MAX17227J

400mV to 5.5V Input, 500mA nanoPower Boost Converter with Short-Circuit Protection and Automatic Pass-Through Mode

General Description

The MAX17227J is a nanoPower boost converter capable of delivering a load up to 500mA peak inductor current and offering automatic pass-through operation, True Shutdown™, cycle-by-cycle inductor current limit, short-circuit, and thermal-protection features. The MAX17227J offers ultra-low quiescent current, small total solution size, and high efficiency throughout the load and line range. The MAX17227J is ideal for battery-powered applications where long battery life is a must and high efficiency is required at all power levels.

The MAX17227J utilizes an adaptive on-time, pulse-frequency-modulation (PFM) control scheme that consumes ultra-low quiescent current. The MAX17227J features True Shutdown mode, where the output disconnects from the input with no forward or reverse current. The active discharge resistor feature pulls the charge from the output capacitor.

The MAX17227J is offered in space-saving and cost-effective 1.58mm x 0.89mm, 6-bump WLP (3 x 2, 0.4mm pitch) and 2mm x 2mm, 8-pin TDFN packages. The operating temperature range is from -40°C to +125°C.

Applications

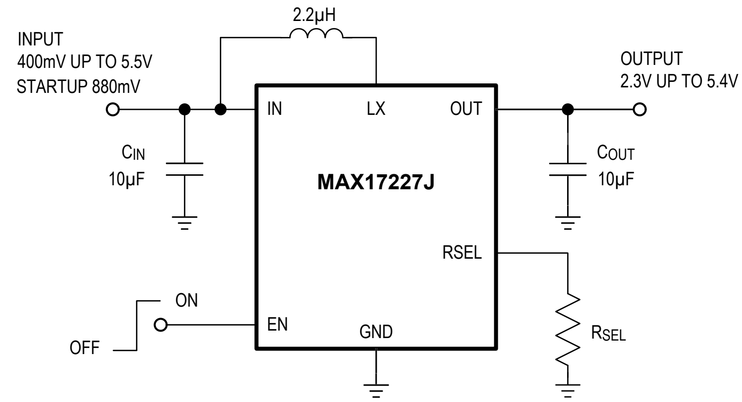
- Medical
  - Clinical Instrumentation
  - Battery-Powered Medical Equipment
- Industrial
  - Emergency Lighting
  - IoT Sensors
- Consumer
  - Wi-Fi® Module
  - Near-Band IoT
  - Wearable Devices

Benefits and Features

- 350nA Quiescent Supply Current
- Output Short-Circuit Protection
- Automatic Pass-Through Mode
  - Overcurrent and Overtemperature Protected
- 95% Peak Efficiency, 89% or Higher at 500µA
- Typical 300mA Output Current at 5.0V (V_{IN} > 3.6V)
- 400mV to 5.5V Input Voltage Range
- 880mV Minimum Startup Voltage
- Single Resistor-Adjustable Output Voltage
  - 2.3V to 5.2V Output Voltage Range with 100mV Steps
  - 5.4V Output Voltage Setting Available
- 500mA Peak Inductor Current Limit
- Active Discharge Feature
- Thermal Shutdown Protection
- Multiple Package Options:
  - 1.58mm x 0.89mm, 0.4mm Pitch, 6-Bump (3 x 2) WLP
  - 2mm x 2mm, 8-Pin TDFN
- -40°C to +125°C Operating Temperature Range

***Ordering Information* appears at end of data sheet.**

Typical Operating Circuit



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Absolute Maximum Ratings

IN, EN, RSEL, OUT to GND .... -0.3V to +6V
LX RMS Current .... $-1.6A_{RMS}$ to $+1.6A_{RMS}$
IN RMS Current .... $-0.8A_{RMS}$ to $+0.8A_{RMS}$
Output Short-Circuit Duration .... Continuous
Continuous Power Dissipation - WLP (T_A = +70°C) (derate 10.51mW/°C above +70°C) 840mW
Continuous Power Dissipation - TDFN (T_A = +70°C) (derate 11.7mW/°C above +70°C) 937.9mW
Operating Temperature Range ....-40°C to +125°C
Maximum Junction Temperature .... +150°C
Storage Temperature Range ....-65°C to +150°C
Soldering Temperature (reflow) .... +260°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.

Package Information

TDFN

Package Code	T822+3C
Outline Number	21-0168
Land Pattern Number	90-0065
Thermal Resistance, Four-Layer Board:	
Junction to Ambient ($θ_{JA}$)	85.3°C/W
Junction to Case ($θ_{JC}$)	8.9°C/W

WLP

Package Code	N60O1+1
Outline Number	21-100390
Land Pattern Number	Refer to *Application Note 1891*
Thermal Resistance, Four-Layer Board:	
Junction to Ambient ($θ_{JA}$)	95.15°C/W
Junction to Case ($θ_{JC}$)	N/A

For the latest package outline information and land patterns (footprints), go to *www.maximintegrated.com/packages*. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to *www.maximintegrated.com/thermal-tutorial*.

Electrical Characteristics

(V_{IN} = 1.5V, R_{SEL} = 191kΩ, V_{OUT} = 3.3V, T_J = -40°C to +125°C, typical values are at T_J = +25°C, C_{IN} = 10μF, C_{OUT} = 10μF, unless otherwise noted. (*Note 1*))

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Minimum Input Voltage	V_{IN_MIN}	Runs from output after startup, I_{OUT} = 1mA		400		mV
Input Voltage Range	V_{IN}	Guaranteed by LX maximum on-time	0.95		5.5	V
Minimum Startup Input Voltage	V_{IN_START}	R_L ≥ 3kΩ, *Typical Operating Circuit*, T_J = +25°C		0.88	0.95	V
Output Voltage Range	V_{OUT_RANGE}	See Table 1; for V_{IN} < V_{OUT} target (*Note 2*)	2.3		5.4	V
Output Accuracy, LPM	V_{ACC_LPM}	V_{OUT} falling (*Note 3*)	-1		+1	%

Electrical Characteristics (continued)

(V_{IN} = 1.5V, R_{SEL} = 191kΩ, V_{OUT} = 3.3V, T_J = -40°C to +125°C, typical values are at T_J = +25°C, C_{IN} = 10μF, C_{OUT} = 10μF, unless otherwise noted. (Note 1))

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Accuracy, ULPM	V_{ACC_ULPM}	V_{OUT} rising, when LX stops switching (Note 4)		+1.5	+2.7	+4.6	%
DC Load Regulation	ACC_{LOAD}	Load from 20mA to I_{OUT} at 80% of peak inductor current			-1		%
DC Line Regulation	ACC_{LINE}	Duty cycle varied from 25% to maximum			-1		%
Input Shutdown Current	I_{SD_IN}	V_{EN} = 0V, V_{OUT} = 0V, T_J = +25°C			1	100	nA
Quiescent Supply Current into IN	I_{Q_IN}	V_{EN} = V_{IN}, not switching, V_{OUT} = 105% of target voltage, T_J = +25°C, R_{SEL} = open			12		nA
Quiescent Supply Current into OUT	I_{Q_OUT}	V_{EN} = V_{IN}, not switching, V_{OUT} = 105% of target voltage, T_J = +25°C, R_{SEL} = open			350	660	nA
Maximum LX On-Time	t_{ONMAX}	T_J = +25°C			1.6		μs
LX On-Time in CCM	$t_{ON\_1.2V}$	V_{IN} = 1.2V	T_J = +25°C	580	620	660	ns
			T_J = -40°C to +125°C	540	620	700	
	$t_{ON\_3.0V}$	V_{IN} = 3.0V	T_J = +25°C		300		
LX Maximum Duty Cycle	DC	R_{SEL} = 10kΩ, V_{IN} = 1.2V, T_J = +25°C (Note 5)		80	86		%
		R_{SEL} = 10kΩ, V_{IN} = 1.2V (Note 5)		78	86		
		R_{SEL} = 191kΩ, V_{IN} = 3.0V (Note 5)		70	75		
LX Leakage Current	I_{LEAK_LX}	V_{LX} = V_{IN} = 5.5V, V_{OUT} = V_{EN} = 0V	T_J = +25°C		1	100	nA
IN Pass-Through Current Limit	I_{IN_PT}	V_{IN} = V_{EN} = 3.3V, V_{OUT} = 2.3V		0.7	1.0		A
Inductor Peak Current Limit	I_{PEAK_LX}	V_{OUT} = 3.3V, (Note 6)	T_J = +25°C	0.45	0.5	0.55	A
High-Side FET R_{DSON}	R_{DS_H}	V_{OUT} = 3.3V			170	280	mΩ
Low-Side FET R_{DSON}	R_{DS_L}	V_{OUT} = 3.3V			80	160	mΩ
Pass-Through R_{DSON}	R_{DS_PT}	V_{IN} = 3.3V, V_{EN} = 0V			400	650	mΩ
Zero-Crossing Threshold	I_{ZX_LX}	(Note 6)		15	25	35	mA
Soft-Start Rate	t_{SS_RATE}	Target V_{OUT} = 5.0V			3		V/ms
Enable Input Leakage	I_{LEAK_EN}	T_J = +25°C, V_{EN} = 5.5V			0.3	100	nA
Enable Voltage Threshold	V_{EN_IH}	V_{EN} rising, LX begins switching			0.6	0.95	V
	V_{EN_IL}	V_{EN} falling, LX stops switching		0.15	0.55		
Required Select Resistor Accuracy	ACC_{RSEL}	**Note:** Use the resistor from Table 1.		-1		+1	%
Select Resistor Detection Time	t_{RSEL}	C_{RSEL} < 2pF (Note 7)		240	600	1320	μs

Electrical Characteristics (continued)

(V_{IN} = 1.5V, R_{SEL} = 191kΩ, V_{OUT} = 3.3V, T_J = -40°C to +125°C, typical values are at T_J = +25°C, C_{IN} = 10µF, C_{OUT} = 10µF, unless otherwise noted. (Note 1))

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Thermal Shutdown Threshold	T_{SHUT}	OUT disabled	T_J rising		165		°C
			T_J falling		150		
Active Discharge Resistance	R_{OUT_DIS}	V_{EN} = 0		225	450	900	Ω

Note 1: Limits over the specified operating temperature and supply voltage range are guaranteed by design and characterization, and production tested at room temperature only.

Note 2: Guaranteed by the required select resistor accuracy parameter.

Note 3: Output accuracy in low-power mode when I_{OUT} > $I_{OUT\_TRANSITION}$ and inductor current is not in continuous-conduction mode (CCM). This accuracy does not include load, line, or ripple.

Note 4: Output accuracy in ultra-low-power mode when I_{OUT} < $I_{OUT\_TRANSITION}$. This accuracy does not include load, line, or ripple.

Note 5: Guaranteed by measuring LX frequency and duty cycle. Maximum duty cycle is a function of input voltage since LX on-time varies with V_{IN}.

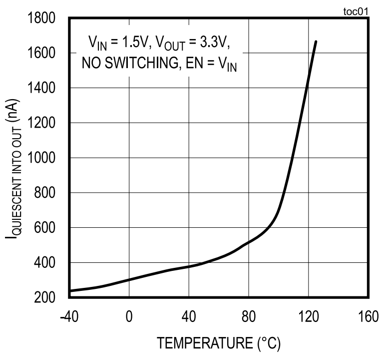
Note 6: This is a static measurement. The actual peak current limit depends on V_{IN} and L due to propagation delays.

Note 7: This is the time required to determine the R_{SEL} value. This time adds to the startup time.

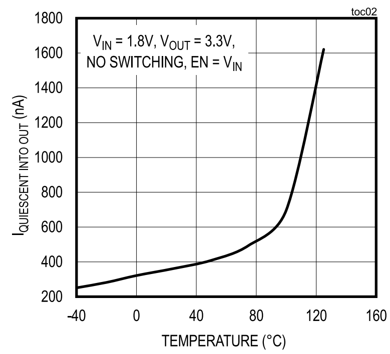
Typical Operating Characteristics

(V_{IN} = 1.5V, V_{OUT} = 3.3V, L = 2.2µH, C_{IN} = 10µF, C_{OUT} = 10µF, T_A = +25°C, unless otherwise noted.)

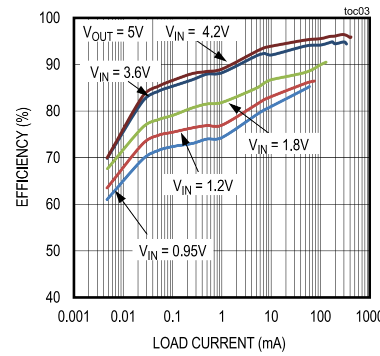
QUIESCENT SUPPLY CURRENT INTO OUT PIN vs. TEMPERATURE



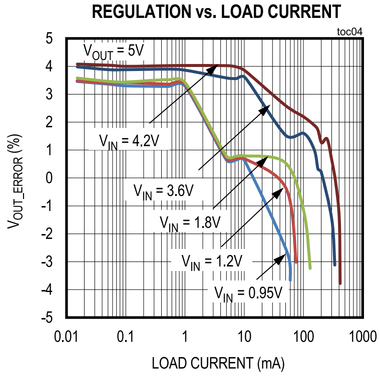
QUIESCENT SUPPLY CURRENT INTO OUT PIN vs. TEMPERATURE



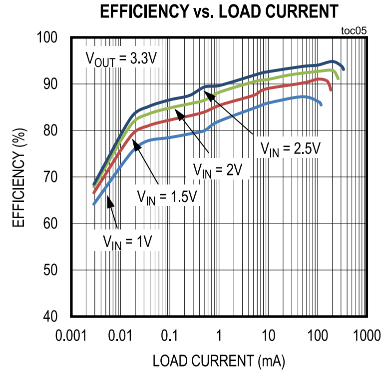
EFFICIENCY vs. LOAD CURRENT



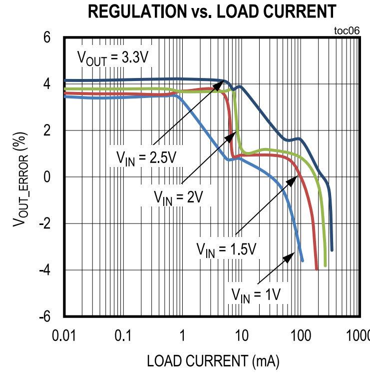
REGULATION vs. LOAD CURRENT



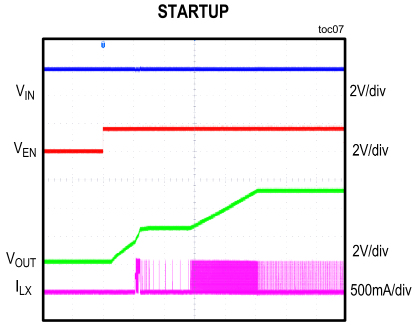
EFFICIENCY vs. LOAD CURRENT



REGULATION vs. LOAD CURRENT

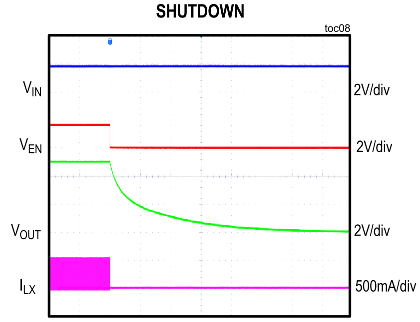


STARTUP



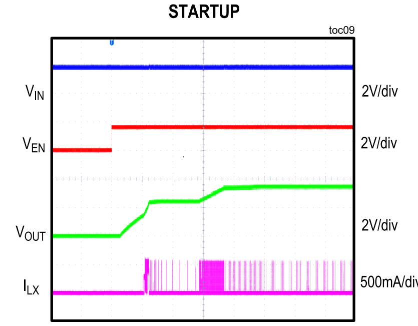
V_{IN} = 1.8V, V_{OUT} = 5V, R_{LOAD} = 3kΩ
400µs/div

SHUTDOWN



V_{IN} = 1.8V, V_{OUT} = 5V, R_{LOAD} = 3kΩ
8ms/div

STARTUP

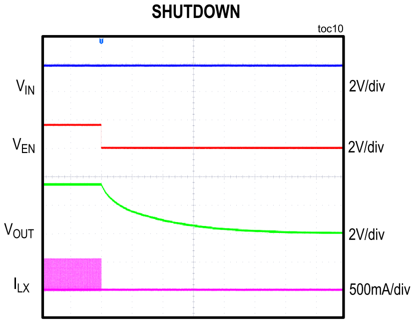


V_{IN} = 1.8V, V_{OUT} = 3.3V, R_{LOAD} = 3kΩ
400µs/div

Typical Operating Characteristics (continued)

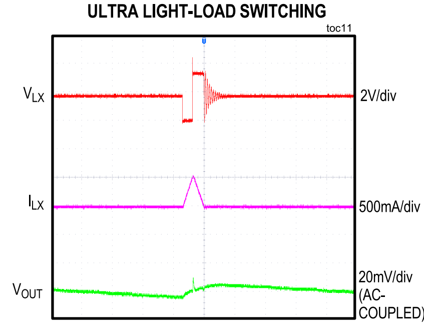
(V_{IN} = 1.5V, V_{OUT} = 3.3V, L = 2.2µH, C_{IN} = 10µF, C_{OUT} = 10µF, T_A = +25°C, unless otherwise noted.)

SHUTDOWN



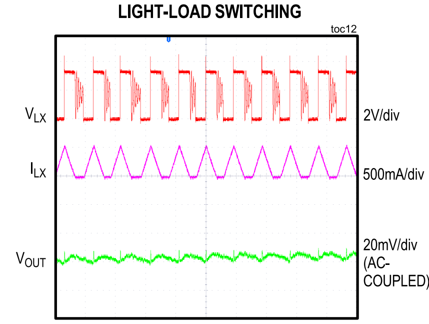
V_{IN} = 1.8V, V_{OUT} = 3.3V, R_{LOAD} = 3kΩ
8ms/div

ULTRA LIGHT-LOAD SWITCHING



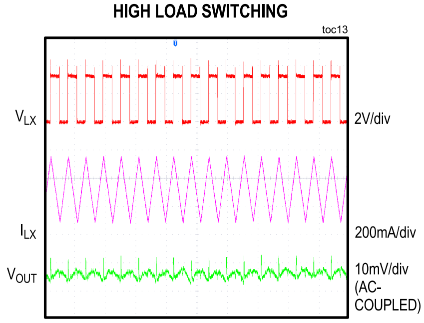
V_{IN} = 1.8V, V_{OUT} = 3.3V, I_{OUT} = 10mA
1µs/div

LIGHT-LOAD SWITCHING



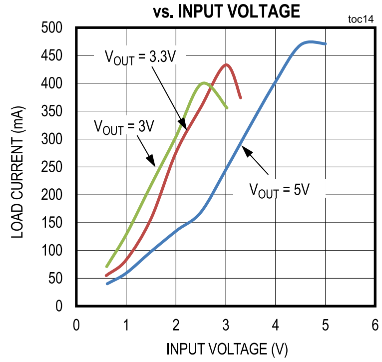
V_{IN} = 1.8V, V_{OUT} = 3.3V, I_{OUT} = 100mA
1µs/div

HIGH LOAD SWITCHING

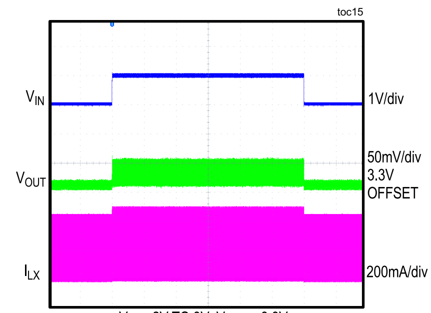


V_{IN} = 1.8V, V_{OUT} = 3.3V, I_{OUT} = 165mA
1µs/div

MAXIMUM OUTPUT CURRENT vs. INPUT VOLTAGE

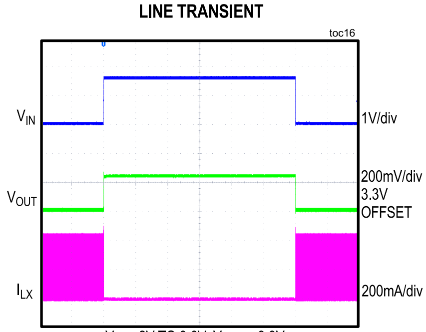


LINE TRANSIENT



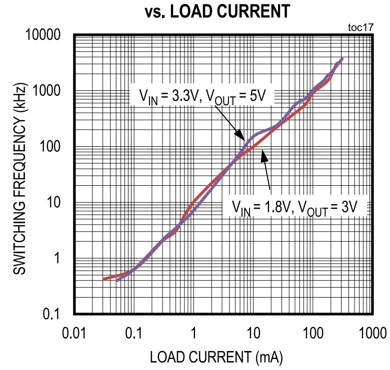
V_{IN} = 2V TO 3V, V_{OUT} = 3.3V,
I_{OUT} = 100mA, T_{RISE} = T_{FALL} = 1µs
4ms/div

LINE TRANSIENT

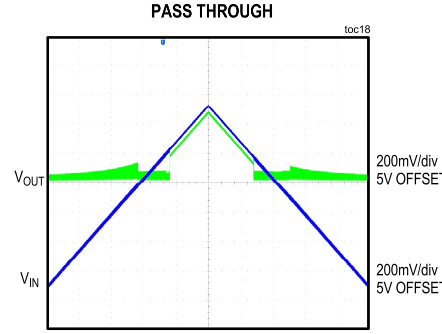


V_{IN} = 2V TO 3.6V, V_{OUT} = 3.3V,
I_{OUT} = 100mA, T_{RISE} = T_{FALL} = 1µs
4ms/div

SWITCHING FREQUENCY vs. LOAD CURRENT



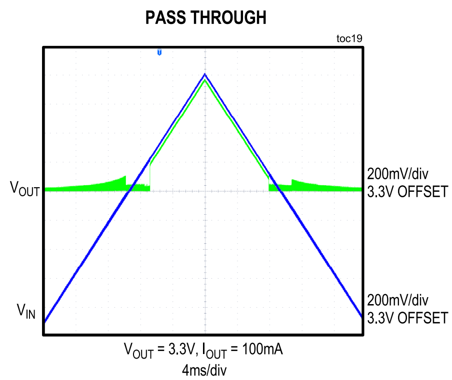
PASS THROUGH



V_{OUT} = 5V, I_{OUT} = 100mA
4ms/div

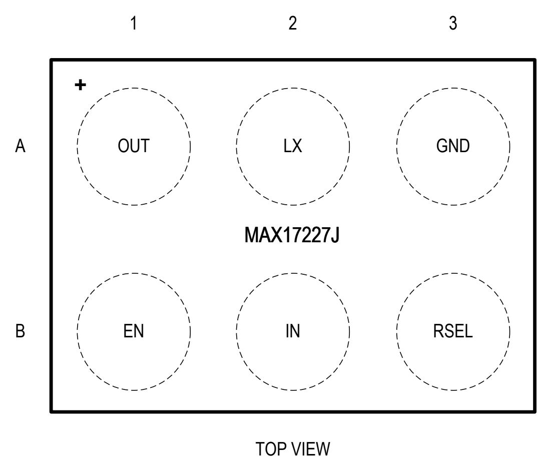
Typical Operating Characteristics (continued)

(V_{IN} = 1.5V, V_{OUT} = 3.3V, L = 2.2µH, C_{IN} = 10µF, C_{OUT} = 10µF, T_A = +25°C, unless otherwise noted.)

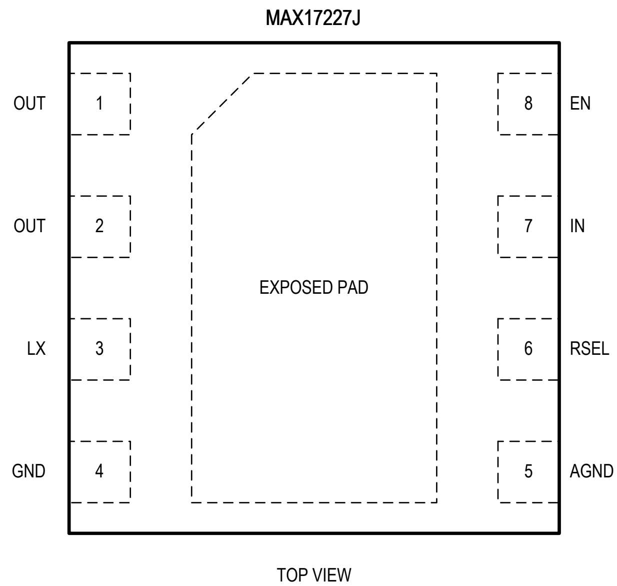


Pin Configurations

WLP



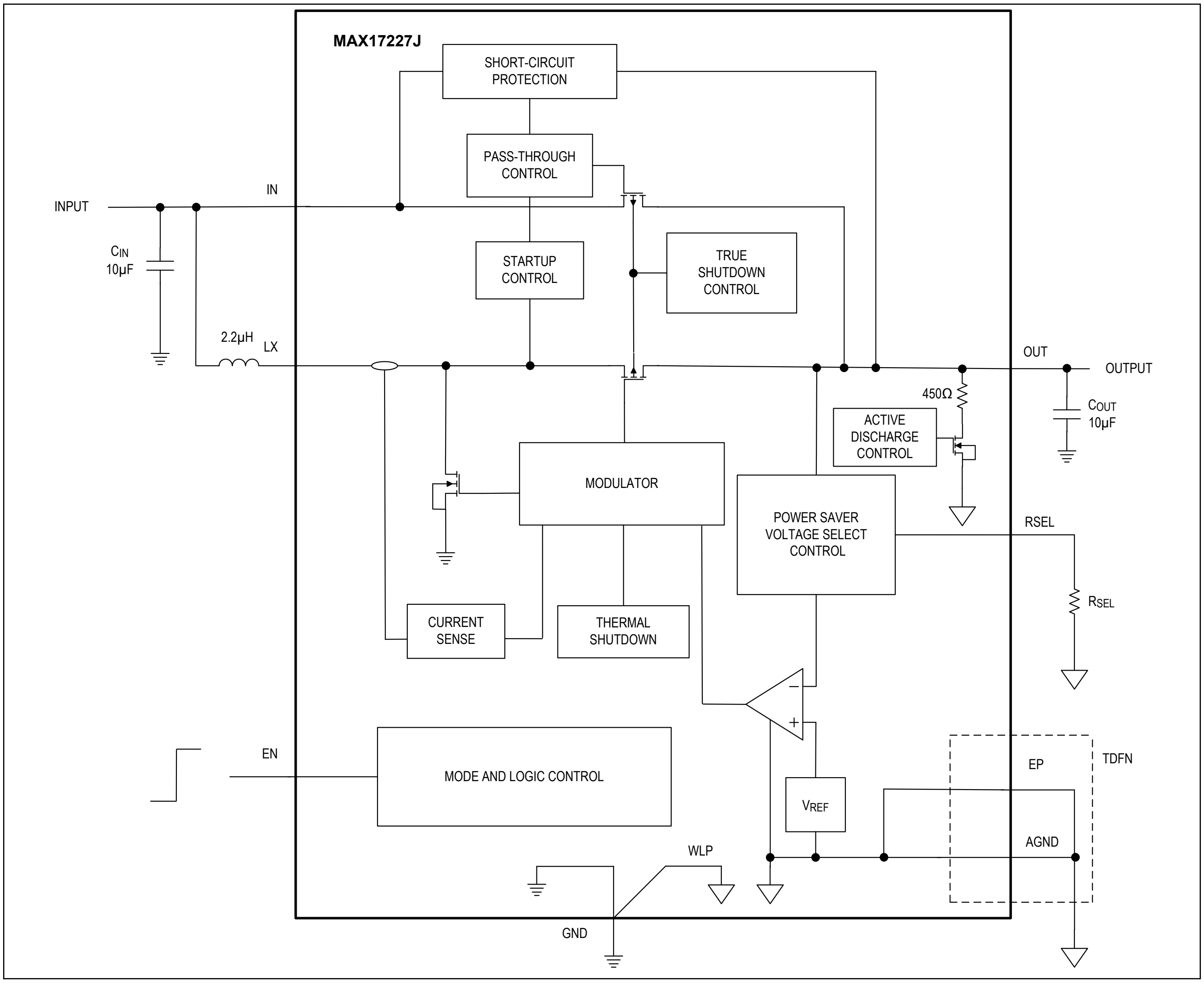
TDFN



Pin Description

PIN		NAME	FUNCTION
WLP	TDFN		
A1	1, 2	OUT	Output Pin. Connect a 10μF (C_{EFF_MIN} = 6μF) X7R ceramic capacitor to ground.
A2	3	LX	Switching Node. Connect a 2.2μH inductor from LX to IN.
A3	4	GND	Power Ground Pin. Connect to GND.
—	5	AGND	Analog Ground Pin. Connect to application board GND. Connect to the exposed pad (EP) externally in the PCB layout at a single point.
B3	6	RSEL	Output Voltage Select Pin. Connect a resistor from RSEL to GND based on the desired output voltage. See Table 1. Care must be taken that the total capacitance on this pin should be less than 2pF. See the *PCB Layout Guidelines* for more information.
B2	7	IN	Input Pin. Connect a 10μF (C_{EFF_MIN} = 6μF) X7R ceramic capacitor to ground. Depending on the specific application requirements, more capacitance may be needed.
B1	8	EN	Enable Input Pin. Force this pin high to enable the device. Force this pin low to disable the device and enter shutdown mode.
—	EP	EP	Exposed Pad. Connect EP to the application board GND. Functionally connect to AGND. Connect the GND and AGND pins to EP externally in the PCB layout with short traces under the device.

Functional Diagram



Detailed Description

The MAX17227J is an ultra-low I_Q (350nA) synchronous step-up converter optimized for battery-powered systems requiring long battery running time, high efficiency across a wide load range, and a small solution size. This device can operate across a wide 0.4V to 5.5V input voltage range. The output voltage is programmed in the 2.3V to 5.2V range with 100mV resolution using a single resistor connected from the RSEL pin to ground. A preprogrammed 5.4V output voltage is also available; however, the device does not support ultra-low-power mode (ULPM) when the target output voltage is 5.4V. An active discharge resistor in the MAX17227J pulls the charge from output capacitor through an active discharge resistor to ground when the part is shut down.

The MAX17227J utilizes an adaptive on-time pulse frequency modulation (PFM) control scheme that allows ultra-low quiescent current and high efficiency over a wide output current range. The peak inductor current is set by an on-time or cycle-by-cycle 500mA current limit. The device provides a True Shutdown feature in which the load is completely disconnected from the input to minimize leakage current, and an automatic pass-through feature when the input voltage is higher than the output voltage. The MAX17227J also features short-circuit and thermal protection, even when disabled.

Control Scheme

The MAX17227J boost converter is controlled by a unique, adaptive on-time pulse frequency modulation scheme that allows very-high-efficiency operation across the full load current range. The MAX17227J automatically switches between ULPM, low-power mode (LPM), and high-power mode (HPM) of operation depending on the load current. Figure 1 and Figure 2 show typical waveforms while in each mode.

The output voltage is regulated 2.7% higher while in ULPM (V_{ACC_ULPM}). This reduces effective skip frequency, thus significantly improving the system efficiency. In addition, operating marginally above the regulation threshold, the MAX17227J has an excellent transient response when a large load-transient event occurs. The device is typically in ULPM when the system is in standby state. Once the output voltage exceeds the ULPM regulation level, the device goes into a sleep mode, consuming very low quiescent current. It wakes up to resume switching when the output voltage falls below the threshold. While in this mode, the device regulates output while consuming only 350nA of current. Such low current consumption translates into a great performance, achieving 90% efficiency at a 10µA load current.

The MAX17227J transitions to LPM once the load current is high enough that it forces the device to switch faster than 17µs. The load current level at which this transition happens is a function of the operating condition and component selection. The user can calculate the value of the load current where ULPM transitions to LPM using the following equation:

$$I_{OUT\_TRANSITION} = \left(\frac{(t_{ON})^2}{2xL}\right) \times \left(\frac{V_{IN}}{\frac{V_{OUT}}{V_{IN}} - 1}\right) \times \left(\frac{\eta}{17\mu s}\right)$$

For example, for V_{IN} = 1.2V, V_{OUT} = 3V, and L = 2.2µH, the UPLM-to-LPM transition current happens at approximately 5.1mA, assuming 85% efficiency.

The MAX17227J enters HPM when the inductor current transitions from discontinuous-conduction mode (DCM) to CCM. The inductor current ripple is reduced in CCM operation in order to assure proper mode transitions. The voltage is regulated by an error amplifier that compares the output voltage to the internal reference and adjusts inductor current accordingly, thus achieving great load regulation performance of 1%.

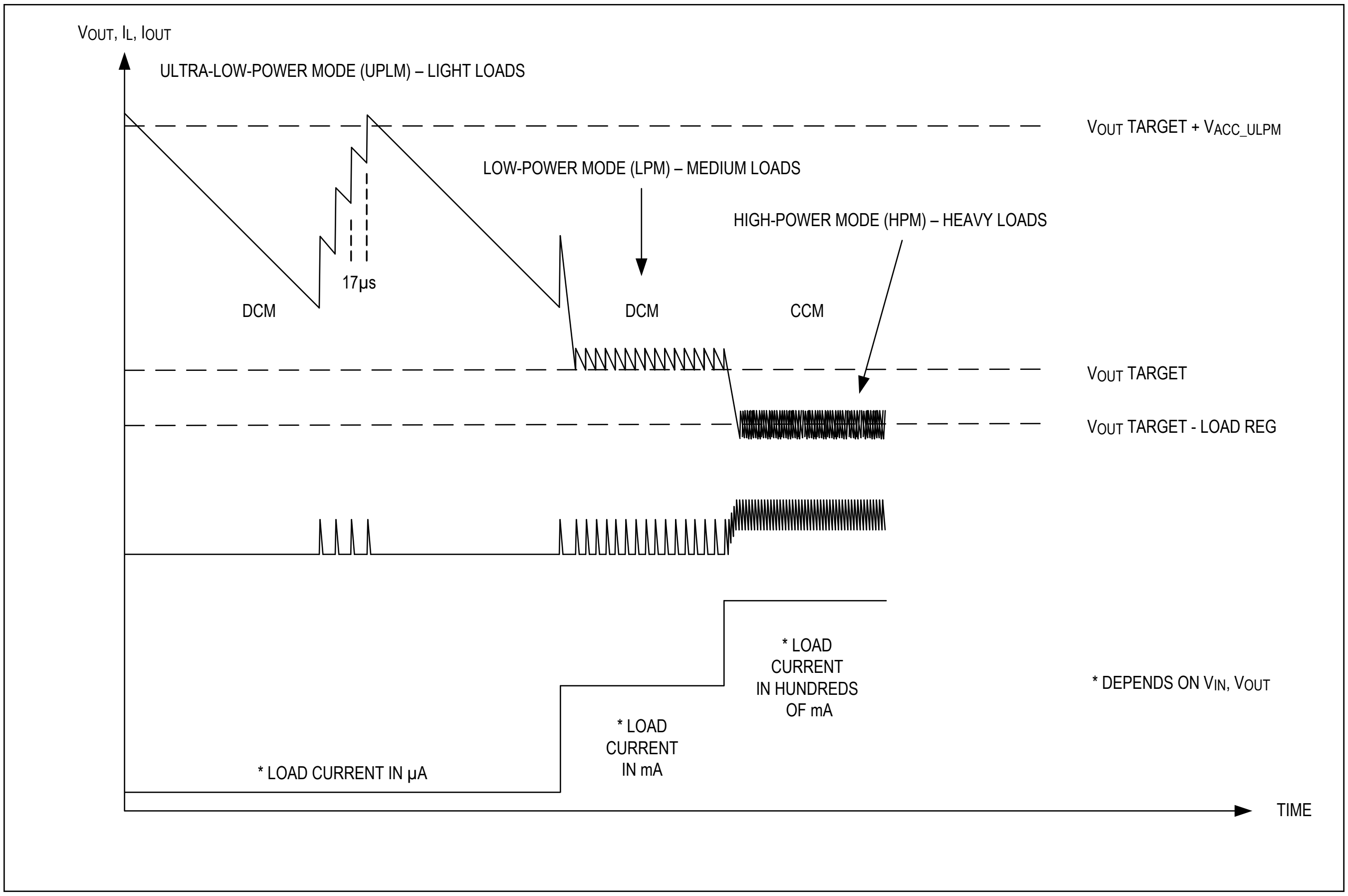


Figure 1. ULPM, LPM, HPM Transition Waveforms

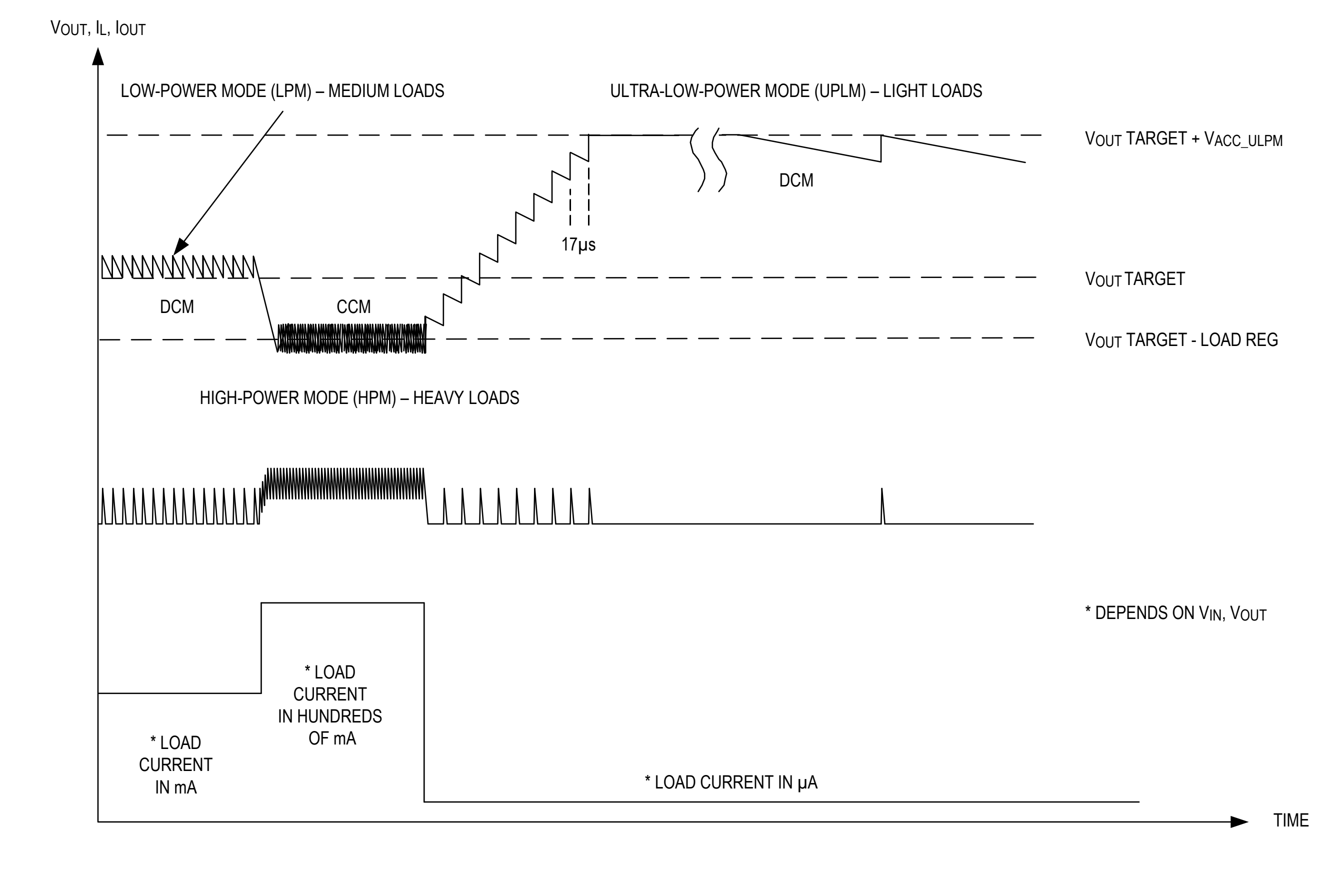


Figure 2. LPM, HPM, ULPM Transition Waveforms

Output Voltage Selection

The MAX17227J has a unique, single resistor output selection method for selecting 31 different voltages from 2.3V to 5.4V, as shown in Table 1.

At startup, the MAX17227J sources up to 200µA during the selected resistor detection time, typically for 600µs (t_{RSEL}), to read the R_{SEL} value.

The total capacitance on the RSEL pin should be less than 2pF. See the *PCB Layout Guidelines* for more information.

The R_{SEL} output voltage selection method has many benefits:

- In conventional boost converters, current is drawn from the output continuously through a feedback resistor-divider. In the MAX17227J, 200µA of current is drawn from the output only during startup, which helps to increase efficiency at light loads.
- Only one resistor is needed versus the two resistors needed in typical feedback connections, thereby providing lower cost and smaller size.
- R_{SEL} allows customers to stock just one part in their inventory system and use it in multiple projects with different output voltages just by changing a single, standard 1% resistor.
- R_{SEL} allows much higher internal feedback resistors instead of lower impedance external feedback resistors to enable ultra-low-power applications.

Select the R_{SEL} resistor value by choosing the desired output voltage in Table 1.

Table 1. R_{SEL} Selection Table

TARGET OUTPUT VOLTAGE V_{OUT} (V)	R_{SEL} STANDARD RESISTOR 1% (kΩ)
2.3	Open
2.4	909
2.5	768
2.6	634
2.7	536
2.8	452
2.9	383
3.0	324
3.1	267
3.2	226
3.3	191
3.4	162
3.5	133
3.6	113
3.7	95.3
3.8	80.6
3.9	66.5
4.0	56.2
4.1	47.5
4.2	40.2
4.3	34.0
4.4	28.0
4.5	23.7
4.6	20.0
4.7	16.9
4.8	14.0
4.9	11.8
5.0	10.0
5.1	8.45
5.2	7.15
5.4*	4.99

* Indicates ULPM disabled.

Fixed-Output Voltage Version

In applications where board space is at a premium, contact a Maxim Integrated representative to order fixed-output versions that do not require the R_{SEL} resistor to program the output voltage. The RSEL pin must be left floating for fixed output versions. The output voltage can be preprogrammed in the 2.3V to 5.2V range with 100mV resolution. A 5.4V output target level is also available; ULPM is disabled at this output target level.

Features

Enable

The MAX17227J includes an enable input pin (EN). Connect the EN pin to the IN pin or force this pin high to turn on the boost converter. Force this pin low to disable the device and enter True Shutdown mode. In True Shutdown mode, the MAX17227J stops switching and the active discharge resistor discharges the output capacitor.

Soft-Start Control

After the EN pin goes above its rising threshold (V_{EN_IH}), the MAX17227J begins the startup.

The device uses a pass-through switch to precharge the output capacitor to the input voltage. After precharge, it acquires the target output voltage after reading the external R_{SEL} resistance. The MAX12772J will boost to charge the output to at least 2.3V if the pass-through switch can not charge the output voltage to 2.3V prior to reading the R_{SEL} acquisition. Then the device will boost if the target output voltage is greater than input voltage. The ramp rate during boost is fixed to 3V/ms.

The MAX17227J is able to start up with a 0.88V input voltage into a load resistance of 3kΩ or larger. The device will be load current limited if it is enabled when V_{IN} is between 0.88V and 2.0V. If the load current is so heavy that it does not allow the MAX17227J to charge the output above 1.5V, the device cannot reach its output target level until V_{IN} is increased or the load current is reduced.

The MAX17227J initiates a controlled soft-start in the event a supply voltage is applied at high dV/dt rate; for example, during installation of a fresh battery. While in regulation, if V_{IN} steps abruptly above V_{OUT} for more than 1V, the device will reset. The output voltage droop in this case is a function of the load current, output capacitance, and time required for soft-start to complete, which is typically 1.6ms.

When the MAX17227J is enabled while V_{IN} is 1V or more above the output voltage target, the device remains in pass-through mode, and the output voltage is R_{DS_PT} x I_{LOAD} when the voltage drops below V_{IN}.

Automatic Pass-Through Mode

The MAX17227J automatic pass-through mode is activated when the input voltage is greater than the output voltage, typically by 0.4V. The output gets connected to the input through a low-resistance pass-through switch so that the system can run and operate from the input pin efficiently. The output voltage follows the input voltage closely with a voltage drop of the pass-through switch resistance. The current through the pass-through switch is limited to 1A (I_{IN_PT}). In the pass-through mode, the device is short-circuit and overtemperature protected.

Prior to entry into pass-through mode, the high-side FET stops switching. However, the part continues to switch and regulate the output voltage using the low-side FET and the body diode of the high-side FET.

The output voltage during pass-through mode depends on the load current and input voltage. The resulting output voltage is calculated as:

$$V_{OUT} = V_{IN} - (R_{DS\_PT} \times I_{LOAD})$$

where R_{DS_PT} is the on-resistance of the pass-through switch.

Overload Operation

The MAX17227J is protected from an output overload condition for all input voltages even when the input voltage is greater than the target output voltage in pass-through mode or during the startup or boost mode of operation.

Short-Circuit Protection

The MAX17227J is protected from an output short-circuit condition by current and thermal overload circuits. Once the short-circuit event is detected, the high-side FET and inductor are bypassed and the short-circuit protection block gets engaged through the pass-through switch. The short-circuit current (I_{IN_PT}) is limited to 1A. The part also features soft output short-circuit detection, where it bypasses and protects the inductor using the current-limited pass-through switch, even during an inductor current overload event. Under this condition, the part heats up due to high power dissipation and will likely enter thermal shutdown.

Thermal Shutdown

The MAX17227J features thermal shutdown. The converter and short-circuit protection device turns off when the junction temperature exceeds +165°C. Once the device cools by 15°C, the converter resumes operation. If the fault condition is not removed, the regulator will cycle on and off.

Design Procedure

Inductor Selection

It is recommended to use a 2.2μH inductor. This inductor value provides the best size and efficiency trade-off in most applications.

Input Capacitor

Input capacitors reduce current peaks from the input supply and increase efficiency. For the input capacitor, choose a ceramic capacitor because they have the lowest equivalent series resistance (ESR), smallest size, and lowest cost. Other capacitor types can be used as well, but has larger ESR. The biggest downside of ceramic capacitors is that their capacitance derates with higher a DC bias and, therefore, a minimum standard 10μF (C_{EFF_MIN} = 6μF) ceramic capacitor is recommended at the input for all applications. For applications that use batteries with a high source impedance greater than 1Ω, more capacitance may be needed. A good starting point is to use the same capacitance value at the input as well as output. In applications where V_{IN} is approaching V_{OUT}, more input capacitance is required to minimize input voltage ripple.

At a minimum, a standard 10μF (C_{EFF_MIN} = 6μF) X7R ceramic capacitor is recommended for all applications. Due to DC bias effects, the effective capacitance can be 80% lower than the nominal capacitor value. The capacitor data sheet must be consulted for proper DC bias, AC ripple, and temperature capacitance derating.

Output Capacitor

A 10μF ceramic capacitor is recommended for all applications. The output capacitor (C_{OUT}) is required to keep the output voltage ripple small and to ensure loop stability. C_{OUT} must have low impedance at the switching frequency. Ceramic capacitors are recommended due to their small size and low ESR. Make sure that the minimum effective capacitance is 6μF over temperature, DC bias, and AC ripple capacitor data sheet specifications. Capacitors with X7R temperature characteristics typically perform well. In applications where V_{IN} is approaching V_{OUT}, more output capacitance is required to minimize output voltage ripple.

PCB Layout Guidelines

Careful PCB layout is especially important in nanoPower DC-DC converters. Poor layout can affect the IC performance, causing problems such as electromagnetic interference (EMI) and electromagnetic compatibility (EMC) issues, ground bounce, and voltage drops. Poor layout can also affect regulation and stability.

A good layout is implemented using the following rules:

- Place the inductor, input capacitor, and output capacitor close to the IC using short traces. These components carry high switching currents, and long traces act like antennas. The output capacitor placement is the most important in the PCB layout and should be placed directly next to the IC. The inductor and input capacitor placement are secondary to the output capacitor's placement, but should remain close to the IC.
- The connection from the bottom plate of the output capacitor and the ground pin of the device must be extremely short as should be that of the input capacitor.
- Similarly, the top plate of output capacitor and the OUT pin of the device must be short as well.
- Minimize the surface area used for LX, since this is the noisiest node.
- Keep the main power path from IN, LX, OUT, and GND as tight and short as possible.
- Route the output voltage path away from the inductor and LX_ switching node to minimize noise and magnetic

interference.

- Maximize the size of the ground metal on the component side to help with thermal dissipation. Use a ground plane with several vias connecting to the component-side ground to further reduce noise interference on sensitive circuit nodes.
- Lastly, the trace used for RSEL should neither be too long nor should it produce a capacitance of more than 2pF.

It is recommended to consult the MAX17227J EV kit layout.

Thermal Considerations

In most applications, the IC does not dissipate much heat due to its high efficiency. But in applications where the IC runs at high ambient temperature with heavy loads, the heat dissipated may cause the temperature to exceed +125°C or the maximum junction temperature of the part. If the junction temperature reaches approximately +165°C ($T_{J\ RISING}$), thermal overload protection is activated. The maximum power dissipation depends on the thermal resistance of the IC package and application circuit board.

The power dissipated (P_D) in the device is:

$P_D = P_{IN} - P_{OUT} - P_{IND}$

where:

P_{IND} is the power dissipated in the inductor that includes DC, AC, and core losses.

P_{OUT} is the power delivered to the load.

The maximum allowed power dissipation is:

$P_{D\_MAX} = (T_{JMAX} - T_A)/\theta_{JA}$

where:

($T_{JMAX} - T_A$) is the temperature difference between the MAX17227J maximum rated junction temperature (+125°C) and the surrounding ambient temperature.

θ_{JA} is the thermal resistance of the junction through the package, PCB, copper traces, and other materials to the surrounding ambient temperature.

Ordering Information

PART NUMBER	TEMPERATURE RANGE	PIN-PACKAGE
MAX17227JANT+T	-40°C to +125°C	6 WLP
MAX17227JATA+*	-40°C to +125°C	8 TDFN

** Future product—contact factory for availability.*

+Denotes a lead(Pb)-free/RoHS-compliant package.

T = Tape and reel.

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	4/21	Initial release	—