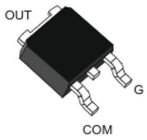
STDES-HBR001V1

Data brief

16 A hybrid relay reference design

STDES-HBR001V1



ACST1220H-8B

STSID140-12

Product summary
STDES-HBR001V1

Key product
ACST1220H-8B
STSID140-12

Features

- Ready to test 16 A hybrid relay
- Automatic control with complete driving circuit
- 12 A AC switch with self-overvoltage ACST1220H-8B
- 16 A relay
- Isolated thyristor driver STSID140-12
- Two control modes: ZVS or random control

Applications

- Motor control soft starter
- UPS bypass switching
- Charging station pre-charge
- Power and energy circuit breaker

Description

Hybrid relay allows combining efficient switching and improved reliability. The STDES-HBR001V1 is a ready-to-use reference design which allows controlling a hybrid relay just like a standard electromechanical relay, helping remove adoption barriers and accelerate development.

The reference features a 16 A relay in parallel with a 12 A AC switch ACST1220H-8B. The latter is an AC switch with self-overvoltage protection in the compact surface mounted package DPAK.

The reference design includes a complete driving circuit featuring the compact surface-mount isolated thyristor driver STSID140-12.

1 Getting started

Figure 1. Pictograms

Danger: *Use the STDES-HBR001V1 board only after applying a fire-resistant cover. The cover is not included in the board package.*

There is a danger of serious personal injury, property damage, or death due to electrical shock and burn hazards if the kit or components are improperly used or installed incorrectly.

Warning: *The kit is not electrically isolated from the high-voltage supply AC-DC input.*

The evaluation board is directly linked to the mains voltage. No insulation is ensured between the accessible parts and the high voltage. All measurement equipment must be isolated from the mains before powering the board.

When using an oscilloscope with the evaluation board, it must be isolated from the AC line. This prevents shock from occurring as a result of touching any single point in the circuit, but does Not prevent shock when touching two or more points in the circuit.

Caution: *During assembly, testing, and operation, the evaluation board poses several inherent hazards, including bare wires, moving or rotating parts and hot surfaces. All operations involving transportation, installation, use, and maintenance must be performed by skilled technical personnel who are familiar with the installation, use, and maintenance of power electronic systems.*

The board has to be connected directly on the mains. Non-isolated parts at high-voltage levels are present on both sides of the PCB.

The current flowing through the triac generates heat. Be aware that, due to the thermal inertia, the board could remain hot even after the current has ceased to flow.

***Workarea safety**:*

- *The work area must be clean and tidy*
- *Do not work alone when boards are powered*
- *Protect the area against any unauthorized access by putting suitable barriers and signs*
- *A system architecture that supplies power to the evaluation board must be equipped with additional control and protective devices in accordance with the applicable safety requirements (that is, compliance with technical equipment and accident prevention rules).*

***Electrical safety**:*

- *Remove the power supply from the evaluation board and electrical loads before performing any electrical measurement*
- *Arrange measurement setup, wiring, and configuration, paying attention to the high voltage section*
- *Once the setup is complete, power the board. Fuse protection is not included with this evaluation board.*

Danger: *Do not touch the evaluation board when it is powered or immediately after it has been disconnected from the voltage supply as several parts and power terminals containing potentially energized capacitors need time to discharge, and heat-sink and transformers may still be very hot.*

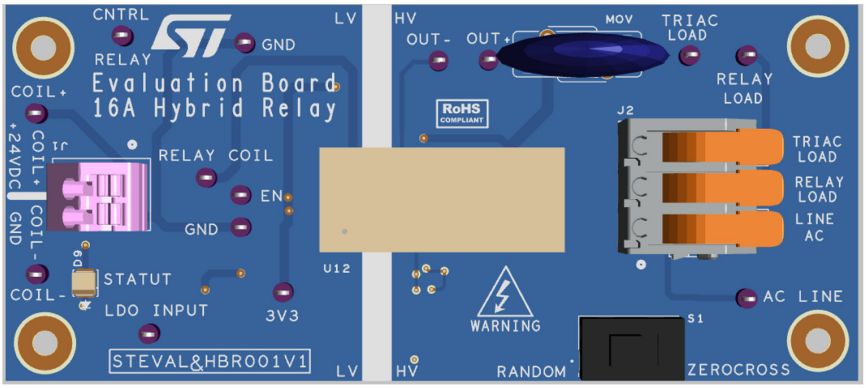
Personal safety:

- Always wear suitable personal protective equipment, such as insulating gloves and safety glasses
- Take adequate precautions and install the board to prevent accidental touch
- Use protective shields, such as an insulating box with interlocks.

2 Pinout and recommendations

To review the hybrid relay principle, refer to application note AN4993, “How to implement an SCR or triac in hybrid relay applications.”

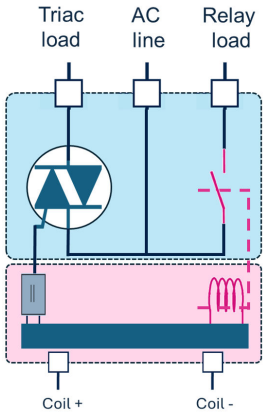
Figure 2. STDES-HBR001V1 main components



On this 16 A hybrid relay reference design, connect the triac and relay loads as needed for the application. Connect the 24 V dc power supply to COIL+ and GND to COIL-.

The relay and triac drive circuits are included.

Figure 3. STDES-HBR001V1 pinout



The STDES-HBR001V1 reference design includes switch S1, which allows the user to select how to turn on the hybrid relay. The user can select random control or zero-cross control. This selection affects how the triac switches on, either randomly or at the zero-crossing.

The zero cross option turns on the triac at the first zero cross of the AC line cycle. The random option can turn on the triac at any time when the board is under control.

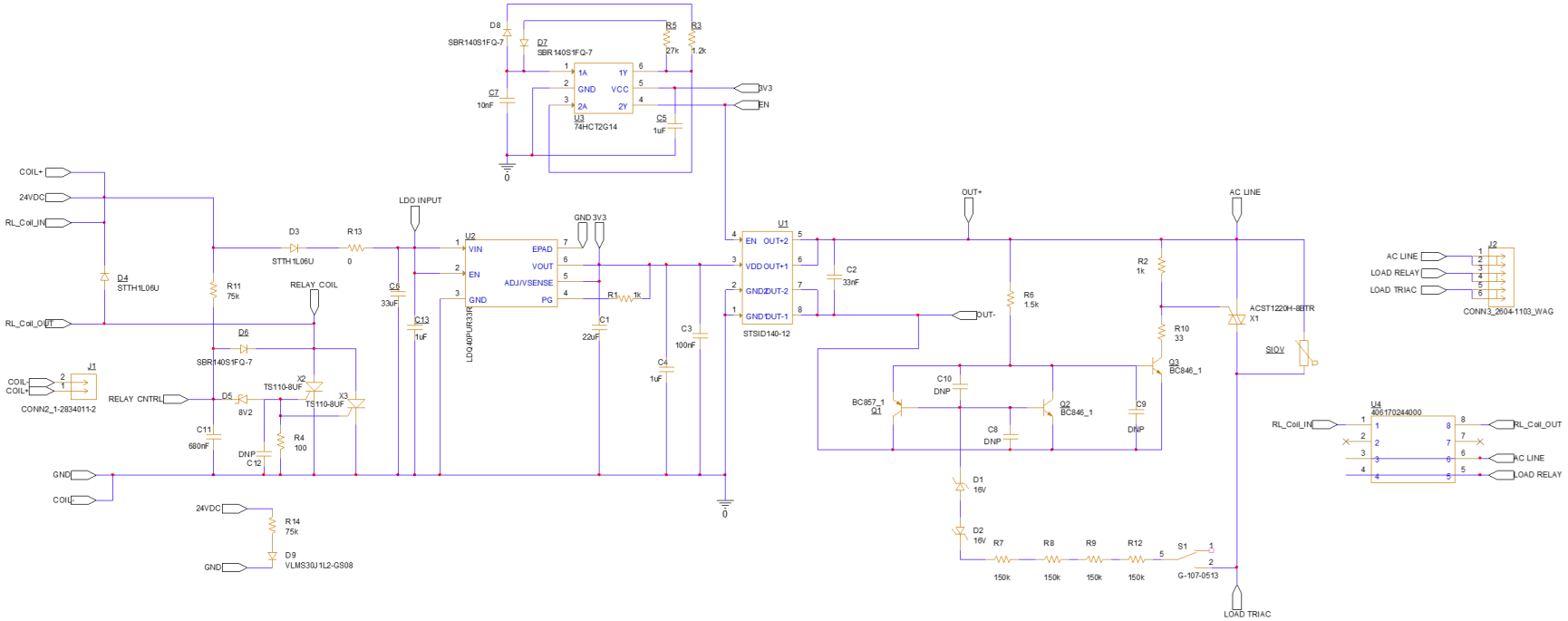
Section 5: Use case: 16 A hybrid relay features a concrete use case of a 16 A hybrid relay.

Table 1. STDES-HBR001V1 pinout

Pins reference	Definition	Comments
COIL+	DC power supply	+24 VDC
COIL-	Low voltage ground reference	GND
TRIAC LOAD	Input load connection	16 A
RELAY LOAD	Input load connection	16 A
LINE AC	AC line terminal connection	N/A

3 Schematics

Figure 4. STDES-HBR001V1 schematics



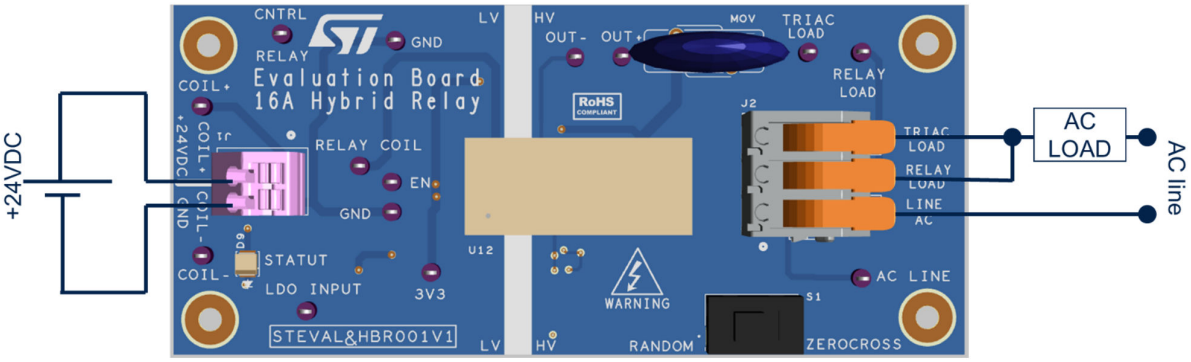
4 BOM

Table 2. **STDES-HBR001V1 bill of materials**

Designator	Part / Value	Description
U1	STSID140-12	Surface-mount isolated thyristor driver
X1	ACST1220H-8BTR	12 A overvoltage protected AC Switch
X2,X3	TS110-8UF	High surge voltage 1.25 A SCR for circuit breaker
U2	LDQ40PUR33R	250 mA low-dropout LDO
U3	74HCT2G14	Dual inverting Schmitt trigger from Nexperia
U4	406170244000	1RT 16A 24V DC sensitive relay from Finder
C1	22uF	Capacitor > 10 VDC
C2	33nF	Capacitor > 10 VDC
C3	100nF	Capacitor > 10 VDC
C4,C5	1uF	Capacitor > 10 VDC
C6	33uF	Capacitor > 25 VDC
C7	10nF	Capacitor > 10 VDC
C8,C9,C10,C12	DNP	Capacitor
C11	680nF	Capacitor > 50 VDC
C13	1uF	Capacitor > 50 VDC
D1,D2	16V	Diode
D3,D4	STTH1L06U	Diode
D5	8V2	Diode
D6,D7,D8	SBR140S1FQ-7	Diode
D9	VLMS30J1L2-GS08	Diode
J1	1-2834011-2	2 Position Wire to Board Terminal Block connector
J2	2604-1103	PCB terminal block; lever; 4 mm²; Pin spacing 5 mm; 3-pole connector 2604-1103
Q1	BC857	PNP Transistor, 100 mA, 45 V, 3-Pin SOT-23
Q2,Q3	BC846	PNP Transistor, 100 mA, 65 V, 3-Pin SOT-23
R1	1k	Resistor
R2	1000	Resistor
R3	1.2k/ 1%	Resistor
R4	100	Resistor
R5	27k / 1%	Resistor
R6	1.5k/ 1%	Resistor
R7,R8,R9,R12	150k/ 1%	Resistor
R10	33	Resistor
R11,R14	75k/ 1%	Resistor
R13	0	Resistor
SIOV	DNP	ND
S1	G-107-0513	Slide Switches SPDT 125VAC/VDC .5A
TP1, TP2, TP3, TP4,TP5, TP6, TP7, TP8,TP9, TP10, TP11, TP12,TP13, TP14	AC LINE	PCB test points

5 Use case: 16 A hybrid relay

Figure 5. Pin out of 16 A hybrid relay using STDES-HBR001V1



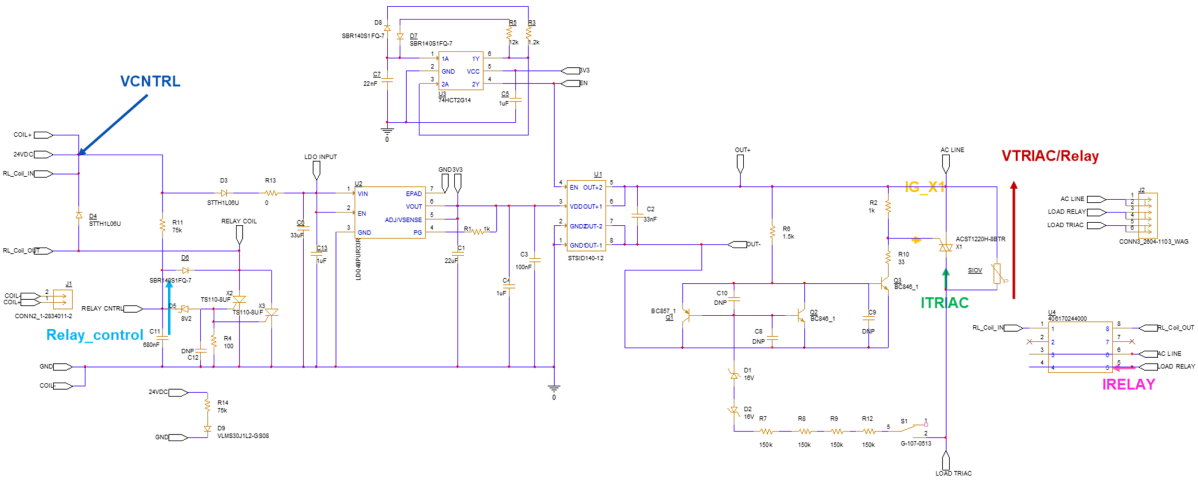
By shorting the triac load and relay load connectors as shown in Figure 5, a 16 A hybrid relay is obtained. The hybrid relay is then ready for use in different applications. To set up the hybrid relay, follow these steps:

1. Use the S1 switch to select one of the following modes:
   – ZEROCROSS mode: synchronized switching at the AC zero-crossing
   – RANDOM mode: immediate switching regardless of the AC phase.
2. On the J2 orange terminal block:
   – Connect the load wire to the triac LOAD terminal and the RELAY LOAD terminal
   – Connect the AC mains line (L) wire to the AC line terminal.
   – Connect the neutral (N) wire of the AC load directly to the neutral of the AC mains.
3. On the J1 orange terminal block:
   – Connect the positive wire of the 24 V dc supply to COIL+
   – Connect the ground (GND) of the supply to COIL−.

Apply AC mains first. Then power on the 24 V supply. The status LED indicates the relay state.

Figure 6 shows signals across the hybrid relay, as visualized on the oscilloscope.

Figure 6. Visualized signals across STDES-HBR001V1 schematics



The yellow signal is the drive current at the triac gate. The red signal is the voltage between the AC line and the short-circuited triac load or relay load. The green signal is the current through the triac. The dark blue signal is the COIL+ value, which is +24 V dc when power is applied. The light blue signal is the relay control signal.

The control mode can be random control or zero-cross control.

The triac switches on first to eliminate arcing. Then, the mechanical relay closes and carries the load current with minimal on-state losses. During turn-off, the triac switches off before the mechanical relay opens.

In random control mode, the triac switches on at any time when the control signal (+24 V dc) is applied (Figure 7).

In zero-cross control mode, the triac switches on at the first AC line zero-crossing when the control signal (+24 V dc) is applied (Figure 8).

In both modes, the triac switches off after a delay when the control signal (+24 V dc) is removed (Figure 9).

Figure 7. STDES-HBR001V1 operation during the turn-on phase in random control mode

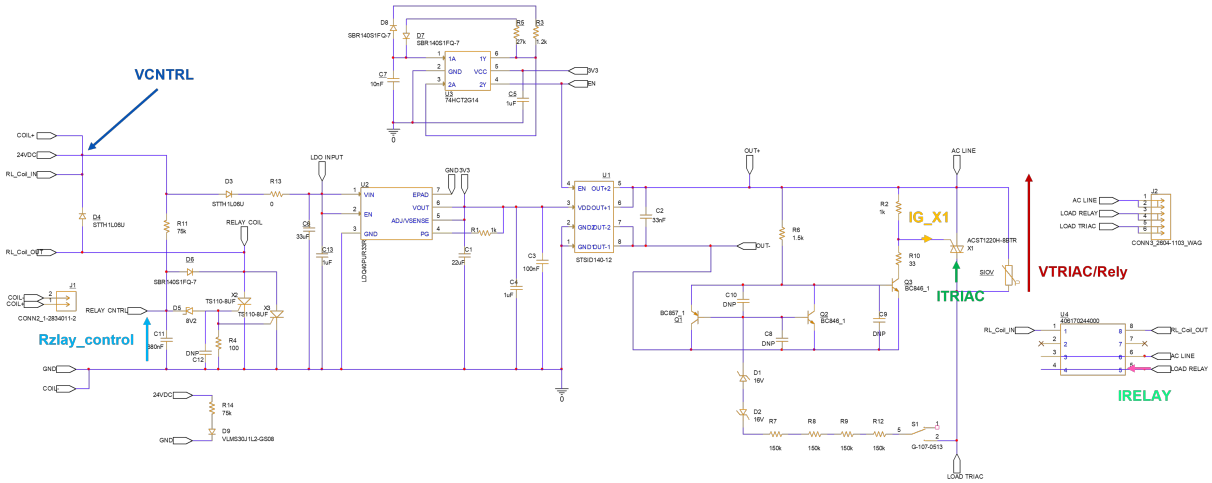


Figure 8. STDES-HBR001V1 operation during the turn-on phase in zero cross control mode

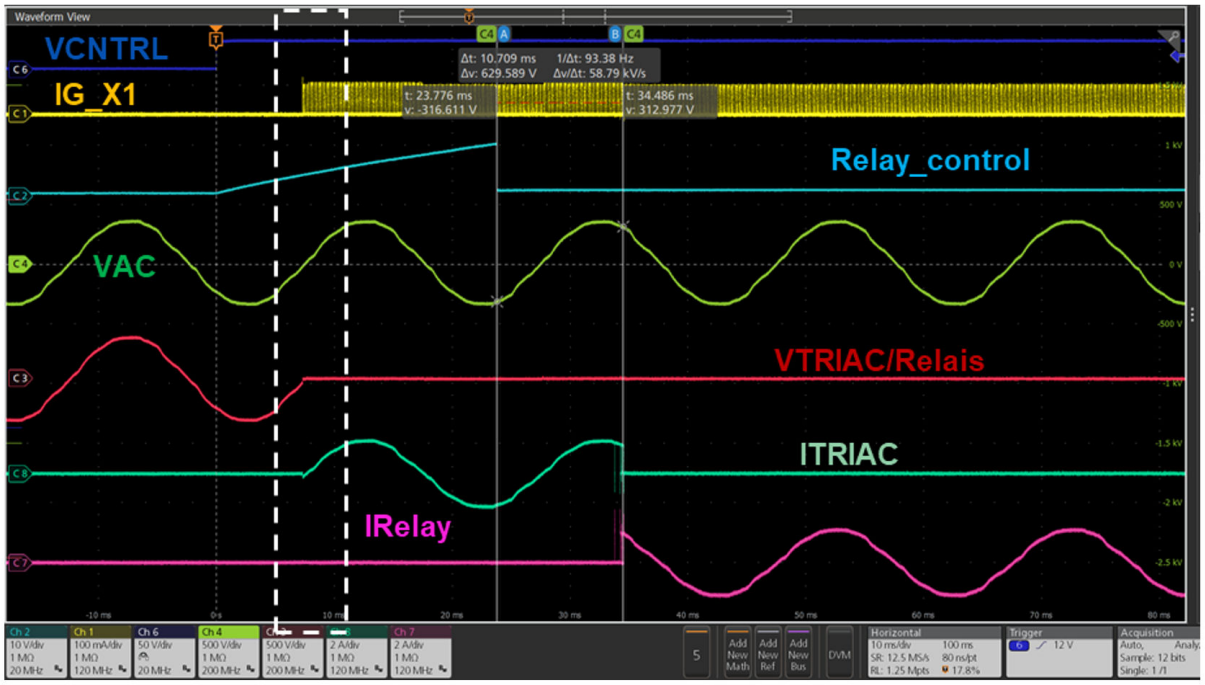
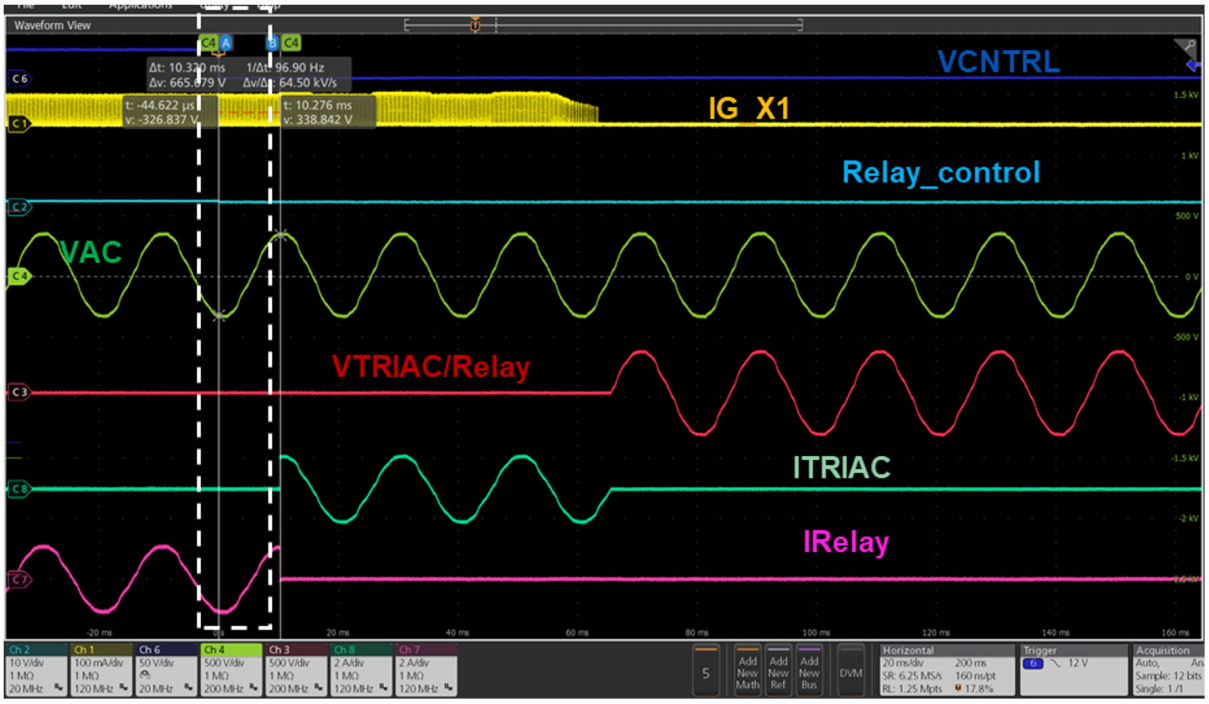


Figure 9. **STDES-HBR001V1 operation during the turn-off phase in random or zero cross control mode**



6 Layout

Figure 10. **STDES-HBR001V1 layout top view**

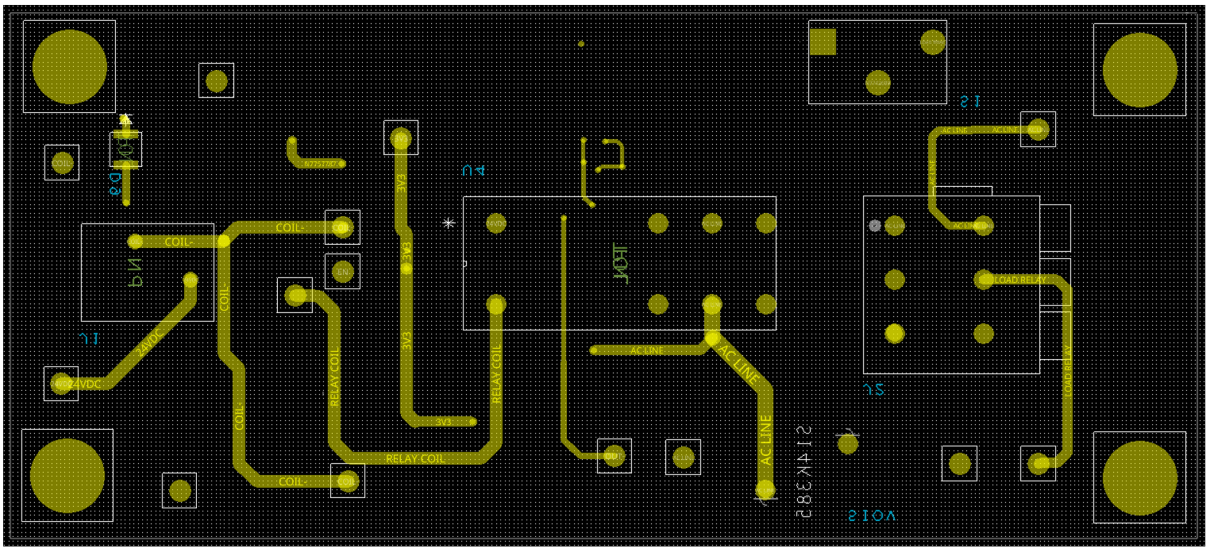
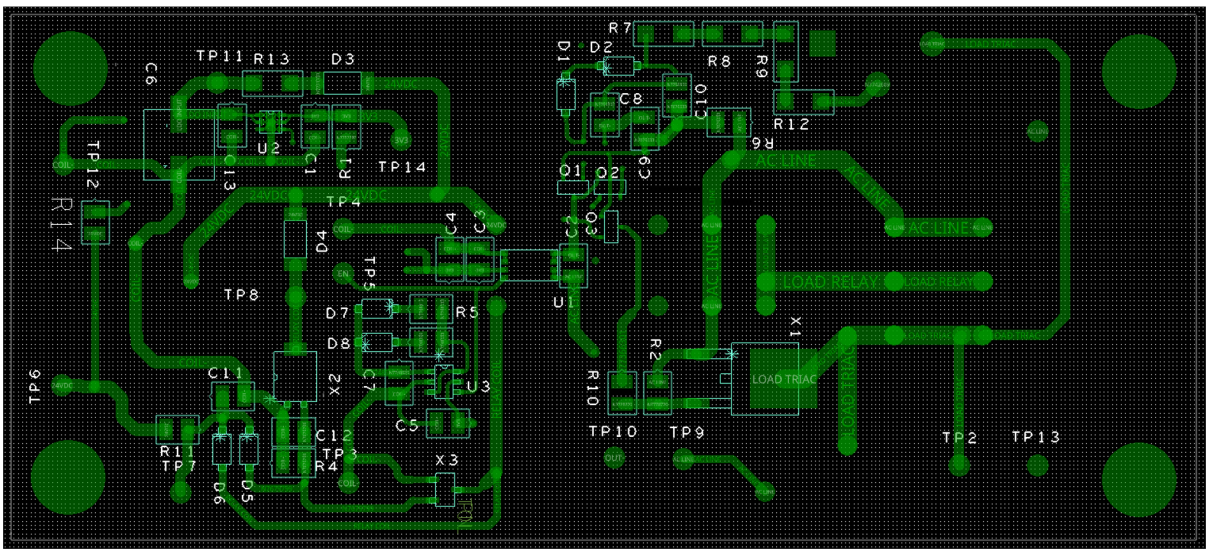


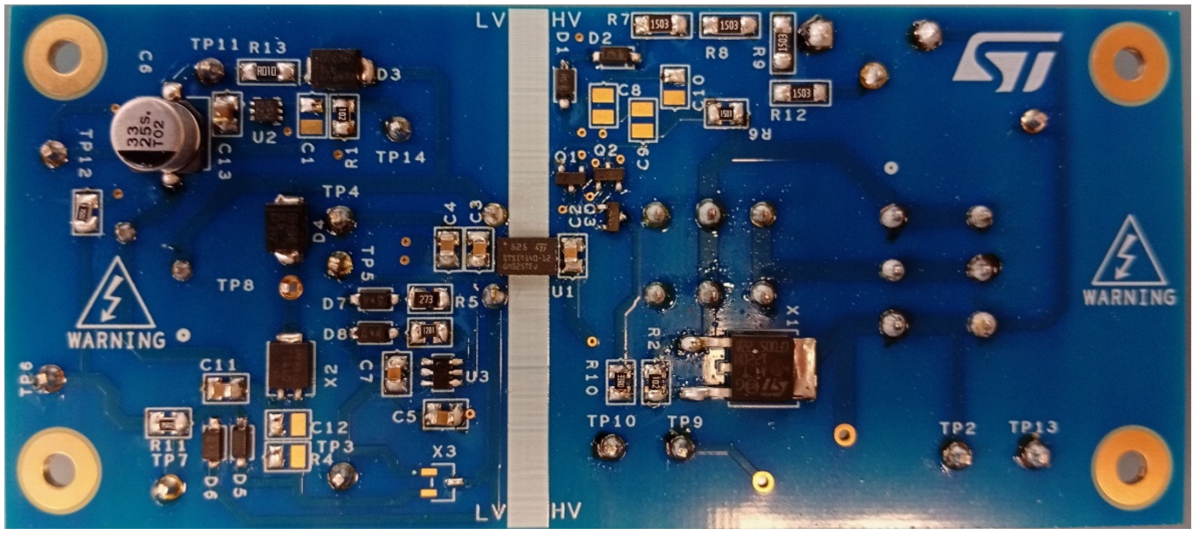
Figure 11. **STDES-HBR001V1 layout bottom view**



7 2D views

Figure 12. **STDES-HBR001V1 top view**

Figure 13. **STDES-HBR001V1 bottom view**



8 3D views

Figure 14. **STDES-HBR001V1 3D top view**

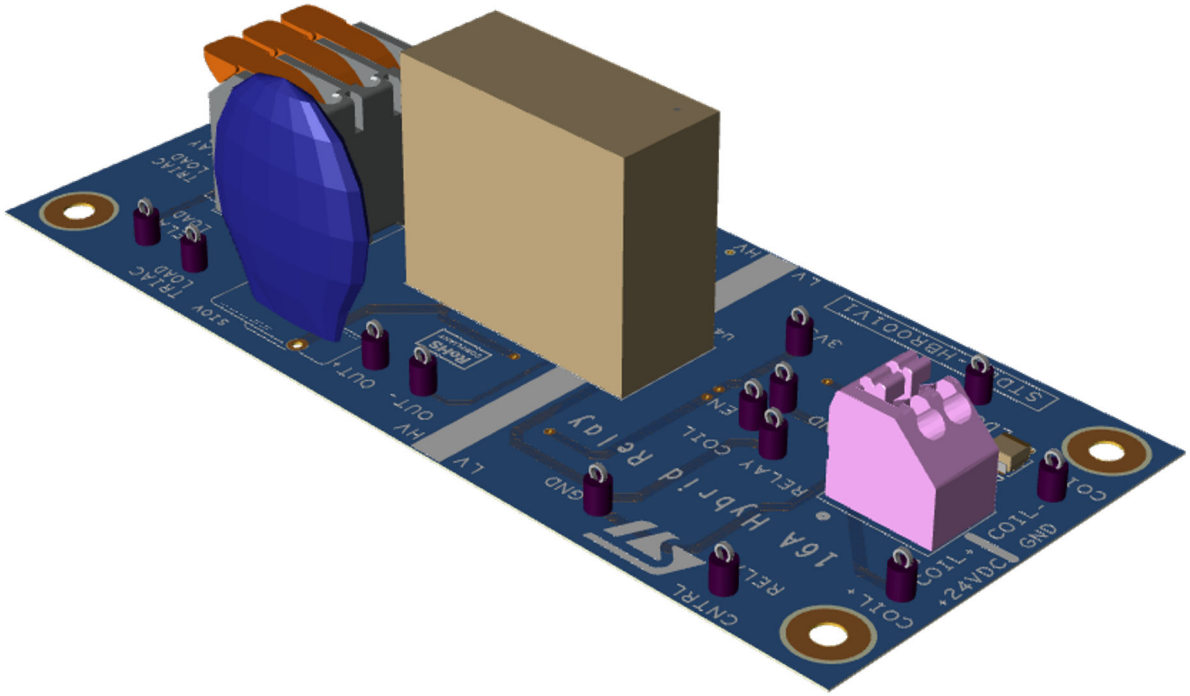
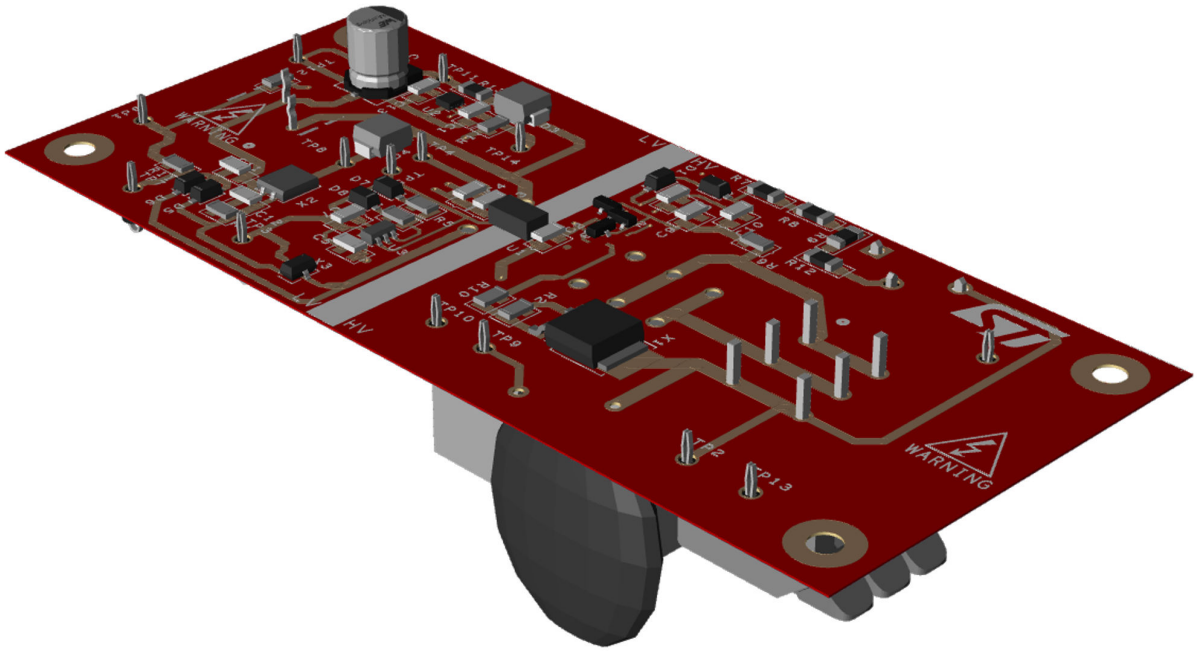


Figure 15. **STDES-HBR001V1 3D bottom view**



Revision history

Table 3. **Document revision history**

Date	Revision	Changes
19-Jun-2026	1	Initial release.

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