19-0149; Rev 0; 6/93

MAXIM

5V/3.3V/3V 2A Step-Down, PWM, Switch-Mode DC-DC Regulators

General Description

The MAX727/MAX728/MAX729 are monolithic, bipolar, pulse-width modulation (PWM), switch-mode, step-down DC-DC regulators. Each is rated at 2A. 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.

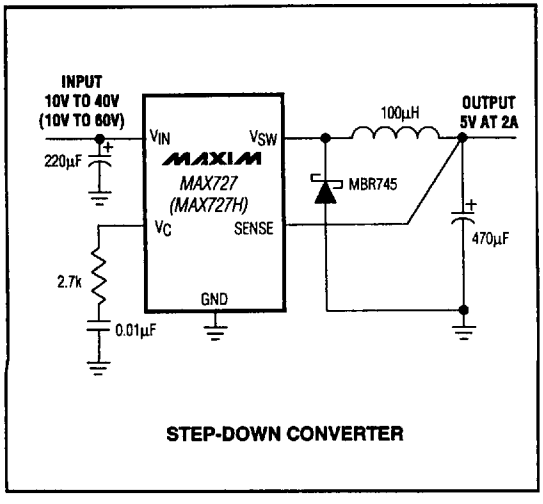
These regulators have excellent dynamic and transient response characteristics, while featuring cycle-by-cycle current limiting to protect against overcurrent faults and short-circuit output faults. They also have a wide 8V to 40V input range (up to 60V for the high-voltage "H" version).

Each regulator is available in 5-pin TO-220, 7-pin TO-220, 4-pin TO-3, and 16-pin SO packages. These devices have a preset 100kHz oscillator frequency and a preset current limit of 2.6A. The 7-pin and 16-pin packages allow 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 Applications
Multiple-Output Buck Converter

Typical Operating Circuit



STEP-DOWN CONVERTER

Features

- **Input Range: Up to 40V**
  Up to 60V (H Version)
- **2A On-Chip Power Switch**
- **Fixed Outputs: 5V (MAX727)**
  3.3V (MAX728)
  3V (MAX729)
- **100kHz Switching Frequency**
- **Excellent Dynamic Characteristics**
- **Few External Components**
- **8.5mA Quiescent Current**
- **TO-220 and TO-3 Packages**
- **16-Pin SO Package**

Ordering Information

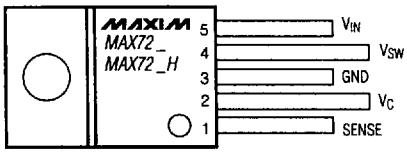
PART	TEMP. RANGE	PIN-PACKAGE
MAX727CWE	0°C to +70°C	16 Wide SO*
MAX727C/D	0°C to +70°C	Dice**
MAX727CCK	0°C to +70°C	5 TO-220
MAX727CCM	0°C to +70°C	7 TO-220†
MAX727CKS	0°C to +70°C	4 TO-3†
MAX727ECK	-40°C to +85°C	5 TO-220
MAX727ECM	-40°C to +85°C	7 TO-220†
MAX727EKS	-40°C to +85°C	4 TO-3†
MAX727MKS	-55°C to +125°C	4 TO-3†

Ordering Information continued on last page.

* *Contact factory for availability and applications information.*
***Contact factory for dice specifications.*
† *Contact factory for package availability.*

Pin Configurations

FRONT VIEW



5-PIN TO-220

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

5V/3.3V/3V 2A Step-Down, PWM, Switch-Mode DC-DC Regulators

ABSOLUTE MAXIMUM RATINGS

Input Voltage
- MAX72_ 45V
- MAX72_H 64V

Switch Voltage with Respect to Input Voltage
- MAX72_ 64V
- MAX72_H 75V

Switch Voltage with Respect to GND Pin (V_{SW} negative)
- MAX72_ (Note 8) 35V
- MAX72_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:
- MAX72_C_ _/HC_ _ ..... 0°C to +70°C
- MAX72_E_ _/HE_ _ ..... -40°C to +85°C
- MAX72_MKS/HMKS ..... -55°C to +125°C

Junction Temperature Ranges:
- MAX72_C_ _/HC_ _ ..... 0°C to +125°C
- MAX72_E_ _/HE_ _ ..... -40°C to +125°C
- MAX72_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} = 0.5A				1.2	V
	I_{SW} = 2A				1.7	
Switch-Off Leakage	V_{IN} = 25V, V_{SW} = 0V	T_j = +25°C			150	µA
	$V_{IN} = V_{MAX}$, V_{SW} = 0V (Note 2)	T_j = +25°C			250	
Supply Current (Note 3)	$V_{IN} \le 40V$, 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)	$T_A \ge$ +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}	2.0	2.6	3.2	A
	R_{LIM} = 10kΩ (Note 7)	T_j = +25°C		1.8		
	R_{LIM} = 7kΩ (Note 7)	T_j = +25°C		1.2		
Maximum Duty Cycle			85	90		%
Switching Frequency		T_j = +25°C	90	100	110	kHz
		$T_j \le$ +125°C	85		120	
	$V_{OUT} = V_{SENSE}$ = 0V (Note 6)	T_j = +125°C		20		
Switching Frequency Line Regulation	8V ≤ V_{IN} ≤ V_{MAX} (Note 2)			0.03	0.10	%/V
Error-Amplifier Voltage Gain (Note 8)	1V ≤ V_C ≤ 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

5V/3.3V/3V 2A 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	MAX727	4.85	5.00	5.15	V
		MAX728	3.20	3.30	3.40	
		MAX729	2.90	3.00	3.10	
SENSE Pin Divider Resistance	T_j = +25°C	MAX727	3.0	5.0	8.0	kΩ
		MAX728	2.5	4.2	7.0	
		MAX729	2.2	3.8	6.5	
Output Voltage Tolerance	V_{OUT} (nominal) = 5V (MAX727), 3.3V (MAX728), or 3V (MAX729); 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)					4.0	°C/W

Note 1: For switch currents between 1A and 2A, maximum switch-on voltage can be calculated via linear interpolation.

Note 2: V_{MAX} = 40V for MAX727/MAX728/MAX729 and 60V for MAX727H/MAX728H/MAX729H.

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 (MAX727), 2.0V (MAX728), or 1.8V (MAX729). Switch current limit is tested with V_{SENSE} adjusted to give a 1µs minimum switch-on time.

Note 7: $$R_{LIM} = \left[\frac{I_{LIM}}{1A} \times 5.5k\Omega\right] + 1k\Omega$$

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

Note 9: Guaranteed, not production tested. TO-220 and TO-3 packages only.

5V/3.3V/3V 2A Step-Down, PWM, Switch-Mode DC-DC Regulators

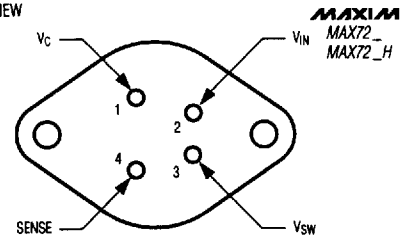
Pin Description

PIN				NAME	FUNCTION
5-PIN TO-220	4-PIN TO-3	7-PIN TO-220	16-PIN SO		
1	4	5	8	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	11	V_C	Error-Amplifier Output. A series RC network connected to this pin compensates the MAX727/MAX728/MAX729. 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 MAX727/MAX728/MAX729 to an external TTL clock in the 115kHz to 170kHz range.
3	CASE	4	5, 7, 10, 12	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	13, 14, 15, 16	V_{SW}	Internal Power Switch Output. The switch output can swing 40V below ground and is rated for 2A.
5	2	1	1, 2, 3, 4	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	6	I_{LIM}	Switch current limit can be reduced by connecting an external resistor (R_{LIM}) from I_{LIM} to GND (7-pin and 16-pin versions only).
–	–	7	9	SHUT	Shutdown is achieved by pulling SHUT low (7-pin and 16-pin versions only). Below 2.45V turns off the switch. Below 0.3V forces total device shutdown.

5V/3.3V/3V 2A Step-Down, PWM, Switch-Mode DC-DC Regulators

Pin Configurations (continued)

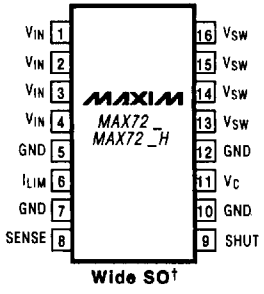
BOTTOM VIEW



4-PIN TO-3†

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

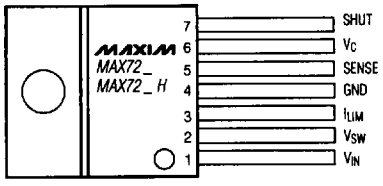
TOP VIEW



Wide SO†

†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 2A Step-Down, PWM, Switch-Mode DC-DC Regulators

Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX727HCWE	0°C to +70°C	16 Wide SO*
MAX727HC/D	0°C to +70°C	Dice**
MAX727HCCK	0°C to +70°C	5 TO-220
MAX727HCCM	0°C to +70°C	7 TO-220†
MAX727HCKS	0°C to +70°C	4 TO-3†
MAX727HECK	-40°C to +85°C	5 TO-220
MAX727HECM	-40°C to +85°C	7 TO-220†
MAX727HEKS	-40°C to +85°C	4 TO-3†
MAX727HMKS	-55°C to +125°C	4 TO-3†
MAX728CWE	0°C to +70°C	16 Wide SO*
MAX728C/D	0°C to +70°C	Dice**
MAX728CCK	0°C to +70°C	5 TO-220
MAX728CCM	0°C to +70°C	7 TO-220†
MAX728CKS	0°C to +70°C	4 TO-3†
MAX728ECK	-40°C to +85°C	5 TO-220
MAX728ECM	-40°C to +85°C	7 TO-220†
MAX728EKS	-40°C to +85°C	4 TO-3†
MAX728MKS	-55°C to +125°C	4 TO-3†
MAX728HCWE	0°C to +70°C	16 Wide SO*
MAX728HC/D	0°C to +70°C	Dice**
MAX728HCCK	0°C to +70°C	5 TO-220
MAX728HCCM	0°C to +70°C	7 TO-220†
MAX728HCKS	0°C to +70°C	4 TO-3†
MAX728HECK	-40°C to +85°C	5 TO-220
MAX728HECM	-40°C to +85°C	7 TO-220†
MAX728HEKS	-40°C to +85°C	4 TO-3†
MAX728HMKS	-55°C to +125°C	4 TO-3†

PART	TEMP. RANGE	PIN-PACKAGE
MAX729CWE	0°C to +70°C	16 Wide SO*
MAX729C/D	0°C to +70°C	Dice**
MAX729CCK	0°C to +70°C	5 TO-220
MAX729CCM	0°C to +70°C	7 TO-220†
MAX729CKS	0°C to +70°C	4 TO-3†
MAX729ECK	-40°C to +85°C	5 TO-220
MAX729ECM	-40°C to +85°C	7 TO-220†
MAX729EKS	-40°C to +85°C	4 TO-3†
MAX729MKS	-55°C to +125°C	4 TO-3†
MAX729HCWE	0°C to +70°C	16 Wide SO*
MAX729HC/D	0°C to +70°C	Dice**
MAX729HCCK	0°C to +70°C	5 TO-220
MAX729HCCM	0°C to +70°C	7 TO-220†
MAX729HCKS	0°C to +70°C	4 TO-3†
MAX729HECK	-40°C to +85°C	5 TO-220
MAX729HECM	-40°C to +85°C	7 TO-220†
MAX729HEKS	-40°C to +85°C	4 TO-3†
MAX729HMKS	-55°C to +125°C	4 TO-3†

** Contact factory for availability and applications information.*
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