



# 1.5A Boost DC/DC Converter with Phase-Locked Loop

December 2001

## FEATURES

- Synchronizable or Constant Frequency Low Noise Output
- Synchronizable Up to 4.5MHz
- Wide Input Voltage Range: 2.8V to 18V
- Low Profile Surface Mount Solution (All Ceramic Capacitors)
- Low  $V_{CESAT}$  Switch: 240mV at 1A
- Adjustable Output from  $V_{IN}$  to 35V
- Small Thermally Enhanced 10-Lead MSOP Package

## APPLICATIONS

- Instruments
- Avionics
- Data Acquisition
- Communications
- Imaging
- Ultrasound

## DESCRIPTION

The LT<sup>®</sup>1310 boost DC/DC converter combines a 1.5A current mode PWM switcher with an integrated phase-lock loop, allowing the user to set the switching frequency anywhere from 10kHz to 4.5MHz. Intended for use in applications where switching frequency must be accurately controlled, the LT1310 can generate 12V at up to 400mA from a 5V input.

Switching frequency is set with an external capacitor, and the device can be operated in either free-running or phase-locked mode. A wide capture range of nearly 2:1 allows the free-running frequency to be set using standard 10% tolerance NPO dielectric capacitors.

The LT1310 is available in the tiny thermally enhanced 10-lead MSOP package.

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## TYPICAL APPLICATION

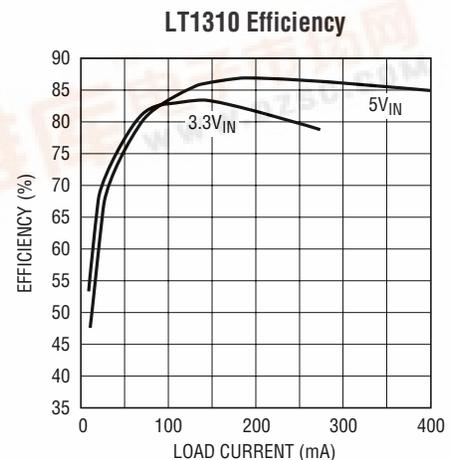
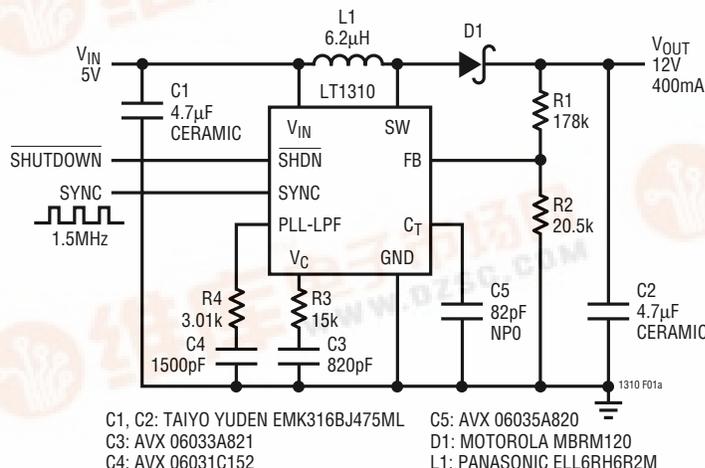


Figure 1. 5V to 12V Converter Synchronized at 1.5MHz

1310 F01b



# LT1310

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

$V_{IN}$ .....	18V
$\overline{SHDN}$ .....	18V
SYNC .....	18V
FB .....	5V
$C_T$ .....	5V
$V_C$ .....	2V
PLL-LPF .....	2V
SW .....	36V
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

<p>MSE EXPOSED PAD PACKAGE 10-LEAD PLASTIC MSOP</p> <p><math>T_{JMAX} = 125^{\circ}\text{C}</math>, <math>\theta_{JA} = 40^{\circ}\text{C/W}</math> EXPOSED PAD IS GROUND (MUST BE SOLDERED TO PCB)</p>	ORDER PART NUMBER
	LT1310EMSE
	MSE PART MARKING
	LTRZ

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

## ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^{\circ}\text{C}$ .  $V_{IN} = 3.3\text{V}$ ,  $V_{\overline{SHDN}} = 3.3\text{V}$ , unless otherwise noted. (Note 2)

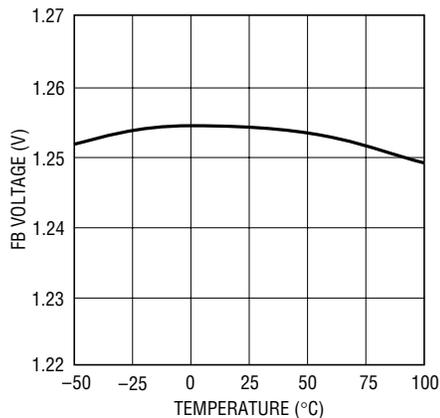
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Undervoltage Lockout				2.8	V
Maximum Input Voltage				18	V
Feedback Voltage		● 1.242 1.236	1.255	1.268 1.268	V V
FB Pin Bias Current			60	150	nA
Reference Line Regulation	$V_{IN} = 2.9\text{V}$ to $18\text{V}$		0.01	0.05	%/V
Error Amplifier Transconductance	$\Delta I = 5\mu\text{A}$		350		$\mu\text{A/V}$
Error Amplifier Voltage Gain			200		V/V
SW Current Limit		1.5	2.1	2.8	A
SW Saturation Voltage	$I_{SW} = 1\text{A}$		0.240	0.320	V
SW Maximum Duty Cycle	$C_T = 220\text{pF}$ $C_T = 47\text{pF}$	80 78	84 83		% %
SW Minimum On Time	$I_{SW} = 150\text{mA}$ , $V_C = 0.25\text{V}$		70		ns
VCO Frequency	$C_T = 220\text{pF}$ , PLL-LPF = High $C_T = 220\text{pF}$ , PLL-LPF = High $C_T = 220\text{pF}$ , PLL-LPF = Low $C_T = 47\text{pF}$ , PLL-LPF = High	● 0.950 0.800	1.10	1.25 1.30 500 3.3	MHz MHz kHz Mhz
Frequency Foldback	$C_T = 220\text{pF}$ , PLL-LPF = High, FB = 0V		200		kHz
PLL Lock Range	$C_T = 220\text{pF}$ , Maximum $C_T = 220\text{pF}$ , Minimum (Percent Change from Max)	0.950 -40	1.10 -50	1.25	MHz %
Supply Current	$\overline{SHDN} = \text{High}$ $\overline{SHDN} = \text{Low}$		11.5	15 1	mA $\mu\text{A}$
SW Leakage Current	Switch Off, SW = 3.3V		0.1	5	$\mu\text{A}$
$\overline{SHDN}$ Pin Bias Current	$V_{\overline{SHDN}} = 2.4\text{V}$		35	65	$\mu\text{A}$
$\overline{SHDN}$ Pin High	Active Mode	2.4			V
$\overline{SHDN}$ Pin Low	Shutdown Mode			0.4	V

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** The LT1310E 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.

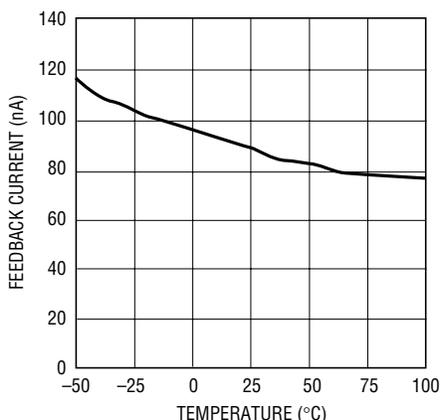
# TYPICAL PERFORMANCE CHARACTERISTICS

**Feedback Voltage**



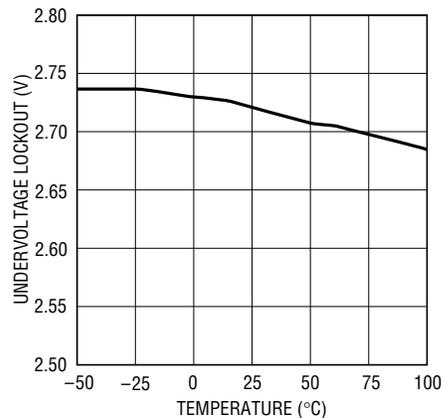
1310 G01

**Feedback Pin Current**



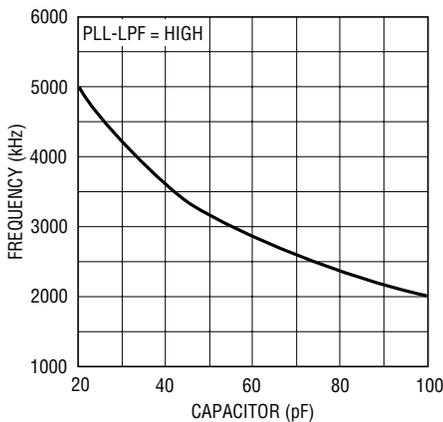
1310 G02

**Undervoltage Lockout**



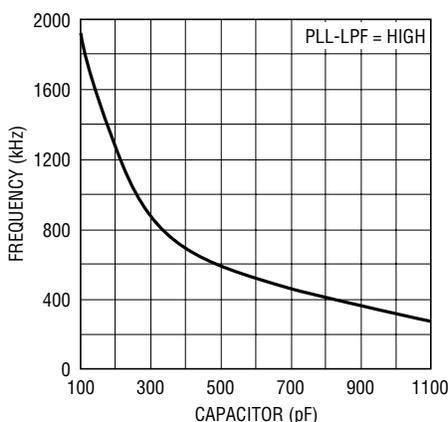
1310 G03

**Oscillator Frequency vs  $C_T$  Capacitor**



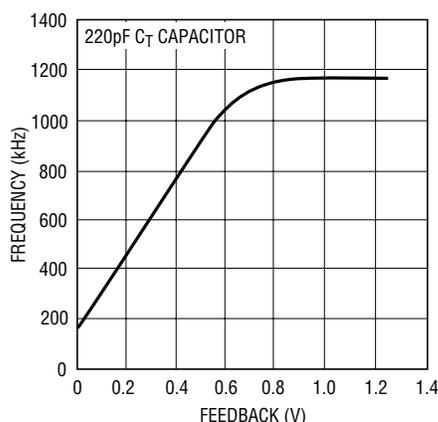
LT1372 • G10

**Oscillator Frequency vs  $C_T$  Capacitor**



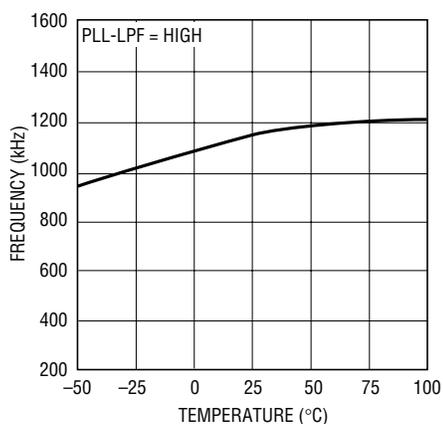
1310 G05

**Oscillator Frequency vs Feedback Voltage**



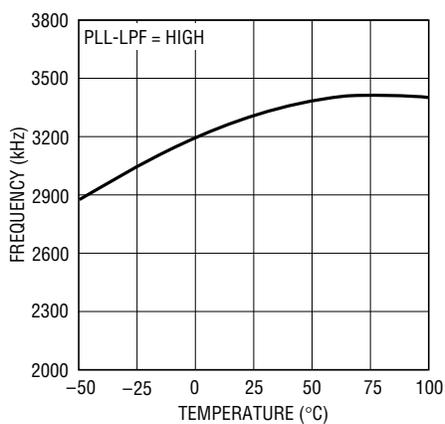
1310 G06

**Oscillator Frequency 220pF Capacitor on  $C_T$  Pin**



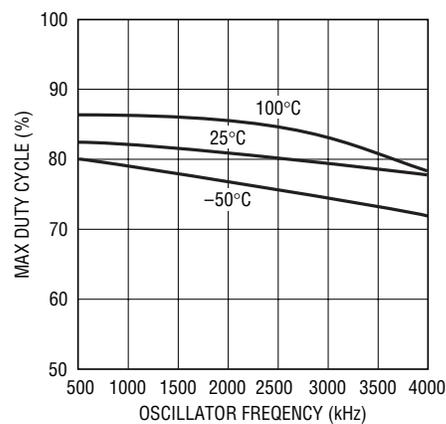
1310 G07

**Oscillator Frequency 47pF Capacitor on  $C_T$  Pin**



1310 G08

**Maximum Duty Cycle vs Oscillator Frequency**

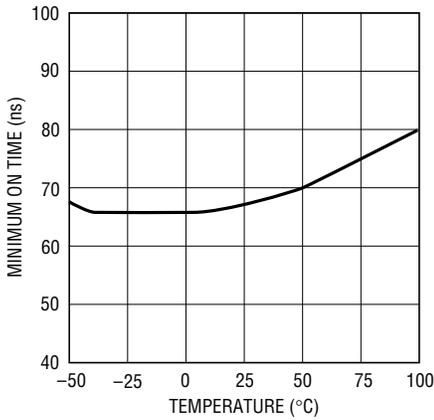


1310 G09

# LT1310

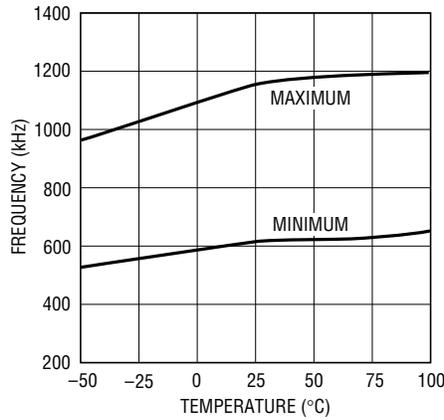
## TYPICAL PERFORMANCE CHARACTERISTICS

Switch Minimum On Time



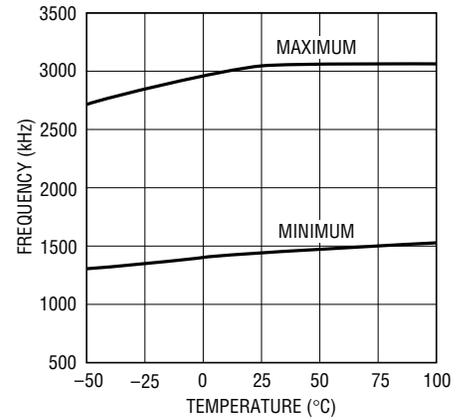
1310 G10

PLL Lock Range  
220pF Capacitor on C<sub>T</sub> Pin



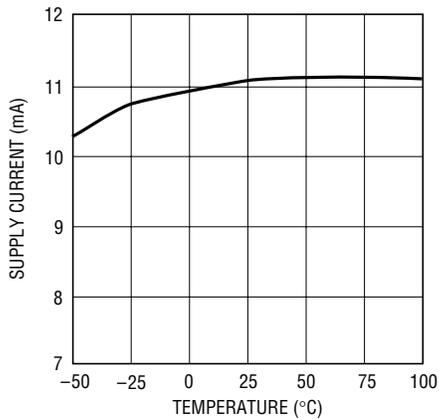
1310 G11

PLL Lock Range  
47pF Capacitor on C<sub>T</sub> Pin



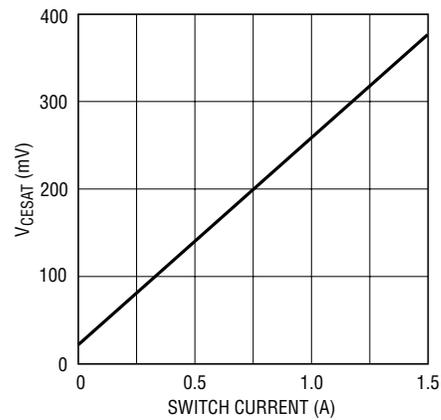
1310 G12

Supply Current



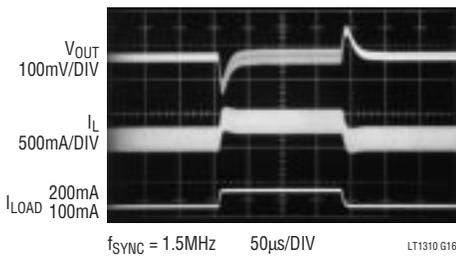
1310 G13

Switch V<sub>CE(SAT)</sub>



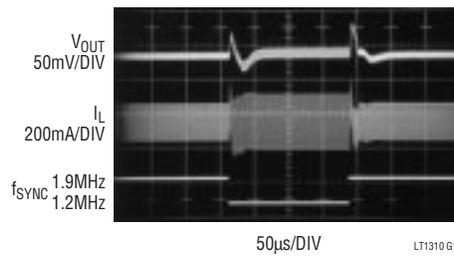
1310 G15

Transient Response



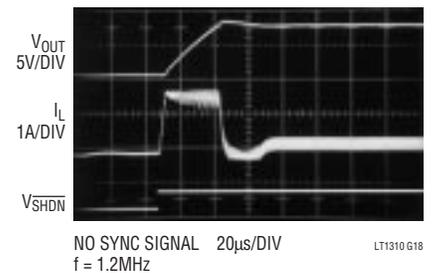
LT1310 G16

PLL Response



LT1310 G17

Start-Up Response



LT1310 G18



# LT1310

## OPERATION

To understand operation, refer to the Block Diagram. The LT1310 contains a boost switching regulator that can be phase locked to an external synchronizing signal. The boost regulator uses current mode control and contains a 1.5A NPN power transistor. This type of control uses two feedback loops. The main control loop sets output voltage and operates as follows: a load step causes  $V_{OUT}$  and the FB voltage to be slightly perturbed. The error amplifier A1 responds to this change in FB by driving the  $V_C$  pin either higher or lower. Because switch current is proportional to the  $V_C$  pin voltage, this change causes the switch current to be adjusted until  $V_{OUT}$  is once again satisfied. Loop compensation is taken care of by an RC network from the  $V_C$  pin to ground. Inside this main loop is another that sets current limit on a cycle-by-cycle basis. This loop utilizes current comparator A2 to control peak current. The oscillator issues a set pulse to the flip-flop at the beginning of each cycle, turning the switch on. With the switch now in the ON state, the SW pin is effectively connected to ground. Current ramps up in the inductor linearly at a rate of  $V_{IN}/L$ . Switch current is set by the  $V_C$  pin voltage and when the voltage across  $R_{SENSE}$  trips the current comparator, a reset pulse will be generated and the switch will be turned off. Since the inductor is now loaded up with current, the SW pin will fly high until it is clamped by the catch diode, D1. Current will flow through the diode decreasing at a rate of  $(V_{OUT} - V_{IN})/L$  until the oscillator issues a new set pulse, causing the cycle to repeat.

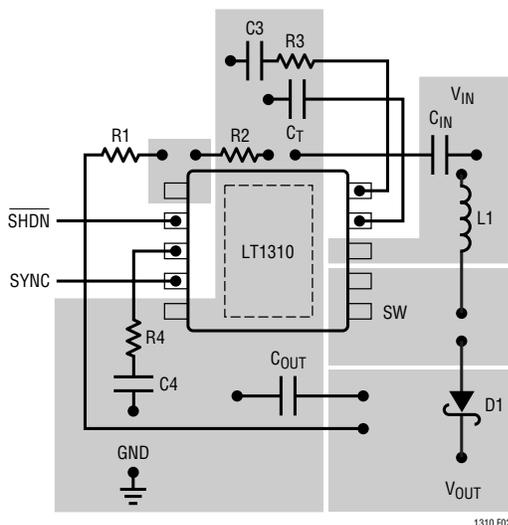


Figure 2. Suggested Layout

The LT1310 is phase lockable up to 4.5MHz, giving the user precise control over switching frequency. The phase detector compares the incoming sync signal to the internal oscillator signal. If the switching frequency is lower than the sync signal, or if the phase lags the sync signal, then the phase detector output will source current into the PLL-LPF pin, driving it higher. The PLL-LPF pin is also the input to the voltage controlled oscillator. If the sync signal is slower than the switching frequency, the PLL-LPF pin will sink current until the PLL-LPF pin voltage drops. When locked, the PLL-LPF pin rests at a voltage between 0V and 1.3V. The PLL-LPF pin is capable of sinking or sourcing approximately 30 $\mu$ A.

### $C_T$ Selection for Operating Frequency

The LT1310's internal voltage controlled oscillator frequency range is set by an external timing capacitor,  $C_T$ . A graph for selecting  $C_T$  vs operating frequency is shown in Figure 3. The VCO frequency is proportional to the PLL-LPF pin voltage with maximum frequency corresponding to maximum PLL-LPF pin voltage. For Figure 2, the PLL-LPF pin is pulled high with a 10k resistor to  $V_{IN}$ .

When using Figure 3's graph for synchronizable applications, choose  $C_T$  according to a frequency value approximately 33% above your center frequency. For this case, the PLL-LPF pin will be driven by the internal phase detector and should be connected only to the RC filter shown in Figure 1.

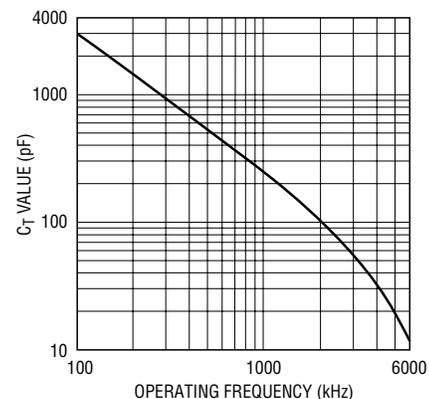
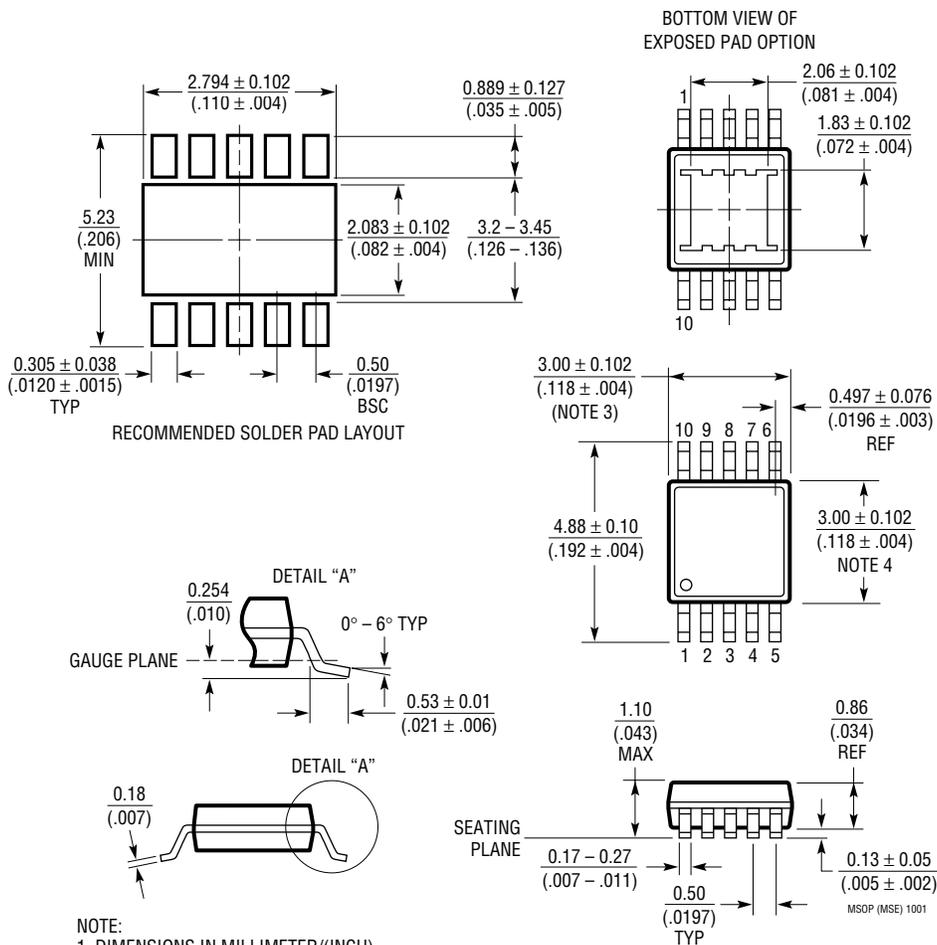


Figure 3.  $C_T$  vs Operating Frequency

# PACKAGE DESCRIPTION

**MSE Package**  
**10-Lead Plastic MSOP**  
 (Reference LTC DWG # 05-08-1663)

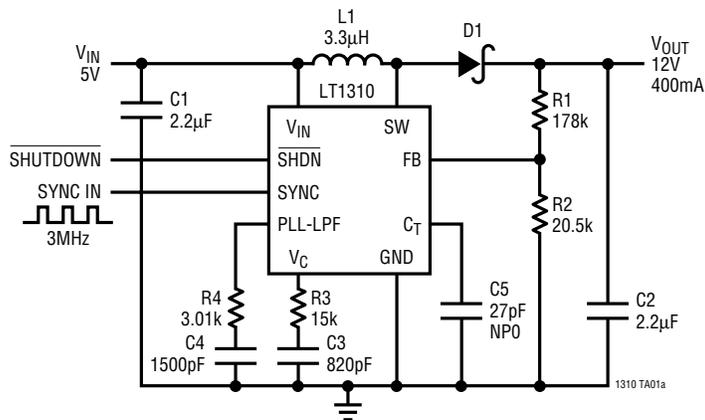


- NOTE:
1. DIMENSIONS IN MILLIMETER/(INCH)
  2. DRAWING NOT TO SCALE
  3. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.  
 MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.152mm (.006") PER SIDE
  4. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.  
 INTERLEAD FLASH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

# LT1310

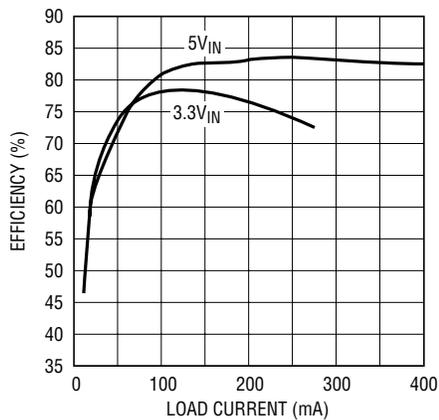
## TYPICAL APPLICATION

3MHz 5V to 12V Converter



C1, C2: TAIYO YUDEN LMK212BJ225MG  
 D1: MOTOROLA MBRM120  
 L1: PANASONIC ELL6RH3R3M

Efficiency



1310 TA01b

## RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1767	Monolithic 1.5A, 1.25MHz Step-Down Switching Regulator	V <sub>IN</sub> : 3V to 25V, Current Mode, 8-Lead MSOP
LT1930	1A, 1.2MHz/2.2MHz Step-Up DC/DC Converters in ThinSOT™	12V at 300mA from 5V Input, ThinSOT Package
LT1946	1.2MHz Boost DC/DC Converter with 1.5A Switch and Soft-Start	8V at 430mA from 3.3V Input, 8-Lead MSOP Package
LTC3402	2A, 3MHz Micropower Synchronous Boost Converter	97% Efficiency, 10-Lead MSOP Package

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