19-0182; Rev 0; 9/93

MAXIM

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.

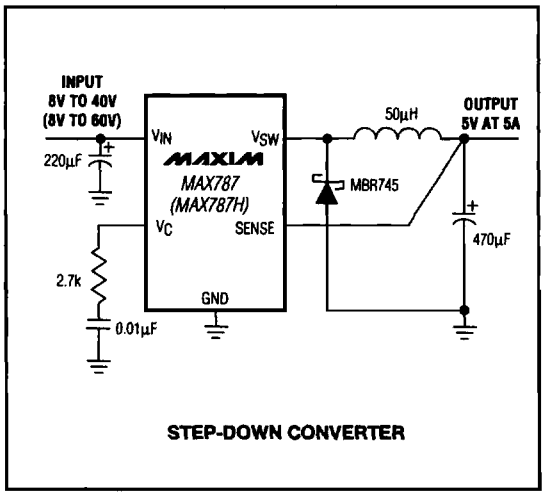
The MAX787/MAX788/MAX789 have excellent dynamic and transient response characteristics, while featuring cycle-by-cycle current limiting to protect against overcurrent faults and short-circuit output faults. They also have a wide 8V to 40V input range (up to 60V for the high-voltage "H" version).

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



STEP-DOWN CONVERTER

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**

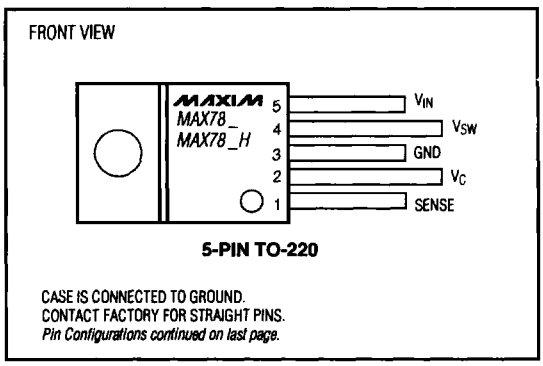
Ordering Information

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



5-PIN TO-220

CASE IS CONNECTED TO GROUND.
CONTACT FACTORY FOR STRAIGHT PINS.
Pin Configurations continued on last page.

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_{SW} = 1A	$T_j \geq 0°C$			1.85	V
		$T_j < 0°C$			2.10	
	I_{SW} = 5A	$T_j \geq 0°C$			2.30	
		$T_j < 0°C$			2.50	
Switch-Off Leakage	$V_{IN} \leq 25V$, V_{SW} = 0V	T_j = +25°C		5	300	µA
	$V_{IN} = V_{MAX}$, V_{SW} = 0V (Note 2)	T_j = +25°C		10	500	
Supply Current (Note 3)	$V_{IN} \leq 40V$, V_{SENSE} = 5.5V			8.5	11	mA
	"H" version only, 40V < V_{IN} < 60V			9	12	
	V_{SHUT} = 0.1V (Note 4)			140	300	µA
Minimum Operating Supply Voltage				7.3	8.0	V
Minimum Start-Up Supply Voltage (Note 5)	$T_A \geq$ +25°C			3.5	4.8	V
	$T_A <$ +25°C			3.5	5.0	
Switch-Current Limit (Note 6)	I_{LIM} open	$T_j = T_{MIN}$ to T_{MAX}	5.5	6.5	8.5	A
	R_{LIM} = 10kΩ (Note 7)	T_j = +25°C		4.5		
	R_{LIM} = 7kΩ (Note 7)	T_j = +25°C		3		
Maximum Duty Cycle			85	90		%
Switching Frequency		T_j = +25°C	90	100	110	kHz
		$T_j \leq$ +125°C	85		120	
	$V_{OUT} = V_{SENSE}$ = 0V (Note 6)	T_j = +25°C		20		
Switching Frequency Line Regulation	8V ≤ $V_{IN} \leq V_{MAX}$ (Note 2)			0.03	0.10	%/V
Error-Amplifier Voltage Gain	1V ≤ $V_C \leq$ 4V	T_j = +25°C		2000		V/V
Error-Amplifier Transconductance		T_j = +25°C	3700	5000	8000	µmho
Error-Amplifier Source Current	$V_{SENSE} = V_{OUT}$ + 10%	T_j = +25°C	100	140	225	µA
Error-Amplifier Sink Current	$V_{SENSE} = V_{OUT}$ - 10%	T_j = +25°C	0.7	1.0	1.6	mA

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°C	MAX787	3.0	5.0	8.0	kΩ
		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°C		±0.5	±2.0	%
		T_j = T_{MIN} to T_{MAX}		±1.0	±3.0	
Output Voltage Line Regulation	8V ≤ V_{IN} ≤ V_{MAX} (Note 2)			0.005	0.020	%/V
V_C Voltage	0% duty cycle	T_j = +25°C		1.5		V
V_C Voltage Temperature Coefficient	0% duty cycle	T_j = T_{MIN} to T_{MAX}		-4		mV/°C
SHUT Pin Current	V_{SHUT} = 5V		5	10	20	µA
	V_{SHUT} ≤ $V_{THRESHOLD}$ (≈ 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	°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 ≥ 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 1µs 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.

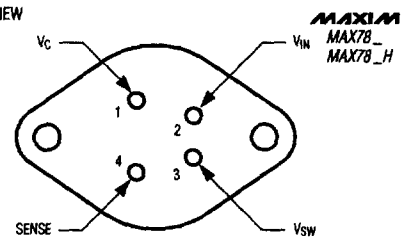
5V/3.3V/3V 5A Step-Down, PWM, Switch-Mode DC-DC Regulators

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 200µF or 220µF.
–	–	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.

Pin Configurations (continued)

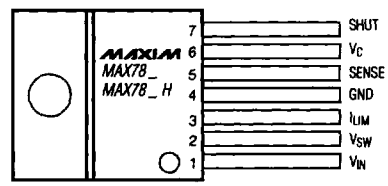
BOTTOM VIEW



4-PIN TO-3†

CASE IS CONNECTED TO GROUND.
†CONTACT FACTORY FOR AVAILABILITY.

FRONT VIEW



7-PIN TO-220†

CASE IS CONNECTED TO GROUND.
CONTACT FACTORY FOR STAGGERED PINS.
†CONTACT FACTORY FOR AVAILABILITY.

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

Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX787HCCK	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_{OUT} (V)	I_{OUT} 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