

# High Efficiency Synchronous Step-Down Regulator with Ultralow Quiescent Current

## DESCRIPTION

Demonstration circuit DC2005A is a synchronous step-down regulator using an [LTC<sup>®</sup>3624](#) monolithic buck regulator. The DC2005A operates from an input voltage range of 2.7V to 17V and provides an adjustable output voltage range from 1.2V to 5V ( $V_{OUT} < V_{IN}$ ) at 2A of output current. A user-selectable mode input is provided to allow the user to trade off ripple noise for light load efficiency.

Burst Mode<sup>®</sup> operation provides the highest efficiency at light load, while pulse-skipping mode provides the lowest voltage ripple. The MODE pin can also be used to sync the switching frequency to an external clock.

The switching frequency is fixed at 1MHz or 2.25MHz with a  $\pm 40\%$  synchronizing range. The regulator features ultralow quiescent current and high efficiency over a wide  $V_{OUT}$  range.

The DC2005A uses very low profile surface mount components and all ceramic output capacitors. The compact 8-lead DFN (3mm  $\times$  3mm) package makes the LTC3624 an excellent choice for battery-powered equipment, general purpose step-down power supply, and emergency radio applications.

It is recommended to read the data sheet and demo manual of the LTC3624 prior using or making any changes to DC2005A.

**Design files for this circuit board are available at <http://www.linear.com/demo>**

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## PERFORMANCE SUMMARY Specifications are at $T_A = 25^\circ\text{C}$

PARAMETER	CONDITIONS	VALUE
Input Voltage Range		2.7V to 17V
Onboard User Selectable Output Voltages	$V_{IN} = 2.7\text{V to } 17\text{V}, I_{OUT} = 2\text{A} (V_{OUT} \leq V_{IN})$	1.2V, 1.8V, 2.5V, 3.3V and 5V
Default Mode Setting	JP2	Burst Mode Operation (BM)
Default Switching Frequency		1MHz
Default Output Voltage, $V_{OUT}$	$V_{IN} = 12\text{V}, V_{OUT} = 5\text{V}, I_{OUT} = 0\text{A to } 2\text{A}$	$5\text{V} \pm 2\%$
Maximum Continuous Output Current, $I_{OUT}$		2A
Output Voltage Ripples (Peak-to-Peak)	$V_{IN} = 12\text{V}, V_{OUT} = 5\text{V}, I_{OUT} = 2\text{A}$	9.4mV (See Figure 5)
Load Transient Response	$V_{IN} = 12\text{V}, V_{OUT} = 5\text{V}, I_{OUT} = 1\text{A to } 2\text{A}$	See Figure 6
Thermal Image	$V_{IN} = 12\text{V}, V_{OUT} = 5\text{V}, I_{OUT} = 2\text{A}, 1\text{MHz}$	See Figure 7
Efficiency	$V_{IN} = 12\text{V}, V_{OUT} = 5\text{V}, I_{OUT} = 2\text{A}, \text{BM}, 1\text{MHz}$	90.4% (See Figure 3)

## QUICK START PROCEDURE

Demonstration circuit DC2005A is easy to set up to evaluate the performance of the LTC3624. Please refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

1. Place jumpers in the following positions for a typical 5V output application:

**Table 1. Typical 5V Output Voltage Jumper Selection**

JP1	JP2	JP7
RUN	MODE/SYNC	VOUT
ON	BM	5.0V

2. With power off, connect the input power supply at VIN (E1) and GND (E2).
3. Connect the load between VOUT (E8) and GND (E9). Preset the load to 0A.
4. Connect the DMMs to the input and output to monitor the input voltage and output voltage.
5. Turn on the power supply at the input. The RUN pin jumper should be at ON position. Measure and make sure the input supply voltage is 12V. The output voltage should be 5V  $\pm$ 2%.
6. Once the input and output voltages are properly established adjust the loads within the operating range (0A to 2A max) and observe the output voltage regulation, output ripple voltage, switch node waveform and other parameters. Refer to Figure 2 for proper input/output voltage ripple measurement.

7. To select other output voltages, use the on board user selectable output voltage jumpers. Shutting down LTC3624 by placing RUN pin jumper (JP1) to the OFF position or turn off the input power supply. Refer to the following table (Table 2) for the output voltage selection and repeat steps 2 to 6:

**Table 2. Output Voltage Jumper Selection**

JP3	JP4	JP5	JP6	JP7	JP8
1.2V	1.8V	2.5V	3.3V	5V	*User Select

\* Note: If JP8 is selected, R6 needs to be calculated and inserted to obtain the desired output voltage.

**Note 1:** To measure the input/output voltage ripple properly, do not use the long ground lead on the oscilloscope probe. See Figure 2 for the proper scope probe technique. Short, stiff leads need to be soldered to the (+) and (-) terminals of an output capacitor. The probe's ground ring needs to touch the (-) lead and the probe tip needs to touch the (+) lead.

**Note 2:** The DC2005A can also be used to evaluate LTC3624-2 (2.25MHz) by simply changing U1 to LTC3624-2 and L1 to 1.5 $\mu$ H (Coilcraft XAL4020-152ME).

**QUICK START PROCEDURE**

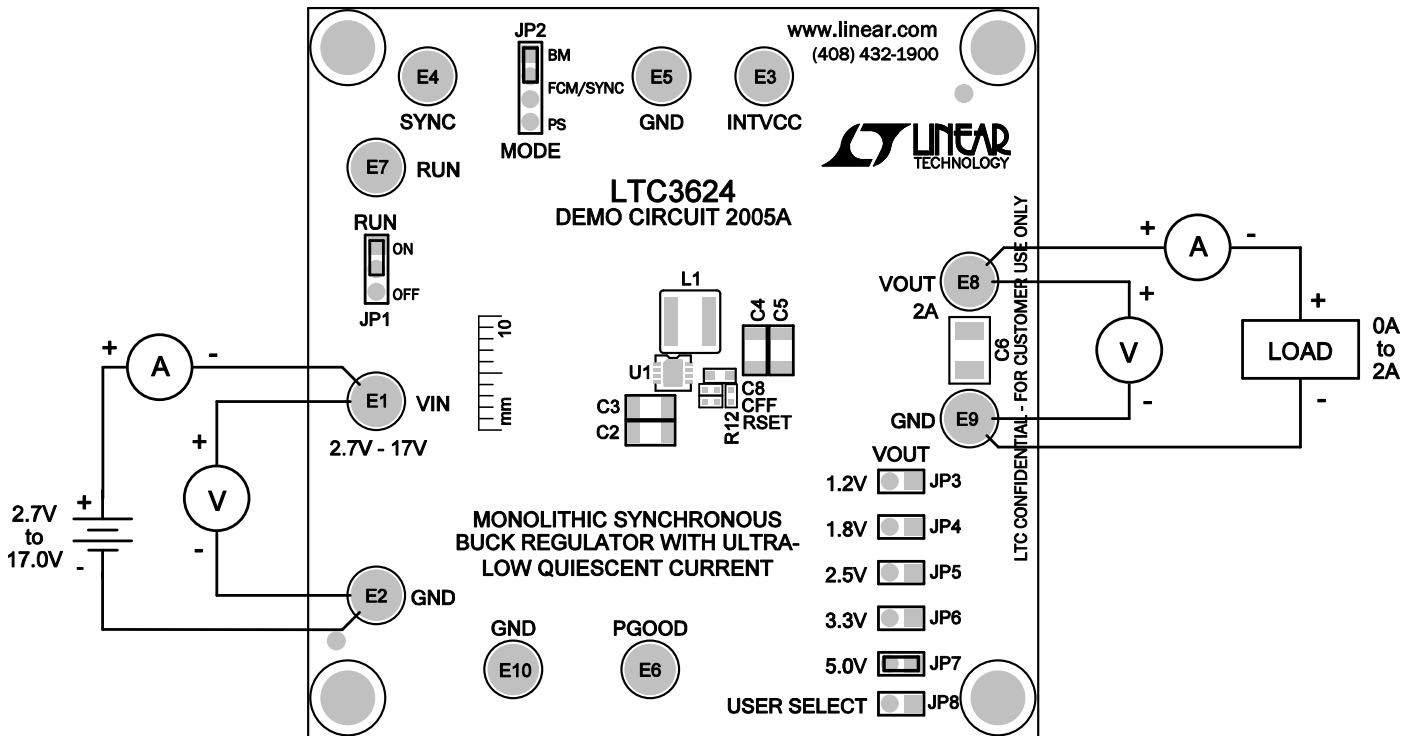


Figure 1. Proper Equipment Measurement Setup

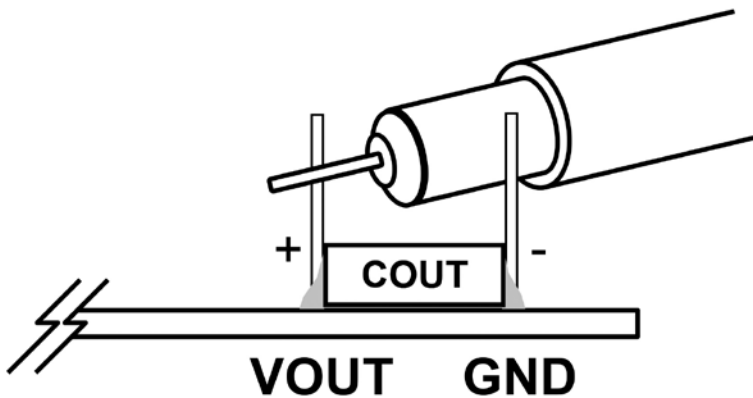


Figure 2. Scope Probe Placements for Measuring Input or Output Ripple

## QUICK START PROCEDURE

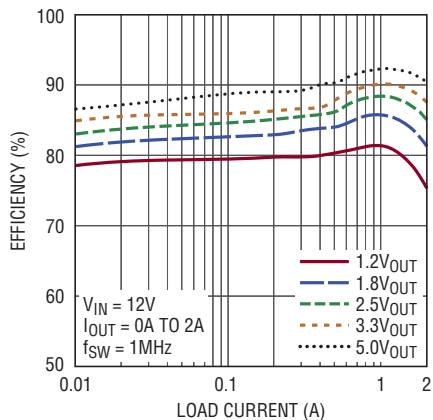


Figure 3. Measured Efficiency in Burst Mode Operation (BM)

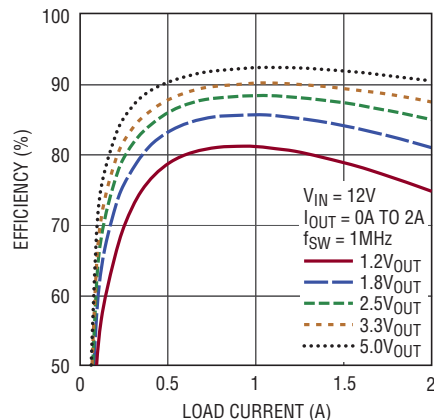


Figure 4. Measured Efficiency in Forced Continuous Mode (FCM)

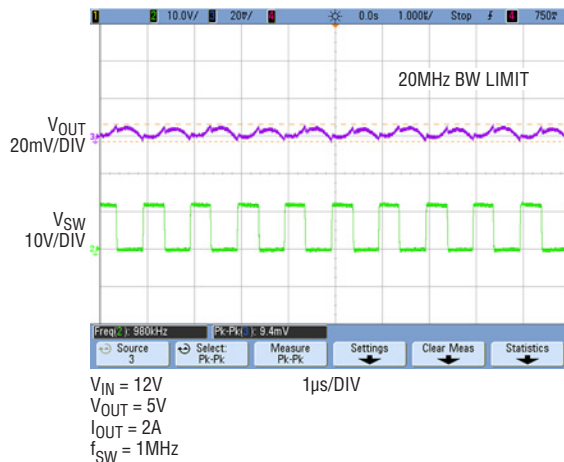


Figure 5. Measured Output Voltage Ripple

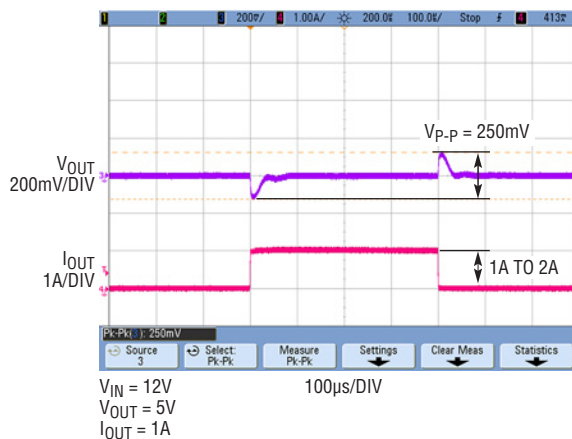
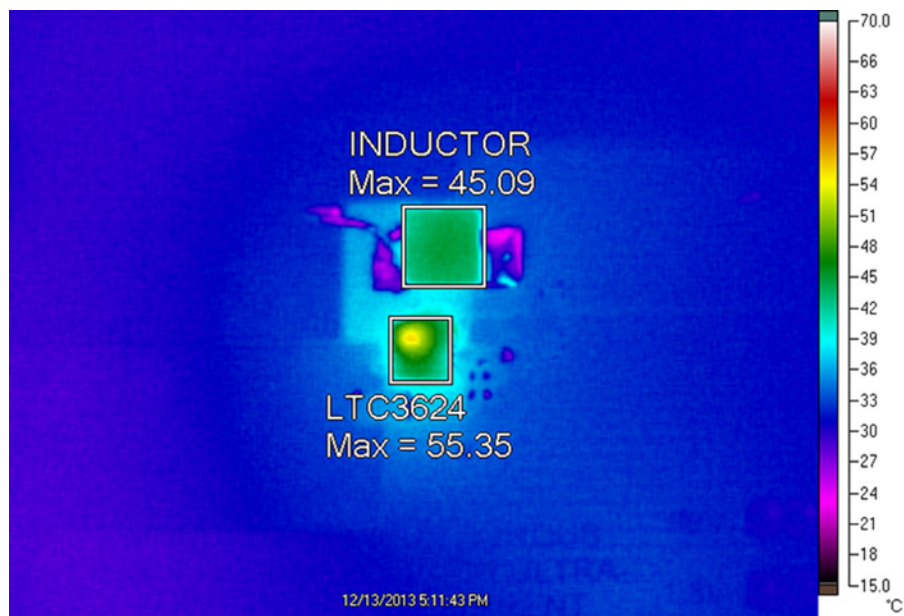


Figure 6. Load Transient Response

**QUICK START PROCEDURE**



NO FORCED AIRFLOW  
 $T_A = 24^\circ\text{C}$   
 $V_{IN} = 12\text{V}$   
 $V_{OUT} = 5\text{V}$   
 $I_{OUT} = 2\text{A}$   
 $f_{sw} = 1\text{MHz}$

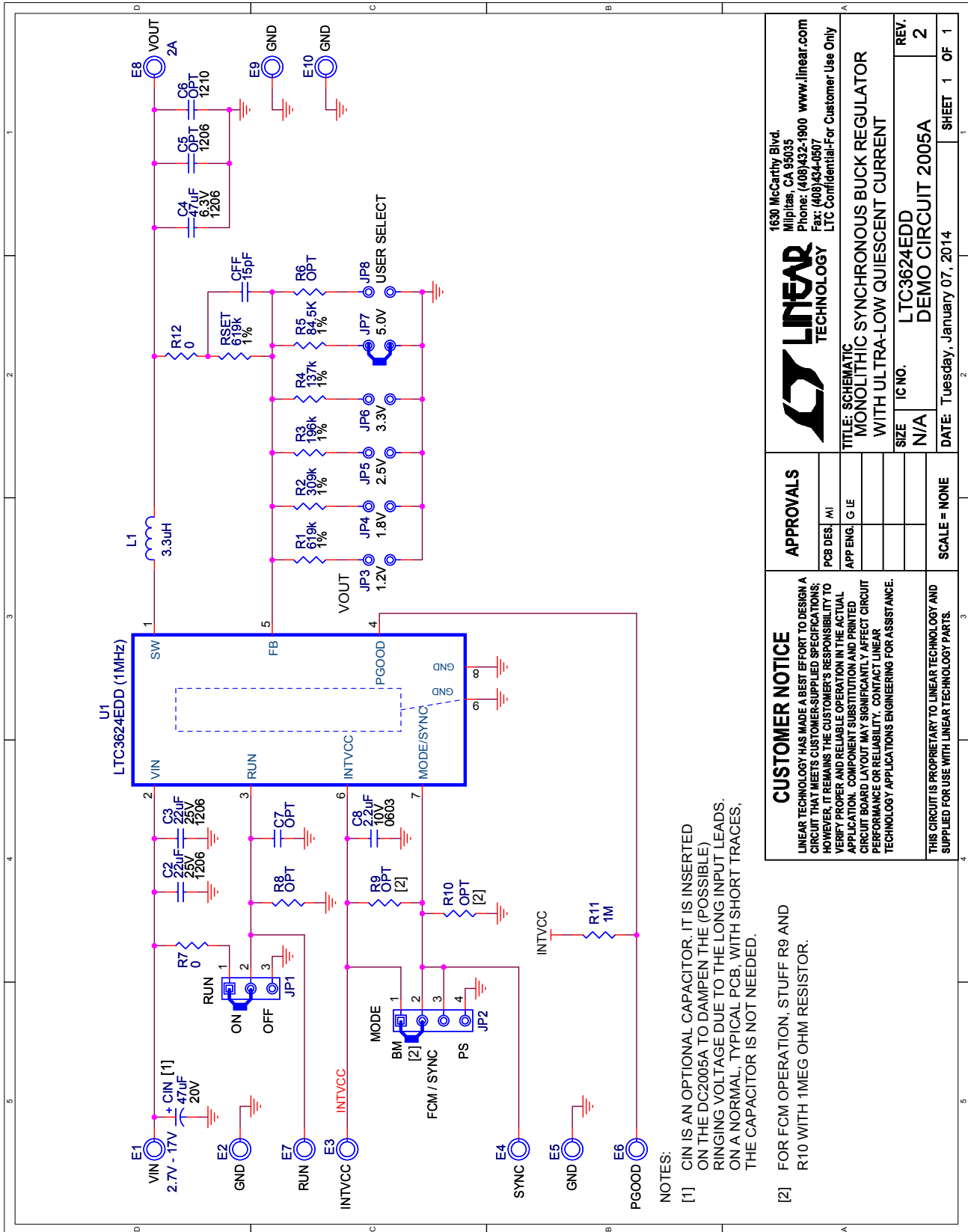
**Figure 7. Thermal Performance**

# DEMO MANUAL DC2005A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components</b>				
1	1	CFF	CAP, 0402 15pF 5% 50V NPO	AVX 04025A150JAT2A
2	1	CIN	CAP, 47μF 20% 20V 33mΩ	PANASONIC OSCON 20SVPA47M
3	2	C2,C3	CAP, 1206 22μF10% 25V X5R	MURATA GRM31CR61E226KE15L
4	1	C4	CAP, 1206 47μF 20% 6.3V X5R	TAIYO YUDEN JMK316BJ476ML-T
5	1	C8	CAP, 0603 2.2μF 10% 10V X5R	MURATA GRM188R61A225KE34P
6	1	L1	IND, 3.3μH	COILCRAFT XAL4030-332ME
7	2	R1, RSET	RES, 0402 619k 1% 1/16W	VISHAY CRCW0402619KFKED
8	1	R2	RES, 0402 309k 1% 1/16W	VISHAY CRCW0402309KFKED
9	1	R3	RES, 0402 196k 1% 1/16W	VISHAY CRCW0402196KFKEA
10	1	R4	RES, 0402 137k 1% 1/16W	VISHAY CRCW0402137KFKED
11	1	R5	RES, 0402 84.5k 1% 1/16W	VISHAY CRCW040284K5FKED
12	2	R7, R12	RES, 0402 0Ω JUMPER	VISHAY CRCW04020000Z0ED
13	1	R11	RES, 0402 1MΩ 5% 1/16W	VISHAY CRCW04021M00JNED
14	1	U1	IC, MONOLITHIC SYNCHRONOUS BUCK REGULATOR	LINEAR TECH LTC3624EDD
<b>Additional Demo Board Circuit Components</b>				
1	0	C5	CAP, 1206 22μF 20% 6.3V X5R OPTION	TAIYO YUDEN EMK316BJ226ML-T OPTION
2	0	C6	CAP, 1210 OPTION	OPTION
3	0	C7	CAP, 0402 OPTION	OPTION
4	0	R6, R8	RES, 0402 OPTION	OPTION
5	0	R9, R10	RES, 0402 1MΩ 5% 1/16W OPTION	VISHAY CRCW04021M00JNED OPTION
<b>Hardware</b>				
1	10	E1, E2, E3, E4, E5, E6, E7, E8, E9, E10	TURRET	MILL-MAX 2501-2-00-80-00-00-07-0
2	1	JP1	HEADER, 3-PIN, 2mm	SAMTEC TMM-103-02-L-S
3	1	JP2	HEADER, 4-PIN, 2mm	SAMTEC TMM-104-02-L-S
4	6	JP3, JP4, JP5, JP6, JP7, JP8	HEADER, 2-PIN, 2mm	SAMTEC TMM 102-02-L-S
5	4	MH1, MH2, MH3, MH4	STANDOFF, SNAP ON	KEYSTONE_8833
6	3	JP1, JP2, JP3	SHUNT, 2mm	SAMTEC 2SN-BK-G

**SCHEMATIC DIAGRAM**



<b>APPROVALS</b>		<b>CUSTOMER NOTICE</b> LINEAR TECHNOLOGY HAS MADE A BEST EFFORT TO DESIGN A CIRCUIT THAT MEETS CUSTOMER-SUPPLIED SPECIFICATIONS; HOWEVER, IT REMAINS THE CUSTOMER'S RESPONSIBILITY TO VERIFY PROPER AND RELIABLE OPERATION IN THE ACTUAL APPLICATION. COMPONENT SUBSTITUTION AND PRINTED CIRCUIT BOARD LAYOUT MAY SIGNIFICANTLY AFFECT CIRCUIT PERFORMANCE OR RELIABILITY. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE.  THIS CIRCUIT IS PROPRIETARY TO LINEAR TECHNOLOGY AND SUPPLIED FOR USE WITH LINEAR TECHNOLOGY PARTS.
PCB DES.	MI	
APP ENG.	G LE	
SCALE	NONE	
TITLE: SCHEMATIC MONOLITHIC SYNCHRONOUS BUCK REGULATOR WITH ULTRA-LOW QUIESCENT CURRENT SIZE IC NO. LTC3624EDD REV. 2 DEMO CIRCUIT 2005A		SHEET 1 OF 1
DATE: Tuesday, January 07, 2014		

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