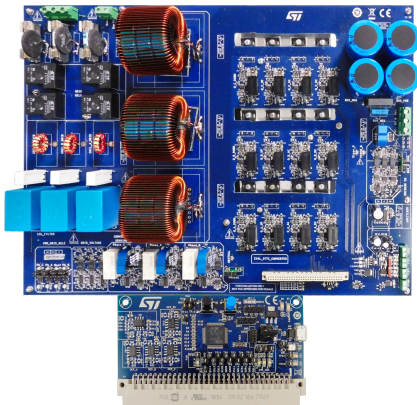


15 kW, three-phase, three-level active front end (AFE) bidirectional converter for industrial and electric vehicle DC fast charging applications



Fully assembled board developed for performance evaluation only,
not available for sale



Features

- 3-phase, 3-level bidirectional AC-DC power converter:
 - Rated nominal DC voltage: 800 V_{DC}
 - Rated nominal AC voltage: 400 V_{AC} at 50 Hz
 - Nominal power: 15 kW
- AC to DC rectifier mode:
 - Power factor: PF >0.99
 - Inrush current control and soft startup
- DC to AC inverter mode:
 - Active and reactive power control
 - Integrated grid connection solution
- Power section based on SiC MOSFETs:
 - High frequency operation (70kHz)
 - High efficiency: >98%
 - Passive element weight and size reduction
- Control section based on [STM32G474RET3](#) microcontroller:
 - P2P compatible with different power converters solutions
 - Four integrated high-performance op-amps
 - Control and monitoring interfaces: SWD, UART, I²C, DACs
 - 64-pin digital power connector
 - Overcurrent and overvoltage protection

Description

This reference design represents a complete solution for three-phase AC/DC and DC/AC (800 V_{DC} to 400 V_{AC}) applications based on a digital platform optimized for power conversion.

It is well suited for the Active Front End (AFE) stage in high power charging stations, industrial battery chargers and UPS. The high switching frequency of the SiC MOSFETs and the multilevel structure allow nearly 99% efficiency as well as the optimization of passive power components in terms of size and cost.

The [STDES-PFCBIDIR](#) is a fully assembled kit developed for performance evaluation only, not available for sale.

Product summary	
15 kW, 3-level, 3-phase bidirectional converter	STDES-PFCBIDIR
Firmware for active front end (AFE) bidirectional converter for industrial and electric vehicle DC fast charging applications	STSW-PFCBIDIR
Mainstream Arm Cortex-M4 core with DSP and FPU, 170MHz with 512Kbytes of Flash memory, Math Accelerator, HR Timer, High Analog level integration	STM32G474RET3
SiC Power MOSFET 650 V,	SCTW35N65G2V

Product summary	
45 A, 55 mΩ in HiP247 package	
Automotive-grade SiC Power MOSFET 1200 V, 33 A, 75 mΩ in HiP247 package	SCTW40N120G2VAG
Galvanically isolated 4 A single gate driver	STGAP2SM
Fixed frequency VIPer plus family	VIPER26HD
Applications	PFC Converter - Three Phase Input DC Fast Charging Station

1 Bidirectional converter reference design overview

This reference design consists of the following separate components:

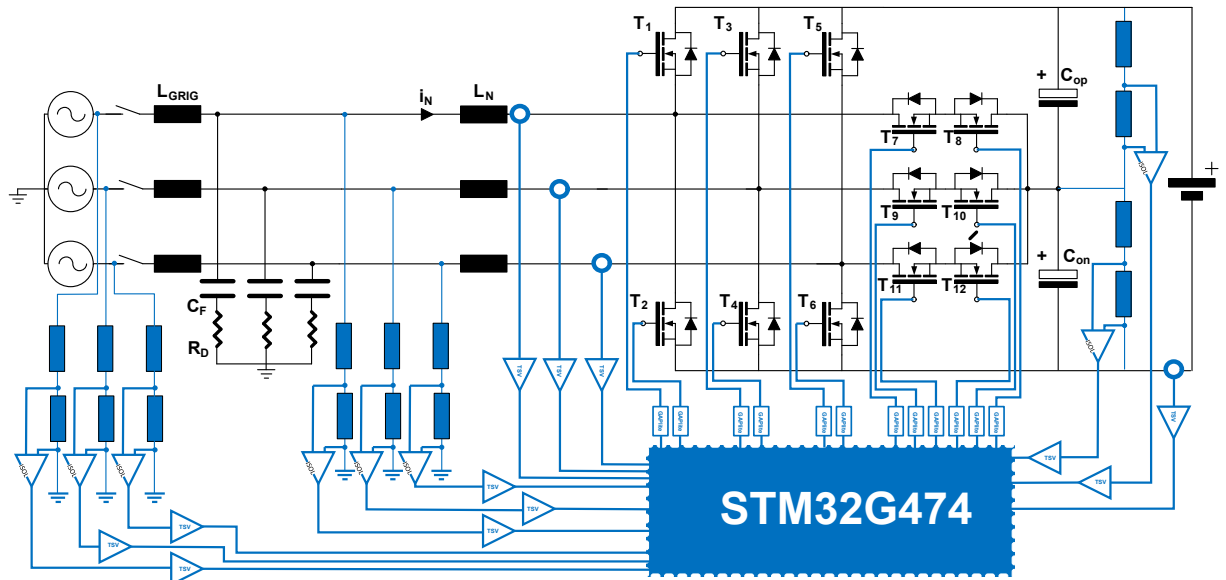
- A board with the power converter, LCL filter, sensing circuit, inrush circuit, grid connection management circuit and on-board auxiliary power supply.
- A control module based on the [STM32G4 Series](#) microcontroller with connectors for communication and test-points and status indicators for testing and debugging.

The input and output current and voltage measurements necessary for responsive control are acquired through isolated measurement blocks, and the STM32 microcontroller manages connection and disconnection with the AC electrical network, as well as load and source DC management in either inverter or rectifier mode.

The driving signals for the switching devices are managed by corresponding [STGAP2S](#) gate drivers to ensure independent management of switching frequencies and dead time.

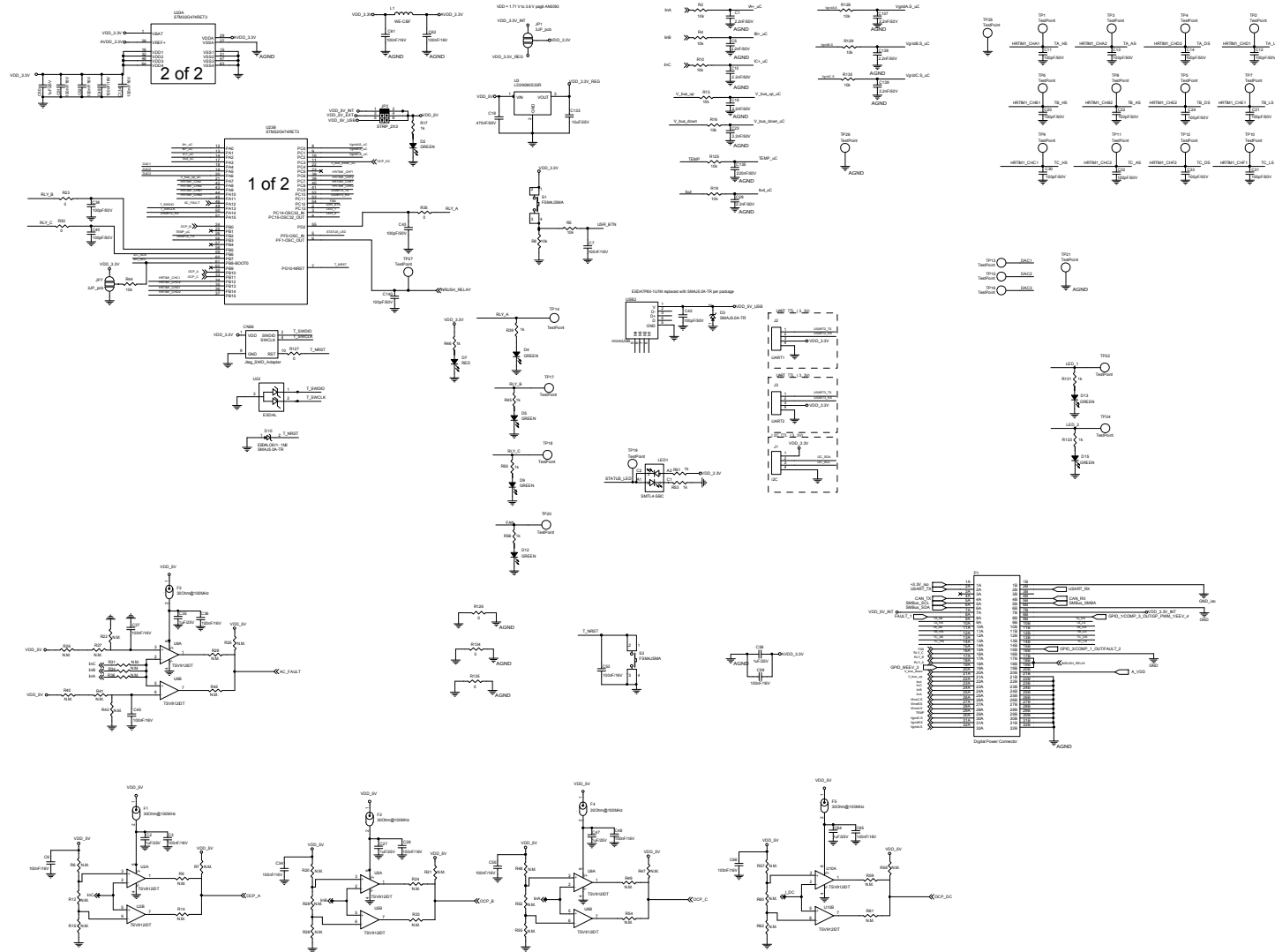
The hardware math accelerator in the MCU boosts the trigonometric operations of the voltage oriented control (VOC) algorithm, allowing the power converter to achieve very high power quality.

Figure 1. Bidirectional converter block diagram



2 Schematic diagrams

Figure 2. STDES-PFCBIDIR schematic diagram - control board



- Refer to datasheet for PCB orientation of the LED1
- Solder a 22 μ F / 10V electrolytic capacitor in parallel to C133
- 32A-28A | 31A-27A | 30A-26A of P1 connector must be shorted.

Figure 3. STDES-PFCBIDIR schematic diagram - power board: AC current sensing

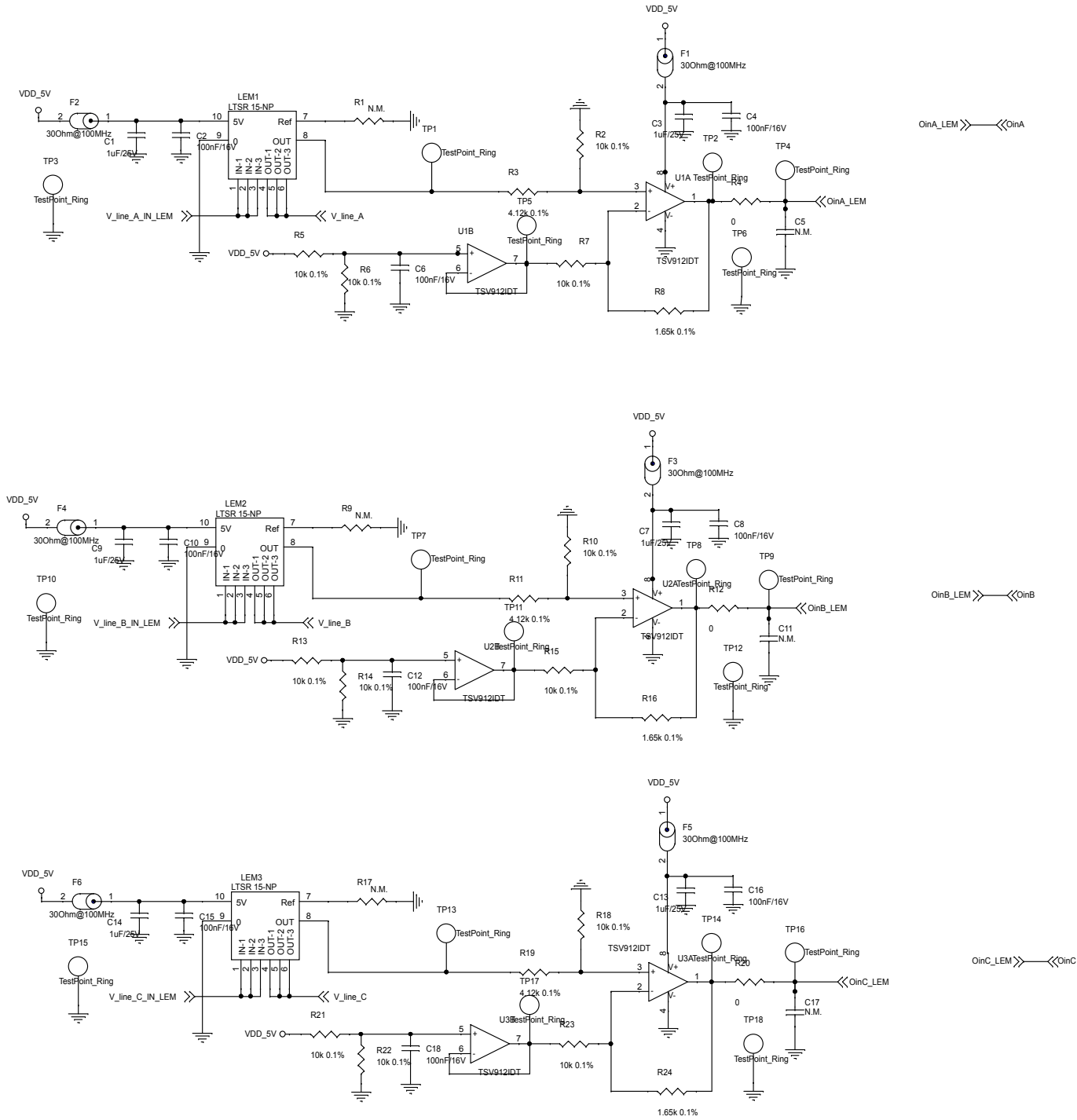


Figure 4. STDES-PFCBIDR schematic diagram - power board: AC voltage sensing

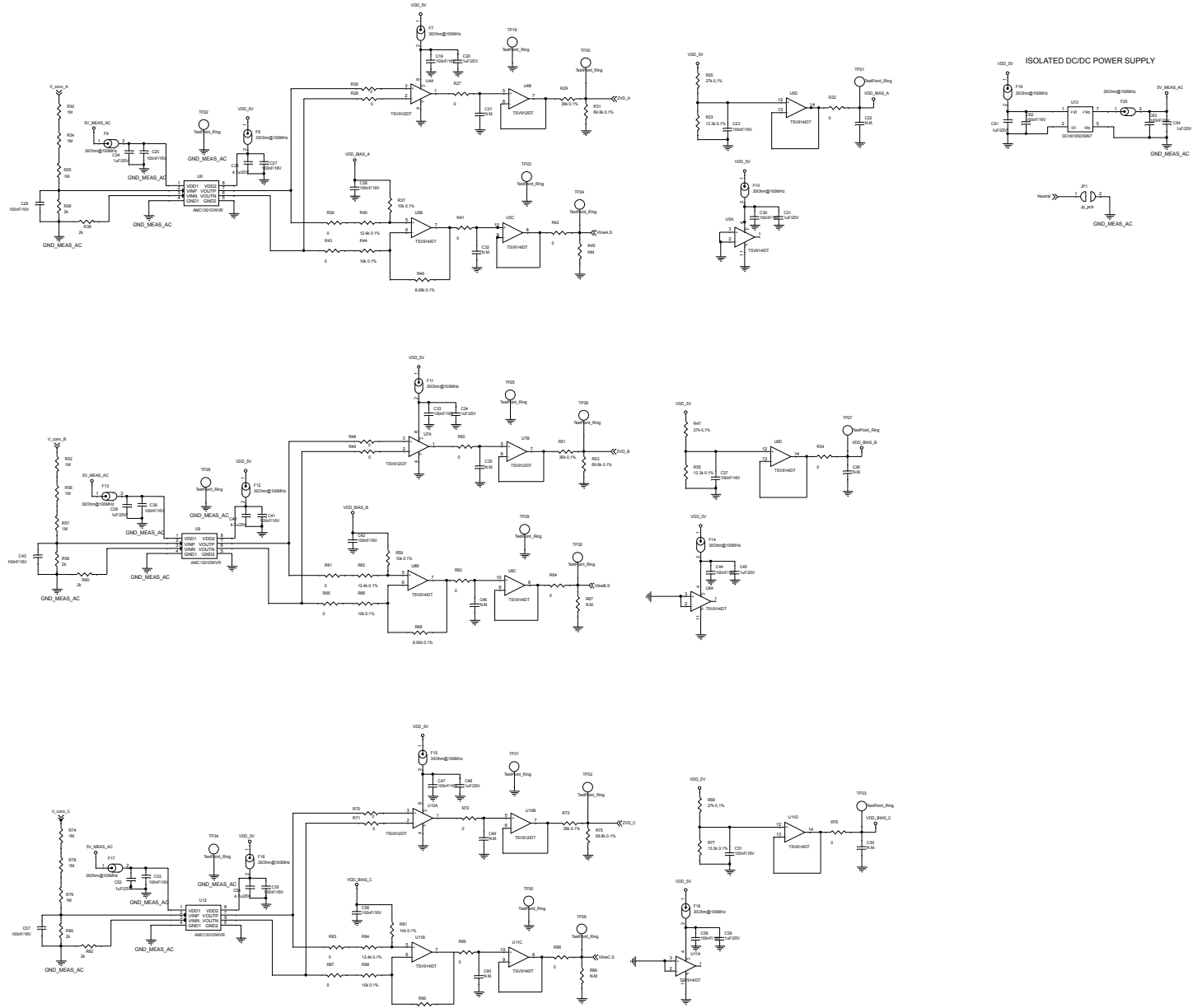


Figure 5. STDES-PFCBIDIR schematic diagram - power board: aux power DC-DC

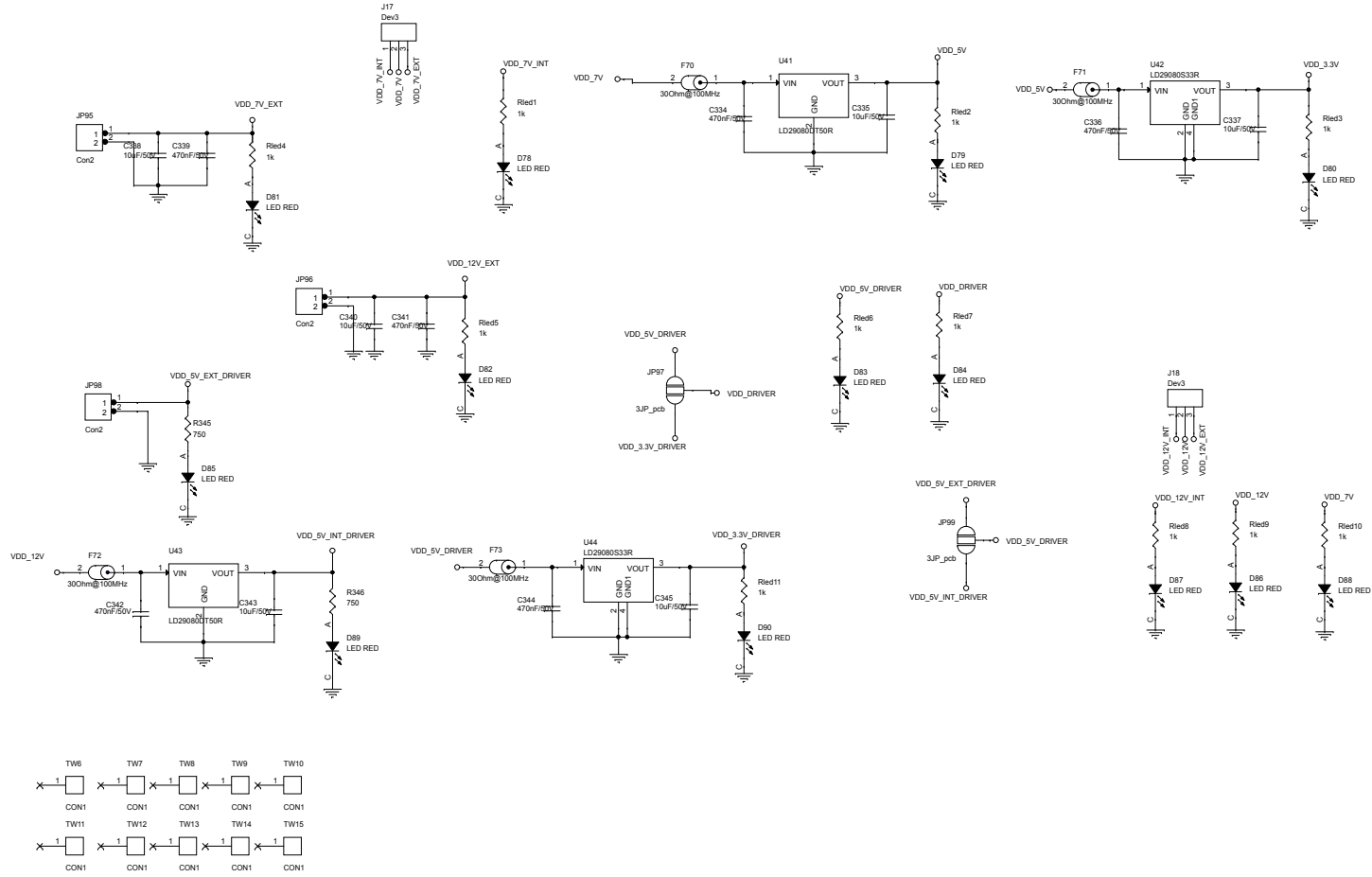


Figure 6. STDES-PFCBIDIR schematic diagram - power board: aux power VIPER

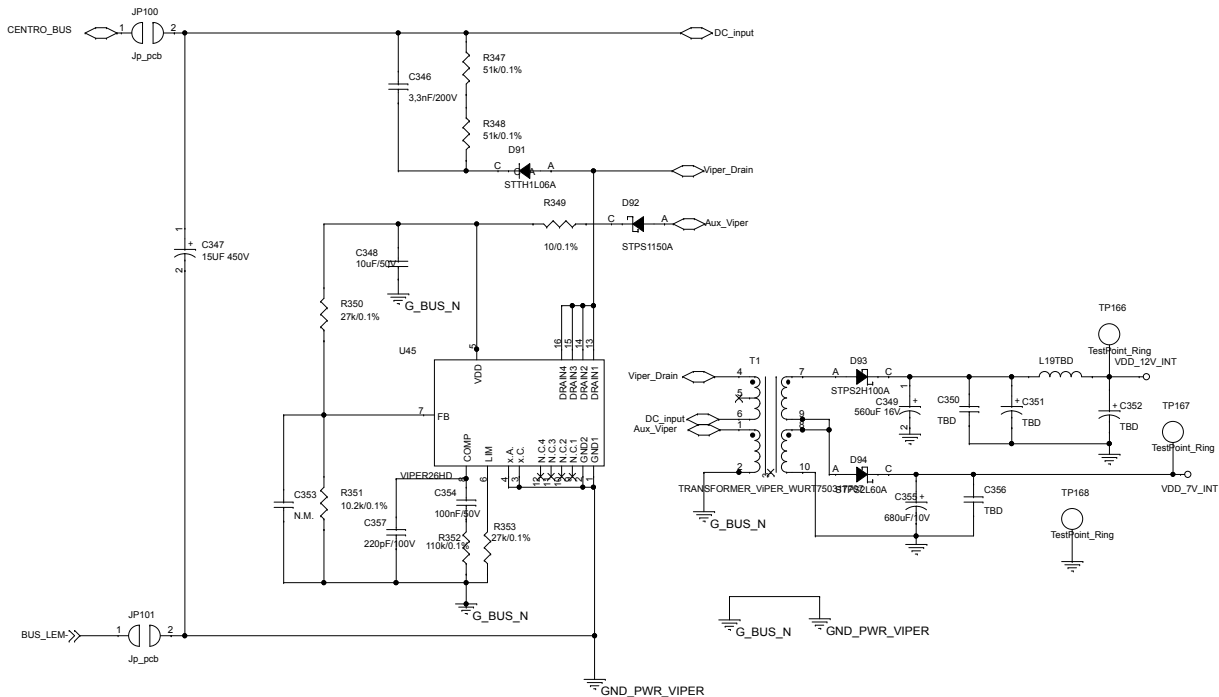


Figure 7. STDES-PFCBIDIR schematic diagram - power board: connector

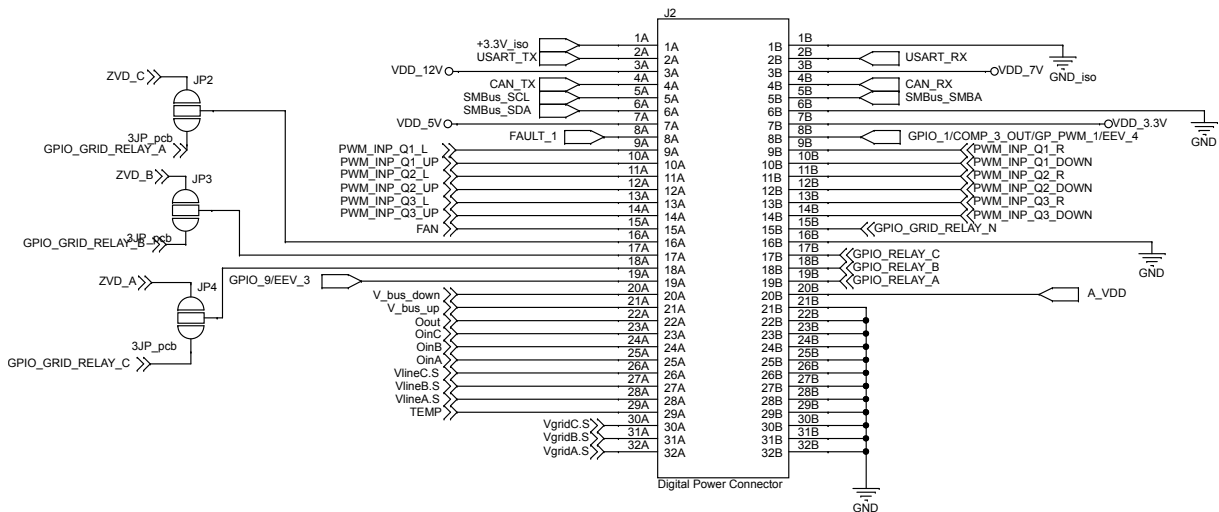


Figure 8. STDES-PFCBIDIR schematic diagram - power board: DC current sensing

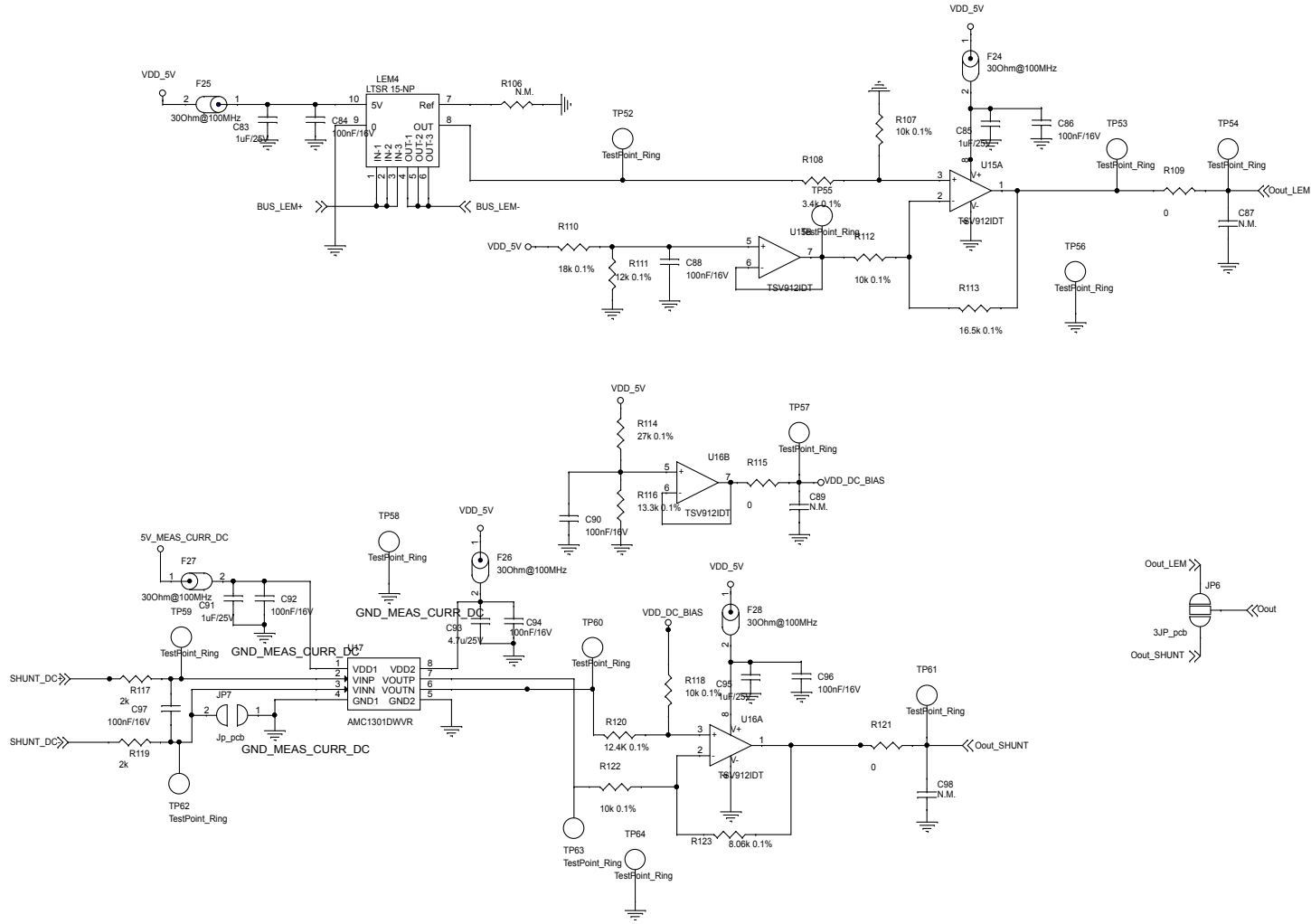


Figure 9. STDES-PFCBIDIR schematic diagram - power board: DC voltage sensing

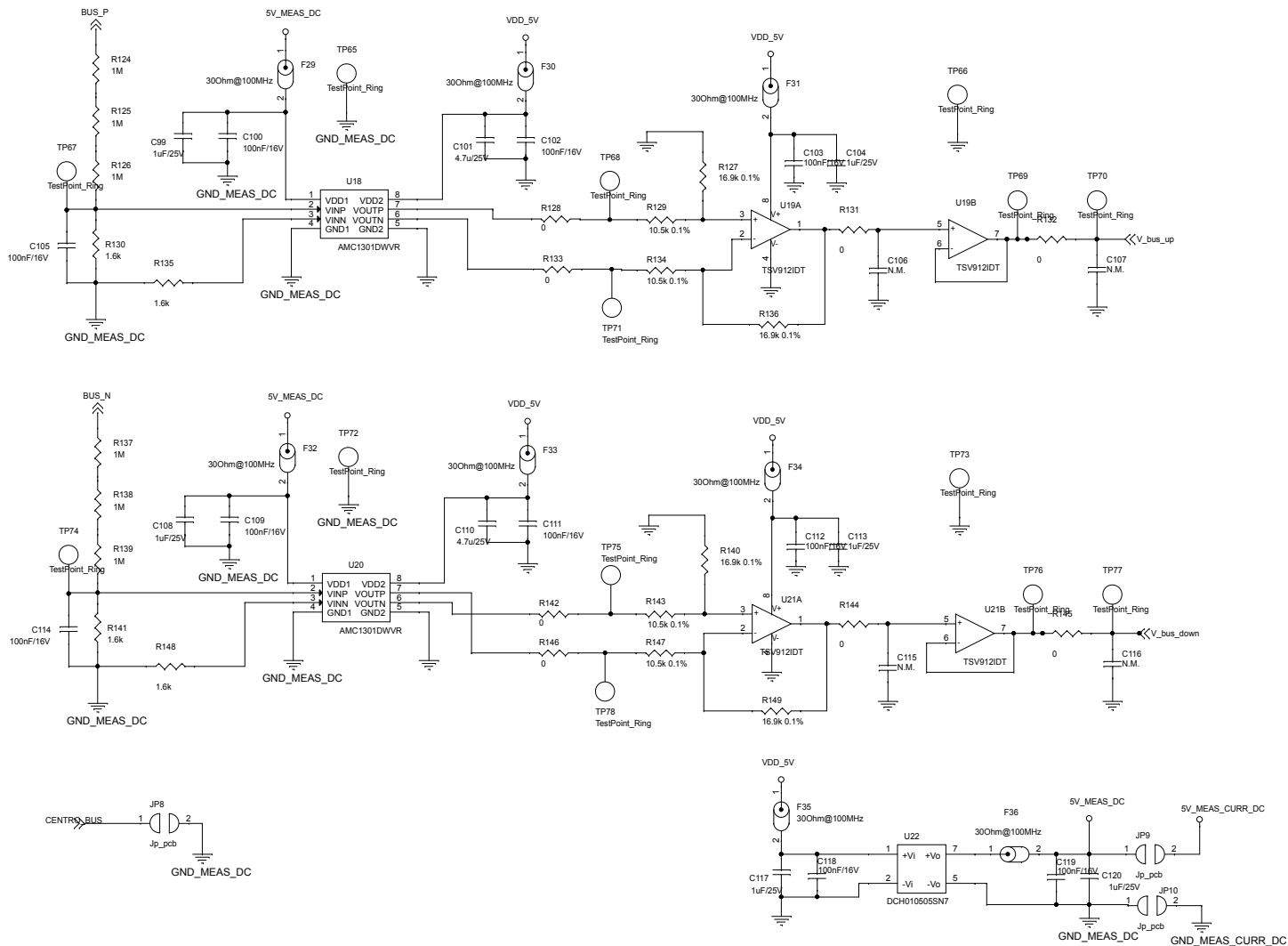


Figure 10. STDES-PFCBIDR schematic diagram - power board: gate drivers (x12)

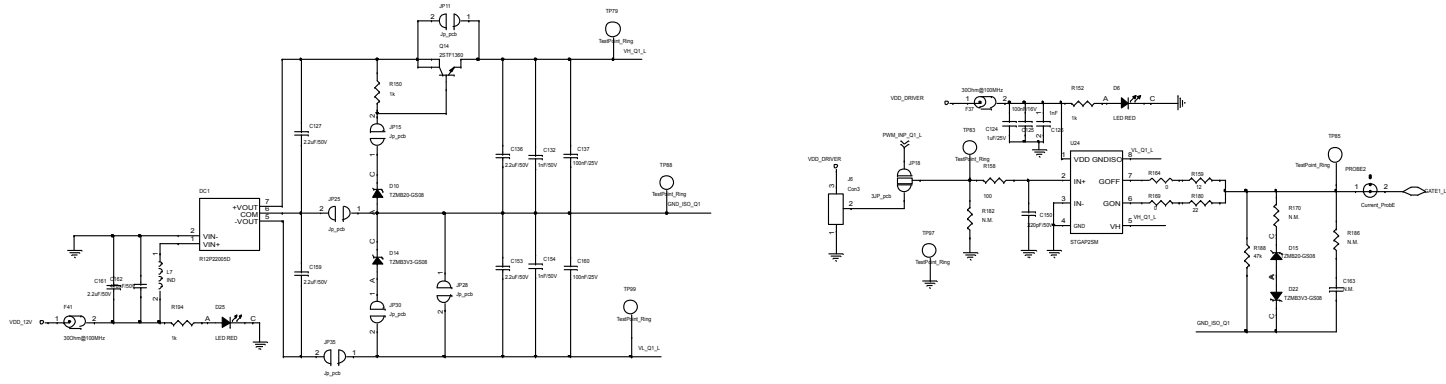


Figure 11. STDES-PFCBIDR schematic diagram - power board: grid voltage sensing



Figure 12. STDES-PFCBIDIR schematic diagram - power board: power section

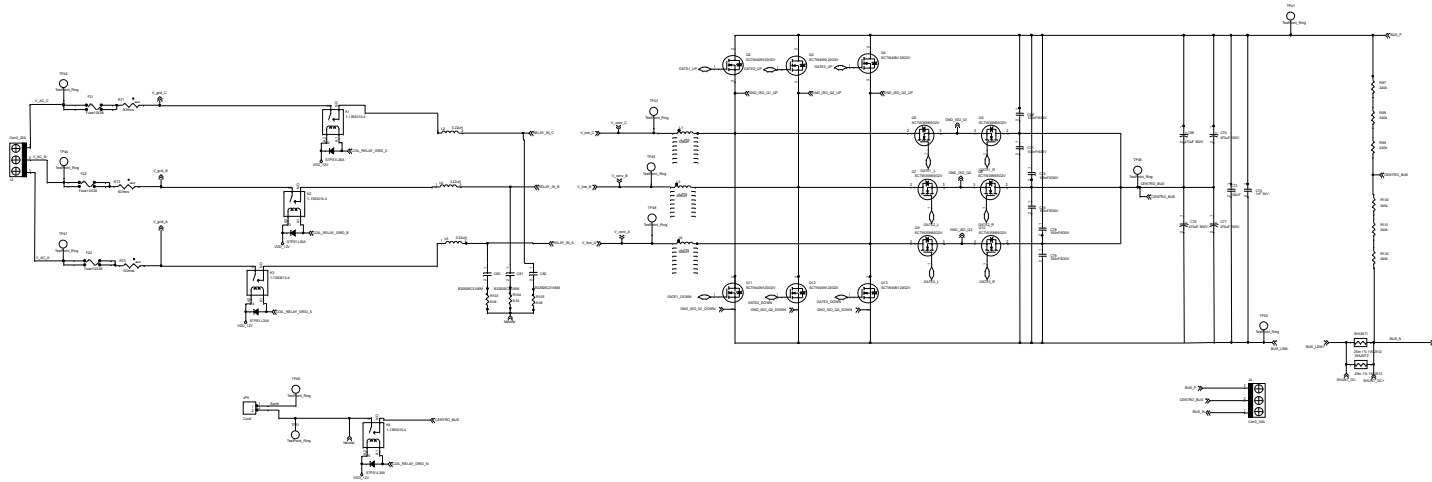


Figure 13. STDES-PFCBIDIR schematic diagram - power board: active inrush current and AC grid connection management

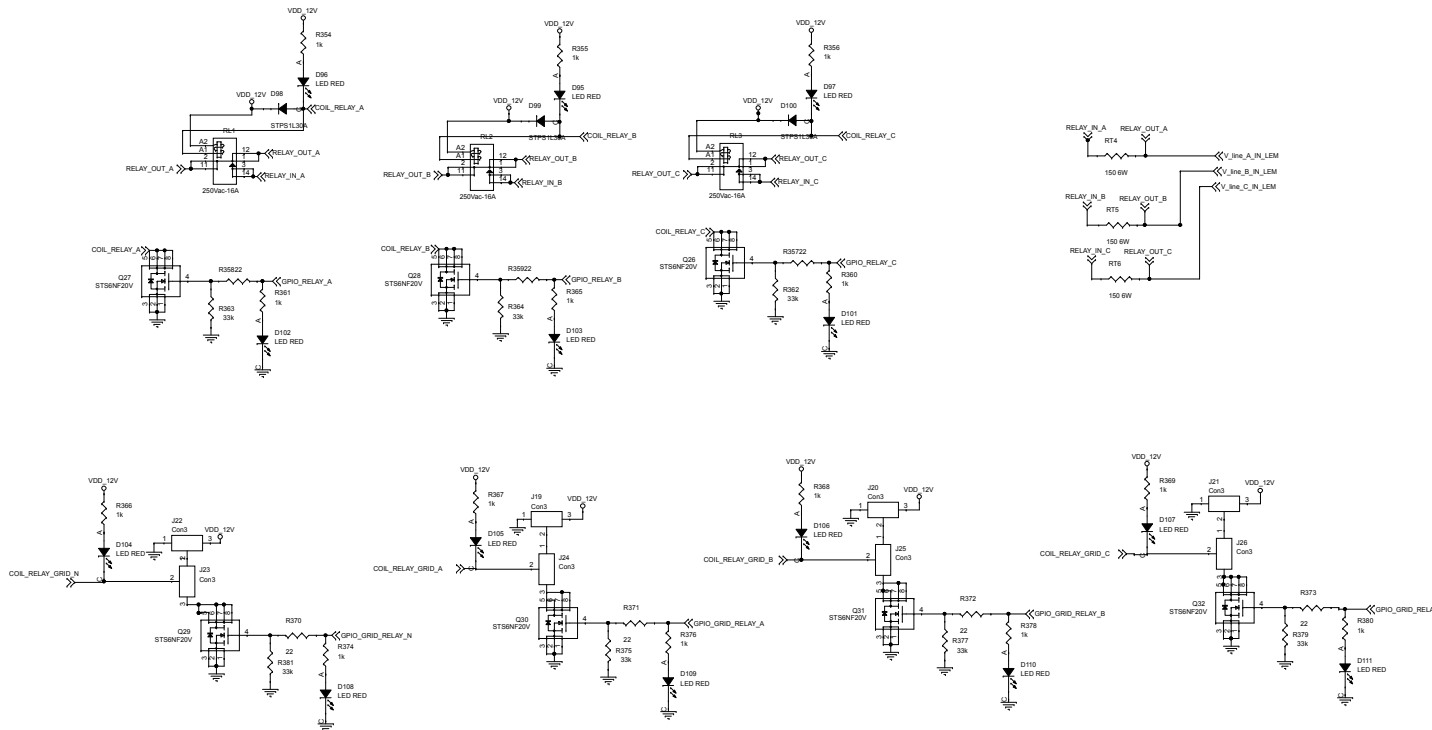
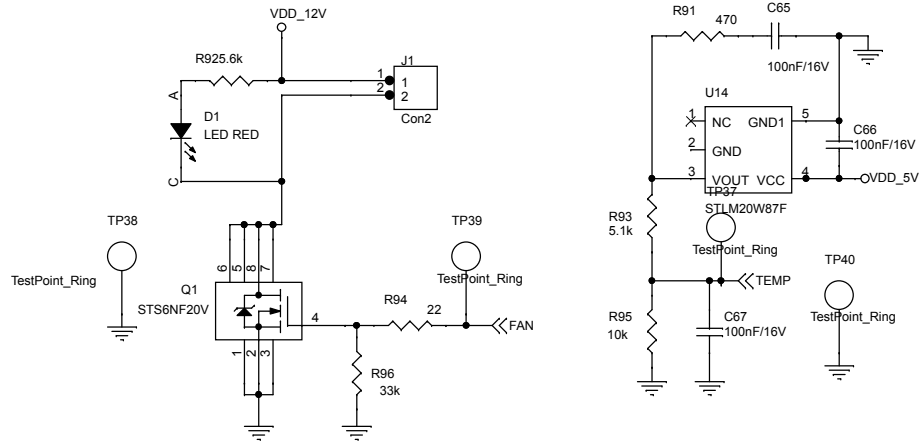


Figure 14. STDES-PFCBIDIR schematic diagram - power board: temp control



Revision history

Table 1. Document revision history

Date	Version	Changes
05-Nov-2019	1	Initial release.
08-Mar-2022	2	Added logo. Updated cover page features, product summary and Section 2 Schematic diagrams

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