

99.3% efficiency, 2 kW, 3-channel interleaved totem-pole PFC with resonant ZVS digital control



The picture shown is for illustration purpose only.
Actual product may vary depending on buyer's selection and availability.



Features

- 99.3% peak efficiency at 230 V_{AC}, with all bias losses included
- >99.1% flat efficiency from 30% load at 230 V_{AC}
- Heatsink-free and fan-free cooling
- Input voltage range: 90 to 253 V_{AC}
- Line frequency range: 47 to 63 Hz
- Maximum output power: 2 kW at 230 V_{AC}, 1 kW at 115 V_{AC}
- Output voltage: 390 ± 2 V
- Power factor: > 0.99 at full load, 230 V_{AC}
- Total harmonic distortion (THDi): <3% at full load, 230 V_{AC}
- Power section based on MDmesh SJ Power MOSFETs
- Digital control section based on the [STM32G474QE](#) microcontroller
 - Hysteresis current mode control
 - Variable frequency ZVS operation
 - Average switching frequency: 60 kHz (for each channel at full load)
 - Cycle-by-cycle regulation
 - Input voltage and load feedforward
 - Phase shedding
 - Burst-mode operation
 - Overcurrent/voltage/temperature protections
 - Inrush current limiter function
- Modular hardware architecture
- Dimensions (cm): L x W x H = 29.6 x 9.1 x 4.5
- Power density: 1.85 W/cm³ (30.4 W/inc³)

Product summary	
2 kW 3-channel interleaved Totem-Pole PFC with resonant ZVS digital control	STEVAL-TTPPFC01
Mainstream Arm Cortex-M4 MCU 170 MHz with 512 Kbytes of Flash memory, Math Accelerator, HR Timer, High Analog level integration	STM32G474QET6
N-channel 600 V, 36 mOhm typ., 62 A MDmesh DM6 Power MOSFET in a TO-247 package	STW70N60DM6
N-channel 650 V, 0.012 Ohm typ., 138 A MDmesh M5 Power MOSFET in a Max247 package	STY145N65M5
Galvanically isolated 4 A single gate driver	STGAP2SMTR
VIPerPlus family: Quasi-resonant high performance off line high voltage converter	VIPER35LD
Applications	Server & Telecom Power / TV PSU / PFC Converter - Single Phase Input / Digital Power

Description

The [STEVAL-TTPPFC01](#) offers a very high flat efficiency PFC solution in a full digital three-channel interleaved totem-pole topology. A conversion efficiency higher than 99.1% using ST MDmesh DM6 superjunction power MOSFETs is obtained, as well as a very high power factor and low THDi.

The PFC operates in the zero voltage switching (ZVS) resonant mode with hysteresis current control, which is fully implemented in the [STM32G474QE](#) microcontroller, thanks to the integrated DACs, fast comparators, and high-resolution timer peripheral HRTIM, to ensure a high dynamic and precise cycle-by-cycle current control.

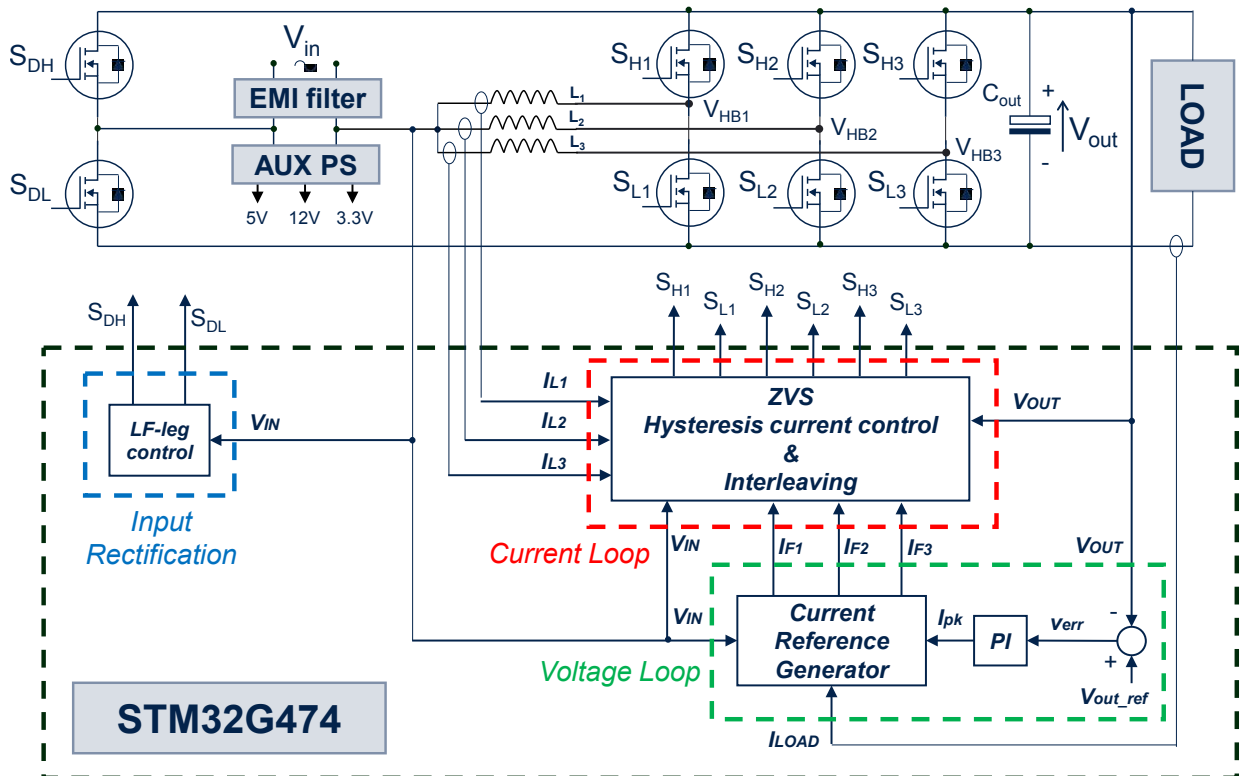
The [STEVAL-TTPPFC01](#) evaluation kit is a modular solution, which consists of: a power board, which contains all the main passive devices and all the daughter boards plug connectors; a control board, which embeds the [STM32G474QE](#) microcontroller; an auxiliary power supply board, which generates all the voltages for driving, sensing, MCU, etc.; three high-frequency half-bridge boards; a low-frequency half-bridge board.

1 Detailed description

The STEVAL-TTPPFC01 implements ZVS-PFC control with the STM32G474QE microcontroller. It includes a voltage loop for the output voltage regulation, a fast ZVS hysteresis current control with interleaving, and the input rectification function for the mains synchronization.

A fast input and load feedforward enhance the PFC dynamic response in case a load step or input voltage variation occur.

Figure 1. STEVAL-TTPPFC01 block diagram



The PFC stage is based on a totem-pole boost circuit design with three parallel channels to take advantage of the interleaving operation, that is, less ripple and a higher apparent switching frequency in the PFC input current. It allows using smaller and less expensive input EMI filters, boost inductors, and switching devices.

The STW70N60DM6 MOSFETs used as high-frequency switches offer one of the most effective switching behaviors available in the market for the most demanding high-efficiency topologies and ZVS converters.

The STY145N65M5 MOSFET is used for the low-frequency half-bridge. Thanks to its extremely low on-resistance, it is particularly suitable for applications that require high power and superior efficiency.

The VIPER35LD generates the auxiliary voltages: 5 V for sensors, 12 V for driving, and 3.3 V for the MCU and other sensing circuitry.

2 Schematic diagrams

Important: These schematics are for illustration purpose only. Actual product may vary depending on buyer's selection and availability.

Figure 2. STEVAL-TTPPFC01 - power board circuit schematic (1 of 5)

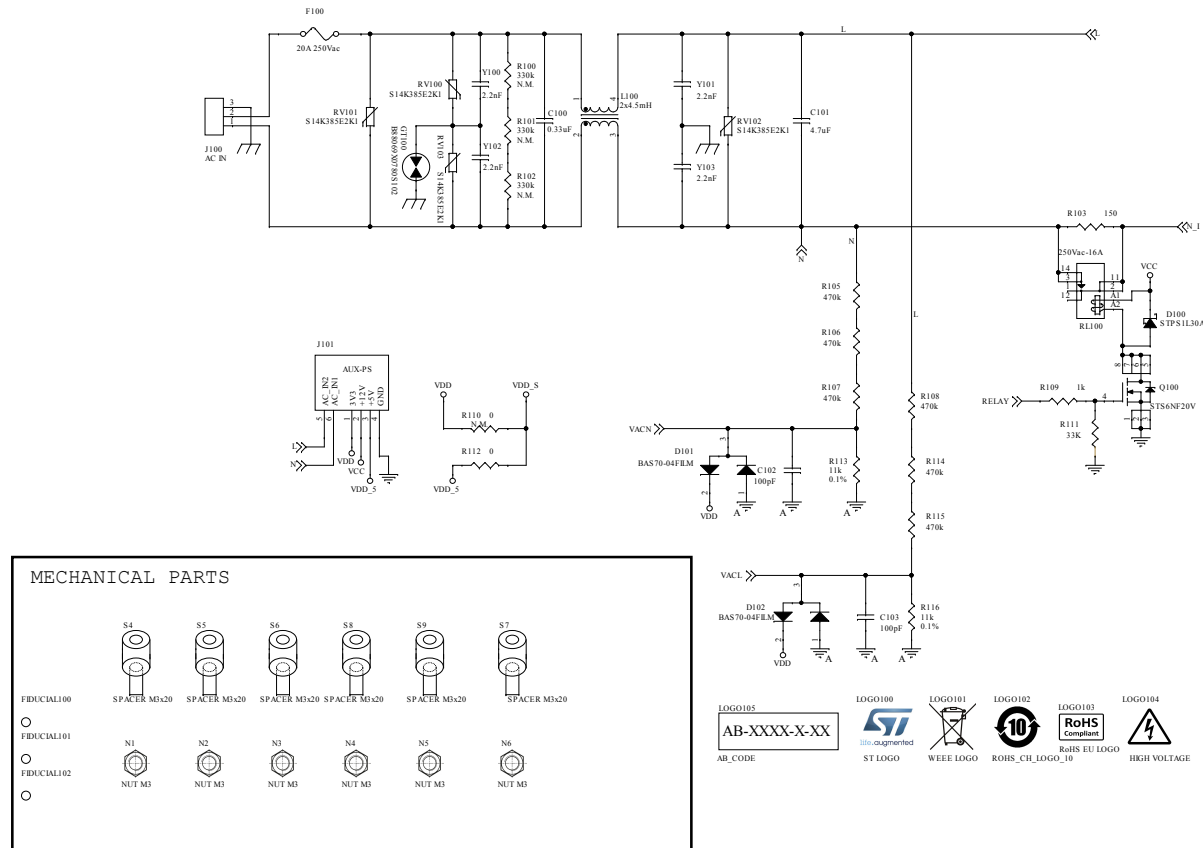


Figure 4. STEVAL-TTPPFC01 - power board circuit schematic (3 of 5)

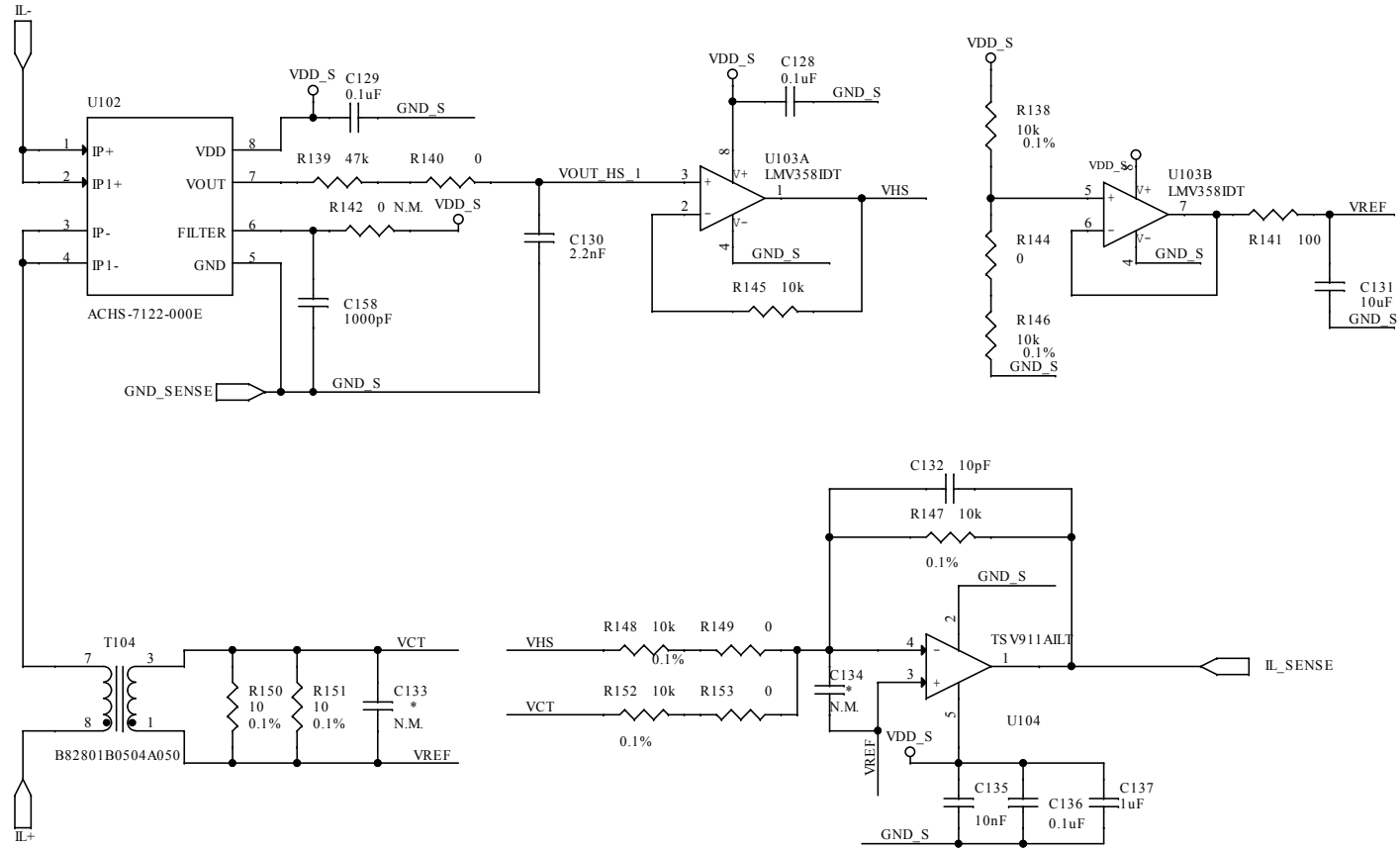


Figure 5. STEVAL-TTPPFC01 - power board circuit schematic (4 of 5)

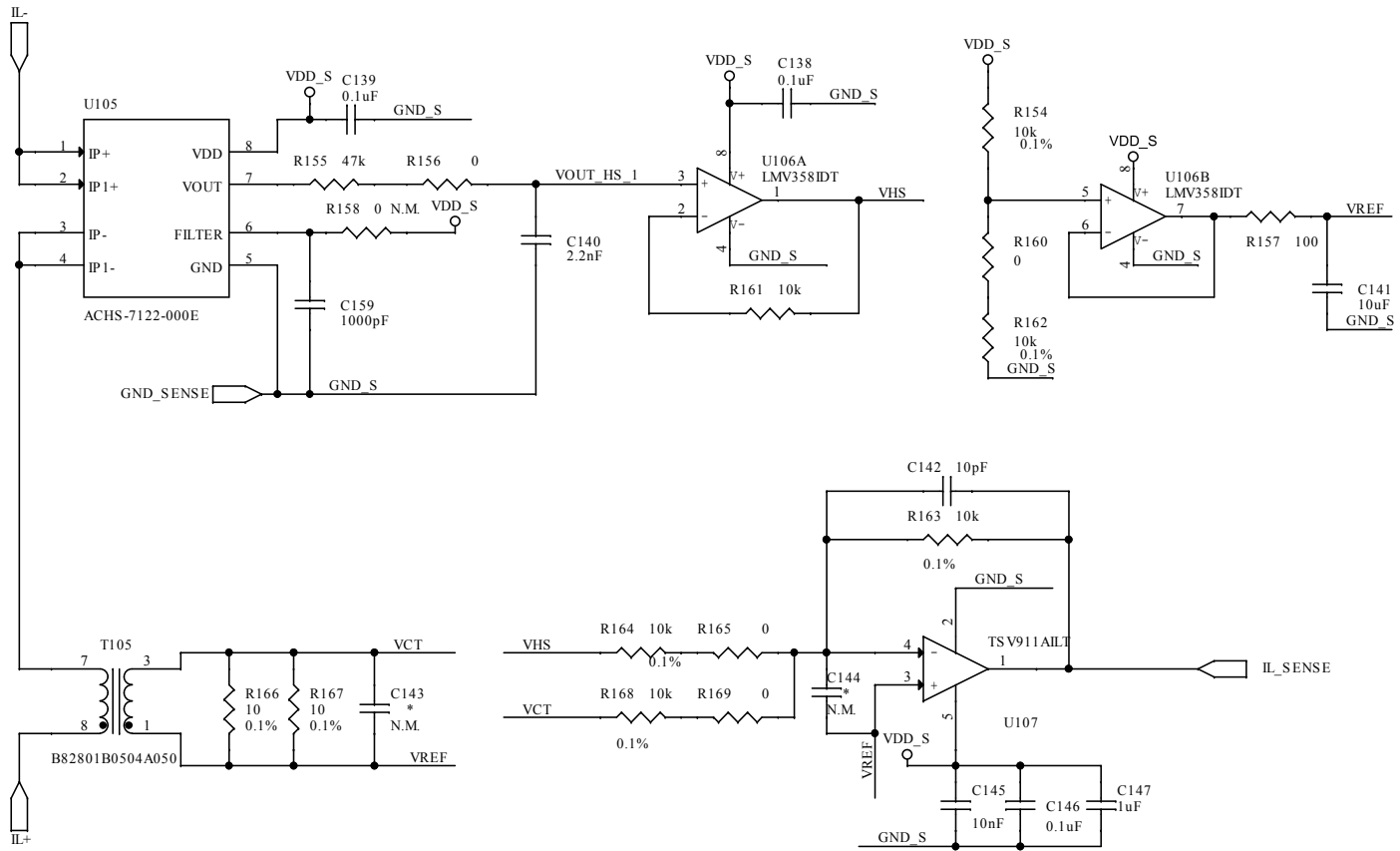
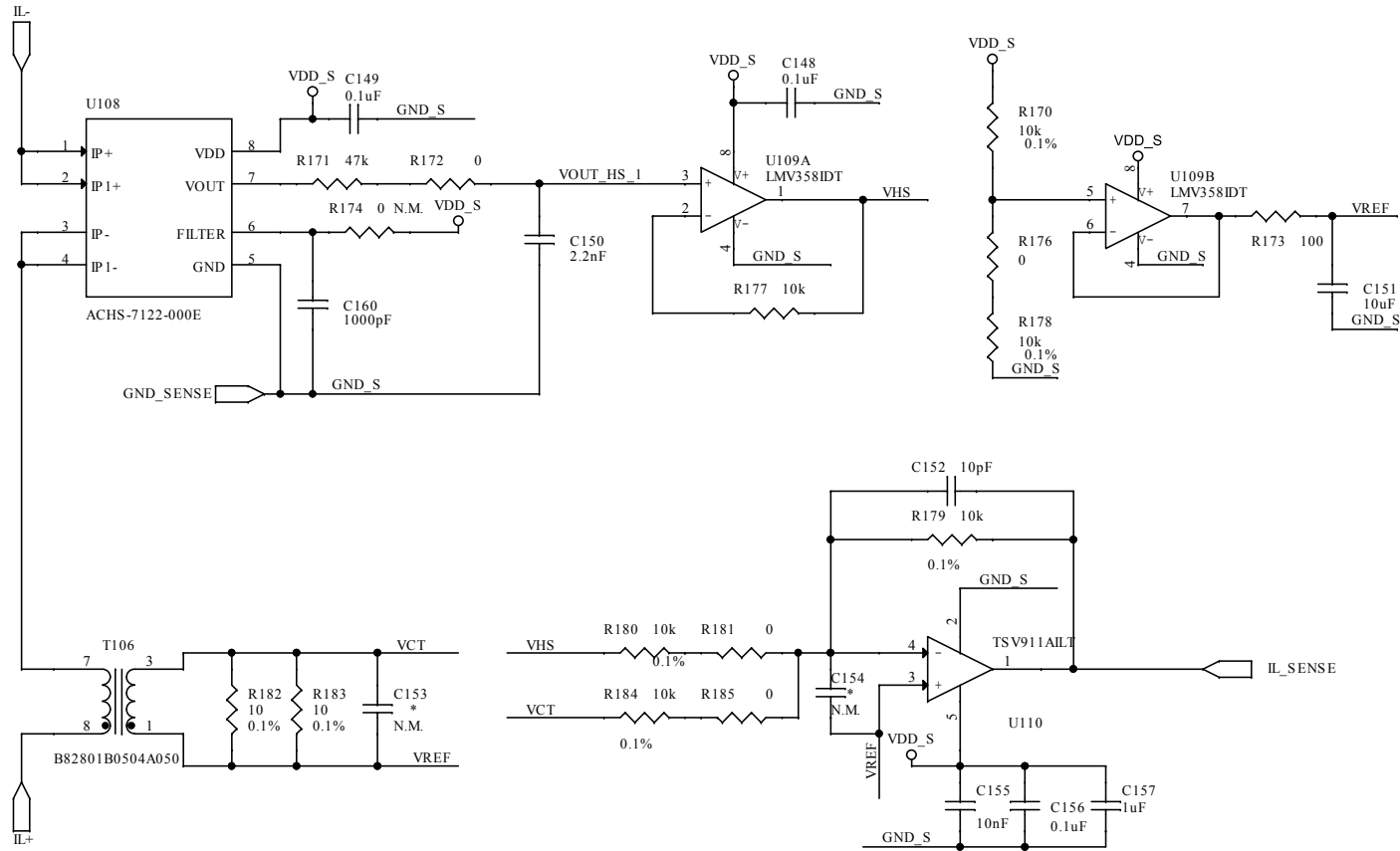


Figure 6. STEVAL-TTPPFC01 - power board circuit schematic (5 of 5)



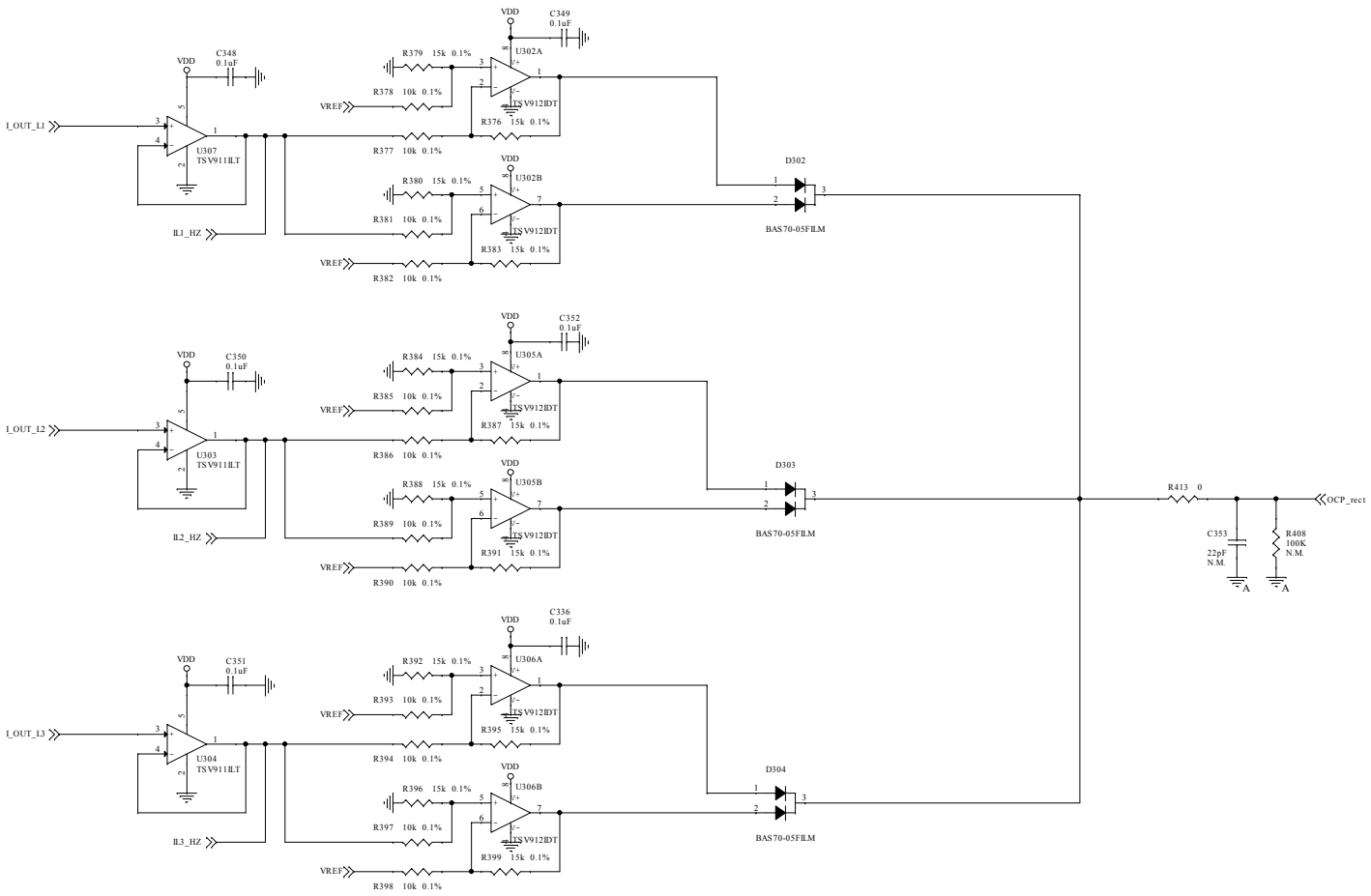


Figure 8. STEVAL-TTPPFC01 - control board circuit schematic (2 of 2)



Figure 9. STEVAL-TTPPFC01 - auxiliary board circuit schematic

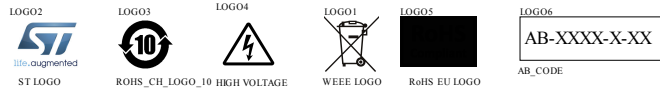
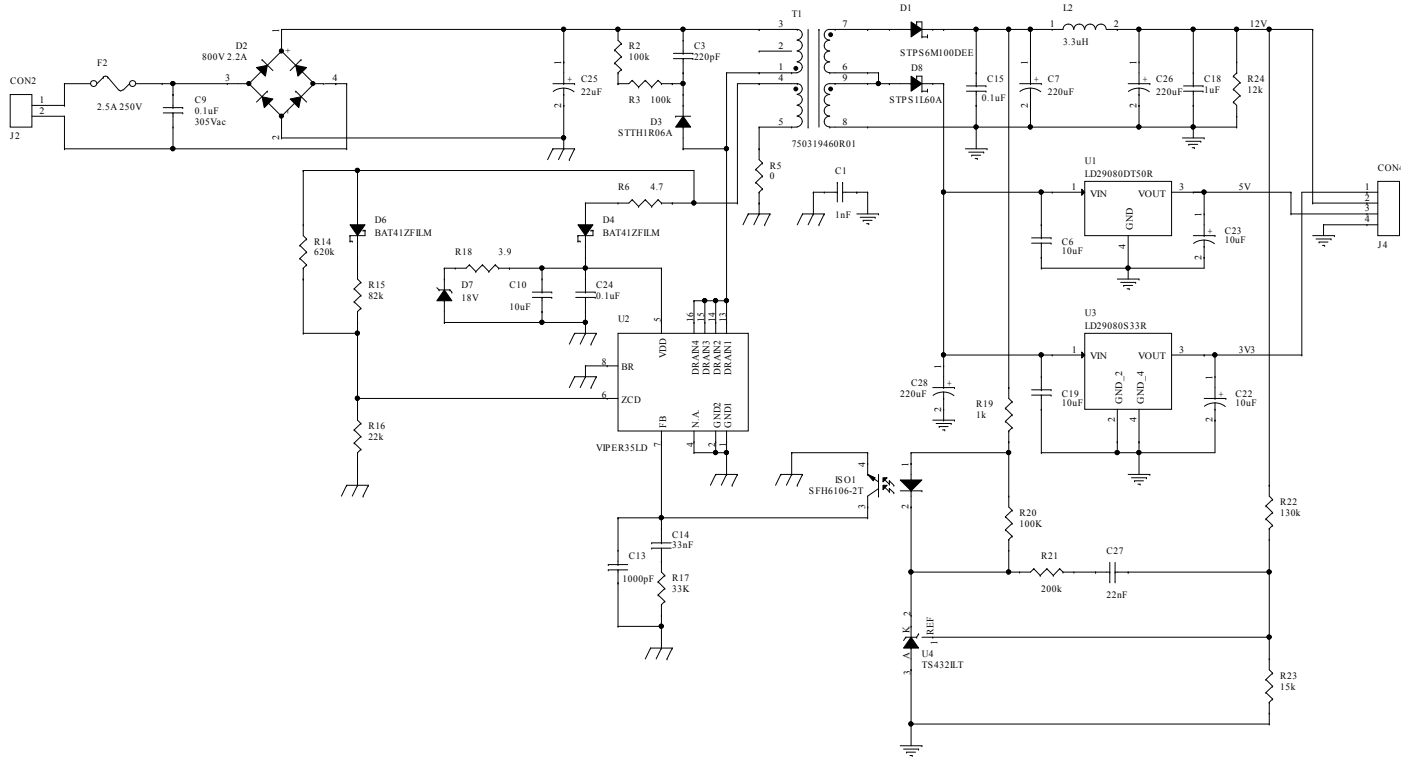
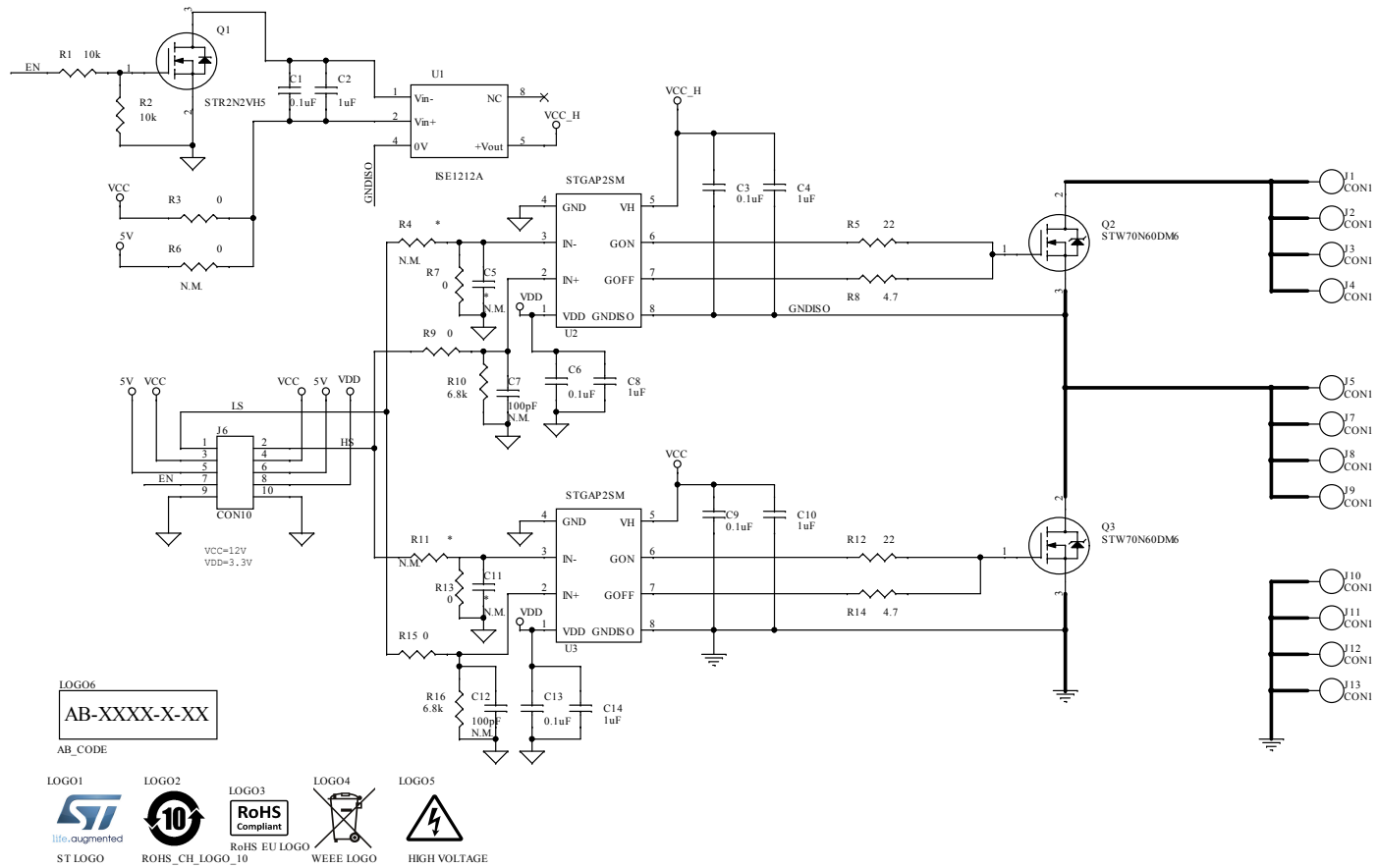


Figure 10. STEVAL-TTPPFC01 - high-frequency half-bridge board circuit schematic



3 Custom evaluation boards information

Notice: These evaluation boards are custom designed and built, in small quantities, according to specific requests from customers and are destined for evaluation and testing of ST products in a research and development setting. Please contact ST to provide your specific requests and get your custom built board(s).

Revision history

Table 1. Document revision history

Date	Revision	Changes
05-Oct-2022	1	Initial release.
25-Oct-2022	2	Updated document title.
31-Jan-2023	3	Updated features.
02-Nov-2023	4	Added note to cover image. Updated Section 2 Schematic diagrams . Added Section 3 Custom evaluation boards information

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