19-3944; Rev 1; 5/06

MAXIM

2.2MHz, 2A Buck Converters with an Integrated High-Side Switch

General Description

The MAX5088/MAX5089 high-frequency, DC-DC converters with an integrated n-channel power MOSFET provide up to 2A of load current. The MAX5088 includes an internal power MOSFET to enable the design of a nonsynchronous buck topology power supply. The MAX5089 is for the design of a synchronous buck topology power supply. These devices operate from a 4.5V to 5.5V or 5.5V to 23V input voltage and a 200kHz to 2.2MHz resistor-programmable switching frequency. The voltage-mode architecture with a peak switch current-limit scheme provides stable operation up to a 2.2MHz switching frequency. The MAX5088 includes a clock output for driving a second DC-DC converter 180° out-of-phase and a power-on-reset ($\overline{\text{RESET}}$) output. The MAX5089 includes a power-good output and a synchronous rectifier driver to drive an external low-side MOSFET in the buck converter configuration for high efficiency.

The MAX5088/MAX5089 protect against overcurrent conditions by utilizing a peak current limit as well as overtemperature shutdown providing a very reliable and compact power source for point-of-load regulation applications. Additional features include synchronization, internal digital soft-start, and an enable input. The MAX5088/MAX5089 are available in a thermally enhanced, space-saving 16-pin TQFN (5mm x 5mm) package and operate over the -40°C to +125°C temperature range.

Applications

xDSL Modem Power Supply

Automotive Radio Power Supply

Servers and Networks

IP Phones/WLAN Access Points

Selector Guide

PART	CONFIGURATION	FEATURES
MAX5088ATE	Nonsynchronous Buck	$\overline{\text{RESET}}$ Output, Clock Output
MAX5089ATE	Synchronous Buck	PGOOD Output, Synchronous FET Driver

Pin Configurations continued at end of data sheet.

Features

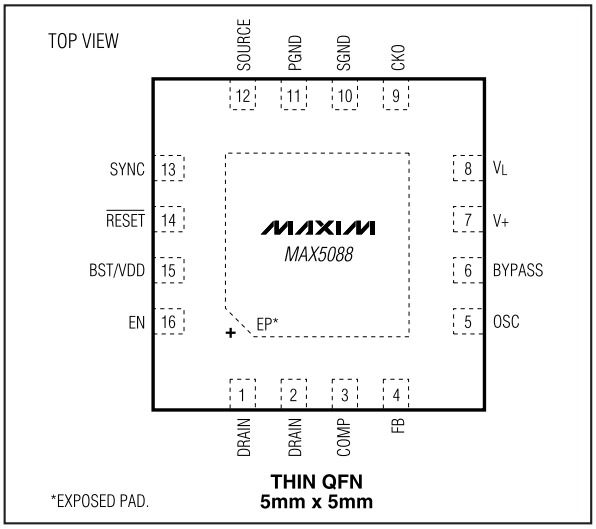
- **4.5V to 5.5V or 5.5V to 23V Input Voltage Range**
- **Output Voltage Adjustable Down to 0.6V**
- **2A Output Current**
- **Synchronous Rectifier Driver Output (MAX5089) for Higher Efficiency**
- **Resistor-Programmable Switching Frequency from 200kHz to 2.2MHz**
- **External Synchronization and Enable (On/Off) Inputs**
- **Clock Output for Driving Second Converter 180° Out-Of-Phase (MAX5089)**
- **Integrated 150mΩ High-Side n-Channel Power MOSFET**
- **Power-On Reset Output (MAX5088)/Power-Good Output (MAX5089)**
- **Short-Circuit Protection**
- **Thermal-Shutdown Protection**
- **Thermally Enhanced 16-Pin TQFN Package Dissipates 2.7W**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	PKG CODE
MAX5088ATE+	-40°C to +125°C	16 TQFN	T1655-2
MAX5089ATE+	-40°C to +125°C	16 TQFN	T1655-2

+Denotes lead-free package.

Pin Configurations



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ABSOLUTE MAXIMUM RATINGS

V+ to PGND .....-0.3V to +25V
BST/VDD, DRAIN to SGND .....-0.3V to +30V
SGND to PGND .....-0.3V to +0.3V
BST/VDD to SOURCE .....-0.3V to +6V
SOURCE to SGND .....-0.6V to +25V
SOURCE or DRAIN Maximum Peak Current .....5A for 1ms
V_L to SGND .....-0.3V to the lower of +6V and (V+ + 0.3V)
SYNC, EN, DL, CKO, OSC, COMP,
FB to SGND .....-0.3V to (V_L + 0.3V)
BYPASS, CKO, OSC, COMP, FB, EN, SYNC, RESET,
PGOOD Maximum Input Current .....±50mA

$\overline{RESET}$, PGOOD to SGND .....-0.3V to +6V
BYPASS to SGND .....-0.3V to +2.2V
V_L and BYPASS Short-Circuit Duration to SGND .....Continuous
Continuous Power Dissipation* (T_A = +70°C)
16-Pin TQFN (derate 33mW/°C above +70°C) 2666mW
Package Thermal Resistance (junction to case) .....1.7°C/W
Operating Temperature Range .....-40°C to +125°C
Junction Temperature Range .....-65°C to +150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C

*As per JEDEC51 Standard (multilayer board).

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+ = V_L = 5V or V+ = 5.5V to 23V, V_{EN} = 5V, T_A = T_J = -40°C to +125°C, unless otherwise noted. Circuits of Figures 5 and 6. Typical values are at T_A = T_J = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SYSTEM SPECIFICATIONS						
Input Voltage Range	V+		5.5		23.0	V
		V+ = V_L	4.5		5.5	V
V+ Operating Supply Current	I_Q	V+ = 12V, V_{FB} = 0.8V R_{OSC} = 10kΩ, no switching		1.8	2.5	mA
V+ Standby Supply Current	I_{STBY}	V+ = 12V, V_{EN} = 0V, PGOOD (MAX5089), $\overline{RESET}$, CKO unconnected (MAX5088), R_{OSC} = 10kΩ		1	1.4	mA
Efficiency	η	Nonsynchronous (MAX5088), f_{SW} = 1.25MHz, V+ = 12V, I_{OUT} = 1.5A, V_{OUT} = 3.3V		79		%
		Synchronous (MAX5089), f_{SW} = 300kHz, V+ = 12V, I_{OUT} = 1.5A, V_{OUT} = 3.3V		90		
V_L REGULATOR (V_L)/BYPASS OUTPUT (BYPASS)						
V_L Undervoltage Lockout	V_{UVLO}	V_L falling		4.1	4.3	V
V_L Undervoltage Lockout Hysteresis	V_{HYST}			137		mV
V_L Output Voltage	V_L	V+ = 5.5V to 23V, I_{VL} = 0 to 40mA	5.0	5.2	5.5	V
BYPASS Output Voltage	V_{BYPASS}	V+ = V_L = 5.2V	1.98	2	2.02	V
BYPASS Load Regulation	ΔV_{BYPASS}	I_{BYPASS} steps from 0 to 50µA, V+ = V_L = 5.2V	0	1.2	10	mV

ELECTRICAL CHARACTERISTICS (continued)

(V+ = V_L = 5V or V+ = 5.5V to 23V, V_{EN} = 5V, T_A = T_J = -40°C to +125°C, unless otherwise noted. Circuits of Figures 5 and 6. Typical values are at T_A = T_J = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
SOFT-START							
Digital Soft-Start Period		Internal 6-bit DAC			4096		Clock periods
Soft-Start Steps					64		Steps
ERROR AMPLIFIER (FB and COMP)							
FB to COMP Transconductance	g_M			1.20	1.8	2.75	mS
FB Input Bias Current	I_{FB}					250	nA
FB Input Voltage Set Point	V_{FB}			0.5940	0.601	0.6095	V
COMP Sink-and-Source Current Capability	I_{COMP}			100	150		µA
INTERNAL MOSFETs							
On-Resistance n-Channel Power MOSFET	R_{ON}	V+ = V_L = 5.2V, I_{SINK} = 100mA			0.150	0.302	Ω
Leakage Current	I_{LEAK}	V_{EN} = 0V, V_{DRAIN} = 23V, SOURCE = PGND				20	µA
Minimum Output Current	I_{OUT}	V_{OUT} = 3.3V, V+ = 12V (Note 2)			2		A
Current Limit	I_{LIMIT}			2.2	2.8	3.5	A
On-Resistance Internal Low-Side Switch	R_{ONLSW}	I_{SWITCH} = 50mA, V+ = V_L = 5.2V			20	38	Ω
SYNCHRONOUS RECTIFIER DRIVER (DL) (MAX5089 Only)							
On-Resistance nMOS	R_{ONDLN}	I_{SINK} = 0.1A			1	6.7	Ω
On-Resistance pMOS	R_{ONDLP}	I_{SOURCE} = 0.1A			1.9	11.1	Ω
Peak Sink Current	I_{IDL_SINK}				1		A
Peak Source Current	I_{IDL_SOURCE}				0.75		A
OSCILLATOR (OSC)/SYNCHRONIZATION (SYNC)/CLOCK OUTPUT (CKO) (MAX5088 Only)							
Clock Output-High Level	V_{CKOH}	V_L = 5.2V, I_{SOURCE} = 5mA		3.54			V
Clock Output-Low Level	V_{CKOL}	V_L = 5.2V, I_{SINK} = 5mA				0.4	V
Switching Frequency	f_{SW}	V+ = V_L = 5.2V	R_{OSC} = 5.62kΩ	1900	2100	2400	kHz
			R_{OSC} = 41.2kΩ	275	312	350	
			R_{OSC} = 10kΩ	1130	1250	1380	
Minimum Controllable On-Time	t_{ON_MIN}				120		ns
Maximum Duty Cycle	D_{MAX}	f_{SW} = 2.2MHz	MAX5088	82	87.5		%
			MAX5089	82	87.5		

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ELECTRICAL CHARACTERISTICS (continued)

(V+ = V_L = 5V or V+ = 5.5V to 23V, V_{EN} = 5V, T_A = T_J = -40°C to +125°C, unless otherwise noted. Circuits of Figures 5 and 6. Typical values are at T_A = T_J = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SYNC Frequency Range (Note 3)	f_{SYNC}		200		2200	kHz
Sync Input to SOURCE Rising-Edge Phase Delay (Note 4)	$SYNC_{PHASE}$	R_{OSC} = 10kΩ, f_{SYNC} = 1.2MHz		65		degrees
Clock Output Phase Delay With Respect to SOURCE Waveform (Note 5)	CKO_{PHASE}	R_{OSC} = 10kΩ, SYNC = GND (MAX5088 only)		115		degrees
SYNC High Threshold	V_{SYNCH}		2.0			V
SYNC Low Threshold	V_{SYNCL}				0.8	V
Minimum SYNC High Pulse Width	t_{SYNC_H}			100		ns
EN, $\overline{RESET}$ (MAX5088)/PGOOD (MAX5089)						
EN Threshold	V_{IH}		2.0			V
	V_{IL}				0.8	
EN Input Bias Current	I_{EN}				250	nA
$\overline{RESET}$ Threshold (Note 6)	V_{TH}	V_{FB} = V_{OUT}	90	92.5	95	% V_{OUT}
PGOOD Threshold (Note 6)	V_{TH}	V_{FB} = V_{OUT}	90	92.5	95	% V_{OUT}
FB to $\overline{RESET}$ or FB to PGOOD Propagation Delay	t_{FD}			3		µs
$\overline{RESET}$ Active Timeout Period	t_{RP}		140	200	254	ms
$\overline{RESET}$, PGOOD Output Voltage	V_{OL}	I_{SINK} = 3mA			0.4	V
$\overline{RESET}$, PGOOD Output Leakage Current	I_{LEAK}	V+ = V_L = 5.2V, $V_{\overline{RESET}}$ or V_{PGOOD} = 6V, V_{FB} = 0.8V			2	µA
THERMAL SHUTDOWN						
Thermal Shutdown	T_{SHDN}	Temperature rising		+170		°C
Thermal-Shutdown Hysteresis				25		°C

Note 1: 100% tested at +125°C. Limits over temperature are guaranteed by design.
Note 2: Output current may be limited by the power dissipation of the package. See the *Power Dissipation* section in the *Applications Information* section.
Note 3: SYNC input frequency is equal to the switching frequency.
Note 4: From the SYNC rising edge to SOURCE rising edge.
Note 5: From the rising edge of the SOURCE waveform to the rising edge of the CKO waveform.
Note 6: $\overline{RESET}$ goes high 200ms after V_{OUT} crosses this threshold, PGOOD goes high after V_{OUT} crosses this threshold.

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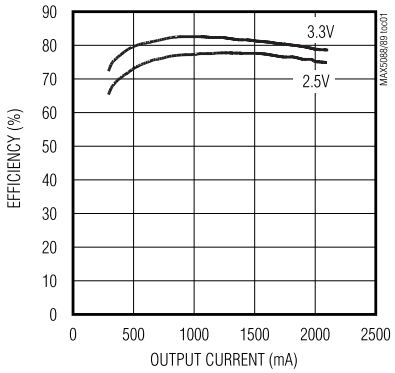
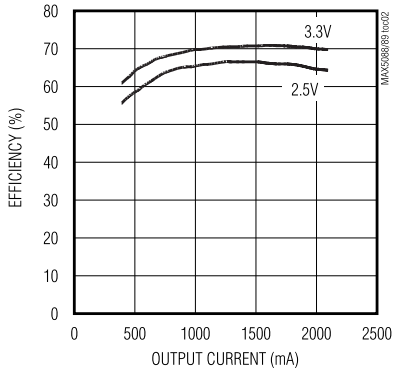
Typical Operating Characteristics

(V+ = V_L = 5.2V, T_A = +25°C, Figures 5 and 6, unless otherwise noted.)

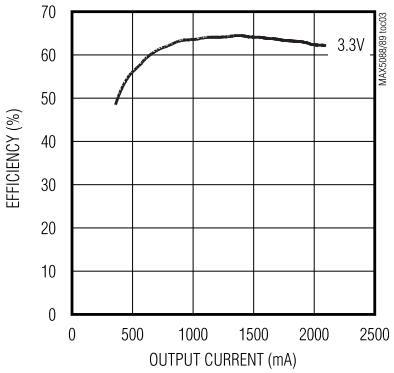
MAX5088 BUCK EFFICIENCY vs. OUTPUT CURRENT (V_{IN} = 5V, f_{SW} = 2.2MHz)



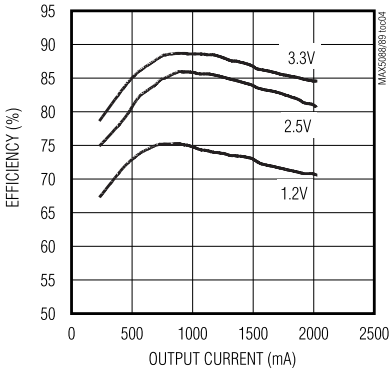
MAX5088 BUCK EFFICIENCY vs. OUTPUT CURRENT (V_{IN} = 12V, f_{SW} = 2.2MHz)



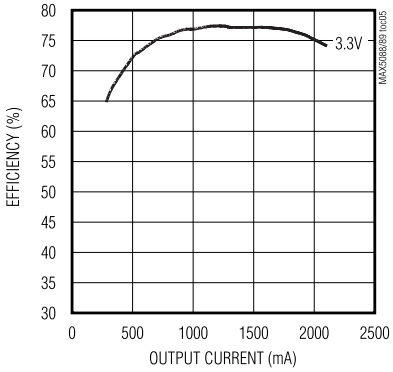
MAX5088 BUCK EFFICIENCY vs. OUTPUT CURRENT (V_{IN} = 16V, f_{SW} = 2.2MHz)



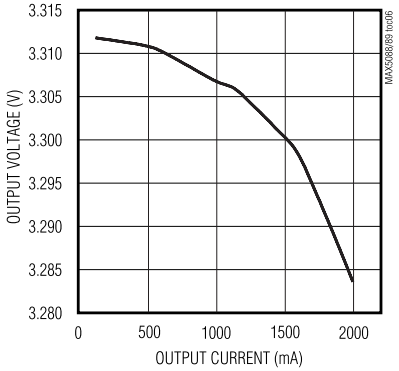
MAX5089 SYNCHRONOUS EFFICIENCY vs. OUTPUT CURRENT (V_{IN} = 12V, f_{SW} = 330kHz, L = 15µH)



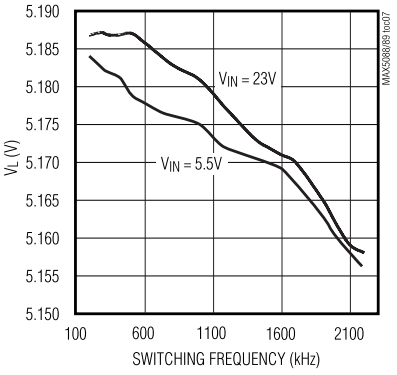
MAX5089 SYNCHRONOUS EFFICIENCY vs. OUTPUT CURRENT (V_{IN} = 12V, f_{SW} = 2.2MHz, L = 4.7µH)



MAX5089 OUTPUT VOLTAGE vs. OUTPUT CURRENT (V_{IN} = 12V, V_{OUT} = 3.3V, f_{SW} = 2.2MHz)



V_L OUTPUT VOLTAGE vs. SWITCHING FREQUENCY



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