



## 5V/3.3V/3V 5A Step-Down, PWM, Switch-Mode DC-DC Regulators

### General Description

The MAX787/MAX788/MAX789 are monolithic, bipolar, pulse-width modulation (PWM), switch-mode, step-down DC-DC regulators. Each is rated at 5A. Very few external components are needed for standard operation because the power switch, oscillator, feedback, and control circuitry are all on-chip. Employing a classic buck topology, these regulators perform high-current step-down functions.

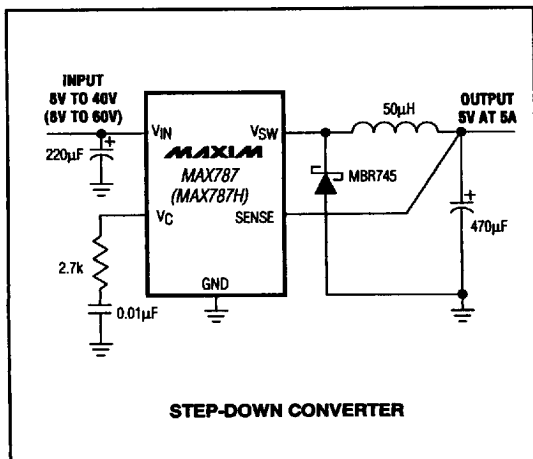
The MAX787/MAX788/MAX789 have excellent dynamic and transient response characteristics, while featuring cycle-by-cycle current limiting to protect against overcurrent faults and short-circuit output faults. They also have a wide 8V to 40V input range (up to 60V for the high-voltage "H" version).

Each regulator is available in 5-pin TO-220, 7-pin TO-220, and 4-pin TO-3. These devices have a preset 100kHz oscillator frequency and a preset current limit of 6.5A. The 7-pin package allows for adjustable current limit and micropower shutdown. See the MAX724/MAX726 data sheet for more applications information.

### Applications

Distributed Power from High-Voltage Buses  
High-Current, High-Voltage Step-Down  
Multiple-Output Buck Converter

### Typical Operating Circuit



### Features

- ◆ Input Range: Up to 40V  
Up to 60V (H Version)
- ◆ 5A On-Chip Power Switch
- ◆ Fixed Outputs: 5V (MAX787)  
3.3V (MAX788)  
3V (MAX789)
- ◆ 100kHz Switching Frequency
- ◆ Excellent Dynamic Characteristics
- ◆ Few External Components
- ◆ 8.5mA Quiescent Current
- ◆ TO-220 and TO-3 Packages

### Ordering Information

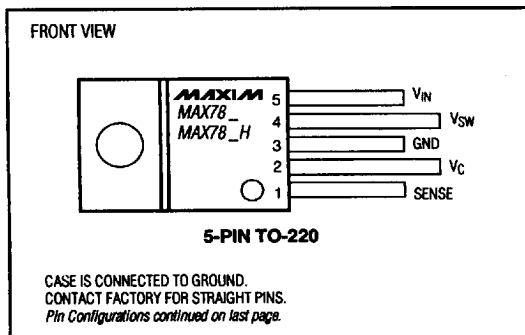
PART	TEMP. RANGE	PIN-PACKAGE
MAX787CCK	0°C to +70°C	5 TO-220
MAX787CCM	0°C to +70°C	7 TO-220†
MAX787CKS	0°C to +70°C	4 TO-3†
MAX787C/D	0°C to +70°C	Dice*
MAX787ECK	-40°C to +85°C	5 TO-220
MAX787ECM	-40°C to +85°C	7 TO-220†
MAX787EKS	-40°C to +85°C	4 TO-3†
MAX787MKS	-55°C to +125°C	4 TO-3†

Ordering Information continued on last page.

\* Contact factory for dice specifications.

† Contact factory for package availability.

### Pin Configurations



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Maxim Integrated Products 4-205

Call toll free 1-800-998-8800 for free samples or literature.

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MAX787/MAX788/MAX789

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# 5V/3.3V/3V 5A Step-Down, PWM, Switch-Mode DC-DC Regulators

## ABSOLUTE MAXIMUM RATINGS

Input Voltage	
MAX78_	45V
MAX78_H	64V
Switch Voltage with Respect to Input Voltage	
MAX78_	64V
MAX78_H	75V
Switch Voltage with Respect to GND Pin ( $V_{SW}$ negative)	
MAX78_ (Note 8)	35V
MAX78_H (Note 8)	45V
SENSE Pin Voltage	-0.3V, +10V
SHUT Pin Voltage (not to exceed $V_{IN}$ )	40V
$I_{LIM}$ Pin Voltage (forced)	5.5V

## Operating Temperature Ranges:

MAX78_C_/_HC_	0°C to +70°C
MAX78_E_/_HE_	-40°C to +85°C
MAX78_MKS/HMKS	-55°C to +125°C

## Junction Temperature Ranges:

MAX78_C_/_HC_	0°C to +125°C
MAX78_E_/_HE_	-40°C to +125°C
MAX78_MKS/HMKS	-55°C to +150°C

Storage Temperature Range -65°C to +160°C

Lead Temperature (soldering, 10sec) +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

( $V_{IN} = 25V$ ,  $T_J = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Switch-On Voltage (Note 1)	I <sub>SW</sub> = 1A	T <sub>J</sub> ≥ 0°C			1.85	V
		T <sub>J</sub> < 0°C			2.10	
	I <sub>SW</sub> = 5A	T <sub>J</sub> ≥ 0°C			2.30	
		T <sub>J</sub> < 0°C			2.50	
Switch-Off Leakage	V <sub>IN</sub> = ≤ 25V, V <sub>SW</sub> = 0V	T <sub>J</sub> = +25°C		5	300	μA
	V <sub>IN</sub> = V <sub>MAX</sub> , V <sub>SW</sub> = 0V (Note 2)	T <sub>J</sub> = +25°C		10	500	
Supply Current (Note 3)	V <sub>IN</sub> ≤ 40V, V <sub>SENSE</sub> = 5.5V			8.5	11	mA
	*H* version only, 40V < V <sub>IN</sub> < 60V			9	12	
	V <sub>SHUT</sub> = 0.1V (Note 4)			140	300	μA
Minimum Operating Supply Voltage				7.3	8.0	V
Minimum Start-Up Supply Voltage (Note 5)	T <sub>A</sub> ≥ +25°C			3.5	4.8	V
	T <sub>A</sub> < +25°C			3.5	5.0	
Switch-Current Limit (Note 6)	I <sub>LIM</sub> open	T <sub>J</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>	5.5	6.5	8.5	A
	R <sub>LIM</sub> = 10kΩ (Note 7)	T <sub>J</sub> = +25°C		4.5		
	R <sub>LIM</sub> = 7kΩ (Note 7)	T <sub>J</sub> = +25°C		3		
Maximum Duty Cycle			85	90		%
Switching Frequency		T <sub>J</sub> = +25°C	90	100	110	kHz
		T <sub>J</sub> ≤ +125°C	85		120	
	V <sub>OUT</sub> = V <sub>SENSE</sub> = 0V (Note 6)			20		
Switching Frequency Line Regulation	8V ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub> (Note 2)			0.03	0.10	%/V
Error-Amplifier Voltage Gain	1V ≤ V <sub>C</sub> ≤ 4V	T <sub>J</sub> = +25°C		2000		V/V
Error-Amplifier Transconductance		T <sub>J</sub> = +25°C	3700	5000	8000	μmho
Error-Amplifier Source Current	V <sub>SENSE</sub> = V <sub>OUT</sub> + 10%	T <sub>J</sub> = +25°C	100	140	225	μA
Error-Amplifier Sink Current	V <sub>SENSE</sub> = V <sub>OUT</sub> - 10%	T <sub>J</sub> = +25°C	0.7	1.0	1.6	mA

# 5V/3.3V/3V 5A Step-Down, PWM, Switch-Mode DC-DC Regulators

## ELECTRICAL CHARACTERISTICS (continued)

( $V_{IN} = 25V$ ,  $T_J = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
SENSE Voltage	$V_C = 2V$	MAX787	4.85	5.00	5.15	V
		MAX788	3.20	3.30	3.40	
		MAX789	2.90	3.00	3.10	
SENSE Pin Divider Resistance	$T_J = +25^\circ C$	MAX787	3.0	5.0	8.0	k $\Omega$
		MAX788	2.5	4.2	7.0	
		MAX789	2.2	3.8	6.5	
Output Voltage Tolerance	$V_{OUT}$ (nominal) = 5V (MAX787), 3.3V (MAX788), or 3V (MAX789); all conditions of input voltage, output voltage, and load current	$T_J = +25^\circ C$		$\pm 0.5$	$\pm 2.0$	%
		$T_J = T_{MIN}$ to $T_{MAX}$		$\pm 1.0$	$\pm 3.0$	
Output Voltage Line Regulation	$8V \leq V_{IN} \leq V_{MAX}$ (Note 2)			0.005	0.020	%/V
$V_C$ Voltage	0% duty cycle	$T_J = +25^\circ C$		1.5		V
$V_C$ Voltage Temperature Coefficient	0% duty cycle	$T_J = T_{MIN}$ to $T_{MAX}$		-4		mV/ $^\circ C$
SHUT Pin Current	$V_{SHUT} = 5V$		5	10	20	$\mu A$
	$V_{SHUT} \leq V_{THRESHOLD}$ ( $\approx 2.5V$ )				50	
SHUT Thresholds	Switch duty cycle = 0%		2.20	2.45	2.70	V
	Fully shut down		0.10	0.30	0.50	
Thermal Resistance Junction to Case (Note 9)					2.5	$^\circ C/W$

**Note 1:** For switch currents between 1A and 5A, maximum switch-on voltage can be calculated via linear interpolation.

**Note 2:**  $V_{MAX} = 40V$  for MAX787/MAX788/MAX789 and 60V for MAX787H/MAX788H/MAX789H.

**Note 3:** By setting the SENSE pin to 5.5V, the  $V_C$  pin is forced to its low clamp level and the switch duty cycle is forced to zero, approximating the zero load condition.

**Note 4:** Device shut down. Switch leakage current not included.

**Note 5:** For proper regulation, total voltage from  $V_{IN}$  to GND must be  $\geq 8V$  after start-up.

**Note 6:** To avoid extremely short switch-on times, the switch frequency is internally scaled down when  $V_{SENSE}$  is less than 2.6V (MAX787), 2.0V (MAX788), or 1.8V (MAX789). Switch current limit is tested with  $V_{SENSE}$  adjusted to give a 1 $\mu s$  minimum switch-on time.

**Note 7:**  $R_{LIM} = \left[ \frac{I_{LIM}}{1A} \times 2k\Omega \right] + 1k\Omega$

**Note 8:** Do not exceed switch-to-input voltage limitation.

**Note 9:** Guaranteed, not production tested.

MAX787/MAX788/MAX789

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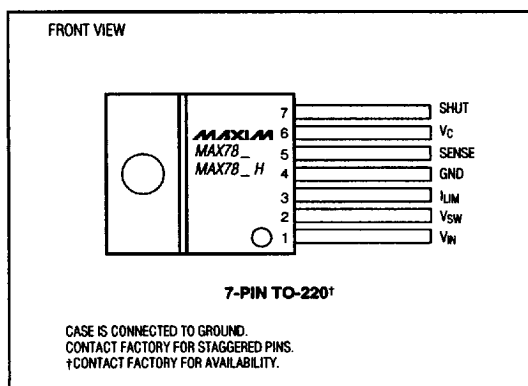
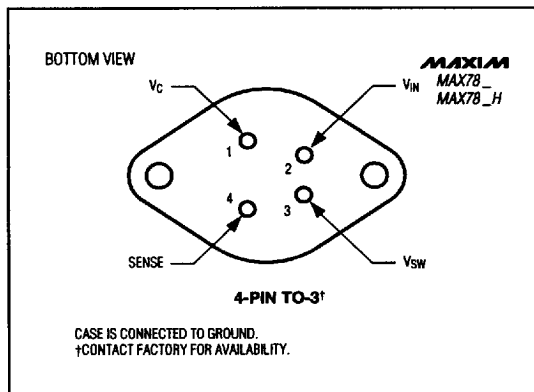
# 5V/3.3V/3V 5A Step-Down, PWM, Switch-Mode DC-DC Regulators

## Pin Description

PIN			NAME	FUNCTION
5-PIN TO-220	4-PIN TO-3	7-PIN TO-220		
1	4	5	SENSE	SENSE Input is the internal error amplifier's input, and should be directly connected to $V_{OUT}$ . SENSE also aids current limiting by reducing oscillator frequency when $V_{OUT}$ is low.
2	1	6	$V_C$	Error-Amplifier Output. A series RC network connected to this pin compensates the MAX787/MAX788/MAX789. Output swing is limited to about 5.8V in the positive direction and -0.7V in the negative direction. $V_C$ can also synchronize the MAX787/MAX788/MAX789 to an external TTL clock in the 115kHz to 170kHz range.
3	CASE	4	GND	Ground requires a short, low-noise connection to ensure good load regulation. The internal reference is referred to GND, so errors at this pin are multiplied by the error amplifier.
4	3	2	$V_{SW}$	Internal Power Switch Output. The switch output can swing 40V below ground and is rated for 5A.
5	2	1	$V_{IN}$	$V_{IN}$ supplies power to the internal circuitry and also connects to the collector of the internal power switch. $V_{IN}$ must be bypassed with a low-ESR capacitor, typically 200 $\mu$ F or 220 $\mu$ F.
-	-	3	$I_{LIM}$	Switch current limit can be reduced by connecting an external resistor ( $R_{LIM}$ ) from $I_{LIM}$ to GND (7-pin version only).
-	-	7	SHUT	Shutdown is achieved by pulling SHUT low (7-pin version only). Below 2.45V turns off the switch. Below 0.3V forces total device shutdown. Leave open, or drive above 2.7V to turn the device fully on.

# 5V/3.3V/3V 5A Step-Down, PWM, Switch-Mode DC-DC Regulators

## Pin Configurations (continued)



MAX787/MAX788/MAX789

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# 5V/3.3V/3V 5A Step-Down, PWM, Switch-Mode DC-DC Regulators

## Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX787HCKK	0°C to +70°C	5 TO-220
MAX787HCCM	0°C to +70°C	7 TO-220†
MAX787HCKS	0°C to +70°C	4 TO-3†
MAX787HC/D	0°C to +70°C	Dice*
MAX787HECK	-40°C to +85°C	5 TO-220
MAX787HECM	-40°C to +85°C	7 TO-220†
MAX787HEKS	-40°C to +85°C	4 TO-3†
MAX787HMKS	-55°C to +125°C	4 TO-3†
MAX788CCK	0°C to +70°C	5 TO-220
MAX788CCM	0°C to +70°C	7 TO-220†
MAX788CKS	0°C to +70°C	4 TO-3†
MAX788C/D	0°C to +70°C	Dice*
MAX788ECK	-40°C to +85°C	5 TO-220
MAX788ECM	-40°C to +85°C	7 TO-220†
MAX788EKS	-40°C to +85°C	4 TO-3†
MAX788MKS	-55°C to +125°C	4 TO-3†
MAX788HCCK	0°C to +70°C	5 TO-220
MAX788HCCM	0°C to +70°C	7 TO-220†
MAX788HCKS	0°C to +70°C	4 TO-3†
MAX788HC/D	0°C to +70°C	Dice*
MAX788HECK	-40°C to +85°C	5 TO-220
MAX788HECM	-40°C to +85°C	7 TO-220†
MAX788HEKS	-40°C to +85°C	4 TO-3†
MAX788HMKS	-55°C to +125°C	4 TO-3†

PART	TEMP. RANGE	PIN-PACKAGE
MAX789CCK	0°C to +70°C	5 TO-220
MAX789CCM	0°C to +70°C	7 TO-220†
MAX789CKS	0°C to +70°C	4 TO-3†
MAX789C/D	0°C to +70°C	Dice*
MAX789ECK	-40°C to +85°C	5 TO-220
MAX789ECM	-40°C to +85°C	7 TO-220†
MAX789EKS	-40°C to +85°C	4 TO-3†
MAX789MKS	-55°C to +125°C	4 TO-3†
MAX789HCCK	0°C to +70°C	5 TO-220
MAX789HCCM	0°C to +70°C	7 TO-220†
MAX789HCKS	0°C to +70°C	4 TO-3†
MAX789HC/D	0°C to +70°C	Dice*
MAX789HECK	-40°C to +85°C	5 TO-220
MAX789HECM	-40°C to +85°C	7 TO-220†
MAX789HEKS	-40°C to +85°C	4 TO-3†
MAX789HMKS	-55°C to +125°C	4 TO-3†

\* Contact factory for dice specifications.

† Contact factory for package availability.

## Product Selection Guide

PART	V <sub>OUT</sub> (V)	I <sub>OUT</sub> MAX (A)
MAX724	Adjustable	5
MAX726	Adjustable	2
MAX727	5	2
MAX728	3.3	2
MAX729	3	2
MAX787	5	5
MAX788	3.3	5
MAX789	3	5