



## 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.

Each regulator is available in a 5-pin TO-220 package. These devices have a preset 100kHz oscillator frequency and a preset current limit of 2.6A. 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

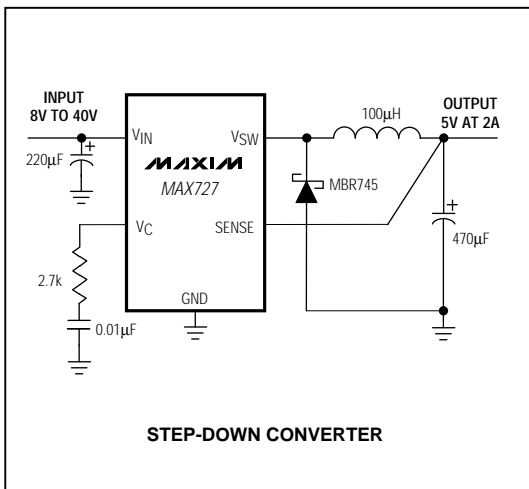
### Features

- ◆ **Input Range: Up to 40V**
- ◆ **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 Package**

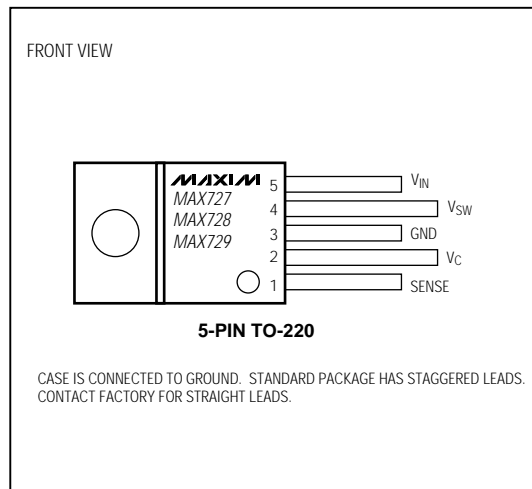
### Ordering Information

| PART      | TEMP. RANGE    | PIN-PACKAGE |
|-----------|----------------|-------------|
| MAX727CCK | 0°C to +70°C   | 5 TO-220    |
| MAX727ECK | -40°C to +85°C | 5 TO-220    |
| MAX728CCK | 0°C to +70°C   | 5 TO-220    |
| MAX728ECK | -40°C to +85°C | 5 TO-220    |
| MAX729CCK | 0°C to +70°C   | 5 TO-220    |
| MAX729ECK | -40°C to +85°C | 5 TO-220    |

### Typical Operating Circuit



### Pin Configuration



MAX727/MAX728/MAX729



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

### ABSOLUTE MAXIMUM RATINGS

|   |                |                                     |                 |
|---|----------------|-------------------------------------|-----------------|
| Input Voltage   | 45V            | Junction Temperature Ranges:        |                 |
| Switch Voltage with Respect to Input Voltage                            | 50V            | MAX72_CCK                           | 0°C to +125°C   |
| Switch Voltage with Respect to GND Pin ( $V_{SW}$ negative)<br>(Note 1) | 35V            | MAX72_ECK                           | -40°C to +125°C |
| SENSE Pin Voltage   | -0.3V, +10V    | Storage Temperature Range           | -65°C to +160°C |
| Operating Temperature Ranges  |                | Lead Temperature (soldering, 10sec) | +300°C          |
| MAX72_CCK   | 0°C to +70°C   |                                     |                 |
| MAX72_ECK   | -40°C to +85°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     |
|-------------------------------------|--|----------------------|------|------|------|-----------|
| Input Supply Voltage Range          |  |                      | 8.0  |      | 40.0 | V         |
| Switch-On Voltage (Note 2)          | $I_{SW} = 0.5A$  |                      |      |      | 1.2  | V         |
|                                     | $I_{SW} = 2A$  |                      |      |      | 1.7  |           |
| Switch-Off Leakage                  | $V_{IN} = 25V$ , $V_{SW} = 0V$                             | $T_j = +25^\circ C$  |      |      | 150  | $\mu A$   |
|                                     | $V_{IN} = 40V$ , $V_{SW} = 0V$                             | $T_j = +25^\circ C$  |      |      | 250  |           |
| Supply Current (Note 3)             | $V_{IN} \leq 40V$ , $V_{SENSE} = 5.5V$                     |                      |      | 8.5  | 11   | mA        |
| Minimum Supply Voltage              | Normal Mode  |                      |      | 7.3  | 8.0  | V         |
|                                     | Start-Up Mode (Note 4)                                     | $T_j \geq 0^\circ C$ |      | 3.5  | 4.8  |           |
|                                     |  | $T_j < 0^\circ C$    |      | 3.5  | 5.0  |           |
| Switch-Current Limit (Note 5)       |  |                      | 2.0  | 2.6  | 3.2  | A         |
| Maximum Duty Cycle                  |  |                      | 85   | 90   |      | %         |
| Switching Frequency                 | $T_j = +25^\circ C$  |                      | 90   | 100  | 110  | kHz       |
|                                     | $T_j \leq +125^\circ C$                                    |                      | 85   |      | 120  |           |
|                                     | $V_{OUT} = V_{SENSE} = 0V$ (Note 5)<br>$T_j = +25^\circ C$ |                      |      | 20   |      |           |
| Switching Frequency Line Regulation | $8V \leq V_{IN} \leq 40V$                                  |                      |      | 0.03 | 0.10 | %/V       |
| Error-Amplifier Voltage Gain        | $1V \leq V_C \leq 4V$                                      | $T_j = +25^\circ C$  |      | 2000 |      | V/V       |
| Error-Amplifier Transconductance    | $T_j = +25^\circ C$  |                      | 3000 | 5000 | 9000 | $\mu mho$ |
| Error-Amplifier Source Current      | $V_{SENSE} = V_{OUT} - 10\%$                               | $T_j = +25^\circ C$  | 100  | 140  | 225  | $\mu A$   |
| Error-Amplifier Sink Current        | $V_{SENSE} = V_{OUT} + 10\%$                               | $T_j = +25^\circ C$  | 0.6  | 1.0  | 1.7  | mA        |

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

MAX727/MAX728/MAX729

## 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                 | $T_j = +25^\circ C$   | MAX727                       | 3.0   | 5.0       | 8.0            | k $\Omega$ |
|  |   | 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 | $T_j = +25^\circ C$          |       | $\pm 0.5$ | $\pm 2.0$      | %          |
|  |   | $T_j = T_{MIN}$ to $T_{MAX}$ |       | $\pm 1.0$ | $\pm 3.0$      |            |
| Output Voltage Line Regulation               | $8V \leq V_{IN} \leq 40V$   |                              | 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/ $^\circ C$ |            |
| Thermal Resistance Junction to Case (Note 6) |   |                              |       | 4.0       | $^\circ C/W$   |            |

**Note 1:** Do not exceed switch-to-input voltage limitation.

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

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

**Note 5:** 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 1 $\mu s$  minimum switch-on time.

**Note 6:** Guaranteed, not production tested.

## Pin Description

| PIN | NAME     | FUNCTION   |
|-----|----------|--|
| 1   | 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   | $V_C$    | 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. See MAX724/MAX726 data sheet. |
| 3   | 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   | $V_{SW}$ | Internal Power Switch Output. The switch output can swing 35V below ground and is rated for 2A.  |
| 5   | $V_{IN}$ | $V_{IN}$ 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 $\mu F$ .  |

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

## Package Information

| DIM   | INCHES    |       | MILLIMETERS |       |
|-------|-----------|-------|-------------|-------|
|       | MIN       | MAX   | MIN         | MAX   |
| A     | 0.140     | 0.190 | 3.56        | 4.82  |
| B     | 0.015     | 0.040 | 0.38        | 1.01  |
| C1    | 0.014     | 0.022 | 0.41        | 0.50  |
| D     | 0.560     | 0.650 | 14.23       | 16.51 |
| E     | 0.380     | 0.420 | 9.66        | 10.66 |
| e     | 0.067 BSC |       | 1.70 BSC    |       |
| F     | 0.045     | 0.055 | 1.14        | 1.39  |
| H1    | 0.230     | 0.270 | 5.85        | 6.85  |
| J1    | 0.080     | 0.115 | 2.04        | 2.92  |
| J2    | 0.170     | 0.185 | 4.32        | 4.70  |
| J3    | 0.327     | 0.335 | 8.31        | 8.51  |
| L     | 0.170     | 0.200 | 4.32        | 5.08  |
| L1    | 0.260     | 0.340 | 6.60        | 8.64  |
| L2    | 0.700     | 0.720 | 17.78       | 18.29 |
| phi P | 0.139     | 0.161 | 3.54        | 4.08  |
| Q     | 0.100     | 0.120 | 2.54        | 3.04  |

21-005-

**5-PIN TO-220  
(STAGGERED LEAD)  
PACKAGE**

| DIM   | INCHES    |       | MILLIMETERS |       |
|-------|-----------|-------|-------------|-------|
|       | MIN       | MAX   | MIN         | MAX   |
| A     | 0.140     | 0.190 | 3.56        | 4.82  |
| B     | 0.015     | 0.040 | 0.38        | 1.01  |
| C1    | 0.014     | 0.022 | 0.41        | 0.50  |
| D     | 0.560     | 0.650 | 14.23       | 16.51 |
| E     | 0.380     | 0.420 | 9.66        | 10.66 |
| e     | 0.067 BSC |       | 1.70 BSC    |       |
| F     | 0.045     | 0.055 | 1.14        | 1.39  |
| H1    | 0.230     | 0.270 | 5.85        | 6.85  |
| J1    | 0.080     | 0.115 | 2.04        | 2.92  |
| L     | 0.500     | 0.580 | 12.70       | 14.73 |
| phi P | 0.139     | 0.161 | 3.54        | 4.08  |
| Q     | 0.100     | 0.120 | 2.54        | 3.04  |

21-4737-

**5-PIN TO-220  
(STRAIGHT LEAD)  
PACKAGE**

CONTACT FACTORY FOR AVAILABILITY

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

4 Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 (408) 737-7600

© 1995 Maxim Integrated Products

Printed USA

MAXIM is a registered trademark of Maxim Integrated Products.