Evaluation Board User Guide

EVAL-LTM4712-A1Z

LTM4712

36V, High Efficiency Dual Phase Buck-Boost µModule Regulator

2 × LTM4712, 24A

General Description

The EVAL-LTM4712-A1Z evaluation board is a power supply generating 12V, 24A (max) from a 5V to 36V input. The EVAL-LTM4712-A1Z is a dual-phase solution featuring the *LTM4712*, a high-efficiency, buck-boost µModule® (micromodule) regulator. The EVAL-LTM4712-A1Z is capable of 24A in buck and buck-boost modes and 12A in boost mode. Derating is necessary for certain V_{IN}, V_{OUT}, frequency, and thermal conditions. See the *Performance Summary* section and the LTM4712 data sheet for more information.

The EVAL-LTM4712-A1Z evaluation board has an optional constant-current feature to deliver a precise, regulated current while the load may vary.

The EVAL-LTM4712-A1Z evaluation board is optimized using a default frequency of 400kHz. The peak current mode control architecture allows easy current sharing. The LTM4712 operates in continuous current mode by default but can be placed in pulse-skipping mode to optimize efficiency at light loads.

The LTM4712 is offered in a 16mm × 16mm × 8.34mm ball grid array (BGA) package suitable for automated assembly by standard surface mount equipment. The µModule package features an inductor on top of the molded substrate for improved heatsinking capability.

The LTM4712 data sheet gives a complete description of the device, including operation and application information. The data sheet must be read in conjunction with this user guide prior to working on or modifying the EVAL-LTM4712-A1Z evaluation board.

Features and Benefits

- Parallel for high-power applications
  - Good current sharing
- Current monitoring pin for all channels
- Optional constant current mode

EVAL-LTM4712-A1Z Board Files

FILE	DESCRIPTION
EVAL-LTM4712-A1Z	Evaluation board design files.

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

EVAL-LTM4712-A1Z Evaluation Board Photo

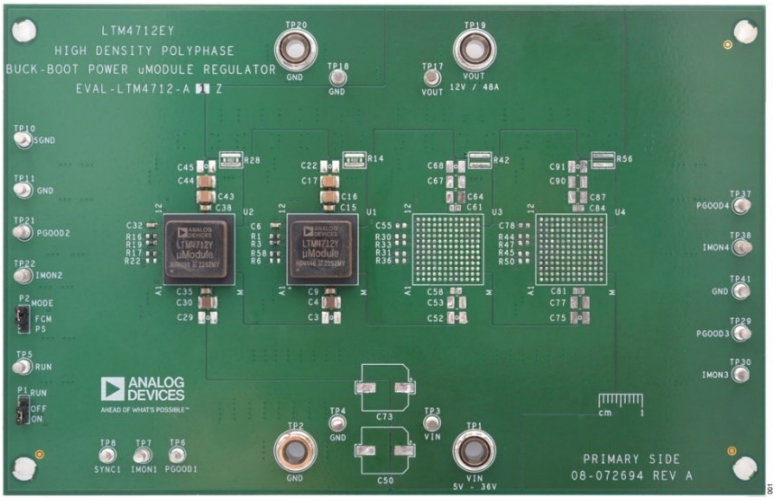


Figure 1. EVAL-LTM4712-A1Z Evaluation Board (Part Marking Is either Ink Mark or Laser Mark)

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

Performance Summary

Specifications are at T_A = 25°C

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	VALUE
Input voltage range	V_{IN}		5		36	V
Output voltage	V_{OUT}	R_{FB} = 4.54kΩ (R12)		12		V
Maximum C_{OUT} voltage		Default C_{OUT}		16		V
Switching frequency	f_{SW}	R_{FREQ} = 140kΩ (R3, R19, R33, R47)		400		kHz
Maximum output current	I_{OUT}	V_{IN} = 10V to 36V, f_{SW} = 400kHz			24	A
Maximum output current	I_{OUT}	V_{IN} = 5V to 10V, f_{SW} = 400kHz			12	A
Efficiency	η	V_{IN} = 12V, I_{OUT} = 24A, f_{SW} = 400kHz		96.3		%
Peak efficiency		V_{IN} = 24V, I_{OUT} = 15A, f_{SW} = 400kHz		97.1		%

Quick Start

Required Equipment

- One power supply
- One electronic load
- Two digital multimeters (DMMs)

Quick Start Procedure

The EVAL-LTM4712-A1Z evaluation board is an easy way to evaluate the performance of the LTM4712 in a multiphase application. See *Figure 2* for proper measurement equipment setup and use the following procedure.

1. Place jumpers in the following positions for a typical $12V_{OUT}$ operation.

JP1	RUN	ON
JP2	MODE	Forced continuous mode (FCM)

2. With power off, connect the input power supply to VIN (TP1) and to GND (TP2).

3. Connect the output load to VOUT (TP19) and to GND (TP20).

4. Connect a DMM between test points VIN (TP3) and GND (TP4) to measure input voltage. Connect another DMM between test points VOUT (TP17) and GND (TP18) to measure DC output voltage.

5. Turn on the power at the input. Set the voltage of the DC power supply between 5V to 36V. Ensure that the input voltage does not exceed 36V. Check that the output voltage measures 12V ±0.5% (or 11.94V to 12.06V).

6. Once the proper output voltage is established, adjust the load within the operating range and measure the output voltage regulation, ripple voltage, efficiency, and other parameters.

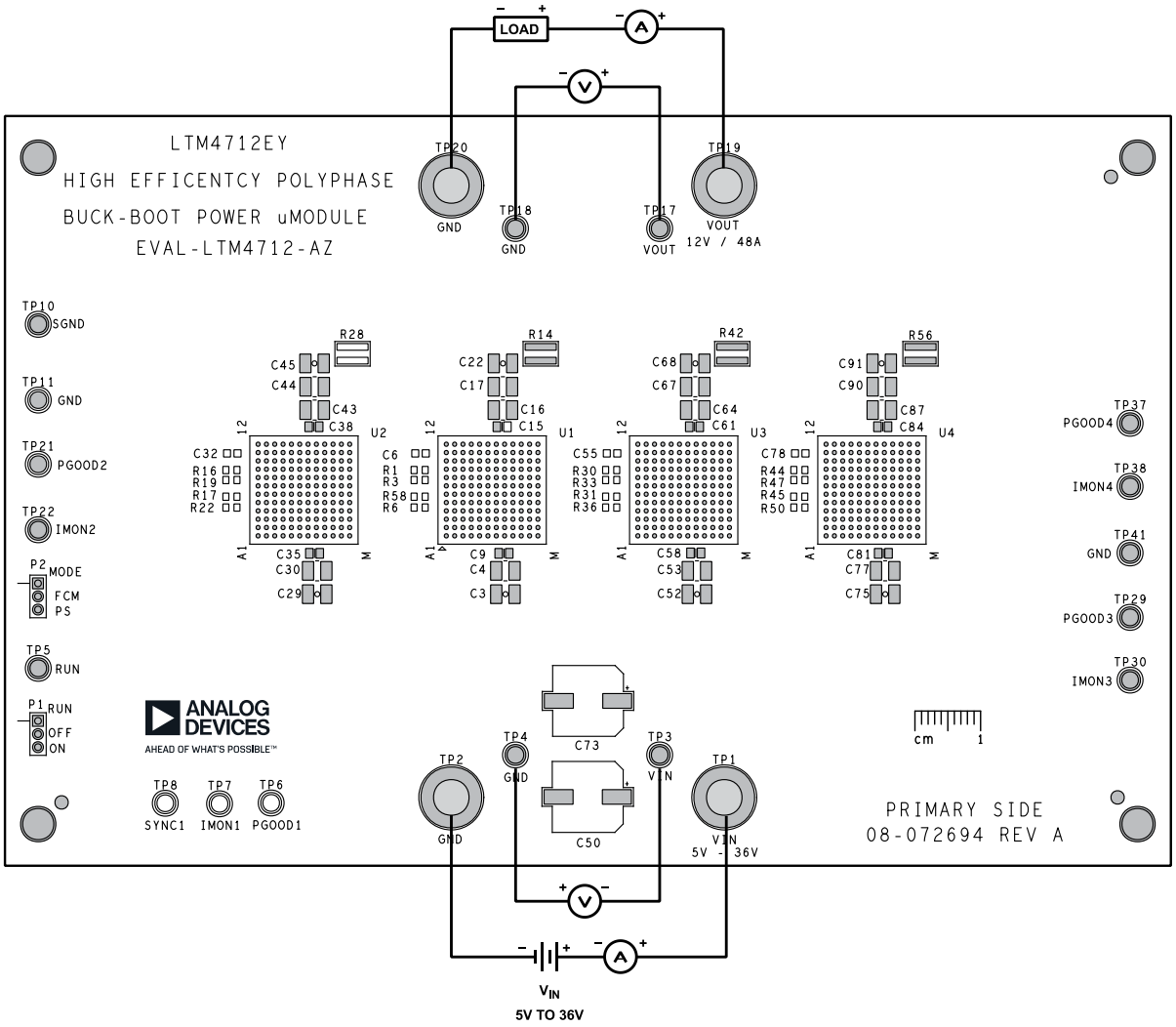


Figure 2. EVAL-LTM4712-A1Z Evaluation Board Test Setup

To measure the input/output voltage ripples properly, do not use the long ground lead on the oscilloscope probe. See *Figure 3* for a 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.

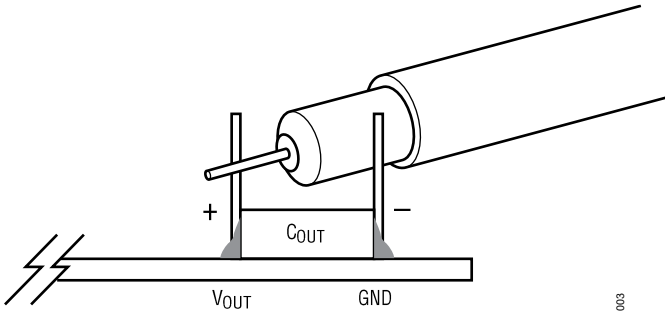


Figure 3. Scope Probe Placement for Measuring Input or Output Ripple Voltage

EVAL-LTM4712-A1Z Evaluation Board Features Procedure

Current Monitoring

The EVAL-LTM4712-A1Z evaluation board features output current monitoring (I_{MON}) for each channel. By measuring the voltage between ISP and ISN with a sense resistor, a voltage directly proportional to the measured current can be observed and used to accurately determine the amount of current supplied by each LTM4712 module (see *Figure 4*).

To accurately monitor the output current in each paralleled µModule, 2mΩ sense resistors are added to each channel output, connecting each channel to a shared V_{OUT}. The respective current values are given by the following equation: $I_{OUT} = [(V_{IMON} - 0.2V)/20]/2m\Omega$.

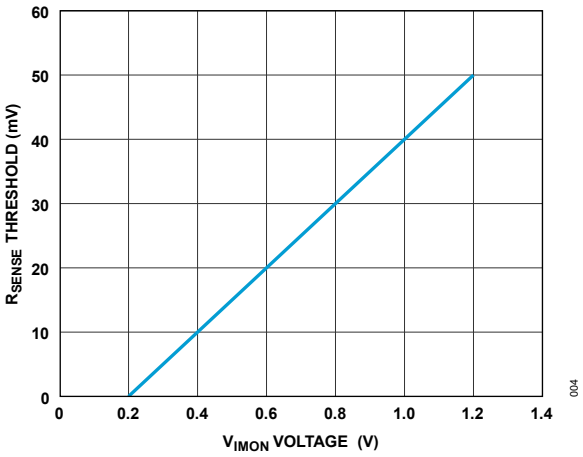


Figure 4. R_{SENSE} Voltage Threshold vs. V_{IMON}

Constant Current Mode (Optional)

The LTM4712 can produce a constant-current output after simple component selection. Each LTM4712 module maintains constant-output current according to (I_{SET}) voltage limit and R_{SENSE} value ($I_{OUT} = V_{SENSE\_MAX}/R_{SENSE}$). The V_{SENSE} is determined by I_{SET} voltage as shown in *Figure 4*. All µModule ICs in parallel must have the same value of R_{ISET} and R_{SENSE}. Refer to the LTM4712 data sheet for more detailed information.

Note

The V_{OUT} needs to be set higher than $n \times (I_{OUT} \times R_{LOAD})$ to maintain constant-current regulation, where *n* is the number of modules in parallel.

For example, using two LTM4712 modules, V_{OUT} is set to 12V (4.54kΩ on R_{FB}), and the R_{SENSE} voltage limit on each part is set to 10mV (26.3kΩ on each I_{SET}).

When a resistive load of 3Ω is placed on the shared output, I_{OUT} follows ($\frac{12V_{OUT}}{3\Omega} = 4A\ total\ or\ 2A\ per\ channel$). As the value of R_{LOAD} decreases, I_{OUT} will increase according to this equation. When the I_{OUT} total reaches 10A, each module supplies 5A, and each R_{SENSE} voltage threshold is reached ($10mV = 5A \times 2m\Omega$). If R_{LOAD} decreases further, instead of allowing I_{OUT} to increase, COMP voltage is pulled lower, and V_{OUT} changes to support a constant-current value of 5A per channel (10A total). Therefore, if R_{LOAD} decreases to 0.5Ω, V_{OUT} decreases to $5V_{OUT}$ to maintain 10A or 5A load per channel ($5V/0.5\Omega/2\ channels = 5A\ per\ channel$).

Typical Performance Characteristics

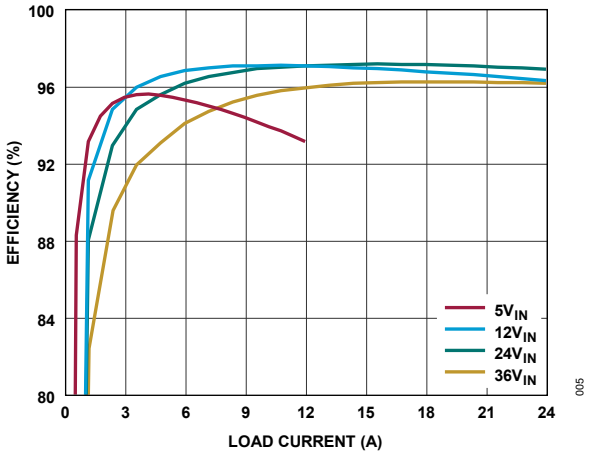


Figure 5. Efficiency vs. Load Current (12V_{OUT}, T_A = 25°C)

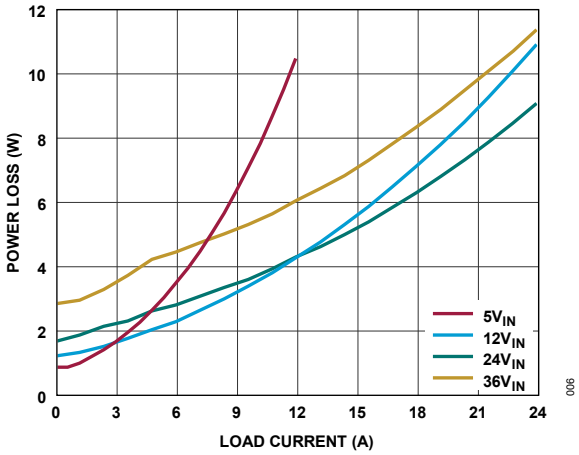


Figure 6. Power Loss vs. Load Current (12V_{OUT}, T_A = 25°C)

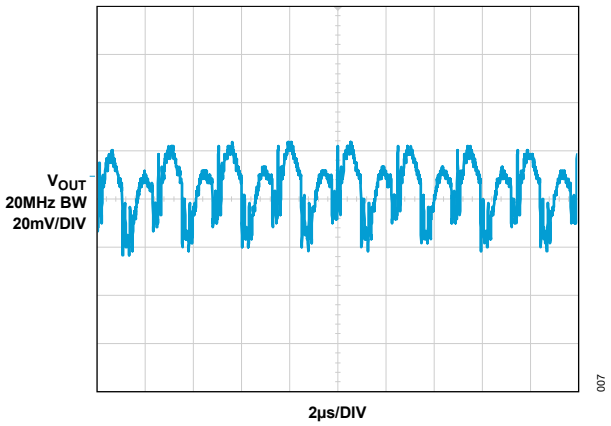


Figure 7. Output Voltage Ripple (Boost Mode)

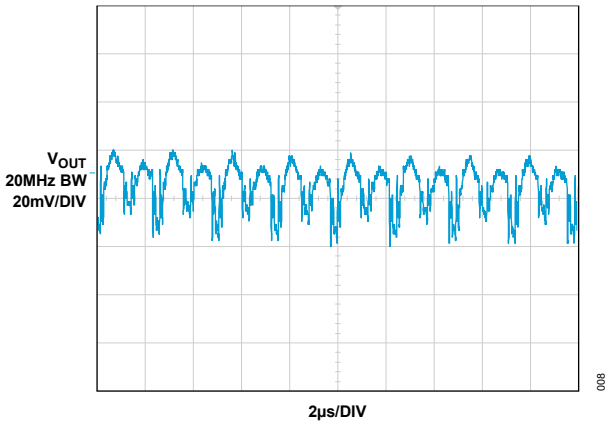
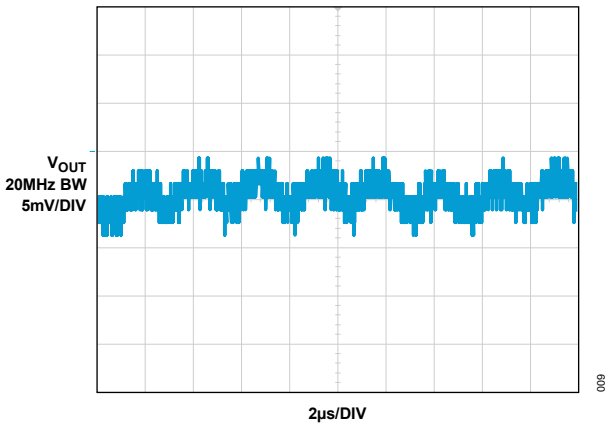
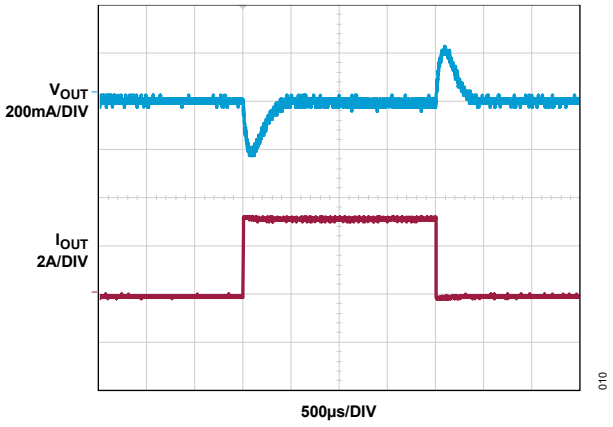


Figure 8. Output Voltage Ripple (Buck-Boost Mode)



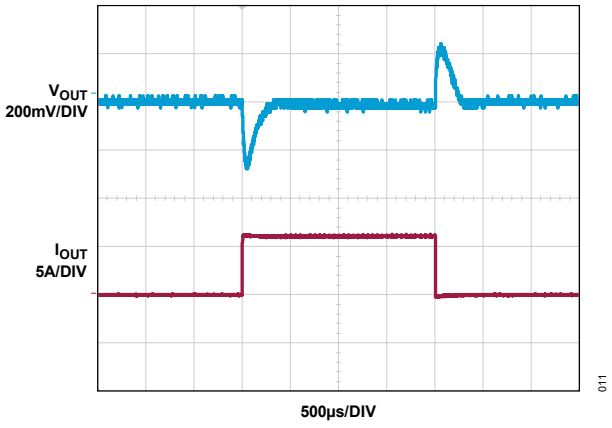
V_{IN} = 24V, V_{OUT} = 12V, I_{OUT} = 24A
f_{SW} = 400kHz
V_{OUT} PEAK-TO-PEAK = 11mV, MEASURED ON C26

Figure 9. Output Voltage Ripple (Buck Mode)



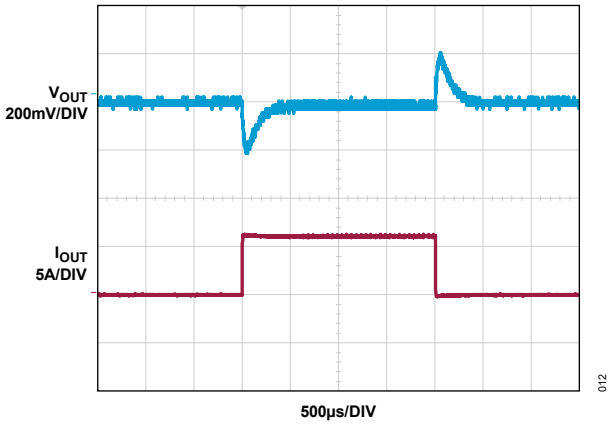
V_{IN} = 5V, V_{OUT} = 12V, I_{OUT} = 0A TO 3A
f_{SW} = 400kHz
V_{OUT} PEAK-TO-PEAK = 490mV

Figure 10. Load Transient Response (Boost Mode)



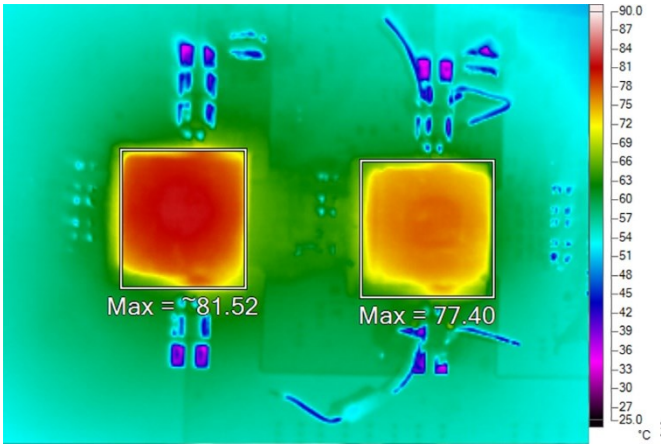
V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 0A TO 6A
f_{SW} = 400kHz
V_{OUT} PEAK-TO-PEAK = 540mV

Figure 11. Load Transient Response (Buck-Boost Mode)



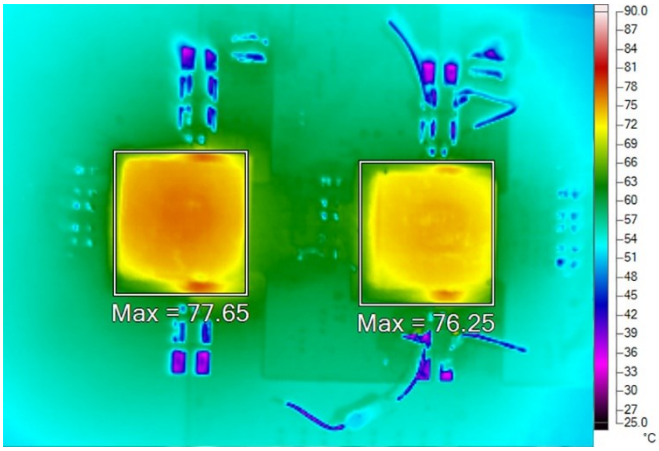
V_{IN} = 24V, V_{OUT} = 12V, I_{OUT} = 0A TO 6A
f_{SW} = 400kHz
V_{OUT} PEAK-TO-PEAK = 420mV

Figure 12. Load Transient Response (Buck Mode)



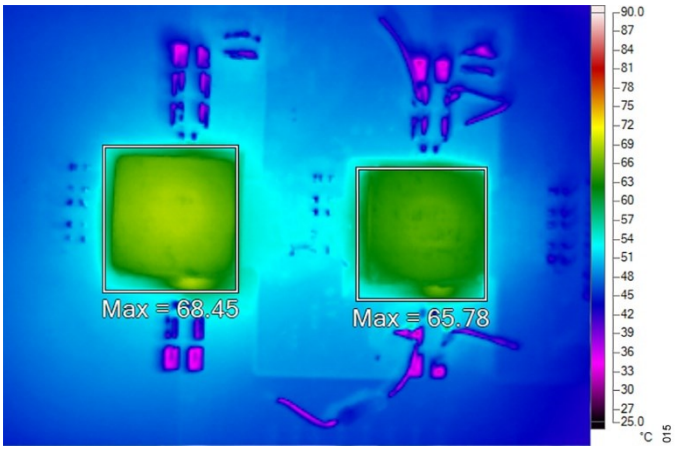
V_{IN} (V)	V_{OUT} (V)	LOAD (A)	MAX CASE TEMP (°C)
12	12	24	81.5

Figure 13. Buck-Boost Mode Measured Thermal Capture with 0LFM Airflow, T_A = 25°C



V_{IN} (V)	V_{OUT} (V)	LOAD (A)	MAX CASE TEMP (°C)
6	12	12	77.7

Figure 14. Boost Mode Measured Thermal Capture with 0LFM Airflow, T_A = 25°C



V_{IN} (V)	V_{OUT} (V)	LOAD (A)	MAX CASE TEMP (°C)
24	12	24	68.5

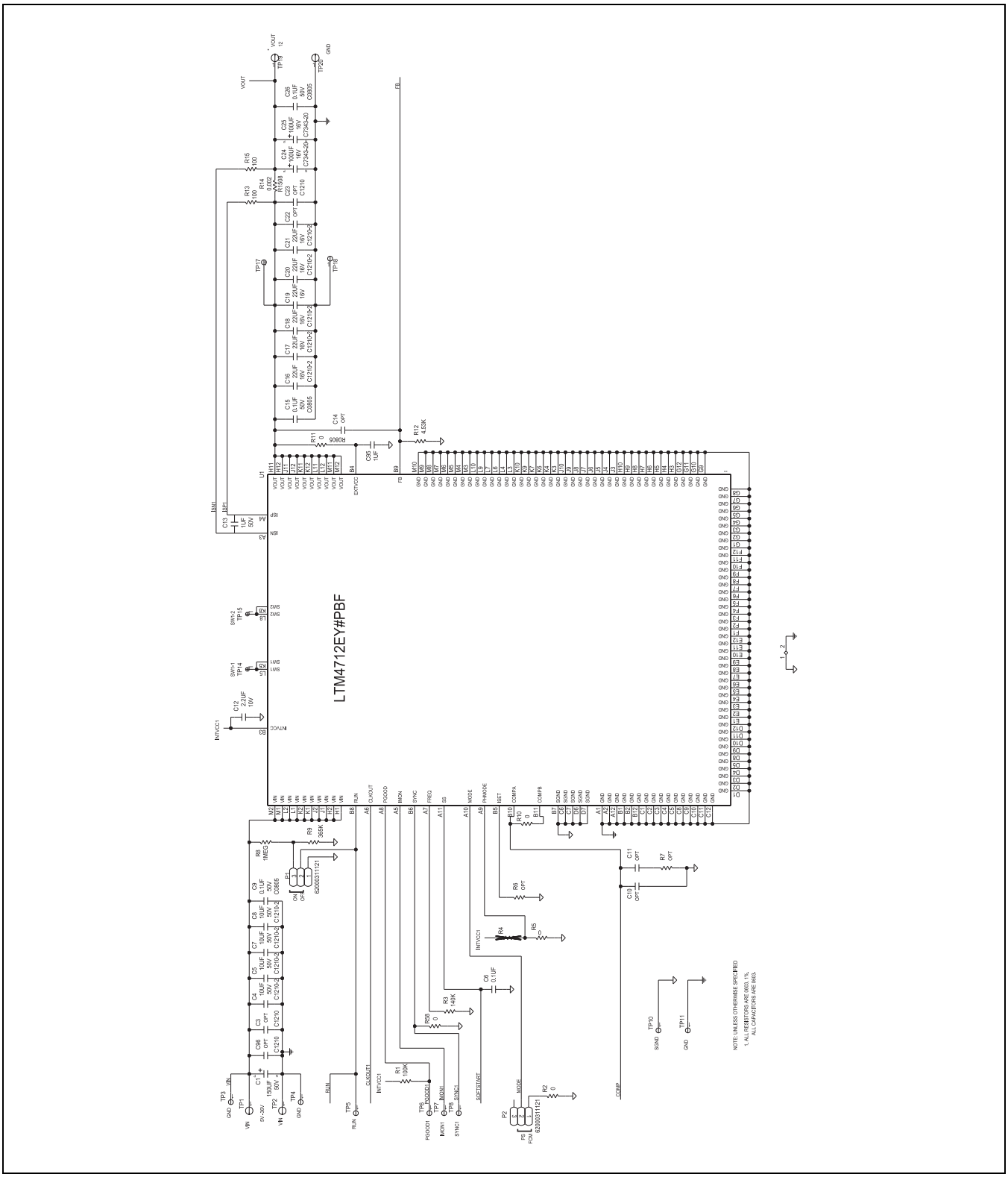
Figure 15. Buck Mode Measured Thermal Capture with 0LFM Airflow, T_A = 25°C

EVAL-LTM4712-A1Z Evaluation Board Bill of Materials

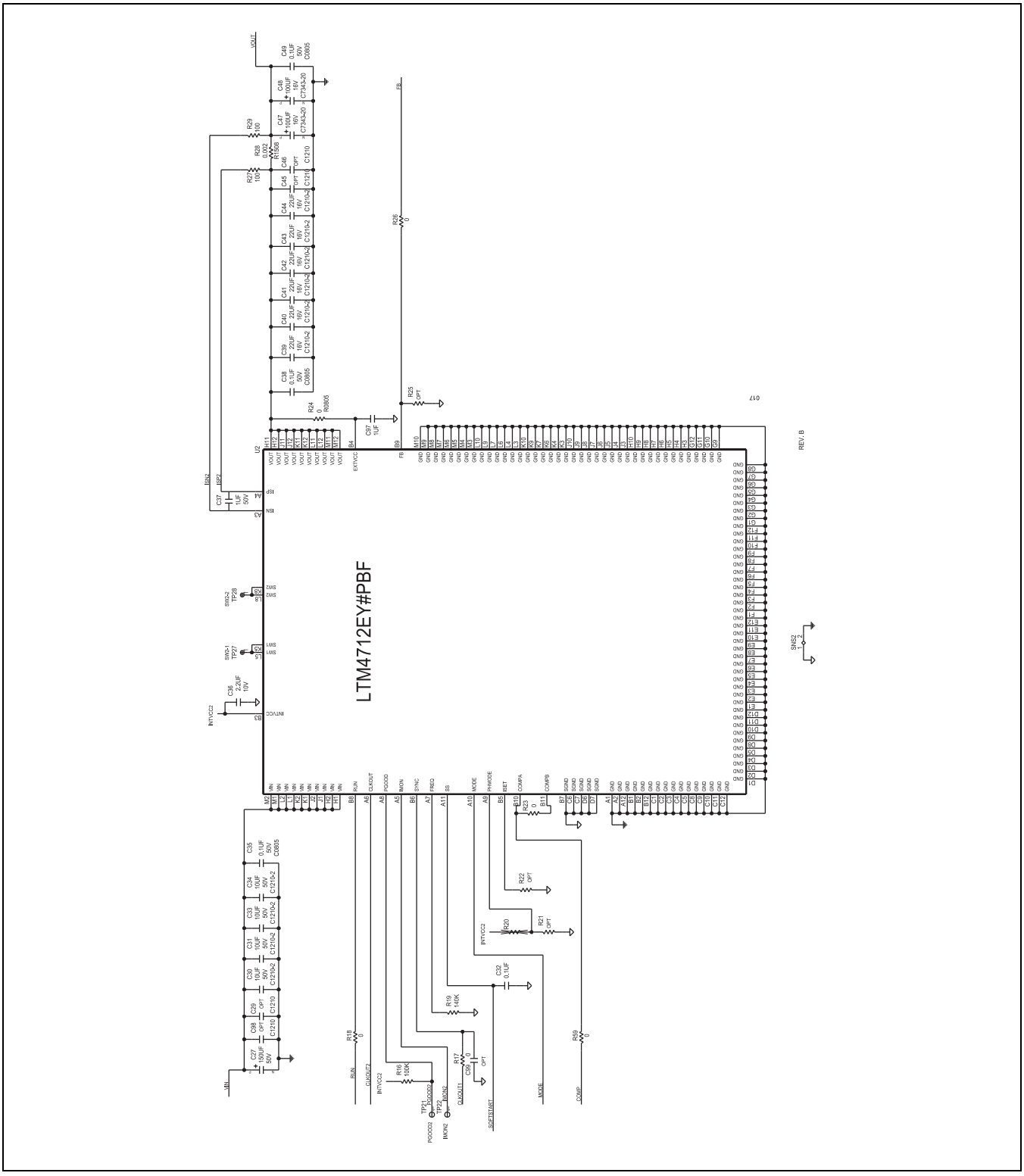
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	4	C1, C27, C50, C73	CAP. ALUM POLY 150µF 50V 20% 10mm × 10.2mm AEC-Q200 670mA 2000h	PANASONIC, EEEFK1H151P
2	4	C95, C97, C101, C104	CAP. CER 1µF 16V 10% X7R 0603	TAIYO YUDEN, EMK107B7105KA-T
3	4	C12, C36, C59, C82	CAP. CER 2.2µF 10V 10% X7R 0603	MURATA, GRM188R71A225KE15D
4	4	C13, C37, C60, C83	CAP. CER 1µF 50V 10% X7R 0603	TAIYO YUDEN, MSASU168AB7105KTNA01
5	10	C9, C15, C26, C35, C38, C49, C58, C61, C81, C84	CAP. CER 0.1µF 10% 50V X7R 0805	AVX CORPORATION, 08055C104KAT2A
6	24	C16-C21, C39-C44, C62-C67, C85-C90	CAP. CER 22µF 16V 10% X7R 1210	MURATA, GRM32ER71C226KEA8L
7	9	C24, C25, C47, C48, C70-C72, C93, C94	CAP. TANT POLY 100µF 20% 16V 7343-20, 0.05Ω ESR	PANASONIC, 16TQC100MYF
8	16	C4, C5, C7, C8, C30, C31, C33, C34, C53, C54, C56, C57, C76, C77, C79, C80	CAP. CER 10µF 50V 10% X7R 1210	MURATA, GRM32ER71H106KA12L
9	4	C6, C32, C55, C78	CAP. CER 0.1µF 16V 10% X7R 0603	AVX, 0603YC104KAT2A
10	4	R1, R16, R30, R44	RES. SMD 100kΩ 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW0603100KFKEA
11	22	R2, R4, R10, R17, R18, R20, R23, R26, R31, R32, R34, R37, R40, R45, R46, R48, R51, R54, R58-R61	RES. SMD 0Ω JUMPER 1/10W 0603 AEC-Q200 PRECISION POWER	VISHAY, CRCW06030000Z0EA
12	4	R11, R24, R38, R52	RES. SMD 0Ω JUMPER 1/8W 0805 AEC-Q200	VISHAY, CRCW08050000Z0EA
13	1	R12	RES. SMD 2.26kΩ 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW06032K26FKEA
14	8	R13, R15, R27, R29, R41, R43, R55, R57	RES. SMD 100Ω 1% 1/10W 0603 AEC-Q200	PANASONIC, ERJ-3EKF1000V
15	4	R14, R28, R42, R56	RES. SMD 0.002Ω 1% 1W 1508 LONG-SIDE TERMINAL	SUSUMU CO, LTD, RL3720WT-R002-F
16	4	R3, R19, R33, R47	RES. SMD 158kΩ 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW0603158KFKEA
17	1	R8	RES. SMD 1MΩ 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW06031M00FKEA
18	1	R9	RES. SMD 365kΩ 1% 1/10W 0603 AEC-Q200	VISHAY, CRCW0603365KFKEA
19	4	U1-U4	IC, 36V_{IN} 12A BUCK-BOOST µModule REGULATOR, BGA-144	ANALOG DEVICES, LTM4712
Additional Evaluation Board Circuit Components				
1	6	C10, C11, C14, C99, C102, C105	CAP., OPTION, 0603	
2	16	C3, C22, C23, C29, C45, C46, C52, C68, C69, C75, C91, C92, C96, C98, C100, C103	CAP., OPTION, 1210	

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
3	12	R5, R6, R7, R21, R22, R25, R35, R36, R39, R49, R50, R53	RES., OPTION, 0603	
Hardware For Evaluation Board Only				
1	17	TP3-TP8, TP10, TP11, TP17, TP18, TP21, TP22, TP29, TP30, TP37, TP38, TP41	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
2	4	TP1, TP2, TP19, TP20	CONN-PCB BANANA JACK	KEYSTONE ELECTRONICS, 575-4
3	2	P1, P2	CONN-PCB 3-POS MALE HDR UNSHROUDED SINGLE ROW ST, 2mm PITCH, 2.70mm SOLDER TAIL	WURTH ELEKTRONIK, 62000311121
4	4	MOUNTING HOLE	STANDOFF, SELF-RETAINING SPACER, 12.7mm LENGTH	WURTH ELEKTRONIK, 702935000
5	2	XJP1, XJP2	SHUNT FEMALE 2-POS 2mm	WURTH ELEKTRONIK, 60800213421

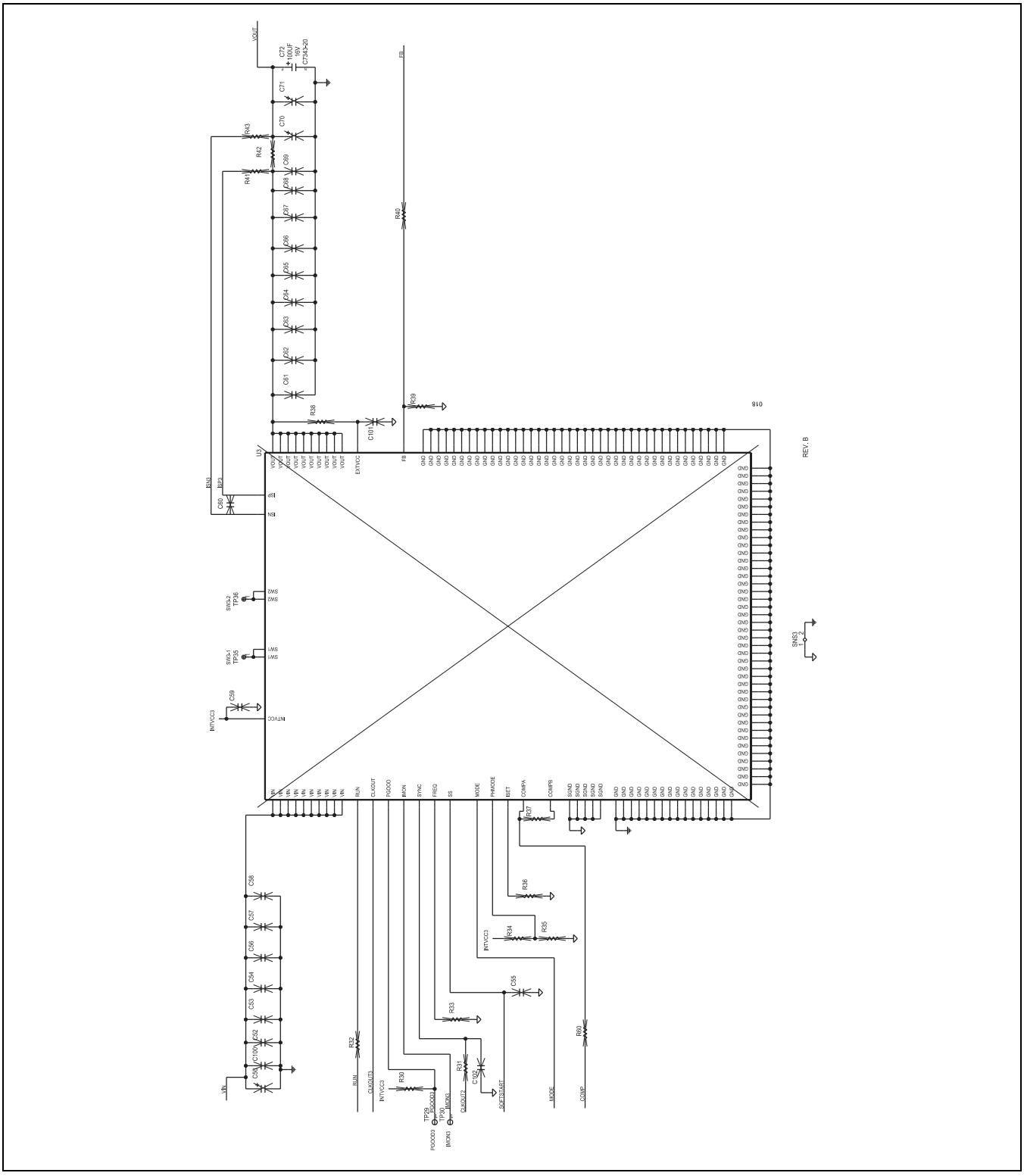
EVAL-LTM4712-A1Z Evaluation Board Schematics



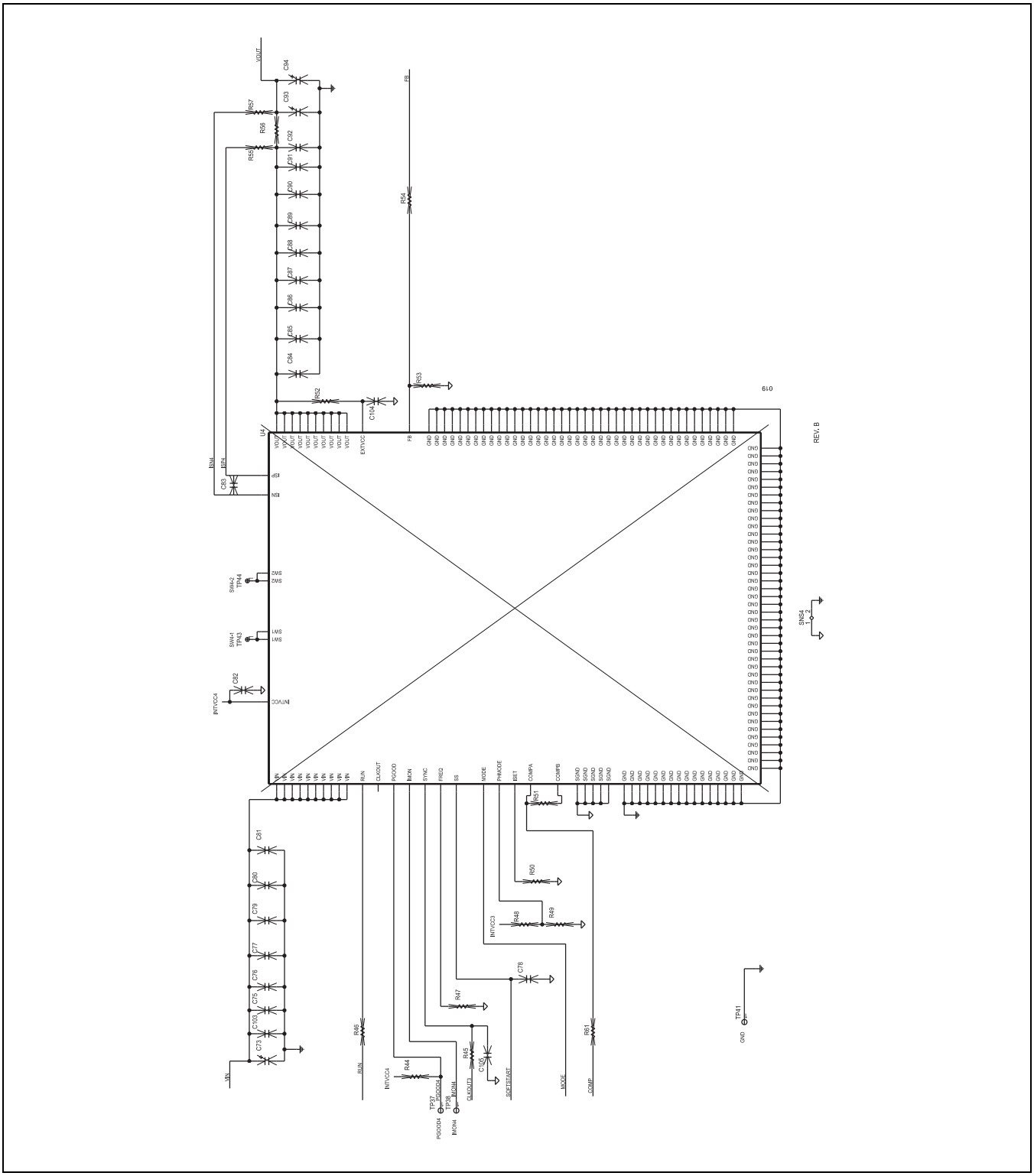
EVAL-LTM4712-A1Z Evaluation Board Schematics (continued)



EVAL-LTM4712-A1Z Evaluation Board Schematics (continued)



EVAL-LTM4712-A1Z Evaluation Board Schematics (continued)



Ordering Information

PART	TYPE
EVAL-LTM4712-A1Z	36V, 24A max, high-efficiency dual phase buck-boost µModule regulator featuring two LTM4712 power modules.

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	3/25	Initial release.	—

Notes