Evaluation Board User Guide

EVAL-LTC7872-AZ

LTC7872/LTC7060

48V-to-14V, 4-phase, 1.7kW Bidirectional Supply

General Description

The evaluation board EVAL-LTC7872-AZ is a high power, high efficiency, four-phase bidirectional converter featuring the LTC7872 and LTC7060. The terminals labeled V_{HIGH} and V_{LOW} are either inputs or outputs depending on the direction of power flow. When the switch SW1 is set to the BUCK position, V_{LOW} provides a 14V output and V_{HIGH} is the input with a range of 30V to 75V with a maximum load current of 120A. When the switch SW1 is in the BOOST position, V_{HIGH} provides a 48V output and V_{LOW} is the input with a range of 10V to 14V with a maximum load current of 34A at a 14V input voltage. The maximum I_{LOW} current is 120A in both directions. The maximum output power is 1.7kW when operating as a buck within the input voltage range. When operating as a boost, the maximum output power is 1.6kW when the input voltage is 14V. External airflow is required when operating at maximum power in either direction of power flow. The MOSFETs in each phase are driven by the LTC7060 half-bridge driver.

The inductor current for each phase is sensed with a low 1mΩ sense resistor using a highly accurate AC/DC current-sensing architecture with low power dissipation. The LTC7872's constant-current loop provides a DC current limit for the current flowing in or out of the V_{LOW} terminal depending on the state of the BUCK pin. This current can be programmed with the SETCUR pin and monitored with the IMON pin.

Features

- SPI-Compatible Port
- Pin-Selectable, Light-Load Operating Modes
  - Buck: FCM, DCM, and Burst Mode Operation
  - Boost: FCM and DCM
- Optional Jumper to Enable Spread-Spectrum Modulation
- Footprints for Optional PG-HSOF-8-1 MOSFETs and Coupled Inductors
- Optional UVLO Circuits for V_{HIGH} and V_{LOW}
- SYNC, CLKOUT, RUN, FAULT, PGOOD, and PWMEN Pins
- A DC2026C Linduino Board and QuikEval Software Allow:
  - Increasing or Decreasing the V_{LOW}/V_{HIGH} Regulation Voltage When SW1 Switch Is in Buck/Boost Position
  - Changes to the DC Current Limit Using the SETCUR Pin
  - Making Adjustments to the Frequency Spread and Modulation Rate of the Spread Spectrum Circuit When Spread Spectrum Is Enabled
  - Monitoring the Operational Status and Faults of the LTC7872

Design files for this circuit board are available.

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Performance Summary (T_A = 25°C)

Buck Mode

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage	V_{HIGH}		30		75	V
Output Voltage	V_{LOW}		13.6	14	14.4	V
Output Current	I_{LOW}		120			A
Operating Frequency	f_{SWITCH}			150		kHz
Efficiency		V_{HIGH} = 48V I_{LOW} = 120A AIRFLOW = 2.5m/s		96.7		%

Boost Mode

PARAMETER	SYMBOL	CONDITIONS	MIN			TYP
Input Voltage	V_{LOW}		10		14	V
Output Voltage	V_{HIGH}		46.8	48	49.2	V
Output Current	I_{HIGH}	V_{LOW} = 14V			34	A
		V_{LOW} = 12V			30	
		V_{LOW} = 10V			25	
Operating Frequency	f_{SWITCH}			150		kHz
Efficiency		V_{LOW} = 14V I_{HIGH} = 34A AIRFLOW = 2.5m/s		95		%

Quick Start Procedure

Buck Mode

1. See the measurement setup in *Figure 1* for Buck mode.
2. With the power off, connect the input power supply to the board through the V_{HIGH} and GND terminals. Connect the load to the V_{LOW} and GND terminals.
3. Connect the voltmeters to monitor V_{HIGH} and V_{LOW}.
4. Place the SW1 switch in the Buck position.
5. Ensure jumpers are set as follows:
   a. Place JP1 (MODE) in the FCM position.
   b. Place JP2 (RUN) in the ON position.
   c. Place JP3 (External Bias from Linduino) in the NO position.
   d. Place JP5 (V_{HIGH}/V_{LOW} UVLO circuits) in the NONE position.
6. With no load and the input power supply set to 0V, turn on the power supply. Slowly increase the power supply to 30V.
7. Verify that the proper output voltage is set to 14V (± 2.85%).
8. Once the proper output voltage is established, adjust the input supply voltage, adjust the load, and observe the output voltage regulation, ripple voltage, efficiency, and other parameters. **Note:** Ensure that the input power supply voltage does not exceed 75V.

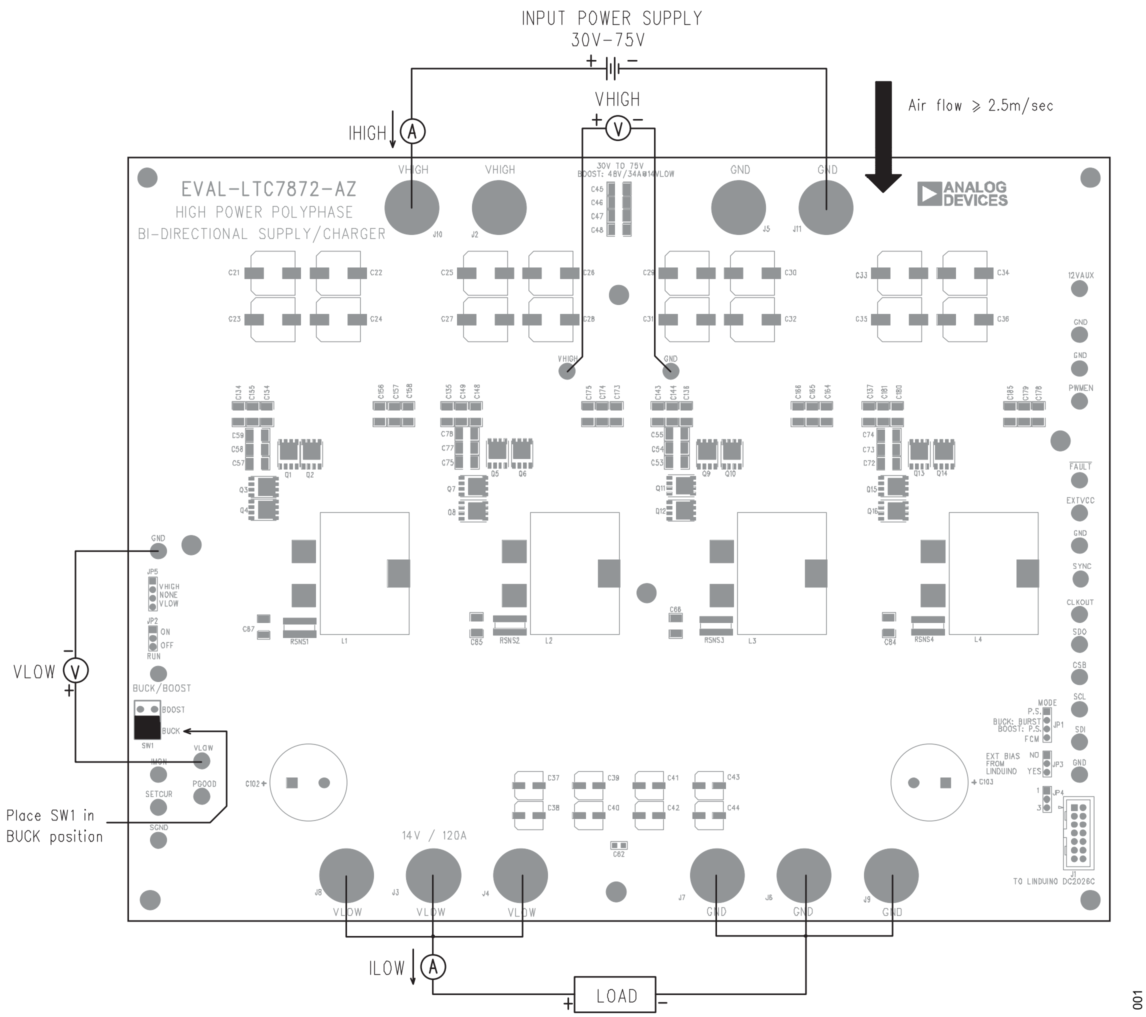


Figure 1. Measurement Setup for Buck Mode

Boost Mode

1. See the measurement setup in *Figure 2* for Boost mode.
2. With the power off, connect the input power supply to the board through the V_{LOW} and GND terminals. Connect the load to the V_{HIGH} and GND terminals.
3. Connect the voltmeters to monitor V_{HIGH} and V_{LOW}.
4. Place switch SW1 in the Boost position.
5. Ensure jumpers are set as follows:
   a. Place JP1 (MODE) in the FCM position.
   b. Place JP2 (RUN) in the ON position.
   c. Place JP3 (External Bias from Linduino) in the NO position.
   d. Place JP5 (V_{HIGH}/V_{LOW} UVLO circuits) in the NONE position.
6. With no load and input power supply set to 0V, turn on the power supply. Slowly increase the power supply to 10V.
7. Verify that the proper output voltage is set to 48V (± 2.5%).
8. Once the proper output voltage is established, adjust the input supply voltage, adjust the load, and observe the output voltage regulation, ripple voltage, efficiency, and other parameters. **Note:** Ensure that the input power supply does not exceed 14V.

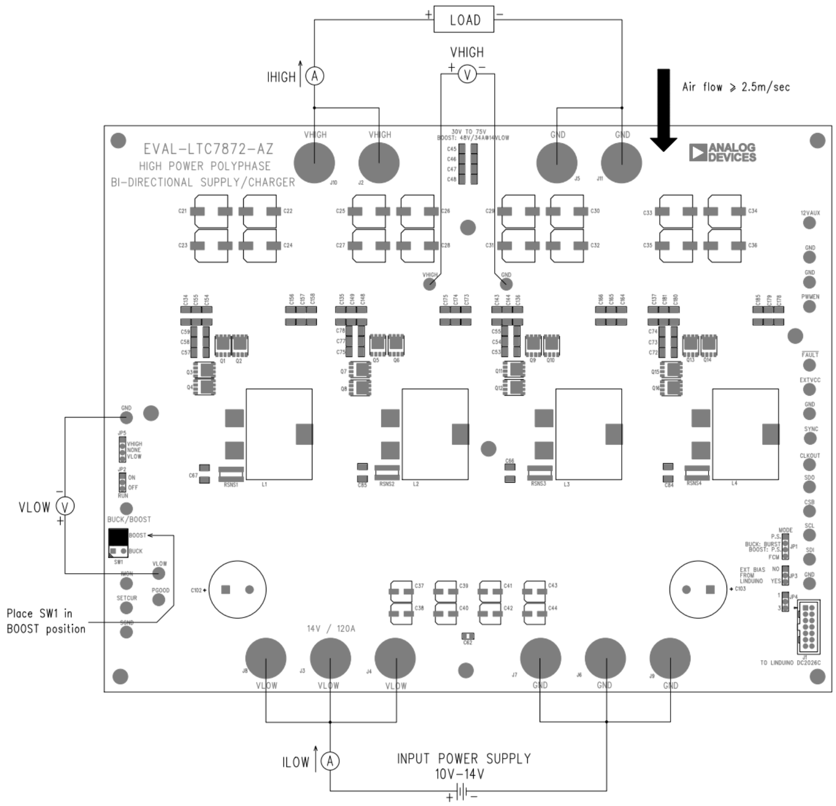


Figure 2. Measurement Setup for Boost Mode

SPI

Follow these steps to control or monitor the EVAL-LTC7872-AZ from QuikEval on a host computer.

9. See *Figure 3* for SPI setup.
10. If QuikEval is already installed, update to the latest version by selecting Tools → Update Program. If not, refer to the *Tools & Simulations* section of the product page on the Analog.com website to download the QuikEval software.
11. Download and install the LTC7872 QuikEval Module (ins7872.msi) from Analog.com website by navigating to the *Tools & Simulations* section of the product page. This module is an installer file that sets up the LTC7872 GUI.
12. Once installed, LTC7872 GUI is saved as **DC3038A**. DC3038A is the previous board number for the EVAL-LTC7872-AZ.
13. If SW1 is in the Buck position, connect the input power supply to V_{HIGH} and GND and load to V_{LOW} and GND. If SW1 is in the Boost position, connect the input power supply to V_{LOW} and GND and load to V_{HIGH} and GND.
14. Apply a voltage within the specified input range to either V_{HIGH} or V_{LOW} depending on the direction of power flow.
15. Connect the EVAL-LTC7872-AZ and DC2026C Linduino board.
    a. Connect the USB cable to the computer.
    b. Connect the other end of the USB cable to the DC2026C.
    c. Plug the 14-pin ribbon cable to the DC2026C.
    d. Connect the other end of the 14-pin ribbon cable to J1 on the EVAL-LTC7872-AZ.

Note: For more details about the DC2026C Linduino board, refer to the DC2026C demo manual.

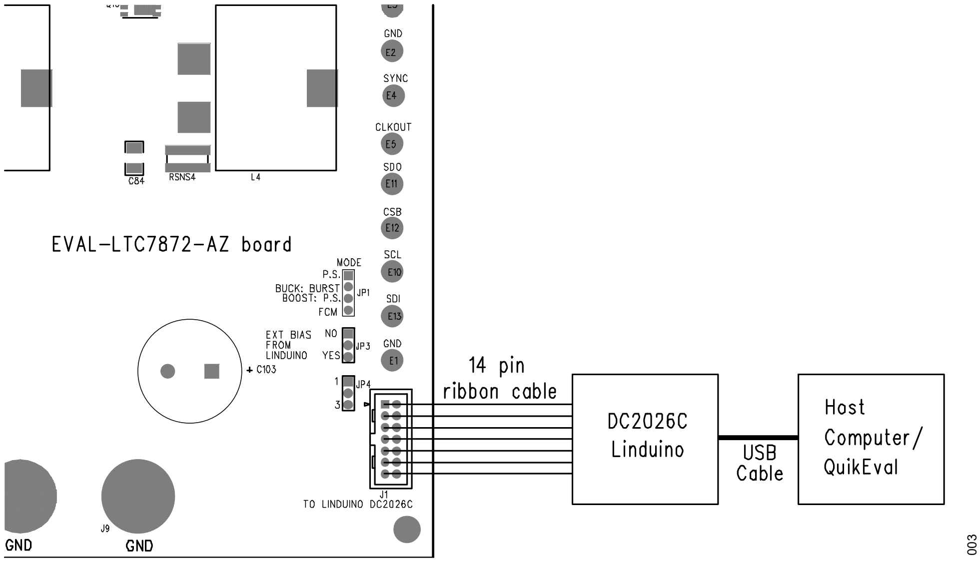


Figure 3. Connection Setup of the EVAL-LTC7872-AZ with the DC2026C Linduino Board

16. Start QuikEval on the host computer. The LTC7872 QuikEval GUI is shown in *Figure 4*.
17. Use QuikEval to monitor and control the LTC7872.
    a. The dashboard displayed in GUI shows the LTC7872 configurations, status, and fault reports.
    b. To read the status, press the **Read Once** button or the **Read Continuously** button on the dashboard.
    c. QuikEval can margin V_{LOW}, V_{HIGH} and the DC I_{LOW} current limit up or down by writing to the register that controls the current source digital to analog converter (IDAC) for the VFB_{LOW}, VFB_{HIGH}, or SETCUR pins. To use this feature, make sure the **Read Continuously** button is not enabled; this button is gray when not enabled.
    d. An optional design tool can be enabled from the **File** menu. Once enabled, it appears to the right of the dashboard in the GUI. It calculates the required IDAC value to margin the V_{LOW}, V_{HIGH} or DC I_{LOW} current limit to a given value. To use this tool, enter the values for the feedback divider or SETCUR resistor and then enter the value for the desired V_{LOW}, V_{HIGH}, or IL(MAX), which is the DC I_{LOW} current limit. The design tool then provides the calculated IDAC value. To update the LTC7872's registers, enter the calculated IDAC values on the dashboard and then press the respective **Update** button.

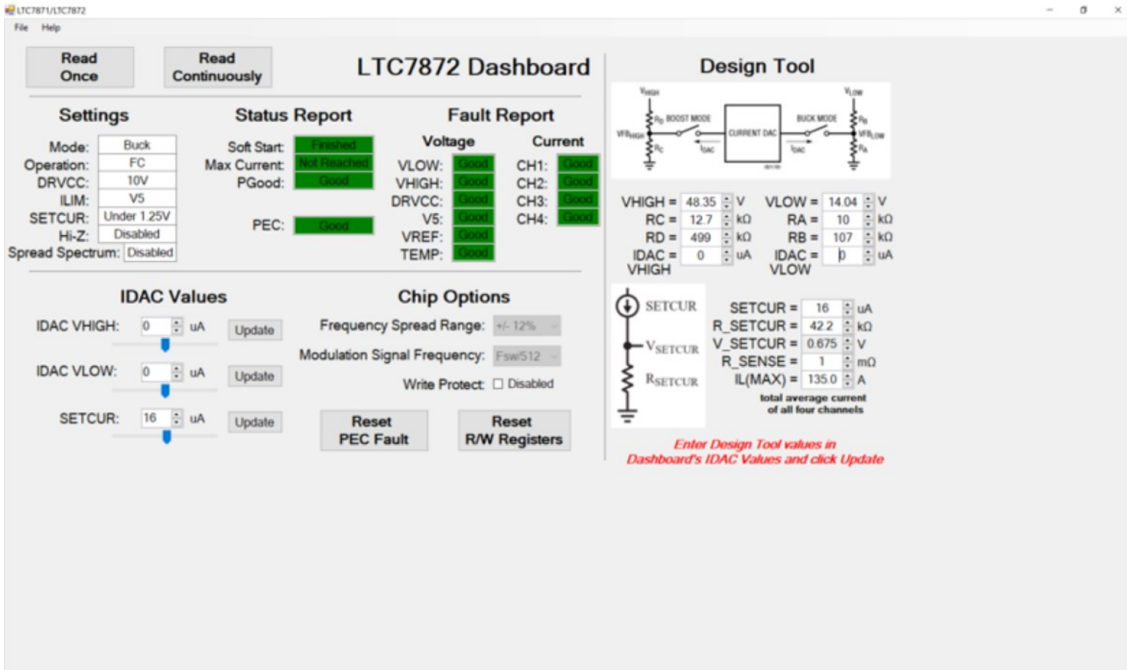


Figure 4. LTC7872 QuikEval GUI

Ripple Voltage Measurement

When measuring the output or input voltage ripple, do not use the long ground lead on the oscilloscope probe. See *Figure 5* for the recommended measurement technique. Short, stiff leads need to be soldered to the (+) and (–) terminals of an output or input capacitor. The probe's ground ring needs to touch the (–) lead and the probe tip needs to touch the (+) lead.

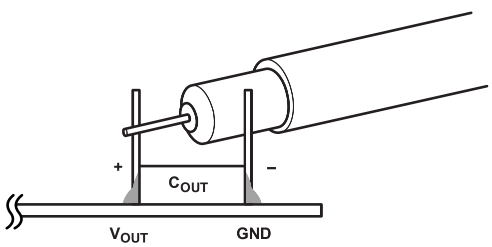


Figure 5. Measuring Ripple Voltage

Thermal Considerations

With full continuous load on the output in either direction at ambient room temperature, an external airflow greater than 2.5m/s is recommended. All the efficiency curves and thermal images shown in the *Performance (T_A = 25°C)* section were taken with this amount of airflow from an adjustable external fan.

Performance (T_A = 25°C)

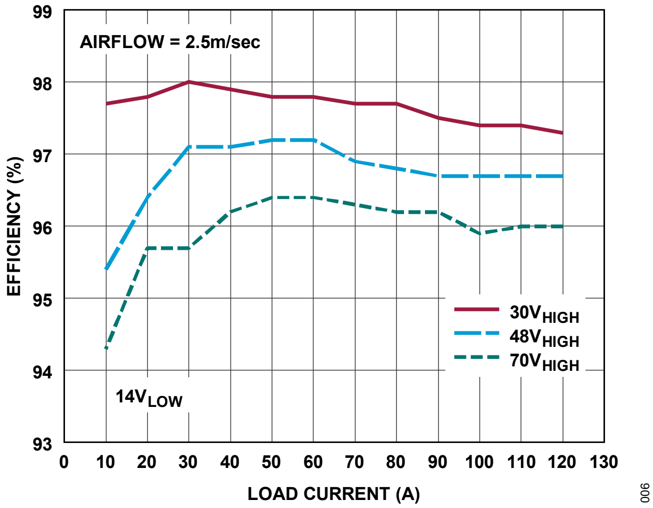


Figure 6. Efficiency vs Load Current in BUCK – FCM, External Fan Is Used (Airflow = 2.5m/s)

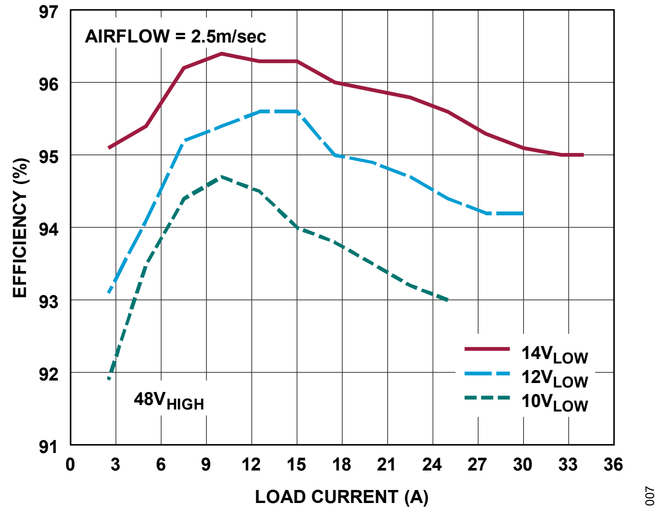


Figure 7. Efficiency vs Load Current in BOOST – FCM, External Fan Is Used (Airflow = 2.5m/s)

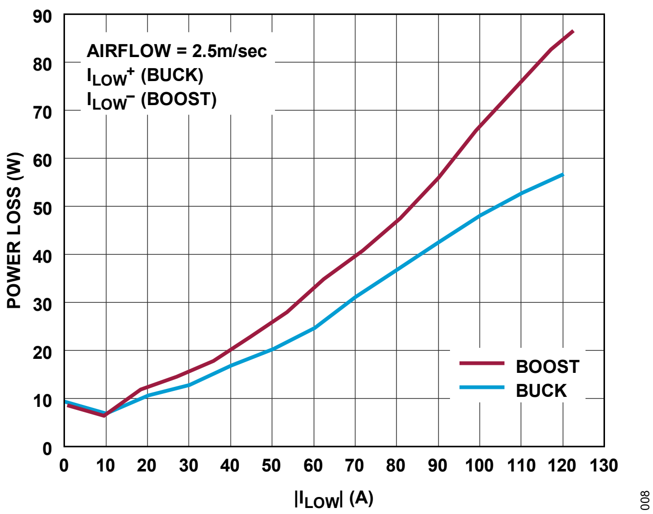


Figure 8. Buck vs Boost Power Loss Comparison in FCM, V_{HIGH} = 48V, VLOW = 14V, External Fan Is Used (Airflow = 2.5m/s)

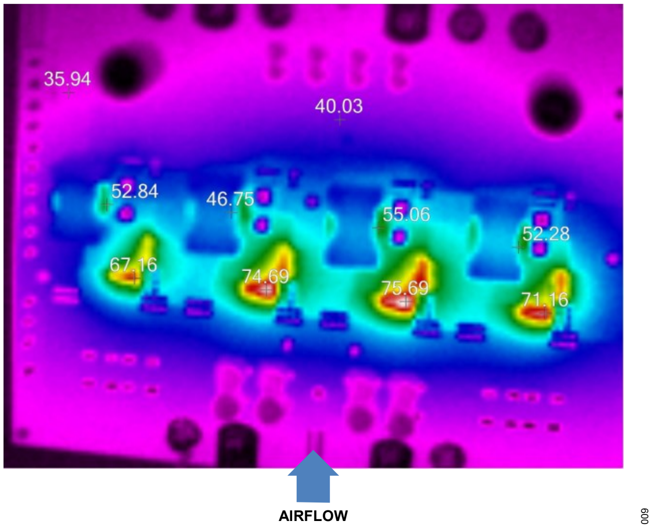


Figure 9. Thermal Image While Operating as a BUCK, V_{HIGH} = 48V, V_{LOW} = 14V, Load = 120A, External Fan Is Used (Airflow = 2.5m/s)

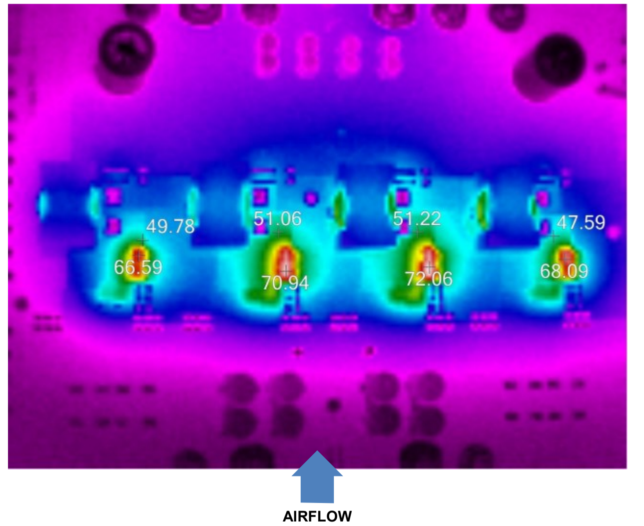


Figure 10. Thermal Image While Operating as a BOOST, V_{LOW} = 14V, V_{HIGH} = 48V, Load = 34A, External Fan Is Used (Airflow = 2.5m/s)

Schematic

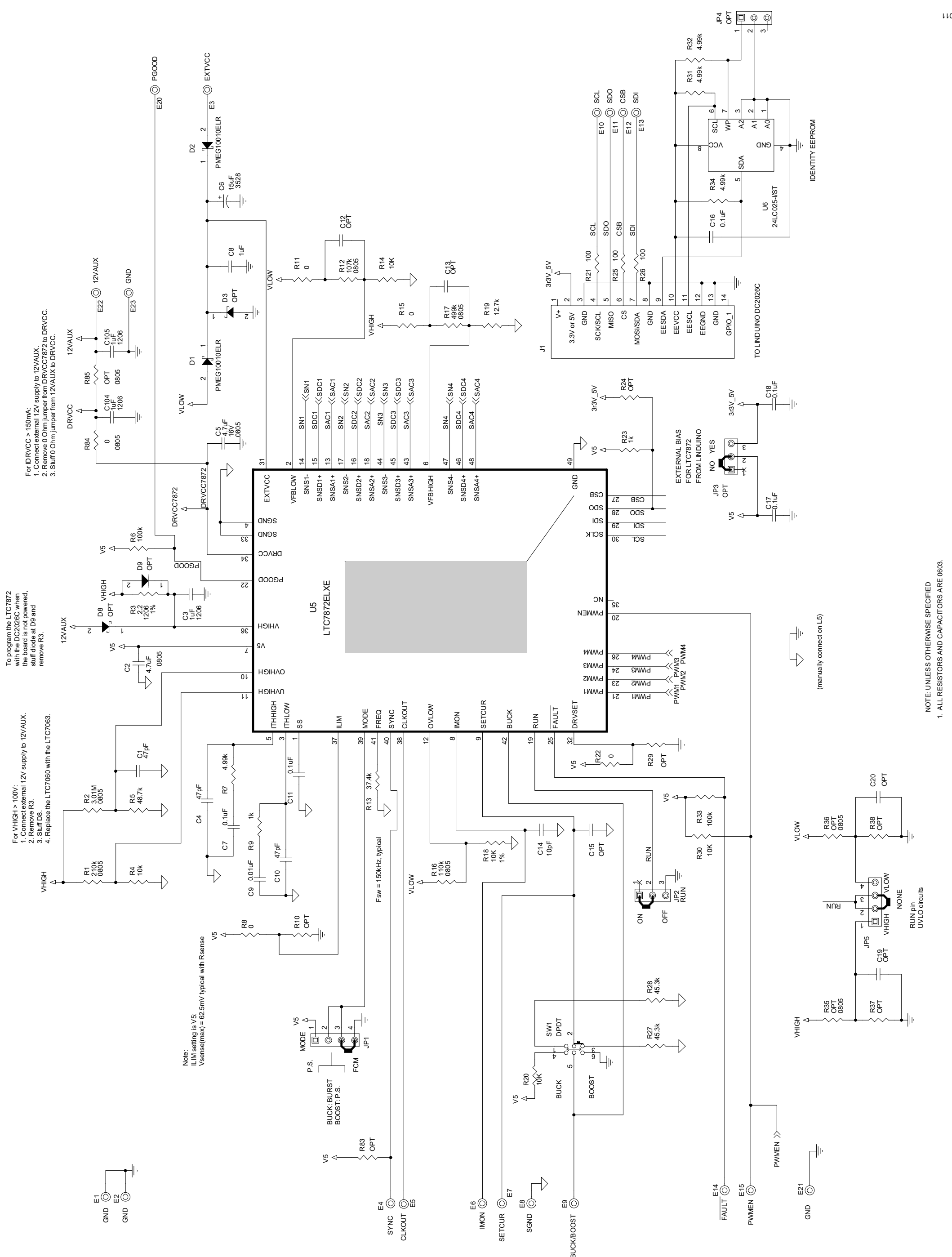
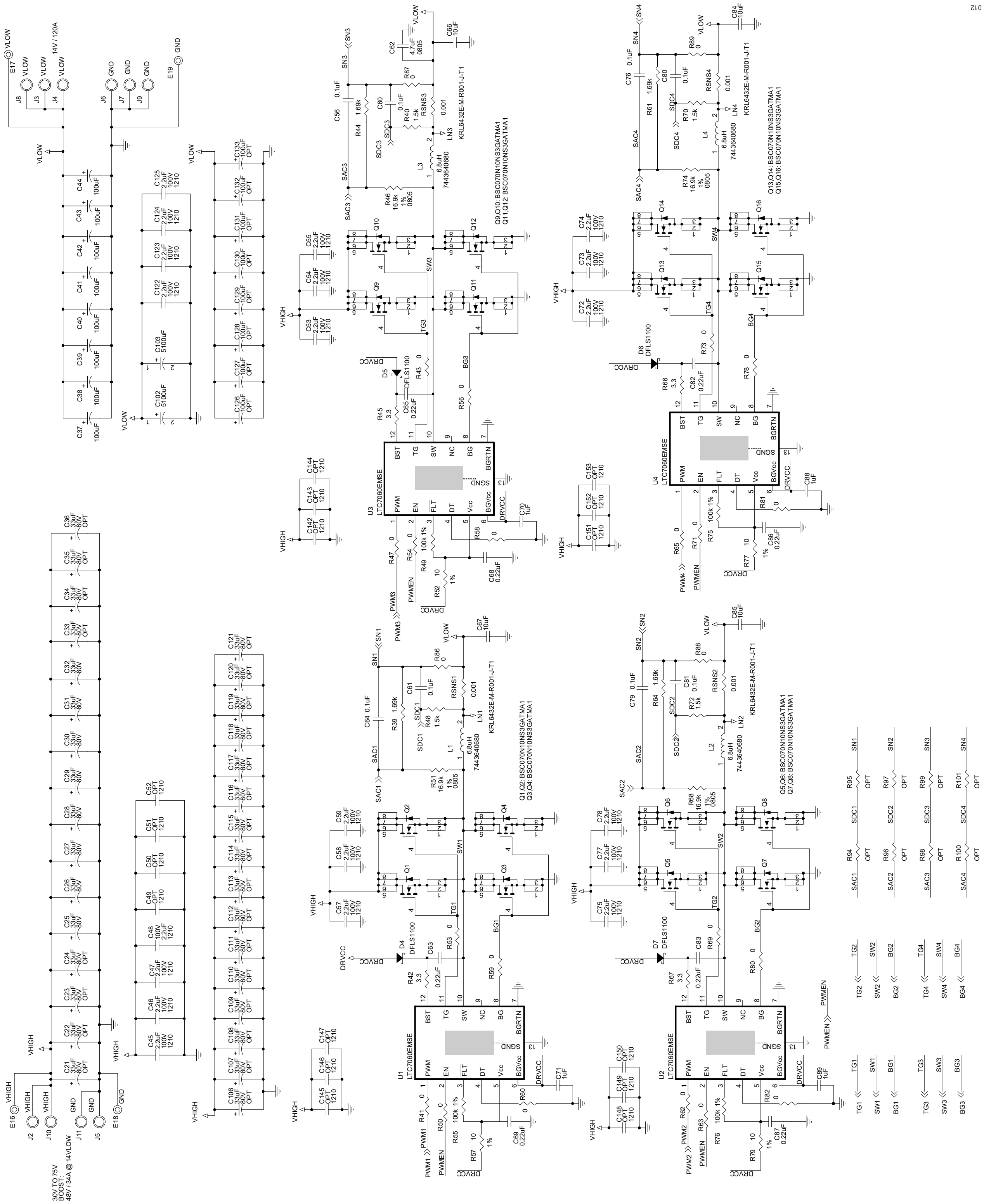


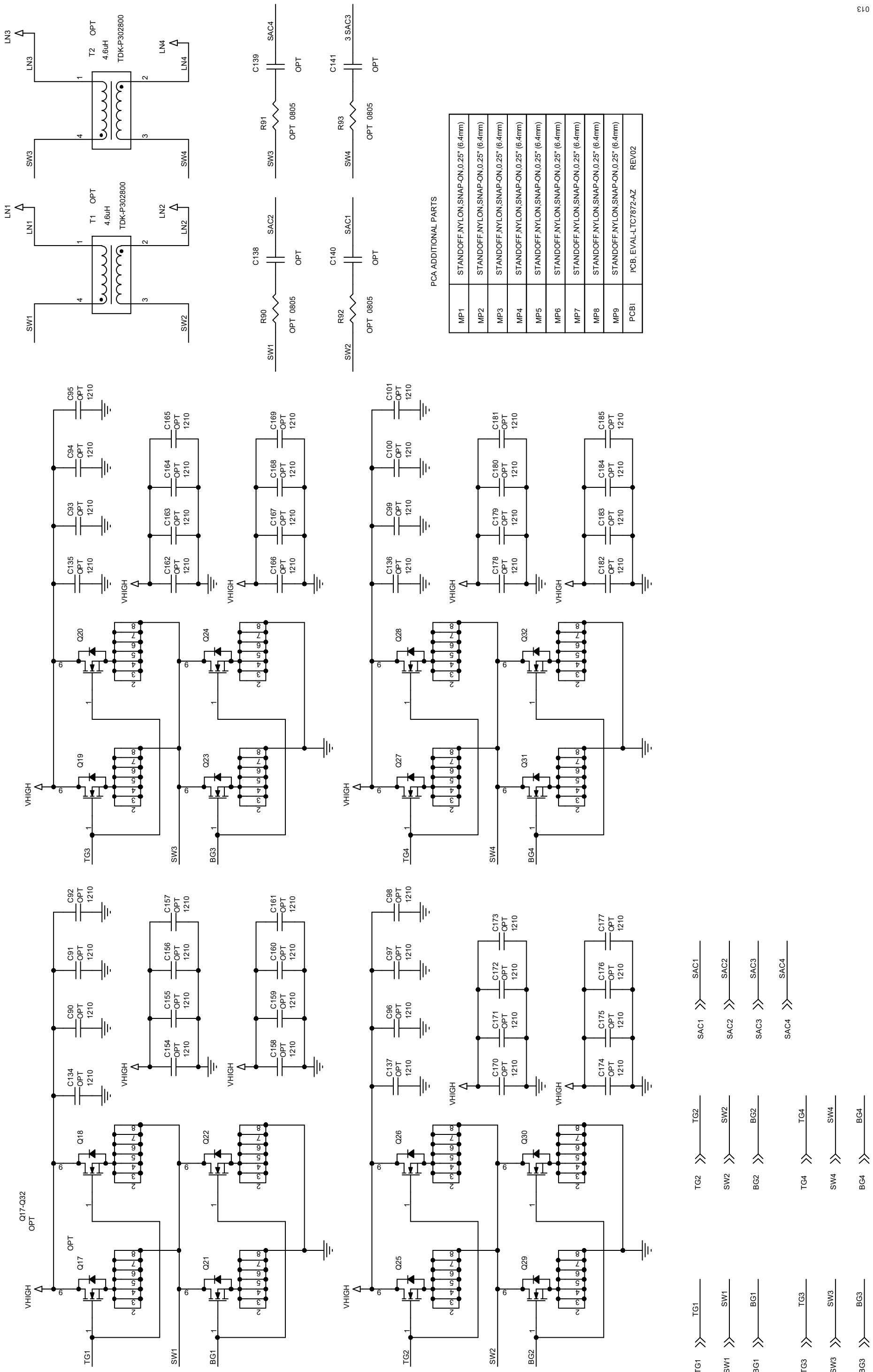
Figure 11. EVAL-LTC7872-AZ Schematic

Schematic (continued)



EVAL-LTC7872-AZ Schematic (Continued)

Schematic (continued)



EVAL-LTC7872-AZ Schematic (Continued)

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	2/25	Initial release	—

Notes