Evaluation Board User Guide

EVAL-LTM4652-AZ

LTM4652

Bidirectional Dual 25A or Single 50A Step-Down µModule Regulator

General Description

The EVAL-LTM4652-AZ evaluation board features the LTM®4652EY, source/sink dual ±25A or single ±50A output switching mode step-down DC-to-DC µModule® regulator. The input voltage is from 4.5V to 18V. The output voltage is programmable from 0.6V to 5V. The EVAL-LTM4652-AZ evaluation board can deliver 25A maximum current from each channel. As explained in the LTM4652 data sheet, the output current derating is necessary for certain V_{IN}, V_{OUT}, and thermal conditions. The EVAL-LTM4652-AZ evaluation board operates in continuous-conduction mode (CCM) in heavy load conditions. For high efficiency at low load currents, pulse-skipping mode (PSM) is selected with the MODE jumper (JP1) for noise-sensitive applications. Two outputs can be connected in parallel for a single 50A output solution with optional jumper resistors. The evaluation board allows the user to program how its output ramps up and down through the TRACK/SS pin. The output can be set up to either coincidentally, or ratiometrically track with another supply's output. Remote output voltage sensing is available for improved output voltage regulation at the load point. These features and the compact size of the LTM4652, 16mm × 16mm × 4.92mm, BGA package, make it ideal for use in many high-density point-of-load (POL) regulation applications. The LTM4652 data sheet must be read in conjunction with this user guide for working on or modifying the EVAL-LTM4652-AZ evaluation board.

Features and Benefits

- Bidirectional Output Current up to ±25A
  - Parallel Channel Current Sharing up to ±50A
- Current Mode Control/Fast Transient Response
- Output Voltage Differential Remote Sensing

EVAL-LTM4652-AZ Evaluation Board Files

FILE	DESCRIPTION
EVAL-LTM4652-AZ	Design files

***Ordering Information* appears at end of this user guide.**

Quick Start

Required Equipment

- Three Power Supplies
- Three Electronic Loads
- Three Digital Multimeters (DMMs)
- Two Load Protection Diodes

Quick Start Procedure

Sourcing Current Condition Procedure

The EVAL-LTM4652-AZ evaluation board is easy to set up to evaluate the performance of the LTM4652. See *Figure 2* for proper measurement setup and use the following sourcing current condition procedure.

1. Before powering up the EVAL-LTM4652-AZ, place jumpers in the following positions for a typical application:

JP1	JP2	JP3	JP4	JP5	JP6
MODE	RUN1	RUN2	TRACK1	5V BIAS	TRACK2
CCM	ON	ON	ON	OFF	SOFT START

2. With power off, connect the input power supply to VIN (J4) and GND (J5). Connect VIN supply to 12V.
3. With power off, connect the first output load to VOUT1 (J6) and GND (J7). Connect the second output load to VOUT2 (J8) and GND (J9). Preset the loads to 0A.
4. Connect the first DMM between test points VOUT1 (E6) and GND (E7). Connect the second DMM between test points VOUT2 (E8) and GND (E9).
5. Turn on the power supply at the input and set the voltage between 4.5V and 18V. The output voltage in Channel 1 should be 1.2V ±1% (1.188 ~ 1.212V) and the output voltage in Channel 2 should be 1.52V ±1% (1.485V ~ 1.535V).
6. Once the proper output voltage is established, adjust the input voltage to 12V and the load within the operating range and observe the output voltage regulation, output voltage ripple, efficiency, and other parameters. Output ripple should be measured at J1 and J2 with Bayonet Neill–Concelman (BNC) cables. The 50Ω termination should be set on the oscilloscope or BNC cables.

One Analog Way, Wilmington, MA 01887-2356, U.S.A. | Tel: 781.329.4700

Evaluation Board Photo

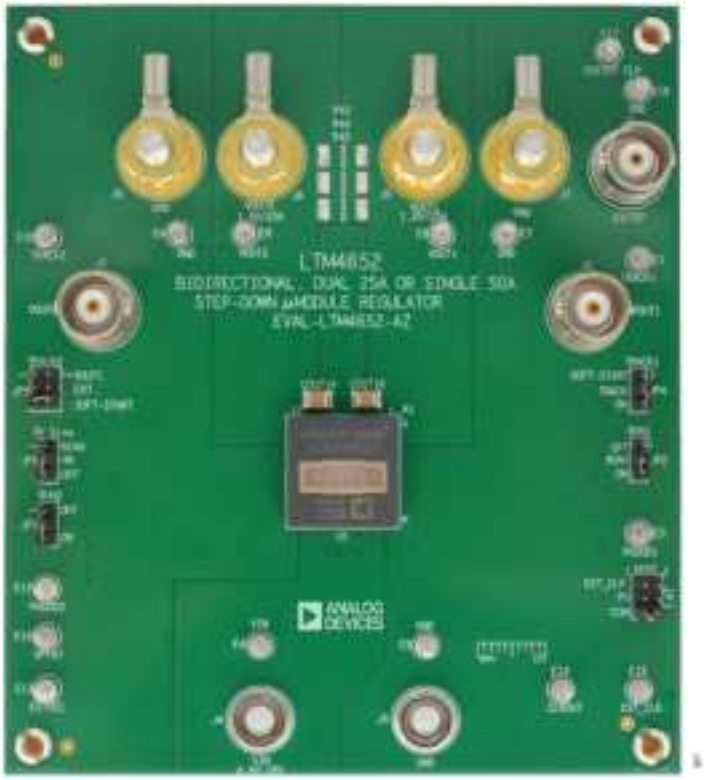


*Figure 1. **EVAL-LTM4652-AZ** Evaluation Board (Part Marking Is either Ink Mark or Laser Mark)*

Performance Summary

Specifications are at T_A = 25°C

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	VALUE
Input voltage range	V_{IN}		4.5		18	V
Output voltage	V_{OUT1}	R_{FB} = 60.4kΩ		1.2		V
	V_{OUT2}	R_{FB} = 40.2kΩ		1.5		V
Switching frequency	f_{SW}	R_{FREQ} = 95.3kΩ		400		kHz
Maximum output current	I_{OUT}	V_{IN} = 4.5V to 18V, f_{SW} = 400kHz			25	A
Efficiency	η	V_{IN} = 12V, V_{OUT} = 1.2V, I_{OUT} = 25A, f_{SW} = 400kHz		86.2		%
		V_{IN} = 12V, V_{OUT} = 1.5V, I_{OUT} = 25A, f_{SW} = 400kHz		88.1		%

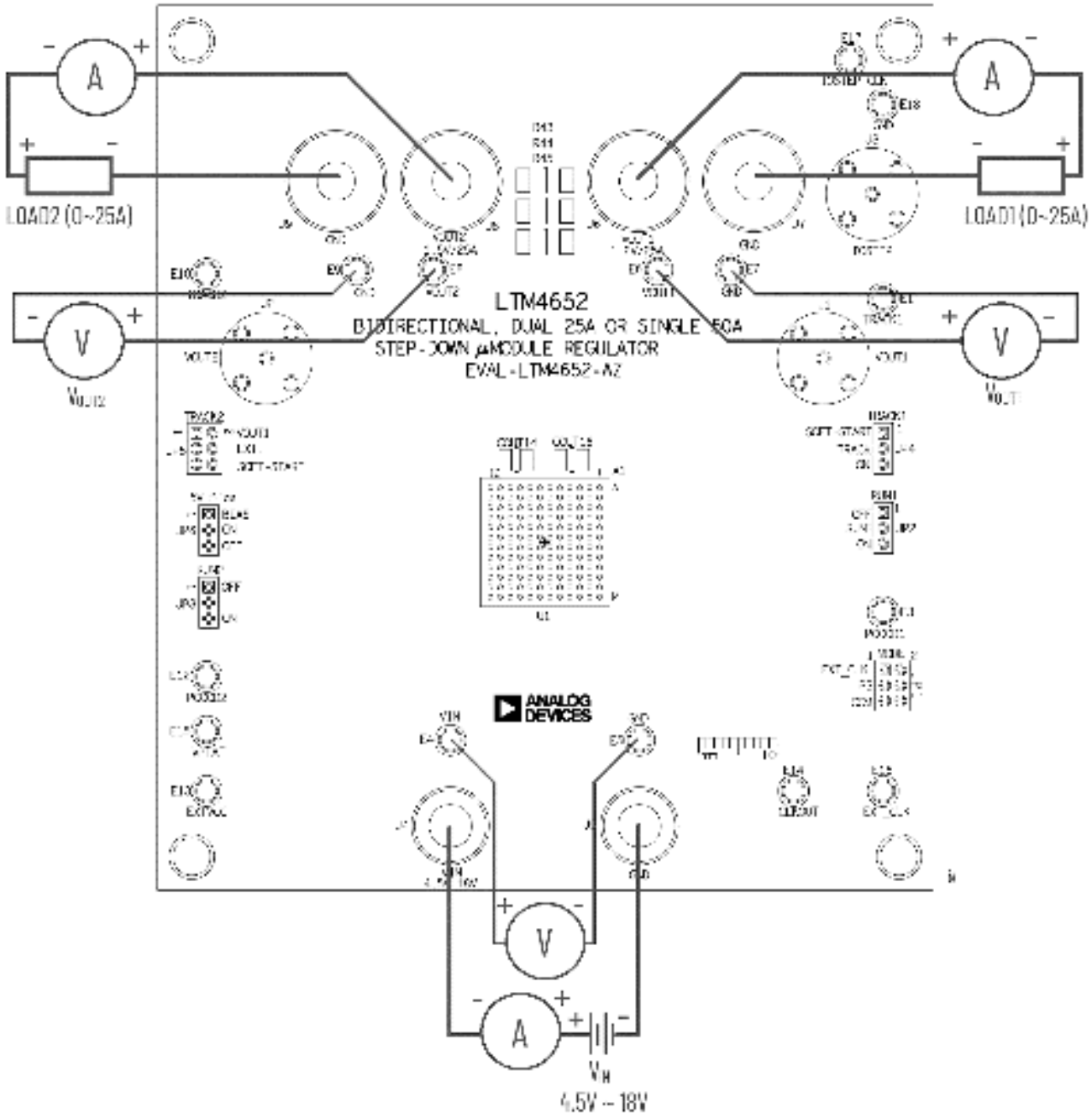


Figure 2. Test Setup of EVAL-LTM4652-AZ Evaluation Board

Sinking Current Condition Procedure

See *Figure 3* for proper measurement equipment setup for the sinking current condition and use the following test procedure. This procedure shows how to use an electric load to test sinking current capability.

1. Before powering up the EVAL-LTM4652-AZ, place jumpers in the following positions for a typical application:

JP1	JP2	JP3	JP4	JP5	JP6
MODE	RUN1	RUN2	TRACK1	5V BIAS	TRAC2
CCM	ON	ON	ON	OFF	SOFT START

2. With power off, connect an ammeter to VIN (J4), then connect the input power supply and free-wheeling load in parallel between the ammeter and GND (J5).

3. On the Channel 1 output, starting from GND (J7), connect the bias supply, the output load, and the load reverse protection diode to VOUT1 (J6). The diode should have a current rating greater than the maximum desired output load value and a voltage rating greater than VF_DIODE + $|V_{OUT}|$. Refer to 1N5831 as an example. Repeat this step with a second power supply, load, and protection diode for Channel 2.

4. Connect a DMM between the input test points: VIN (E4) and GND (E5) to monitor the input voltage. Connect a DMM between VOUT1 (E6) and GND (E7) to monitor DC output VOUT1. Connect a second DMM between VOUT2 (E8) and GND (E9) to monitor DC output VOUT2.

5. Turn on the output bias power supply, measure, and increase the voltage to 10V. Turn on the input power supply voltage and raise the VIN between 4.5V and 18V. The output voltage on Channel 1 should be 1.2V ±1% (1.188 ~ 1.212V) and the output voltage in Channel 2 should be 1.52V ±1% (1.485V ~ 1.535V).

6. Once the input and output voltages are properly established, adjust the input voltage to 12V.

7. When sinking current in this configuration, an electronic load is used as the free-wheeling load, and it must be turned on first. Turn on the free-wheeling load and increase above $I_{OUT} \times |V_{OUT}|/V_{IN}$. Current will be flowing from the V_{IN} power supply and into the free-wheeling load.

8. The output sinking current can now be applied on each channel within the operating range of 0A to a maximum 25A load. Observe the output voltage regulation, output ripple voltage, switching node waveforms, and other parameters.

   Note: When removing the loads and powering the circuit off, this procedure must be followed in reverse step order. Decrease the sinking current(s) to 0A and turn off the output load, decrease the free-wheeling load to 0A, and turn off the free-wheeling load, the run pin may be pulled low here. Then, turn off the V_{IN} supply, and lastly, turn off the output V_{BIAS} power supply.

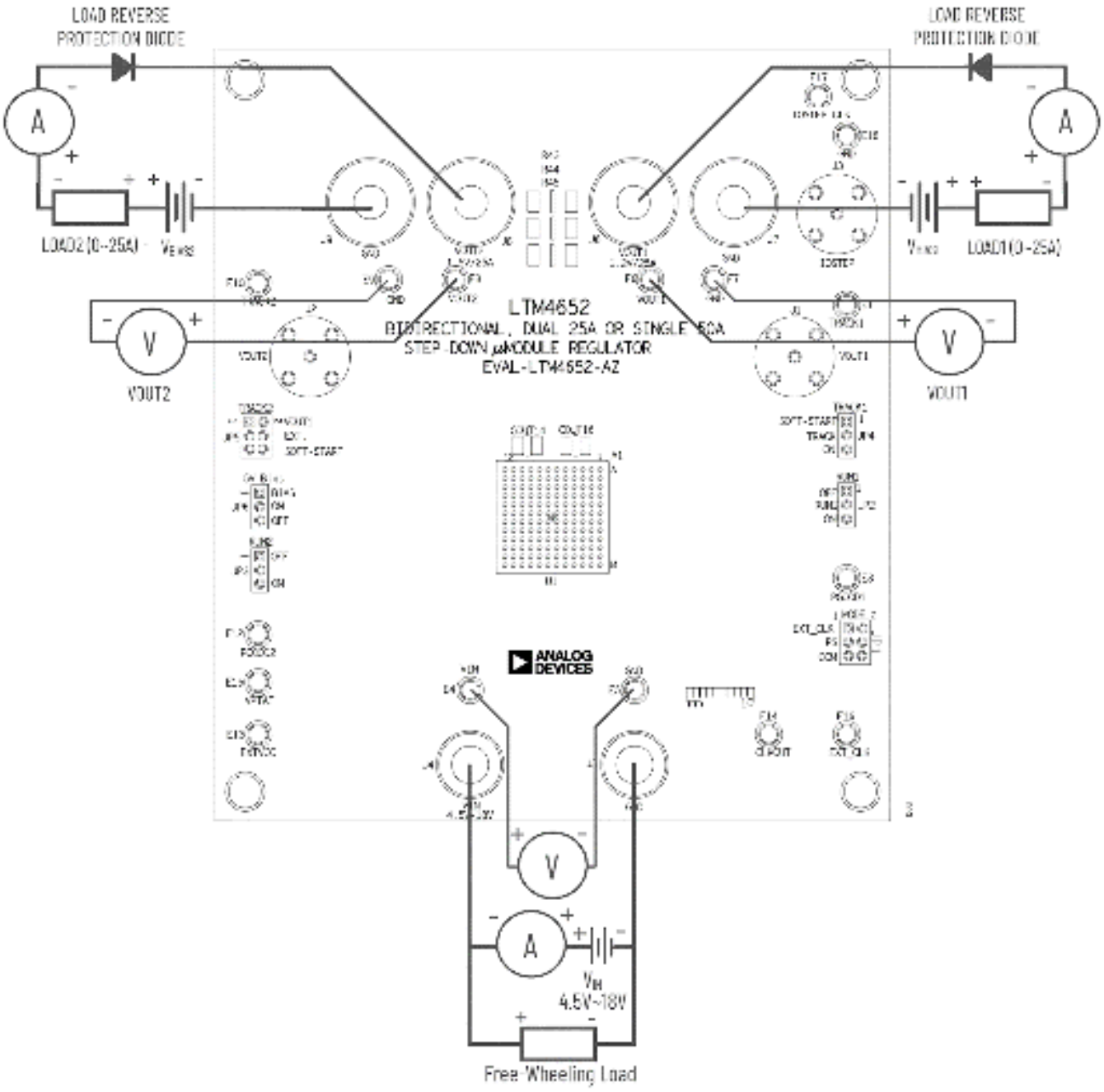


Figure 3. Test Setup of EVAL-LTM4652-AZ Evaluation Board

The EVAL-LTM4652-AZ provides a convenient onboard BNC terminal to accurately measure the output ripple voltage. Connect a short BNC cable on (J1) to an oscilloscope (scope probe ratio 1:1, AC-coupling) to observe the output ripple voltage.

To measure the input/output voltage ripples properly, do not use the long ground lead on the oscilloscope probe. See *Figure 4* for the proper probing technique of input/output voltage ripples. Short, stiff leads need to be soldered to the (+) and (–) terminals of an input or output capacitor. The probe's ground ring needs to touch the (–) lead, and the probe tip needs to touch the (+) lead.

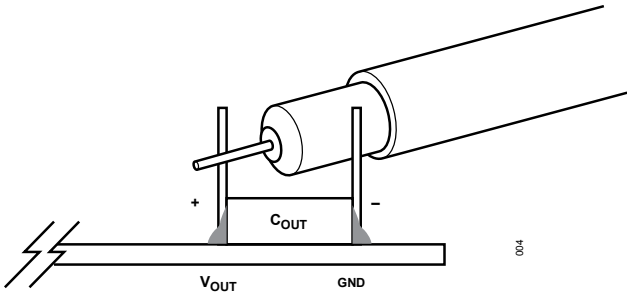


Figure 4. Scope Probe Placement for Measuring Input or Output Ripple Voltage

EVAL-LTM4652-AZ Evaluation Board Features

- ***Onboard Load Step Circuit.*** The EVAL-LTM4652-AZ provides onboard load transient circuits to quickly check ΔV_{OUT} peak-to-peak deviation during rising or falling dynamic load transients for each channel. The simple load step circuit consists of a 40V N-channel power MOSFET in series with a 10mΩ, 0.5W, 1% current sense resistor. The MOSFET is configured as a voltage control current source (V_{CCS}) device; therefore, the output current step and its magnitude are created and controlled by adjusting the amplitude of the applied input voltage step at the gate of the MOSFET. Use a function generator to provide a voltage pulse between IOSTEP CLK (E17) and GND; this voltage pulse should be set at a pulse width of less than 2ms and a maximum duty cycle of less than 1% to avoid excessive thermal stress on the MOSFET devices. The output current step is measured directly across the current sense resistors and monitored by connecting the BNC cable from IOSTEP (J3) to the input of the oscilloscope (scope probe ratio 1:0.01, dc-coupling). The equivalent voltage to the current scale is 10mV/1A. The load step current slew rate dI/dt can be varied by adjusting the rise time and fall time of the input voltage pulse. Switch the jumper resistors R34 or R35 (on the backside of the board) to apply load transient on Channel 1 or Channel 2, correspondingly.

- **Temperature Sensing.** The LTM4652 IC temperature is measured with an onboard circuit utilizing Analog Devices *LTC®2997*. The $5V_{BIAS}$ circuit must be enabled by adding 0Ω on R59 and placing jumper JP6 in the ON position. The LTC2997 converts the voltage from a diode-configured PNP transistor inside the LTM4652 through its $TEMP^+$ and $TEMP^-$ pins into V_{PTAT}. This V_{PTAT} voltage correlates to the LTM4652 IC temperature using the following conversion: $TEMP\ (K) = V_{PTAT}/4mV$.

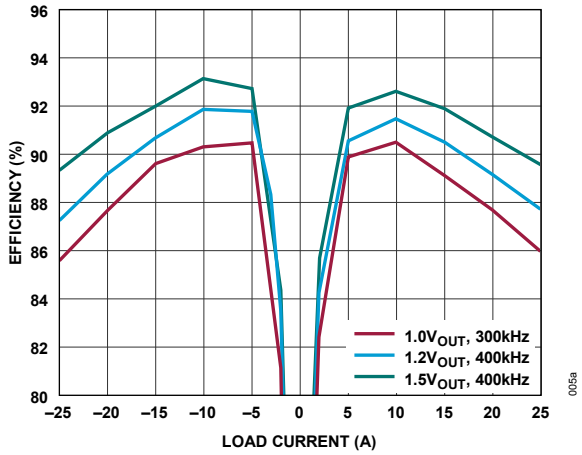
- **Driving SW with an External Clock.** The LTM4652 can be synchronized to an external clock signal. Place the JP1 jumper on EXT_CLK and apply a 0V ~ 3V, square wave clock signal (250kHz to 780kHz) on the CLKIN test point (E16).

- **Output Voltage Tracking.** The outputs of LTM4652 can track another supply. The jumpers JP4 and JP5 allow choosing soft-start or output tracking. If tracking external voltage is selected, the corresponding test points, TRACK1 (E1) or TRACK2 (E10), must be connected to a valid voltage signal.

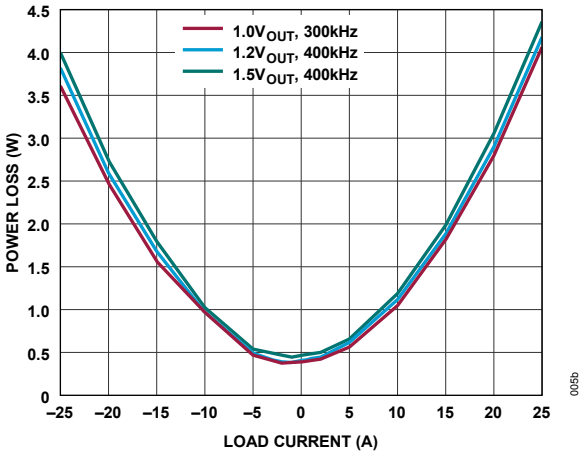
- **Dual-Phase Single-Output Operation.** The LTM4652 modules can be configured for a 2-phase single output for up to 50A on EVAL-LTM4652-AZ. Install 0Ω resistors on R14, R17, R28, R39, R43, R44, R45 and remove R7, R19. The output voltage is then set by R25 based on the following equation: $V_{OUT} = 0.6V(1 + 60.4k/R25)$.

- **Output Voltage Remote Sensing.** The Onboard differential remote sense amplifier can be connected to either of the LTM4652 outputs to accurately regulate the output voltage at the remote point-of-load. To use the differential amplifier, remove R48 and R55 and connect DIFFN, DIFFP, and DIFFOUT either to Channel 1 (R29, R32, R21) or to Channel 2 (R31, R33, R11).

Typical Performance Characteristics

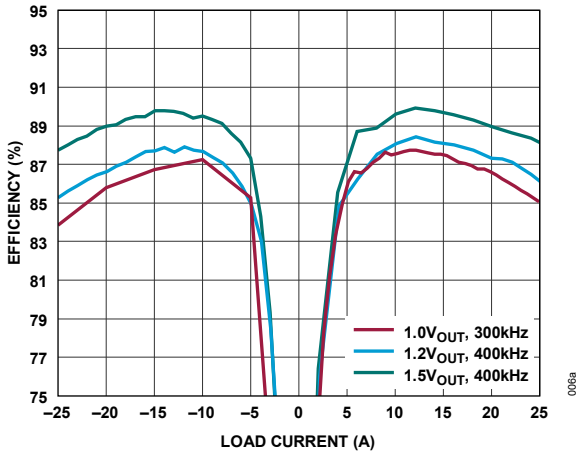


(a) Efficiency

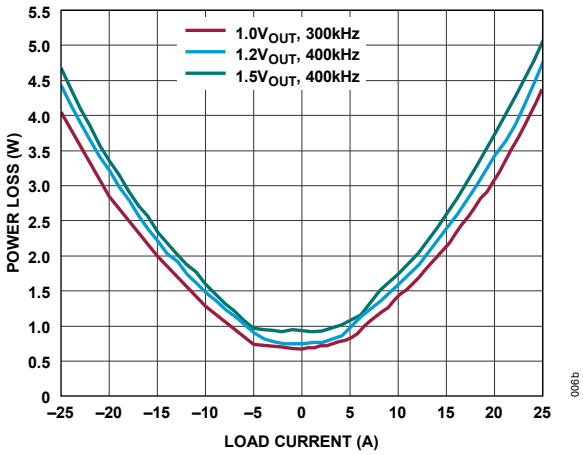


(b) Power Loss

Figure 5. Measured Supply at V_{IN} = 5V

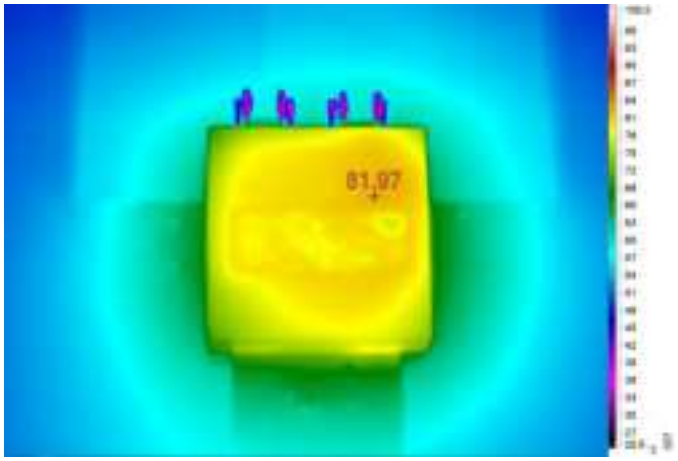


(a) Efficiency



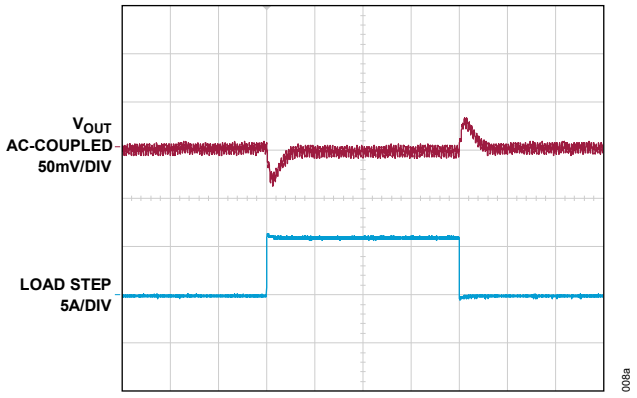
(b) Power Loss

Figure 6. Measured Supply at V_{IN} = 12V

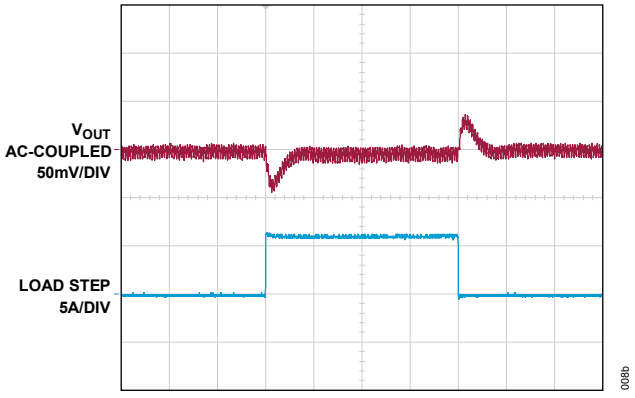


V_{IN} (V)	V_{OUT1} (V)	LOAD1 (A)	V_{OUT2} (V)	LOAD2 (A)	FREQ (kHz)	AIRFLOW (LFM)	MAX CASE TEMP (°C)
12	1.2	25	1.5	25	400	0	83

Figure 7. Measured Thermal Captures without Forced Airflow

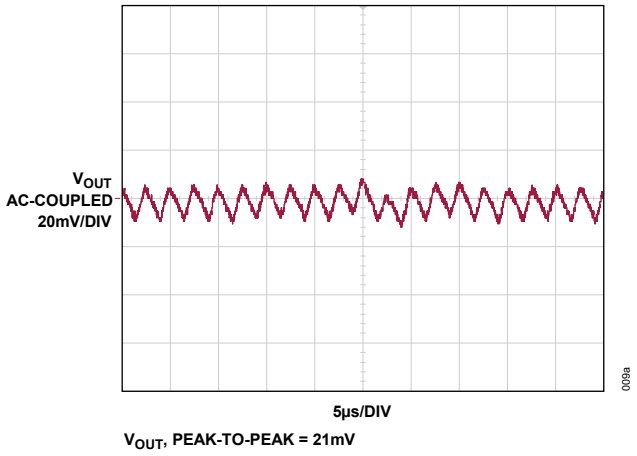


(a) $1.2V_{OUT}$

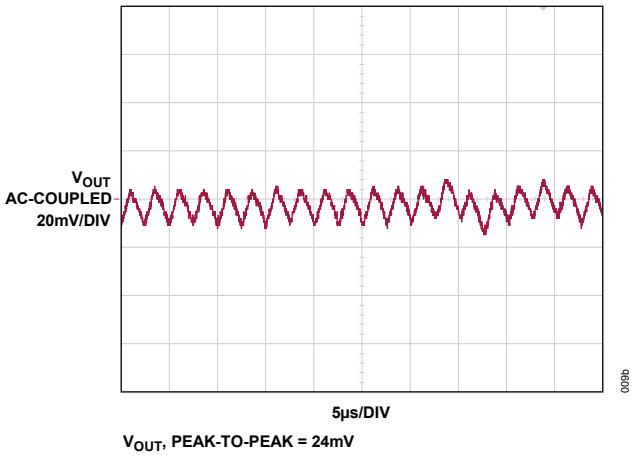


(b) $1.5V_{OUT}$

Figure 8. Load Transient Response



(a) 1.2V_{OUT}, 400kHz, 20MHz Bandwidth



(b) 1.5V_{OUT}, 400kHz, 20MHz Bandwidth

Figure 9. Tested Single Channel Operation V_{OUT} AC Ripple at 12V_{IN}, I_{OUT} = 25A

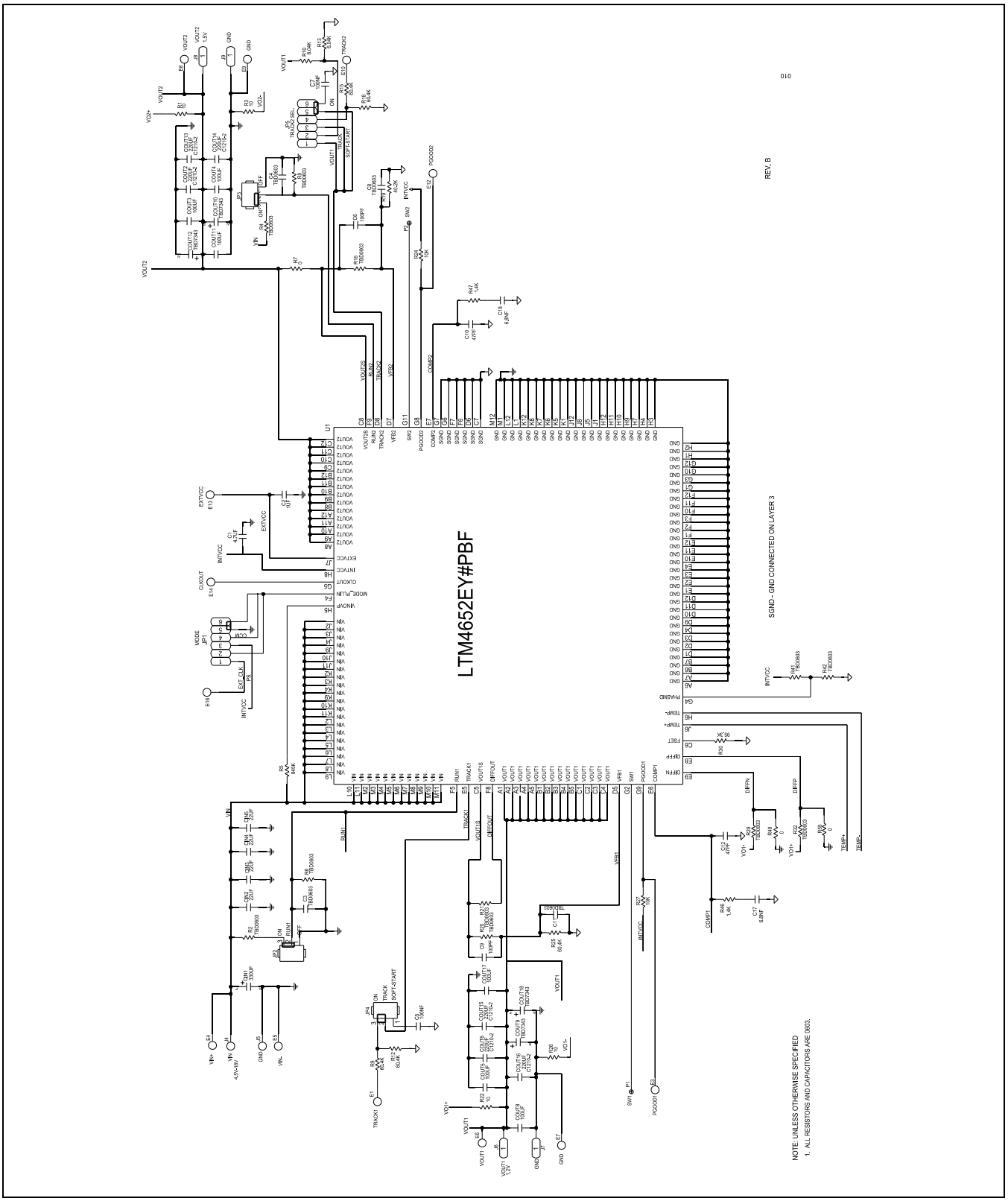
EVAL-LTM4652-AZ Evaluation Board Bill of Materials

QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components			
1	C1	CAP. CER 4.7µF 16V 20% X5R 0805	KEMET, C0805C475M4PACTU
2	C10, C12	CAP. CER 47pF 50V 5% C0G 0603	WURTH ELEKTRONIK, 885012006055
4	C13-C16	CAP. CER 1µF 10V 10% X7R 0603	KEMET, C0603C105K8RACTU
2	C17, C18	CAP. CER 6.8nF 50V X7R 0603	WURTH ELEKTRONIK, 885012206088
1	C19	CAP. CER 470pF 50V 10% X7R 0603	AVX CORPORATION, 06035C471KAT2A
1	C2	CAP. CER 1µF 25V 10% X7R 0805 AEC-Q200	TDK, CGA4J3X7R1E105K125AB
1	C20	NRND – CAP. CER 0.1µF 25V 10% X7R 0603	TDK, C1608X7R1E104K080AA
1	C21	CAP. CER 10µF 16V 20% X5R 1210	WÜRTH ELEKTRONIK, 885012109009
1	C22	CAP. CER 220pF 50V 10% X7R 0603	WÜRTH ELEKTRONIK, 885012206079
1	C23	CAP. CER 0.047µF 50V 10% X7R 0603 AEC-Q200 LOW ESR	TDK, CGA3E2X7R1H473K080AA
2	C25, C26	CAP. CER 100µF 16V 20% X5R 1210	TAIYO YUDEN, EMK325ABJ107MM-P
2	C5, C7	CAP. CER 100nF 25V 10% X5R 0402	TDK, C1005X5R1E104K050BC
2	C6, C9	CAP. CER 100pF 50V 5% C0G 0603	WÜRTH ELEKTRONIK, 885012006057
1	CN1	CAP. ALUM POLY 330µF 25V 20% 10mm × 12.6mm 0.014Ω 5000mA 5000H	PANASONIC, 25SVPF330M
4	CIN2-CIN5	CAP. CER 22µF 25V 10% X5R 1210	SAMSUNG, CL32A226KAJNNNE
6	COUT3-COUT5, COUT8, COUT11, COUT17	CAP. CER 100µF 6.3V 20% X5R 1210	SAMSUNG, CL32A107MQVNNNE
6	COUT2, COUT6, COUT13-COUT16	CAP. CER 220µF 6.3V 20% X5R 1210	MURATA, GRM32ER60J227ME05L

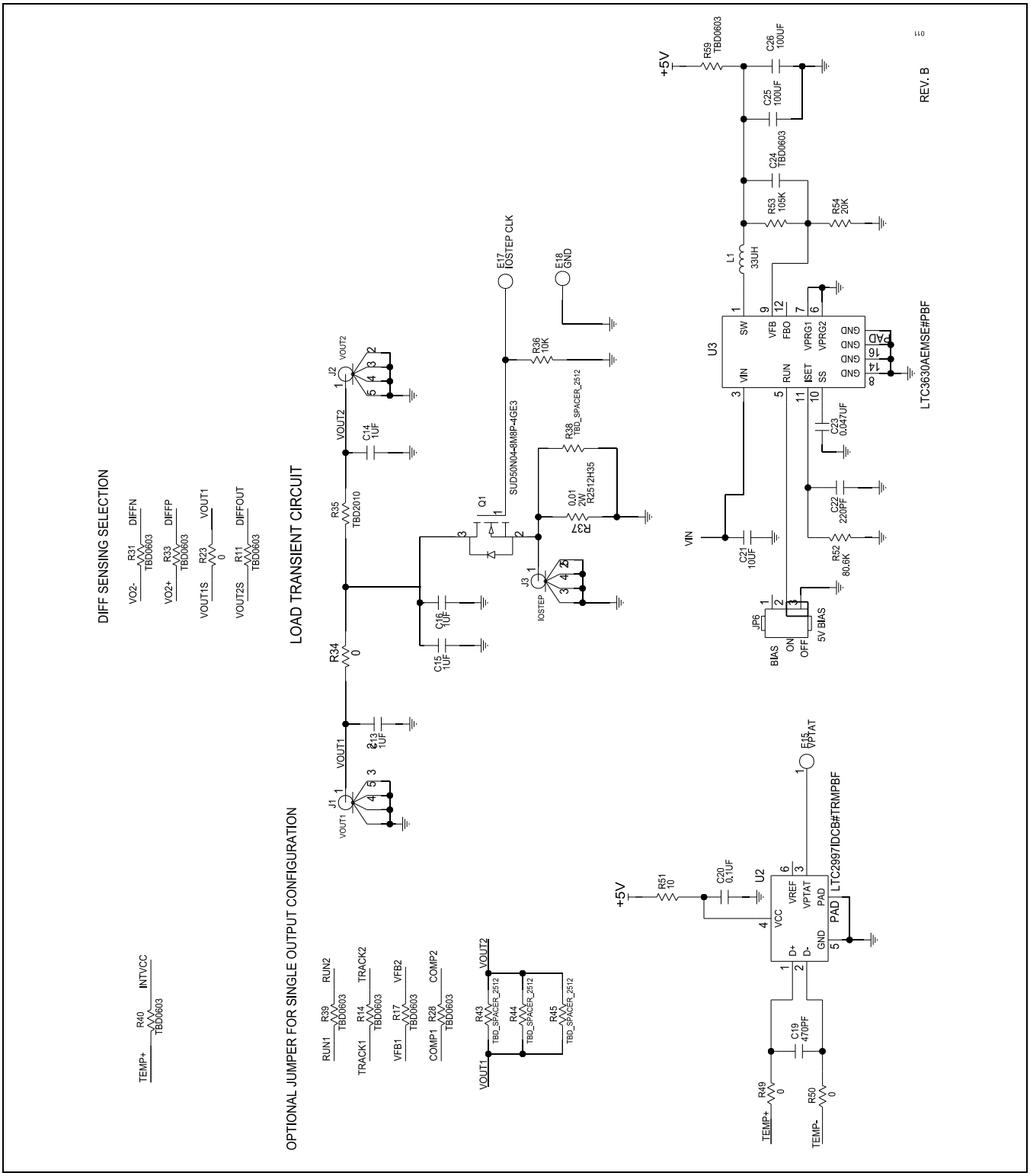
QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
1	L1	IND SHIELDED POWER, 105Ω DCR 3.6A	COILCRAFT INC, XAL6060-333MEC
1	Q1	TRAN N-CH MOSFET 40V 14A	VISHAY, SUD50N04-8M8P-4GE3
5	R1, R3, R22, R26, R51	RES. SMD 10Ω 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW060310R0FKEA
6	R7, R23, R48-R50, R55	RES. SMD 0Ω JUMPER 1/10W 0603 AEC-Q200 PRECISION POWER	VISHAY, CRCW06030000Z0EA
2	R10, R13	RES. SMD 6.04kΩ 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW06036K04FKEA
5	R9, R12, R15, R18, R25	RES. SMD 60.4kΩ 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW060360K4FKEA
1	R19	RES. SMD 40.2kΩ 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW060340K2FKEA
3	R24, R27, R36	RES. SMD 10kΩ 1/10W 1% 0603	VISHAY, CRCW060310K0FKEA
1	R30	RES. SMD 95.3kΩ 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW060395K3FKEA
1	R37	RES. SMD 0.01Ω 1% 2W 2512 AEC-Q200	VISHAY, WSL2512R0100FEA18
2	R46, R47	RES. SMD 1.4kΩ 1% 1/10W 0603 AEC-Q200	PANASONIC, ERJ-3EKF1401V
1	R5	RES. SMD 845kΩ 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW0603845KFKEA
1	R52	RES. SMD 80.6kΩ 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW060380K6FKEA
2	R53	RES. SMD 105kΩ 1% 1/10W 0603 AEC-Q200	PANASONIC, ERJ-3EKF1053V
1	R54	RES. SMD 20kΩ 5% 1/10W 0603 AEC-Q200	PANASONIC, ERJ-3GEYJ203V
1	U1	IC-ADI SOURCE/SINK DUAL OR SINGLE µModule REGULATOR WITH INPUT OVERVOLTAGE PROTECTION, BGA144	ANALOG DEVICES, LTM4652EY#PBF
1	U2	IC-ADI REMOTE/INTERNAL TEMPERATURE SENSOR, DFN6	ANALOG DEVICES, LTC2997IDCB#TRMPBF
1	U3	IC-ADI STEP-DOWN DC-TO-DC CONVERTER SYNCHRONOUS 76V 0.5A AUTOMOTIVE 16LD MSOP	ANALOG DEVICES, LTC3630AEMSE#PBF
Additional Evaluation Board Circuit Components			
	C3, C4, C8, C11, C24	CAP., OPTION, 0603	
	COUT9, COUT10, COUT12, COUT18	CAP., OPTION, 7343	
	R2, R4, R6, R8, R11, R14, R16, R17, R20, R21, R28, R29, R31-R33, R39-R42, R59	RES., OPTION, 0603	
	R35	RES., OPTION, 2010	
	R19, R22, R26, R27, R30, R31, R33, R34, R38, R39, R46, R51, R53, R58, R60, R61, R63, R66, R68	RES., OPTION, 2512	
	R34	RES. SMD 0Ω JUMPER 2010 AEC-Q200	VISHAY, CRCW20100000Z0EF
Hardware: For Evaluation Board Only			
16	E1-E10, E12, E13-E18	CONN-PCB SOLDER TERMINAL TEST POINT TURRET 0.094″ MTG. HOLE PCB 0.062″ THK	MILL-MAX, 2501-2-00-80-00-00-07-0
3	J1-J3	CONN-PCB BNC JACK ST 50Ω	AMPHENOL CONNEX, 112404

QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
2	J4, J5	CONN-PCB BANANA JACK	KEYSTONE ELECTRONICS, 575-4
4	J6-J9	CONN-PCB THREADED BROACHING STUD, 625MIL LENGTH	PENN ENGINEERING
4	J6-J9	CONNECTOR RING LUG TERMINAL, 10 CRIMP, NON-INSULATED	KEYSTONE, 8205
4	J6-J9	WASHER, #10 FLAT STEEL	KEYSTONE, 4703
8	J6-J9	NUT, HEX STEEL, 10-32 THREAD, 9.27mm OUT DIA	KEYSTONE, 4705
2	JP1, JP5	CONN-PCB 6-POS MALE HDR UNSHROUDED DUAL ROW ST, 2mm PITCH, 2.70mm SOLDER TAIL	WÜRTH ELEKTRONIK, 62000621121
4	JP2-JP4, JP6	CONN-PCB 3-POS MALE HDR UNSHROUDED SINGLE ROW ST, 2mm PITCH, 2.70mm SOLDER TAIL	WÜRTH ELEKTRONIK, 62000311121
4	MH1-MH4	STANDOFF, BRD SPT SNAP FIT 12.7mm LENGTH	KEYSTONE, 8833
6	XJP1-XJP6	SHUNT FEMALE 2-POS 2mm	WÜRTH ELEKTRONIK, 60800213421

EVAL-LTM4652-AZ Evaluation Board Schematic



EVAL-LTM4652-AZ Evaluation Board Schematic (continued)



Ordering Information

PART	TYPE
EVAL-LTM4652-AZ	The EVAL-LTM4652-AZ evaluation board features the LTM4652EY µModule regulator.

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	09/24	Initial release.	—

Notes