---|---|---|---|
| Supply Voltage Range | $V_{IN}$ | $R_{LOAD}$ = 100Ω | | 2.7 | 5.5 | V |
| Output Voltage Range | $V_{OUT}$ | $R_{LOAD}$ = 100Ω | | -2.5 | $-V_{IN}$ | V |
| Maximum Output Current | $I_{OUT(MAX)1}$ | $V_{IN}$ = 5V, $V_{OUT}$ = -3.3V | | 200 | | mA |
| | $I_{OUT(MAX)2}$ | $V_{IN}$ = 3.3V, $V_{OUT}$ = -2.5V | | 145 | | |
| Quiescent Supply Current (Free-Run Mode) | $I_{Q(FREE-RUN)}$ | No load, $V_{FB}$ = $V_{IN}$ | MAX889R | | 12 | mA |
| | | | MAX889S | | 24 | |
| | | | MAX889T | | 48 | |
| Quiescent Supply Current (Regulated Mode) | $I_{Q(REGULATED)}$ | No load, $V_{OUT}$ regulated to -3.3V | MAX889R | | 7 | mA |
| | | | MAX889S | | 12 | |
| | | | MAX889T | | 22 | |
| Shutdown Supply Current | $I_{\overline{SHDN}}$ | $V_{\overline{SHDN}}$ = 0 | | | 50 | µA |
| Open-Loop Output Resistance (Free-Run Mode) | $R_O$ | $V_{FB}$ = $V_{IN}$ | | | 4.5 | Ω |
| $\overline{SHDN}$ FB Input Bias Current | | | | | ±1 | µA |
| FB Input Offset Voltage | | $I_{LOAD}$ = 0 | | | ±35 | mV |
| IN Undervoltage Lockout Threshold | | $V_{IN}$ rising (30mV hysteresis) | | 2.3 | 2.6 | V |
| $\overline{SHDN}$ Logic High | $V_{IH}$ | $V_{IN}$ = +2.7V to +5.5V | | 0.7 x $V_{IN}$ | | V |
| $\overline{SHDN}$ Logic Low | $V_{IL}$ | | | | 0.3 x $V_{IN}$ | |
| Switching Frequency | $f_{OSC}$ | MAX889R | | 0.375 | 0.62 | MHz |
| | | MAX889S | | 0.75 | 1.25 | |
| | | MAX889T | | 1.5 | 2.5 | |

**Note 1:** Specifications to -40°C are guaranteed by design, not production tested.

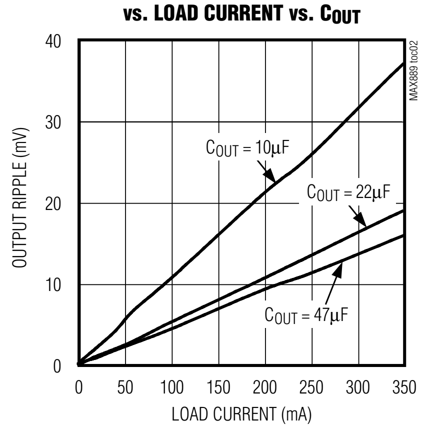
## *Typical Operating Characteristics*

(Circuit of Figure 1, $V_{IN}$ = $V_{\overline{SHDN}}$ = +5V, capacitors from Table 1, $T_A$ = +25°C, unless otherwise noted.)

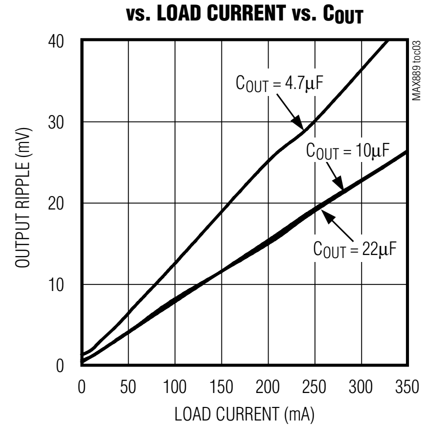
**OUTPUT VOLTAGE vs. LOAD CURRENT**




**MAX889R OUTPUT RIPPLE vs. LOAD CURRENT vs. $C_{OUT}$**




**MAX889S OUTPUT RIPPLE vs. LOAD CURRENT vs. $C_{OUT}$**

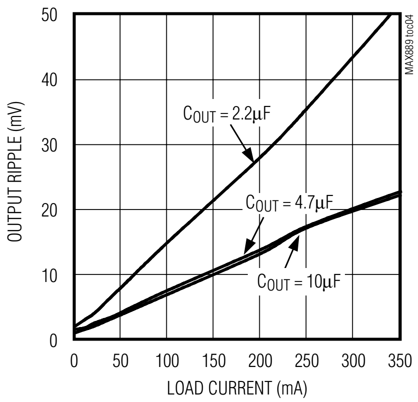


# High-Frequency, Regulated, 200mA, Inverting Charge Pump

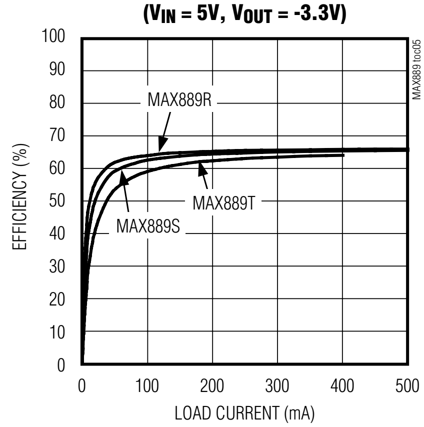
## Typical Operating Characteristics (continued)

(Circuit of Figure 1, $V_{IN}$ = $V_{\overline{SHDN}}$ = +5V, capacitors from Table 1, $T_A$ = +25°C, unless otherwise noted.)

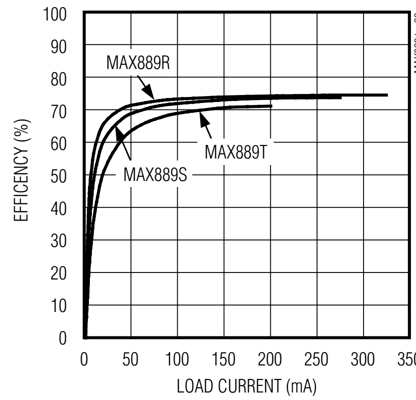
**MAX889T OUTPUT RIPPLE vs. LOAD CURRENT vs. $C_{OUT}$**



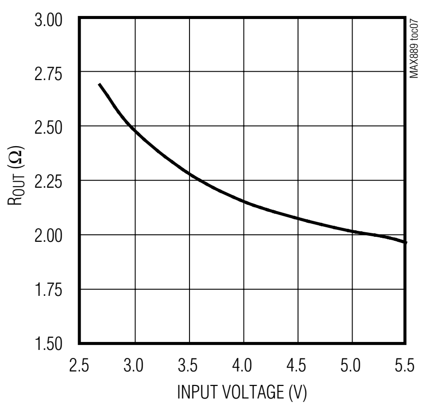

**EFFICIENCY vs. LOAD CURRENT ($V_{IN}$ = 5V, $V_{OUT}$ = -3.3V)**



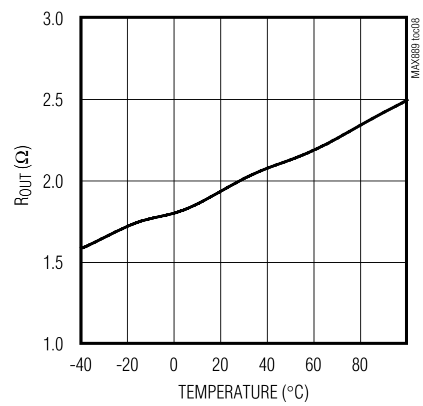

**EFFICIENCY vs. LOAD CURRENT ($V_{IN}$ = 3.3V, $V_{OUT}$ = -2.5V)**



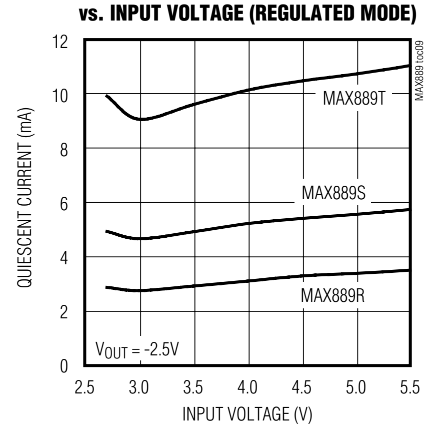

**FREE-RUN OUTPUT RESISTANCE vs. INPUT VOLTAGE**



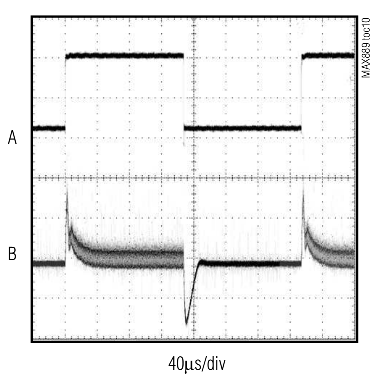

**FREE-RUN OUTPUT RESISTANCE vs. TEMPERATURE**




**QUIESCENT SUPPLY CURRENT vs. INPUT VOLTAGE (REGULATED MODE)**

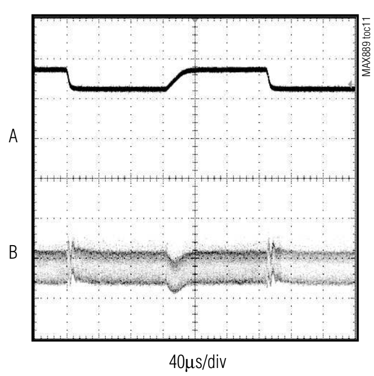



**MAX889S LOAD-TRANSIENT RESPONSE**



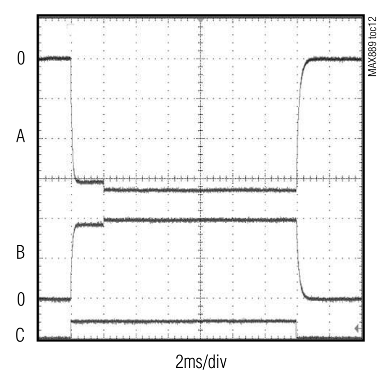

20 TO 200mA LOAD STEP
CIRCUIT OF FIGURE 4
A: $I_{OUT}$, 100mA/div
B: $V_{OUT}$, 20mV/div, AC-COUPLED

**MAX889S LINE-TRANSIENT RESPONSE**




$I_{OUT}$ = 200mA
CIRCUIT OF FIGURE 4
A: $V_{IN}$, 2V/div
B: $V_{OUT}$, 10mV/div, AC-COUPLED

**MAX889S STARTUP AND SHUTDOWN**




$I_{OUT}$ = 200mA
A: $V_{OUT}$, 1V/div
B: $I_{IN}$, 100mA/div
C: $V_{\overline{SHDN}}$, 10V/div

## Pin Description

| PIN | NAME | FUNCTION |
|---|---|---|
| 1 | IN | Power-Supply Positive Voltage Input |
| 2 | CAP+ | Positive Terminal of Flying Capacitor |
| 3 | GND | Power Ground |
| 4 | CAP- | Negative Terminal of Flying Capacitor |
| 5 | OUT | Inverting Charge-Pump Output |
| 6 | $\overline{SHDN}$ | Shutdown Control Input. Drive $\overline{SHDN}$ low to shut down the MAX889. Connect $\overline{SHDN}$ to IN for normal operation. |
| 7 | FB | Feedback Input. Connect FB to a resistor-divider from IN (or other positive reference voltage source) to OUT for regulated output voltages. Connect to IN for free-run mode. |
| 8 | AGND | Analog Ground |

## Detailed Description

The MAX889 high-current regulated charge-pump DC-DC inverter provides up to 200mA. It features the highest available output current while using small capacitors (Table 1). The three versions available differ in their switching frequencies ($f_{OSC}$)—MAX889R/MAX889S/MAX889T with $f_{OSC}$ = 500kHz/1MHz/2MHz, respectively. Higher frequencies allow the use of smaller components (Table 1). Even smaller capacitor values than those listed in Table 1 are suitable when the devices are loaded at less than their rated output current. Designed specifically for compact applications, a complete regulating circuit requires only three small capacitors and two resistors, Figure 1. In addition, the MAX889 includes soft-start, shutdown control, short-circuit, and thermal protection.

The oscillator, control circuitry, and four power MOSFET switches are included on-chip. The charge pump runs continuously at the operating frequency. During one-half of the oscillator period, switches S1 and S2 close (Figure 2), charging the transfer capacitor ($C_{FLY}$) to the input voltage (CAP- = GND, CAP+ = IN). During the other half cycle, switches S3 and S4 close (Figure 3), transferring the charge on $C_{FLY}$ to the output capacitor (CAP+ = GND, CAP- = OUT).

### Voltage Regulation

Voltage regulation is achieved by controlling the flying-capacitor charging rate. The MAX889 controls the charge on $C_{FLY}$ by modulating the gate drive to S1 (Figure 2) to supply the charge necessary to maintain output regulation. When the output voltage droops, $C_{FLY}$ charges higher due to increased gate drive. Since the device switches continuously, the regulation scheme minimizes output ripple, and the output noise spectrum contains well-defined frequency components. Feedback voltage is sensed with a resistor-divider between an externally supplied positive reference or the supply voltage and the negative inverted output. The feedback loop servos FB to GND. The effective output impedance in regulation is 0.05Ω. The output remains in regulation until dropout is reached. Dropout depends on the output voltage setting and load current (see Output Voltage vs. Load Current in *Typical Operating Characteristics*).

### Free-Run Mode (Unregulated Voltage Inverter)

The MAX889 may be used in an unregulated voltage inverter mode that does not require external feedback resistors, minimizing board space. Connecting FB to IN places the MAX889 in free-run mode. In this mode, the charge pump operates to invert directly the input supply voltage ($V_{OUT} = -(V_{IN} - I_{OUT} \times R_O)$). Output resistance is typically 2Ω and can be approximated by the following equation:

$$R_O \cong [1 / (f_{OSC} \times C_{FLY})] + 2R_{SW} + 4ESR_{CFLY} + ESR_{COUT}$$

The first term is the effective resistance of an ideal switched-capacitor circuit (Figures 2 and 3), and $R_{SW}$ is the sum of the charge pump's internal switch resistances (typically 0.8Ω at $V_{IN}$ = 5V). The last two terms take into consideration the equivalent series resistance

(ESR) of the flying and output capacitors. The typical output impedance is more accurately determined from the *Typical Operating Characteristics*.

### *Current Limit and Soft-Start*

The MAX889 features a foldback current-limit/soft-start scheme that allows it to limit inrush currents during startup, overload, and output short-circuit conditions. Additionally, it permits a safe, timed recovery from fault conditions. This protects the MAX889 and prevents low-current or higher output impedance input supplies (such as alkaline cells) from being overloaded at start-up or short-circuit conditions.

The MAX889 features two current-limit/soft-start levels with corresponding response to rising and falling output voltage thresholds of -0.6V and -1.5V. When the falling output voltage crosses -1.5V, such as during an overload condition, the input current is immediately limited to 400mA by weakening the charge-pump switches. When the falling output voltage crosses -0.6V, such as during a short-circuit condition, the MAX889 further weakens the charge-pump switches, immediately limiting input current to 200mA.

During startup or short-circuit recovery, the MAX889 limits input current to 200mA with charge-pump switches at their weakest level. Rising output voltage crossing -0.6V initiates a 2ms timer, after which the MAX889 increases switch strength to the next level. The rising output voltage crossing -1.5V initiates a 2ms timer, after which the MAX889 provides full-strength operation.

### *Shutdown*

When $\overline{SHDN}$ (a CMOS-compatible input) is driven low, the MAX889 enters 0.1µA shutdown mode. Charge-pump switching halts. Connect $\overline{SHDN}$ to IN or drive high for normal operation.

### *Thermal Shutdown*

The MAX889 features thermal shutdown with hysteresis for added protection against fault conditions. When the die temperature exceeds 160°C, the internal oscillator stops, suspending device operation. The MAX889 resumes operation when the die temperature falls 15°C. This prevents the device from rapidly oscillating around the temperature trip point.

## *Applications Information*

### *Resistor Selection (Setting the Output Voltage)*

The accuracy of $V_{OUT}$ depends on the accuracy of the voltage biasing R1 in Figure 1. Use a separate reference voltage if greater accuracy than provided by $V_{IN}$ is desired (Figure 4). Keep the feedback node as small as possible, with resistors mounted close to the FB pin.

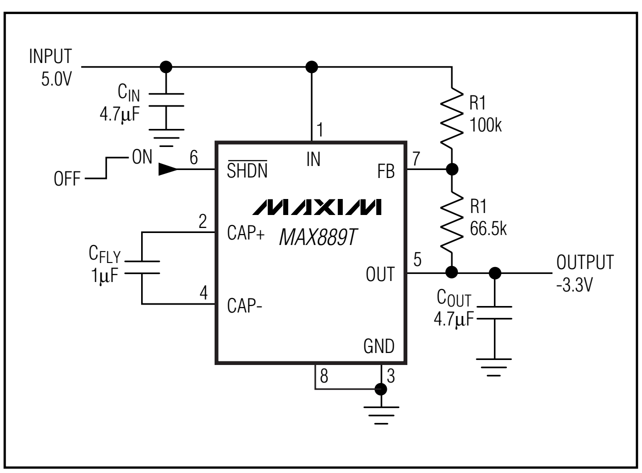



*Figure 1. Typical Application Circuit.*

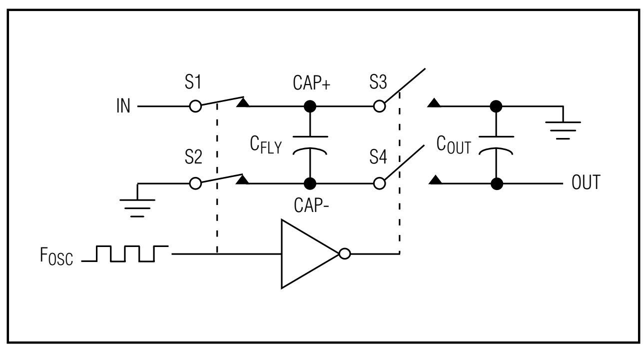



*Figure 2. Charging $C_{FLY}$*

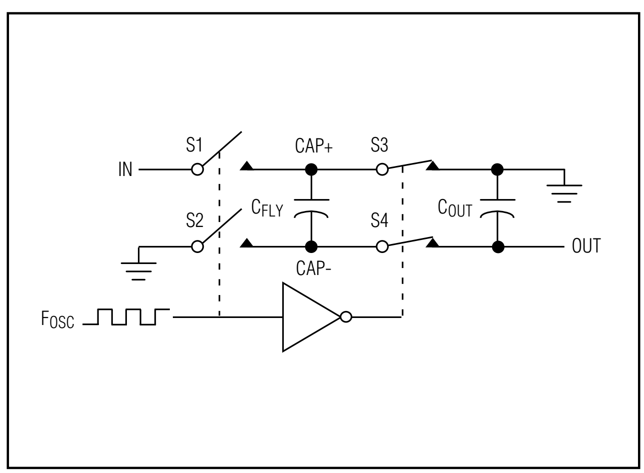



*Figure 3. Transferring Charge on $C_{FLY}$ to $C_{OUT}$*

Adjust the output voltage to a negative voltage from -2.5V to $-V_{IN}$ with external resistors R1 and R2 as shown in Figures 1 and 4. FB servos to GND. Choose R1 to be 100kΩ or less. Calculate R2 for the desired output voltage:

$$V_{OUT} = -V_{REF} (R2 / R1)$$

$$R2 = R1 (V_{OUT} / -V_{REF})$$

where $V_{REF}$ can be either $V_{IN}$ or a positive reference source.

Typically, choose a voltage-divider current of at least 30µA to minimize the effect of FB input current and capacitance:

$$R1 \le V_{REF} / 30\mu A$$

$$R2 < -V_{OUT} / 30\mu A$$

### Capacitor Selection

The appropriate capacitors used with the MAX889 depend on the switching frequency. Table 1 provides suggested values for $C_{IN}$, $C_{FLY}$, and $C_{OUT}$.

Surface-mount ceramic capacitors are preferred for $C_{IN}$, $C_{OUT}$, and $C_{FLY}$ due to their small size, low cost, and low ESR. To ensure proper operation over the entire temperature range, choose ceramic capacitors with X7R (or equivalent) low-temperature-coefficient (tempco) dielectrics. See Table 2 for a list of suggested capacitor suppliers.

The output capacitor stores the charge transferred from the flying capacitor and services the load between oscillator cycles. A good general rule is to make the output capacitance at least five-times greater than the flying capacitor.

Output voltage ripple is largely dependent on $C_{OUT}$. Choosing a low-ESR capacitor of sufficient value is important in minimizing the peak-to-peak output voltage ripple, which is approximated by the following equation:

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

where $C_{OUT}$ is the output capacitor value, $ESR_{COUT}$ is the output capacitor's ESR, and $f_{OSC}$ is the MAX889 switching frequency. Ceramic capacitors have the lowest ESR and are recommended for $C_{OUT}$. Where larger capacitance at low cost is desired, a low-ESR tantalum capacitor may be used for $C_{OUT}$. See Table 2 for a list of suggested capacitor suppliers.

To ensure stability over the entire operating temperature range, choose a low-ESR output capacitor using the following equation:

$$C_{OUT} \ge \left(\frac{15.5}{f_{MIN}}\right)\left(\frac{R1}{R1 + R2}\right)\sqrt{I_{OUT}}$$

where $C_{OUT}$ is the output capacitor value, and $f_{MIN}$ is the minimum oscillator frequency in the *Electrical Characteristics* table.

To ensure stability for regulated output mode, suitable output capacitor ESR should be determined by the following equation:

$$R_{ESR} \le \left(\frac{19.2 \times 10^{-3}}{\sqrt{I_{OUT}}}\right)\left(1 + \frac{R2}{R1}\right)$$

### Power Dissipation

The power dissipated in the MAX889 depends on the input voltage, output voltage, and output current. Device power dissipation is accurately described by:

$$P_{DISS} = I_{OUT} (V_{IN} - (-V_{OUT})) + (I_Q \times V_{IN})$$

where $I_Q$ is the device quiescent current. $P_{DISS}$ must be less than the package dissipation rating (see *Absolute Maximum Ratings*). Pay particular attention to power dissipation limits when generating small negative voltages from large positive input voltages.

### Layout Considerations

The MAX889's high oscillator frequencies demand good layout techniques that ensure stability and help maintain the output voltage under heavy loads. Take the following steps to ensure optimum layout:

1) Mount all components as close together as possible.
2) Place the feedback resistors R1 and R2 close to the FB pin, and minimize the PC trace length at the FB circuit node.
3) Keep traces short to minimize parasitic inductance and capacitance.
4) Use a ground plane with $C_{IN}$ and $C_{OUT}$ placed in a star ground configuration (see the MAX889SEVKIT layout).

# High-Frequency, Regulated, 200mA, Inverting Charge Pump

## Table 1. Capacitor Selection Table

| PART | FREQUENCY | $C_{FLY}$ | $C_{OUT}$ | $C_{IN}$ REGULATED | $C_{IN}$ FREE-RUN |
|---|---|---|---|---|---|
| MAX889R | 0.5MHz | 4.7µF | 22µF | 22µF | 4.7µF |
| MAX889S | 1MHz | 2.2µF | 10µF | 10µF | 2.2µF |
| MAX889T | 2MHz | 1µF | 4.7µF | 4.7µF | 1µF |

## Table 2. Low-ESR Capacitor Manufacturers

| PRODUCTION METHOD | MANUFACTURER | SERIES | PHONE | FAX |
|---|---|---|---|---|
| Surface-Mount Tantalum | AVX | TPS series | 803-946-0690 | 803-626-3123 |
| | Kemet | 494 series | 864-963-6300 | 864-963-6521 |
| | Matsuo | 267 series | 714-969-2491 | 714-960-6492 |
| | Sprague | 593D, 595D series | 603-224-1961 | 603-224-1430 |
| Surface-Mount Polymer | Sanyo | POSCAP-APA | 619-661-6835 | 619-661-1055 |
| Surface-Mount Ceramic | AVX | X7R | 803-946-0690 | 803-626-3123 |
| | Kemet | X7R | 864-963-6300 | 864-963-6521 |
| | Matsuo | X7R | 714-969-2491 | 714-960-6492 |
| | Murata | GRM X7R | 814-237-1431 | 814-238-0490 |

## Chip Information

TRANSISTOR COUNT: 1840

PROCESS: BiCMOS

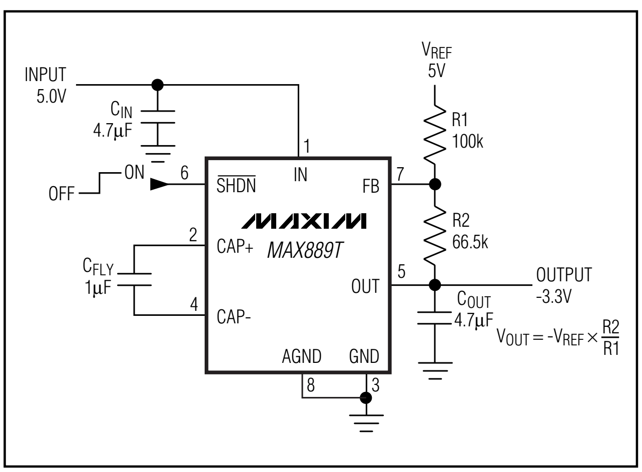
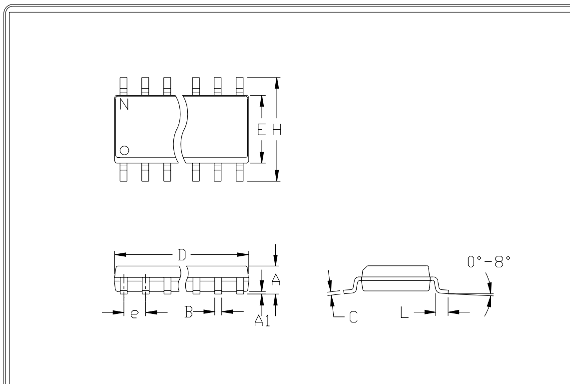



*Figure 4. Separate VREF for Voltage Divider*

## Package Information




| | INCHES MIN | INCHES MAX | MILLIMETERS MIN | MILLIMETERS MAX |
|---|---|---|---|---|
| A | 0.053 | 0.069 | 1.35 | 1.75 |
| A1 | 0.004 | 0.010 | 0.10 | 0.25 |
| B | 0.014 | 0.019 | 0.35 | 0.49 |
| C | 0.007 | 0.010 | 0.19 | 0.25 |
| e | 0.050 | | 1.27 | |
| E | 0.150 | 0.157 | 3.80 | 4.00 |
| H | 0.228 | 0.244 | 5.80 | 6.20 |
| h | 0.010 | 0.020 | 0.25 | 0.50 |
| L | 0.016 | 0.050 | 0.40 | 1.27 |

| | INCHES MIN | INCHES MAX | MILLIMETERS MIN | MILLIMETERS MAX | N | MS012 |
|---|---|---|---|---|---|---|
| D | 0.189 | 0.197 | 4.80 | 5.00 | 8 | A |
| D | 0.337 | 0.344 | 8.55 | 8.75 | 14 | B |
| D | 0.386 | 0.394 | 9.80 | 10.00 | 16 | C |

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
4. CONTROLLING DIMENSION: MILLIMETER
5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE
6. N = NUMBER OF PINS

MAXIM 120 SAN GABRIEL DR SUNNYVALE CA 94086 FAX (408) 737 7194 PROPRIETARY INFORMATION | TITLE: PACKAGE FAMILY OUTLINE: SOIC .150" | 1/1 | DOCUMENT CONTROL NUMBER: 21-0041 REV: A

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