ISL78227EV1Z

Evaluation Board User Guide

UG064
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Description

The ISL78227EV1Z board demonstrates the 2-phase synchronous boost operation of the ISL78227. It verifies the high efficiency of synchronous boost operation and all the features of the IC including input Constant Current (CC) control, analog/digital tracking, diode emulation, phase dropping, etc.

Specifications

This board has been configured and optimized for the following operating conditions. Refer to "Operating Range" on page 3 for more detailed descriptions.

- VIN_MIN = 7.5V (or lower, refer to "Operating Range")
- VIN_TYP = 12V
- VIN_MAX = 30V (typical)
- VOUT = 36V (typical)
- IOUT_MAX = 12A (typical)
- IIN_AVG_MAX = 41.5A (typical)
- f_{SW} = 200kHz

Key Features

- Input/output voltage withstands 55V DC and 60V transients
- Input average Constant Current (CC) control loop
- PWM and analog track functions
- Forced PWM operation with negative current limiting
- External synchronization
- Selectable Continuous Conduction Mode (CCM), Diode Emulation (DE) and Phase Dropping (PH_DROP) modes
- Comprehensive protections
- Selectable Hiccup or Latch-off fault responses
- Boards can be stacked for parallel operations
- Monitoring test points for key signals

References

- ISL78227 Datasheet

Ordering Information

PART NUMBER	DESCRIPTION
ISL78227EV1Z	ISL78227 Evaluation Board

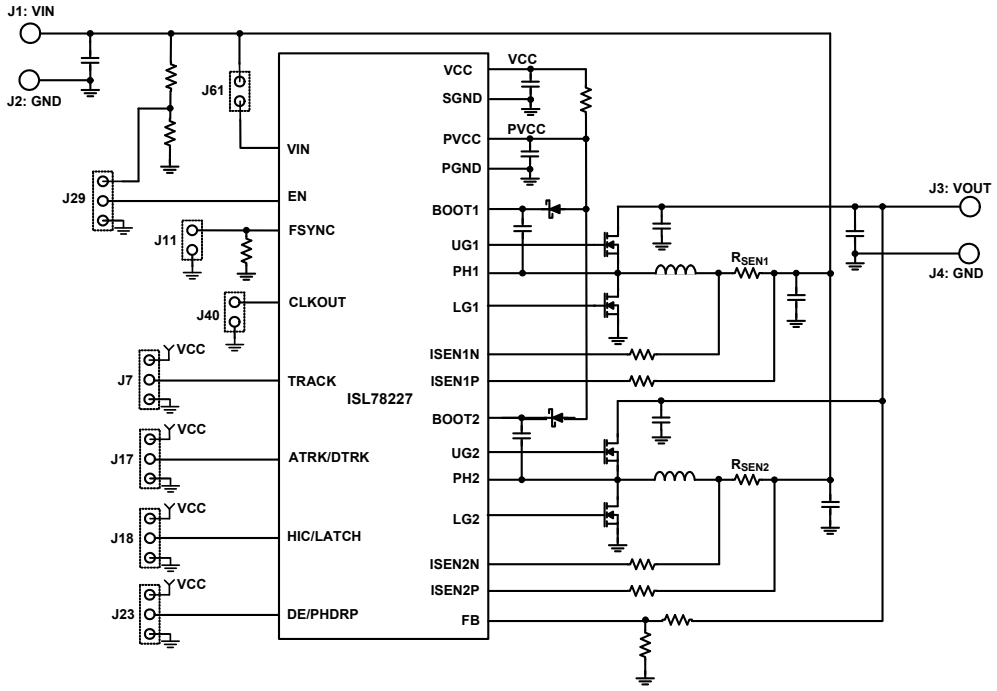


FIGURE 1. ISL78227EV1Z BLOCK DIAGRAM

ISL78227EV1Z Evaluation Board

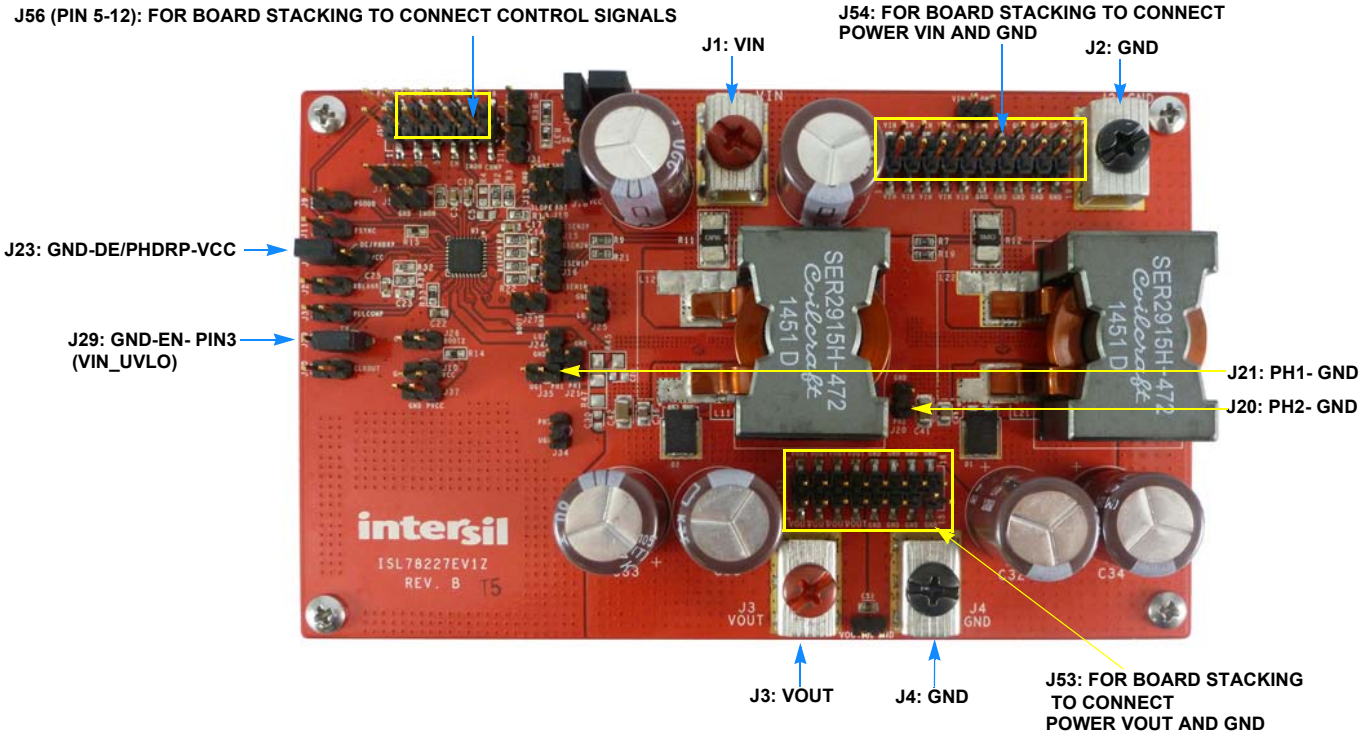


FIGURE 2. TOP VIEW OF THE ISL78227EV1Z

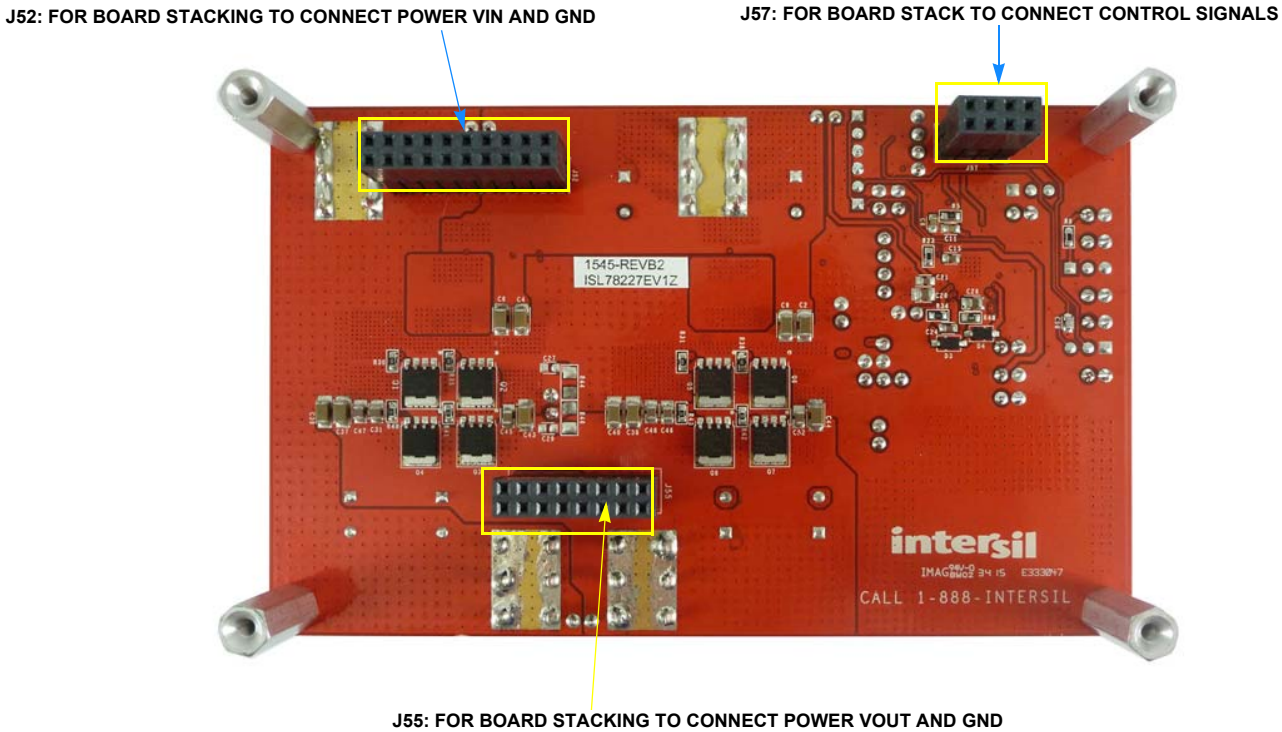


FIGURE 3. BOTTOM VIEW OF THE ISL78227EV1Z

Recommended Equipment

- 0V to 60V power supply with 45A source current capability
- 0V to 5V power supply with 0.5A source current capability
- Load capable of 20A (or up to 30A)
- Function generator
- 2 to 4 Digital Multimeters (DMM)
- 1 oscilloscope

Functional Description

The ISL78227EV1Z evaluation board pictures are shown in Figures 2 and 3. The board supports a quick evaluation of various features of the ISL78227.

The ISL78227EV1Z demonstrates ISL78227 as the controller of a high efficiency 2-phase synchronous boost.

The ISL78227EV1Z demonstrates the IC's unique function of accepting either digital or analog signals for the user to adjust the reference voltage externally.

The ISL78227EV1Z demonstrates the ISL78227's unique feature of average Constant Current (CC) control for the input current. The board can have the average input current as a controlled constant without shutdown, which helps the user to optimize the system with the power devices' capability that is fully utilized by the well-controlled constant input current.

The ISL78227EV1Z has connector options to select Continuous Conduction Mode (CCM), Diode Emulation (DE) and Phase Dropping (PH_DROP) modes.

Two ISL78227EV1Z evaluation boards can be stacked to demonstrate 2 ICs operating in parallel to control a 4-phase boost regulator.

Operating Range

- VIN_MIN = 7.5V or lower.
  - The board starts up when the input voltage, V_{IN}, rises above 10V and shuts down when V_{IN} falls below 7.5V. This 10V/7.5V input voltage UVLO is determined by the resistor divider (R_{36}, R_{37}) from the input voltage to the EN pin. These V_{IN} UVLO thresholds can be modified by changing the resistor divider values.
  - With the ISL78227's EN pin (through J29's center pin) directly controlled by the external supply instead of the V_{IN} UVLO described above, the board can operate at V_{IN} as low as 5V to 6V while the output power is limited by IIN_MAX (41.5A typical, controlled by the input CC control).
- VIN_TYP = 12V
- VIN_MAX = 30V (typical). To keep V_{OUT} regulated at 36V, the maximum input voltage is typically 30V determined by the minimum duty cycle.
- V_{OUT} = 36V (typical)
- IOUT_MAX = 12A (typical at 12V V_{IN}, depending on V_{IN} due to the IIN_AVG_MAX being 41.5A controlled by the input CC control)
- IIN_AVG_MAX = 41.5A (typical, controlled by the input CC control)
- f_{SW} = 200kHz
- The board is set in CCM mode by default with J23's Pin 2 (DE/PHDRP) shorted to Pin 3 (GND) by the jumper.
- The board is set to have Hiccup mode as the fault protection response with J18's Pin 2 (HIC/LATCH) connected to VCC by the jumper.
- Per phase inductor's peak current limit is set at 38.5A (OC1: cycle-by-cycle, continuously switching).
- Per phase inductor's peak current fault protection is set at 48.5A (OC2_PEAK fault, Hiccup response set by J18's default setting).
- The board is set to accept an analog signal as the input (J17's Pin 2 (ATRK/DTRK) shorted to VCC by the jumper).

Quick Guide for Configurations and Test Points

Figures 4 and 5 show the schematics of this evaluation board. The "Bill of Materials" are listed on page 12. The layout information of the board can be found in Figures 10 through 19.

Table 1 on page 10 shows the detailed descriptions for all the connectors/monitor pins.

Key signals such as VCC, PVCC, SS, FB, COMP, EN, PGOOD, CLKOUT, PHx, LGx, etc., are available at the monitoring pins for easy measurement. Figures 20 through 47 show the performance data taken with this evaluation board at the default configurations.

The board setting can be changed by configuring the connection of the corresponding connectors (header/pin type) or replacing the resistors and/or capacitors populated on the board. Some examples are described as follows:

- J23 is for selection of CCM/DE/PH_DROP modes (refer to Table 2 in the ISL78227 datasheet). The board is set in CCM mode by default. Do Not short J23 on both sides at the same time.
  - Short J23's Pin 2 (DE/PHDRP) to VCC with jumper for the DE mode
  - Leave all J23's 3 pins open for DE plus Phase Dropping mode
  - Short J23's Pin 2 (DE/PHDRP) to GND for the CCM mode (default board setting)

- J18 is for selection of the fault protection response modes (Hiccup/Latch-off). Do Not short J18 on both sides at the same time.
  - Short J18's Pin 2 (HIC/LATCH) to VCC with the jumper for default Hiccup fault response (default board setting)
  - Short J18's Pin 2 (HIC/LATCH) to GND with the jumper for default Latch-off fault response
- The switching frequency on the ISL78227EV1Z is fixed at 200kHz. To change the frequency, replace R_{15}, which is connected between FSYNC and GND. Please refer to the "Oscillator and Synchronization" section in the ISL78227 datasheet for detail. The switching clock can be synchronized with an external clock source applied at the FSYNC pin (through J11). The external clock frequency range can be 50kHz to 1.1MHz.
- The output voltage of ISL78227EV1Z is fixed at 36V in default setting. This can be changed by replacing the feedback resistor R_3 or R_2. When changing the feedback resistor, the maximum output current will be changed accordingly because the maximum input current is controlled to be fixed by input CC.
- The input average CC limit (41.5A typical) can be adjusted by replacing the resistor R_1, which is connected to IMON pin. For the setting of the average CC control, please refer to "Average Current Sense for 2 Phases - IMON" and "Constant Current Control (CC)" sections in the ISL78227 datasheet.
- The per phase inductor's cycle-by-cycle peak current limit (OC1) can be changed by replacing the current sense resistor R_{11} (R_{12}) and/or current sense gain setting resistors R_9, R_{10}, R_{21}, R_{22} (R_7, R_8, R_{19}, R_{20}) for the respective phases. Please refer to "Current Sensing" and "Cycle-by-Cycle Peak Overcurrent Limiting/Protection" sections in ISL78227 datasheet for details. Note: if these resistors are changed, the R_1 may need to be changed accordingly to keep the desired CC control level.

Quick Start Guide

Setup of Test Equipment

As described in "Recommended Equipment" on page 3, prepare 2 power supplies, 1 electronic load, 2 - 4 DMMs and 1 oscilloscope.

- The first power supply 60V/45A (V_{IN} power supply) will be used for the V_{IN} power rail.
- The second power supply 5V/0.5A (EN power supply) will be used to supply bias for EN. This power supply is not necessary if EN is connected to V_{IN} resistor divider with J29's Pin 2 shorted with Pin 3 by the jumper.
- The electronic load (or resistive load) will be used as the load for V_{OUT} and should have a capability to sink 20A (or up to 30A).
- The DMMs will be used to monitor output voltage, input voltage and other signals such as PVCC, VCC, IMON, FB, etc. if interested.

External Connections and Setup Before Start-Up

- Connect the VIN power supply between VIN (J1) and GND (J2). Before start-up, typically set the VIN power supply voltage to 12V. The power supply output should remain off before start-up.
- Connect the EN power supply (if used) between EN and GND using J29's Pin 2 (EN) and GND (Pin 1). Typically, set the EN power supply voltage in range of 3V to 5V. The power supply output should remain off before start-up.
- Connect the electronic load between VOUT (J3) and GND (J4). Set the electronic load to 0A for the first start-up. The load should remain off before start-up.
- Place the DMMs appropriately where the signals are to be measured. The input and output voltage can be measured using J6 and J30. (Note: To measure the voltage of high current nodes, it is recommended to use a Kelvin connection to avoid the effect of parasitic resistances of the connections. These connections are supplied at J6 and J30.)
- Set the oscilloscope probes to monitor PH1 (J21), PH2 (J20), VOUT (J30), IMON (J5), or any other signals.

Start-Up and Measurement

On the ISL78227EV1Z, the user can select one of the 3 basic operation modes of CCM/DE/PH_DROP (refer to Table 2 in the ISL78227 datasheet) by configuring J23.

1. **CCM mode -** The ISL78227EV1Z board is set in CCM mode by default with J23's Pin 2 (DE/PHDRP) shorted to GND with the jumper.

- Before powering up, keep EN power supply and VIN power supply outputs off. Keep the electronic load off.
- Set VIN power supply to 12V (or desired voltage). Turn on the output of VIN power supply.
  - Confirm the VIN voltage of the evaluation board is correct.
  - Confirm the supply current of VIN power supply is small.
- Enable the output of the EN power supply.
  - Confirm the evaluation board output voltage is 36V (typical).
  - Confirm the CCM switching pulses at PH1 and PH2. The PH1 (PH2) switching frequency is 200kHz (typical).
- Increase the load to heavy load - Slowly increase the load from 0A to 10A. Keep the input voltage around 12V. The input current is around 31A. Check to see if PH1/PH2 waveforms are normal and if V_{OUT} is regulated at 36V.
- Increase the load to CC mode - Continue to slowly increase the load. At the same time, the user can monitor the IMON pin voltage using the DMM or oscilloscope. When the load increases to around 14A, V_{OUT} starts to drop below 36V (at around 34.5V) and the IMON pin voltage reaches 1.6V. This shows the CC loop is working and the input current is controlled to be fixed at 41.5A (typical). When the load current continues to increase, the input current is fixed at 41.5A (controlled by the CC loop) and the V_{OUT} continues to drop. The heavier the load, the lower the V_{OUT}, which is the characteristic

of constant power (V_{IN} is kept at 12V fixed and the input current is controlled at 41.5A fixed).

- Power off
  - Turn off the load to 0A
  - Turn off the EN power supply
  - Power down VIN power supply

2. **DE mode plus Phase Drop mode -** Remove the jumper at J23 and keep J23 open. The ISL78227's DE/PHDRP pin is floating and the IC is set in DE+PH_DROP mode.

- Enable the system and repeat the procedures in Step 1.
- Confirm the input voltage, output voltage, load current and operation mode.
  - At no load, only Phase 1 is switching and it is pulse skipping. Phase 2 is dropped and not switching.
  - When the load increases to a level when the IMON voltage is higher than 1.15V, Phase 2 is added and switching.
  - CC control at overloading has the same scenario described in Step 1.

3. **DE mode** - Short J23's Pin 2 (DE/PHDRP) and Pin 1 (VCC) with a jumper to set the IC in DE Mode. Leave J23 Pin 3 (GND) floating.

- Enable the system and repeat the procedures in Step 1.
- Confirm the input voltage, output voltage, load current and operation mode.
  - At no load, either Phase 1, or Phase 2, or both is/are switching at Discontinuous Conduction Mode (DCM) and pulse skipping.
  - When the load increases from 0 to a certain light load, both Phase 1 and Phase 2 are switching at DCM mode.
  - When the load is higher than a certain level (inductor current is higher than the boundary current between DCM and CCM), Phase 1 and Phase 2 will be switching at CCM mode.
  - CC control at overloading has the same scenario described in Step 1.

ISL78227EV1Z Schematic

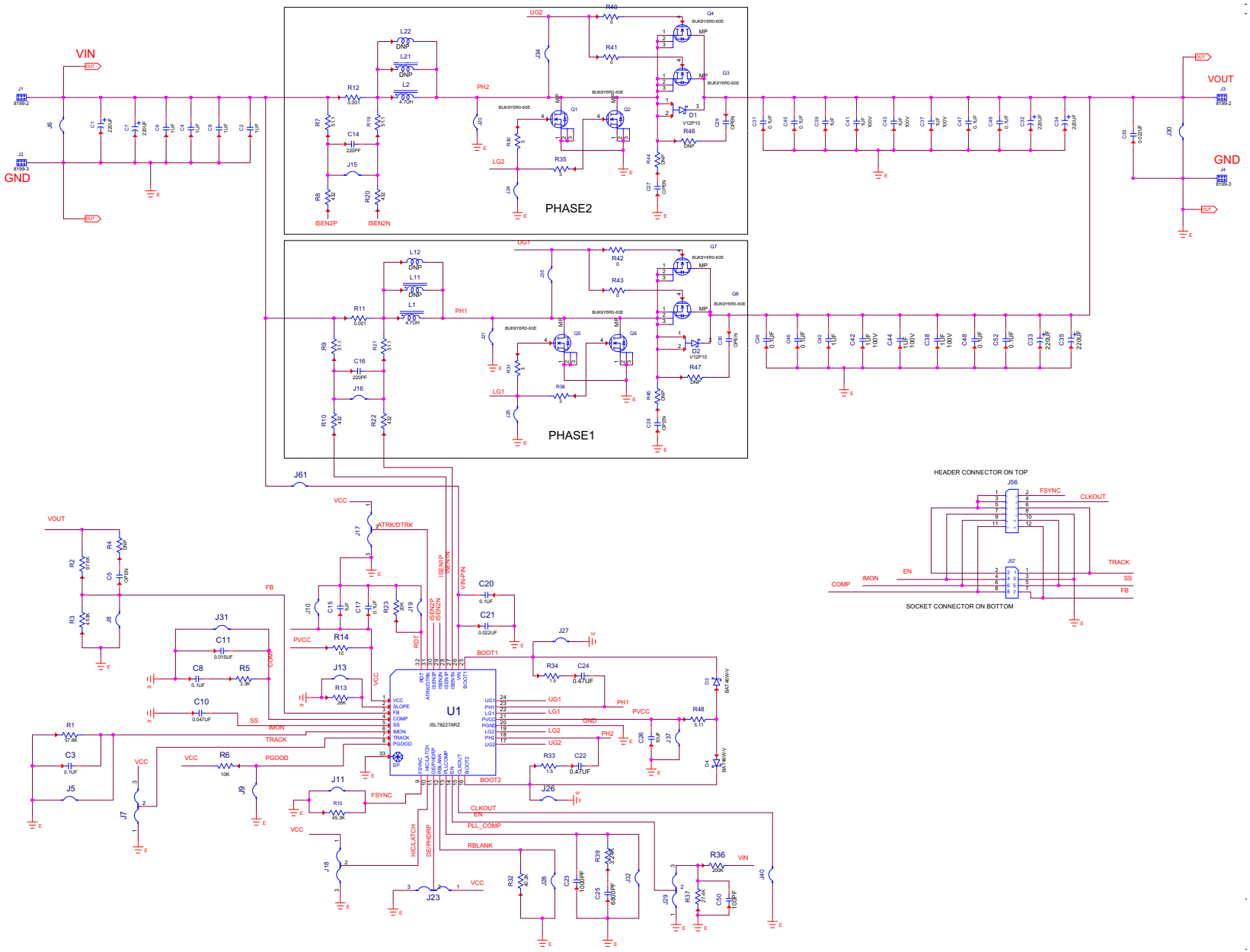


FIGURE 4. ISL78227EV1Z BOARD SCHEMATIC - PAGE 1

ISL78227EV1Z Schematic (Continued)

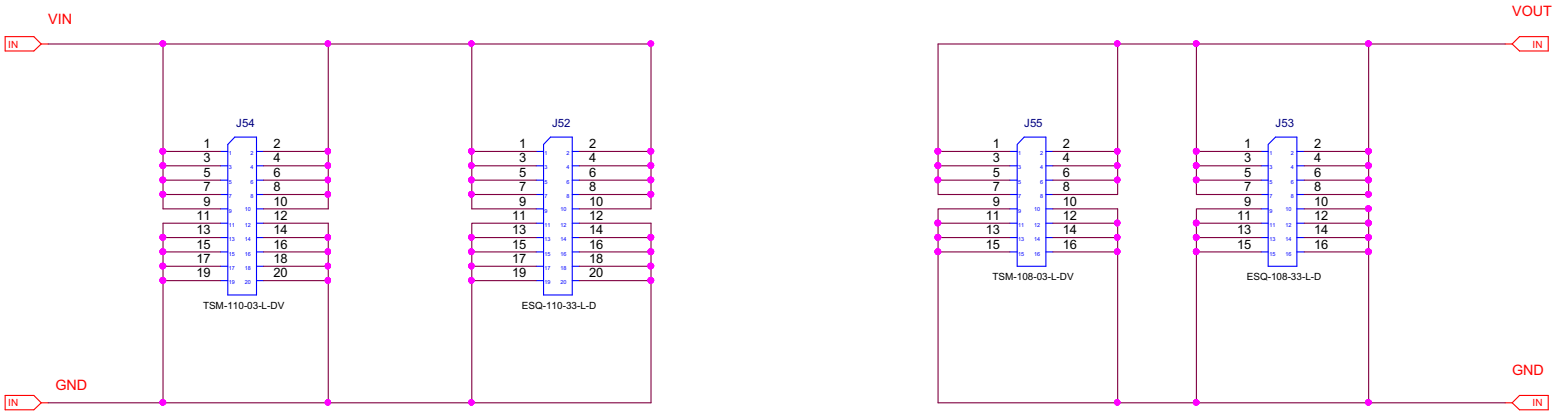


FIGURE 5. ISL78227EV1Z BOARD SCHEMATIC - PAGE 2

Stack Two Boards for Parallel Operation

Two ISL78227EV1Z boards can be stacked. This allows for two ISL78227s to operate in parallel achieving a 4-phase interleaved boost regulator.

The ISL78227EV1Z has connectors to stack multiple boards for parallel operation. Figures 6 and 7 show two ISL78227EV1Z boards stacked. To stack two boards properly, align the two boards with one on top of the other, and plug in the 3 groups of connectors described in the following (first 3 bullet points). Directions for stacking board #1 on top of board #2:

- Plug board #2's J54 (header/pin type, on board top) into board #1's J52 (socket type, on board bottom) to connect both boards' inputs together.
- Plug board #2's J53 (header/pin type, on board top) into board #1's J55 (socket type, on board bottom) to connect both boards' outputs together.
- Plug board #2's J56's Pin 5-12 (header/pin type, on board top) into board #1's J57 (socket type, 8 pins, on board bottom) to connect both boards' signals needed for the boards' parallel operation, e.g., TRACK, GND, EN, SS, IMON, FB and COMP signals.
- Short board #1's J56's Pin 3 and Pin 4 with the jumper to connect board #1's CLKOUT signal to the board #2's FSYNC input.
- Short board #2's J56's Pin 1 and Pin 2 with the jumper to connect board #2's FSYNC input to the board #1's CLKOUT signal.
- External setup:
  - Connect the input V_{IN} power supply to J1/J2 of both boards.
  - Connect the load to J3/J4 of both boards. Since both boards' EN pin signals are tied together, only one external EN power supply (3V to 5V) is needed for enable/disable through J29's Pins 1-2 of top board.
- Power Up:
  - Keep EN power supply off.
  - Turn on the VIN power supply.
  - Then turn on the EN power supply.
- Power Down:
  - Turn off the EN power supply.
  - Then turn off the VIN power supply.

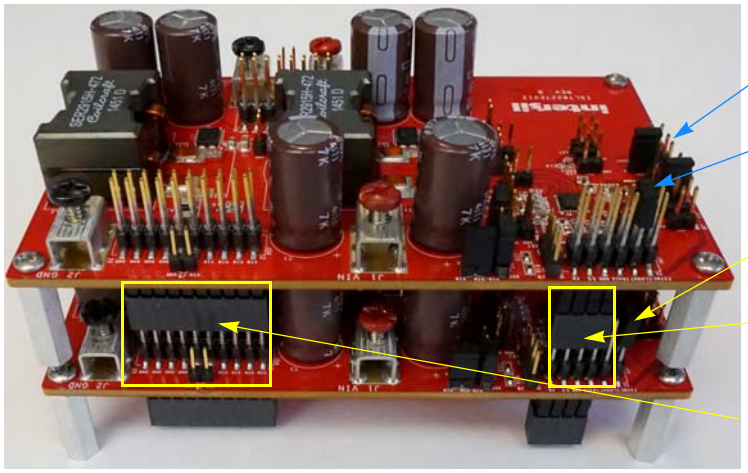


FIGURE 6. STACK TWO ISL78227EV1Z FOR PARALLEL OPERATION TO ACHIEVE 4-PHASE INTERLEAVED BOOST REGULATOR (VIEW FROM INPUTS SIDE)

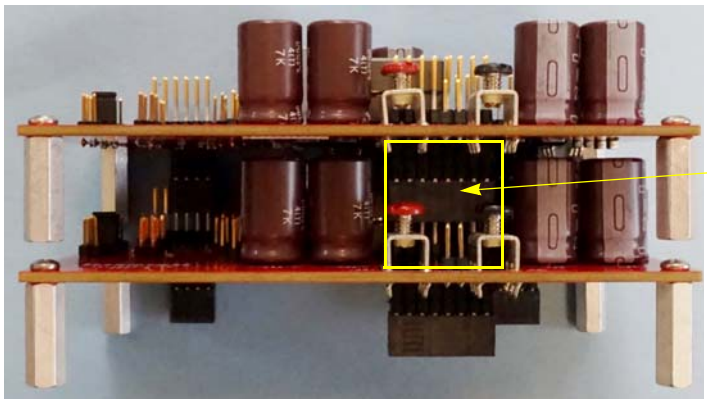


FIGURE 7. STACK TWO ISL78227EV1Z FOR PARALLEL OPERATION TO ACHIEVE 4-PHASE INTERLEAVED BOOST REGULATOR (VIEW FROM OUTPUTS SIDE)

PCB Layout Guidelines

For a DC/DC converter design, the PCB layout is very important to ensure the desired performance.

1. Place input ceramic capacitors as close as possible to the IC's VIN and PGND/SGND pins.
2. Place the output ceramic capacitors as close as possible to the power MOSFET. Keep this loop (output ceramic capacitor and MOSFETs for each phase) as small as possible to reduce voltage spikes induced by the trace parasitic inductances when MOSFETs are switching ON and OFF.
3. Place the output aluminum capacitors close to power MOSFETs also.
4. Keep the phase node copper area small but large enough to handle the load current.
5. Place the input aluminum and some ceramic capacitors close to the input inductors and power MOSFETs.
6. Place multiple vias under the thermal pad of the IC. The thermal pad should be connected to the ground copper plane with as large an area as possible in multiple layers to effectively reduce the thermal impedance. Figure 8 shows the layout example for vias in the IC bottom pad.

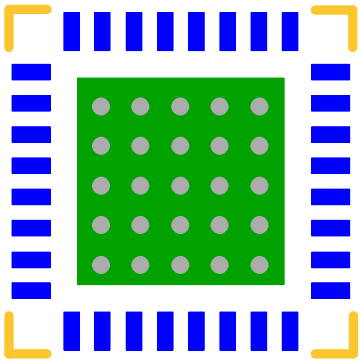


FIGURE 8. RECOMMENDED LAYOUT PATTERN FOR VIAS IN THE IC BOTTOM PAD

7. Place the 10µF decoupling ceramic capacitor at the PVCC pin and as close as possible to the IC. Put multiple vias close to the ground pad of this capacitor.
8. Place the 1µF decoupling ceramic capacitor at the VCC pin and as close as possible to the IC. Put multiple vias close to the ground pad of this capacitor.
9. Keep the bootstrap capacitor as close as possible to the IC.
10. Keep the driver traces as short as possible and with relatively large width (25 mil to 40 mil is recommended), and avoid using via or minimal number of vias in the driver path to achieve the lowest impedance.
11. Place the current sense setting resistors and the filter capacitor (shown as R_{SETxB}, R_{BIASxB} and C_{ISENx} in the ISL78227 datasheet) as close as possible to the IC. Keep each pair of the traces close to each other to avoid undesired switching noise injections.
12. The current sensing traces must be laid out very carefully since they carry tiny signals with only tens of mV.
13. For the current sensing traces close to the power sense resistor (R_{SENx}), the layout pattern shown in Figure 9 is recommended. Assuming the R_{SENx} is placed in the top layer (red), route one current sense connection from the middle of one R_{SENx} pad in the top layer under the resistor (red trace). For the other current sensing trace, from the middle of the other pad on R_{SENx} in top layer, after a short distance, via down to the second layer and route this trace right under the top layer current sense trace.

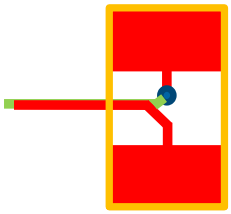


FIGURE 9. RECOMMENDED LAYOUT PATTERN FOR CURRENT SENSE TRACES REGULATOR

14. Keep the current sensing traces far from the noisy traces like gate driving traces (LGx, UGx and PHx), phase nodes in power stage, BOOTx signals, output switching pulse currents, driving bias traces and input inductor ripple current signals, etc.

TABLE 1. CONNECTOR/MONITOR-PIN DESCRIPTIONS

CONNECTOR /TEST POINT	SIGNAL NAME	DESCRIPTION
J1	VIN	Positive power input terminal for the boost regulator input.
J2	GND	Power ground input terminal for the boost regulator input.
J3	VOUT	Positive power output terminal for the boost regulator output.
J4	GND	Power ground output terminal for the boost regulator output.
J5	GND - IMON	Test point to monitor the IMON voltage. A jumper can be added to short the IMON pin to ground to disable the constant current limit (41.5A typical). To adjust the constant current control level, replace resistor (R_1) between IMON and GND.
J6	GND, VIN	Test point to monitor input voltage VIN (Do Not short with jumper).
J7	GND (Pin 1), TRACK (Pin 2), VCC (Pin 3)	Pin 2 is for monitoring TRACK voltage. It can also be used to inject a tracking reference signal to the TRACK pin. When the TRACK function is not used, short Pin 2 (TRACK) and Pin 2 (VCC) with the jumper. Do Not short both sides at the same time.
J8	GND, FB	Test point to monitor FB voltage (Do Not short with jumper).
J9	GND, PGOOD	Test point to monitor PGOOD voltage.
J10	GND, VCC	Test point to monitor VCC voltage (Do Not short with jumper).
J11	GND, FSYNC	External synchronization clock input terminal or test point for the FSYNC pin voltage (Do Not short with jumper).
J13	SLOPE, GND	Test point to monitor IMON voltage (Do Not short with jumper).
J15		Test points to monitor Phase 2 current sense input signals.
J16		Test points to monitor Phase 1 current sense input signals.
J17	VCC (Pin 1), ATRK/DTRK (Pin 2), GND (Pin 3)	TRACK input mode (analog tracking or digital tracking input) selection pins. Connect to VCC with jumper for analog tracking input or short to GND for digital tracking input (Do Not short both sides at the same time).
J18	VCC (Pin 1), HIC/LATCH (Pin 2), GND (Pin 3)	Default fault protection response mode (Hiccup/Latch-off) selection pins. Connect to VCC with jumper for Hiccup fault response as default or short to GND for Latch-off fault response as default (Do Not short both sides at the same time).
J19	RDT, GND	Test point to monitor RDT voltage (Do Not short with jumper).
J20	GND, PH2	Test point to monitor the PH2 waveform (Do Not short with jumper).
J21	GND, PH1	Test point to monitor the PH1 waveform (Do Not short with jumper).
J23	VCC (Pin 1), DE/PHDRP (Pin 2), GND (Pin 3)	CCM/DE/PH_DROP modes selection pins. Connect to VCC with jumper for DE mode; Leave all the 3 pins open for DE plus Phase Dropping mode; Short to GND for CCM mode (Do Not short both sides at the same time).
J24	GND, LG2	Test point to monitor the LG2 waveform (Do Not short with jumper).
J25	GND, LG1	Test point to monitor the LG1 waveform (Do Not short with jumper).
J26	GND, BOOT2	Test point to monitor the BOOT2 waveform (Do Not short with jumper).
J27	GND, BOOT1	Test point to monitor the BOOT1 waveform (Do Not short with jumper).
J28	GND, RBLANK	Test point to monitor RBLANK voltage (Do Not short with jumper).
J29	GND (Pin 1), EN (Pin 2), Pin 3 (For VIN_UVLO)	Enable/Disable options. Pin 2 (EN) can be used to apply external signal to enable and disable the IC. To connect Pin 2 (EN) to Pin 3 with jumper connects the resistor divider (R_{36}, R_{37}, dividing input voltage) output to the EN pin, in such a way the part has an input voltage UVLO. The board starts up when input voltage V_{IN} > 10V and shuts down when V_{IN} < 7.5V. This 10V/7.5V V_{IN} UVLO setting can be changed by changing the resistor divider values. Do Not short both sides at the same time.
J30	GND, VOUT	Test point to monitor output voltage VOUT (Do Not short with jumper).

TABLE 1. CONNECTOR/MONITOR-PIN DESCRIPTIONS (Continued)

CONNECTOR /TEST POINT	SIGNAL NAME	DESCRIPTION
J31	COMP, GND	Test point to monitor COMP voltage (Do Not short with jumper).
J32	GND, PLLCOMP	Test point to monitor PLLCOMP voltage (Do Not short with jumper).
J34	PH2, UG2	Test point to monitor UG2-PH2 voltage waveforms (Do Not short with jumper). Differential voltage probe is required to monitor UG2-PH2 waveforms.
J35	PH1, UG1	Test point to monitor UG1-PH1 voltage waveforms (Do Not short with jumper). Differential voltage probe is required to monitor UG1-PH1 waveforms.
J37	GND, PVCC	Test point to monitor PVCC voltage (Do Not short with jumper).
J40	GND, CLKOUT	Test point to monitor CLKOUT voltage (Do Not short with jumper).
J52	VIN, GND	Socket type connector for power input at board bottom side. It is used to stack boards. It is plugged in by J54 (header/pin type connector) of the other board.
J53	VOUT, GND	Header/pin type connector for power output at board top side. It is used to stack boards. It is plugged in by J55 (socket type connector) of the other board. Pins 1-8: V_{OUT}, Pins 9-16: GND.
J54	VIN, GND	Header/pin type connector for power input at board top side. It is used to stack boards. It is plugged to J52 (socket type connector) of the other board. Pins 1-10: V_{IN}, Pins 11-20: GND.
J55	VOUT, GND	Socket type connector for power output at board bottom side. It is used to stack boards. It is plugged in by J53 (header/pin type connector) of the other board.
J56	Pin 1: FSYNC if Pin 1 and Pin 2 shorted by jumper; CLKOUT if Pin 3 and Pin 4 shorted by jumper. Pin 2: FSYNC Pin 3: FSYNC if Pin 1 and Pin 2 shorted by jumper; CLKOUT if Pin 3 and Pin 4 shorted by jumper. Pin 4: CLKOUT Pin 5: FSYNC if Pin 1 and Pin 2 shorted by jumper; CLKOUT if Pin 3 and Pin 4 shorted by jumper. Pin 6: TRACK Pin 7: EN Pin 8: GND Pin 9: IMON Pin 10: SS Pin 11: COMP Pin 12: FB	Header/pin type connector on board top side for connections of signals needed for the boards' parallel operation. Its Pins 5-12 are used to plug into another board's J57 (socket type connector, 8 pins) with both boards stacked. Check the description in J57 for details.
J57	Pin 1: TRACK Pin 2: FSYNC if J56 Pin 1 and Pin 2 shorted by jumper; CLKOUT if J56 Pin 3 and Pin 4 shorted by jumper. Pin 3: GND Pin 4: EN Pin 5: SS Pin 6: IMON Pin 7: FB Pin 8: COMP	Socket type connector on the board's bottom side for connections of the signals needed for the boards' parallel operation. With it being plugged by Pins 5-12 of J56 (header/pin type connector) of the other board, the two boards' signals of TRACK, GND, EN, SS, IMON, FB and COMP are connected respectively. With board #1, J56 Pin 3 and Pin 4 are shorted by the jumper and board #2 J56 Pin 1 and Pin 2 are shorted by the jumper, board #1 CLKOUT is connected to board #2 FSYNC. With board #1, J56 Pin 1 and Pin 2 are shorted by the jumper and board #2 J56 Pin 3 and Pin 4 are shorted by the jumper, board #2 CLKOUT is connected to board #1 FSYNC.
J61	VIN, VIN_PIN	Short with jumper to connect input voltage to the ISL78227 IC VIN pin.

Bill of Materials

REFERENCE DESIGNATOR	MANUFACTURER PART NUMBER	MANUFACTURER	DESCRIPTION
C1, C7, C32-C35	EKZE800ELL221MK20S	UNITED CHEMI-CON	Capacitor, Alum. Electrolytic, RADIAL, 12.5X20, 220µF, 80V, 20%, ROHS
C10	Various	Various	Capacitor, Ceramic, SMD, 0603, 0.047µF, 50V, 10%, X7R, ROHS
C11	Various	Various	Capacitor, Ceramic, SMD, 0603, 0.015µF, 50V, 10%, X7R, ROHS
C14, C16	Various	Various	Capacitor, Ceramic, SMD, 0603, 220pF, 100V, 10%, X7R, ROHS
C15	Various	Various	Capacitor, Ceramic, SMD, 0603, 1.0µF, 16V, 10%, X7R, ROHS
C2, C4, C6, C9, C37-C44	Various	Various	Capacitor, Ceramic, SMD, 1206, 1µF, 100V, 10%, X7R, ROHS
C20, C31, C36, C45-C49, C52	Various	Various	Capacitor, Ceramic, SMD, 0805, 0.1µF, 100V, 10%, X7R, ROHS
C21, C53	Various	Various	Capacitor, Ceramic, SMD, 0603, 0.022µF, 100V, 10%, X7R, ROHS
C22, C24	Various	Various	Capacitor, Ceramic, SMD, 0603, 0.47µF, 16V, 10%, X7R, ROHS
C23	Various	Various	Capacitor, Ceramic, SMD, 0603, 1000pF, 50V, 10%, X7R, ROHS
C25	Various	Various	Capacitor, Ceramic, SMD, 0603, 6800pF, 50V, 10%, X7R, ROHS
C26	Various	Various	Capacitor, Ceramic, SMD, 0805, 10µF, 6.3V, 10%, X5R, ROHS
C3, C8, C17	Various	Various	Capacitor, Ceramic, SMD, 0603, 0.1µF, 50V, 10%, X7R, ROHS
C5, C27-C30			Capacitor, Ceramic, SMD, 0603, DNP-PLACE HOLDER
C50	Various	Various	Capacitor, Ceramic, SMD, 0603, 100pF, 50V, 5%, C0G, ROHS
D1, D2	V12P10-M3/86A-T	VISHAY	Diode-Schottky, SMD, TO-277A(SMPC), 100V, 12A, ROHS
D3, D4	BAT46W-E3-08-T	DIODES INC.	Diode-Schottky, SMD, SOD-123, 100V, 0.15A, ROHS
J1, J3	8199-2	KEYSTONE	CONN-SCREW TERMINAL, Through-Hole, 6P, SNAP-IN, 30A, RED, BRASS, ROHS
J2, J4	8199-3	KEYSTONE	CONN-SCREW TERMINAL, Through-Hole, 6P, SNAP-IN, 30A, BLK, BRASS, ROHS
J5, J6, J8-J11, J13, J15, J16, J19-J21, J24-J28, J30-J32, J34, J35, J37, J40, J61	69190-202HLF	BERG/FCI	Connector-Header, 1x2, RETENTIVE, 2.54mm Pitch, 0.230x 0.120, ROHS
J52	ESQ-110-33-L-D	SAMTEC	Connector-Socket, ELEVATED, Through-Hole, 2x10, DUALROW, 2.54mm Pitch, ROHS
J53	TSM-108-03-L-DV	SAMTEC	Connector-Header, SMD, 2x8, 2.54mm Pitch, VERTICAL, ROHS
J54	TSM-110-03-L-DV	SAMTEC	Connector-Header, SMD, 2x10, 2.54mm Pitch, VERTICAL, ROHS
J55	ESQ-108-33-L-D	SAMTEC	Connector-Socket, ELEVATED, Through-Hole, 2x8, DUALROW, 2.54mm Pitch, ROHS
J56	TSM-106-03-L-DV	SAMTEC	Connector-Header, SMD, 2x6, 2.54mm Pitch, VERTICAL, ROHS
J57	ESQ-104-33-L-D	SAMTEC	Connector-Socket, ELEVATED, Through-Hole, 2x4, DUALROW, 2.54mm Pitch, ROHS
J7, J17, J18, J23, J29	68000-236HLF-1X3	BERG/FCI	Connector-Header, 1x3, BREAK AWAY, 1x36, 2.54mm Pitch, ROHS

Bill of Materials (Continued)

REFERENCE DESIGNATOR	MANUFACTURER PART NUMBER	MANUFACTURER	DESCRIPTION
Jumpers shorting: J17-Pins 1-2, J18-Pins 1-2, J23-Pins 2-3, J29-Pins 2-3, J61-Pins 1-2	SPC02SYAN	SULLINS	Connector-Jumper, SHORTING, 2-PIN, BLACK, GOLD, ROHS
L1, L2	SER2915H-472KLB-T	COILCRAFT	Power Inductor, SMD, 27X19.1, 4.7µH, 20%, 1.8mΩ, ROHS
L11, L12, L21, L22	DNP		Power Inductor, SMD, DNP-PLACE HOLDER
Q1-Q8	BUK9Y6R0-60E	NXP SEMICONDUCTOR	Transistor-MOSFET , N-CHANNEL, SMD, 56LFPAK, 60V, 100A, 6mΩ, ROHS
R1	Various	Various	Resistor, SMD, 0603, 57.6kΩ, 1/10W, 1%, TF, ROHS
R11, R12	ERJ-M1WTF1M0U	PANASONIC	RES-CURR.SENSE, SMD, 2512, 0.001Ω, 1W, 1%, TF, ROHS
R13	Various	Various	Resistor, SMD, 0603, 28kΩ, 1%, ROHS
R14	Various	Various	Resistor, SMD, 0603, 10Ω, 1/10W, 1%, TF, ROHS
R15	Various	Various	Resistor, SMD, 0603, 61.9kΩ, 1%, ROHS
R2	Various	Various	Resistor, SMD, 0603, 97.6kΩ, 1/10W, 1%, TF, ROHS
R23	Various	Various	Resistor, SMD, 0603, 20kΩ, 1%, ROHS
R3	Various	Various	Resistor, SMD, 0603, 4.53kΩ, 1/10W, 1%, TF, ROHS
R30, R31, R35, R38	Various	Various	Resistor, SMD, 0603, 3Ω, 1%, ROHS
R32	Various	Various	Resistor, SMD, 0603, 40.2kΩ, 1%, ROHS
R33, R34	Various	Various	Resistor, SMD, 0603, 1.5Ω, 1%, ROHS
R36	Various	Various	Resistor, SMD, 0603, 200kΩ, 1%, ROHS
R37	Various	Various	Resistor, SMD, 0603, 27.4kΩ, 1%, ROHS
R39	Various	Various	Resistor, SMD, 0603, 3.24k, 1%, ROHS
R4			Resistor, SMD, 0603, DNP-PLACE HOLDER
R40-R43	Various	Various	Resistor, SMD, 0603, 0Ω, 1/10W, TF, ROHS
R44, R45, R46, R47			Resistor, SMD, 1206, DNP-PLACE HOLDER
R48	Various	Various	Resistor, SMD, 0603, 5.11Ω, 1/10W, 1%, TF, ROHS
R5	Various	Various	Resistor, SMD, 0603, 3.3kΩ, 1%, ROHS
R6	Various	Various	Resistor, SMD, 0603, 10kΩ, 1%, ROHS
R7, R9, R19, R21	Various	Various	Resistor, SMD, 0603, 51.1Ω, 1%, ROHS
R8, R10, R20, R22	Various	Various	Resistor, SMD, 0603, 432Ω, 1%, ROHS
U1	ISL78227ARZ	INTERSIL	IC-2 PHASE BOOST CONTROLLER, 32P, WFQFN, 5x5, ROHS
	ISL78227EV1ZREVBPCB		PCB, ROHS

Board Layout

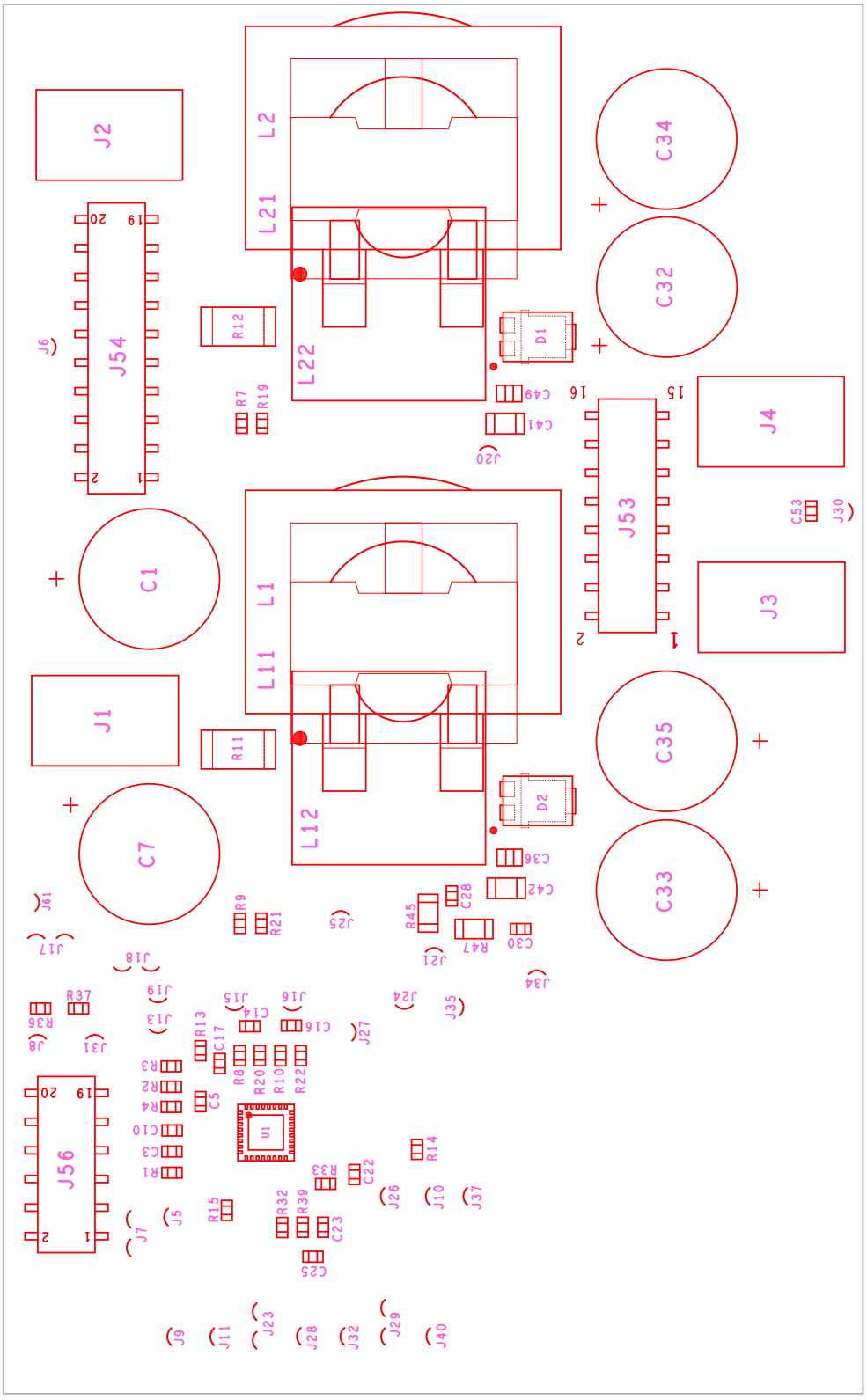


FIGURE 10. TOP COMPONENT ASSEMBLY

Board Layout (Continued)

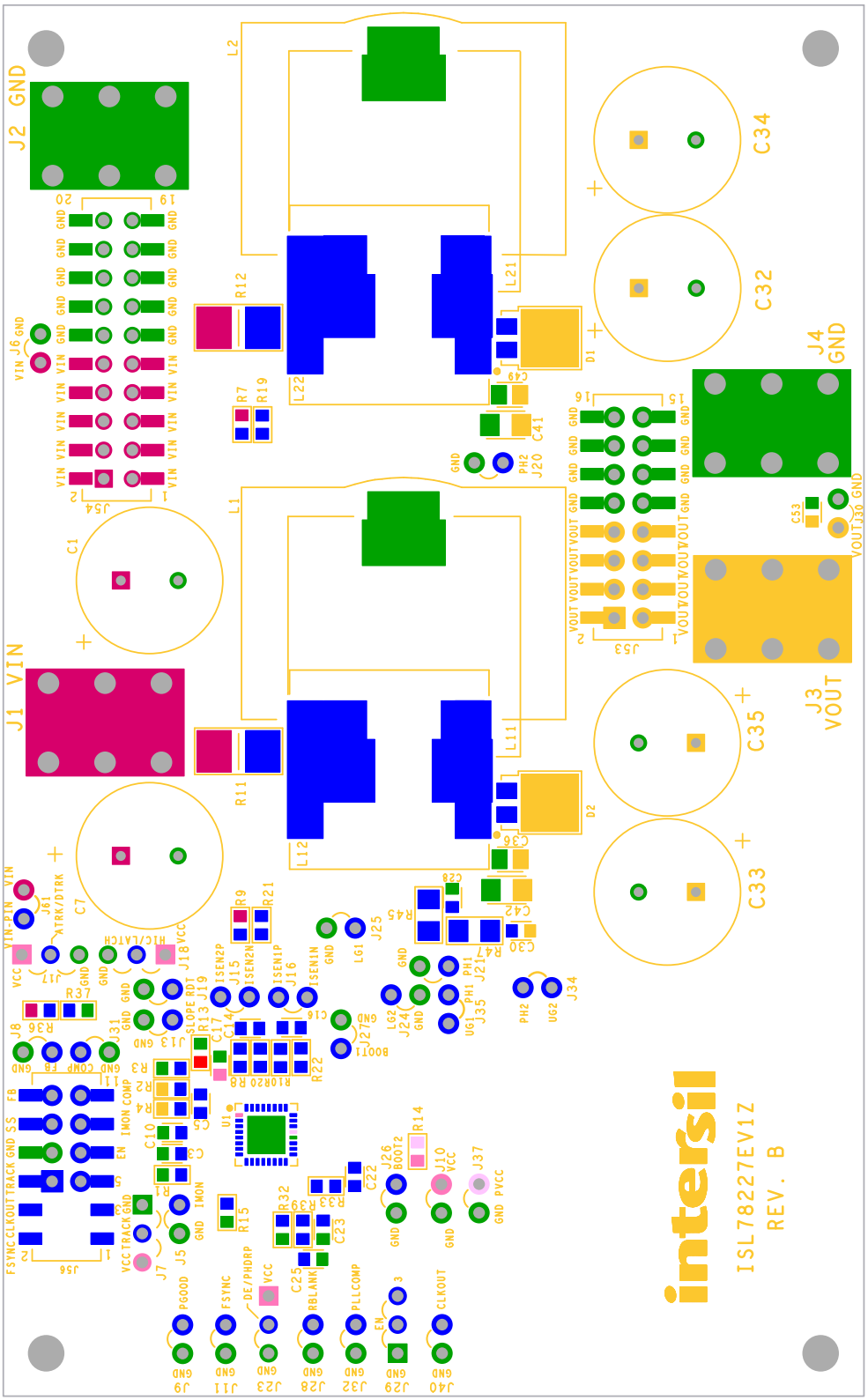


FIGURE 11. TOP SILKSCREEN AND PIN PADS

Board Layout (Continued)

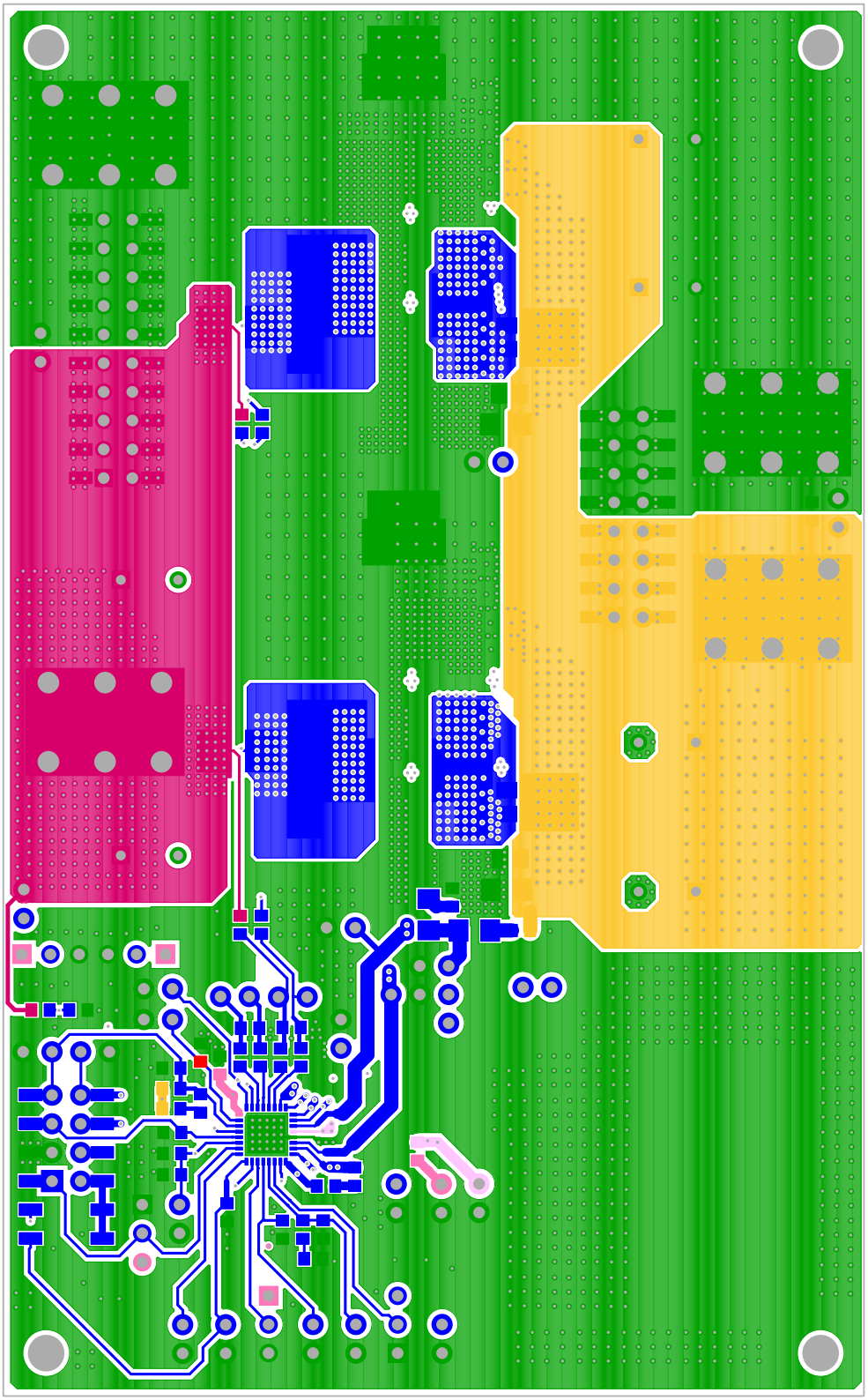


FIGURE 12. TOP LAYER

Board Layout (Continued)

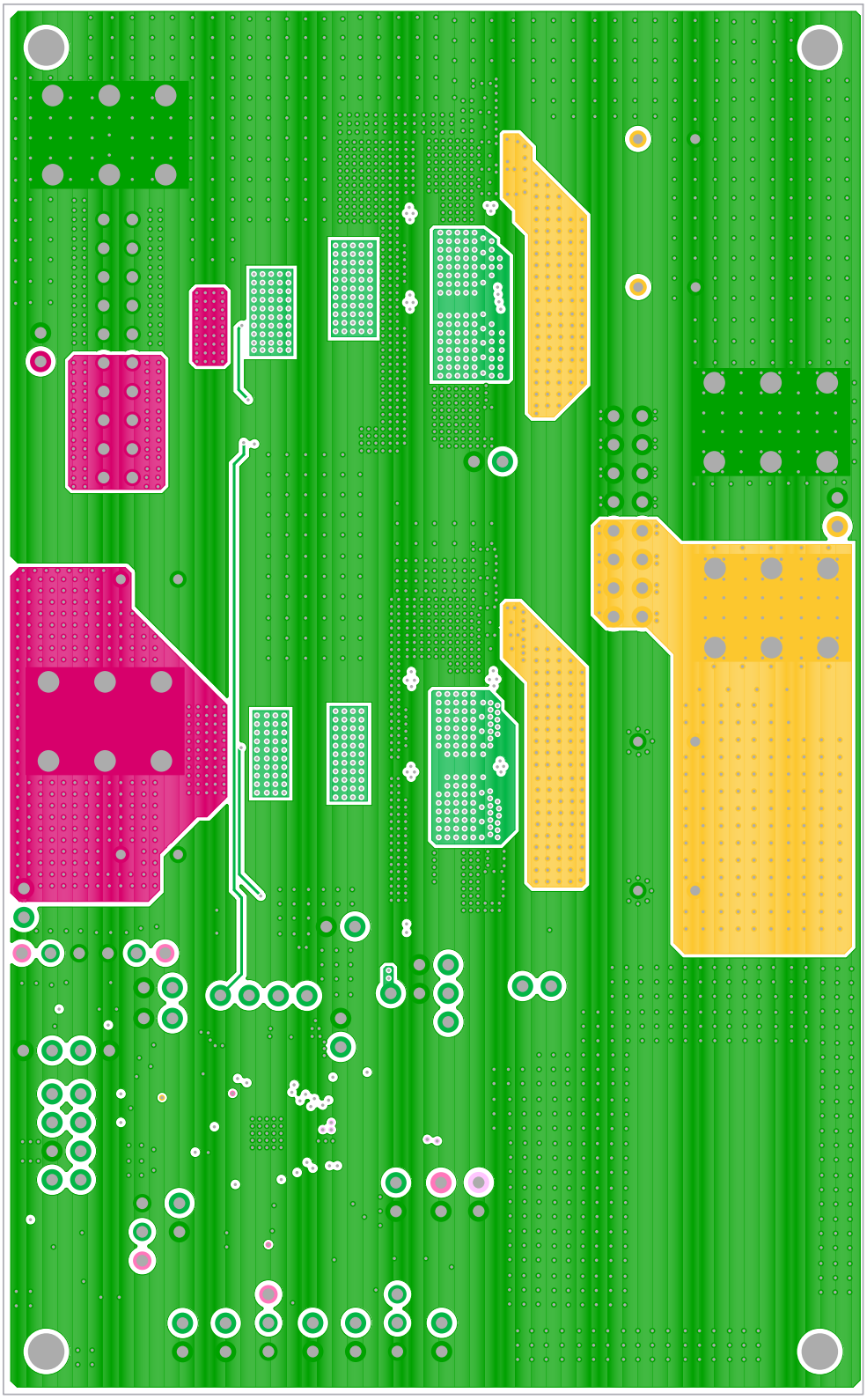


FIGURE 13. 2nd LAYER

Board Layout (Continued)

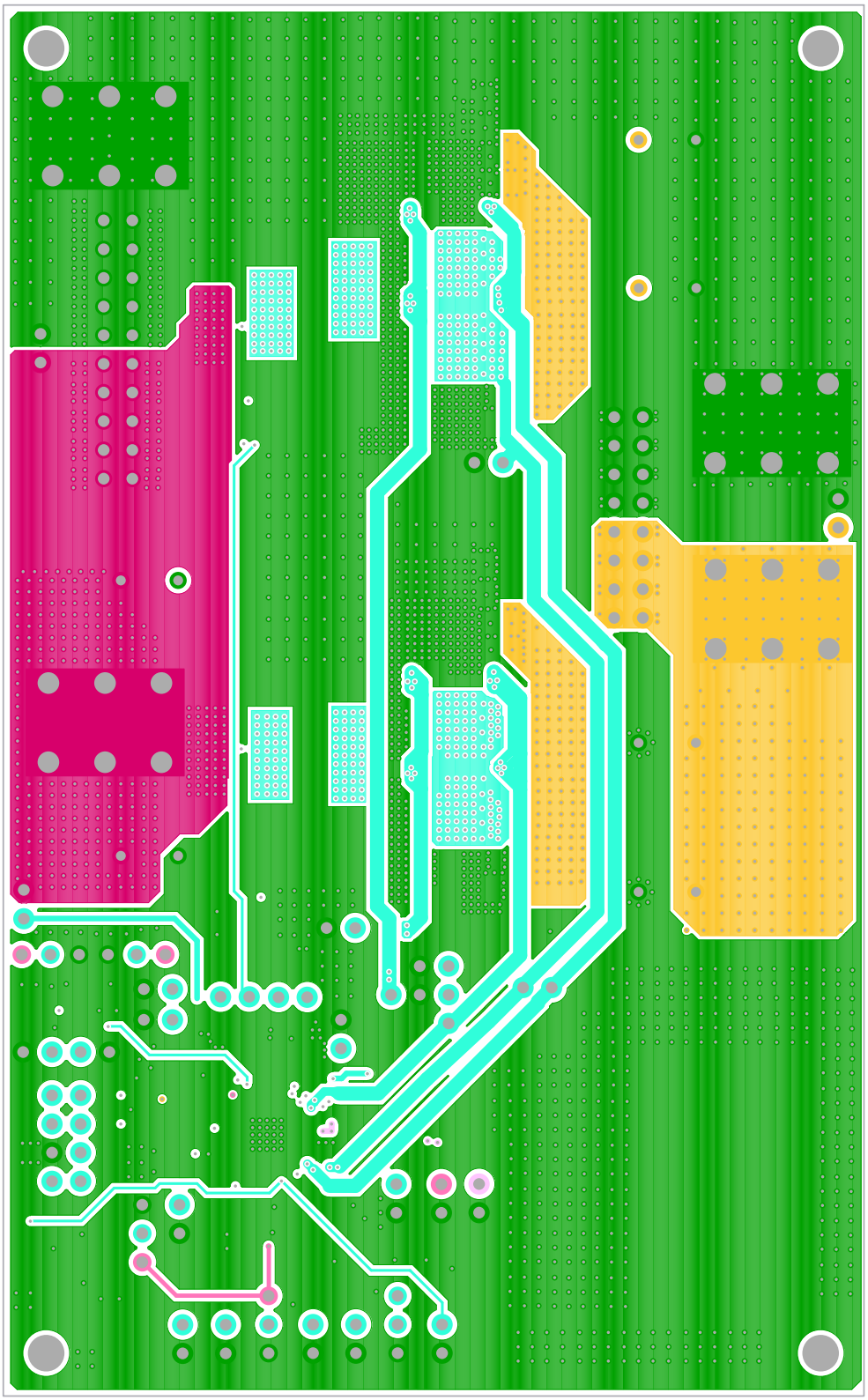


FIGURE 14. 3rd LAYER

Board Layout (Continued)

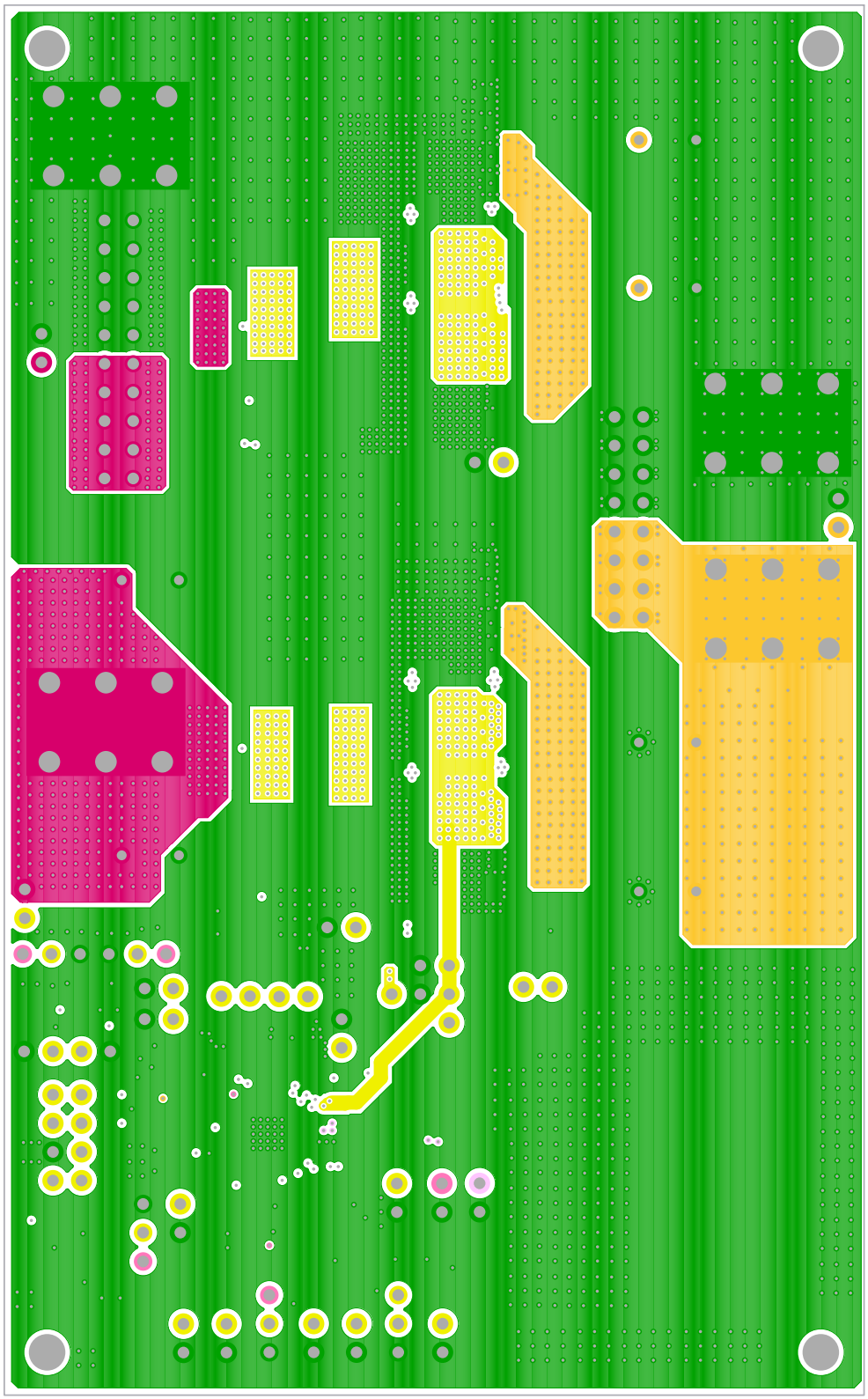


FIGURE 15. 4th LAYER

Board Layout (Continued)

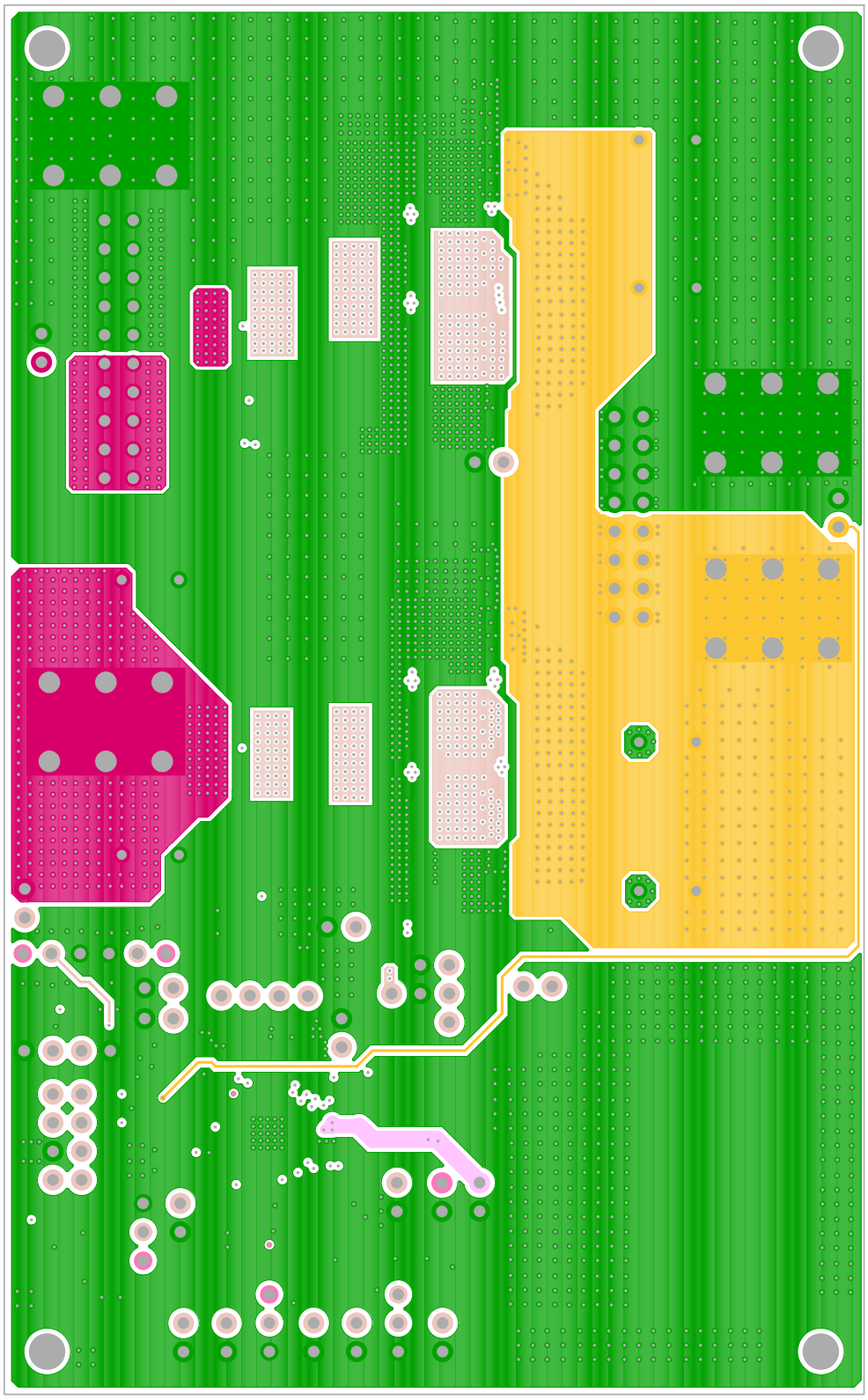


FIGURE 16. 5th LAYER

Board Layout (Continued)

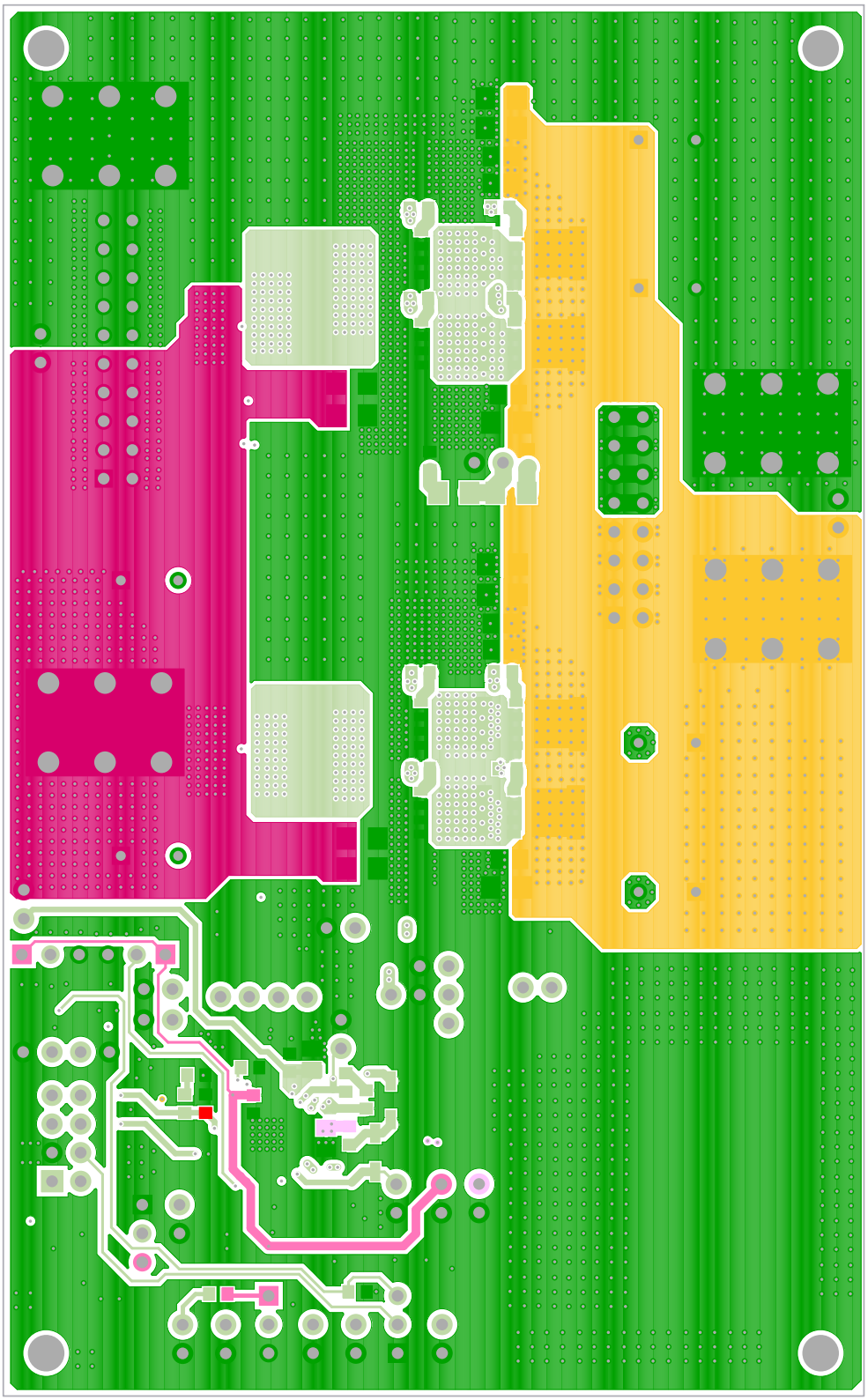


FIGURE 17. BOTTOM LAYER

Board Layout (Continued)

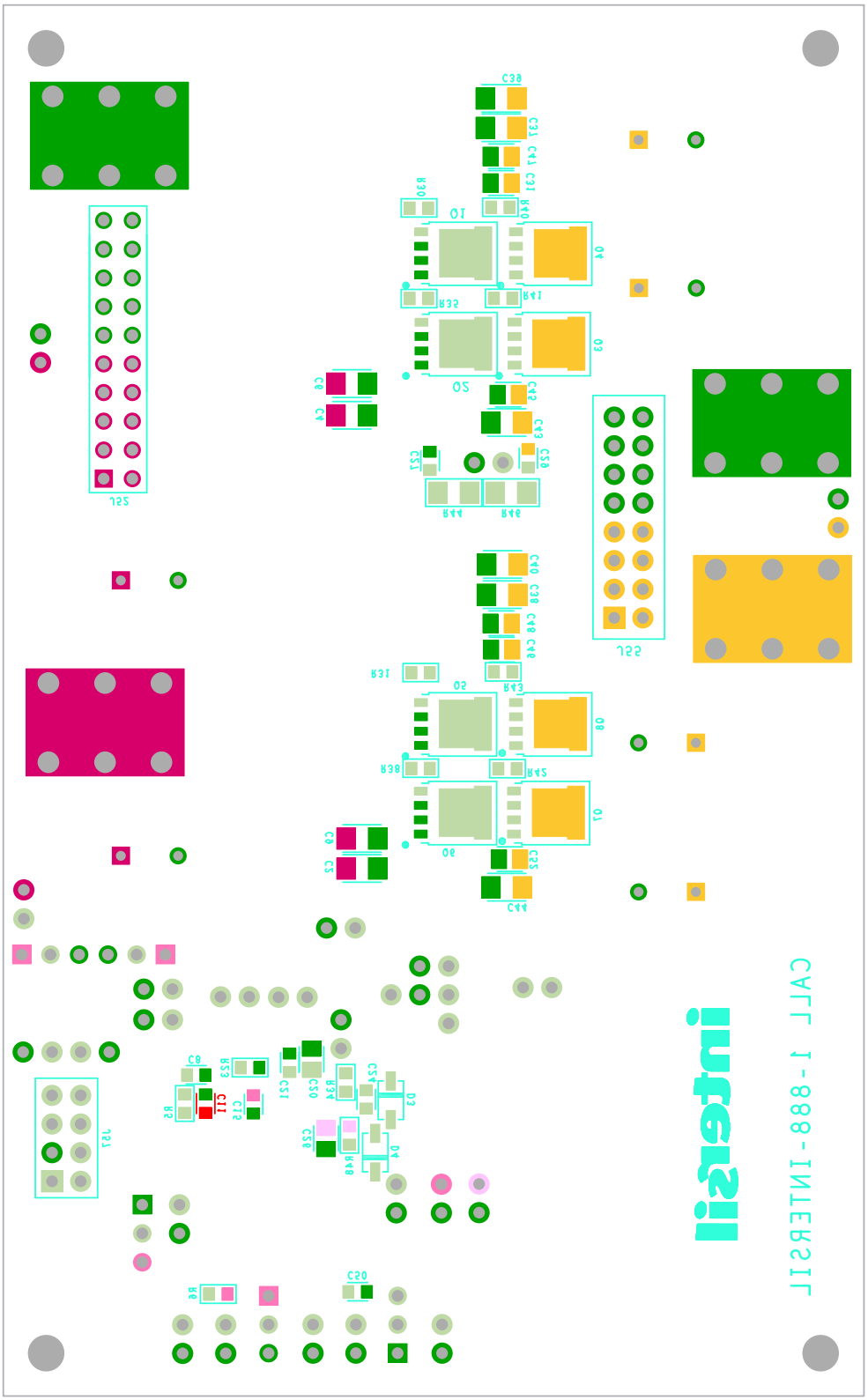


FIGURE 18. BOTTOM SILKSREEN AND PIN PADS

Board Layout (Continued)

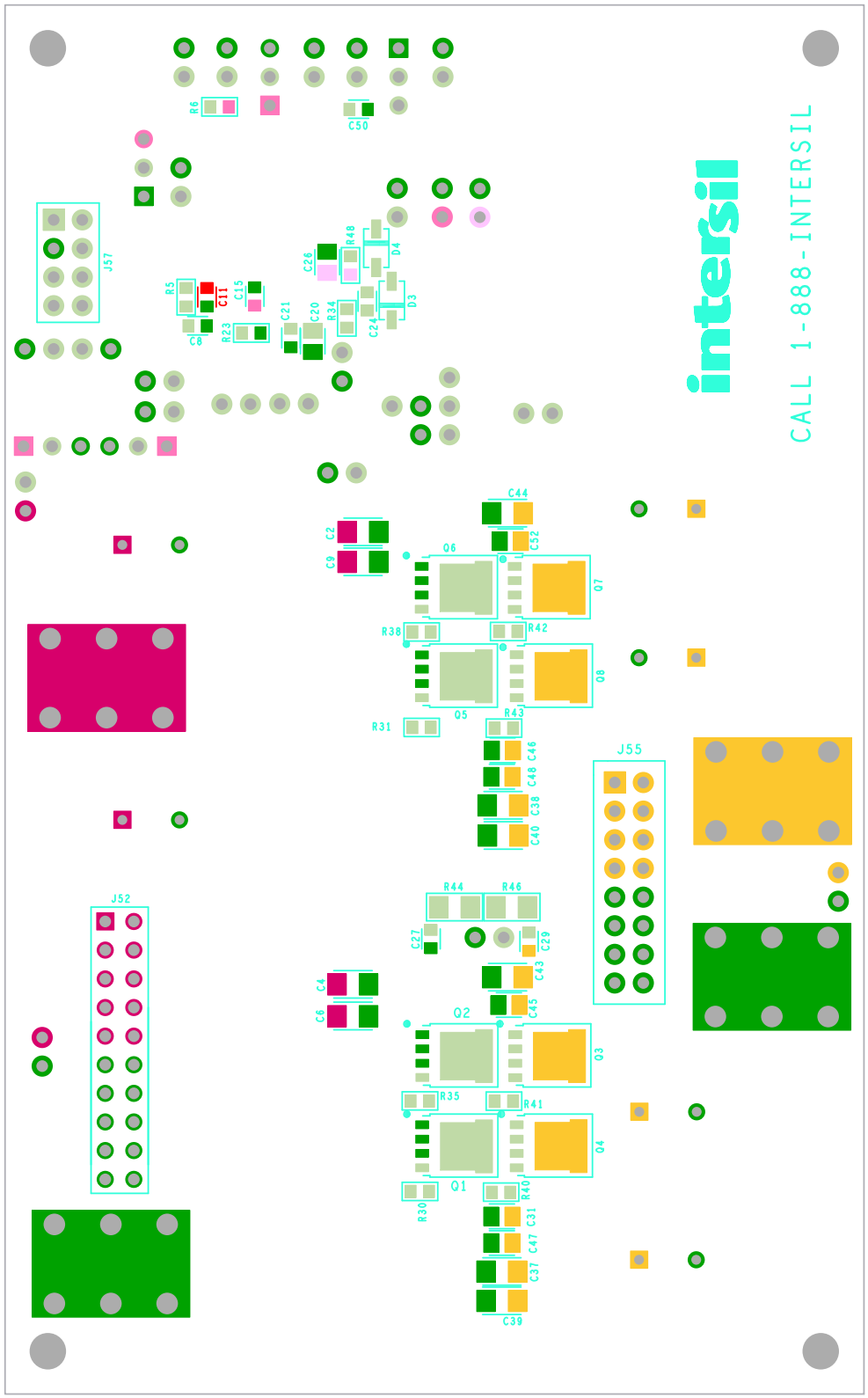
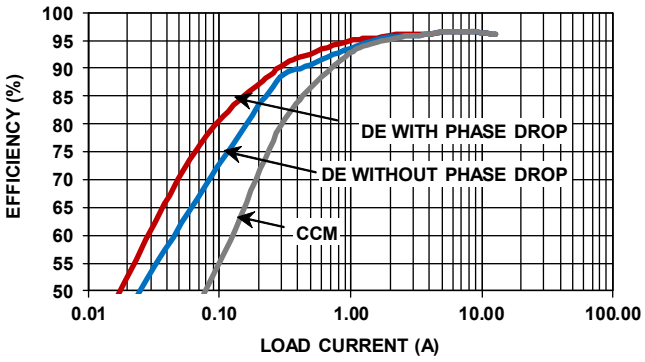


FIGURE 19. BOTTOM SILKSREEN AND PIN PADS (MIRRORED)

Performance Curves

Unless otherwise specified, operating conditions for the oscilloscope waveforms are V_{IN} = 12V, V_{OUT} = 36V and T_A = +25°C.



NOTE: (See Typical Application in Figure 4 in the ISL78227 datasheet.)

FIGURE 20. EFFICIENCY vs LOAD, 2-PHASE BOOST, 3 MODES OPERATION, f_{SW} = 200kHz, V_{IN} = 12V, V_{OUT} = 36V, T_A = +25°C

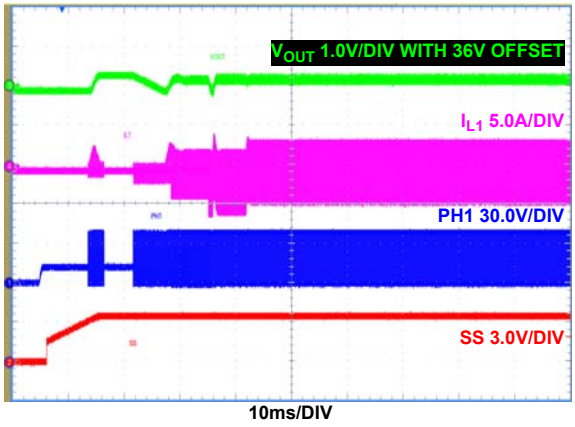


FIGURE 21. EN INTO PREBIASED OUTPUT, CCM MODE (DE/PHDRP = GND), I_{OUT} = 0A

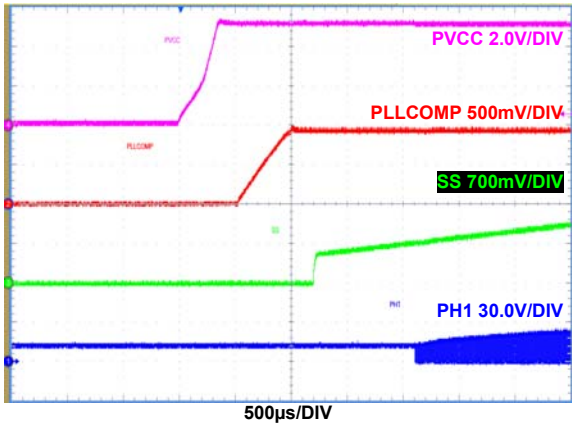


FIGURE 22. EN ON AND INITIALIZATION TO START-UP, I_{OUT} = 0A

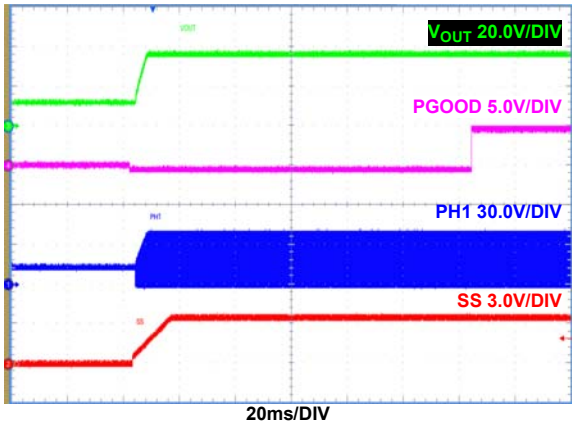


FIGURE 23. SOFT-START, CCM MODE (DE/PHDRP = GND), I_{OUT} = 8A

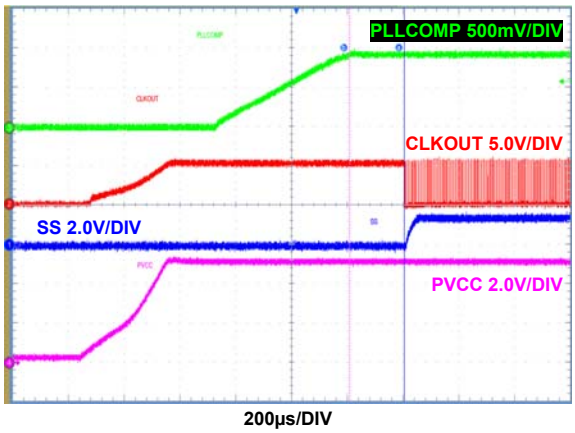


FIGURE 24. EN ON AND INITIALIZATION TO START-UP, I_{OUT} = 0A

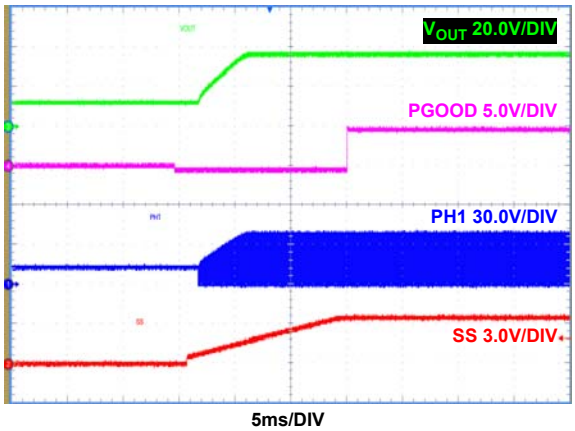


FIGURE 25. SOFT-START, DE+PHDROP MODE (DE/PHDRP = FLOAT), I_{OUT} = 8A

Performance Curves

Unless otherwise specified, operating conditions for the oscilloscope waveforms are V_{IN} = 12V, V_{OUT} = 36V and T_A = +25°C. **(Continued)**

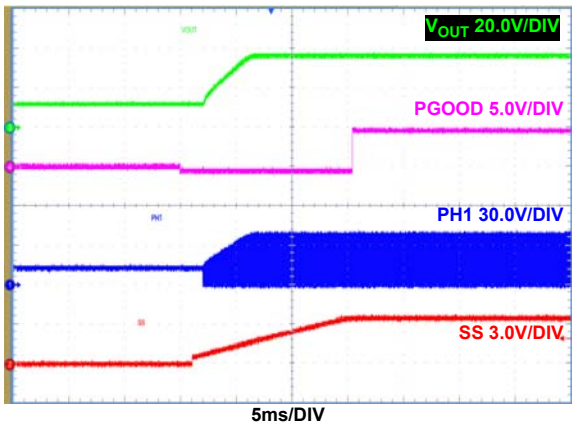


FIGURE 26. SOFT-START, DE MODE (DE/PHDRP = VCC), I_{OUT} = 8A

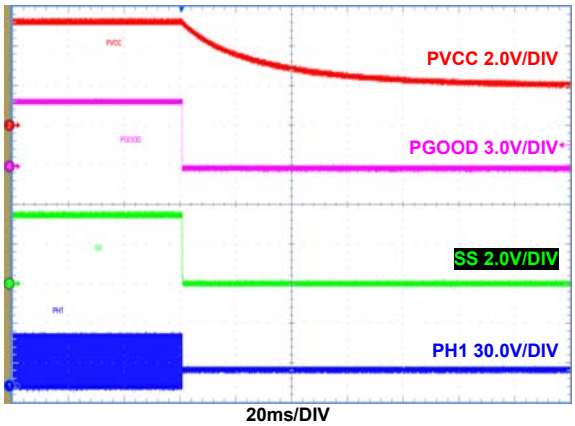


FIGURE 27. EN SHUTDOWN, PVCC/PGOOD/SS FALL, I_{OUT} = 0A

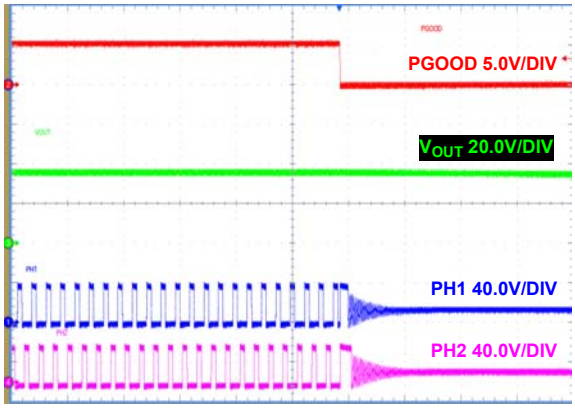


FIGURE 28. EN SHUTDOWN, I_{OUT} = 8A

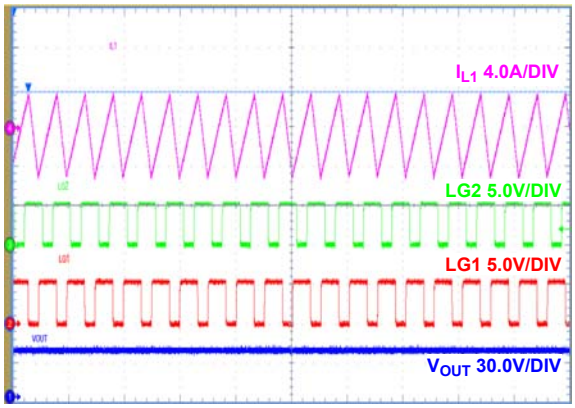


FIGURE 29. CCM MODE (DE/PHDRP = GND), PHASE 1 INDUCTOR RIPPLE CURRENT, I_{OUT} = 0A

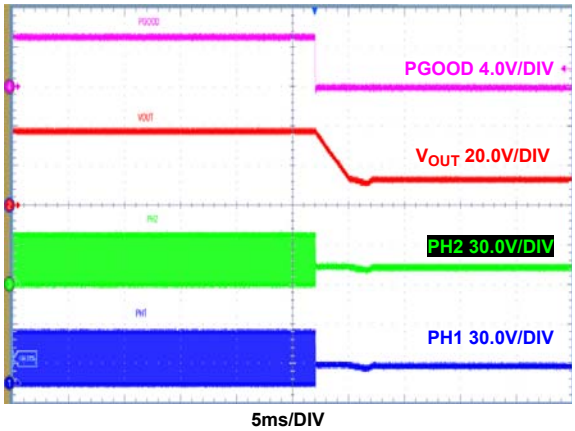


FIGURE 30. EN SHUTDOWN, I_{OUT} = 8A

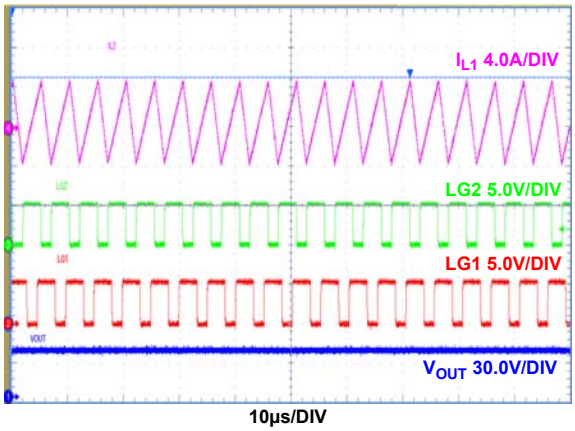


FIGURE 31. CCM MODE (DE/PHDRP = GND), PHASE 1 INDUCTOR RIPPLE CURRENT, I_{OUT} = 0A

Performance Curves

Unless otherwise specified, operating conditions for the oscilloscope waveforms are V_{IN} = 12V, V_{OUT} = 36V and T_A = +25°C. **(Continued)**

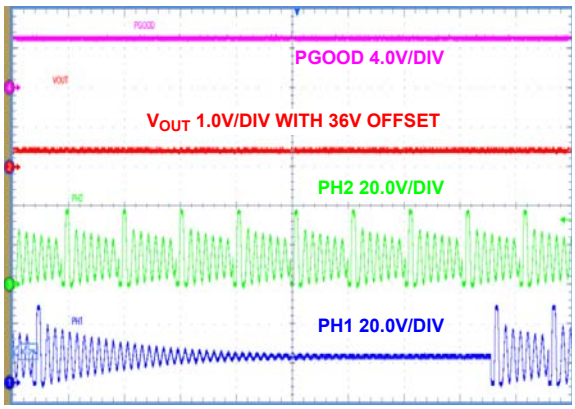


FIGURE 32. DE MODE (DE/PHDRP = VCC), DIODE EMULATION OPERATION, PULSE SKIPPING, I_{OUT} = 0A

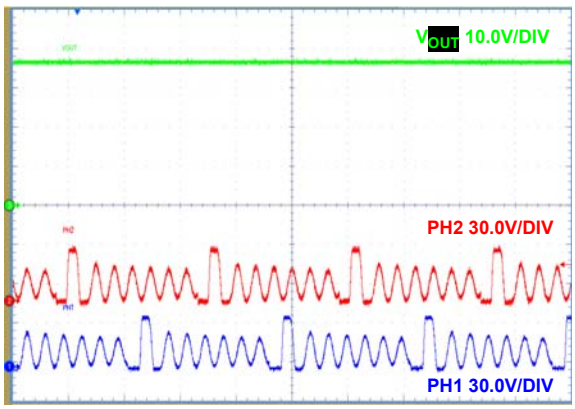


FIGURE 33. DE MODE (DE/PHDRP = VCC), DIODE EMULATION OPERATION, I_{OUT} = 29mA

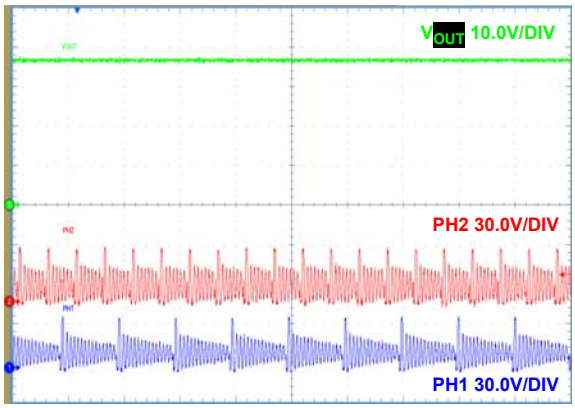


FIGURE 34. DE MODE (DE/PHDRP = VCC), PH1 AND PH2 DIODE EMULATION OPERATION, PULSE SKIPPING, I_{OUT} = 7mA

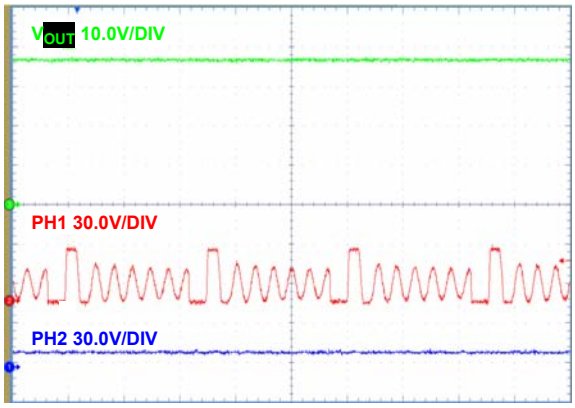


FIGURE 35. DE+PH_DROP MODE (DE/PHDRP = FLOAT), PH1 DIODE EMULATION WITH PH2 DROPPED, I_{OUT} = 29mA

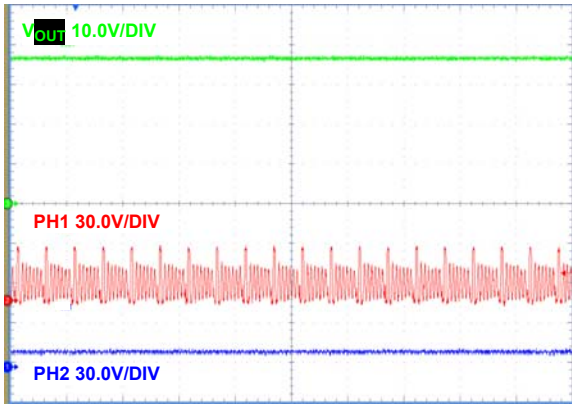


FIGURE 36. DE+PHDRP MODE (DE/PHDRP = FLOAT), PH1 DIODE EMULATION WITH PH2 DROPPED, I_{OUT} = 7mA

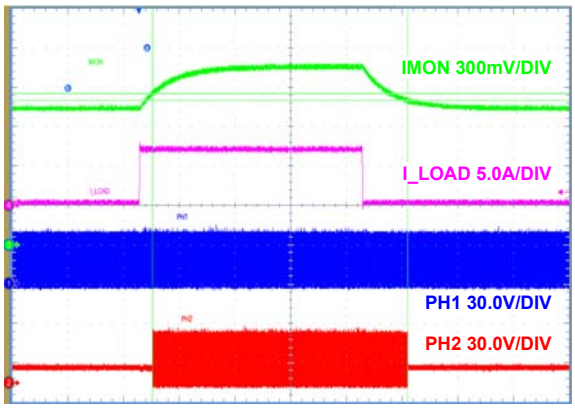


FIGURE 37. DE+PHDRP MODE (DE/PHDRP = FLOAT), PH2 ADDED AND DROPPED, UNDER TRANSIENT STEP LOAD OF 1A TO 8A

Performance Curves

Unless otherwise specified, operating conditions for the oscilloscope waveforms are V_{IN} = 12V, V_{OUT} = 36V and T_A = +25°C. **(Continued)**

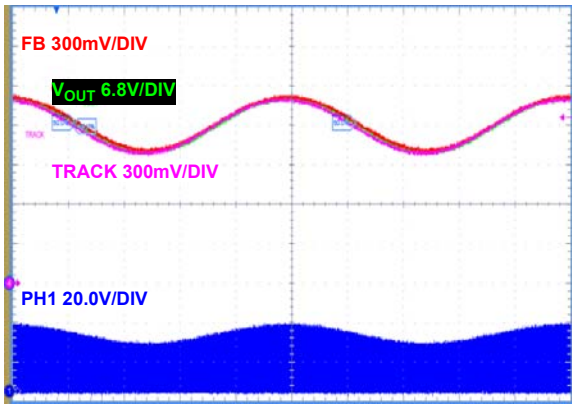


FIGURE 38. ANALOG TRACKING 100Hz SINUSOIDAL SIGNAL, CCM MODE (DE/PHDRP = GND), ATRK/DTRAK = VCC, I_{OUT} = 1A

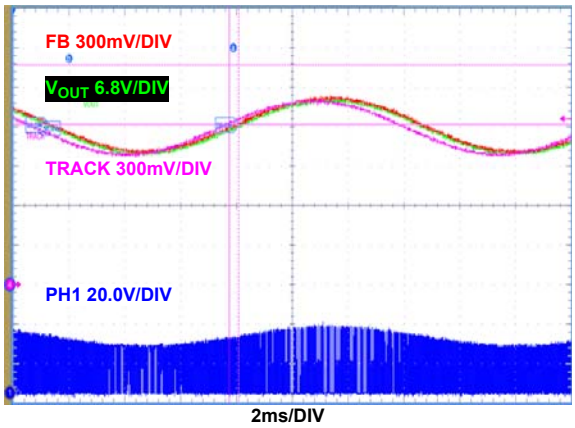


FIGURE 39. ANALOG TRACKING 300Hz SINUSOIDAL SIGNAL AT THE TRACK PIN, CCM MODE (DE/PHDRP = GND), ATRK/DTRAK = VCC, I_{OUT} = 1A

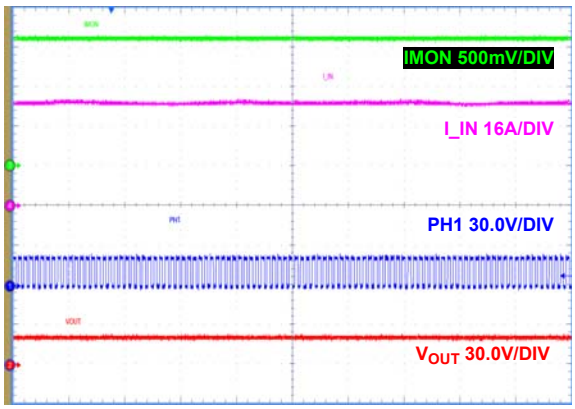


FIGURE 40. STEADY-STATE OPERATION OF INPUT CONSTANT CURRENT MODE, I_{IN} CONTROLLED AT 43A CONSTANT, V_{OUT} = 19.5V

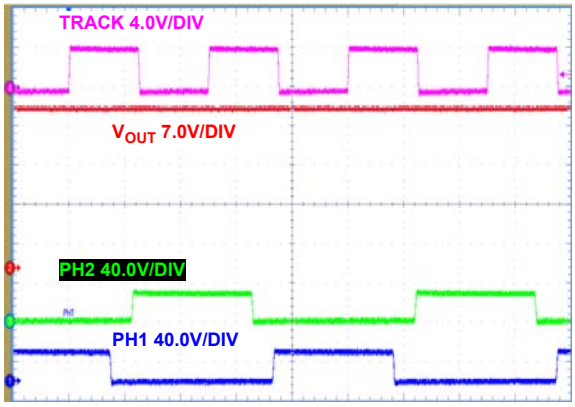


FIGURE 41. DIGITAL TRACKING (TRACKING SIGNAL, FREQUENCY = 400kHz, D = 0.5, V_{OUT} = 28.3V

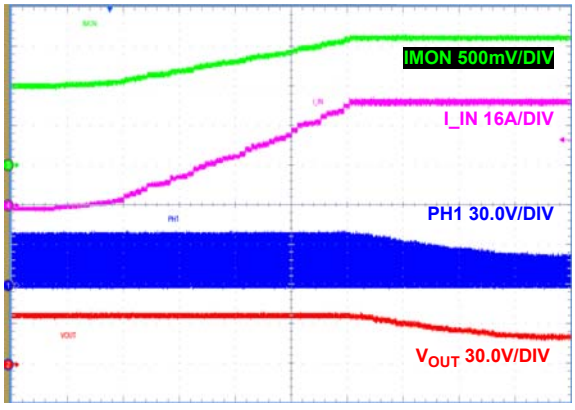


FIGURE 42. LOAD CURRENT KEEP INCREASING FROM NO LOAD TO OVERLOAD (25A), V_{OUT} STARTS TO DROP WHEN INPUT CONSTANT CURRENT MODE STARTS TO WORK, INPUT CURRENT IS FINALLY CONTROLLED TO BE CONSTANT

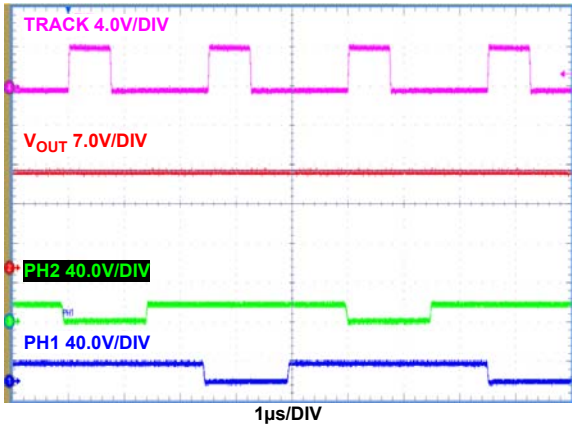


FIGURE 43. DIGITAL TRACKING (TRACKING SIGNAL, FREQUENCY = 400kHz, D = 0.3), V_{OUT} = 17V

Performance Curves

Unless otherwise specified, operating conditions for the oscilloscope waveforms are V_{IN} = 12V, V_{OUT} = 36V and T_A = +25°C. **(Continued)**

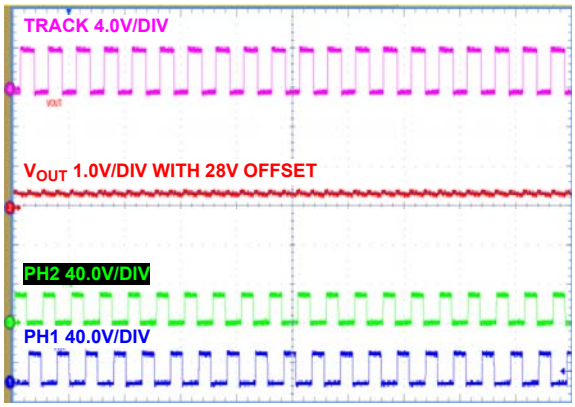


FIGURE 44. DIGITAL TRACKING, (TRACKING SIGNAL, FREQUENCY = 200kHz, D = 0.5), V_{OUT} = 28.3V

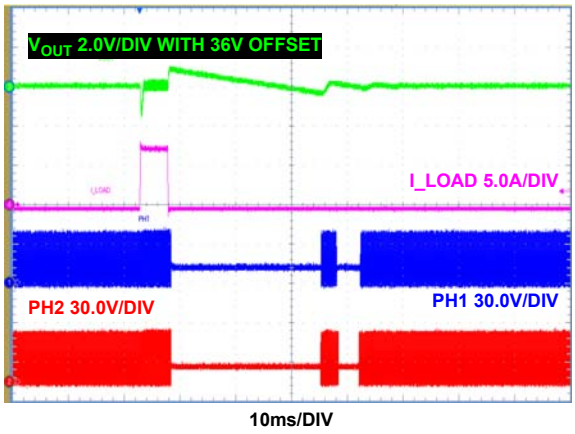


FIGURE 45. DE MODE (DE/PHDRP = VCC), TRANSIENT RESPONSE, I_{OUT} = 0.03 TO 8A STEP LOAD

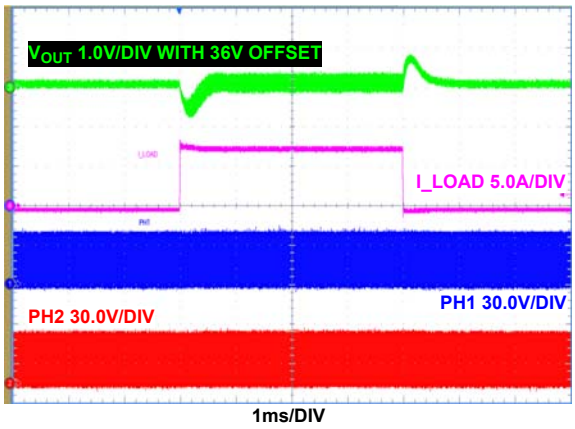


FIGURE 46. CCM MODE (DE/PHDRP = GND), TRANSIENT RESPONSE, I_{OUT} = 0 TO 8A STEP LOAD

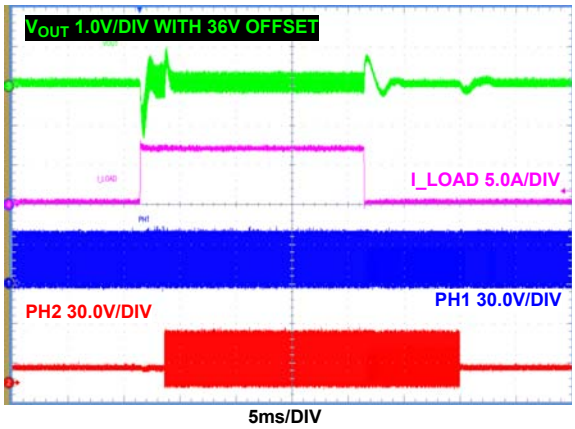


FIGURE 47. DE+PH_DROP MODE (DE/PHDRP = FLOAT), TRANSIENT RESPONSE, I_{OUT} = 1 TO 8A STEP LOAD