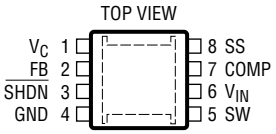
ABSOLUTE MAXIMUM RATINGS

(Note 1)

V_{IN} Voltage 16V
SW Voltage ..... –0.4V to 40V
FB, V_C, COMP, SS Voltages 6V
$\overline{SHDN}$ Voltage 16V
Current Into FB Pin ..... ±1mA
Maximum Junction Temperature ..... 125°C
Operating Temperature Range (Note 2) ... –40°C to 85°C
Storage Temperature Range ..... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) ..... 300°C

PACKAGE/ORDER INFORMATION



MS8E PACKAGE
8-LEAD PLASTIC MSOP

T_{JMAX} = 125°C, θ_{JA} = 40°C/W, θ_{JC} = 10°C/W
EXPOSED PAD (PIN 9) IS GND (MUST BE SOLDERED TO PCB)

ORDER PART NUMBER	MS8E PART MARKING
LT3489EMS8E	LTBYF

Order Options Tape and Reel: Add #TR
Lead Free: Add #PBF Lead Free Tape and Reel: Add #TRPBF
Lead Free Part Marking: http://www.linear.com/leadfree/

Consult LTC Marketing for parts specified with wider operating temperature ranges.

ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = 3V, $V_{\overline{SHDN}} = V_{IN}$ unless otherwise noted. (Note 2)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Minimum Operating Voltage				2.4	2.6	V
Maximum Operating Voltage					16	V
Feedback Voltage		 ●	1.22 1.21	1.235	1.26 1.26	V V
FB Pin Bias Current	V_{FB} = 1.25V (Note 3)	●		100	250	nA
Error Amp Transconductance	ΔI = 10μA			100		μmhos
Error Amp Voltage Gain				80		V/V
Quiescent Current	$V_{\overline{SHDN}}$ = 2.5V, Not Switching			2	4	mA
Quiescent Current in Shutdown	$V_{\overline{SHDN}}$ = 0V, V_{IN} = 3V			0	1	μA
Reference Line Regulation	2.6V ≤ V_{IN} ≤ 16V			0.01	0.05	%
Switching Frequency		●	1.8	2	2.2	MHz
Maximum Switch Duty Cycle		●	85	90		%
Switch Current Limit	(Note 4)	●	2.5	3.5	5	A
Switch V_{CESAT}	I_{SW} = 2A			0.23		V
Switch Leakage Current	V_{SW} = 5V			0.01	1	μA
$\overline{SHDN}$ Pin Current	$V_{\overline{SHDN}}$ = 5V $V_{\overline{SHDN}}$ = 1.4V $V_{\overline{SHDN}}$ = 0V			100 20 2		μA μA μA
$\overline{SHDN}$ Pin Threshold			0.3	1.5	2	V
Soft-Start Charging Current	V_{SS} = 0.5V		5	10	20	μA

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: The LT3489E is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the 40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

Note 3: Current flows out of the FB pin.

Note 4: Current limit guaranteed by design and/or correlation to static test. Current limit is independent of duty cycle and is guaranteed by design.

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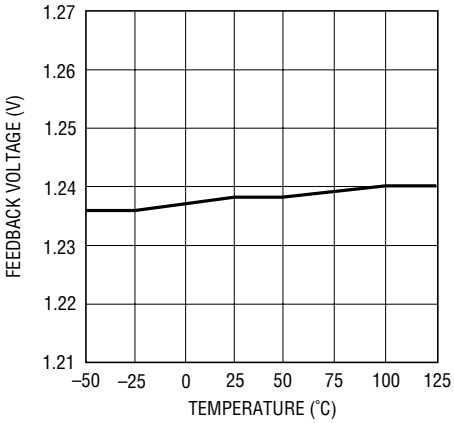
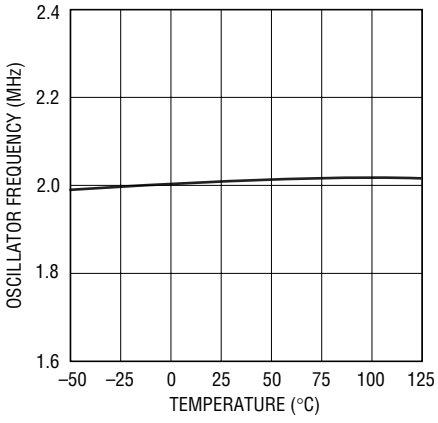
TYPICAL PERFORMANCE CHARACTERISTICS T_A = 25°C unless otherwise noted.

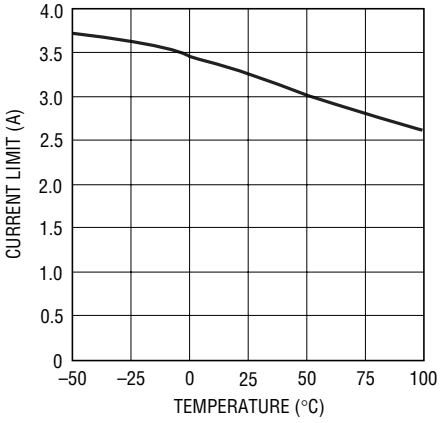
Feedback Pin Voltage



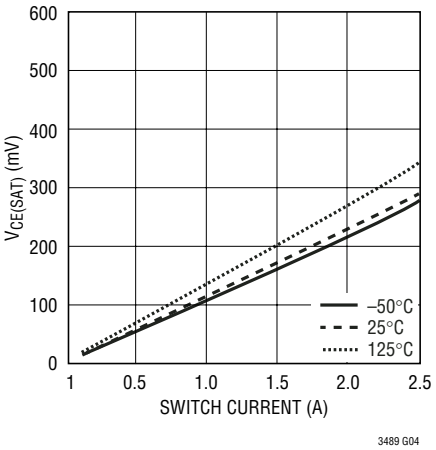
Oscillator Frequency



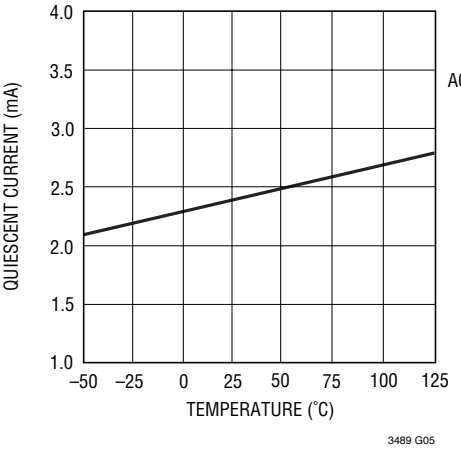
Current Limit



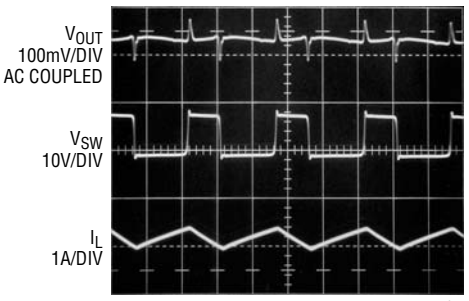
Switch $V_{CE(SAT)}$ Voltage



Quiescent Current



Switching Waveform for the Cover Page Circuit



V_{IN} = 3.3V 200ns/DIV
A_{VDD} = 8V
I_{LOAD}, A_{VDD} = 400mA
V_{ON} = 23V, 10mA
V_{OFF} = –8V, 20mA

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PIN FUNCTIONS

V_C (Pin 1): Error Amplifier Output Pin. Tie external compensation network to this pin, or use the internal compensation network by shorting the V_C pin to the COMP pin.

FB (Pin 2): Feedback Pin. Reference voltage is 1.235V. Connect resistive divider tap here. Minimize the trace area at FB. Set V_{OUT} according to $V_{OUT} = 1.235 \bullet (1 + R1/R2)$.

SHDN (Pin 3): Shutdown Pin. Tie to 2V or more to enable device. Ground to shut down. Do not float this pin.

GND (Pin 4): Ground. Tie directly to local ground plane.

SW (Pin 5): Switch Pin. This is the collector of the internal NPN power switch. Minimize the metal trace area connected to this pin to minimize EMI.

V_{IN} (Pin 6): Input Supply Pin. Must be locally bypassed.

COMP (Pin 7): Internal Compensation Pin. Provides an internal compensation network. Tie directly to the V_C pin for internal compensation. Tie to GND if not in use.

SS (Pin 8): Soft-Start Pin. Place a soft-start capacitor here. Upon start-up, 10µA of current charges the capacitor to 1.8V. Use a larger capacitor for slower start-up. Leave floating if not in use.

Exposed Pad (Pin 9): Ground. Must be soldered to PCB.

BLOCK DIAGRAM

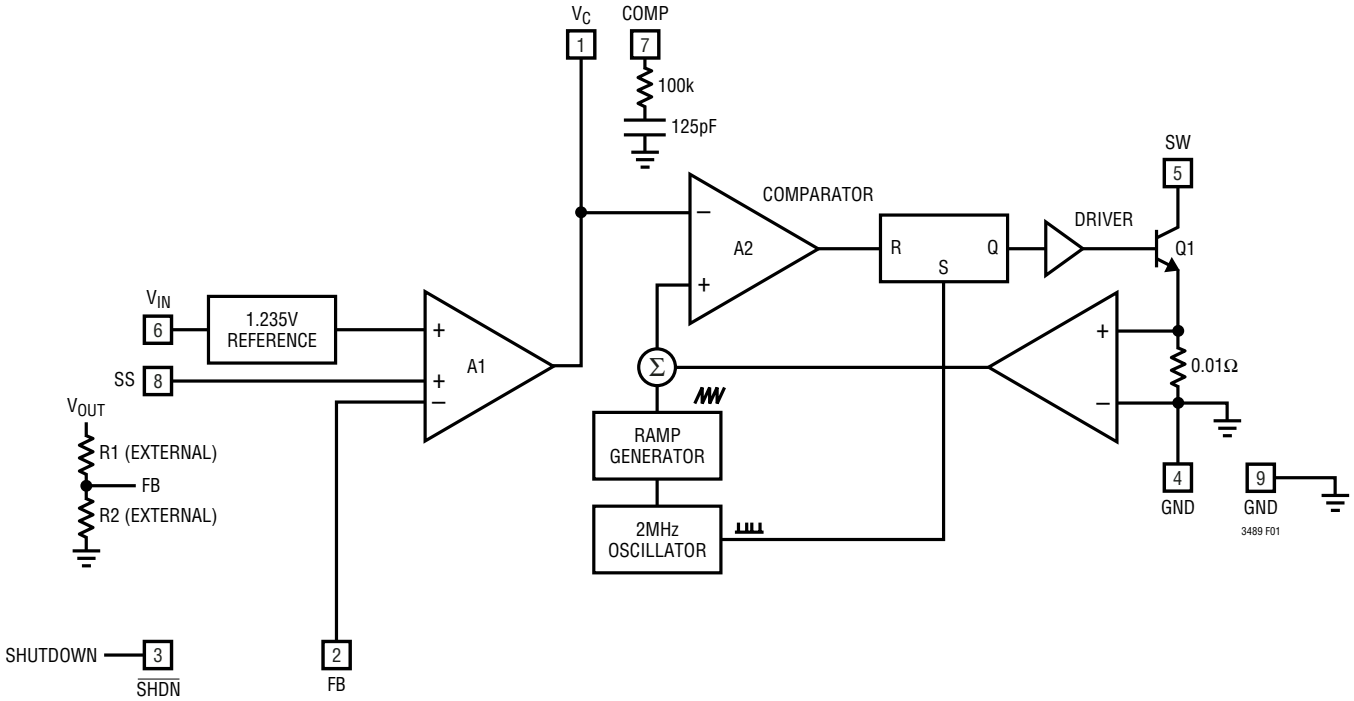

Figure 1. Block Diagram

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OPERATION

The LT3489 uses a constant frequency, current mode control scheme to provide excellent line and load regulation. Please refer to Figure 1 for the following description of the part's operation. At the start of the oscillator cycle, the SR latch is set, turning on the power switch, Q1. The switch current flows through the internal current sense resistor generating a voltage. This voltage is added to a stabilizing ramp and the resulting sum is fed into the positive terminal of the PWM comparator, A2. When this voltage exceeds the level at the negative input of A2, the SR latch is reset, turning off the power switch. The level at the negative input of A2 (V_C pin) is set by the error amplifier (g_m) and is simply an amplified version of the difference between the feedback voltage and the reference voltage of 1.235V. In this manner, the error amplifier sets the correct peak current level to keep the output in regulation.

A soft-start function is provided to enable a clean start-up for the LT3489. When the part is brought out of shutdown, 10µA of current is sourced out of the SS pin. By connecting an external capacitor to the SS pin, the rate of voltage rise on the pin can be set. Typical values for the soft-start capacitor range from 10nF to 200nF. The SS pin indirectly limits the rate of rise on the V_C pin, which in turn limits the peak switch current. Current limit is not shown in Figure 1. The switch current is constantly monitored and not allowed to exceed the nominal value of 2.5A. If the switch current reaches 2.5A, the SR latch is reset regardless of the output of comparator A2. This current limit helps protect the power switch as well as the external components connected to the LT3489.

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APPLICATIONS INFORMATION

Inductor Selection

Several inductors that work well with the LT3489 are listed in Table 1. This table is not exclusive; there are many other manufacturers and inductors that can be used. Consult each manufacturer for more detailed information and for their entire selection of related parts, as many different sizes and shapes are available. Ferrite core inductors should be used to obtain the best efficiency, as core losses at 2MHz are much lower for ferrite cores than for the cheaper powdered-iron ones. Choose an inductor that can handle at least 2.5A without saturating, and ensure that the inductor has a low DCR (copper wire resistance) to minimize I^2R power losses. A 2.2µH to 5µH inductor will be the best choice for most LT3489 designs. Note that in some applications, the current handling requirements of the inductor can be lower, such as in the SEPIC topology where each inductor only carries one-half of the total switch current. The inductors shown in Table 1 were chosen for small size. For better efficiency, use similar valued inductors with a larger volume.

Capacitor Selection

Low ESR (equivalent series resistance) capacitors should be used at the output to minimize the output ripple voltage. Multilayer ceramic capacitors are an excellent choice, as they have an extremely low ESR and are available in very small packages. X5R or X7R dielectrics are preferred, as these materials retain the capacitance over wide voltage and temperature ranges. A 4.7µF to 20µF output capacitor is sufficient for most applications, but systems with very low output currents may need only a 1µF or 2.2µF output capacitor. Solid tantalum or OS-CON capacitors can be used, but they will occupy more board area than a ceramic and will have a higher ESR. Always use a capacitor with a sufficient voltage rating.

Ceramic capacitors also make a good choice for the input decoupling capacitor, which should be placed as close as possible to the LT3489. A 2.2µF to 4.7µF input capacitor is sufficient for most applications. Table 2 shows a list of several ceramic capacitor manufacturers. Consult the manufacturers for detailed information on their entire selection of ceramic parts.

Table 1. Recommended Inductors

PART	L (µH)	TYPICAL DCR (mΩ)	SIZE L × W × H (mm)	VENDOR
SD25-2R2 SD25-3R3 SD25-4R7	2.2 3.3 4.7	31 38 47	5.45 × 5.45 × 2.7	CooperBussmann (888) 414-2645 www.cooperet.com
A916CY-2R7M A916CY-3R3M A916CY-4R7M	2.7 3.3 4.7	18.3 21.4 26.3	6 × 6 × 3.5	Toko www.toko.com
LQH55DN2R2M03 LQH55DN3R3M03 LQH55DN4R7M03	2.2 3.3 4.7	29 36 41	5.7 × 5 × 4.7	Murata (770) 436-1300 www.murata.com

Table 2. Ceramic Capacitor Manufacturers

Taiyo Yuden	(408) 573-4150 www.t-yuden.com
AVX	(843) 448-9411 www.avxcorp.com
Murata	(770) 436-1300 www.murata.com

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APPLICATIONS INFORMATION

Diode Selection

Schottky diodes, with their low forward voltage drop and fast switching speed, are ideal for LT3489 applications. Table 3 lists several Schottky diodes that work well with the LT3489. The diode's average current rating must exceed the average output current. The diode's maximum reverse voltage must exceed the output voltage. The diode conducts current only when the power switch is turned off (typically less than 50% duty cycle), so a 3A diode is sufficient for most designs. The companies below also offer Schottky diodes with high voltage and current ratings.

Table 3. Suggested Diodes

MANUFACTURER PART NUMBER	MAXIMUM CURRENT (A)	MAXIMUM REVERSE VOLTAGE (V)	MANUFACTURER
UPS340	3	40	Microsemi
UPS315	3	15	www.microsemi.com
B220	2	20	Diodes, Inc
B230	2	30	www.diodes.com
B240	2	40	
B320	3	20	
B330	3	30	
B340	3	40	
SBM340	3	40	

Frequency Compensation

To compensate the feedback loop of the LT3489, a series resistor-capacitor network should be connected from the COMP pin to GND. For most applications, a capacitor in the range of 220pF to 680pF will suffice. A good starting value for the compensation capacitor, C_C, is 470pF. The compensation resistor, R_C, is usually in the range of 20k to 100k. A thorough analysis of the switching regulator control loop is not within the scope of this data sheet and will not be presented here, but values of 20k and 680pF will be a good choice for many designs.

Setting Output Voltage

To set the output voltage, select the values of R1 and R2 (see Figure 1) according to the following equation:

$$R1 = R2 \bullet \left(\frac{V_{OUT}}{1.235V} - 1 \right)$$

A good range for R2 is from 5k to 30k.

Board Layout

The high speed operation of the LT3489 demands careful attention to board layout. For high-current switching regulators like the LT3489, the board layout must have good thermal performance. Vias located underneath the part should be connected to an internal ground plane to improve heat transfer from the LT3489 to the PCB board. You will not get advertised performance with careless layout. Thermal and noise consideration must be taken into account. Figure 2 shows the recommended component placement for a boost converter.

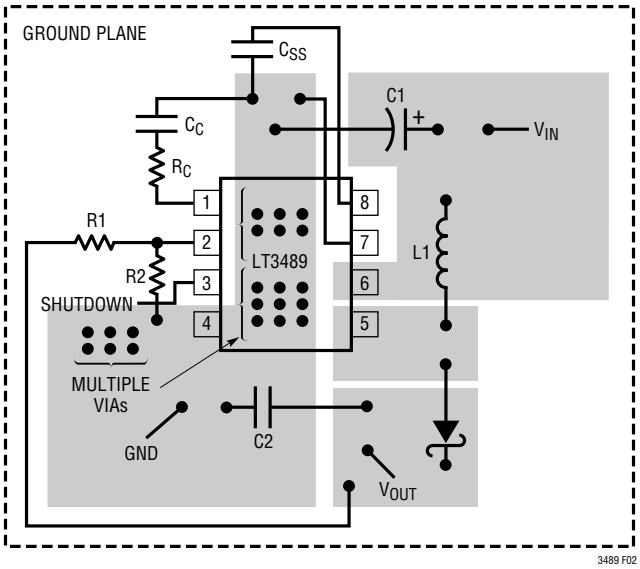

Figure 2. Recommended Component Placement for Boost Converter. Note Direct High Current Paths Using Wide PC Traces. Minimize Trace Area at Pin 1 (V_C) and Pin 2 (FB). Use Multiple Vias to Tie Pin 4 Copper to Ground Plane. Use Vias at One Location Only to Avoid Introducing Switching Currents Into the Ground Plane

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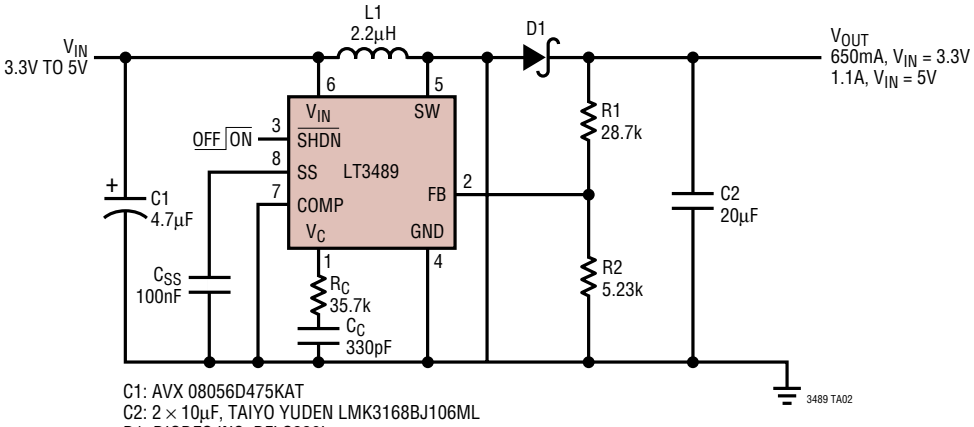
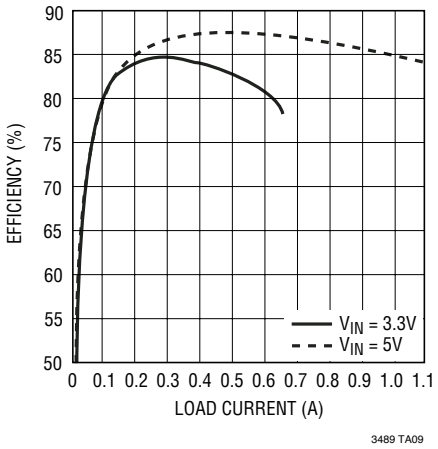
TYPICAL APPLICATIONS

8V Output Boost Converter

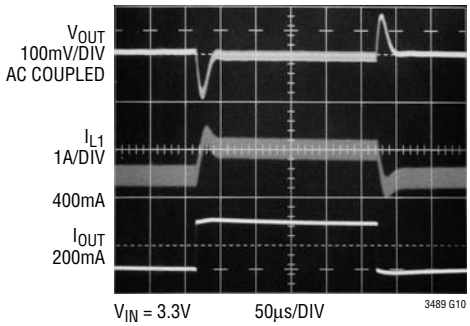


C1: AVX 08056D475KAT
C2: 2 × 10µF, TAIYO YUDEN LMK3168BJ106ML
D1: DIODES INC. DFLS220L
L1: COOPER BUSSMANN SD25-2R2
*EXPOSED PAD MUST ALSO BE GROUNDED

Efficiency



Transient Response



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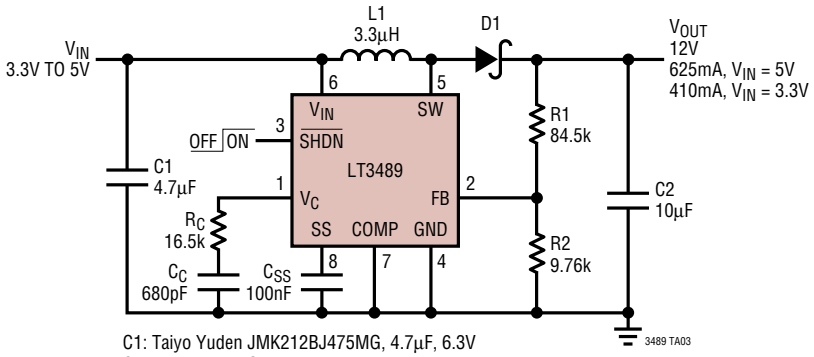
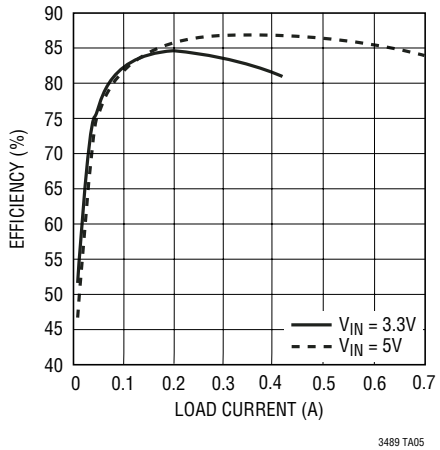
TYPICAL APPLICATIONS

12V Output Boost Converter

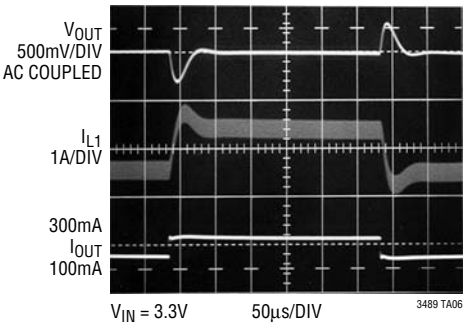


C1: Taiyo Yuden JMK212BJ475MG, 4.7µF, 6.3V
C2: Taiyo Yuden GMK316BJ106ML, 10µF, 35V
D1: Diodes, Inc. DFLS220
L1: Toko A916CY-3R3M (Type D63CB)

Efficiency



Transient Response



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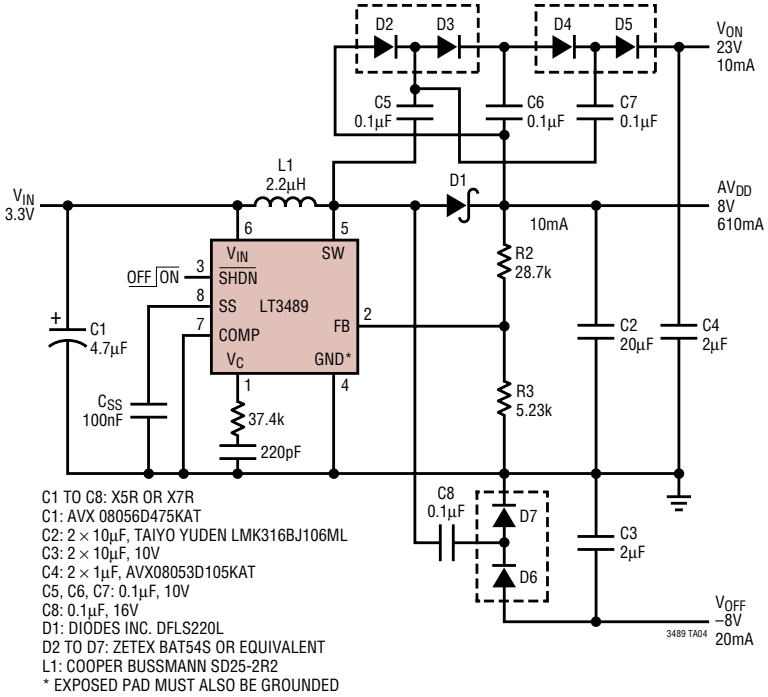
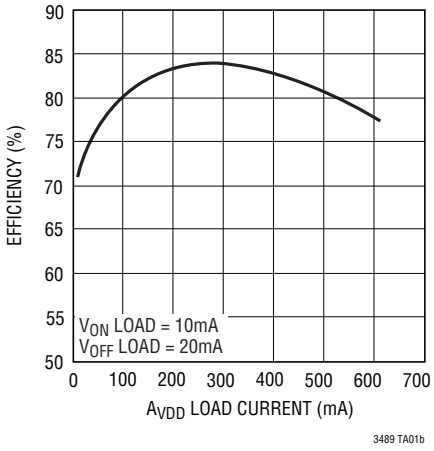
TYPICAL APPLICATION

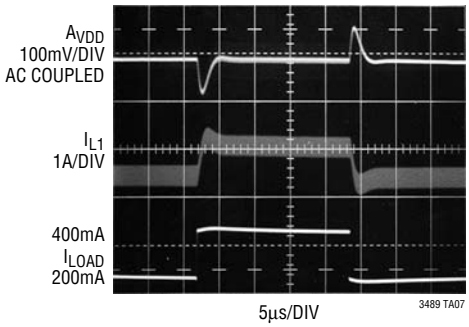


C1 TO C8: X5R OR X7R
C1: AVX 08056D475KAT
C2: 2 × 10µF, TAIYO YUDEN LMK316BJ106ML
C3: 2 × 10µF, 10V
C4: 2 × 1µF, AVX08053D105KAT
C5, C6, C7: 0.1µF, 10V
C8: 0.1µF, 16V
D1: DIODES INC. DFLS220L
D2 TO D7: ZETEX BAT54S OR EQUIVALENT
L1: COOPER BUSSMANN SD25-2R2
* EXPOSED PAD MUST ALSO BE GROUNDED

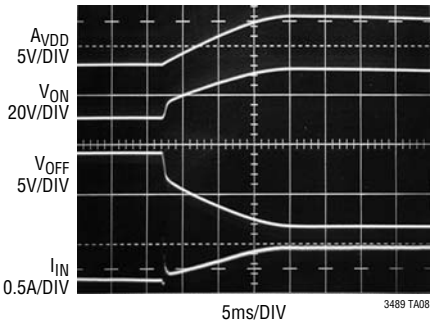
Effciency



Transient Response



Start-Up Waveforms



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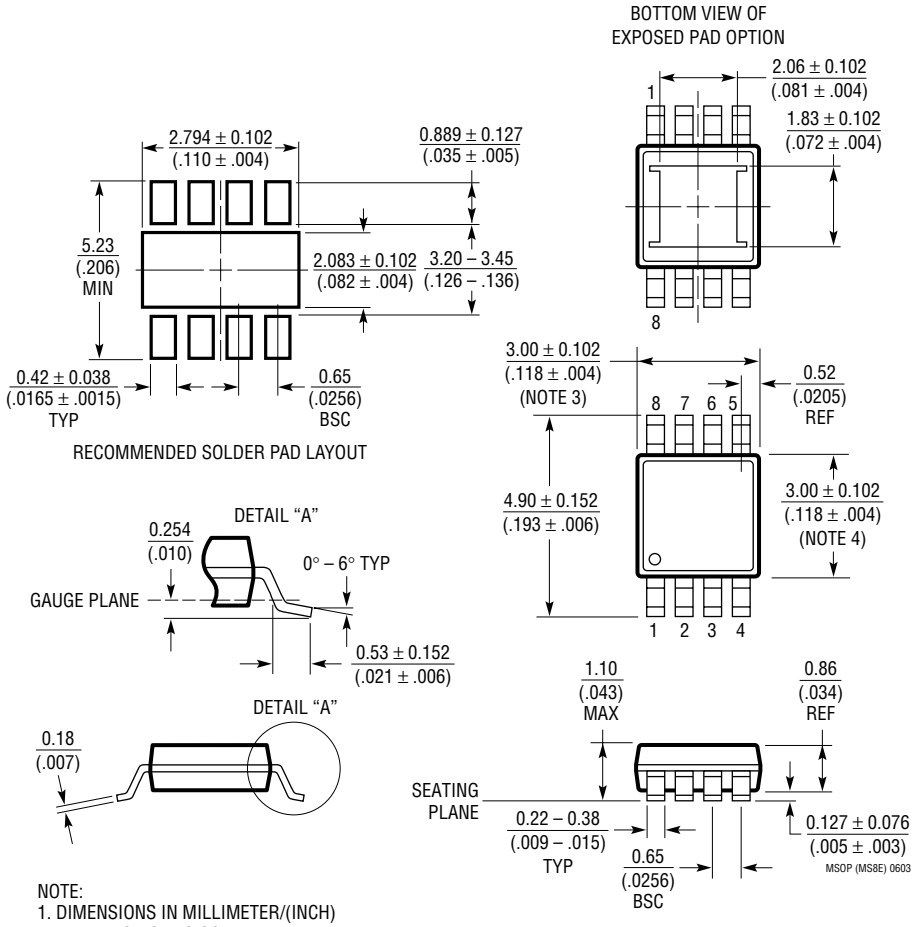
PACKAGE DESCRIPTION

MS8E Package
8-Lead Plastic MSOP
(Reference LTC DWG # 05-08-1662)



NOTE:
1. DIMENSIONS IN MILLIMETER/(INCH)
2. DRAWING NOT TO SCALE
3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
   MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
   INTERLEAD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
5. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.102mm (.004") MAX

Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of its circuits as described herein will not infringe on existing patent rights.

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RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1613	550mA (I_{SW}), 1.4MHz, High Efficiency Step-Up DC/DC Converter	V_{IN}: 0.9V to 10V, $V_{OUT(MAX)}$ = 34V, I_Q = 3mA, I_{SD} = <1μA, ThinSOT™ Package
LT1615/LT1615-1	300mA/80mA (I_{SW}), High Efficiency Step-Up DC/DC Converters	V_{IN}: 1V to 15V, $V_{OUT(MAX)}$ = 34V, I_Q = 20μA, I_{SD} = <1μA, ThinSOT Package
LT1618	1.5A (I_{SW}), 1.25MHz, High Efficiency Step-Up DC/DC Converter	V_{IN}: 1.6V to 18V, $V_{OUT(MAX)}$ = 35V, I_Q = 1.8mA, I_{SD} = <1μA, MS Package
LT1930/LT1930A	1A (I_{SW}), 1.2MHz/2.2MHz, High Efficiency Step-Up DC/DC Converters	V_{IN}: 2.6V to 16V, $V_{OUT(MAX)}$ = 34V, I_Q = 4.2mA/5.5mA, I_{SD} = <1μA, ThinSOT Package
LT1935	2A (I_{SW}), 1.2MHz/2.7MHz, High Efficiency Step-Up DC/DC Converter	V_{IN}: 2.3V to 16V, $V_{OUT(MAX)}$ = 38V, I_Q = 3mA, I_{SD} = <1μA, ThinSOT Package
LT1946/LT1946A	1.5A (I_{SW}), 1.2MHz, High Efficiency Step-Up DC/DC Converters	V_{IN}: 2.45V to 16V, $V_{OUT(MAX)}$ = 34V, I_Q = 3.2mA, I_{SD} = <1μA, MS8 Package
LT1961	1.5A (I_{SW}), 1.25MHz, High Efficiency Step-Up DC/DC Converter	V_{IN}: 3V to 25V, $V_{OUT(MAX)}$ = 35V, I_Q = 0.9mA, I_{SD} = 6μA, MS8E Package
LT3436	3A (I_{SW}), 1MHz, 34V Step-Up DC/DC Converter	V_{IN}: 3V to 25V, $V_{OUT(MAX)}$ = 34V, I_Q = 0.9mA, I_{SD} = <6μA, TSSOP-16E Package
LT3464	85mA (I_{SW}), High Efficiency Step-Up DC/DC Converter with Integrated Schottky and PNP Disconnect	V_{IN}: 2.3V to 10V, $V_{OUT(MAX)}$ = 34V, I_Q = 25μA, I_{SD} = <1μA, ThinSOT Package
LT3467/LT3467A	1.1A (I_{SW}), 1.3MHz/2.7MHz, High Efficiency Step-Up DC/DC Converters	V_{IN}: 2.6V to 16V, $V_{OUT(MAX)}$ = 40V, I_Q = 1.2mA, I_{SD} = <1μA, ThinSOT Package
LT3477	3A (I_{SW}), 3.5MHz, High Efficiency Step-Up DC/DC Converter with Dual Rail-to-Rail Current Sense	V_{IN}: 2.5V to 24V, $V_{OUT(MAX)}$ = 40V, I_Q = 5mA, I_{SD} = <1μA, QFN, TSSOP-20E Packages
LT3479	3A (I_{SW}), 3.5MHz, High Efficiency Step-Up DC/DC Converter	V_{IN}: 2.5V to 24V, $V_{OUT(MAX)}$ = 40V, I_Q = 5mA, I_{SD} = <1μA, DFN. TSSOP-16E Packages

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