MAXIM

High-Voltage, Low-Power Linear Regulators for Notebook Computers

General Description

The MAX8718/MAX8719 are micropower, 8-pin TDFN linear regulators that supply always-on, keep-alive power to CMOS RAM, real-time clocks (RTC), and microcontrollers in systems with high-voltage batteries. The circuits consist of a 100mA linear regulator and a power-good comparator (PGOOD) with fixed-output delay. Key features include wide input voltage range, low-dropout voltage, and low-quiescent supply current.

Despite a miserly 25μA (max) no-load quiescent current, the MAX8718/MAX8719 have good line- and load-transient response and excellent AC power-supply rejection. They provide a clean fixed 5V or 3.3V output (MAX8718), or an adjustable 1.24V to 28V output (MAX8719), even when subjected to fast supply-voltage changes that occur during the switchover from battery to AC-adapter input power. The space-saving TDFN package has excellent thermal characteristics and tolerates up to 1951mW of power dissipation. Internal foldback current limiting and thermal shutdown protect the regulator from overload and thermal faults.

In addition to the main notebook-computer application, these devices are useful in other low-power, high-voltage applications (4V < V_{IN} < 28V) such as smart batteries, current control loops, telecom emergency power, and housekeeping power for off-line supplies.

The MAX8718/MAX8719 are available in a thermally enhanced 3mm x 3mm, 8-lead TDFN package.

Features

♦ **4V to 28V Input Range**

♦ **18μA Quiescent Supply Current**

♦ **<3μA Shutdown Supply Current**

♦ **100mA Output Current**

♦ **3.3V or 5V, Pin-Selectable Output (MAX8718)**

♦ **Adjustable 1.24V to 28V Output (MAX8719)**

♦ **±2% Output Accuracy**

♦ **Thermal-Overload Protection**

♦ **Delayed Power-Good Output**

♦ **Thermally Enhanced 8-Pin TDFN Package**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	OUTPUT VOLTAGE
MAX8718ETA	-40°C to +85°C	8 TDFN 3mm x 3mm	3.3V/5V
MAX8719ETA	-40°C to +85°C	8 TDFN 3mm x 3mm	Adjustable

Applications

CMOS/RTC Backup Power

Microcontroller Power

Notebook Computers

Smart-Battery Packs

PDAs and Handy-Terminals

Battery-Powered Systems

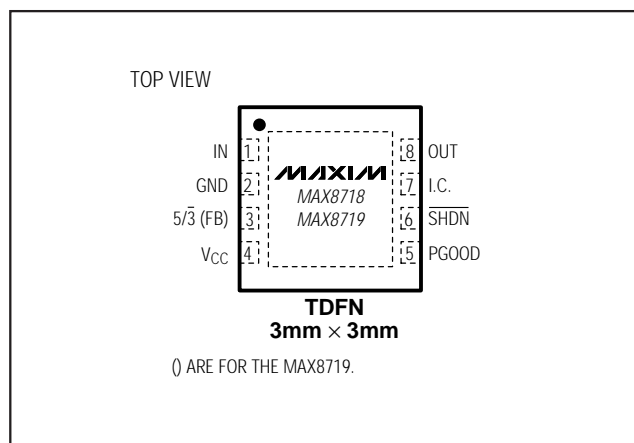## Pin Configuration

TOP VIEW

IN 1	8 OUT
GND 2	7 I.C.
5/3̄ (FB) 3	6 SHDN̄
V_CC 4	5 PGOOD

MAX8718
MAX8719

TDFN
3mm × 3mm

() ARE FOR THE MAX8719.

MAXIM _____ *Maxim Integrated Products* 1

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

High-Voltage, Low-Power Linear Regulators for Notebook Computers

ABSOLUTE MAXIMUM RATINGS

IN to GND...-0.3V to +30V
$\overline{\text{SHDN}}$ to GND ....-0.3V to (V_{IN} + 0.3V)
5/$\overline{3}$ (MAX8718) to GND.......................................-0.3V to +6V
FB (MAX8719) to GND ....-0.3V to +6V
OUT (MAX8718) to GND ....-0.3V to +6V
OUT (MAX8719) to GND ....-0.3V to +30V
V_{CC} to GND (MAX8718) ....-0.3V to +6V
V_{CC} to GND (MAX8719) ....-0.3V to +2.7V
PGOOD to GND ....-0.3V to +30V

I.C. to GND ....-0.3V to +6V
OUT Short Circuit to GND...30s
Continuous Power Dissipation (T_A = +70°C)
  8-Pin TDFN (derate 24.4mW/°C above +70°C) 1951mW
Operating Temperature Range ....-40°C to +85°C
Junction Temperature..+150°C
Storage Temperature Range ....-65°C to +150°C
Lead Temperature (soldering, 10s) ....+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

(Circuit of Figure 1. V_{IN} = 15V, I_{OUT} = 5µA, **T_A = 0°C to +85°C**. Typical values are at T_A = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}		4		28	V
Supply Current (MAX8718)	I_{IN}	$\overline{\text{SHDN}}$ = IN, T_A = +25°C		12	18	µs
		$\overline{\text{SHDN}}$ = IN, V_{IN} = 6V to 28V			25	µA
V_{CC} Input Current (MAX8719)		0V < V_{CC} < 2.7V, T_A = +25°C	-0.1		+0.1	µA
		0V < V_{CC} < 2.7V, T_A = 0°C to +85°C		0.04		
V_{CC} Input Current (MAX8718)		0V < V_{CC} < 5.5V, T_A = +25°C			3.4	µA
		0V < V_{CC} < 5.5V, T_A = 0°C to +85°C		2.3		
OUT Minimum Load Current					5	µA
Shutdown Supply Current		$\overline{\text{SHDN}}$ = 0V		1.2	3	µA
Dropout Supply Current		V_{OUT} set to 5V, V_{IN} = 4.7V		85		µA
OUT Output Voltage (MAX8718)		V_{IN} = 6V to 28V, I_{LOAD} = 1mA, 5/$\overline{3}$ = GND, T_A = +25°C	3.26	3.33	3.40	V
		V_{IN} = 6V to 28V, I_{LOAD} = 1mA, 5/$\overline{3}$ = OUT, T_A = +25°C	4.95	5.05	5.15	
		V_{IN} = 6V to 28V, I_{LOAD} = 5µA to 100mA, 5/$\overline{3}$ = GND	3.15		3.48	
		V_{IN} = 6V to 28V, I_{LOAD} = 5µA to 100mA, 5/$\overline{3}$ = OUT	4.75		5.25	
FB Threshold (MAX8719)	V_{FB}	FB = OUT, V_{IN} = 6V to 28V, I_{LOAD} = 1mA	1.215	1.240	1.265	V
		FB = OUT, V_{IN} = 6V to 28V, I_{LOAD} = 5µA to 100mA (Note 2)	1.18		1.28	
FB Input Current (MAX8719)	I_{FB}	V_{FB} = 1.3V, T_A = +25°C	-30		+30	nA
		V_{FB} = 1.3V, T_A = 0°C to +85°C		15		
5/$\overline{3}$ Input Current (MAX8718)	$I_{5/\overline{3}}$	$V_{5/\overline{3}}$ = 5V, T_A = +25°C	-30		+30	nA
		$V_{5/\overline{3}}$ = 5V, T_A = 0°C to +85°C		2		
Dropout Voltage	$V_{DROPOUT}$	I_{LOAD} = 100mA (Note 3)			560	mV

MAXIM

ELECTRICAL CHARACTERISTICS (continued)

(Circuit of Figure 1. V_{IN} = 15V, I_{OUT} = 5µA, **T_A = 0°C to +85°C**. Typical values are at T_A = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Current Limit	I_{LIM}	V_{IN} = 6V, T_A = +25°C		210		mA
		V_{OUT} = 0, V_{IN} = 6V	125		340	
Output Reverse Leakage Current		V_{OUT} forced to 5.5V, IN = unconnected		70		µA
Capacitive Load Requirements		MAX8718	0.16			µF/mA
		MAX8719	0.23			
Startup Time Response		Rising edge of IN or $\overline{SHDN}$ to OUT within spec limits, C_{OUT} = 10µF, R_{LOAD} = 500Ω, V_{OUT} = 5V			1	ms
Startup Output Overshoot		C_{OUT} = 10µF, R_{LOAD} = 500Ω, OUT within 90% of the nominal output voltage		0.5		%
V_{CC} Threshold (MAX8718)		T_A = +25°C, rising edge only	$0.88 \times V_{OUT}$	$0.9 \times V_{OUT}$	$0.92 \times V_{OUT}$	V
		0°C < T_A < +85°C, rising edge only	$0.85 \times V_{OUT}$	$0.9 \times V_{OUT}$	$0.95 \times V_{OUT}$	
V_{CC} Threshold (MAX8719)		T_A = +25°C, rising edge only	$0.88 \times V_{FB}$	$0.9 \times V_{FB}$	$0.92 \times V_{FB}$	V
		0°C < T_A < +85°C, rising edge only	$0.85 \times V_{FB}$	$0.9 \times V_{FB}$	$0.95 \times V_{FB}$	
V_{CC} to PGOOD Delay		V_{TH} to (V_{TH} - 100mV)		4.5		µs
PGOOD Active-Timeout Period			100	185	300	ms
PGOOD Output Leakage Current		PGOOD = 5.5V, V_{CC} = 5.5V			0.1	µA
PGOOD Output Low Voltage		I_{SINK} = 1.6mA, V_{CC} = GND			0.3	V
V_{CC} Input Hysteresis				2		%
Thermal-Shutdown Threshold		$V_{\overline{SHDN}}$ = 0 or 15V, 20°C hysteresis		+165		°C
$\overline{SHDN}$ Input Low Voltage					0.25	V
$\overline{SHDN}$ Input High Voltage			1.4			V
$\overline{SHDN}$ Input Bias Current		$V_{\overline{SHDN}}$ = 0 or 15V, T_A = 0°C to +85°C	-1	+0.1	+1	µA

High-Voltage, Low-Power Linear Regulators for Notebook Computers

ELECTRICAL CHARACTERISTICS

(Circuit of Figure 1 V_{IN} = 15V, I_{OUT} = 5µA, **T_A = -40°C to +85°C**, unless otherwise noted.) (Note 4)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}		4		28	V
Supply Current (MAX8718)	I_{IN}	$\overline{SHDN}$ = IN, V_{IN} = 6V to 28V			25	µA
Supply Current (MAX8719)	I_{IN}	$\overline{SHDN}$ = IN, V_{IN} = 6V to 28V			25	µA
OUT Minimum Load Current					5	µA
Shutdown Supply Current		$\overline{SHDN}$ = 0V			3	µA
OUT Output Voltage (MAX8718)		V_{IN} = 6V to 28V, I_{LOAD} = 5µA to 100mA, $5/\overline{3}$ = GND	3.10		3.48	V
		V_{IN} = 6V to 28V, I_{LOAD} = 5µA to 100mA, $5/\overline{3}$ = OUT	4.72		5.25	
FB Threshold (MAX8719)	V_{FB}	FB = OUT, V_{IN} = 6V to 28V, I_{LOAD} = 1mA	1.215		1.265	V
		FB = OUT, V_{IN} = 6V to 28V, I_{LOAD} = 5µA to 100mA (Note 2)	1.18		1.28	
FB Input Current (MAX8719)	I_{FB}	V_{FB} = 1.3V	-40		+40	nA
$5/\overline{3}$ Input Current (MAX8718)	$I_{5/\overline{3}}$	$V_{5/\overline{3}}$ = 5V	-30		+30	nA
Dropout Voltage	$V_{DROPOUT}$	I_{LOAD} = 100mA (Note 3)			560	mV
Output Current Limit	I_{LIM}	V_{OUT} = 0, V_{IN} = 6V	125		375	mA
Capacitive Load Requirements		MAX8718	0.16			µF/mA
		MAX8719	0.23			
Startup Time Response		Rising edge of IN or $\overline{SHDN}$ to OUT within spec limits, C_{OUT} = 10µF, R_{LOAD} = 500Ω, V_{OUT} = 5V			1	ms
V_{CC} Threshold (MAX8718)		-40°C < T_A < +85°C, rising edge only	0.85 × V_{OUT}		0.95 × V_{OUT}	V
V_{CC} Threshold (MAX8719)		-40°C < T_A < +85°C, rising edge only	0.85 × V_{FB}		0.95 × V_{FB}	V
PGOOD Active-Timeout Period			100		300	ms
PGOOD Output Low Voltage		I_{SINK} = 1.6mA, V_{CC} = GND			0.3	V
$\overline{SHDN}$ Input Low Voltage					0.25	V
$\overline{SHDN}$ Input High Voltage			1.4			V
$\overline{SHDN}$ Input Bias Current		$V_{\overline{SHDN}}$ = 0 or 15V, T_A = -40°C to +85°C	-1		+1	µA

Note 1: Limits are 100% production tested at T_A = +25°C. Limits over the operating temperature range are guaranteed through correlation using standard quality control (SQC) methods.

Note 2: Pulse test at V_{IN} = 28V, I_{OUT} = 100mA to avoid exceeding package power-dissipation limits.

Note 3: Dropout voltage is tested by reducing the input voltage until V_{OUT} drops to 100mV below its nominal value as measured with V_{IN} starting 2V above V_{OUT}.

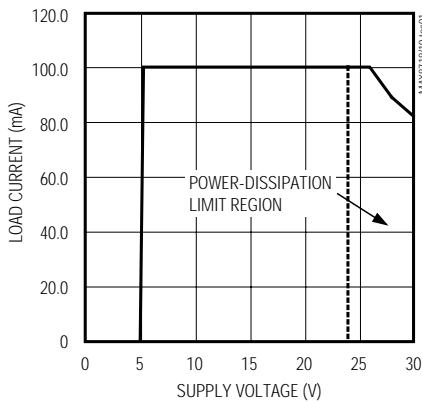**Note 4:** Specifications to -40°C are guaranteed by design, not production tested.

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Typical Operating Characteristics
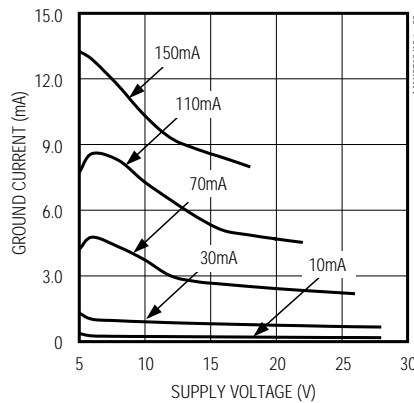
(Circuit of Figure 1. V_{IN} = 15V, V_{OUT} = 3.3V, T_A = +25°C, unless otherwise noted.)
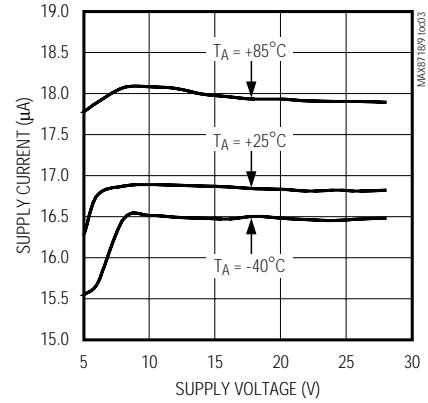
SAFE LOAD-CURRENT OPERATING AREA vs. SUPPLY VOLTAGE
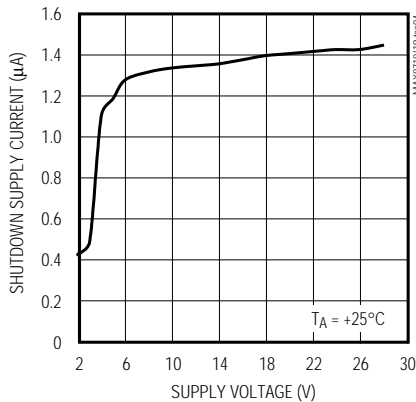
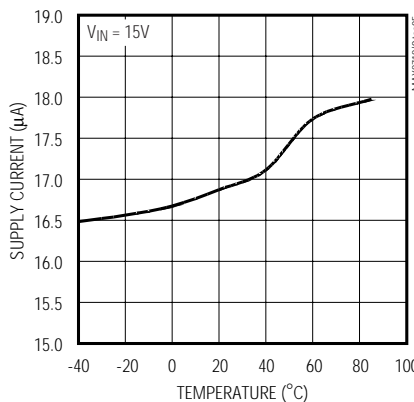**GROUND CURRENT vs. SUPPLY VOLTAGE AT VARIOUS LOADS**
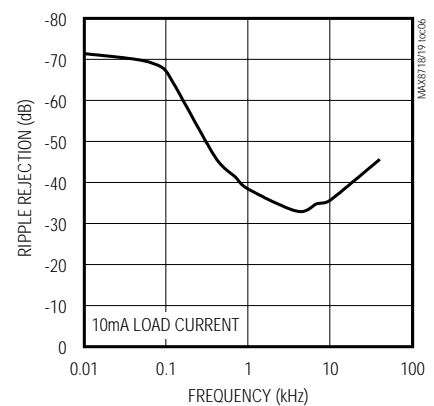
SUPPLY CURRENT vs. SUPPLY VOLTAGE
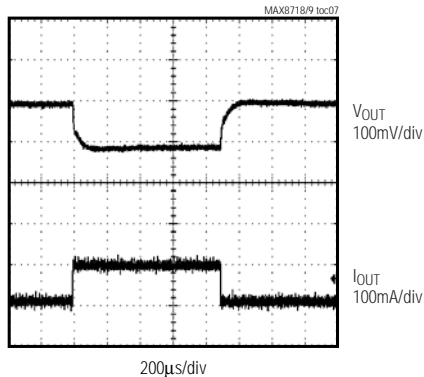
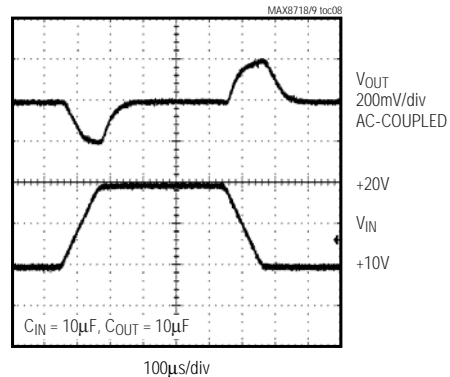**SHUTDOWN SUPPLY CURRENT vs. SUPPLY VOLTAGE**

SUPPLY CURRENT vs. TEMPERATURE

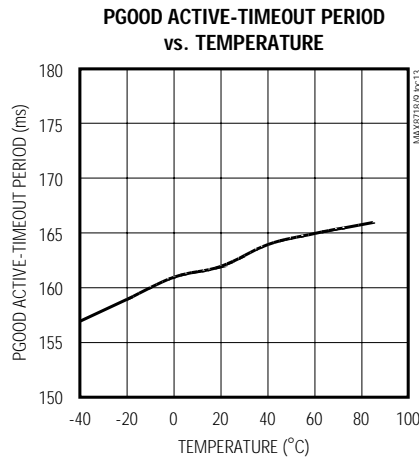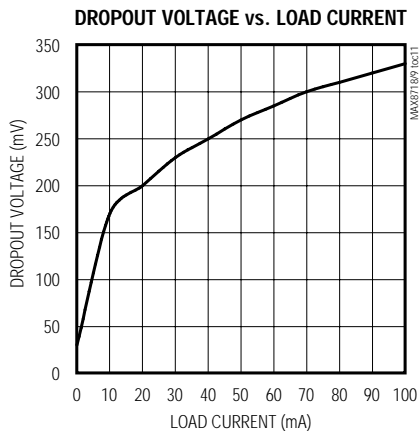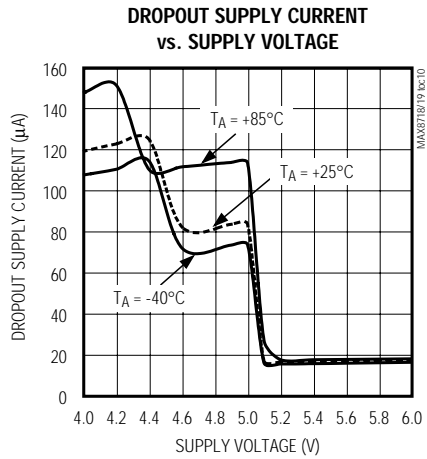**RIPPLE REJECTION vs. FREQUENCY**

LOAD-TRANSIENT RESPONSE

LINE-TRANSIENT RESPONSE

MAX8718/MAX8719

_____Typical Operating Characteristics (continued)

(Circuit of Figure 1. V_{IN} = 15V, V_{OUT} = 3.3V, T_A = +25°C, unless otherwise noted.)

TIME TO EXIT SHUTDOWN

MAX8718/9 toc09

+5V

V_{OUT}

0V

$\overline{SHDN}$
5V/div

V_{IN} = 15V

100µs/div

DROPOUT SUPPLY CURRENT vs. SUPPLY VOLTAGE

MAX8718/9 toc10

T_A = +85°C

T_A = +25°C

T_A = -40°C

DROPOUT SUPPLY CURRENT (µA)

SUPPLY VOLTAGE (V)

DROPOUT VOLTAGE vs. LOAD CURRENT

MAX8718/9 toc11

DROPOUT VOLTAGE (mV)

LOAD CURRENT (mA)

PGOOD TRANSIENT RESPONSE

MAX8718/9 toc12

+5V

V_{CC}

0V

+5V

PGOOD

0V

40ms/div

PGOOD ACTIVE-TIMEOUT PERIOD vs. TEMPERATURE

MAX8718/9 toc13

PGOOD ACTIVE-TIMEOUT PERIOD (ms)

TEMPERATURE (°C)

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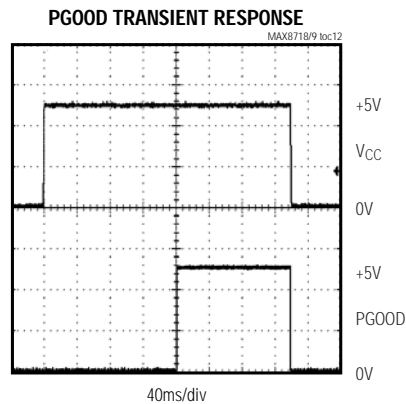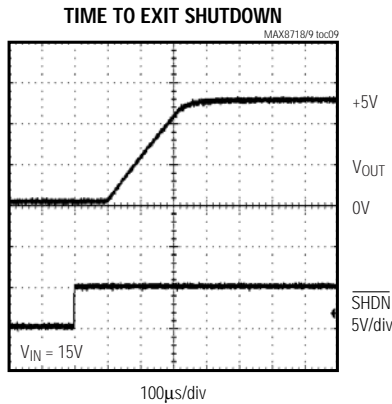
| PIN		NAME	FUNCTION
MAX8718	MAX8719		
1	1	IN	Positive Supply Input. Connect to a +4V to +28V supply.
2	2	GND	Ground
3	—	5/$\overline{3}$	Preset Output-Voltage Select Input. Connect 5/$\overline{3}$ to GND for 3.3V output, or to OUT for 5V output.
—	3	FB	Feedback Input. Regulates to 1.24V nominally.
4	4	V$_{CC}$	PGOOD Sense Input
5	5	PGOOD	Power-Good Output
6	6	$\overline{SHDN}$	Shutdown Control Input
7	7	I.C.	Internal Connection. This pin is internally connected for test purposes; leave it unconnected in the application.
8	8	OUT	100mA Regulator Output
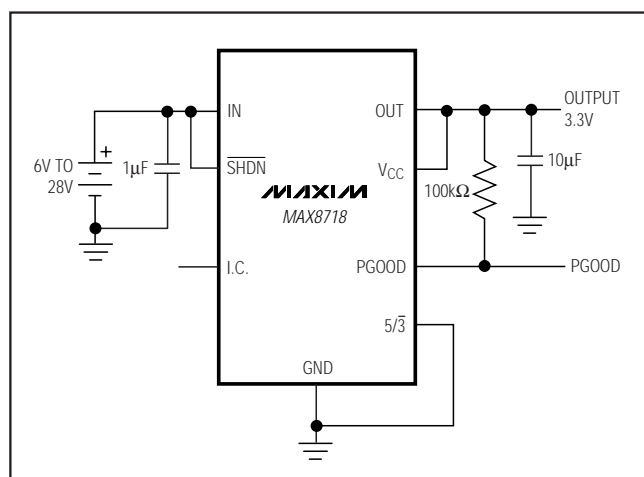
Figure 1. Typical Operating Circuit of the MAX8718
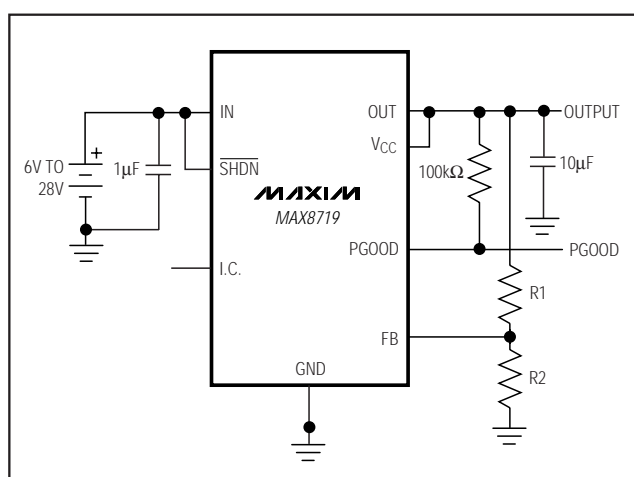

Figure 2. Typical Operating Circuit of the MAX8719

_____Detailed Description

The MAX8718/MAX8719 low-quiescent-current linear regulators are designed primarily for high-input-voltage applications. The MAX8718 supplies a preselected 3.3V or 5.0V output for loads up to 100mA (Figure 1). The MAX8719 provides an adjustable voltage from 1.24V to 28V (Figure 2). The maximum output current is a function of the package's maximum power dissipation for a given temperature. A 5µA load is required to maintain output regulation.

The MAX8718's output voltage is fed back through an internal resistive voltage-divider connected to OUT. Set the output voltage to either 5.0V or 3.3V with the 5/$\overline{3}$

pin. Select the 5V output by connecting 5/$\overline{3}$ to OUT, or the 3.3V output by connecting 5/$\overline{3}$ to GND.

The MAX8719's output is adjustable with an external resistive voltage-divider. The typical feedback threshold is 1.24V (see the *Setting the MAX8719 Output Voltage* section). See Figure 3 for the *MAX8718/ MAX8719 Functional Diagram.*

Shutdown

The device enters shutdown mode when $\overline{SHDN}$ is low. In shutdown mode, the internal pnp power transistor, control circuit, reference, and all biases turn off, reducing the supply current to below 3µA. Connect $\overline{SHDN}$ to IN for automatic startup.
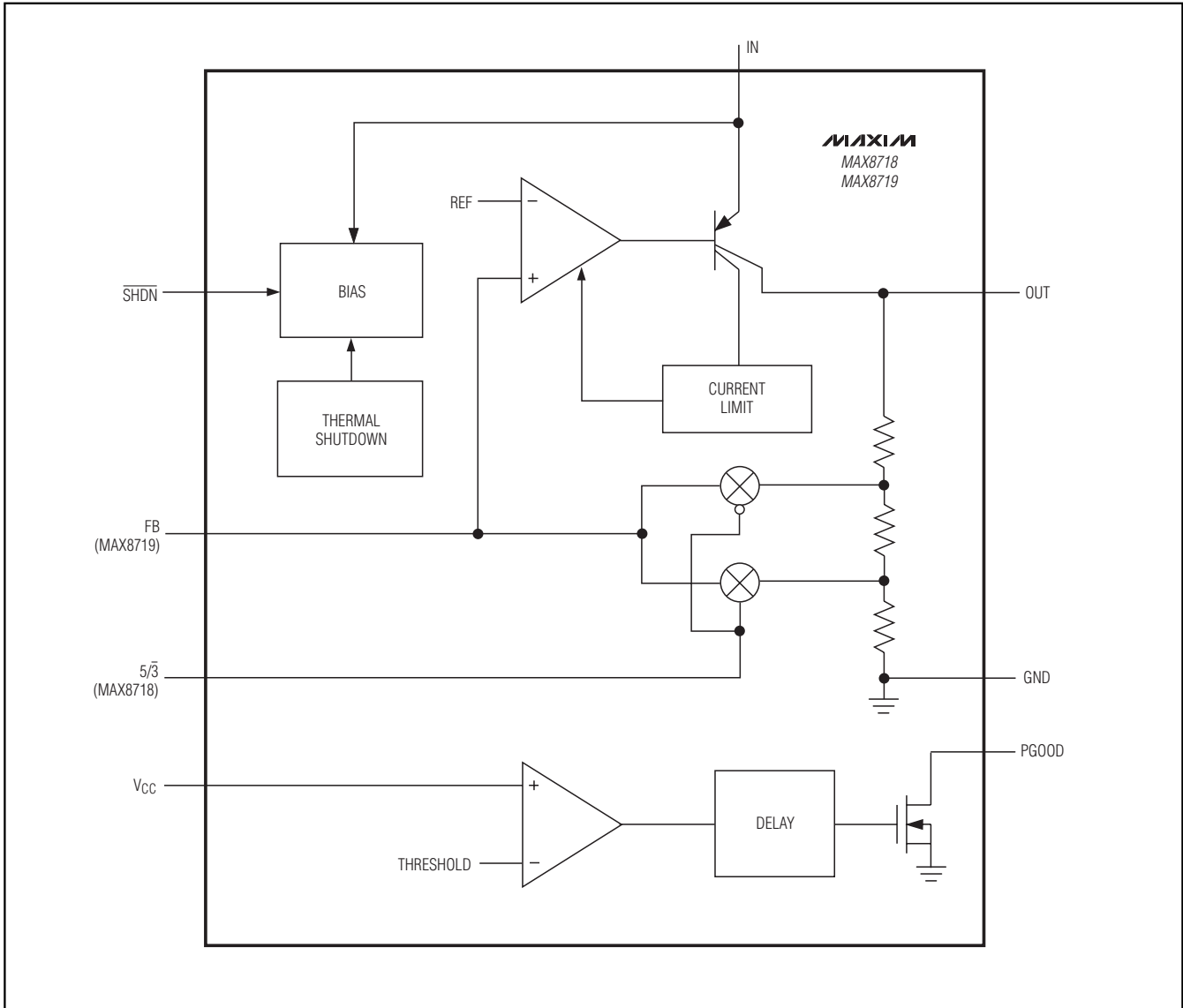
MAX8718/MAX8719

Figure 3. MAX8718/MAX8719 Functional Diagram

Current Limit

Output current is limited to 210mA (typ). The current limit exceeds the 100mA (min) safe operating limit. The output can be shorted to ground for 30 seconds without damaging the part.

Thermal-Overload Protection

When the junction temperature exceeds T_J = +165°C, an internal thermal sensor sends a signal to the shutdown logic, turning off the pass transistor and allowing the IC to cool. The thermal sensor turns the pass tran-

sistor on again after the IC's junction temperature cools by 20°C (typ), causing the output to pulse on and off during continuous thermal-overload conditions.

Operating Region and Power Dissipation

Maximum power dissipation depends on the thermal resistance of the case and circuit board, the temperature difference between the die junction and ambient air, and the rate of airflow. The device's power dissipation is $P = I_{OUT} \times (V_{IN} - V_{OUT})$. The power dissipation at +70°C ambient is 1951mW (see the *Absolute Maximum*
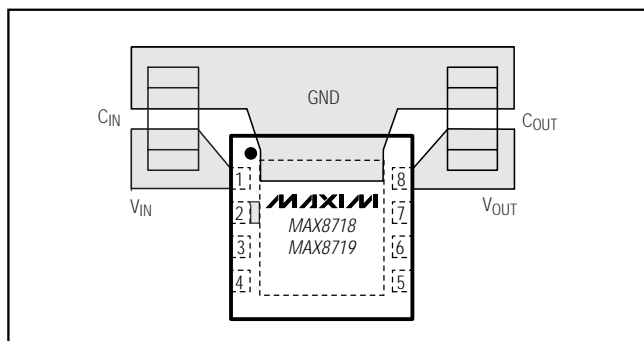
MAXIM

Figure 4. Layout of High-Current Paths

Ratings). The thermal resistance junction-to-case of the TDFN package is 41°C/W, and the maximum safe junction temperature is +150°C.

The GND pin and backside pad performs the dual function of providing an electrical connection to ground and channeling heat away from the package. Connect GND and the backside pad to ground using a metal trace or ground plane. The package's overall thermal resistance varies inversely with the copper PC board area attached to the part. To achieve rated thermal resistance, a copper region of at least 650mm^2 should be attached to the MAX8718/MAX8719s' case.

Applications Information

Setting the MAX8719's Output Voltage
Set the MAX8719's output voltage with a resistive voltage-divider (R1 and R2 in Figure 3). Choose R2 = 125kΩ or less to maintain a 10µA minimum load on OUT. Calculate R1 using the following equation:

$$R1 = R2 \times \left(\frac{V_{OUT}}{V_{FB}} - 1 \right)$$

where V_{FB} = 1.24V (typ).

Capacitor Selection
Use a 0.1µF (min) capacitor on the input. Higher values improve the line-transient response.

Use a 1µF (min) capacitor on the output, or a 15µF capacitor for the full 100mA load current. Otherwise, use a 1µF plus 0.16µF/mA (0.23µF/mA for the MAX8719). For output voltages less than 3.3V, use 15µF instead of 10µF. The output capacitor's equivalent series resistance (ESR) must be less than 1Ω for stable operation.

Output-Voltage Noise
The MAX8718/MAX8719 typically exhibit 5mV$_{P-P}$ of noise during normal operation. This is negligible in most applications. In applications that include analog-to-digital converters (ADCs) of more than 12 bits, consider the ADC's power-supply rejection specifications.

Transient Response
The *Typical Operating Characteristics* show the MAX8718/MAX8719s' load-transient response. When a step-in load current is applied, there are two components to the regulator's response. There is an instantaneous step in the output voltage due to the output capacitor's ESR and the regulator's finite output impedance. The second, slower component is the regulator's active correction to the output voltage. Typical step changes in the OUT load current from 10mA to 20mA produce 20mV transients.

Power-Good Output (PGOOD)
The MAX8718/MAX8719 include an independent power-good monitor. This circuit has an uncommitted sense input (V_{CC}) that can be connected to the regulator's output or similar voltage. In the MAX8718, the comparator threshold tracks the output set point according to the state of 5/$\overline{3}$. In the MAX8719, the comparator threshold is set to the feedback reference voltage. The PGOOD output goes high when V_{CC} is greater than -10% of the regulation set point. There is a fixed 100ms (min) delay when the output goes into regulation, which helps ensure proper output-voltage settling. The PGOOD delay when transitioning out of regulation is much faster, 4.5µs (typ), which permits the system to respond as fast as possible to the out-of-regulation condition.

The power-good monitor has an open-drain output, which can be externally pulled up to OUT. The voltage rating for PGOOD is 28V.

Layout Guidelines
Good layout is important to minimize the effects of noise and ensure accurate voltage regulation. Use appropriate trace widths for the high-current paths and keep traces short to minimize parasitic inductance and capacitance. Figure 4 shows a layout of the high-current paths. Place bypass capacitors close to the IN and OUT pins. When using the MAX8719, the feedback resistors should be placed close to the device to avoid voltage drops on ground that may shift the output voltage. Connect the exposed backside paddle to as large a copper area as practical.
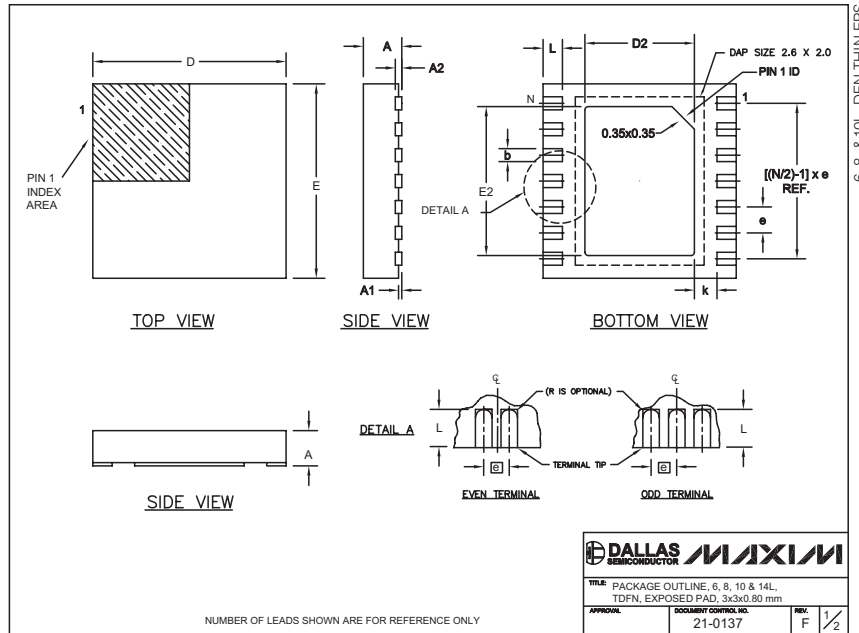
Chip Information
TRANSISTOR COUNT: 1298
PROCESS: BiCMOS

MAX8718/MAX8719

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

6, 8, & 10L, DFN THIN.EPS

TOP VIEW   SIDE VIEW   BOTTOM VIEW

DETAIL A

EVEN TERMINAL   ODD TERMINAL

SIDE VIEW

DALLAS SEMICONDUCTOR /VI/IXI/VI

TITLE: PACKAGE OUTLINE, 6, 8, 10 & 14L, TDFN, EXPOSED PAD, 3x3x0.80 mm

NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY

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	21-0137	F	1/2

COMMON DIMENSIONS

SYMBOL	MIN.	MAX.
A	0.70	0.80
D	2.90	3.10
E	2.90	3.10
A1	0.00	0.05
L	0.20	0.40
k	0.25 MIN.	
A2	0.20 REF.	

PACKAGE VARIATIONS

PKG. CODE	N	D2	E2	e	JEDEC SPEC	b	[(N/2)-1] x e
T633-1	6	1.50±0.10	2.30±0.10	0.95 BSC	MO229 / WEEA	0.40±0.05	1.90 REF
T833-1	8	1.50±0.10	2.30±0.10	0.65 BSC	MO229 / WEEC	0.30±0.05	1.95 REF
T1033-1	10	1.50±0.10	2.30±0.10	0.50 BSC	MO229 / WEED-3	0.25±0.05	2.00 REF
T1433-1	14	1.70±0.10	2.30±0.10	0.40 BSC	- - - -	0.20±0.03	2.40 REF
T1433-2	14	1.70±0.10	2.30±0.10	0.40 BSC	- - - -	0.20±0.03	2.40 REF

NOTES:
1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY SHALL NOT EXCEED 0.08 mm.
3. WARPAGE SHALL NOT EXCEED 0.10 mm.
4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
5. DRAWING CONFORMS TO JEDEC MO229, EXCEPT DIMENSIONS "D2" AND "E2", AND T1433-1 & T1433-2.
6. "N" IS THE TOTAL NUMBER OF LEADS.

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	21-0137	F	2/2