19-2426; Rev 1; 7/06

MAXIM

Regulated 5V USB Charge Pump with Programmable Current Limit

General Description

The MAX5008 charge-pump regulator generates a regulated 5V output up to 125mA with a 2.95V to 5.5V input voltage range. The device includes resistor-programmable overcurrent limit. The MAX5008 requires a minimum number of external components for normal operation. The high 1MHz switching frequency allows the use of small surface-mount ceramic capacitors.

The fault-protection circuitry limits the output current when it exceeds the limit set by an external resistor. The output current can range from 1mA to 150mA to accommodate circuit requirements. A $\overline{FAULT}$ output indicates when the device is in current limit or the output is out of regulation.

A low-power shutdown mode reduces supply current to less than 1µA and places the output in a high-impedance state. The MAX5008 is offered in a space-saving 10-pin µMAX® package that is only 1.1mm high.

Applications

Flash Memory Supplies

USB Host Devices

Battery-Powered Systems

3.3V to 5V Local Conversion

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Features

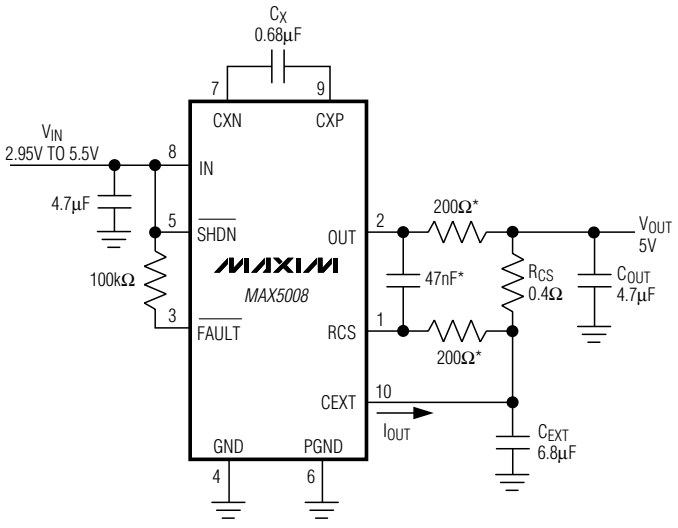
- **Regulated 5V Output Up to 125mA**
- **Indefinite Short-Circuit Protection**
- **Adjustable Output Current Limit**
- **No Inductors Required**
- **0.1µA Shutdown Current**
- **Thermal Shutdown**
- **Fault Output Indicates Overcurrent or Output Voltage Out of Regulation**
- **2.95V to 5.5V Input Voltage Range**
- **10-Pin µMAX Package**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX5008CUB	0°C to +70°C	10 µMAX

Pin Configuration appears at end of data sheet.

Typical Operating Circuit



*USE IF PRECISION CURRENT LIMIT IS REQUIRED.

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ABSOLUTE MAXIMUM RATINGS

IN, $\overline{SHDN}$, RCS, $\overline{FAULT}$, OUT to GND .....-0.3V to +6V
PGND to GND.....±0.3V
CXN to GND .....-0.3V to (V_{IN} + 0.3V)
CXP to GND .....-0.3V to (V_{CEXT} + 0.3V)
CEXT to GND .....-0.3V to (V_{CEXT} + 0.3V)
Short-Circuit Duration to GND .....Indefinite

Continuous Power Dissipation (T_A = +70°C)
10-Pin µMAX.....444mW
Operating Temperature Range.....0°C to +70°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} = $\overline{SHDN}$ = 3V, C_{IN} = 4.7µF, C_X = 0.68µF, C_{EXT} = 6.8µF, C_{OUT} = 4.7µF, R_{CS} = 0.4Ω, T_A = 0°C to +70°C, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range (Note 1)	V_{IN}	I_{OUT} = 125mA, 4.75V ≤ V_{OUT} ≤ 5.25V	2.95		4.25	V
		I_{OUT} = 70mA	2.95		5.50	
Input Undervoltage Lockout Threshold		Rising edge	2.0	2.35	2.6	V
Input Undervoltage Lockout Hysteresis		Falling edge		100		mV
Output Voltage (Note 2)	V_{OUT}	0 ≤ I_{OUT} < 30mA, 2.95V < V_{IN} < 5.5V	4.75	5.0	5.30	V
		0mA ≤ I_{OUT} ≤ 125mA, 2.95V ≤ V_{IN} ≤ 4.25V	4.75	5.0	5.25	
Output Voltage Ripple	V_{RIP}	0mA ≤ I_{OUT} ≤ 125mA		100		mV
V_{OUT} Fault Threshold	V_{TH}	V_{OUT} = 5V (nominal), no load	82.5		92.5	%V_{OUT}
Maximum Output Current	I_{OUT}	V_{OUT} = 5V ±4%	100	140		mA
No-Load Input Current	I_Q	I_{OUT} = 0, V_{IN} = 4.25V		0.6	6	mA
		I_{OUT} = 0, V_{IN} = 3.3V		1	6	
$\overline{SHDN}$ Logic High	$V_{INH,\overline{SHDN}}$		2.4			V
$\overline{SHDN}$ Logic Low	$V_{INL,\overline{SHDN}}$				0.4	V
Shutdown Supply Current	$I_{Q\overline{SHDN}}$	$\overline{SHDN}$ = low		0.1	10	µA
Current-Sense Trip Level	V_{CS}	V_{CS} = I_{OUT} x R_{CS} (Note 3)	55	60	73	mV
$\overline{FAULT}$ Leakage Current		$V_{\overline{FAULT}}$ = 5V, OUT in regulation			1	µA
$\overline{FAULT}$ Logic Low		I_{OUT} > I_{LIMIT}, or V_{OUT} < V_{TH}, I_{FAULT} = 1mA			0.4	V
$\overline{FAULT}$ Assertion Delay (Note 4)	t_{FD}	I_{OUT} > I_{LIMIT}		2		ms
		V_{OUT} < V_{TH}		30		µs
$\overline{FAULT}$ Deassertion Delay (Note 5)	t_{FDD}	I_{OUT} < I_{LIMIT} and V_{OUT} > 4.5V		16		ms
Switching Frequency			0.5	1	1.5	MHz
Startup Time	t_{START}	V_{OUT} > V_{TH}, R_{LOAD} = 46Ω, from rising edge of $\overline{SHDN}$		200		µs

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = $\overline{SHDN}$ = 3V, C_{IN} = 4.7µF, C_X = 0.68µF, C_{EXT} = 6.8µF, C_{OUT} = 4.7µF, R_{CS} = 0.4Ω, T_A = 0°C to +70°C, unless otherwise noted. Typical values are at T_A = +25°C.)

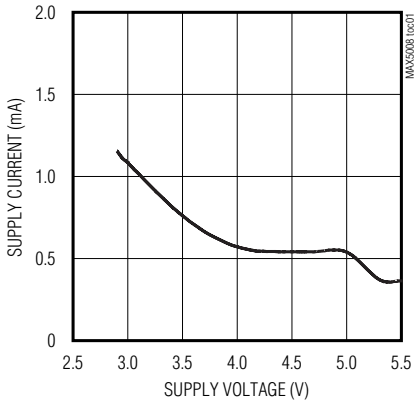
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Thermal Shutdown Junction Temperature				150		°C
Thermal Shutdown Hysteresis				30		°C

Note 1: When the input exceeds 4.25V, the power dissipation on the chip exceeds the maximum rating if the output current is 125mA.
Note 2: The MIN/MAX limits are 100% production tested at +25°C and +70°C, and guaranteed by design at 0°C.
Note 3: I_{OUT} is output current flowing from C_{EXT}.
Note 4: The delay from the fault event to the assertion of $\overline{FAULT}$. Fault delays are specified with either a current fault or a voltage fault, but not both simultaneously.
Note 5: The delay from the removal of the fault event to the deassertion of $\overline{FAULT}$.

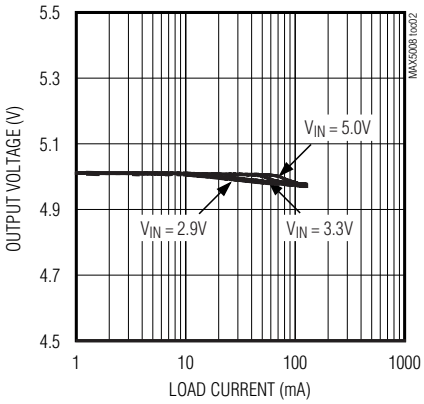
Typical Operating Characteristics

(V_{IN} = 3V, C_{IN} = 4.7µF, C_X = 0.47µF, C_{OUT} = 4.7µF, C_{EXT} = 4.7µF, R_{CS} = 0.4Ω, T_A = +25°C, unless otherwise noted.)

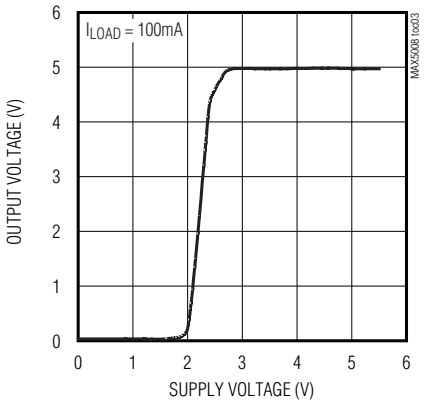
NO-LOAD SUPPLY CURRENT vs. SUPPLY VOLTAGE



OUTPUT VOLTAGE vs. LOAD CURRENT



OUTPUT VOLTAGE vs. SUPPLY VOLTAGE

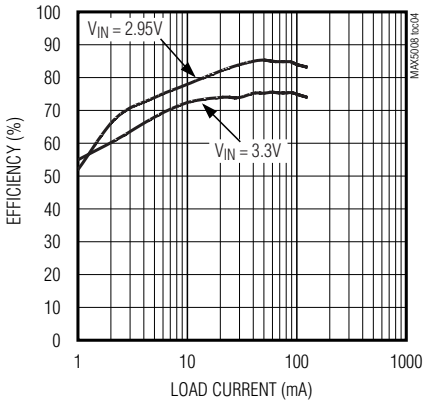


Regulated 5V USB Charge Pump with Programmable Current Limit

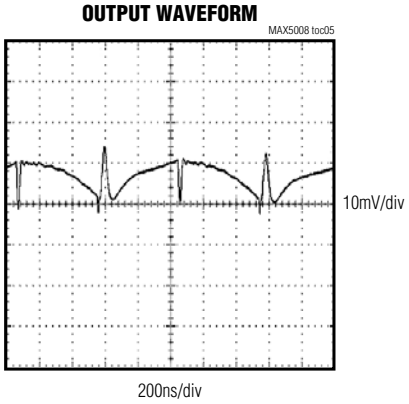
Typical Operating Characteristics (continued)

(V_{IN} = 3V, C_{IN} = 4.7µF, C_X = 0.47µF, C_{OUT} = 4.7µF, C_{EXT} = 4.7µF, R_{CS} = 0.4Ω, T_A = +25°C, unless otherwise noted.)

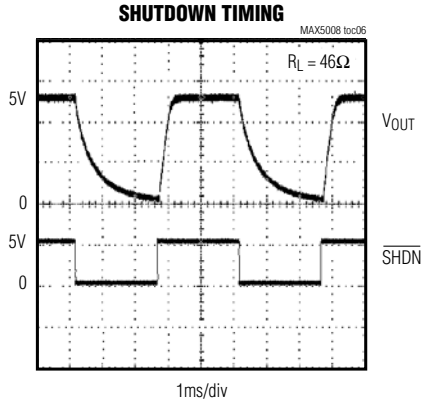
EFFICIENCY vs. LOAD CURRENT



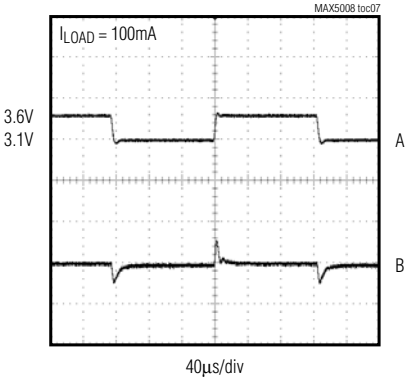
OUTPUT WAVEFORM



SHUTDOWN TIMING

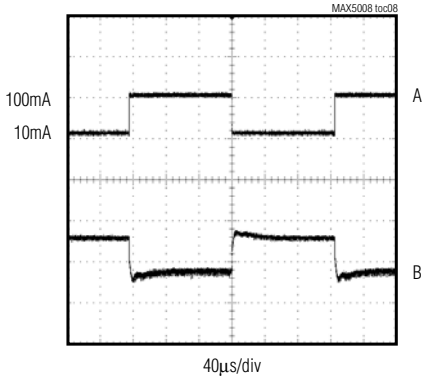


LINE-TRANSIENT RESPONSE



A: INPUT VOLTAGE: 500mV/div
B: OUTPUT VOLTAGE: AC-COUPLED, 100mV/div

LOAD-TRANSIENT RESPONSE



A: LOAD CURRENT
B: OUTPUT VOLTAGE: AC-COUPLED, 100mV/div

Regulated 5V USB Charge Pump with Programmable Current Limit

Pin Description

PIN	NAME	FUNCTION
1	RCS	External Current-Sense Resistor. Connect a resistor from RCS to OUT to set the overcurrent threshold. I_{LIMIT} = 60mV / R_{CS}.
2	OUT	Fixed 5V Output. Bypass OUT to GND with a 4.7µF capacitor.
3	$\overline{FAULT}$	Output Fault Indicator. $\overline{FAULT}$ is asserted when either $I_{OUT} > I_{LIMIT}$ or $V_{OUT} < V_{TH}$. $\overline{FAULT}$ is an open-drain output that is high during normal operation or during shutdown.
4	GND	Ground Pin. Connect GND to PGND.
5	$\overline{SHDN}$	Shutdown Input. When $\overline{SHDN}$ = low, the device turns off. Drive $\overline{SHDN}$ high or connect to IN for normal operation.
6	PGND	Power Ground Pin. Connect PGND to GND.
7	CXN	Negative Terminal of the Charge-Pump Capacitor. Connect a 0.68µF capacitor from CXN to CXP.
8	IN	Input Supply, 2.95V to 5.5V. Bypass IN to GND with a 4.7µF ceramic capacitor.
9	CXP	Positive Terminal of the Charge-Pump Capacitor. Connect a 0.68µF capacitor from CXP to CXN.
10	CEXT	Charge-Pump Output. Bypass CEXT to PGND with a 6.8µF capacitor.

Detailed Description

The MAX5008 charge pump provides a regulated 5V output from a 2.95V to 5.5V input. The device delivers a maximum of 125mA load current. Designed specifically for compact applications, a complete regulator circuit requires a minimum number of external components.

Adjustable Current Limit

The MAX5008 has an adjustable overcurrent protection. An external current-sense resistor is connected from RCS to OUT to set the current limit. The current limit is defined by:

$$I_{LIMIT} = V_{CS} / RCS$$

where V_{CS} is the current-sense trip level, typically 60mV. For example, I_{LIMIT} = 150mA when RCS = 0.40Ω.

When the output current limit is exceeded, the output voltage falls and the device maintains the average output current at I_{LIMIT}. Upon removal of the overcurrent condition, the part resumes normal operation.

$\overline{FAULT}$ Indication

When $I_{OUT} > I_{LIMIT}$ or $V_{OUT} < V_{TH}$, $\overline{FAULT}$ asserts. $\overline{FAULT}$ is an open-drain output that needs to be connected through a 100kΩ (typ) pullup resistor to a logic supply voltage.

Thermal Shutdown

The MAX5008 has internal thermal shutdown circuitry, which shuts down the device when the die temperature exceeds +150°C. The thermal shutdown circuitry has 30°C hysteresis.

Shutdown Mode

Driving $\overline{SHDN}$ low places the device in shutdown mode, which disables the oscillator, the control logic, and the reference. The output goes into high-impedance state and drops to ground if loaded. Placing the device in shutdown mode reduces the supply current to less than 0.1µA. In normal operation, $\overline{SHDN}$ is driven high or connected to IN.

Applications Information

Capacitor Selection

The MAX5008 requires four external capacitors. Their values depend on the required output current. Table 1 shows the capacitor values recommended for different load currents.

Input Voltage Range

The MAX5008 maintains a regulated 5V output with input voltages from 2.95V to 5.5V. If the input voltage exceeds 4.25V, limit the output current to 75mA or less. This keeps the MAX5008 within its maximum power dissipation limits.

Table 1. Recommended Capacitor Values

I_{OUT}	C_{IN} (µF)	C_X (µF)	C_{EXT} (µF)	C_{OUT} (µF)
50mA	3.3	0.33	3.3	3.3
125mA	4.7	0.68	6.8	4.7

Layout Considerations

All capacitors should be located as close to the IC as practical. Connect GND and PGND through a short,

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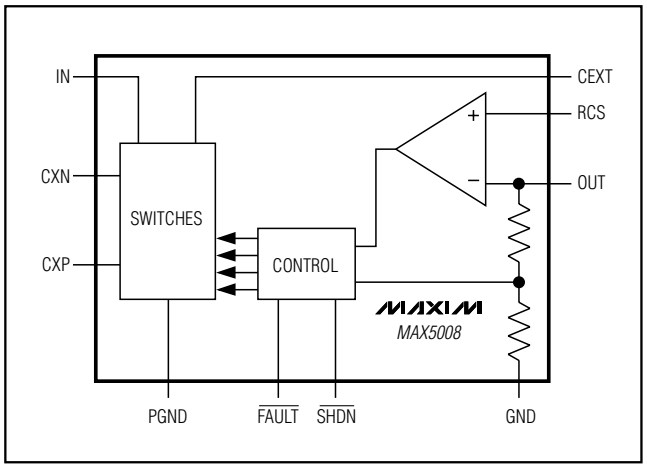
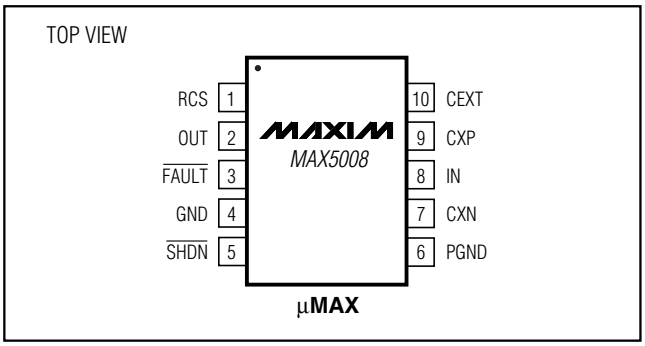
Functional Diagram



Pin Configuration



low-impedance trace, and connect the ground for C_{IN}, C_{EXT}, and C_{OUT} directly to PGND in a star configuration. Connect R_{CS} to C_{EXT} through a short and low impedance trace.

Chip Information

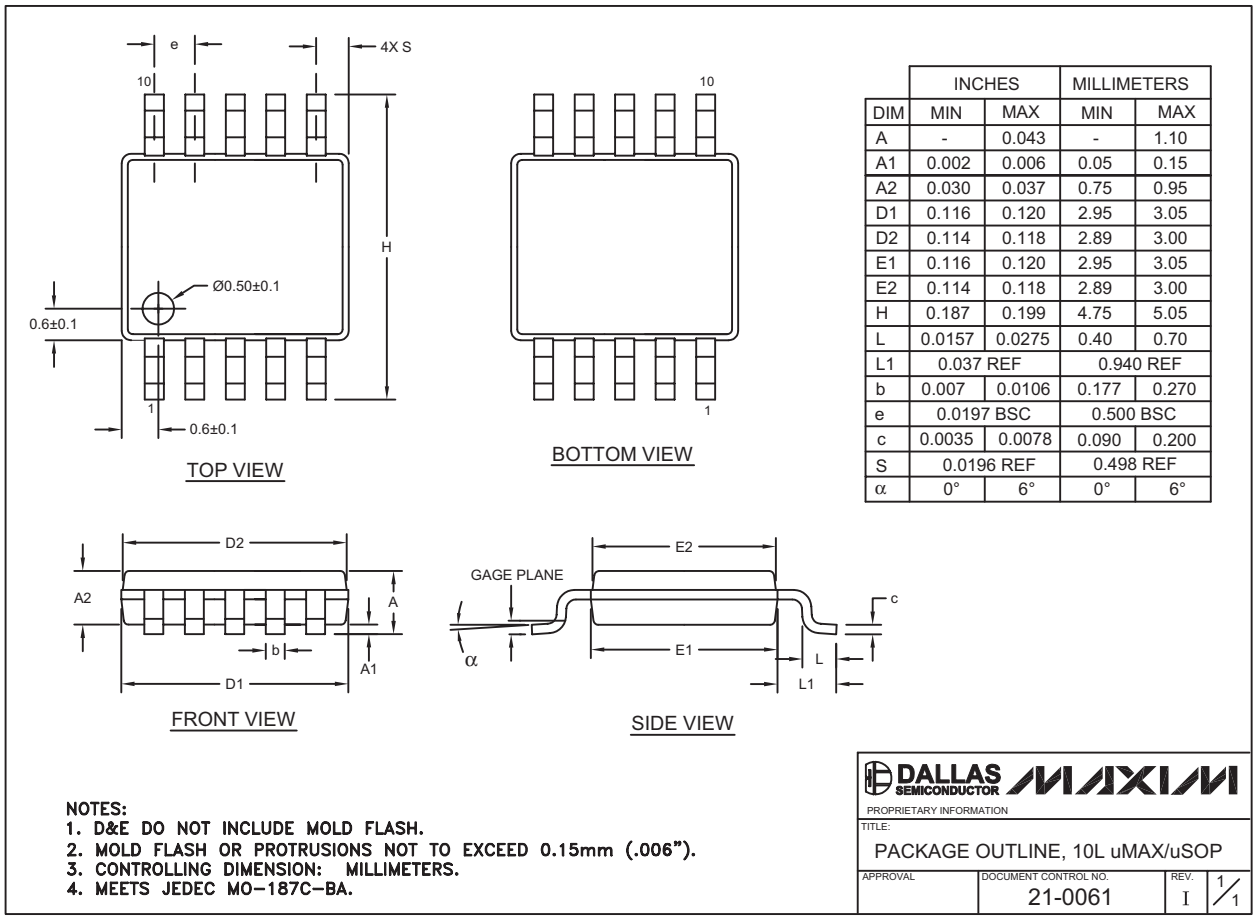
TRANSISTOR COUNT: 2632

PROCESS: BiCMOS

Regulated 5V USB Charge Pump with Programmable Current Limit

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)



	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	-	0.043	-	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
D1	0.116	0.120	2.95	3.05
D2	0.114	0.118	2.89	3.00
E1	0.116	0.120	2.95	3.05
E2	0.114	0.118	2.89	3.00
H	0.187	0.199	4.75	5.05
L	0.0157	0.0275	0.40	0.70
L1	0.037 REF		0.940 REF	
b	0.007	0.0106	0.177	0.270
e	0.0197 BSC		0.500 BSC	
c	0.0035	0.0078	0.090	0.200
S	0.0196 REF		0.498 REF	
α	0°	6°	0°	6°

Revision History

Pages changed at Rev 1: 1, 2, 7

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