

LTC3624

High Efficiency Synchronous Step-Down Regulator with Ultralow Quiescent Current

DESCRIPTION

Demonstration circuit 2359A is a synchronous step-down regulator using [LTC®3624HMSE](#) monolithic buck regulator. The DC2359A 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 continuous output current. A user-selectable mode input is provided with the following options: Burst Mode® operation provides the highest efficiency at light loads, while Pulse-Skipping mode (PS) provides the lowest output voltage ripples. Forced Continuous mode (FC) is also available for low EMI and noise interference.

The MODE/SYNC pin can also be used to synchronize the switching frequency to an external clock signal. The switching frequency is fixed at 1MHz with a $\pm 40\%$ sync capture range.

The regulator features ultralow quiescent current and high efficiencies over a wide V_{IN} and V_{OUT} range. DC2359A

uses very low profile surface mount components and all ceramic output capacitor solutions. The compact 12-lead MSE (5mm $\times$ 4mm $\times$ 1mm) thermally enhanced package makes LTC3624HMSE an excellent choice for battery powered equipment, emergency radio and general purpose step-down power supplies. The H-Grade version is specified over an operating junction temperature range of -40°C to 150°C , typically required for automotive, industrial and military applications that are subject to high ambient temperatures.

It is recommended to read the data sheet and demo manual of LTC3624 prior using or making any changes to DC2359A.

Design files for this circuit board are available at <http://www.linear.com/demo/DC2359A>

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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
On Board User Selectable Output Voltages	$V_{IN} = 2.7\text{V to } 17\text{V}$, $I_{OUT} = 2\text{A}$ ($V_{OUT} < V_{IN}$)	1.2V, 1.8V, 2.5V, 3.3V and 5V
Default Mode Setting	JP2	Burst Mode ("BM" on Circuit Board)
Fixed Switching Frequency	Internally Programmed Frequency	1MHz $\pm 20\%$
Default Output Voltage V_{OUT}	$V_{IN} = 12\text{V}$, $V_{OUT} = 5\text{V}$, $I_{OUT} = 0\text{A to } 2\text{A}$	5V $\pm 2\%$
Maximum Continuous Output Current I_{OUT}		2A
Output Voltage Ripples (Peak to Peak)	$V_{IN} = 12\text{V}$, $V_{OUT} = 5\text{V}$, $I_{OUT} = 2\text{A}$	8.8mV (Figure 7)
Load Transient Response	$V_{IN} = 12\text{V}$, $V_{OUT} = 5\text{V}$, $I_{OUT_STEP} = 1\text{A to } 2\text{A}$, $C_{OUT} = 1 \times 47\mu\text{F}$	219mV (Figure 8)
Thermal Performance	$V_{IN} = 12\text{V}$, $V_{OUT} = 5\text{V}$, $I_{OUT} = 2\text{A}$, $f_{SW} = 1\text{MHz}$, $T_A = 25^{\circ}\text{C}$	Figure 9
Efficiency	$V_{IN} = 12\text{V}$, $V_{OUT} = 5\text{V}$, $I_{OUT} = 2\text{A}$, BM, $f_{SW} = 1\text{MHz}$, $T_A = 25^{\circ}\text{C}$	89.7% (Figure 3)

QUICK START PROCEDURE

Demonstration circuit 2359A is easy to set up to evaluate the performance of the LTC3624HMSE. 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	V _{OUT}
ON	BM	5.0V

2. With power off, connect the input power supply at V_{IN} (E1) and GND (E2)
3. Connect the Load between V_{OUT} (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 voltage ripple, switch node waveform and other parameters. Refer to Figure 2 for proper output voltage ripple measurement.

7. To select other output voltages, use the on board user selectable output voltage jumpers. Shutting down LTC3624HMSE 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 step 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

*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 DC2359A can also be used to evaluate the LTC3624HMSE-2 (2.25MHz) by simply replacing U1 with the LTC3624HMSE-2 and changing inductor L1 to 1.5 μ H (Coilcraft XAL4020-152ME).

QUICK START PROCEDURE

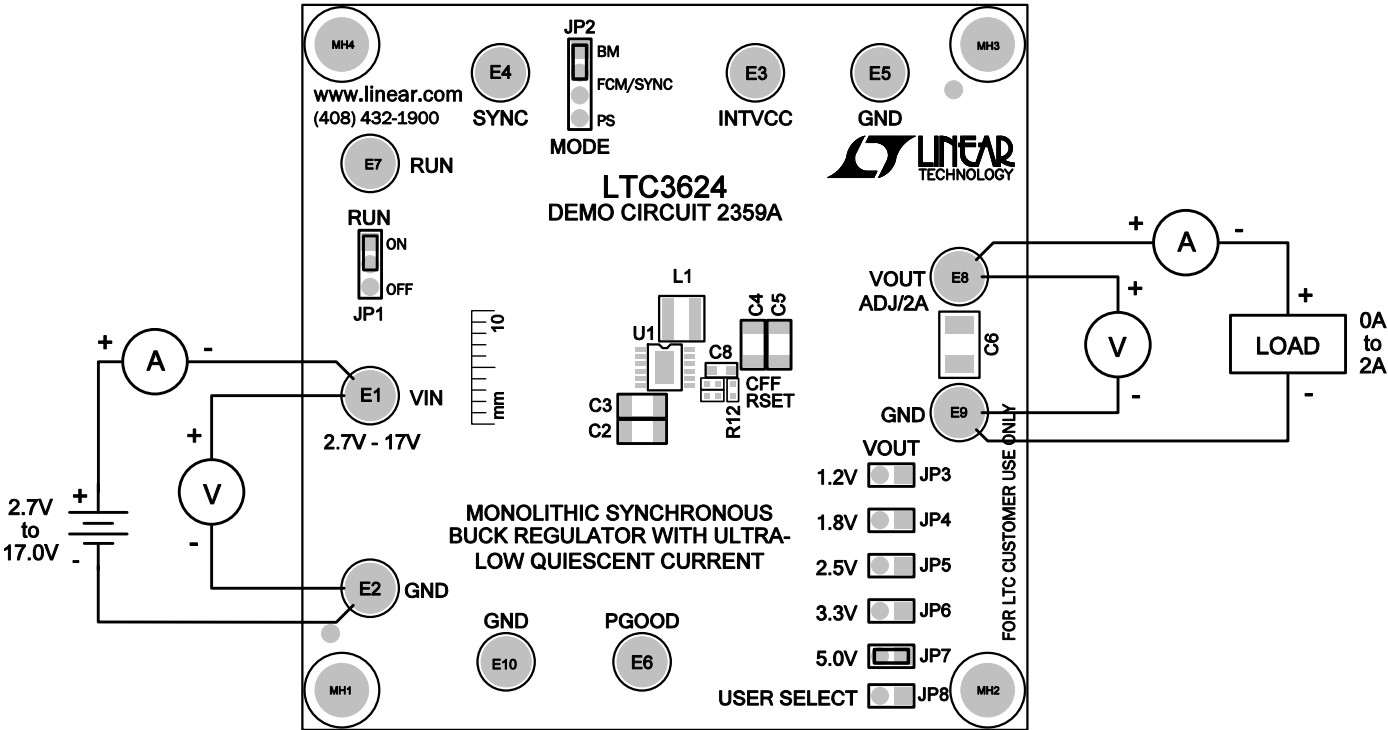


Figure 1. Proper Measurement Equipment Setup

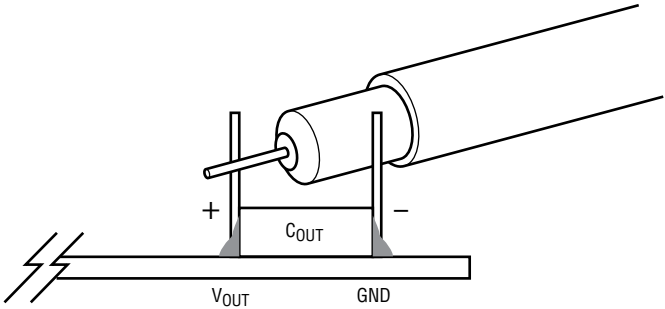


Figure 2. Scope Probe Placement for Measuring Output Voltage Ripple

QUICK START PROCEDURE

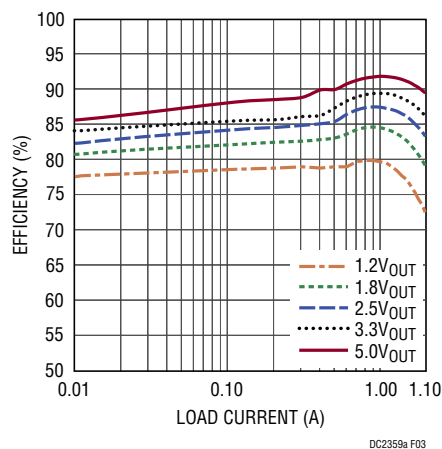


Figure 3. Burst Mode – Efficiency vs Load Current at 12VIN

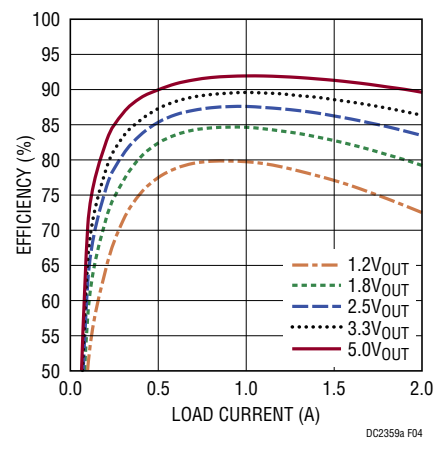


Figure 4. Forced Continuous Mode – Efficiency vs Load Current at 12VIN

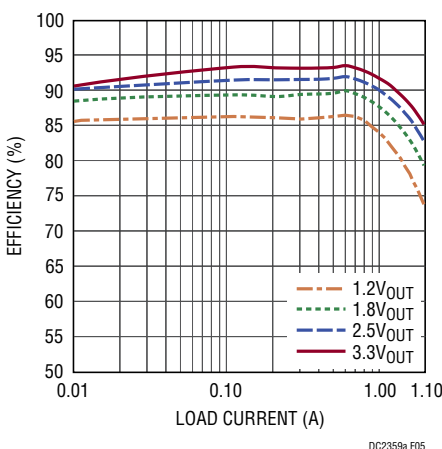


Figure 5. Burst Mode – Efficiency vs Load Current at 5VIN

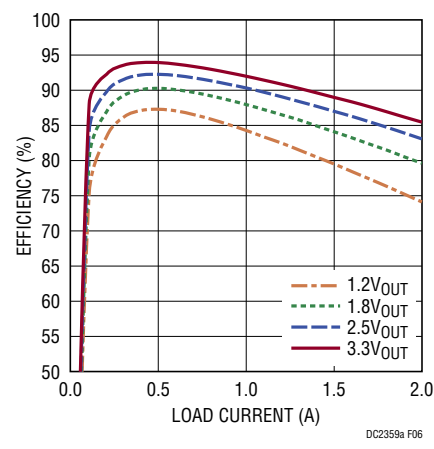
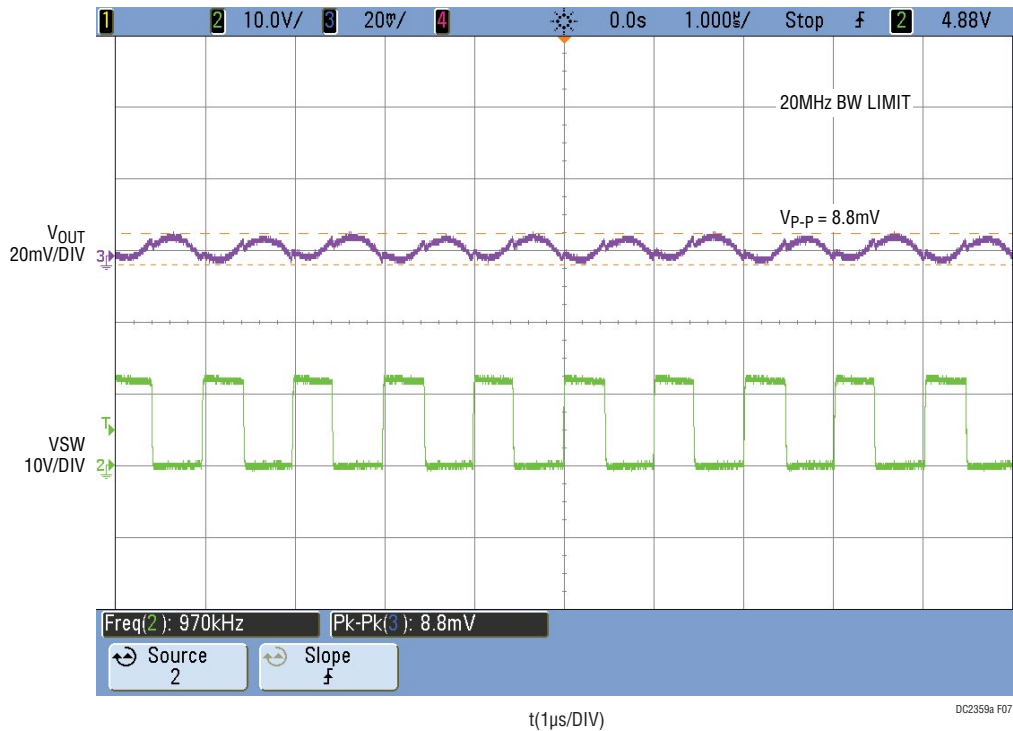


Figure 6. Forced Continuous Mode – Efficiency vs Load Current at 5VIN

QUICK START PROCEDURE



$f_{SW} = 1MHz$
 $V_{IN} = 12V$
 $V_{OUT} = 5V$
 $I_{LOAD} = 2A$
 $L = 3.3\mu H$
 $C_{OUT} = 1x\ 47\mu F/6.3V/X5R/1206$

Figure 7. Measured Output Voltage Ripple

QUICK START PROCEDURE

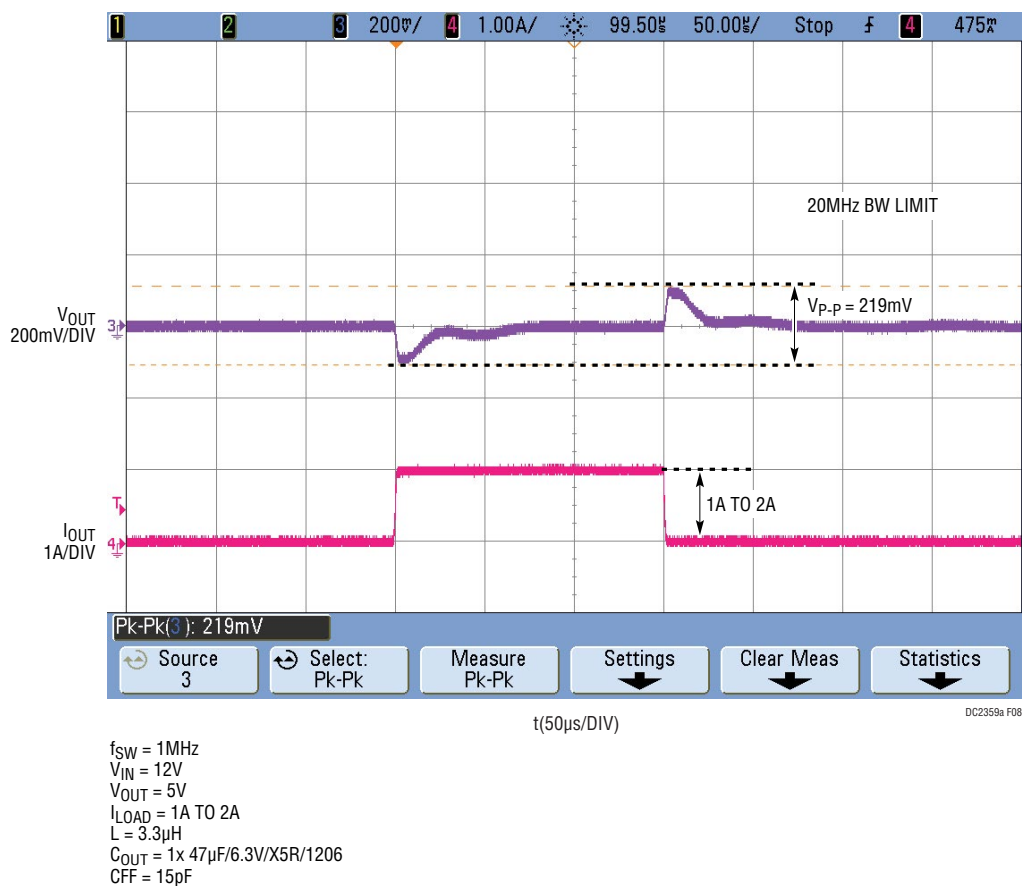


Figure 8. Load Transient Response

QUICK START PROCEDURE



$V_{IN} = 12V$
 $V_{OUT} = 5V$
 $I_{LOAD} = 2A$
 $L = 3.3\mu H$
 $f_{SW} = 1MHz$
 NO FORCED AIRFLOW
 $T_A = 25^{\circ}C$

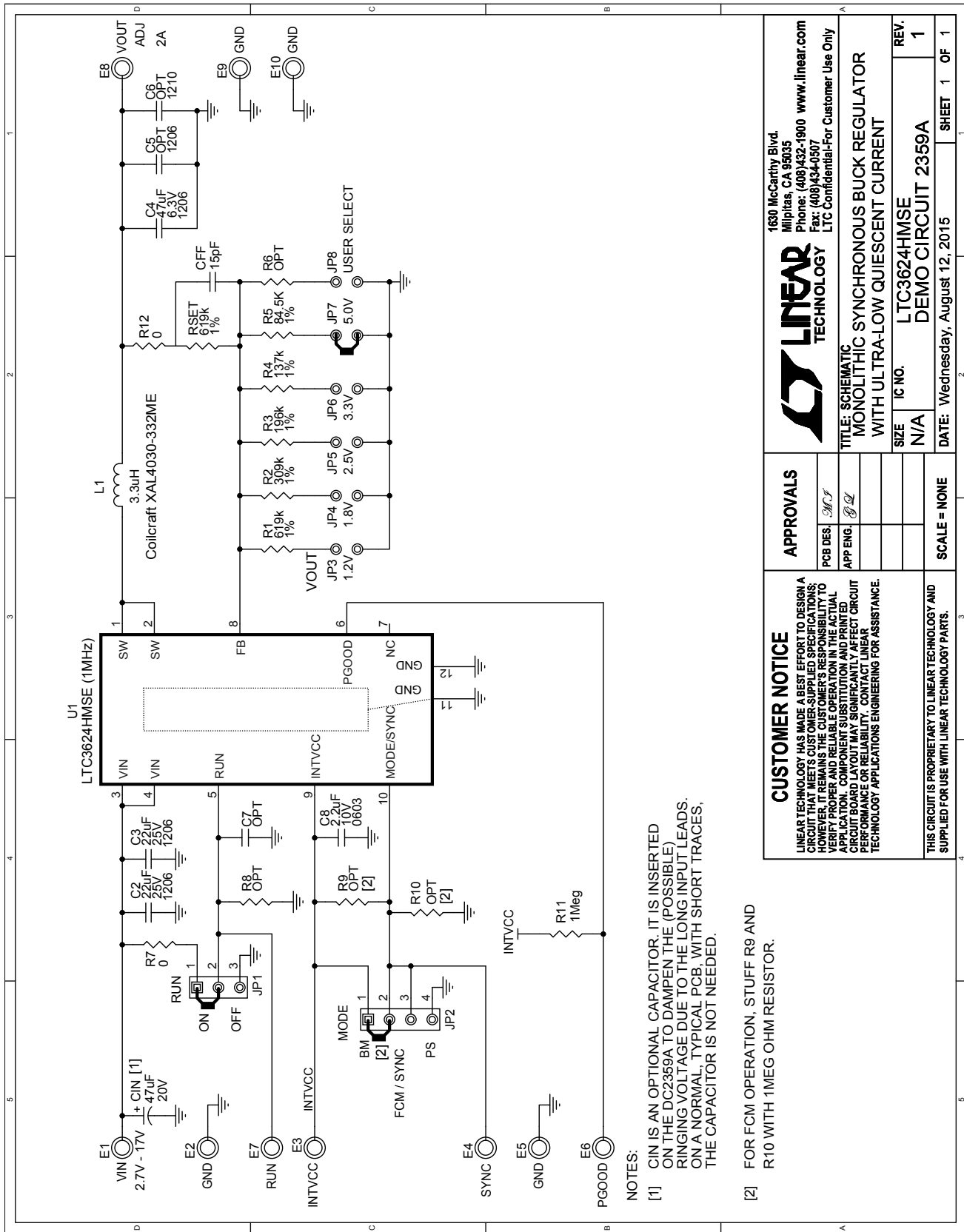
Figure 9. Thermal Performance

DEMO MANUAL DC2359A

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	CFF	CAP, 0402 15pF 1% 50V NPO	AVX 04025U150FAT2A
2	1	CIN	CAP, 47µF 20% 20V 33mΩ	PANASONIC OSCON 20SVPA47M
3	2	C2, C3	CAP, 1206 22µF 10% 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	AVX 0603ZD225KAT2A
6	1	L1	IND, 3.3µH	XAL4030-332ME
7	2	R1, RSET	RES, 0402 619kΩ 1% 1/16W	VISHAY CRCW0402619KFKED
8	1	R2	RES, 0402 309kΩ 1% 1/16W	VISHAY CRCW0402309KFKED
9	1	R3	RES, 0402 196kΩ 1% 1/16W	VISHAY CRCW0402196KFKEA
10	1	R4	RES, 0402 137kΩ 1% 1/16W	VISHAY CRCW0402137KFKED
11	1	R5	RES, 0402 84.5kΩ 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 LTC3624HMSE#PBF
Additional Demo Board Circuit Components				
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, R9, R10	RES, 0402 OPTION	OPTION
Hardware				
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	XJP1, XJP2, XJP7	SHUNT, 2mm	SAMTEC 2SN-BK-G

SCHEMATIC DIAGRAM



CUSTOMER NOTICE 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 MANUFACTURING VARIATIONS MAY AFFECT CIRCUIT PERFORMANCE OR RELIABILITY. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE.		APPROVALS PCB DES. <i>MS</i> APP ENG. <i>BA</i>		1630 McCarthy Blvd. Milpitas, CA 95035 Phone: (408)432-1900 www.linear.com Fax: (408)434-0507 LTC Confidential-For Customer Use Only
TITLE: SCHEMATIC MONOLITHIC SYNCHRONOUS BUCK REGULATOR WITH ULTRA-LOW QUIESCIENT CURRENT		SIZE IC NO. LTC3624HMS-1		REV. 1
DATE: Wednesday, August 12, 2015		DEMO CIRCUIT 2359A		SHEET 1 OF 1

DEMO MANUAL DC2359A

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This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a LTC application engineer.

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