Evaluation Board User Guide

# EVAL-LT7930-AZ

72V, Parallelable, Dual-Phase, 4-Switch Buck-Boost Controller with GaN FETs

## General Description

The EVAL-LT7930-AZ evaluation circuit features the *LT7930* 72V parallelable 4-switch buck-boost controller for gallium nitride (GaN) and silicon MOSFETs. The LT7930 is a four-switch buck-boost switching regulator designed to safely and easily operate above, below, or equal to the output voltage. The constant-frequency, peak-current mode architecture allows a phase-lockable switching frequency up to 1MHz. A programmable input or output current loop regulates the average input or output current, making it suitable for battery charging applications. Additionally, with a wide 5V to 72V input and output range and seamless, low-noise transition between operating regions, the LT7930 is ideal for industrial and telecom systems.

The EVAL-LT7930-AZ operates from a 36V to 65V input voltage range and generates an output of 48V and up to 4kW of output power. The board features two LT7930s in parallel to achieve very high power. The parallel operation is set to a switching frequency of 150kHz, which results in an efficient circuit. The adjacent outputs are phase-shifted by 180° offset to interleave the switching while still providing optimal current sharing.

The LT7930 has a precision voltage reference that can generate an output voltage with a 1% tolerance over the full operating conditions. The LT7930 includes 5V optimized gate drivers to drive GaN FETs or Si NMOS FETs. The controller offers a resistor-programmable dead-time control feature to set short dead times for GaN FETs and longer dead times for Si MOSFETs to maximize efficiency. The converter achieves over 98% efficiency at 3kW output power over the full operating $V_{IN}$ range.

This board can be easily modified to regulate output voltages from 1V to 70V. Its multiphase/multi-ICs parallel operation feature allows for simple alterations for higher power.

The EVAL-LT7930-AZ provides a high-performance, cost-effective solution for generating a 48V output. The LT7930 data sheet gives a complete description of this part, its operation, and applications information. The data sheet must be read in conjunction with this user guide for the EVAL-LT7930-AZ.

***Design files for this circuit board are available on the LT7930 product page.***

## Performance Summary ($T_A$ = +25°C)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| Input Voltage Range | $I_{OUT}$ = 0 to 62A | 36 | | 65 | V |
| Output Voltage | $V_{IN}$ = 36V to 65V | | 48 | | V |
| Maximum Output Power | $V_{IN}$ = 45V to 65V with airflow maximum board temperature < 100°C | | 4.0 | | kW |
| | $V_{IN}$ = 36V with airflow maximum board temperature < 100°C | | 3.0 | | kW |
| | $V_{IN}$ = 40V to 65V without airflow maximum board temperature < 100°C | | 2.5 | | kW |
| | $V_{IN}$ = 36V without airflow maximum board temperature < 100°C | | 2.2 | | kW |
| Switching Frequency | | | 150 | | kHz |
| Run Rising Threshold | | | 34.2 | | V |
| Typical Efficiency | $V_{IN}$ = 36V, $I_{OUT}$ = 63A | | 98.5 | | % |
| | $V_{IN}$ = 48V, $I_{OUT}$ = 83A | | 98.5 | | % |
| | $V_{IN}$ = 65V, $I_{OUT}$ = 83A | | 98.8 | | % |


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## Quick Start Procedure

The EVAL-LT7930-AZ evaluation circuit is easy to set up for evaluating the performance of the LT7930. For a proper measurement equipment setup, see *Figure 1* and use the following procedure:

1. Set the input power supply to a voltage between 36V and 65V. Disable the power supply.

   **Note:** Make sure that the input voltage $V_{IN}$ does not exceed 65V.
2. Connect the positive terminal of the power supply to $V_{IN}$ and the negative terminal to GND.
3. Connect the load (< 83A) between $V_{OUT}$ and GND.
4. Turn the input power supply on and adjust the input voltage to 48V.
5. Verify that the output voltage is 48V on the DMM connected to $V_{OUT}$. If there is no output, temporarily disconnect the load to make sure that the load is not set too high.
6. Once the proper output voltage is established, adjust the load and observe the output voltage regulation, ripple voltage, efficiency, and other parameters.

   **Note:** When measuring the input or output voltage ripple, take care to minimize the length of the oscilloscope probe ground lead. Measure the input or output voltage ripple by connecting the probe tip directly across the $V_{IN}$ or $V_{OUT}$ and GND terminals, preferably across the input or output capacitors.

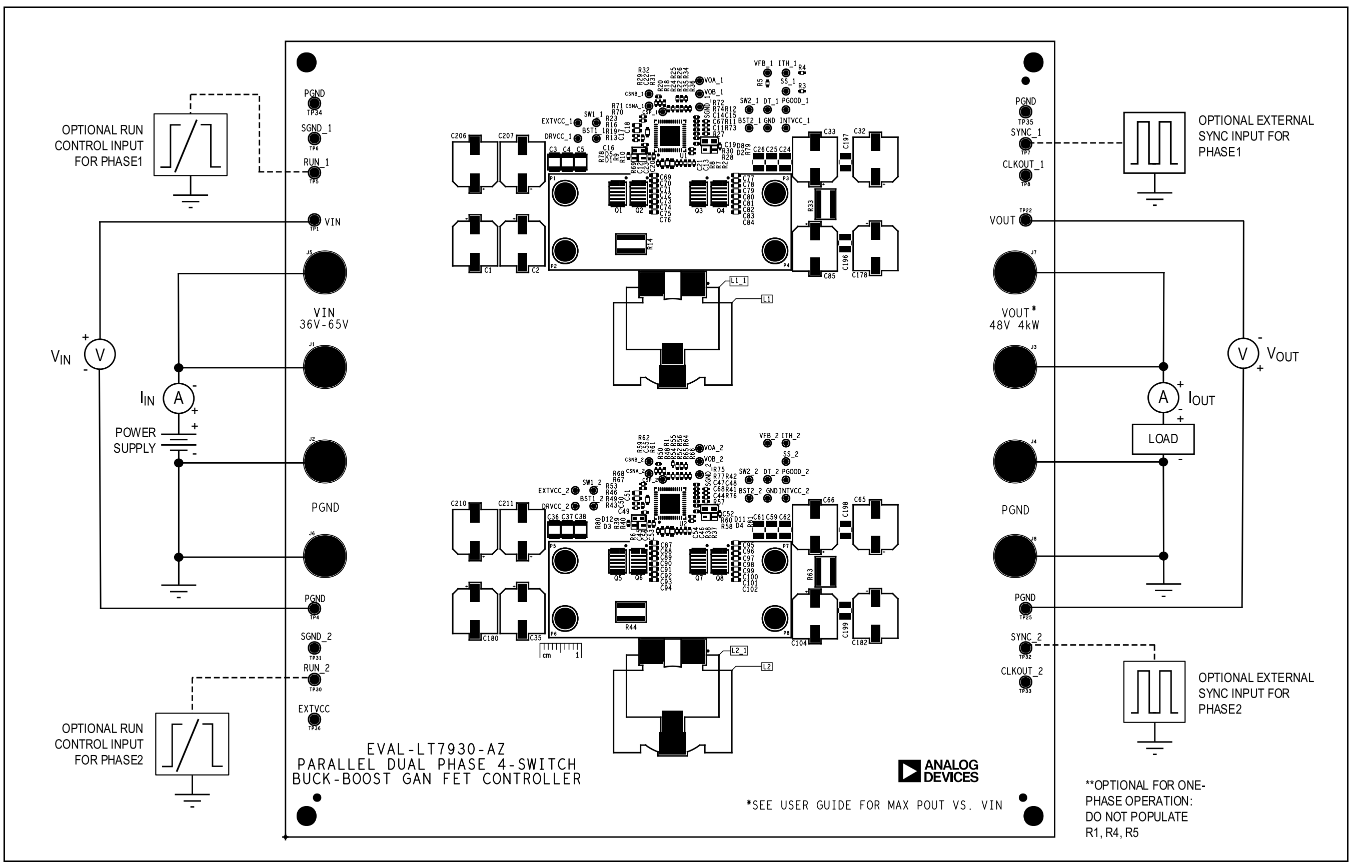



*Figure 1. EVAL-LT7930-AZ Board Connections*

### Adjusting the Output Voltage

The LT7930 supports an adjustable output voltage range from 1V to 72V. To change the output voltage from the programmed 48V, change R35/R36 and R65/R66. Refer to the *Setting the Output Voltage* section in the LT7930 data sheet for details about how to calculate the $V_{FB}$ resistor-divider values for the desired output voltage. All of the corresponding power components must also be changed to meet the desired output voltage.

### Setting the Switching Frequency

Selecting the switching frequency is a trade-off between efficiency and component size. For optimal performance, a switching frequency of 150kHz is chosen for a 48V output. R18 and R48 program the desired switching frequency. The switching frequency is set using the FREQ pin. Refer to the *Frequency Selection and Phase-Locked Loop* section in the LT7930 data sheet for details.

### Setting the Dead Time

The LT7930 offers a resistor-programmable dead-time feature to set the dead time between 0ns and 100ns. Choose a short dead time to reduce the reverse conduction loss, but one that is long enough to avoid shoot-through. For best efficiency, a dead time of 10ns is chosen on the EVAL-LT7930-AZ based on the EPC2361 GaN FET parameters. The dead time is set using the DT pin. To change the dead time, refer to the *Programmable Dead Time* section in the LT7930 data sheet and modify the resistors R73 and R76.

### RUN Control (RUN_1, RUN_2)

The EVAL-LT7930-AZ uses two LT7930 controllers in parallel to generate high output power. The input undervoltage lockout is set at 35V using an external resistor-divider. Utilize the RUN pin's 1.22V (typ) threshold to detect the input undervoltage lockout at a desired input voltage. The resistor-divider (R7/R8, R37/R38) is connected between $V_{IN}$ and SGND to bias the RUN pin, defining the input undervoltage lockout threshold to turn on/off the corresponding controller. The RUN pins of the two LT7930 controllers on the board can be accessed through their respective RUN_x turret.

The EVAL-LT7930-AZ follows a leaderless design where either phase can be independently shut down/enabled using the associated RUN pin. Ensure that the total output power does not exceed 2kW when one phase on the evaluation board is disabled. To enable/disable both phases simultaneously, short the RUN pins of the two LT7930 controllers by populating a 0Ω resistor at R2 and use either of the RUN_x turrets.

### $EXTV_{CC}$ Linear Regulator

The $EXTV_{CC}$ pin allows the $INTV_{CC}$ and $DRV_{CC}$ power to be derived from a high-efficiency external source. On the EVAL-LT7930-AZ, the $EXTV_{CC}$ pin is connected to $V_{OUT}$. The $EXTV_{CC}$ turret can be used to connect an external power supply to source the $EXTV_{CC}$ LDO. When using an external power supply on the $EXTV_{CC}$ turret, make sure to disconnect the $V_{OUT}$ connection to the $EXTV_{CC}$ pin by removing R67 and R70 and adding 0Ω resistors on R82 and R83. An external supply can then be connected between the $EXTV_{CC}$ and PGND turrets.

### Parallel Dual Phase with Interleaved Switching

The LT7930 is designed to be easily paralleled to achieve higher output power. The EVAL-LT7930-AZ features two LT7930s in parallel by connecting the ITH and $V_{FB}$ pins of the two controllers together. The CLKOUT pin of first phase is connected to the SYNC pin of the second phase.

For interleaved dual-phase operation, the first phase is set to send a CLKOUT signal 180° out of phase. If a different phase offset is required, refer to the data sheet and change the resistors around the PHASMD pin. If single-phase operation is required, disconnect R1, R4, and R5, and short the RUN_2 turret to SGND_2.

### Thermal Performance

The LT7930 features excellent thermal performance due to the high efficiency of the synchronous buck-boost circuit operation. The component temperatures of the EVAL-LT7930-AZ with a typical 48V input and 83A load are shown in *Figure 8*. The eight-layer PCB layout features solid copper planes that provide adequate heat spreading across the whole board.

### Heatsink

The EVAL-LT7930-AZ features spaces for heatsinks to extend the power and thermal capabilities significantly. The board is designed for the Wakefield-Vette 567-45AB heatsink and is to be used in conjunction with thermal pads and Wurth Electronik 9774010243R spacers. The spacers should be soldered onto P1-P8, and a thermal pad should be placed between the heatsink and the GaN FETs. Properly screw the heatsink to fully extend the power capabilities of the board.

## EVAL-LT7930-AZ Performance

($V_{OUT}$ = 48V, $I_{OUT}$ = 83A, $f_{SW}$ = 150kHz, $T_A$ = +25°C, unless otherwise noted.)

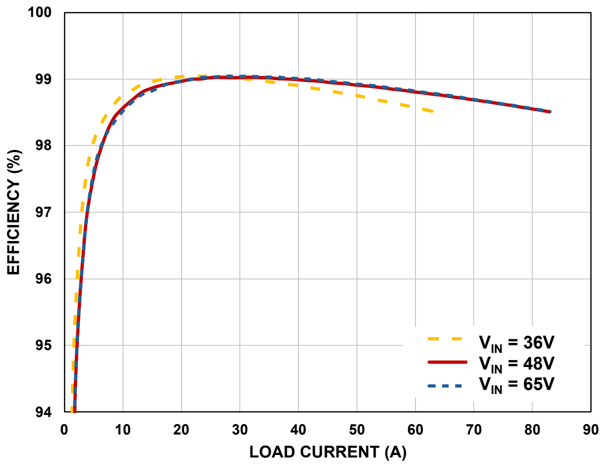



*Figure 2. Efficiency vs. Load Current; Performs with Efficiency >98% across All Input Voltage Ranges at Higher Load*

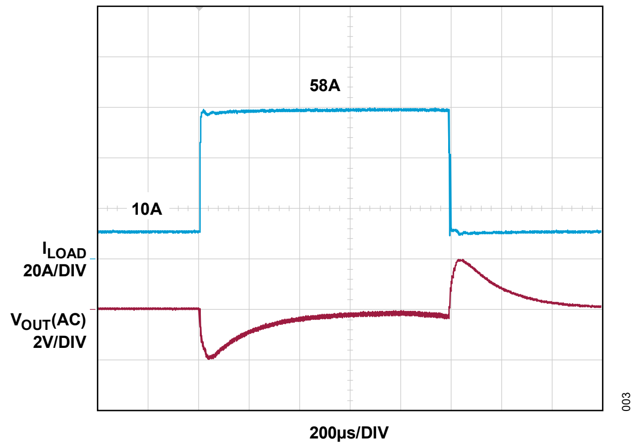



*Figure 3. Load-Step Response with $V_{IN}$ = 36V; Load Stepping from 10A to 58A; Good Load-Step Response with Small Output Capacitor*

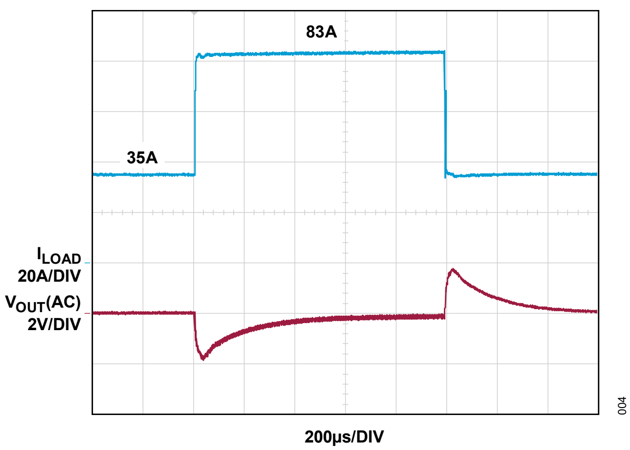



*Figure 4. Load-Step Response with $V_{IN}$ = 48V; Load Stepping from 35A to 83A; Good Load-Step Response with Small Output Capacitor*

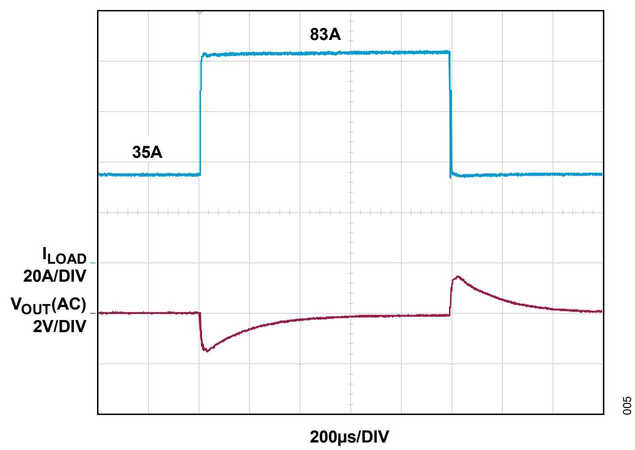



*Figure 5. Load-Step Response with $V_{IN}$ = 65V; Load Stepping from 35A to 83A; Good Load-Step Response with Small Output Capacitor*

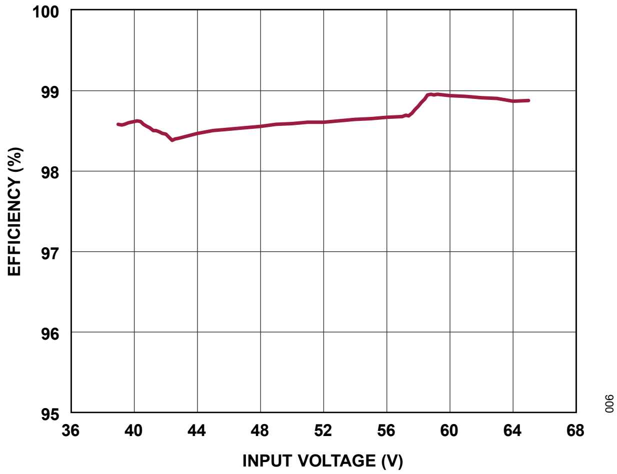



Figure 6. Efficiency vs. Input Voltage at 70A Load; at Output Current of 70A, Can Operate at Efficiency of >98% for Entire Input Voltage Range

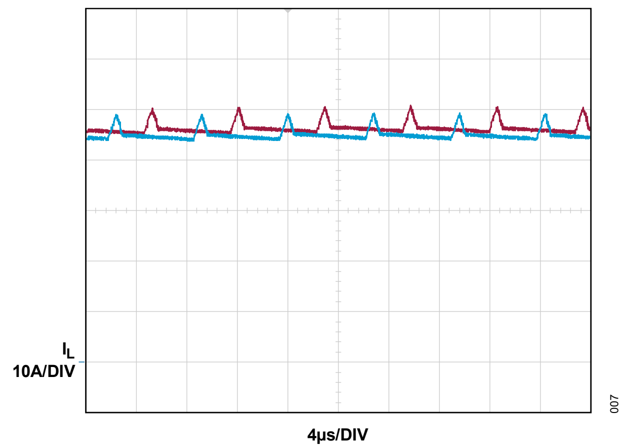



Figure 7. Inductor Currents at 48V Input at 83A Load; Shows Great Inductor Current Sharing between Phases

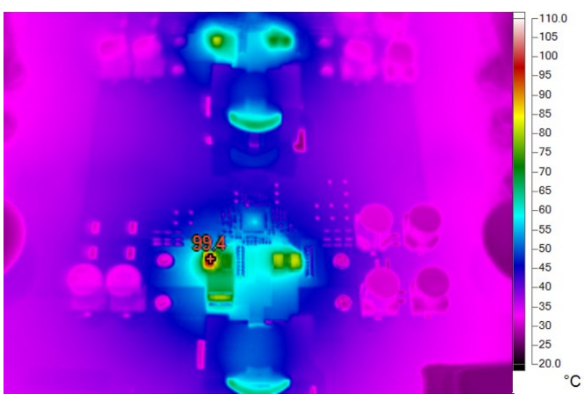



Figure 8. Thermal Performance with 48V Input, 70A Load with Airflow (No Heatsink); Hottest Component on EVAL-LT7930-AZ Stays Cool

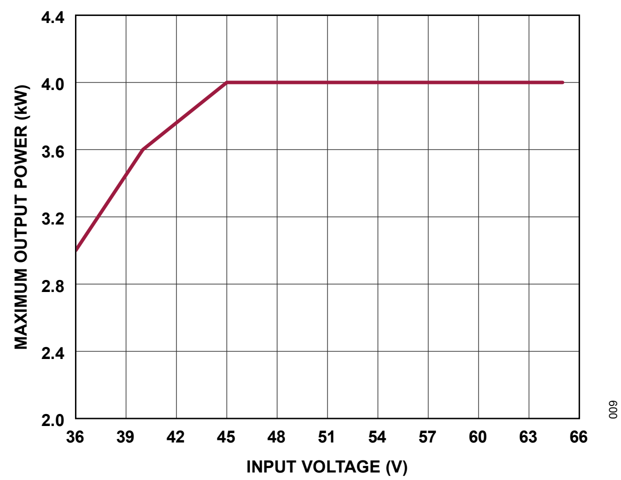



Figure 9. Maximum Recommended Output Power vs. Input Voltage with Airflow; Keeps Maximum Component Temperature under 100°C

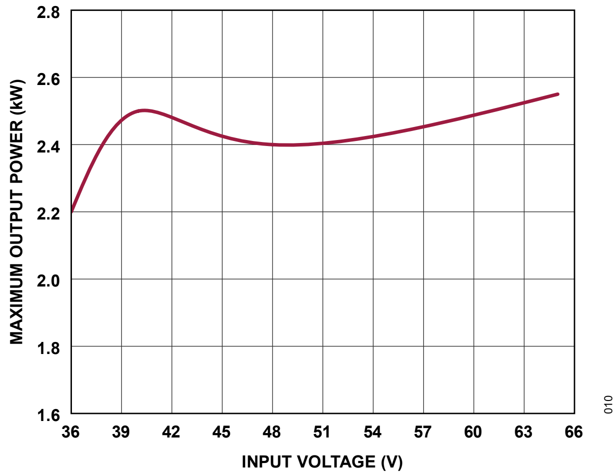



*Figure 10. Maximum Recommended Output Power vs. Input Voltage without Airflow; Keeps Maximum Component Temperature under 100°C*

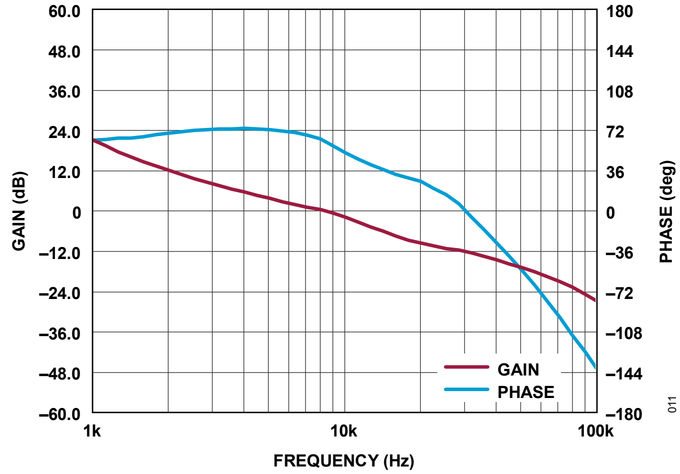
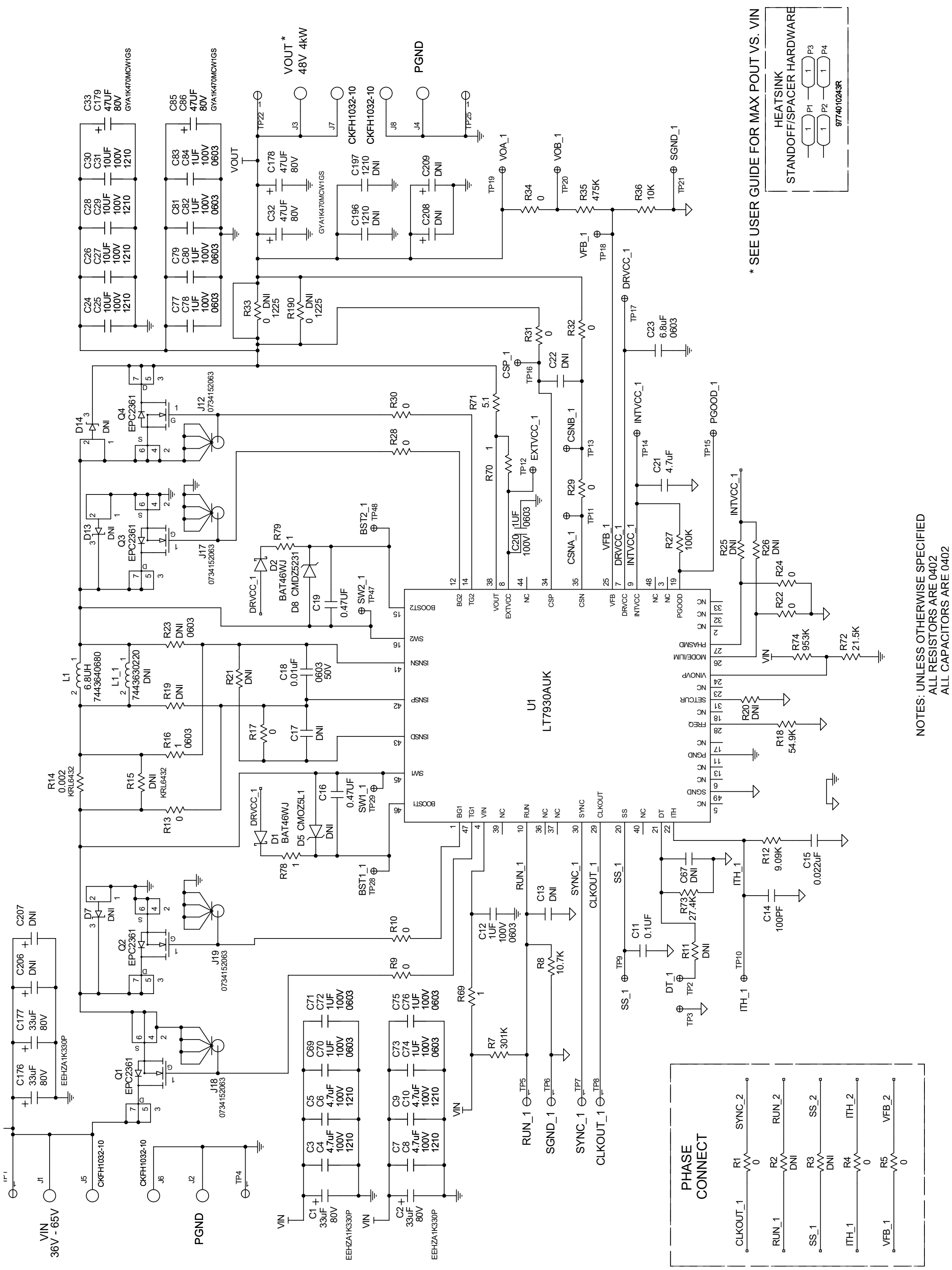


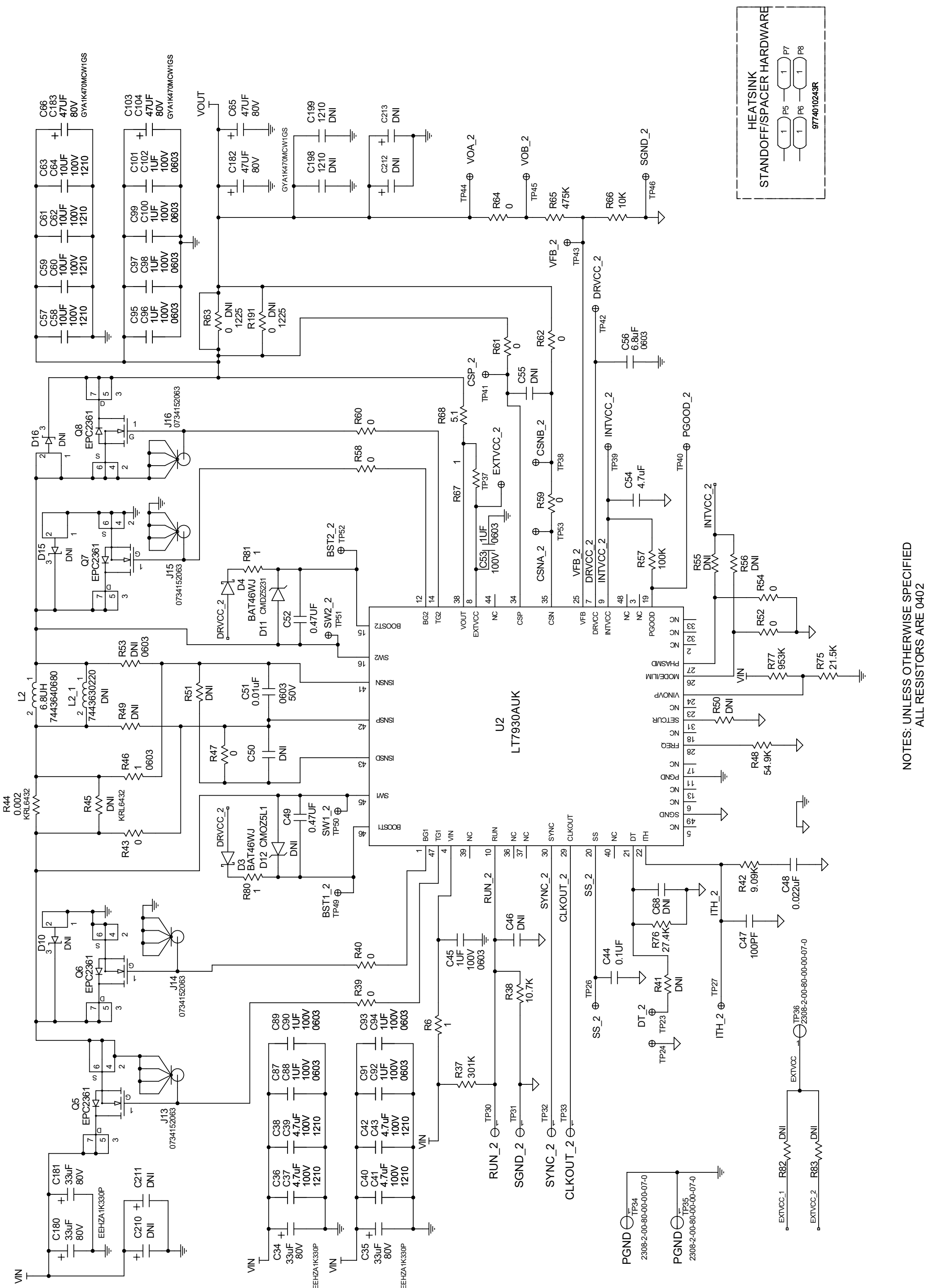

*Figure 11. Bode Plot with $48V_{IN}$ and 83A Load; Bandwidth = 8.4kHz, Phase Margin = 61.8°, Gain Margin = 12dB*

## EVAL-LT7930-AZ Schematics

### High-Efficiency, 36V to 65V Input, $48V_{OUT}$, up to 4kW Output Buck-Boost Converter



## EVAL-LT7930-AZ Schematics (continued)



## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGE NUMBER |
|---|---|---|---|
| 0 | 7/26 | Initial release | — |

## Notes