

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



### Features

- 99.3% peak efficiency at 230 V<sub>AC</sub>, with all bias losses included
- >99.1% flat efficiency from 30% load at 230 V<sub>AC</sub>
- Heatsink-free and fan-free cooling
- Input voltage range: 90 to 253 V<sub>AC</sub>
- Line frequency range: 47 to 63 Hz
- Maximum output power: 2 kW at 230 V<sub>AC</sub>, 1 kW at 115 V<sub>AC</sub>
- Output voltage: 390 ± 2 V
- Power factor: > 0.99 at full load, 230 V<sub>AC</sub>
- Total harmonic distortion (THDi): <3% at full load, 230 V<sub>AC</sub>
- Power section based on MDmesh SJ Power MOSFETs
- Digital control section based on the [STM32G474QET6](#) 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/cm<sup>3</sup> (30.4 W/inc<sup>3</sup>)

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

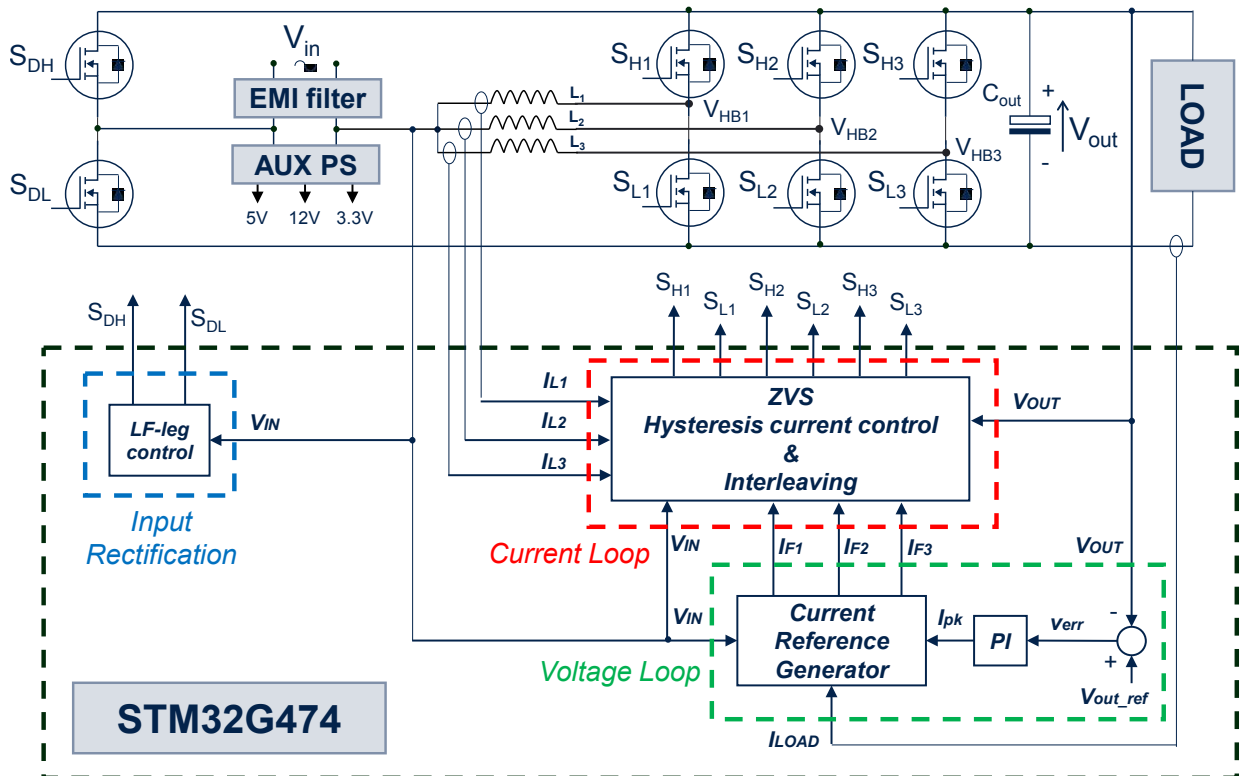
The [STEVAL-TTPPFC01](#) evaluation kit is a modular solution, which consists of: a power board, which contains all the main passive devices and all the daughter boards plug connectors; a control board, which embeds the [STM32G474QE](#) microcontroller; an auxiliary power supply board, which generates 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

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

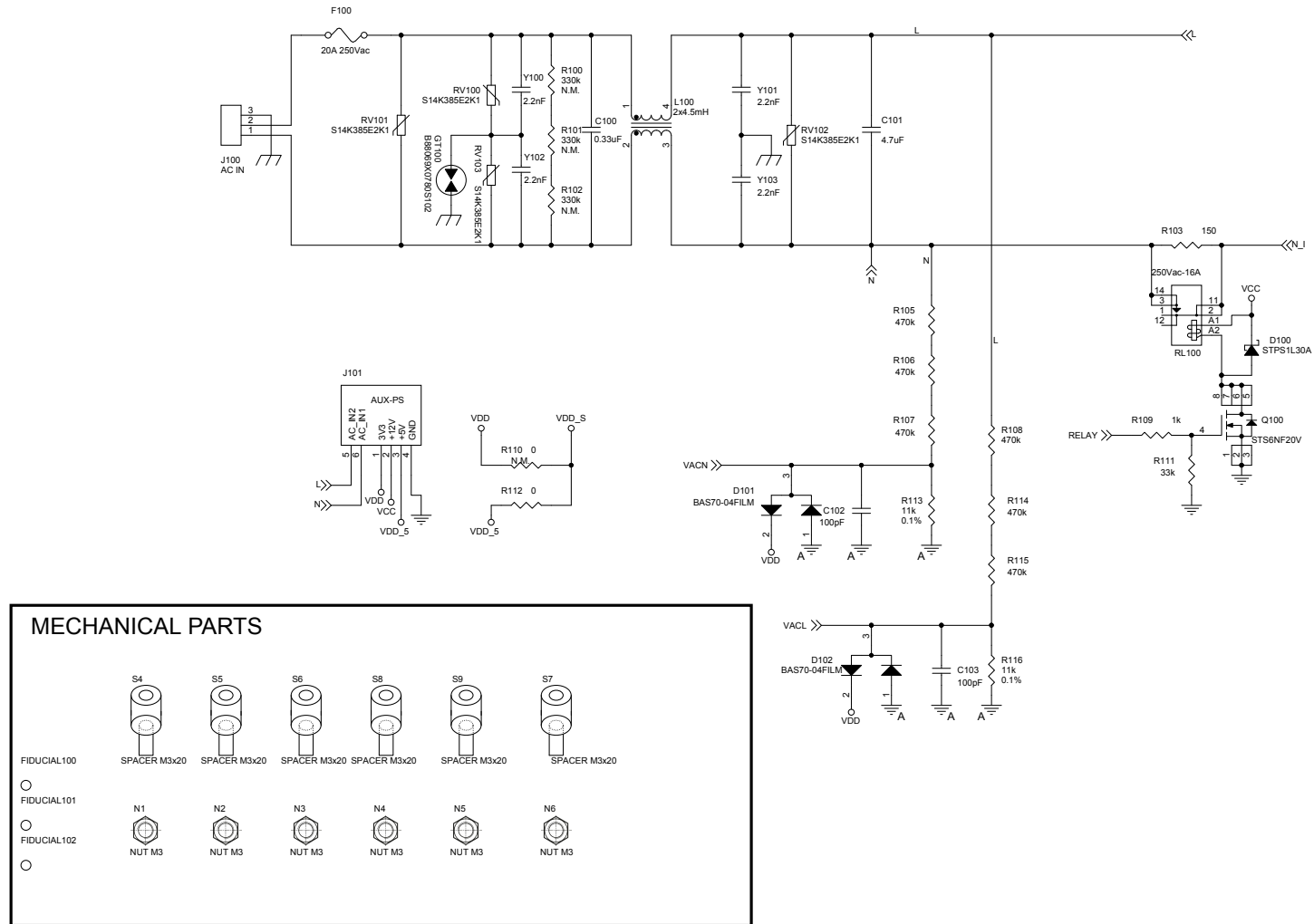


Figure 3. STEVAL-TTPPFC01 - power board circuit schematic (2 of 5)

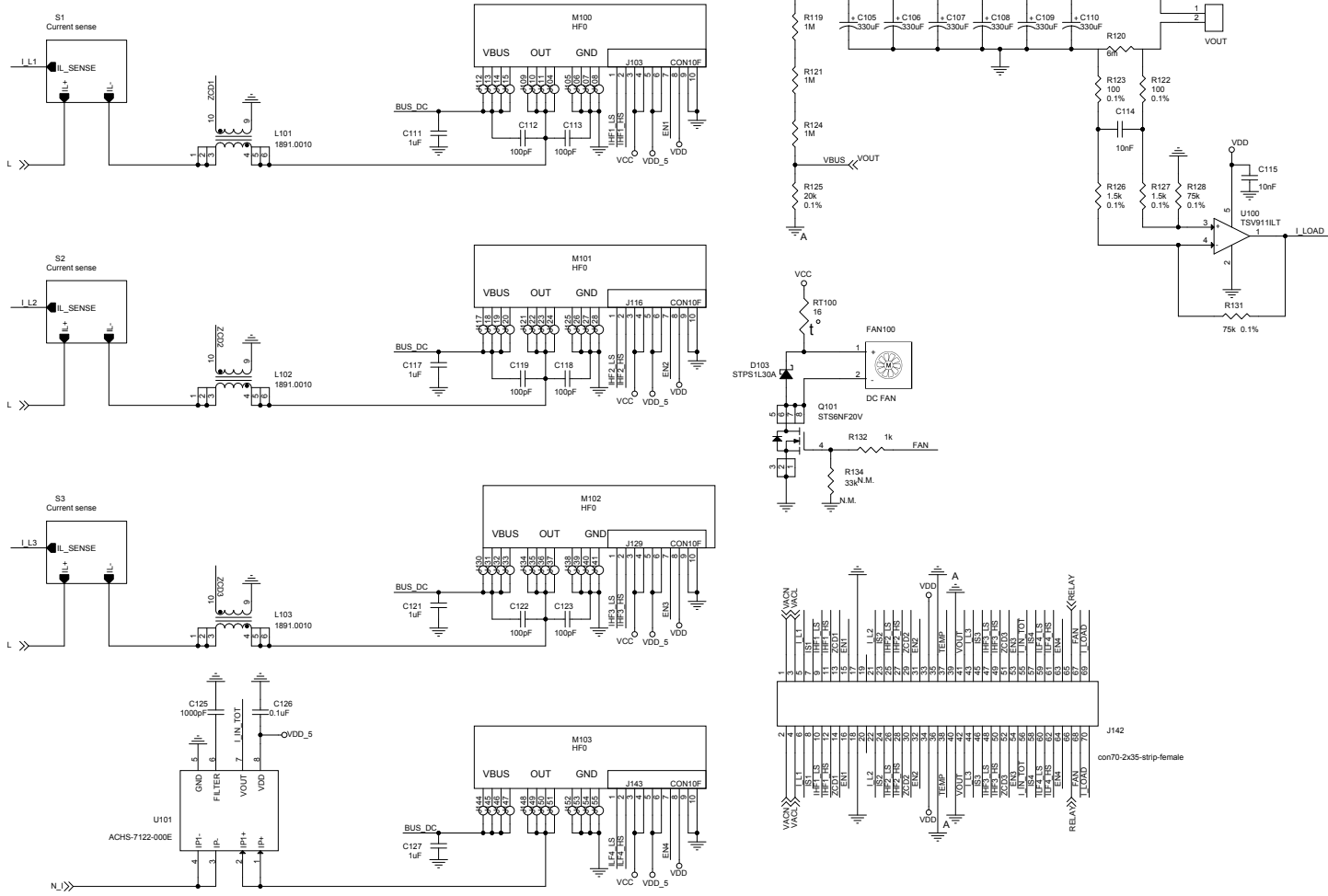


Figure 4. STEVAL-TTPPFC01 - power board circuit schematic (3 of 5)

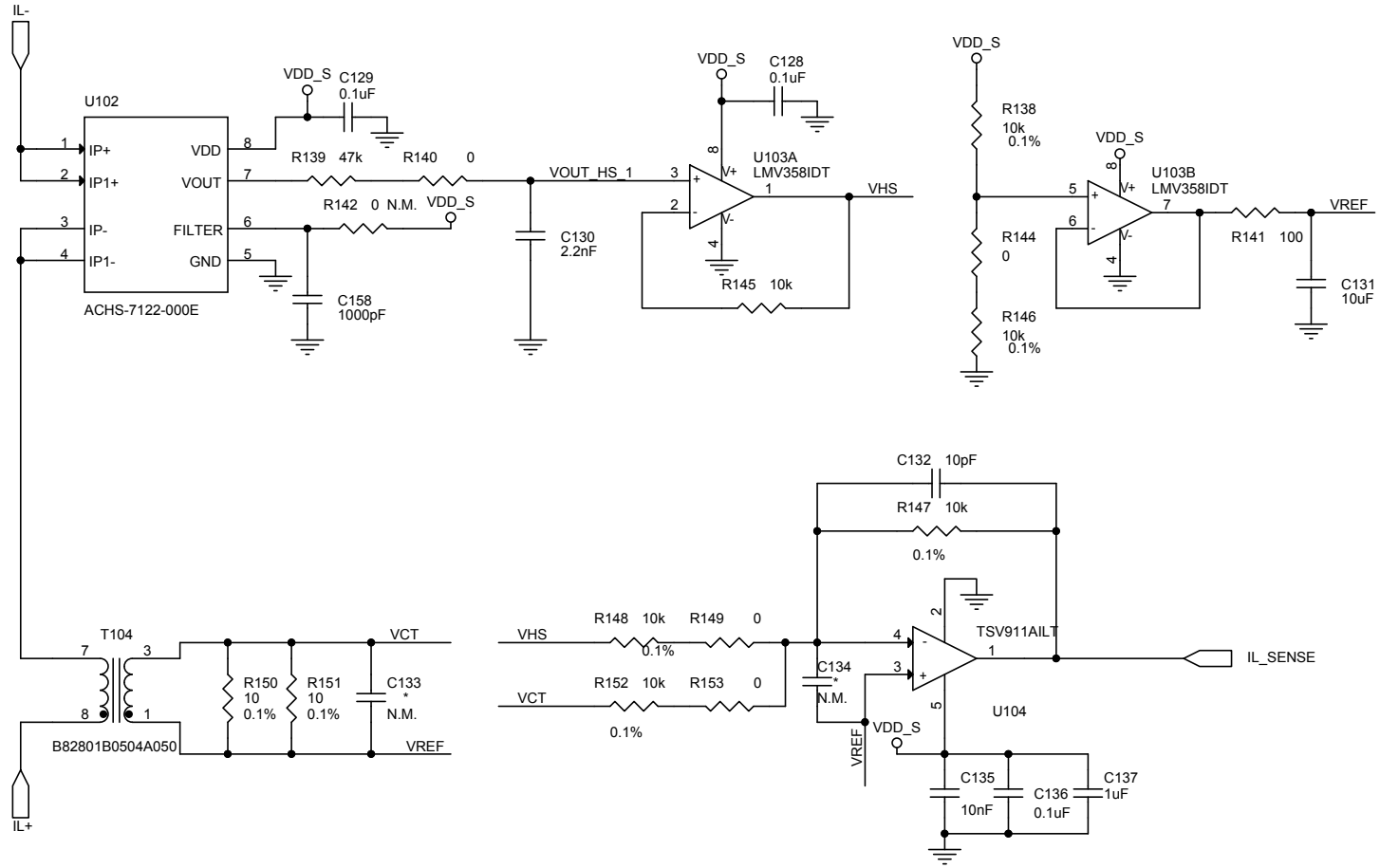


Figure 5. STEVAL-TTPPFC01 - power board circuit schematic (4 of 5)

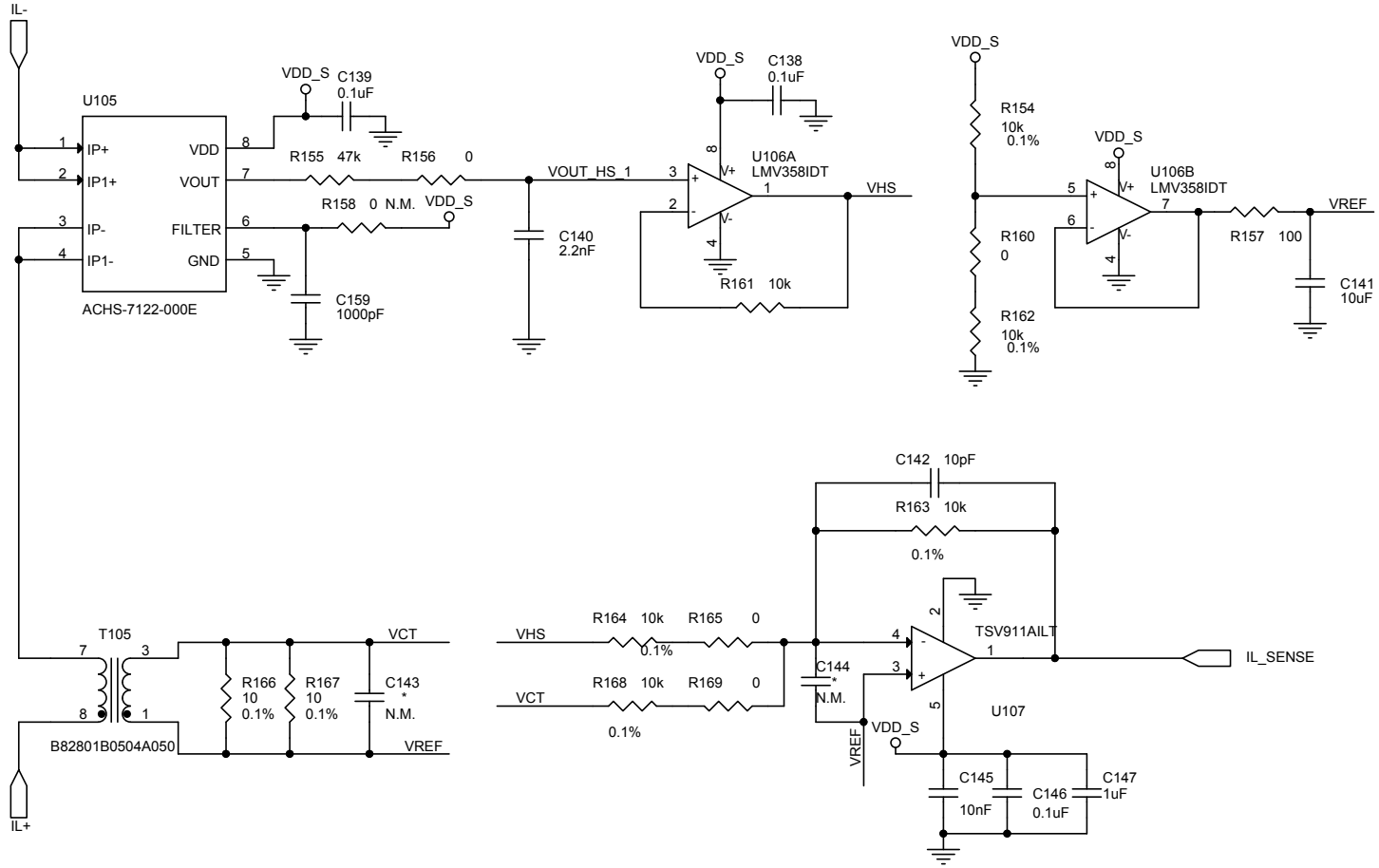


Figure 6. STEVAL-TTPPFC01 - power board circuit schematic (5 of 5)

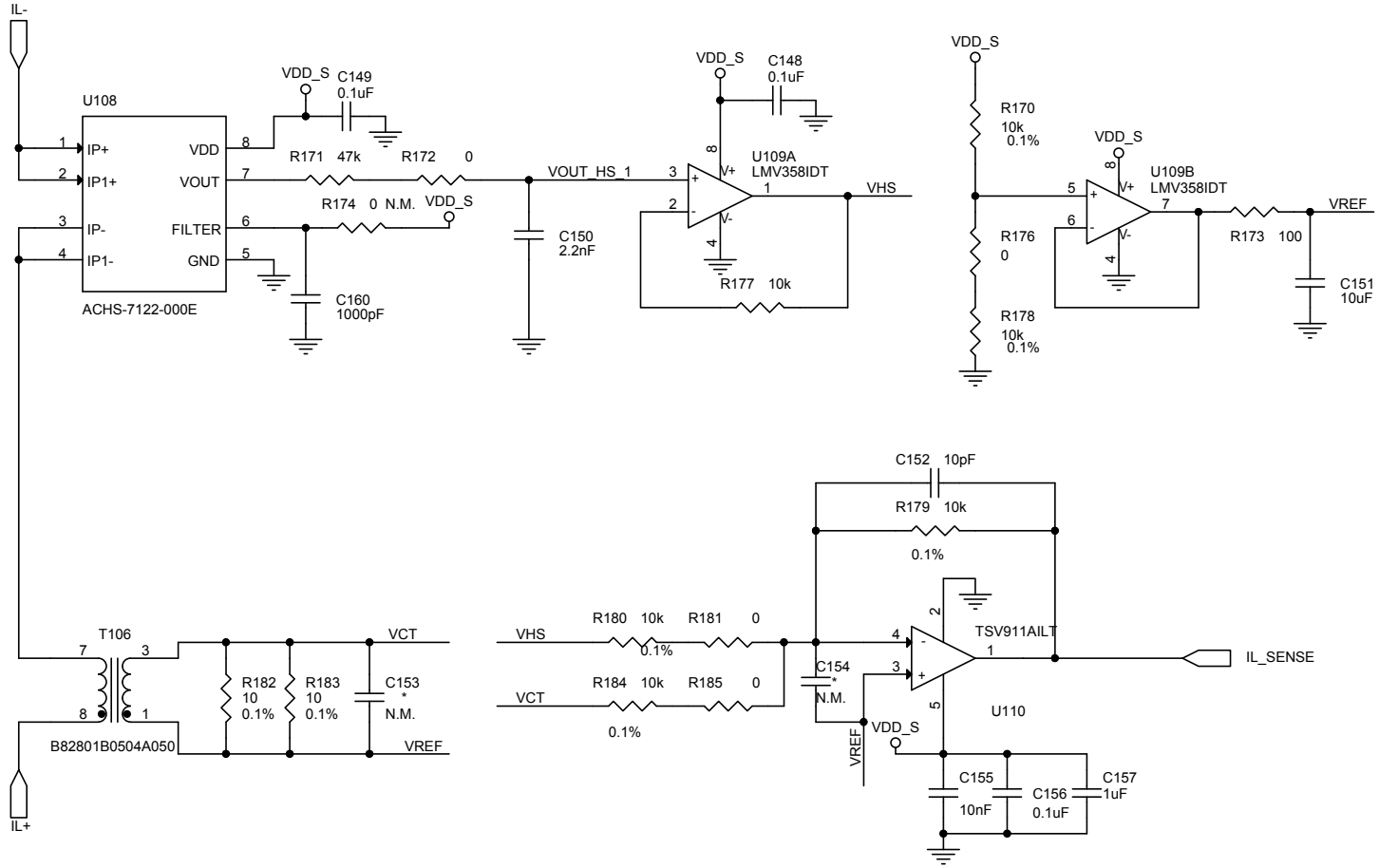


Figure 7. STEVAL-TTPPFC01 - control board circuit schematic (1 of 2)

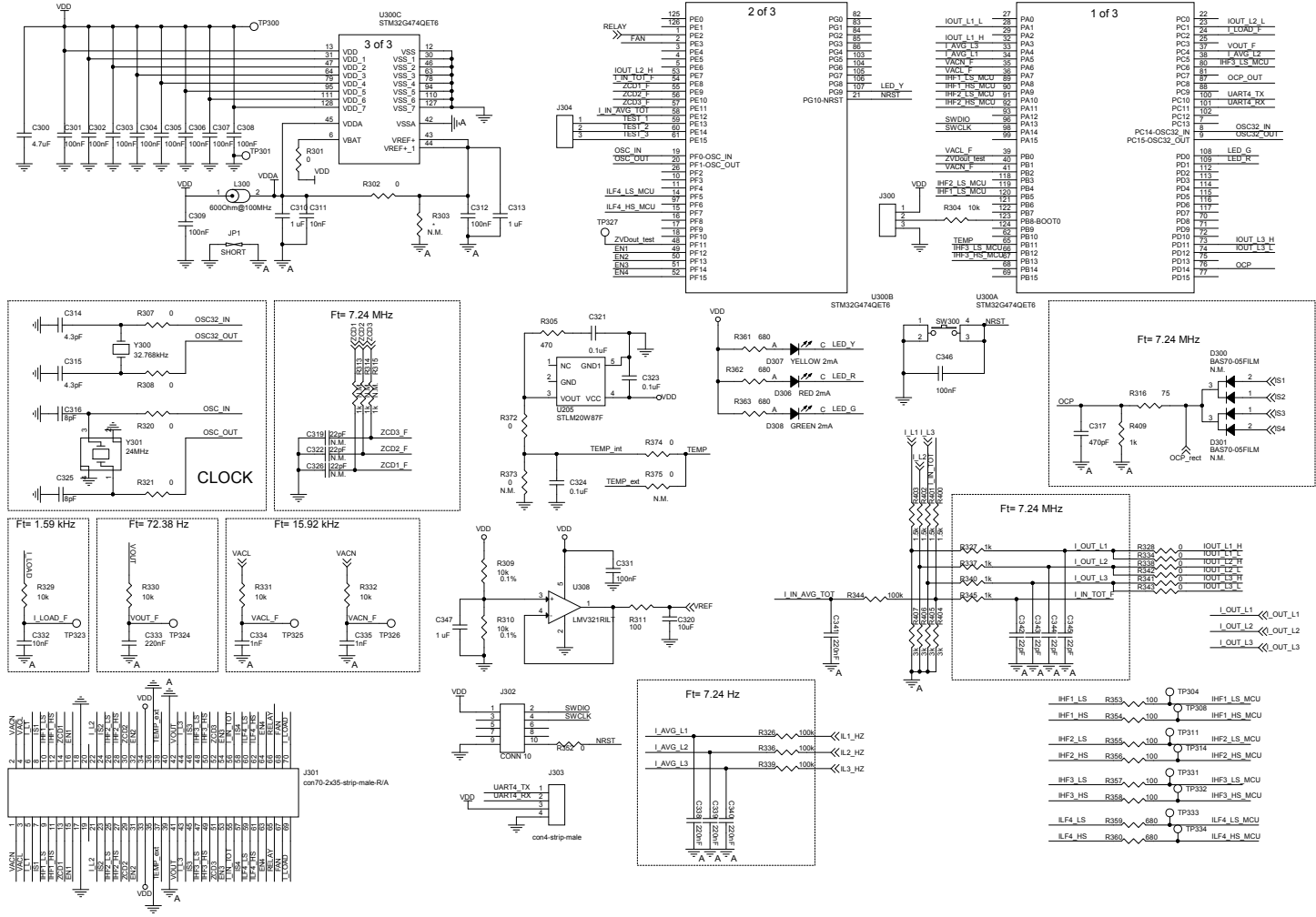




Figure 8. STEVAL-TTPPFC01 - control board circuit schematic (2 of 2)

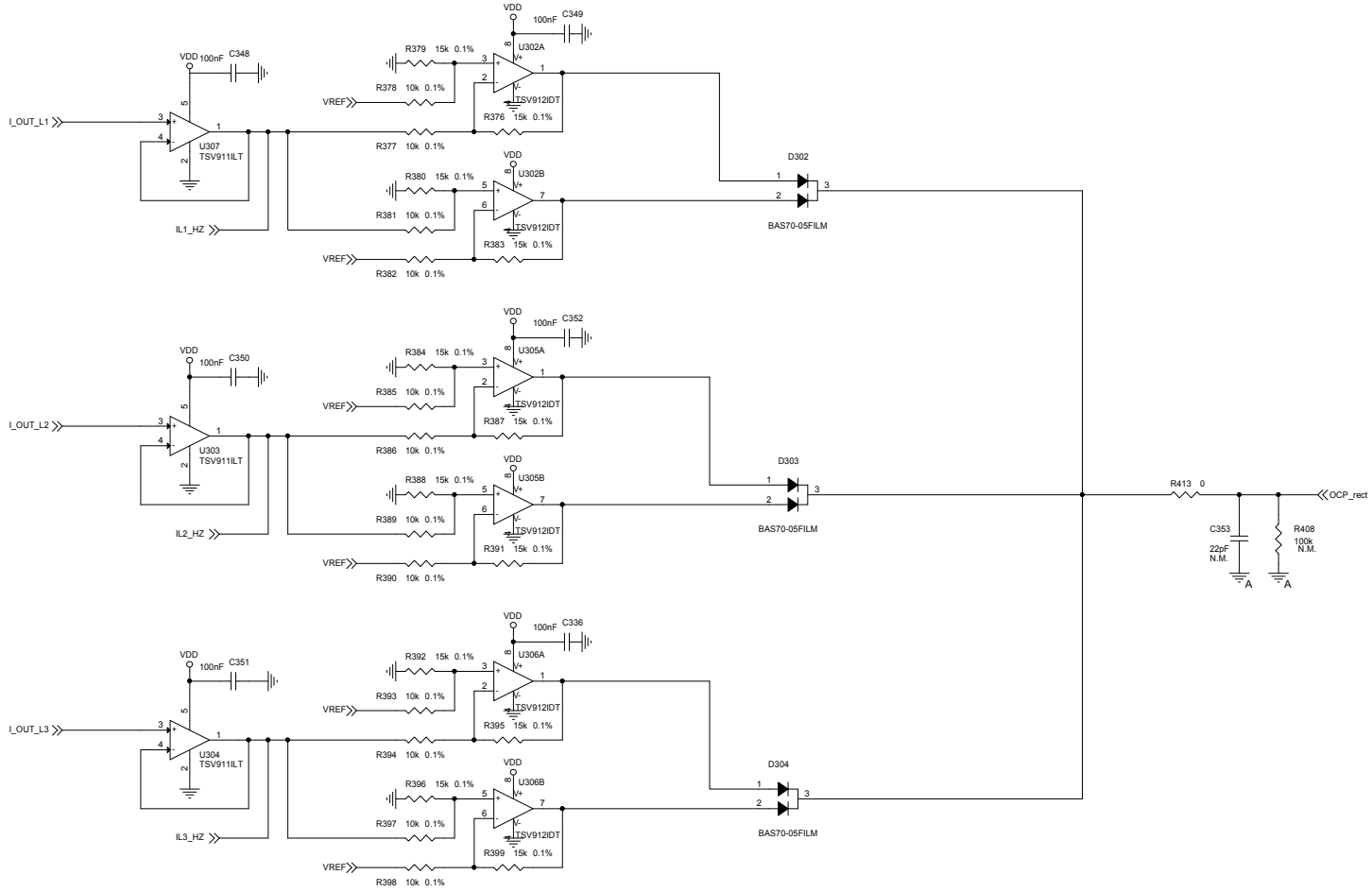


Figure 9. STEVAL-TTPPFC01 - auxiliary board circuit schematic

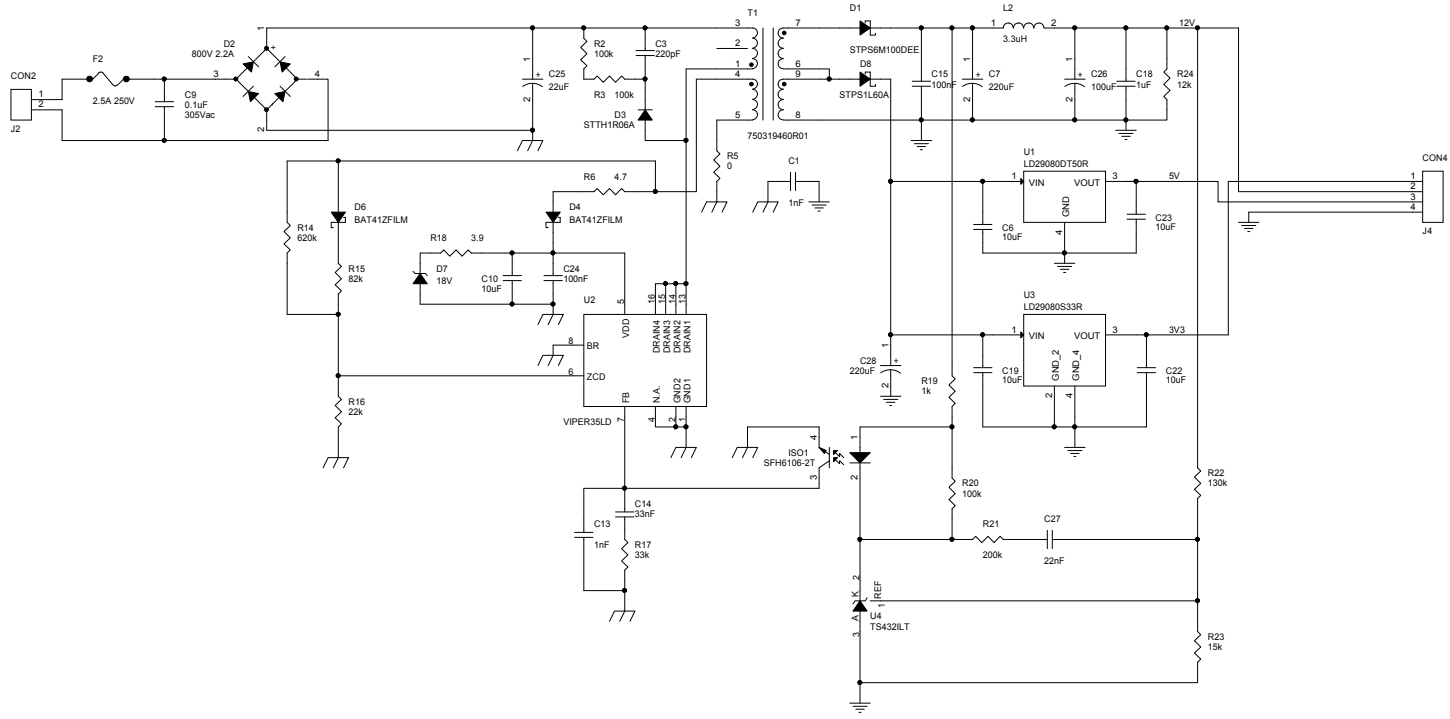


Figure 10. STEVAL-TTPPFC01 - high-frequency half-bridge board circuit schematic

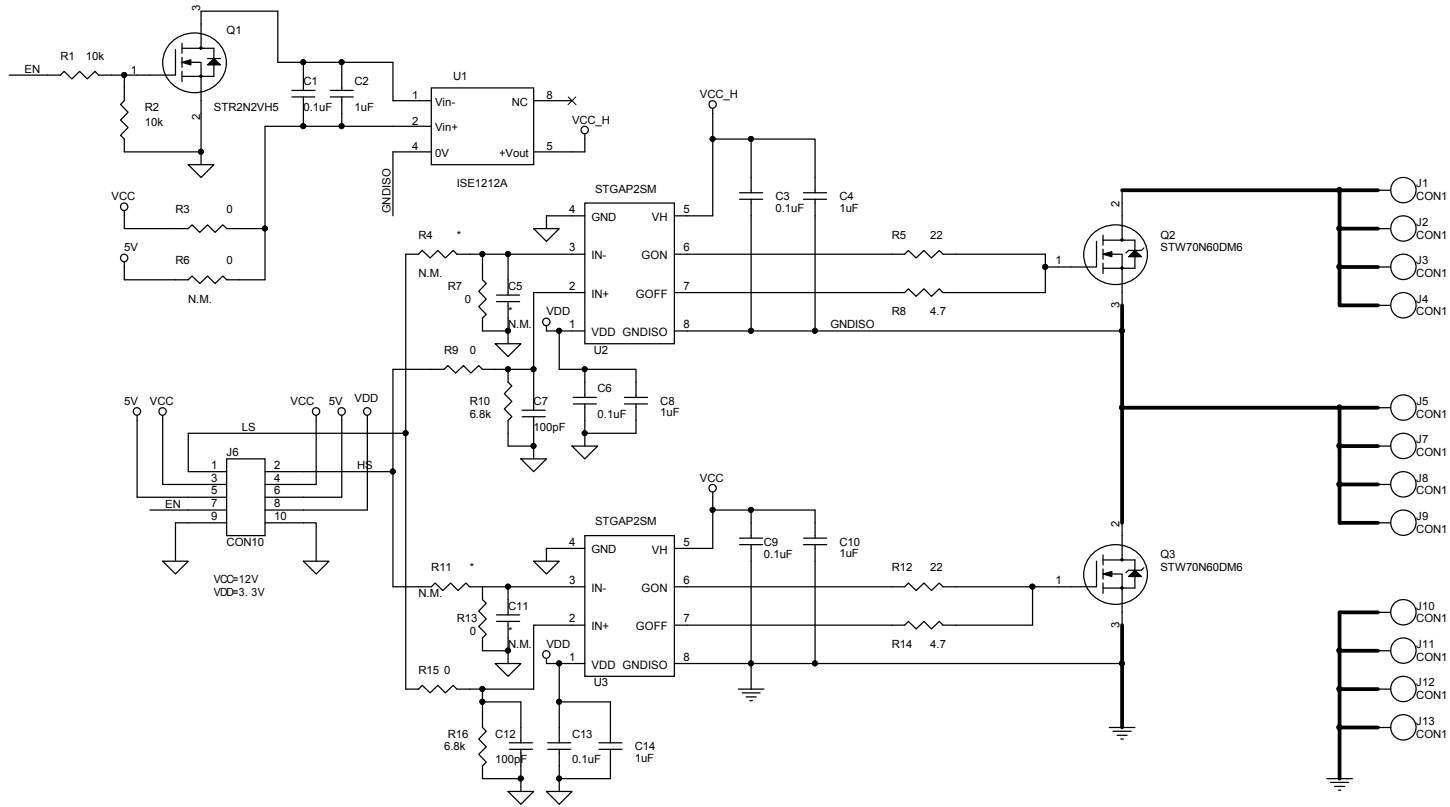
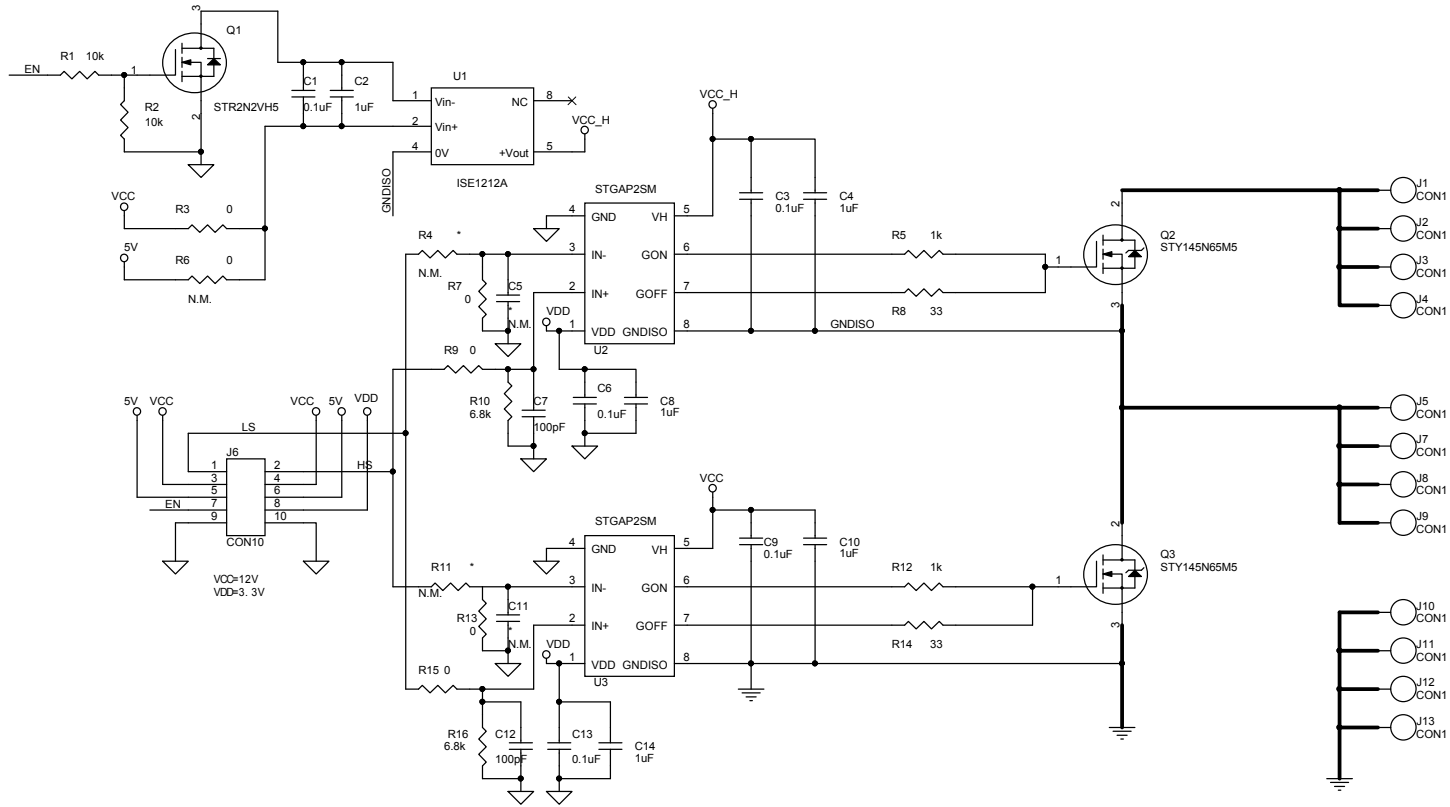


Figure 11. STEVAL-TTPPFC01 - low-frequency half-bridge board circuit schematic



### 3 Kit versions

**Table 1. STEVAL-TTPPFC01 versions**

PCB version	Schematic diagrams	Bill of materials
STEVAL\$TTPPFC01A <sup>(1)</sup>	STEVAL\$TTPPFC01A schematic diagrams	STEVAL\$TTPPFC01A bill of materials

- This code identifies the STEVAL-TTPPFC01 evaluation kit first version. The kit consists of the STEVAL\$TTPPFC01P power board, the STEVAL\$TTPPFC01C control board, the STEVAL\$TTPPFC01X auxiliary board, three STEVAL\$TTPPFC01H high-frequency half-bridge boards, and the STEVAL\$TTPPFC01L low-frequency half-bridge board.*

## Revision history

**Table 2. 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.

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