19-1381; Rev 0; 7/98

EVALUATION KIT AVAILABLE

MAXIM

1-Cell to 2-Cell, Low-Noise, High-Efficiency, Step-Up DC-DC Converter

General Description

The MAX1678 is a high-efficiency, low-voltage, synchronous-rectified, step-up DC-DC converter intended for use in devices powered by 1 to 3-cell alkaline, NiMH, or NiCd batteries or a 1-cell lithium battery. It guarantees a 0.87V start-up voltage and features a low 37µA quiescent supply current.

The device includes a 1Ω, N-channel MOSFET power switch, a synchronous rectifier that acts as the catch diode, a reference, pulse-frequency-modulation (PFM) control circuitry, and circuitry to reduce inductor ringing—all in an ultra-small, 1.1mm-high µMAX package.

The output voltage is preset to 3.3V or can be adjusted from +2V to +5.5V using only two resistors. Efficiencies up to 90% are achieved for loads up to 50mA. The device also features an independent undervoltage comparator (PFI/PFO) and a logic-controlled 2µA shutdown mode.

Features

- **0.87V Guaranteed Start-Up**
- **Up to 90% Efficiency**
- **Built-In Synchronous Rectifier (no external diode)**
- **Ultra-Small µMAX Package, 1.1mm High**
- **37µA Quiescent Current (85µA from 1.5V battery)**
- **2µA Logic-Controlled Shutdown**
- **Power-Fail Detector**
- **Dual Mode™ Output: Fixed 3.3V**
  Adjustable 2V to 5.5V
- **45mA Output Current at 3.3V for 1-Cell Input**
- **90mA Output Current at 3.3V for 2-Cell Input**
- **Inductor-Damping Switch Suppresses EMI**

Applications

Pagers

Remote Controls

Pointing Devices

Personal Medical Monitors

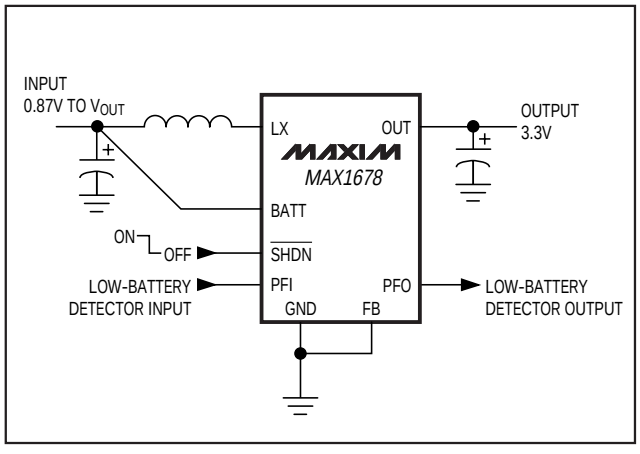
Single-Cell Battery-Powered Devices

Ordering Information

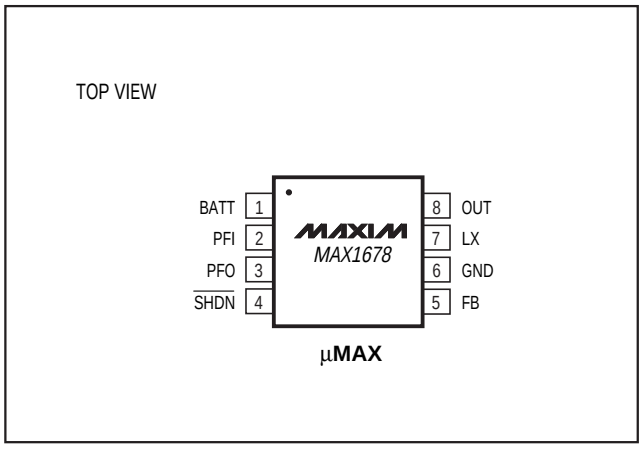
PART	TEMP. RANGE	PIN-PACKAGE
MAX1678EUA	-40°C to +85°C	8 µMAX

Note: To order these devices shipped in tape-and-reel, add a -T to the part number.

Typical Operating Circuit



Pin Configuration



Dual Mode is a trademark of Maxim Integrated Products.

For free samples & the latest literature: http://www.maxim-ic.com, or phone 1-800-998-8800.
For small orders, phone 408-737-7600 ext. 3468.

1-Cell to 2-Cell, Low-Noise, High-Efficiency, Step-Up DC-DC Converter

ABSOLUTE MAXIMUM RATINGS

BATT, OUT,LX, $\overline{SHDN}$ to GND .....-0.3V to +6.0V
OUT, LX Current.....1A
FB, PFI, PFO to GND .....-0.3V to (V_{OUT} + 0.3V)
Reverse Battery Current (T_A = +25°C) (Note 1) 220mA
Continuous Power Dissipation (T_A = +70°C)
µMAX (derate 4.1mW/°C above +70°C) 330mW

Operating Temperature Range .....-40°C to +85°C
Junction Temperature.....+150°C
Storage Temperature Range .....-65°C to +165°C
Lead Temperature (soldering, 10sec) .....+300°C

Note 1: The reverse battery current is measured from the *Typical Operating Circuit's* input terminal to GND when the battery is connected backward. A reverse current of 220mA will not exceed package dissipation limits but, if left for an extended time (more than 10 minutes), may degrade performance.

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_{BATT} = $V_{\overline{SHDN}}$ = 1.3V, I_{LOAD} = 0, FB = GND, **T_A = 0°C to +85°C**, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Minimum Operating Input Voltage	$V_{BATT(MIN)}$			0.7		V
Maximum Operating Input Voltage	$V_{BATT(MAX)}$				5.5	V
Start-Up Voltage (Note 2)		R_L = 3kΩ, T_A = +25°C	0.87			V
Start-Up Voltage Tempco				-2		mV/°C
Output Voltage (Fixed Mode)	V_{OUT}	V_{FB} < 0.1V	3.16	3.3	3.44	V
Output Voltage Range (Adjustable Mode)		External feedback	2.0		5.5	V
FB Set Voltage	V_{FB}	External feedback	1.19	1.23	1.26	V
N-Channel On-Resistance		V_{OUT} = 3.3V		1	1.5	Ω
P-Channel On-Resistance		V_{OUT} = 3.3V		1.5	2.2	Ω
P-Channel Catch Diode Voltage		I_{DIODE} = 100mA, P-channel switch off		0.8		V
Maximum Peak LX Current	$I_{LX(MAX)}$			550		mA
On-Time Constant	K	0.9V < V_{BATT} < 3.3V (t_{ON} = K / V_{BATT})	5.60	8	11.2	V-µs
Quiescent Current into OUT	$I_{Q,OUT}$	V_{OUT} = 3.5V		37	65	µA
Quiescent Current into BATT	$I_{Q,BATT}$			4	8	µA
Shutdown Current into OUT	$I_{SHDN,OUT}$	V_{OUT} = 3.5V		0.1	1	µA
Shutdown Current into BATT	$I_{SHDN,BATT}$	V_{BATT} = 1V		2	3.5	µA
Efficiency	η	I_{LOAD} = 20mA, V_{BATT} = 2.5V (Figure 7)		90		%
FB Input Current		V_{FB} = 1.3V		0.1	10	nA
PFI Trip Voltage	$V_{IL,PFI}$	Falling PFI hysteresis 2%	590	614	632	mV
PFI Input Current		V_{PFI} = 650mV		0.1	10	nA
PFO Low Output Voltage	V_{OL}	V_{PFI} = 0, V_{OUT} = 3.3V, I_{SINK} = 1mA		0.04	0.4	V
PFO Leakage Current		V_{PFI} = 650mV, V_{PFO} = 6V		0.01	1	µA
$\overline{SHDN}$ Input Low Voltage	V_{IL}				0.2 x V_{BATT}	V
$\overline{SHDN}$ Input High Voltage	V_{IH}		0.8 x V_{BATT}			V
$\overline{SHDN}$ Input Current		$\overline{SHDN}$ = GND or BATT		0.1	10	nA

ELECTRICAL CHARACTERISTICS

(V_{BATT} = $V_{\overline{SHDN}}$ = 1.3V, I_{LOAD} = 0, FB = GND, **T_A = -40°C to +85°C**, unless otherwise noted.) (Note 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	MAX	UNITS
Maximum Operating Input Voltage	$V_{BATT(MAX)}$			5.5	V
Output Voltage (Fixed Mode)	V_{OUT}	V_{FB} < 0.1V	3.12	3.48	V
Output Voltage Range (Adjustable Mode)		External feedback	2.0	5.5	V
FB Set Voltage	V_{FB}	External feedback	1.17	1.28	V
N-Channel On-Resistance		V_{OUT} = 3.3V		1.5	Ω
P-Channel On-Resistance		V_{OUT} = 3.3V		2.2	Ω
On-Time Constant	K	0.9V < V_{BATT} < 3.3V (t_{ON} = K / V_{BATT})	5.60	11.2	V-µs
Quiescent Current into OUT	$I_{Q,OUT}$	V_{OUT} = 3.5V		65	µA
Quiescent Current into BATT	$I_{Q,BATT}$			8	µA
Shutdown Current into OUT	$I_{SHDN,OUT}$	V_{OUT} = 3.5V		1	µA
Shutdown Current into BATT	$I_{SHDN,BATT}$	V_{BATT} = 1V		3.5	µA
FB Input Current		V_{FB} = 1.3V		10	nA
PFI Trip Voltage	$V_{IL,PFI}$	Falling PFI hysteresis 2%	580	642	mV
PFI Input Current		V_{PFI} = 650mV		10	nA
PFO Low Output Voltage	V_{OL}	V_{PFI} = 0, V_{OUT} = 3.3V, I_{SINK} = 1mA		0.4	V
PFO Leakage Current		V_{PFI} = 650mV, V_{PFO} = 6V		1	µA
$\overline{SHDN}$ Input Low Voltage	V_{IL}			0.2 x V_{BATT}	V
$\overline{SHDN}$ Input High Voltage	V_{IH}		0.8 x V_{BATT}		V
$\overline{SHDN}$ Input Current		$\overline{SHDN}$ = GND or BATT		10	nA

Note 2: Start-up is guaranteed by correlation to measurements of device parameters (i.e., switch on-resistance, on-time, off-time, and output voltage trip point).

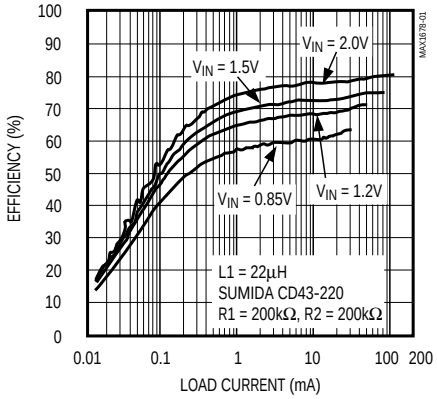
Note 3: Specifications to -40°C are guaranteed by design and not production tested.

1-Cell to 2-Cell, Low-Noise, High-Efficiency, Step-Up DC-DC Converter

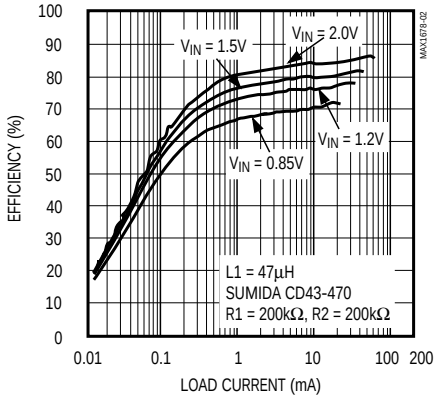
Typical Operating Characteristics

(Circuit of Figure 7 (Fixed Mode, 3.3V) or Figure 8 (Adjustable Mode), T_A = +25°C, unless otherwise noted.)

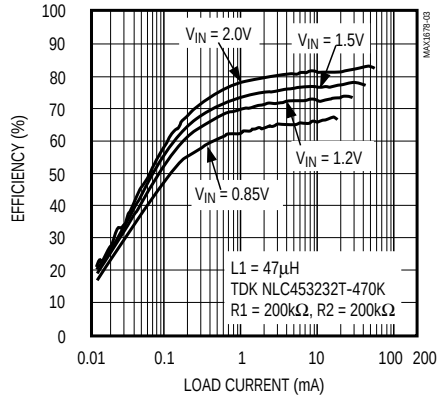
EFFICIENCY vs. LOAD CURRENT (V_{OUT} = 2.4V, L1 = 22µH)



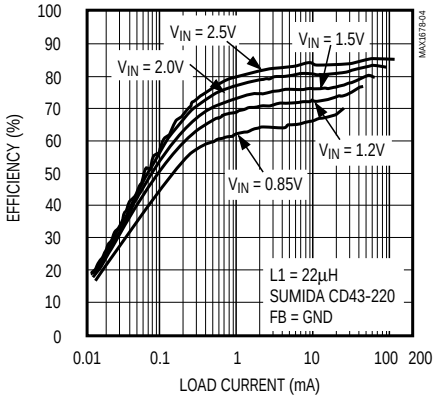
EFFICIENCY vs. LOAD CURRENT (V_{OUT} = 2.4V, L1 = SUMIDA 47µH)



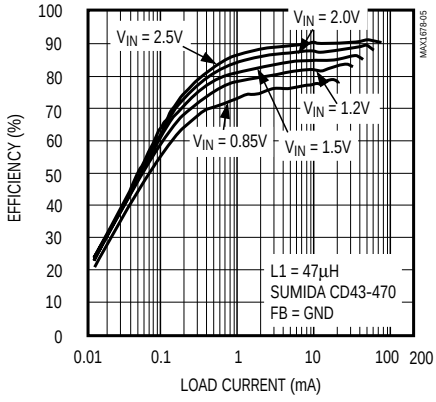
EFFICIENCY vs. LOAD CURRENT (V_{OUT} = 2.4V, L1 = TDK 47µH)



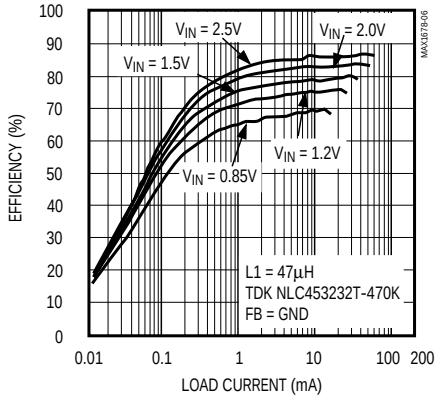
EFFICIENCY vs. LOAD CURRENT (V_{OUT} = 3.3V, L1 = 22µH)



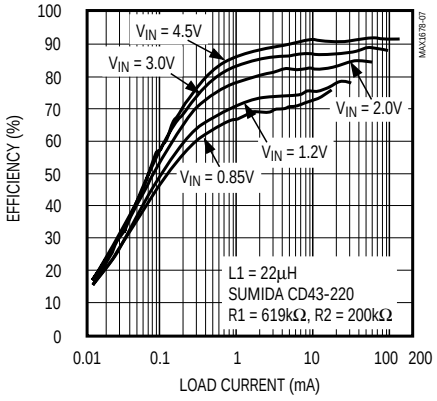
EFFICIENCY vs. LOAD CURRENT (V_{OUT} = 3.3V, L1 = SUMIDA 47µH)



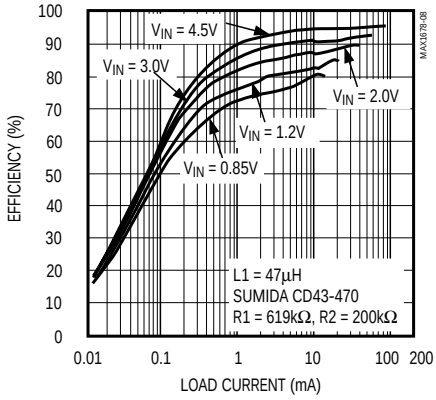
EFFICIENCY vs. LOAD CURRENT (V_{OUT} = 3.3V, L1 = TDK 47µH)



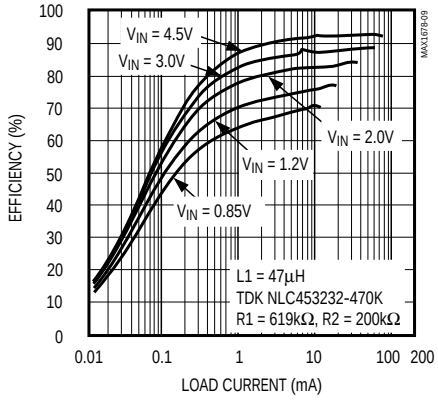
EFFICIENCY vs. LOAD CURRENT (V_{OUT} = 5.0V, L1 = 22µH)



EFFICIENCY vs. LOAD CURRENT (V_{OUT} = 5.0V, L1 = SUMIDA 47µH)



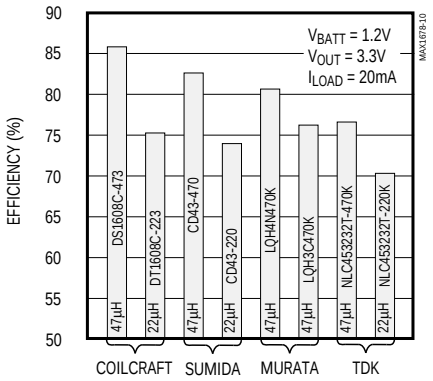
EFFICIENCY vs. LOAD CURRENT (V_{OUT} = 5.0V, L1 = TDK 47µH)



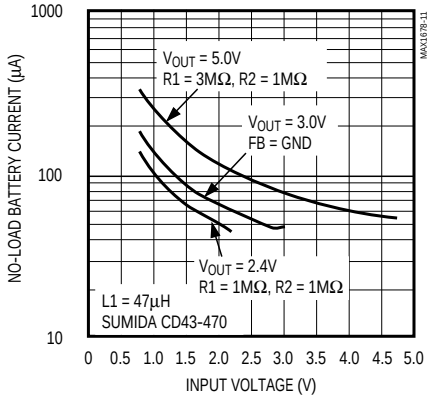
Typical Operating Characteristics (continued)

(Circuit of Figure 7 (Fixed Mode, 3.3V) or Figure 8 (Adjustable Mode), T_A = +25°C, unless otherwise noted.)

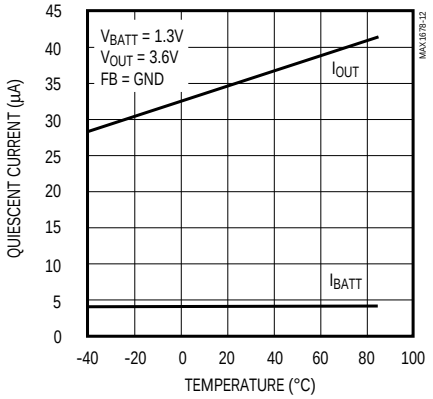
EFFICIENCY WITH DIFFERENT INDUCTORS



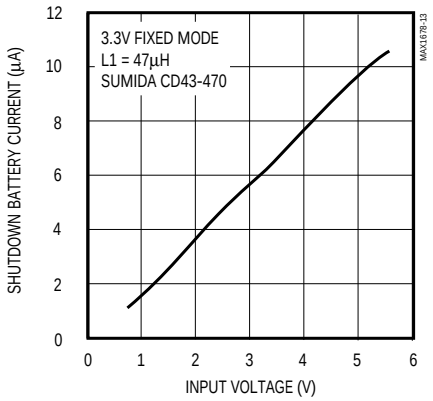
NO-LOAD BATTERY CURRENT vs. INPUT VOLTAGE



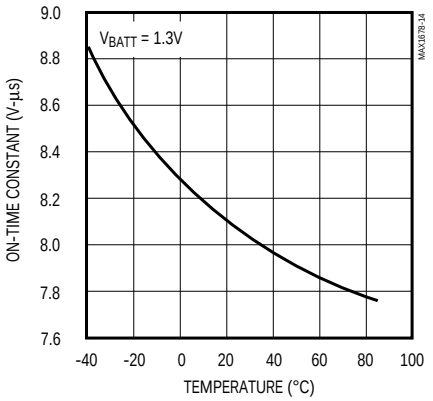
BATT AND OUT QUIESCENT CURRENT vs. TEMPERATURE



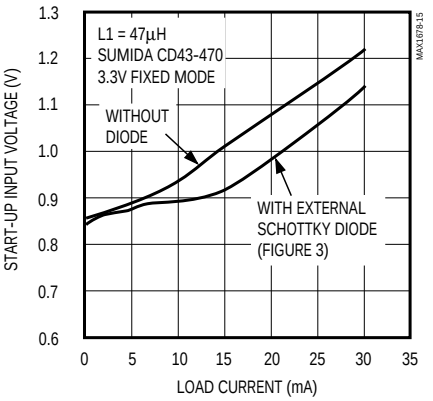
SHUTDOWN BATTERY CURRENT vs. INPUT VOLTAGE



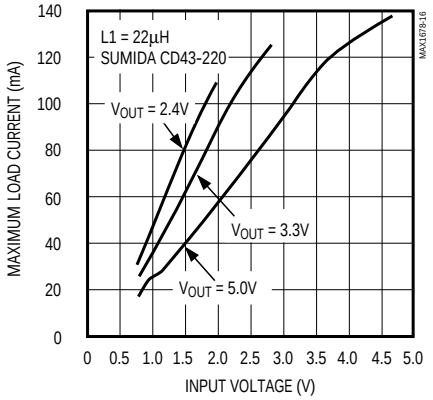
ON-TIME CONSTANT (K) vs. TEMPERATURE



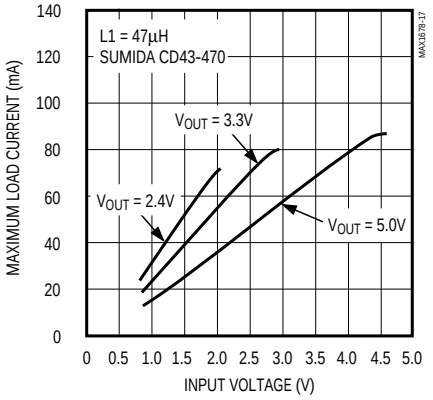
MINIMUM START-UP INPUT VOLTAGE vs. LOAD CURRENT



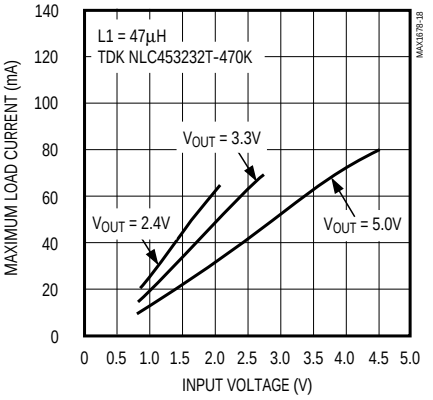
MAXIMUM LOAD CURRENT vs. INPUT VOLTAGE (L1 = 22µH)



MAXIMUM LOAD CURRENT vs. INPUT VOLTAGE (L1 = SUMIDA 47µH)



MAXIMUM LOAD CURRENT vs. INPUT VOLTAGE (L1 = TDK 47µH)

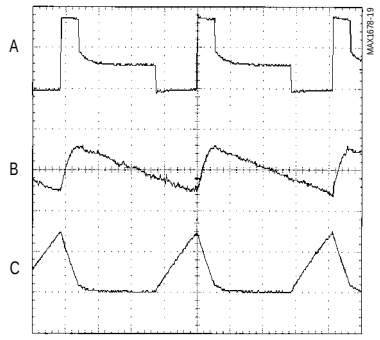


1-Cell to 2-Cell, Low-Noise, High-Efficiency, Step-Up DC-DC Converter

Typical Operating Characteristics (continued)

(Circuit of Figure 7 (Fixed Mode, 3.3V) or Figure 8 (Adjustable Mode), T_A = +25°C, unless otherwise noted.)

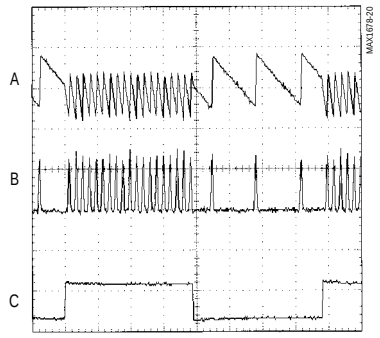
SWITCHING WAVEFORM



5µs/div

V_{OUT} = 3.3V, V_{BATT} = 1.2V, I_{LOAD} = 10mA, C_{OUT} = 10µF,
L1 = SUMIDA CD43-470
A: LX, 2V/div B: V_{OUT}, 50mV/div AC COUPLED
C: INDUCTOR CURRENT, 100mA/div

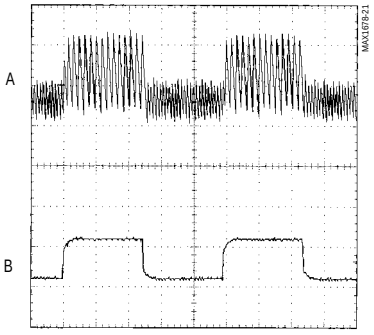
LOAD-TRANSIENT RESPONSE



100µs/div

V_{OUT} = 3.3V, V_{BATT} = 1.2V, C_{OUT} = 10µF,
L1 = SUMIDA CD43-470,
A: V_{OUT}, 50mV/div, AC COUPLED B: INDUCTOR CURRENT,
C: LOAD, 2mA to 12mA 100mA/div

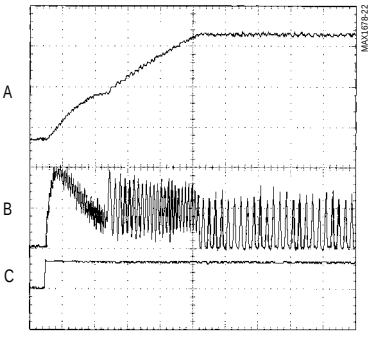
LINE-TRANSIENT RESPONSE



200µs/div

V_{OUT} = 3.3V, V_{BATT} = 1.2V, I_{LOAD} = 10mA, C_{OUT} = 10µF,
L1 = SUMIDA CD43-470
A: V_{OUT}, 50mV/div, AC COUPLED B: V_{IN}, 1V/div, 1.2V to 2.2V

POWER-UP RESPONSE



100µs/div

V_{OUT} = 3.3V, V_{BATT} = 1.2V, I_{LOAD} = 10mA, C_{OUT} = 10µF,
L1 = SUMIDA CD43-470
A: V_{OUT}, 1V/div B: INDUCTOR CURRENT, 100mA/div
C: $\overline{SHDN}$, 5V/div

Pin Description

PIN	NAME	FUNCTION
1	BATT	Battery-Power Input
2	PFI	Power-Fail Input. When the voltage at PFI is below 614mV, PFO sinks current.
3	PFO	Open-Drain Power-Fail Output. PFO sinks current when PFI is below 614mV.
4	$\overline{SHDN}$	Active-Low Shutdown. Connect $\overline{SHDN}$ to BATT for normal operation.
5	FB	Dual-Mode Feedback Input. Connect FB to GND for fixed-output operation (3.3V). Connect FB to a feedback-resistor network for adjustable output voltage operation (2V to 5.5V). FB regulates to 1.23V.
6	GND	Ground
7	LX	N-Channel MOSFET Switch Drain and P-Channel Synchronous-Rectifier Drain
8	OUT	Power Output and IC Power Input (bootstrapped). OUT is the feedback input for 3.3V operation. Connect the filter capacitor close to OUT.

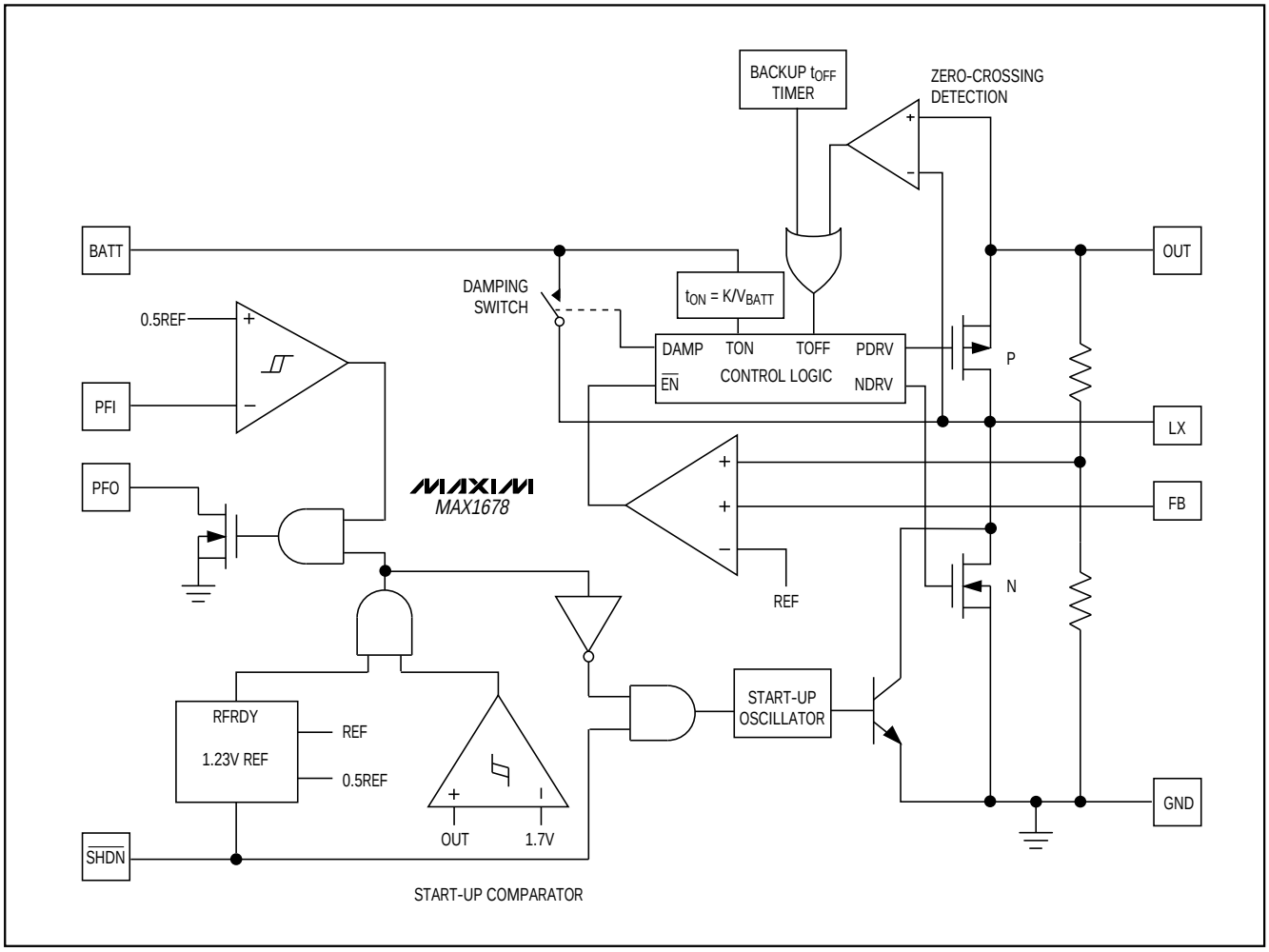


Figure 1. Functional Diagram

Detailed Description

The MAX1678 consists of an internal 1Ω, N-channel MOSFET power switch, a built-in synchronous rectifier that acts as the catch diode, a reference, PFM control circuitry, and an inductor damping switch (Figure 1).

The device is optimized for applications that are powered by 1 to 3-cell alkaline, NiMH, or NiCd batteries, or a 1-cell lithium battery such as pagers, remote controls, and battery-powered instruments. They are designed to meet the specific demands of the operating states characteristic of such systems:

1) *Primary battery is good and load is active:* In this state the load draws tens of milliamperes and the MAX1678 typically offers 80% to 90% efficiency.
2) *Primary battery is good and load is sleeping:* In this state the load draws hundreds of microamperes and the DC-DC converter IC draws very low quiescent current. Many applications maintain the load in this state most of the time.
3) *Primary battery is dead and DC-DC converter is shut down:* In this state the load is sleeping or supplied by the backup battery, and the MAX1678 draws 0.1µA current from the OUT pin.
4) *Primary and backup battery dead:* The DC-DC converter can restart from this condition.

1-Cell to 2-Cell, Low-Noise, High-Efficiency, Step-Up DC-DC Converter

Operating Principle

The MAX1678 employs a proprietary constant-peak-current control scheme that combines the ultra-low quiescent current of traditional pulse-skipping PFM converters with high-load efficiency.

When the error comparator detects that the output voltage is too low, it turns on the internal N-channel MOSFET switch for an internally calculated on-time (Figure 2). During the on-time, current ramps up in the inductor, storing energy in the magnetic field. When the MOSFET turns off during the second half of each cycle, the magnetic field collapses, causing the inductor voltage to force current through the synchronous rectifier, transferring the stored energy to the output filter capacitor and the load. The output filter capacitor stores charge while the current from the inductor is high, then holds up the output voltage until the second half of the next switching cycle, smoothing power flow to the load. The ideal on-time of the N-channel MOSFET changes as a function of input voltage. The on-time is determined as follows:

$$t_{ON} = \frac{K}{V_{BATT}}$$

where K is typically 8V-µs.

The peak inductor current (assuming a lossless circuit) can be calculated from the following equation:

$$I_{PEAK} = \frac{K}{L}$$

The P-channel MOSFET (synchronous rectifier) turns on when the N-channel MOSFET turns off. The circuit operates at the edge of discontinuous conduction; therefore, the P-channel synchronous rectifier turns off immediately after the inductor current ramps to zero. During the dead time after the P-switch has been turned off, the damping switch connects LX and BATT. This suppresses EMI noise due to LC ringing of the inductor and parasitic capacitance at the LX node (see *Damping Switch* section). The error comparator starts another cycle when V_{OUT} falls below the regulation threshold. With this control scheme, the MAX1678 maintains high efficiency over a wide range of loads and input/output voltages while minimizing switching noise.

Start-Up Operation

The MAX1678 contains a low-voltage start-up oscillator (Figure 1). This oscillator pumps up the output voltage to approximately 1.7V, the level at which the main DC-DC converter can operate. The 150kHz fixed-frequency oscillator is powered from the BATT input and drives an NPN switch. During start-up, the P-channel synchronous rectifier remains off and its body diode (or an external diode, if desired) is used as an output rectifier. The minimum start-up voltage is a function of load current (see *Typical Operating Characteristics*). In normal operation, when the voltage at the OUT pin exceeds 1.7V, the DC-DC converter is powered from the OUT pin (bootstrapped) and the main control circuitry is enabled.

Once started, the output can maintain the load as the battery voltage decreases below the start-up voltage. To improve start-up capability with heavy loads, add a Schottky diode in parallel with the P-channel synchronous rectifier (from LX to OUT) as shown in Figure 3 (see *Typical Operating Characteristics*).

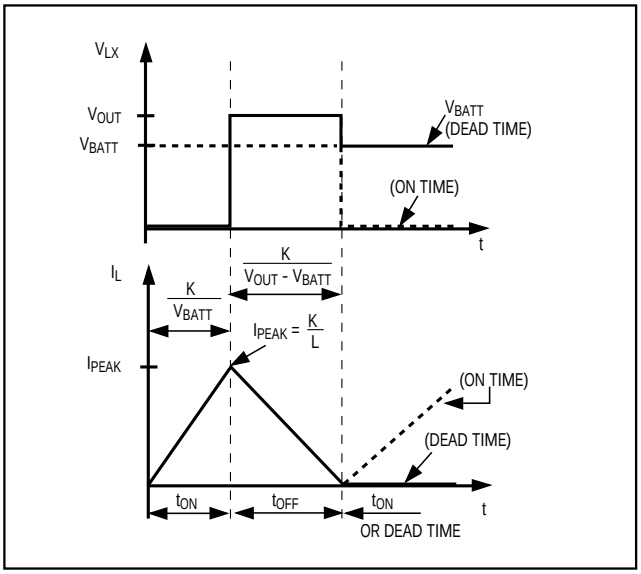


Figure 2. Switching Waveforms

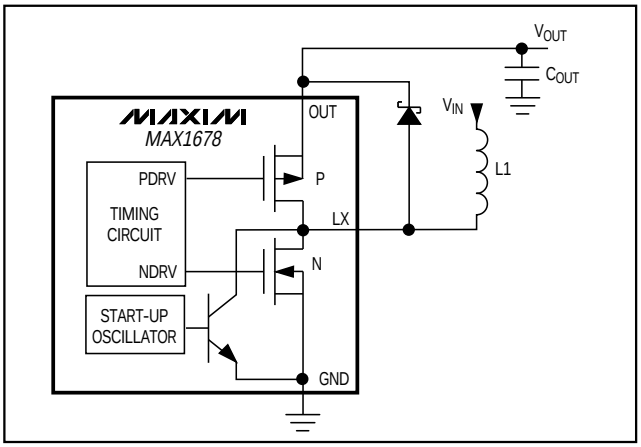


Figure 3. External Schottky Diode to Improve Start-Up with Heavy Load

Shutdown Mode

Pulling the $\overline{SHDN}$ pin low places the MAX1678 in shutdown mode (I_{SHDN} = 2µA typical). In shutdown, the internal switching MOSFET turns off, PFO goes high impedance, and the synchronous rectifier turns off to prevent the flow of reverse current from the output back to the input. However, there is still a forward current path through the synchronous-rectifier body diode from the input to the output. Thus, in shutdown, the output remains one diode drop below the battery voltage (V_{BATT}).

To disable the shutdown feature, connect $\overline{SHDN}$ (a logic input) to BATT or OUT.

Reverse-Battery Protection

The MAX1678 can sustain/survive battery reversal up to the package power-dissipation limit. An internal 5Ω resistor in series with a diode limits reverse current to less than 220mA, preventing damage. Prolonged operation above 220mA reverse-battery current can degrade the device's performance.

Power-Fail Comparator

The MAX1678 has an on-chip comparator for power-fail detection. This comparator can detect a loss of power at the input or output (Figures 7 and 8). If the voltage at the power-fail input (PFI) falls below 614mV, the PFO output sinks current to GND. Hysteresis at PFI is 2%. The power-fail monitor threshold is set by two resistors, R3 and R4, using the following equation:

$$R3 = R4 \times \left(\frac{V_{TH}}{V_{PFI}} - 1 \right)$$

where V_{TH} is the desired threshold of the power-fail detector, and V_{PFI} is the 614mV threshold of the power-fail comparator. Since PFI leakage is 10nA max, select feedback resistor R4 in the 100kΩ to 1MΩ range.

Damping Switch

The MAX1678 is designed with an internal damping switch to minimize ringing at the LX node. The damping switch (Figure 4) connects the LX node to BATT, effectively depleting the inductor's remaining energy. When the energy in the inductor is insufficient to supply current to the output, the capacitance and inductance at LX form a resonant circuit that causes ringing. The damping switch supplies a path to quickly dissipate this energy, suppressing the ringing at LX. This does not reduce the output ripple, but does reduce EMI. Figures 5 and 6 show the LX node voltage waveform without and with the damping switch.

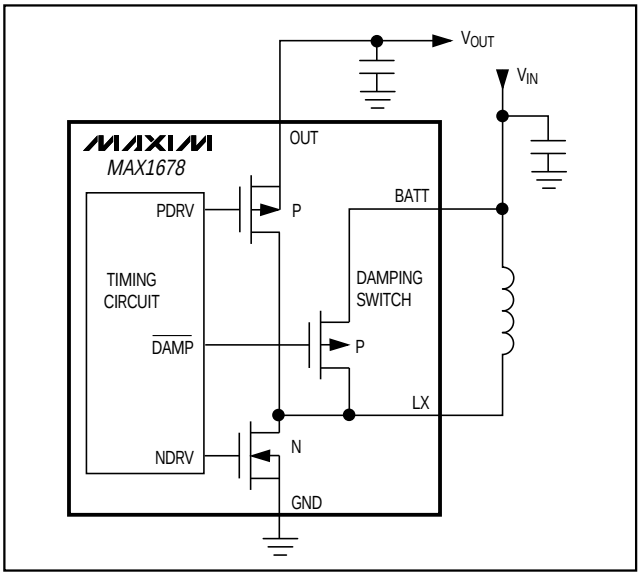


Figure 4. Simplified Diagram of Damping Switch

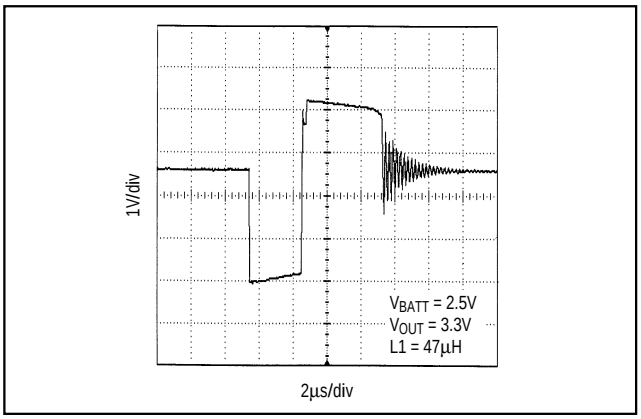


Figure 5. LX Ringing Without Damping Switch (example only)

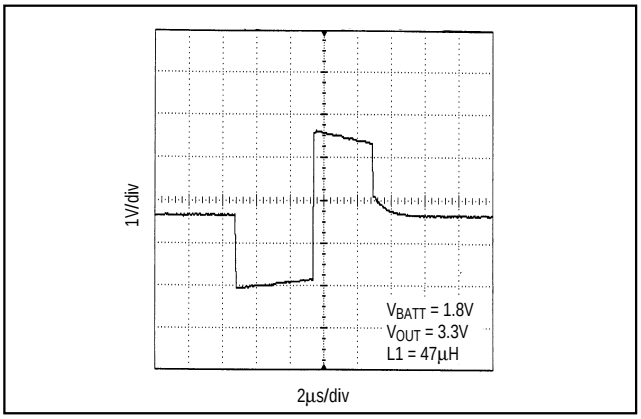


Figure 6. LX Ringing With Damping Switch

1-Cell to 2-Cell, Low-Noise, High-Efficiency, Step-Up DC-DC Converter

Applications Information

Output Voltage Selection

The MAX1678 operates with a fixed 3.3V or adjustable output. To select fixed-voltage operation, connect FB to GND (Figure 7). For an adjustable output between 2V and 5.5V, connect FB to a resistor voltage-divider between OUT and GND (Figure 8). FB regulates to 1.23V.

Since FB leakage is 10nA max, select feedback resistor R2 in the 100kΩ to 1MΩ range. R1 is given by:

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

where V_{REF} = 1.23V.

Maximum Output Current and Inductor Selection

The MAX1678 is designed to work well with a 47µH inductor in most low-power applications. 47µH is a sufficiently low value to allow the use of a small surface-mount coil, but large enough to maintain low ripple. The *Typical Operating Characteristics* section shows performance curves with several 47µH and 22µH coils. Low inductance values supply higher output current but also increase ripple and reduce efficiency. Note that values below 22µH are not recommended due to MAX1678 switch limitations. Higher inductor values reduce peak inductor current (and consequent ripple and noise) and improve efficiency, but also limit output current.

The relationship between current and inductor value is approximately:

$$I_{OUT(MAX)} = M \times \frac{1}{2} \times \frac{K}{L} \times \frac{V_{BATT}}{V_{OUT}}$$

where M is an empirical factor that takes into account losses in the MAX1678 internal switches and in the inductor resistance. K is the V-µs factor that governs the inductor charge time. Nominally, M = 0.9 and K = 8V-µs. M should be further reduced by 0.1 for each ohm of inductor resistance.

The inductor's saturation-current rating must exceed the worst-case peak current limit set by the MAX1678's timing algorithm:

$$I_{PEAK} = \frac{K_{MAX}}{L}$$

where K_{MAX} = 11.2V-µs. It is usually acceptable to exceed most coil saturation-current ratings by 20% with no ill effects; however, the maximum recommended I_{PEAK} for the MAX1678 internal switches is 550mA, so inductor values below 22µH are not recommended. For optimum efficiency, inductor series resistance should be less than 150mV/I_{PEAK}. Table 1 lists suggested inductors and suppliers.

Table 1. Suggested Inductors and Suppliers

PIN	INDUCTOR	PHONE
Coilcraft	DS1608C-223, DS1608C-473	(847) 639-6400
Murata	LQH4N470K, LQH3C470K	(814) 237-1431
Sumida	CD43-220, CD43-470	(847) 956-0666
TDK	NLC453232T-220K, NLC453232T-470K	(847) 390-4373

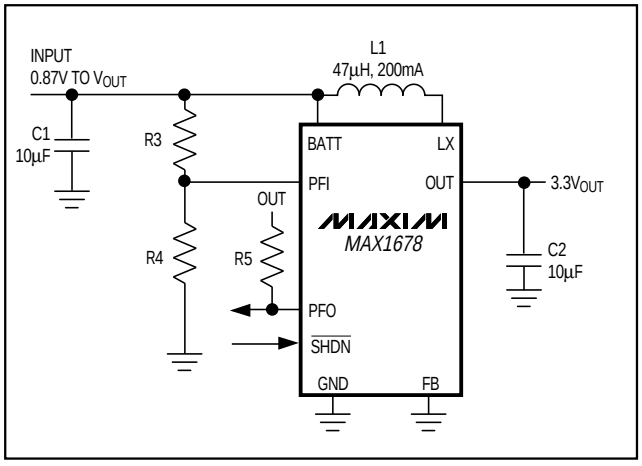


Figure 7. 3.3V Standard Application Circuit

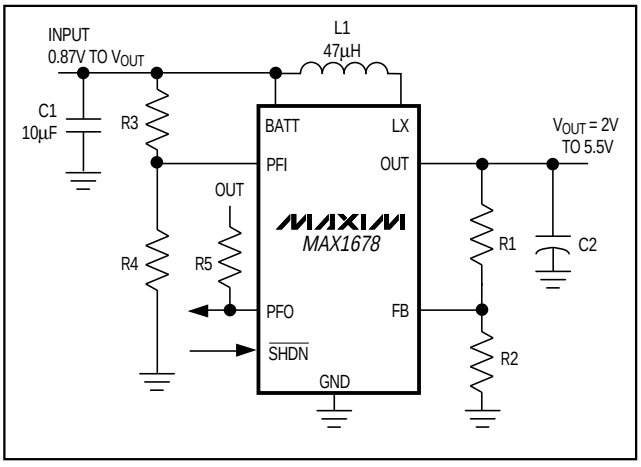


Figure 8. Adjustable Output Circuit

Capacitor Selection

Choose input and output capacitors to service input and output peak currents with acceptable voltage ripple. Capacitor ESR is a major contributor to output ripple (usually more than 60%). A 10µF, ceramic output filter capacitor typically provides 50mV output ripple when stepping up from 1.3V to 3.3V at 20mA. Low input to output voltage differences (i.e., 2 cells to 3.3V) require higher capacitor values (10µF to 47µF).

The input filter capacitor (C_{IN}) also reduces peak currents drawn from the battery and improves efficiency. Low-ESR capacitors are recommended. Ceramic capacitors have the lowest ESR, but low-ESR tantalums represent a good balance between cost and performance. Low-ESR aluminum electrolytic capacitors are tolerable, and standard aluminum electrolytic capacitors should be avoided. Capacitance and ESR variation over temperature need to be taken into consideration for best performance in applications with wide operating temperature ranges. Table 2 lists suggested capacitors and suppliers.

Minimizing Noise and Voltage Ripple

EMI and output voltage ripple can be minimized by following these simple design rules:

1) Place the DC-DC converter and digital circuitry on the opposite corner of the PC board from sensitive RF and analog input stages.
2) Use a closed-core inductor, such as toroid or shielded bobbin, to minimize fringe magnetic fields.
3) Choose the largest inductor value that satisfies the load requirement, to minimize peak switching current and the resulting ripple and noise.
4) Use low-ESR input and output filter capacitors.
5) Follow sound circuit-board layout and grounding rules (see the *PC Board Layout and Grounding* section).

PC Board Layout and Grounding

High switching frequencies and large peak currents make PC board layout an important part of design. Poor design can result in excessive EMI on the feedback paths and voltage gradients in the ground plane. Both of these factors can result in instability or regulation errors. The OUT pin must be bypassed directly to GND, as close to the IC as possible (within 0.2 inches or 5mm).

Place power components—such as the MAX1678, inductor, input filter capacitor, and output filter capacitor—as close together as possible. Keep their traces short, direct, and wide (≥50 mil or 1.25mm), and place their ground pins close together in a star-ground configuration. Keep the extra copper on the board and integrate it into ground as a pseudo-ground plane. On multilayer boards, route the star ground using component-side copper fill, then connect it to the internal ground plane using vias.

Place the external voltage-feedback network very close to the FB pin (within 0.2 inches or 5mm). Noisy traces, such as from the LX pin, should be kept away from the voltage-feedback network and separated from it using grounded copper. The MAX1678 evaluation kit manual shows an example PC board layout, which includes a pseudo-ground plane.

Table 2. Recommended Surface-Mount Capacitor Manufacturers

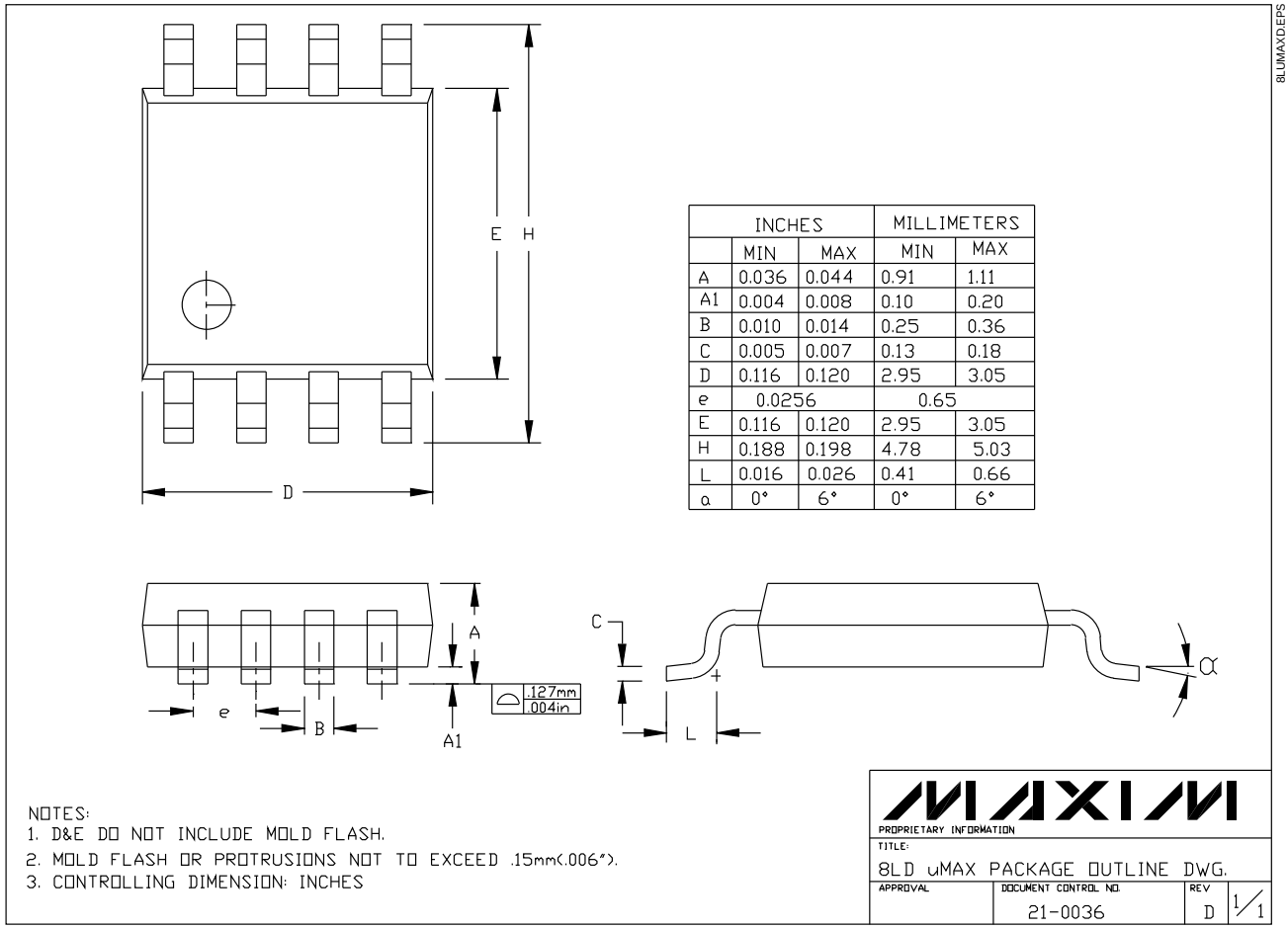
VALUE (µF)	DESCRIPTION	MANUFACTURER	PHONE
4.7 to 47	595D-series tantalum	Sprague	603-224-1961
	TAJ, TPS-series tantalum	AVX	803-946-0690
4.7 to 10	X7R ceramic	TDK	847-390-4373
		AVX	803-946-0690
4.7 to 22	X7R ceramic	Taiyo Yuden	408-573-4150

1-Cell to 2-Cell, Low-Noise, High-Efficiency, Step-Up DC-DC Converter

Chip Information

TRANSISTOR COUNT: 840

Package Information



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.036	0.044	0.91	1.11
A1	0.004	0.008	0.10	0.20
B	0.010	0.014	0.25	0.36
C	0.005	0.007	0.13	0.18
D	0.116	0.120	2.95	3.05
e	0.0256		0.65	
E	0.116	0.120	2.95	3.05
H	0.188	0.198	4.78	5.03
L	0.016	0.026	0.41	0.66
α	0°	6°	0°	6°

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm(.006").
3. CONTROLLING DIMENSION: INCHES

MAXIM
PROPRIETARY INFORMATION
TITLE: 8LD uMAX PACKAGE OUTLINE DWG.
APPROVAL | DOCUMENT CONTROL NO. 21-0036 | REV D | 1/1