

Getting started with the industrial drive system kit based on ACEPACK™ 2 power module

Introduction

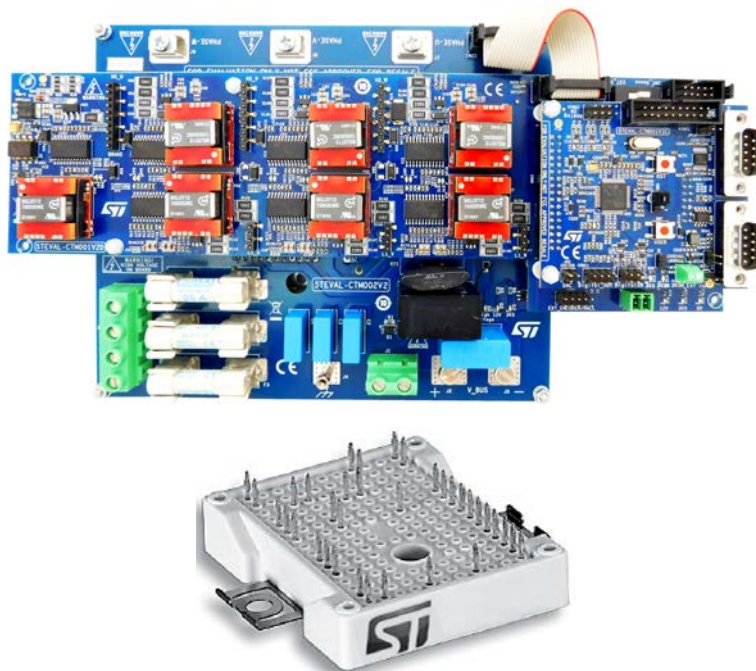
The STEVAL-HKI001V2 is an industrial drive evaluation system designed to demonstrate the capabilities of the A2C35S12M3-F IGBT power module for motor control applications.

It offers a solution for single- or three-phase main input with a converter inverter brake (CIB) topology able to handle a motor current up to 35 A (power module maximum current rating).

The hardware platform is a stackable solution consisting of: a power stage (STEVAL-CTM002V2), which contains the power module and current sensing circuitry, a driving stage (STEVAL-CTM001V2D) which contains the new galvanically isolated STGAP1AS gapDRIVE, with suitable circuitry to drive the embedded IGBTs in the power module, a control board (STEVAL-CTM001V1C), based on the STM32F303RBT7 microcontroller, which is able to execute the field oriented control (FOC) algorithm to obtain the best performance in all motor control applications.

The control board has RS232 and CAN external interfaces to let you monitor and control your application on the evaluation system via PC.

Figure 1. ACEPACK™ 2 industrial drive evaluation system



1 Getting started

1.1 ACEPACK™ 2 evaluation system features

1.1.1 Electrical and functional characteristics

The evaluation system kit features:

- [A2C35S12M3-F](#) ACEPACK™ 2 power module in converter inverter brake (CIB) topology
- Control stage based on [STM32F303](#) ARM® Cortex®-M4 MCU and compatible with ST MC library with STFOC algorithm (sensored and sensorless mode)
- In-rush current, thermal and overcurrent protection
- Brake function with external resistor
- On-board isolated current sensing of 2.1 kV_{RMS}
- Galvanically isolated driving stage with [STGAP1AS](#)
- Additional gate driving for dissipative brake section (external power resistor)
- Protections and sensing (overvoltage, overcurrent, overtemperature, current reading input)
- Input/output interface (analog/digital)

1.1.2 Target applications

Motor drives with input from single or three-phase grid for:

- Industrial motor drives
- Motion/Servo Control
- Pumps

1.2 Safety and operating instructions

1.2.1 General terms

All operations involving transportation, installation and use, as well as maintenance, are to be carried out by skilled technical personnel (national accident prevention rules must be observed). For the purpose of these basic safety instructions, "skilled technical personnel" are considered as suitably qualified people who are familiar with the installation, use, and maintenance of power electronic systems.

Danger:

During assembly, testing, and normal operation, the Evaluation Kit poses several inherent hazards, including bare wires, moving or rotating parts and hot surfaces. There is a danger of serious personal injury if the kit or components are improperly used or incorrectly installed. The kit is not electrically isolated from the AC/DC input. The demonstration board is directly linked to the mains voltage. No insulation is ensured between accessible parts and high voltage. All measuring equipment must be isolated from the mains before powering the board. When using an oscilloscope with the Evaluation Kit, it must be isolated from the AC line. This prevents shock 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. Do not touch the Evaluation Kit after disconnection from the voltage supply: several parts and power terminals, which contain energized capacitors, must be allowed to discharge.

1.2.2 Intended use

This evaluation kit is designed for demonstration purposes only and shall not be used for any commercial purpose. The technical data, as well as information concerning power supply conditions, must be taken from the relevant documentation and strictly observed.

1.2.3 Installation

The evaluation kit installation must be in accordance with the specifications and the target application:

- The kit contains electro-statically sensitive components that are prone to damage through improper use. Electrical components must not be mechanically damaged or destroyed.
- Avoid any contacts with other electronic components.
- During the motor drive, converters must be protected against excessive strain. In particular, no components are to be bent or isolating distances altered during the course of transportation or handling.

1.2.4 Electronic connections

Applicable national accident prevention rules must be followed when working on the main power supply with a motor drive.

The electrical installation must be completed in accordance with the appropriate requirements.

A system architecture which supplies power to the evaluation kit must be equipped with additional control and protective devices in accordance with the applicable safety requirements (e.g. compliance with technical equipment and accident prevention rules).

1.3 System description

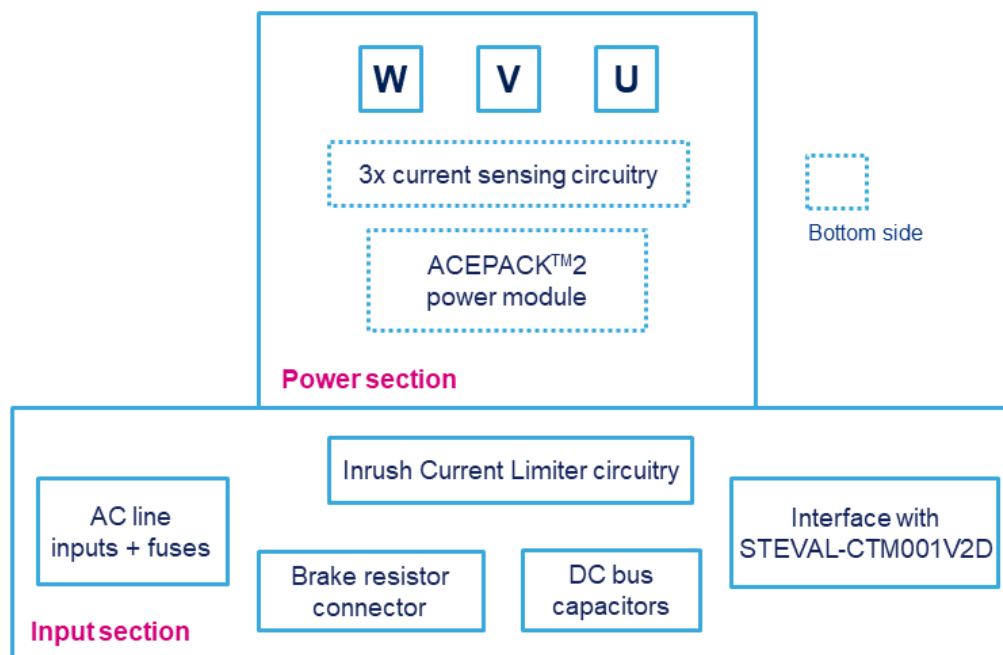
1.3.1 System overview

The STEVAL-CTM002V2 evaluation board is aimed at evaluating the power module for motor control applications.

The board can be schematized in two main blocks:

- Power section: this block hosts the connectors to plug the board itself and the STEVAL-CTM001V2D evaluation board; it also includes 3 isolated current sensors, the [A2C35S12M3-F](#) power module and 3 power connectors for the motor phases.
- Input section: this block is for the single phase and three-phase input with AC line with fuses, inrush current limiter circuitry, connectors for external brake resistor and for connecting the compatible driver board (STEVAL-CTM001V2D).

Figure 2. STEVAL-CTM002V2 evaluation board main blocks



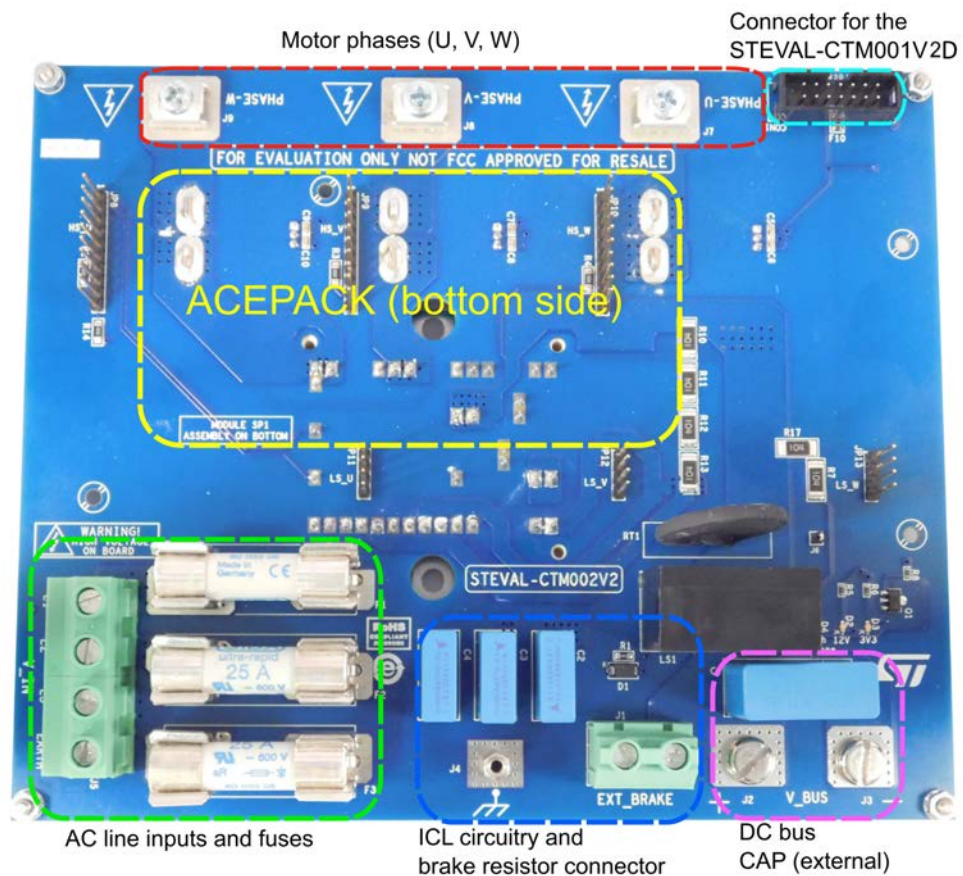
1.3.2 Power section

The power stage of the STEVAL-CTM002V2 evaluation board is based on the A2C35S12M3-F ACEPACK™ 2, available in two package options: solderable and press-fit contact pins.

Three isolated current sensors allow you to implement a FOC algorithm based on the ST motor control software library (X-CUBE-MCSDK).

The power section also hosts the connectors to plug both the driver board (STEVAL-CTM001V2D) via JP8 (HS_U), JP9 (HS_V) and JP10 (HS_W) for the high-side driving (U, V and W motor phases, respectively) and via JP11, JP12 and JP13 (LS_U, LS_V, LS_W) for the low-side driving.

Figure 3. STEVAL-CTM002V2 evaluation board sections



1.3.2.1 ACEPACK™ 2 power module characteristics

The hardware is designed to allow evaluation of the A2C35S12M3 power module, and offers the flexibility of using either the solderable version supplied with the kit or the A2C35S12M3-F (press-fit version).

The power module mainly features:

- Converter inverter brake (CIB) topology:
 - 1600 V very low drop rectifiers for converter
 - 1200 V, 35 A IGBTs and diodes
 - $V_{CE(sat)} = 1.85 \text{ V}$ at $I_C = 35 \text{ A}$
 - Soft and fast recovery diode
- Compact dimension plastic case (52.7 x 48 x 12.0 mm)
- Al_2O_3 direct bonded copper (DBC)
- Integrated NTC temperature sensor
- Available as press-fit pin type
- Typical applications: inverters, motor drives, UPS

Figure 4. A2C35S12M3 power module topology

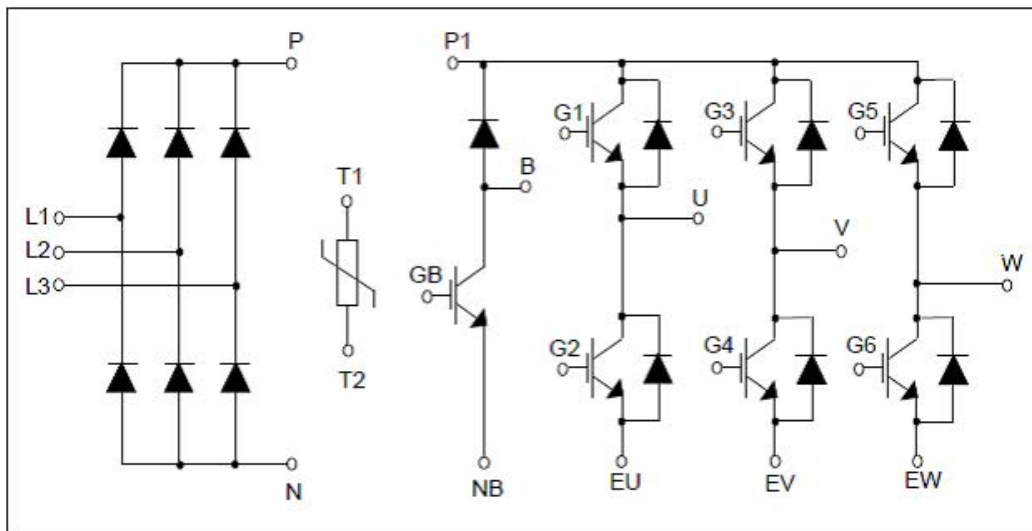
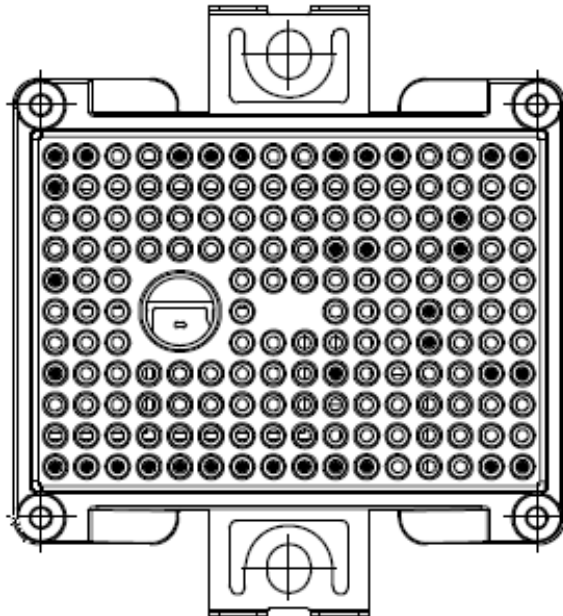


Figure 5. A2C35S12M3 power module package



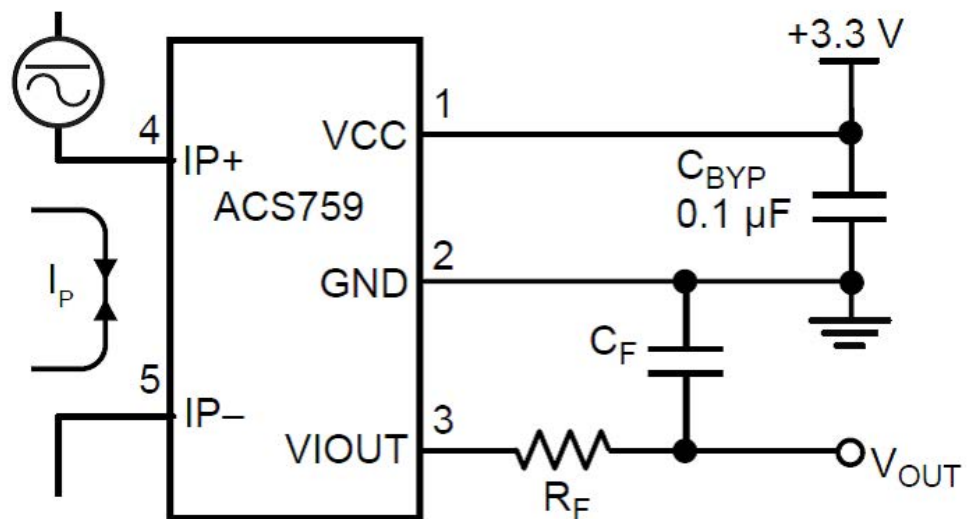
Figure 6. A2C35S12M3 pin arrangements



1.3.2.2 Phase current sensing

In order to allow digital control based on FOC algorithms, the power stage contains current sensing circuitry for the motor phases through three Hall effect current sensors assembled on the bottom side of the power board. These highly accurate sensors are rated 26.4 mV/A with an operating temperature from -40 to 140°C.

Figure 7. A2C35S12M3 current sensor schematic



Two motor phase currents (I_u and I_v) are used by the algorithm and the third one (not used by ST motor control software library) is estimated by the following equation:

$$I_u + I_v + I_w = 0$$

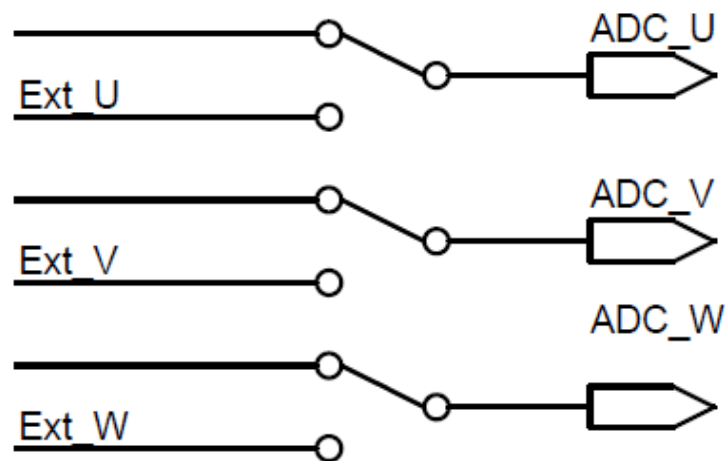
To set the embedded current sensors, use multiple switch SW1 to select `Int_Sense`. If properly set, LED diode D23 turns on.

You also can by-pass this embedded current sensing circuitry and use an external current sensing board (not included). In this case, use multiple switch SW1 to select Ext_Sense. If properly set, the LED diode D24 turns on.

Warning:

The signals from the sensors have to center around 1.65 V (average value at zero current) with a range of 0 to 3.3 V max. A different range may damage circuitry and the microcontroller.

Figure 8. A2C35S12M3 multiple switch selection (external/internal current sensing)



Warning:

Be aware that, depending on the current sensing methodology selected (Int_Sense via the embedded circuitry or Ext_Sense via an external board), a failure event may occur if the multiple switch SW1 is not selected accordingly.

1.3.3

STEVAL-CTM001V2D and STEVAL-CTM001V1C overview

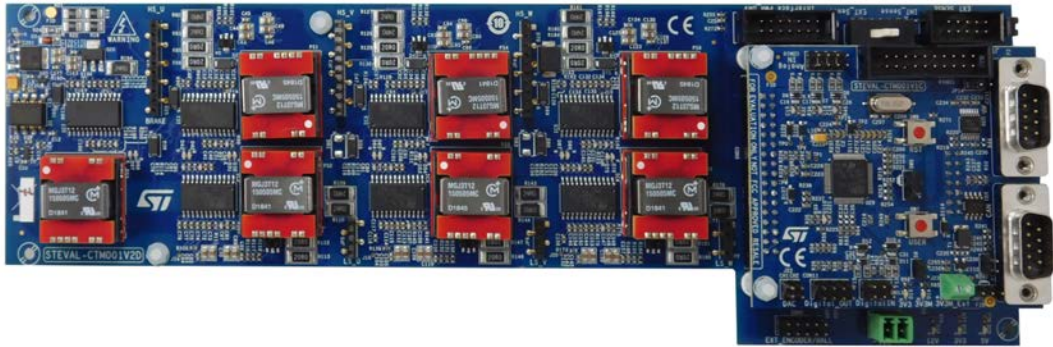
The STEVAL-CTM001V2D evaluation board mainly consists of a power supply section and the driving stage. The driving section is designed around the galvanically isolated [STGAP1AS](#) that offers high-end performance and a range of protection and diagnostics features.

The power supply section is embedded in the driving section and outputs the voltage necessary for the circuitry from the input voltage (Vin) on connector JP1.

The control board (STEVAL-CTM001V1C) is based on the high performance [STM32F303RBT7](#) microcontroller with dedicated peripherals for motor control such as fast ADC conversions and high resolution timers.

The stand-alone control board is connected to the driving stage via the 34-pin motor control connector used in most motor control applications. This standard connector allows you to use a different control board for your application if you wish.

Figure 9. STEVAL-CTM001V2D and STEVAL-CTM001V1C evaluation boards



1.3.3.1

STEVAL-CTM001V1C control board

The STEVAL-CTM001V1C control board is designed around the **STM32F303RBT7** microcontroller based on the high-performance ARM® Cortex®-M4 32-bit RISC core with FPU operating at a frequency up to 72 MHz, with floating point unit (FPU), memory protection unit (MPU) and embedded trace macrocell (ETM).

The family embeds high-speed memories (up to 256 Kbytes of Flash memory, up to 40 Kbytes of SRAM) and an extensive range of enhanced I/O and peripherals connected to two APB buses. These devices offer up to four fast 12-bit ADCs (5Msps), seven comparators, four operational amplifiers, up to two DAC channels, a low-power RTC, up to five general-purpose 16-bit timers, one general-purpose 32-bit timer, and two timers dedicated to motor control. They also feature standard and advanced communication interfaces: up to two I²Cs, up to three SPIs (two SPIs are with multiplexed full-duplex I²Ss), three USARTs, up to two UARTs, CAN and USB.

To achieve audio class accuracy, the I²S peripherals can be clocked via an external PLL.

The STM32F303xB/STM32F303xC family operates in the -40 to +85 °C and -40 to +105 °C temperature ranges from a 2.0 to 3.6 V power supply. A comprehensive set of power-saving mode allows the design of low-power applications.

The microcontroller package chosen for this evaluation board is the 64-pin package LQFP64 (Lowprofile Quad Flat Package - for further details, refer to the relevant datasheet on www.st.com). It has a standard SWD/JTAG (Serial Wire Debug) 20-pin connector to access the registers and the MCU Flash memory for fast programming and debugging supported by the most popular IDE environments.

The control board features:

- 34-pin motor control connector, including signals like fault management, bus voltage monitoring, power module temperature sensing and dissipative braking
- 2 push buttons (1 for user general purpose and 1 for MCU reset)
- 3 user LEDs (2 green LEDs for two different +3.3 V, one specific for microcontroller supply and one for other functionalities; an orange LED for +5 V)
- SWD/JTAG programming connector
- RS232 DB9 male connector
- CAN DB9 male connector

Figure 10. STEVAL-CTM001V1C evaluation board

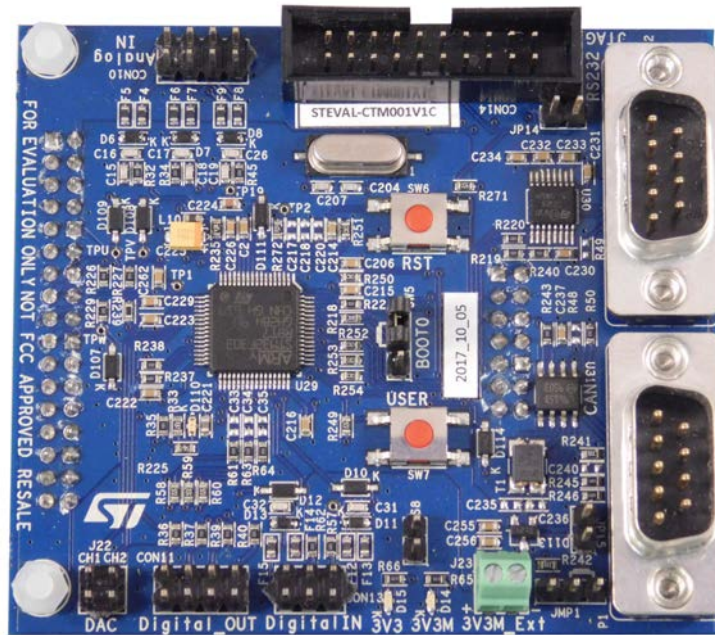
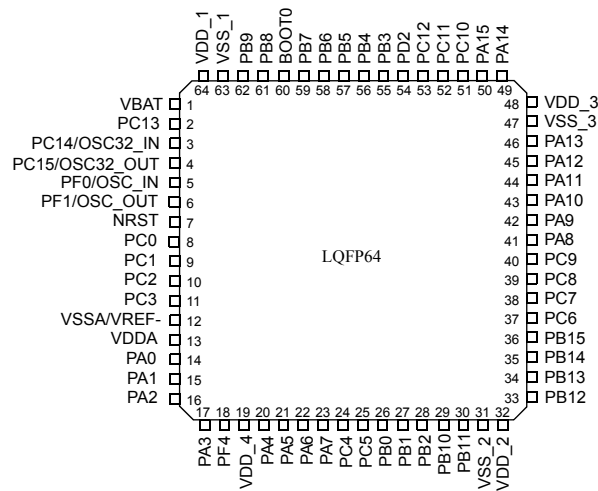


Figure 11. STM32F303xB LQFP64 pin-out



1.3.3.1.1 STM32 PMSM FOC SDK compatible software

The control board is fully compatible with ST Motor Control Workbench (X-CUBE-MCSDK).

This tool has been used to test the board on a 10 kW PMSM motor.

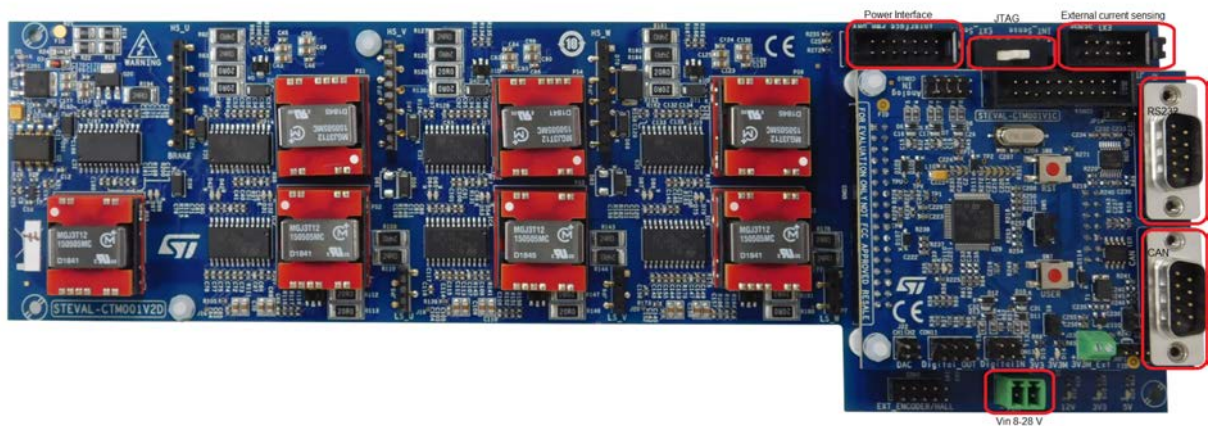
After installing the software, you can connect the evaluation board to a PC or laptop via the STLINK/V2 in-circuit debugger/programmer and a USB-to-serial converter with female to female DB9 serial cable.

1.3.3.2 STEVAL-CTM001V2D driver board power supply and connectors

The STEVAL-CTM001V2D driver board consists of specific functional sections:

- Power supply
- Connectors
- Gate drivers
- Bus voltage monitor
- Temperature monitor
- Dissipative braking

Figure 12. STEVAL-CTM001V2D evaluation board settings with control board



Power supply

The power supply section has been designed to provide the different voltage levels necessary for system operations. Seven insulated DC/DC have been used to provide the supply voltage for the seven gate drivers. The voltage input provided at the JP1 connector must be in the range 8 - 28 V. The power supply section is able to provide the following voltages: +12 V at CON9 for external functions, +5 V and +3.3 V for the control board, and +15 V/-10 V for the gate driver section.

Supply voltage connector

The voltage input is provided at JP1 connector in the range 8-28 V.

Power board connector

The CON8 connector is used for current sensing signals coming from the internal current sensors (based on the shunt resistor and assembled on the power board bottom layer) and for the relay driving functions.

Moreover, six connectors (from JP2 to JP7) are used for the IGBT, braking section driving signal and the NTC sensing.

A high-side emitter on the low side and a collector sensing on the high side are used for the gate driver functionality and for monitoring the DC bus voltage.

Control board connectors

The connectors for the control board are CON4 and CON5.

CON4 is used for serial peripheral interface (SPI) communication signals exchanged between the microcontroller and the gate driver. Through the SPI, you can program each gate driver function parameter and evaluate the diagnostic functionality.

CON5 is the motor control connector for signals like fault management, bus voltage monitoring, power module temperature sensing and dissipative braking.

External signal connectors

CON2 (also called EXT_ENCODER connector) provides a +5 V supply voltage and is used for receiving external signals coming from the Encoder/Hall sensors.

CON16 (also called EXT_SENSE connector) also provides a +5 V supply voltage but allows receiving current signals from an external current sensor board.

1.3.3.2.1 STGAP1AS gate driver characteristics

The STGAP1AS gapDRIVE™ is a 4 kV galvanically isolated single gate driver IC for N-channel MOSFETs and IGBTs with advanced protections, configuration and diagnostics features.

The STGAP1AS architecture isolates the channel from the control and the low voltage interface circuitry through physical galvanic isolation.

The gate driver is characterized by a 5 A output current capability, which means the device is also suitable for high power inverter applications such as motor drivers in hybrid and electric vehicles, and in industrial drives.

The output driver section provides a rail-to-rail output with the possibility of using a negative gate driver supply.

The input-to-output propagation delay is within 100 ns, providing high PWM control accuracy.

Protection functions, such as the Miller clamp, desaturation detection, dedicated sense pin for overcurrent detection, output 2-level turn-off, VCE overvoltage protection, UVLO and OVLO, are included to facilitate the design of a highly reliable solution. Each function parameter can be programmed via the SPI, making the device very flexible and suitable for a wide range of applications. Separate sink and source output provides high flexibility and a reduced bill of materials for external components.

Figure 13. STGAP1AS gapDRIVE™ pin-out

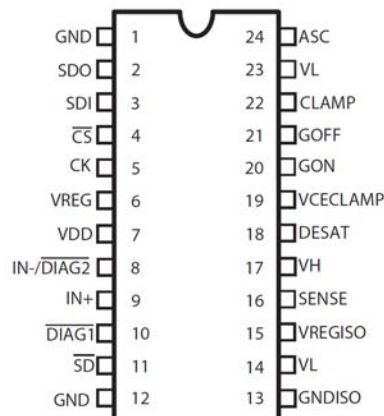


Table 1. STGAP1AS gapDRIVE™ pin description

| Pin no. | Pin name | Type function | Description |
|---------|------------------|-------------------------------|--|
| 7 | V _{DD} | Power supply | Internal 3.3 V regulator input supply pin |
| 6 | V _{REG} | Power supply | Internal 3.3 V regulator output and supply pin |
| 11 | \overline{SD} | Logic input | Shutdown input (active low) |
| 9 | IN+ | Logic input | Gate command input |
| 8 | IN-/DIAG2 | Logic input/open drain output | Gate command input /open drain diagnostic output |
| 10 | DIAG1 | Open drain output | Open drain diagnostic output |
| 1, 12 | GND | Ground | Low voltage section ground |
| 4 | \overline{CS} | Logic input | SPI chip select (active low) |
| 5 | CK | Logic input | SPI clock |

| Pin no. | Pin name | Type function | Description |
|---------|----------------------|---------------|--|
| 3 | SDI | Logic input | SPI serial data input |
| 2 | SDO | Logic output | SPI serial data output |
| 19 | V _{CECLAMP} | Analog input | V _{CE} active clamping protection |
| 18 | DESAT | Analog input | Desaturation protection |
| 15 | V _{REGISO} | Power supply | Internal regulator output pin for decoupling |
| 17 | V _H | Power supply | Positive voltage supply |
| 20 | GON | Analog output | Gate source output |
| 21 | GOFF | Analog output | Gate sink output |
| 22 | CLAMP | Analog output | Miller clamp |
| 14, 23 | V _L | Power supply | Negative supply voltage or ground |
| 13 | GNDISO | Ground | High voltage section (isolated) ground |
| 16 | SENSE | Analog input | Sense input for overcurrent protection |
| 24 | ASC | Analog input | Asynchronous stop command |

1.3.3.2.2 Bus voltage monitoring

A bus voltage monitoring is implemented in the input voltage range 50 to 650 V.

The following table lists the measured input voltage values and the corresponding voltage level of the STM32 microcontroller unit ADC input signal.

Table 2. Bus input voltage vs. STM32 ADC channel input signal

| Input voltage | ADC input |
|--------------------|-----------|
| 325 V | 1.6 V |
| 650 V (max. value) | 3.2 V |

1.3.3.2.3 Temperature monitor

The power module embeds an NTC that provides information about the temperature monitored by the microcontroller, which manages overload/overtemperature events via external signal conditioning and ADC conversion. To protect the hardware in the event of overtemperature, a safe threshold must be set and implemented in the STM32 FOC SDK software library.

Table 3. NTC electrical characteristics

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|--------|----------------------|------------------|------|-------|------|------|
| R25 | Resistance | T = -40°C | | 105.7 | | kΩ |
| R25 | Resistance | T = 25°C | | 4.7 | | kΩ |
| R125 | Resistance | T = 100°C | | 0.426 | | kΩ |
| B | B-constant | T = 25°C to 50°C | | 3500 | | |
| T | Operating temp range | | -40 | | 125 | °C |

1.3.3.2.4 Dissipative braking

If the motor spins faster than the target speed, it enters a generation phase where a certain quantity of energy flows from the motor to the inverter.

This energy must be dissipated to avoid any hardware failure from an overvoltage on the DC bus.

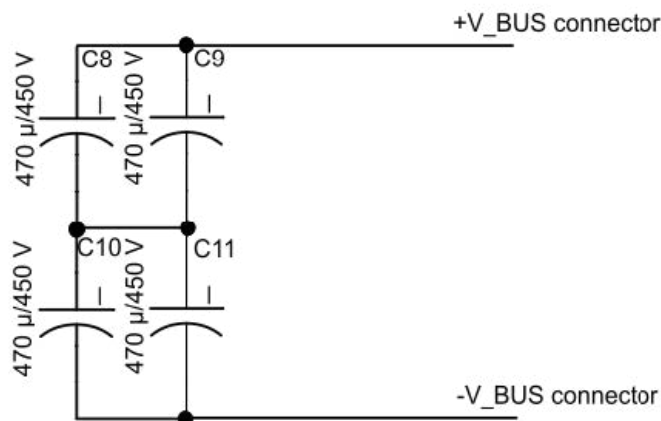
The seventh IGBT (embedded in the ACEPACK™ 2 module) and its dedicated freewheeling diode allows the energy to be dissipated through an external power resistor.

1.3.4 Hardware settings

Follow the steps below to set up the industrial evaluation system.

- Step 1.** Connect the STEVAL-CTM001V2D evaluation board to the STEVAL-CTM002V2 evaluation board by using the STEVAL-CTM001V2D connectors (from JP2 to JP7) and the STEVAL-CTM002V2 connectors (from JP8 to JP13)
- Step 2.** On the STEVAL-CTM001V2D:
- Step 2a.** Set switch SW1 to INT_SENSE position, the D23 LED turns on as soon as the board is switched on
 - Step 2b.** Close jumper S7
 - Step 2c.** Close jumper SW5 in the default position (indicated near the switch)
 - Step 2d.** Connect the ST-LINK to connector CON14
 - Step 2e.** Connect the USB-to-serial converter to P2 connector by using the serial cable DB9 female to female
 - Step 2f.** Connect the 12 V DC power supply to JP1 connector
 - Step 2g.** Turn on the power supply
- Step 3.** Connect the flat cable between CON8 on the STEVAL-CTM001V2D and CON1 on the STEVAL-CTM002V2
- Step 4.** Connect the bulk capacitor bank consisting of the series of two parallel capacitors (four capacitors), between the + and – of the V_BUS connections (on the STEVAL-CTM002V2) as shown below.

Figure 14. STEVAL-CTM002V2 bulk capacitor bank



- Step 5.** On the STEVAL-CTM002V2:
- Step 5a.** Connect the three-phase AC power supply 400 V_{AC} to the J5 connector, including the earth cable
 - Step 5b.** Turn the power supply on at 400 V_{AC} and limit the current to 10 Apk. The D4 LED turns on

1.3.5 Motor control board connectors

Figure 15. STEVAL-CTM001V2D: 34-pin motor control connector (CON3)



Table 4. Motor control connector pin-out

| Pin number | Pin name/function |
|------------|-----------------------------|
| 1 | FAULT |
| 2 | GND |
| 3 | PWM_U_H |
| 4 | GND |
| 5 | PWM_U_L |
| 6 | GND |
| 7 | PWM_V_H |
| 8 | GND |
| 9 | PWM_V_L |
| 10 | GND |
| 11 | PWM_W_H |
| 12 | GND |
| 13 | PWM_W_L |
| 14 | Bus voltage monitoring |
| 15 | ADC_U |
| 16 | GND |
| 17 | ADC_V |
| 18 | GND |
| 19 | ADC_W |
| 20 | GND |
| 21 | Not connected |
| 22 | GND |
| 23 | Dissipative brake |
| 24 | GND |
| 25 | 5VC |
| 26 | Heatsink temperature signal |
| 27 | Not connected |
| 28 | 3.3VC |
| 29 | Not connected |
| 30 | GND |
| 31 | Enc A/H1 |
| 32 | GND |
| 33 | Enc B/H2 |
| 34 | Enc Z/H3 |

Figure 16. RS232 DB9 female connector

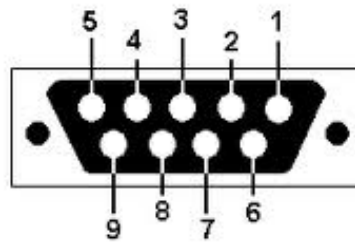


Table 5. RS232 connector pin-out

| Pin number | Pin name/function |
|------------|-----------------------|
| 1 | Not connected |
| 2 | RD – Received data |
| 3 | TD – Transmitted data |
| 4 | Not connected |
| 5 | SG – Signal ground |
| 6 | Not connected |
| 7 | Not connected |
| 8 | Not connected |
| 9 | Not connected |

Figure 17. CAN DB9 male connector

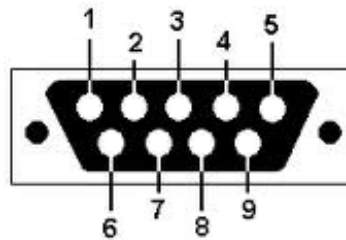
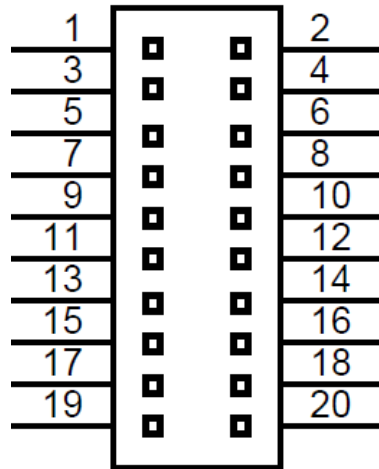


Table 6. CAN connector pin-out

| Pin number | Pin name/function |
|------------|-------------------|
| 1 | Not connected |
| 2 | CAN L |
| 3 | Ground |
| 4 | Not connected |
| 5 | Ground |
| 6 | Ground |
| 7 | CAN H |
| 8 | Not connected |
| 9 | Not connected |

Figure 18. STEVAL-CTM001V2D: JTAG connector (CON14)

Table 7. JTAG connector pin-out

| Pin number | Pin name/Function |
|------------|-------------------|
| 1 | 3.3 V |
| 2 | 3.3 V |
| 3 | JTRST |
| 4 | Ground |
| 5 | JTDI |
| 6 | Ground |
| 7 | JTMS/SWDIO |
| 8 | Ground |
| 9 | JTCK/SWCLK |
| 10 | Ground |
| 11 | Not connected |
| 12 | Ground |
| 13 | JTDO |
| 14 | Ground |
| 15 | JTRST |
| 16 | Ground |
| 17 | Not connected |
| 18 | Ground |
| 19 | Not connected |
| 20 | Ground |

1.3.6 Signal LEDs and push buttons

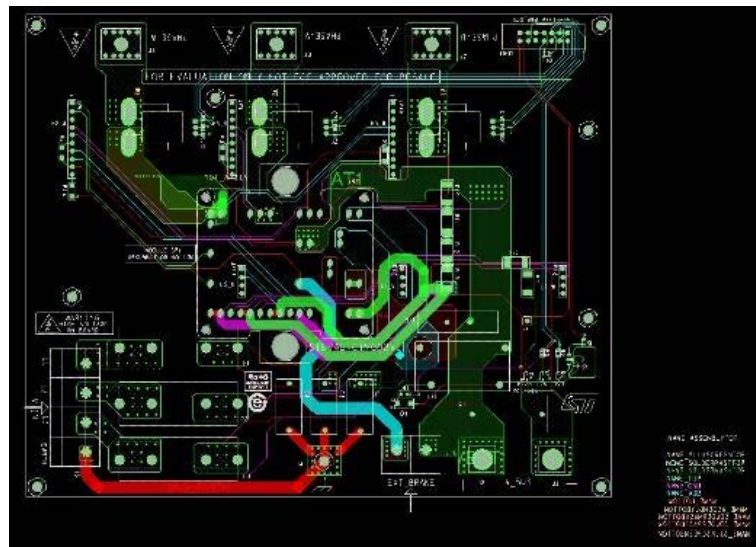
Table 8. LED and button descriptions

| Name | Color | Description | Location |
|-----------------------------|-------|-----------------------------|------------------|
| D2 | RED | 12 V | STEVAL-CTM002V2 |
| D3 | RED | 3V3 | STEVAL-CTM002V2 |
| D4 | RED | DC BUS VOLTAGE | STEVAL-CTM002V2 |
| D5 | RED | DC BUS VOLTAGE | STEVAL-CTM002V2 |
| D14 | GREEN | 3V3_Microcontroller | STEVAL-CTM001V1C |
| D15 | GREEN | 3V3 | STEVAL-CTM001V1C |
| D18 | RED | 12 V | STEVAL-CTM001V2D |
| D19 | RED | 3V3 | STEVAL-CTM001V2D |
| D20 | RED | 5 V | STEVAL-CTM001V2D |
| D23 | GREEN | INT_SENSE | STEVAL-CTM001V2D |
| D24 | GREEN | EXT_SENSE | STEVAL-CTM001V2D |
| D31-D42-D53-D64-D75-D86-D97 | RED | IN_/DIAG | STEVAL-CTM001V2D |
| D32-D43-D54-D65-D76-D87-D98 | RED | DIAG | STEVAL-CTM001V2D |
| SW6 | | STM32 microcontroller reset | STEVAL-CTM001V1C |
| SW7 | | User push-button | STEVAL-CTM001V1C |

2 PCB layout

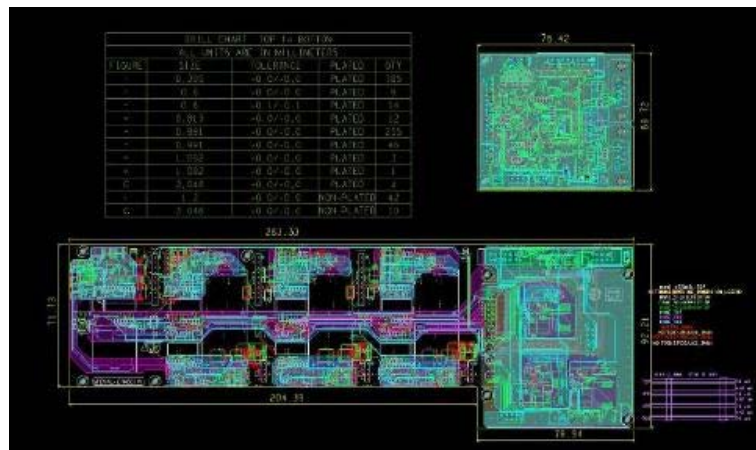
The STEVAL-CTM001V2D and STEVAL-CTM002V2 evaluation boards have different technical characteristics. The STEVAL-CTM002V2 evaluation board is the power section consisting of 2 layers with a PCB thickness of 1.6 mm and a copper thickness of 100 µm. This composition allows better management of the power module high current capability and thermal behavior.

Figure 19. STEVAL-CTM002V2 layout



The STEVAL-CTM001V1C and STEVAL-CTM001V2D have common characteristics: 4 layers with PCB thickness of 1.6 mm and copper thickness of 35 µm.

Figure 20. STEVAL-CTM001V2D layout



3 Schematic diagrams

Figure 21. STEVAL-CTM001V1C schematic circuit (1 of 5)

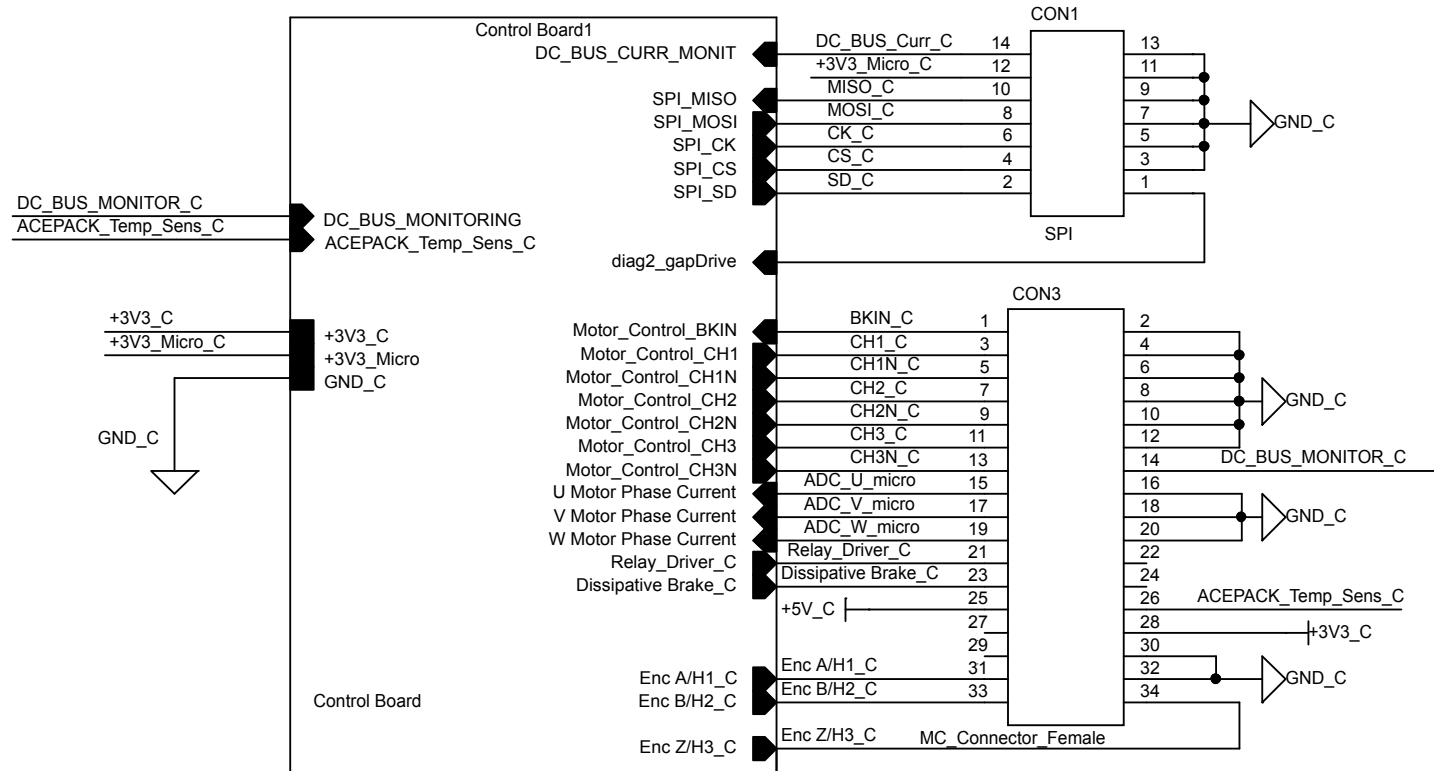


Figure 22. STEVAL-CTM001V1C schematic circuit (2 of 5)

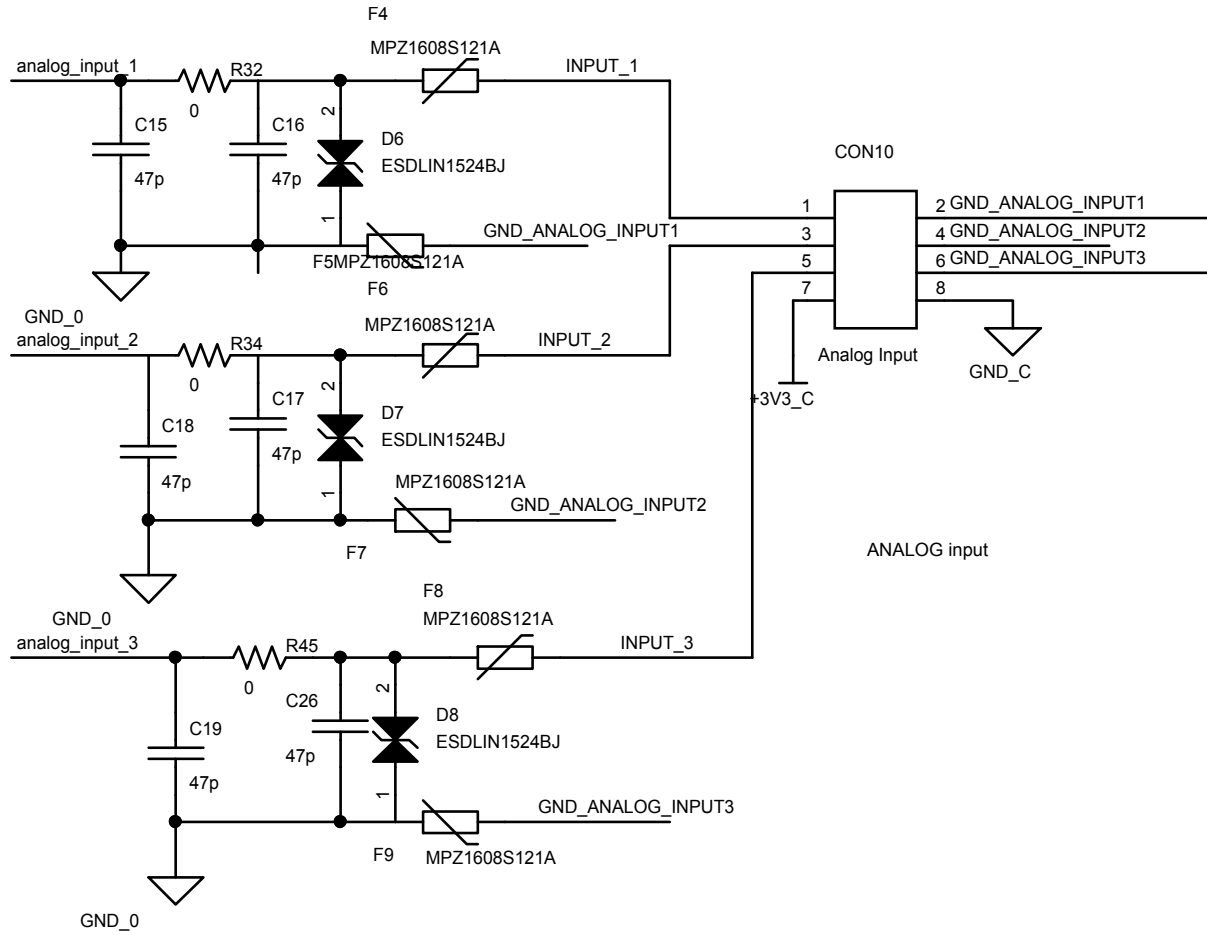


Figure 23. STEVAL-CTM001V1C schematic circuit (3 of 5)

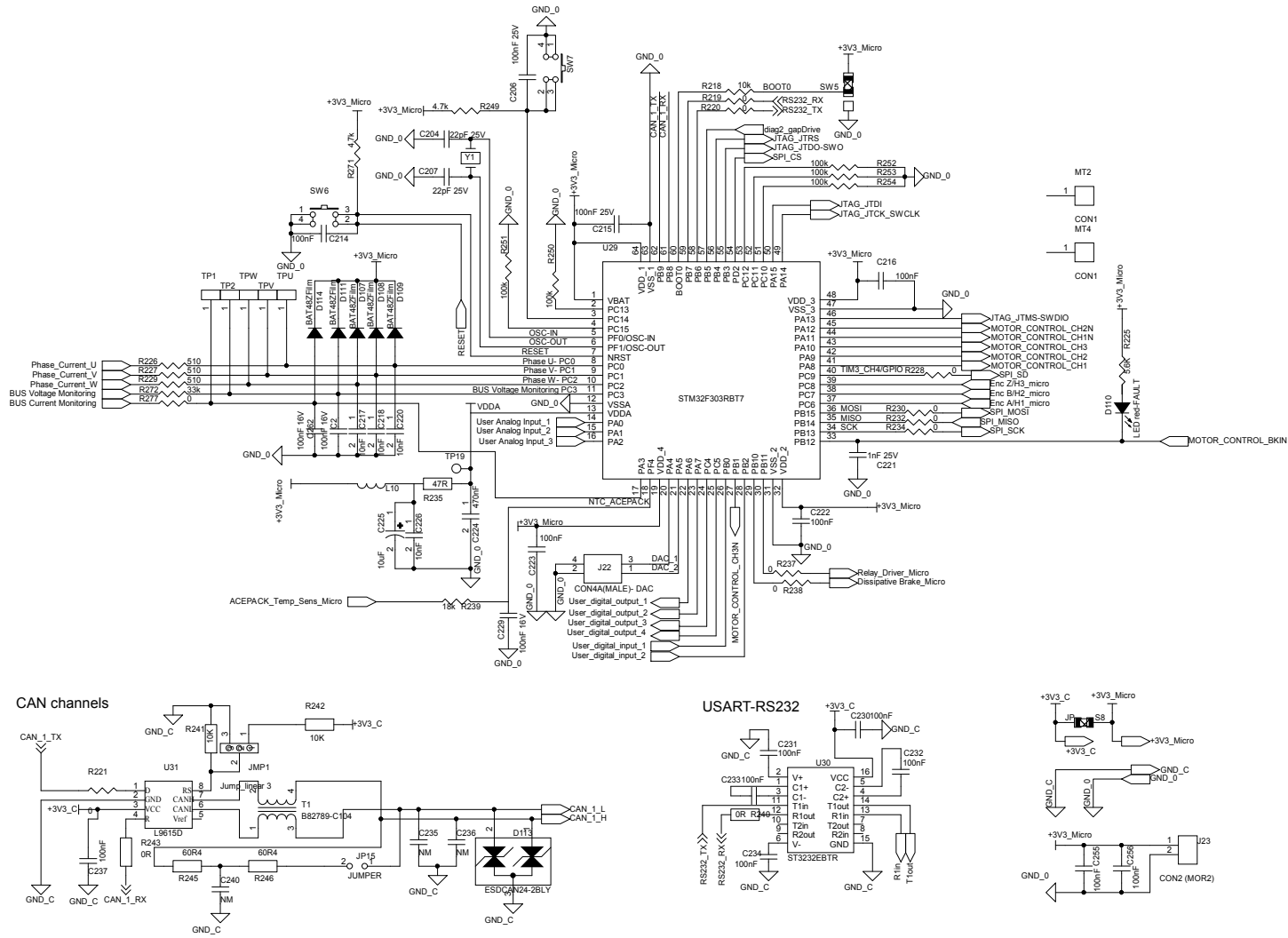


Figure 24. STEVAL-CTM001V1C schematic circuit (4 of 5)

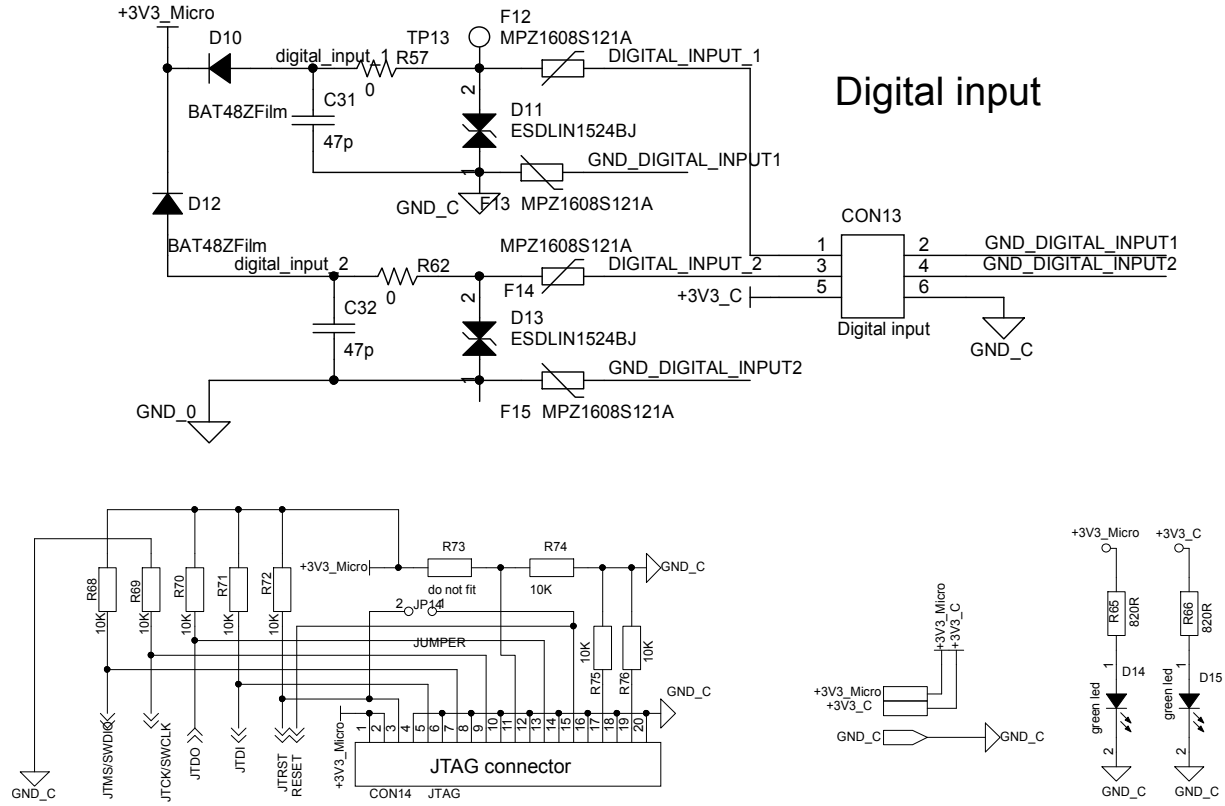


Figure 25. STEVAL-CTM001V1C schematic circuit (5 of 5)

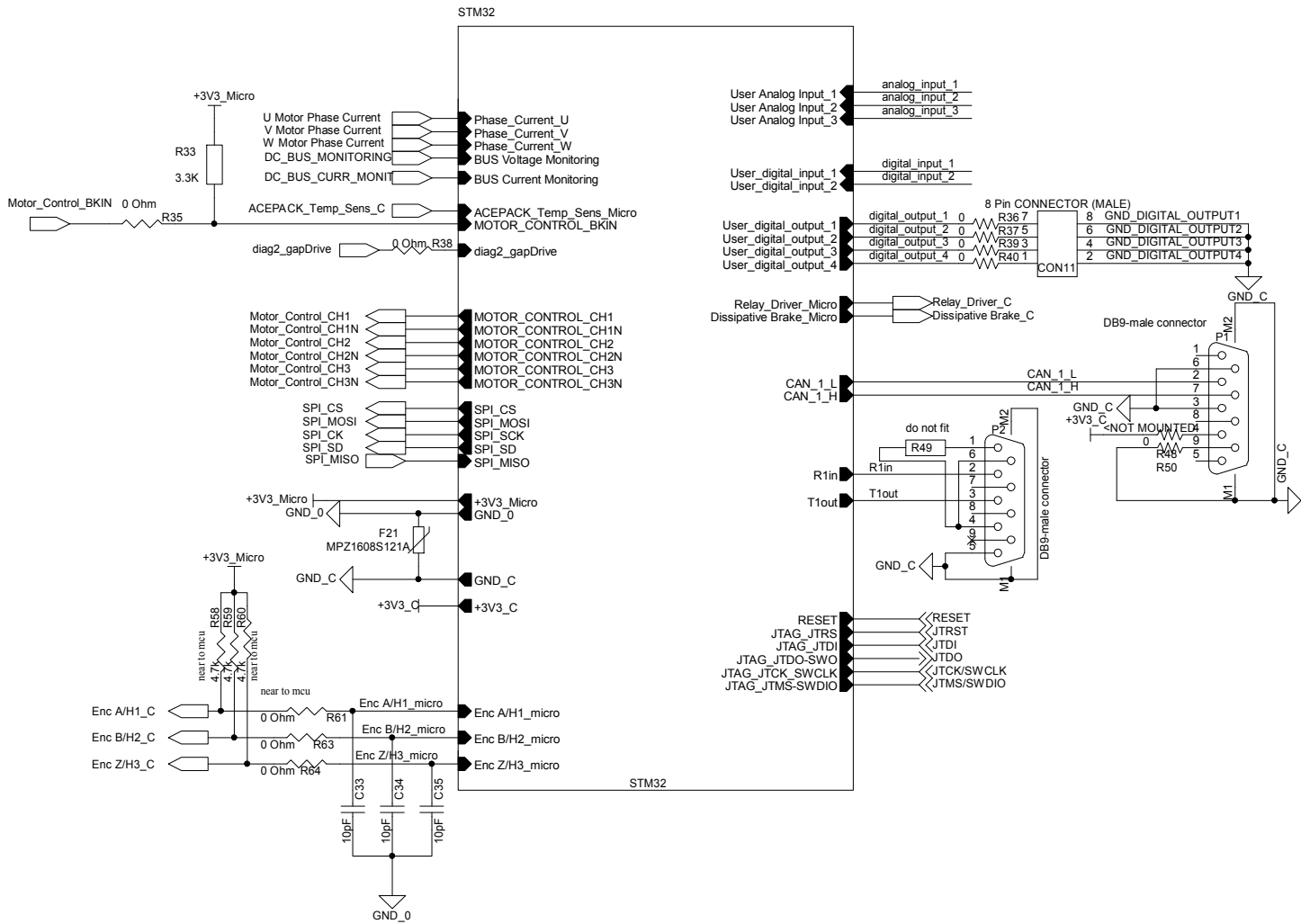


Figure 26. STEVAL-CTM002V2 schematic circuit (1 of 3)

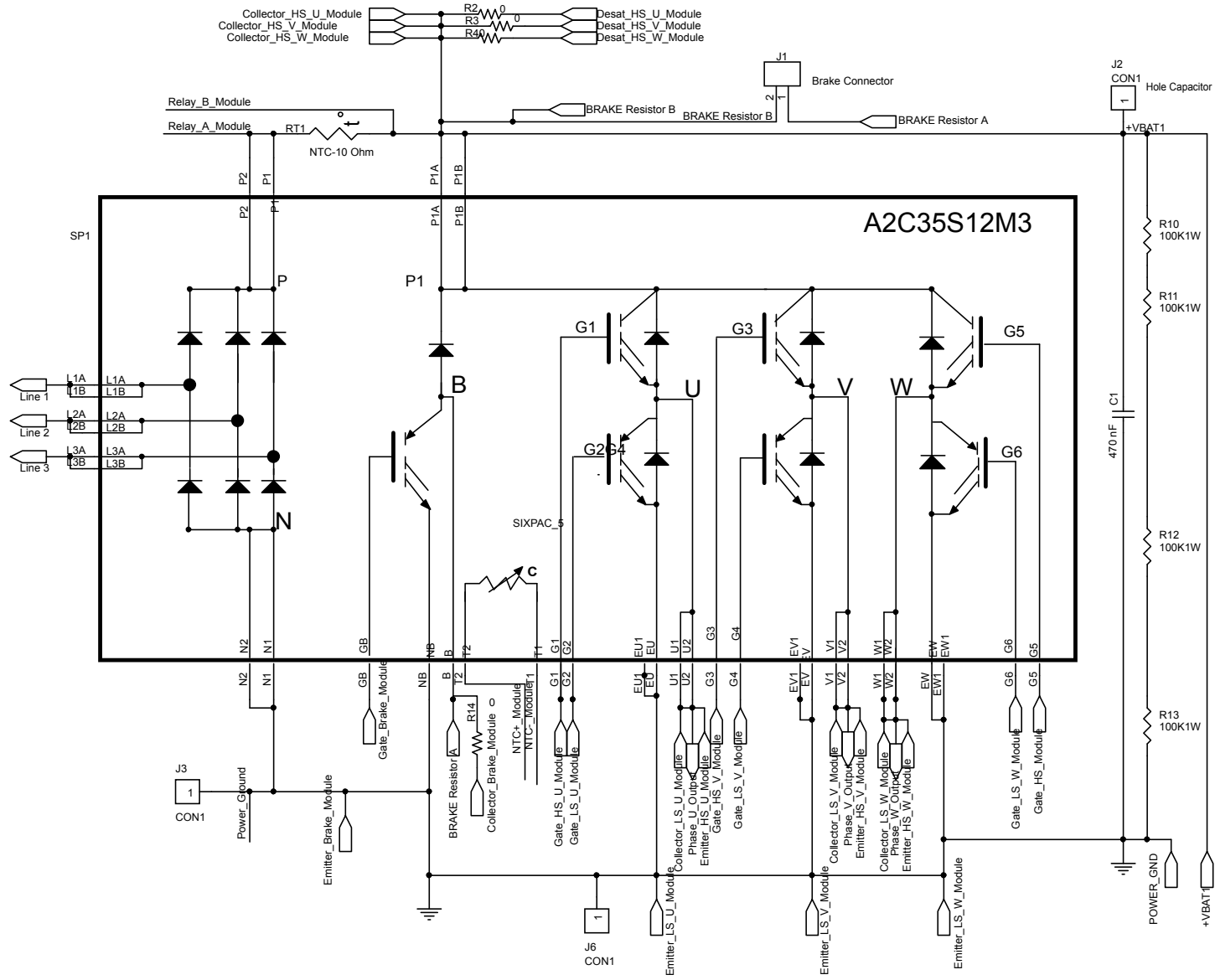


Figure 27. STEVAL-CTM002V2 schematic circuit (2 of 3)

CONNECTORS: POWER BOARD SIDE

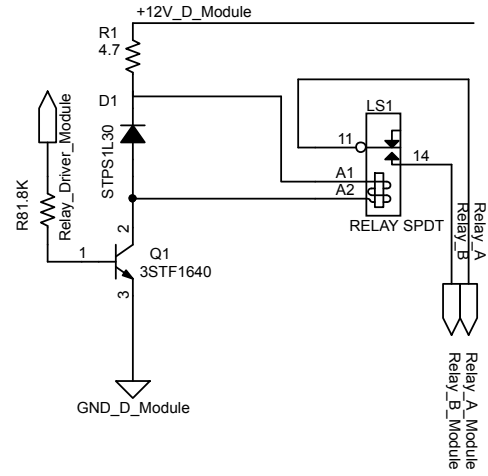
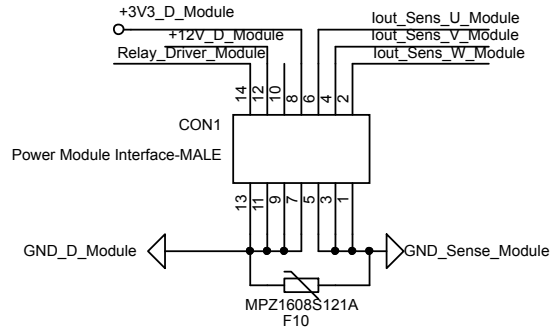
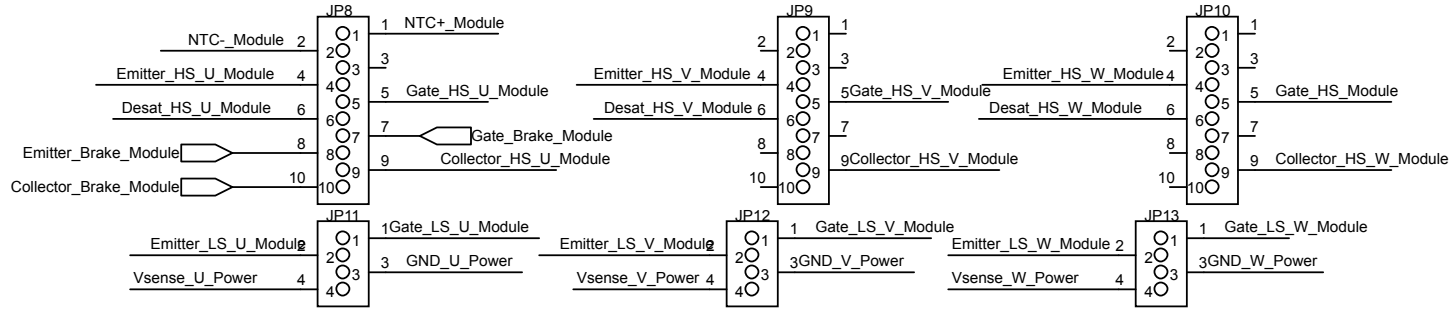


Figure 28. STEVAL-CTM002V2 schematic circuit (3 of 3)

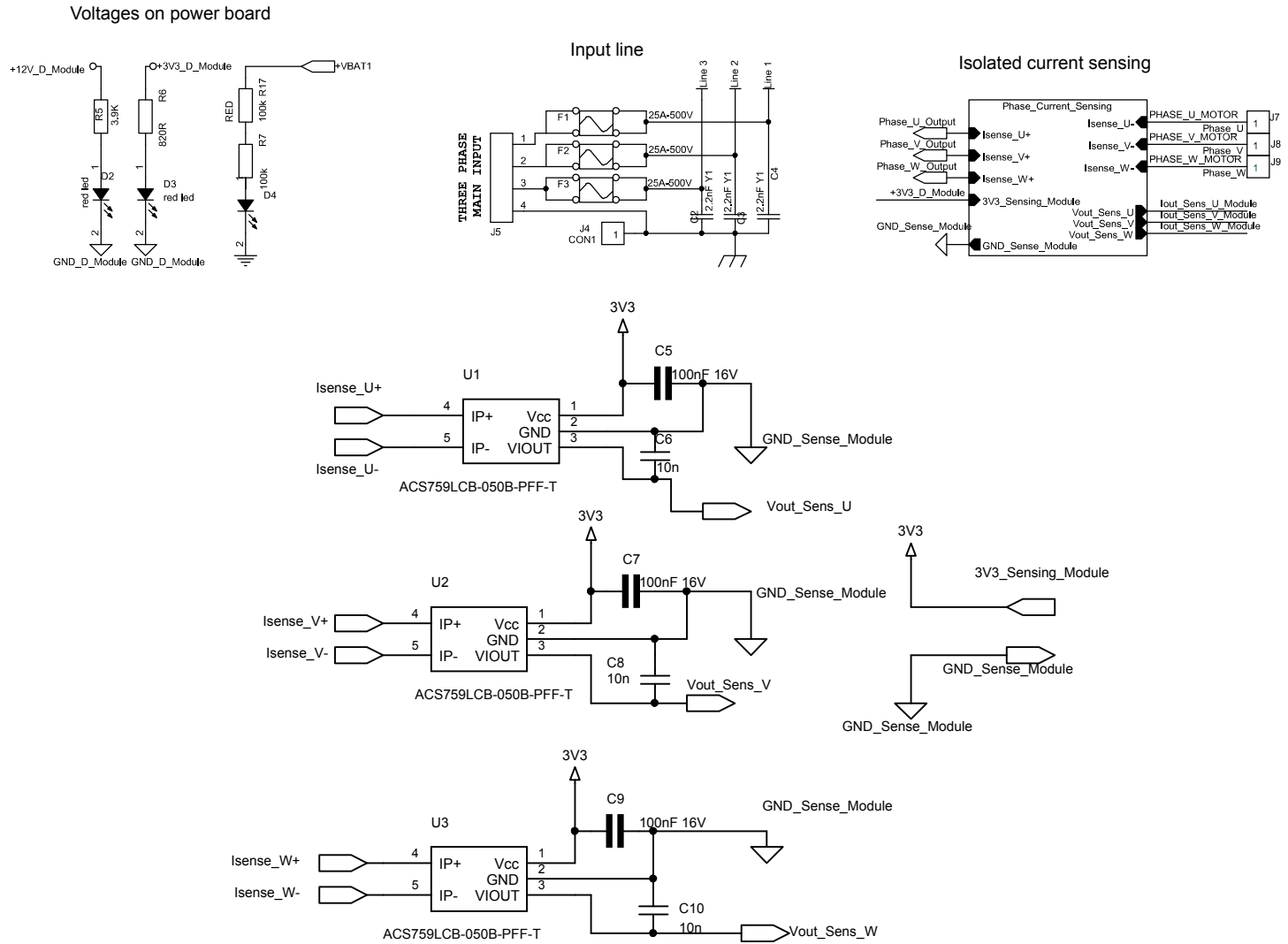
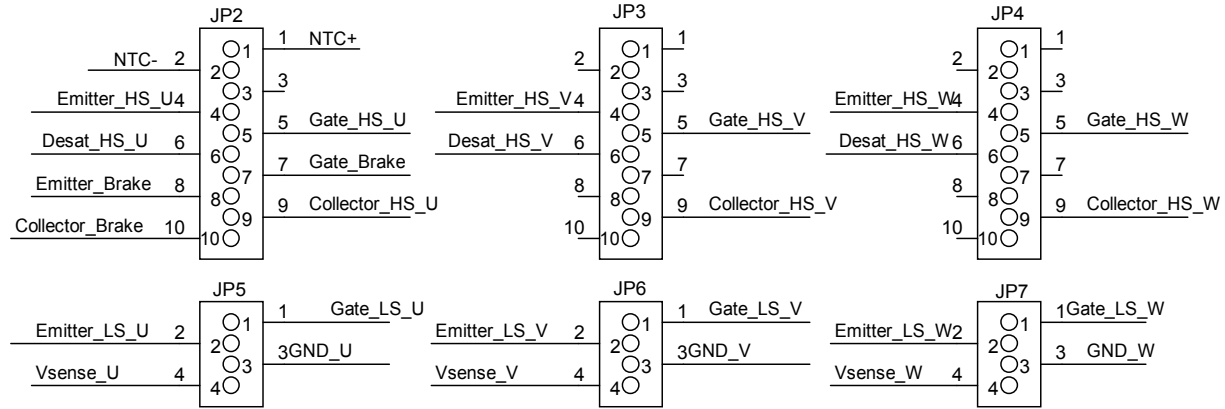


Figure 29. STEVAL-CTM001V2D schematic circuit (1 of 14)



Power Connectors: Driver Board Side

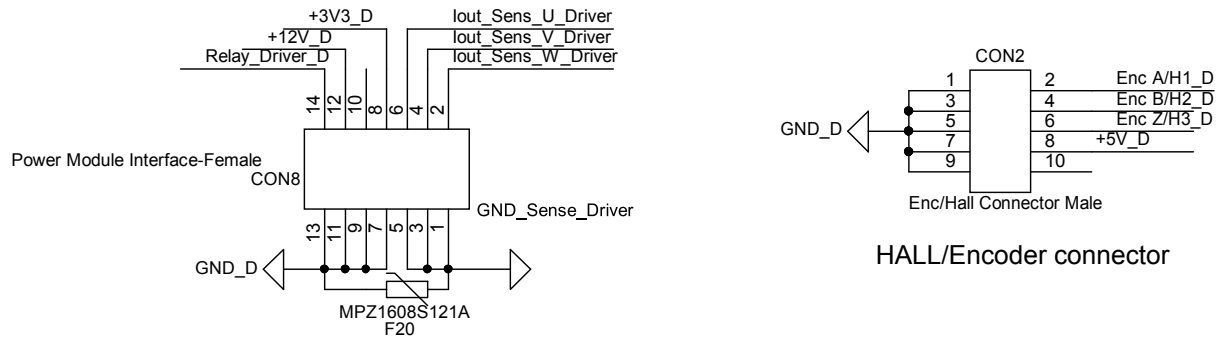


Figure 30. STEVAL-CTM001V2D schematic circuit (2 of 14)

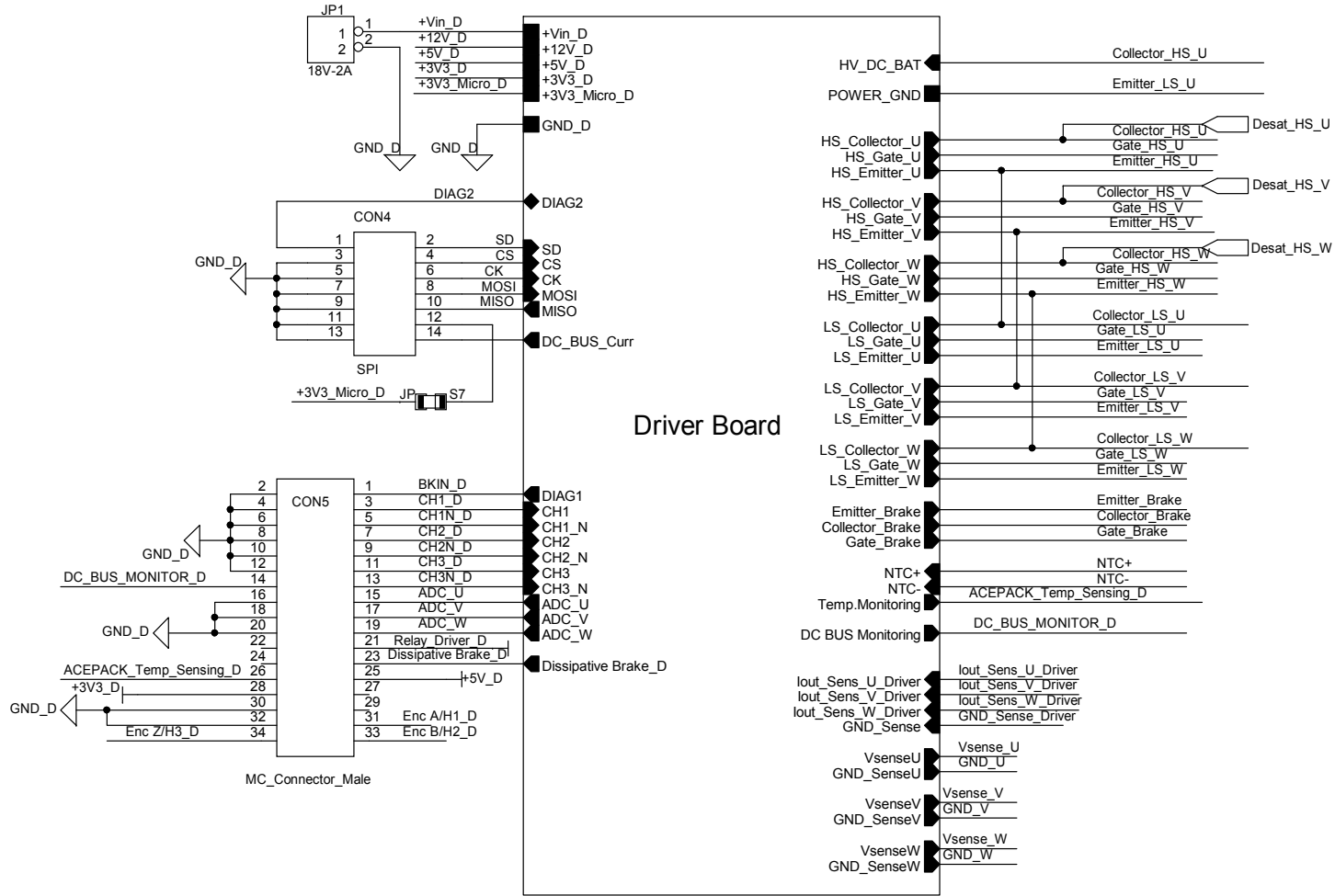


Figure 31. STEVAL-CTM001V2D schematic circuit (3 of 14)

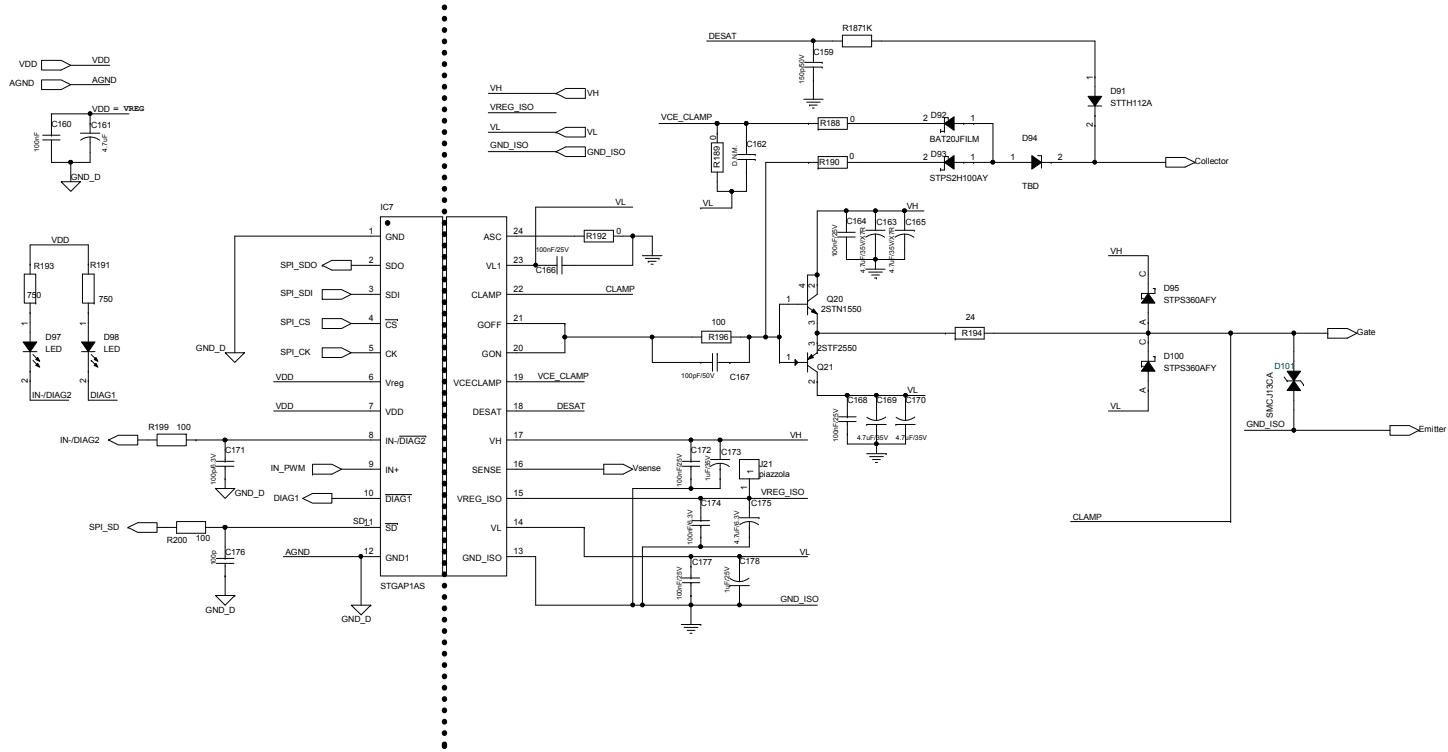


Figure 32. STEVAL-CTM001V2D schematic circuit (4 of 14)

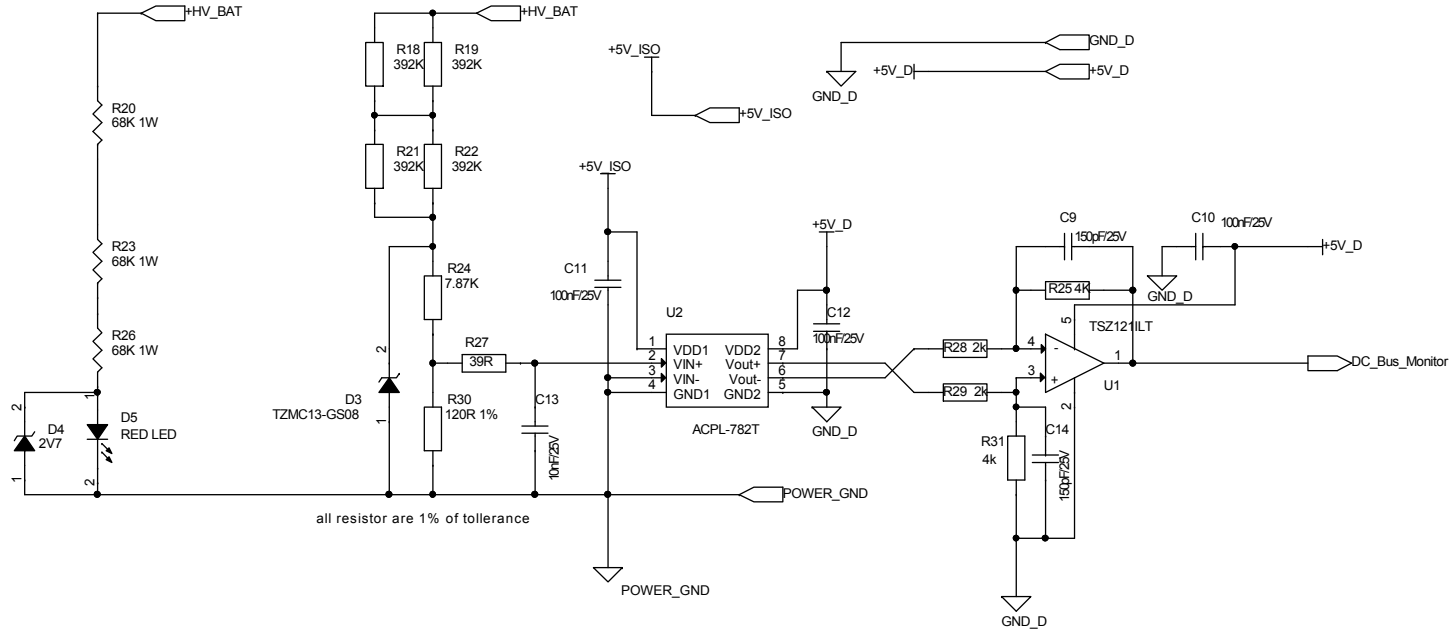
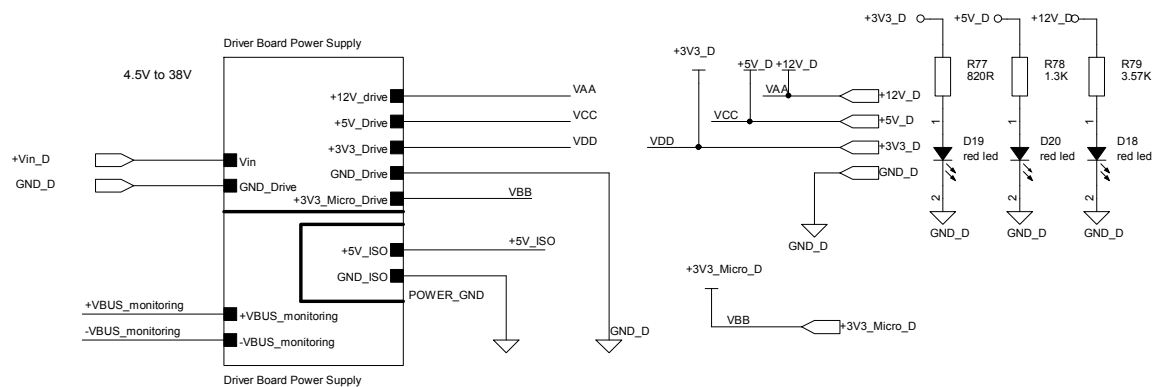
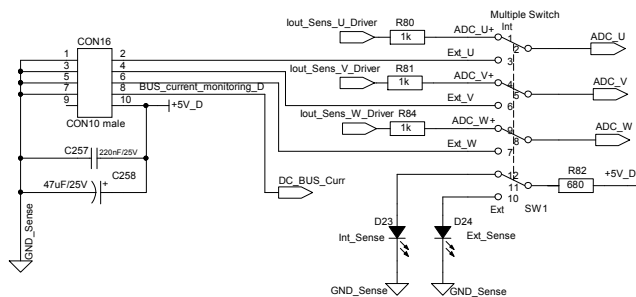


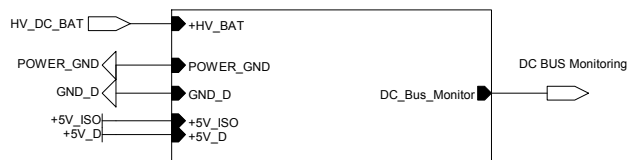
Figure 33. STEVAL-CTM001V2D circuit schematic (5 of 14)



External sensing connector



Bus Voltage Monitoring



NTC

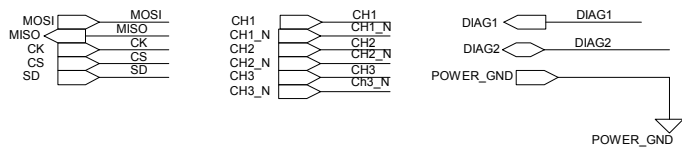
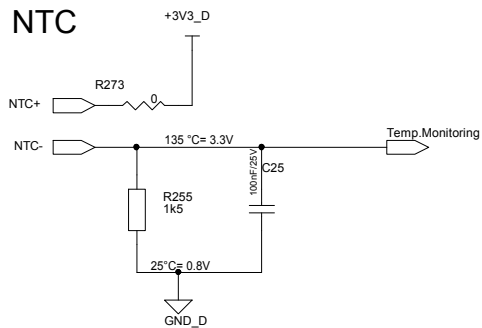


Figure 34. STEVAL-CTM001V2D circuit schematic (6 of 14)

DC-DC Isolated for Driving Section

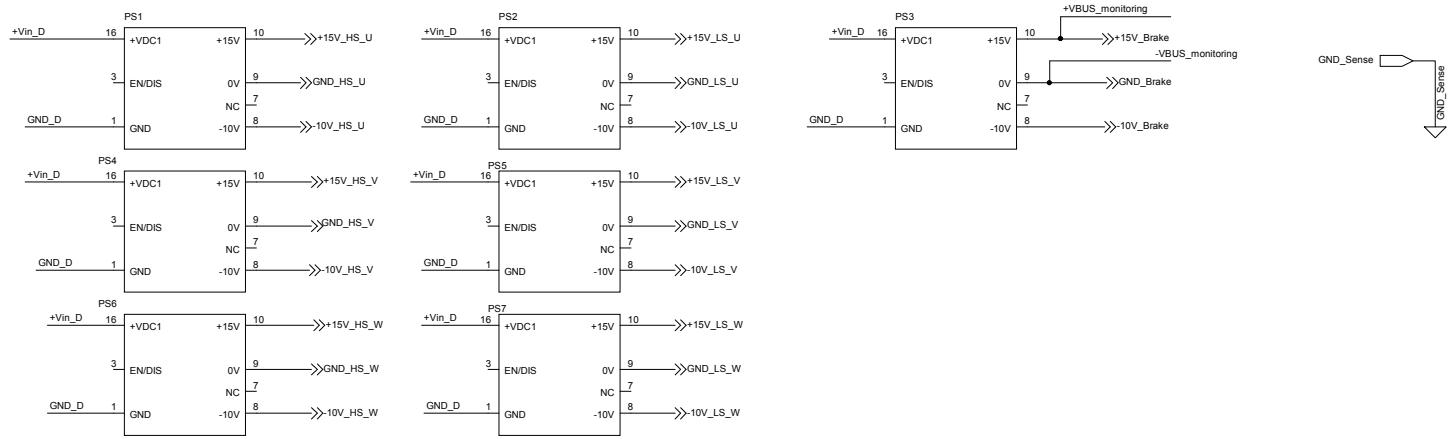


Figure 35. STEVAL-CTM001V2D circuit schematic (7 of 14)

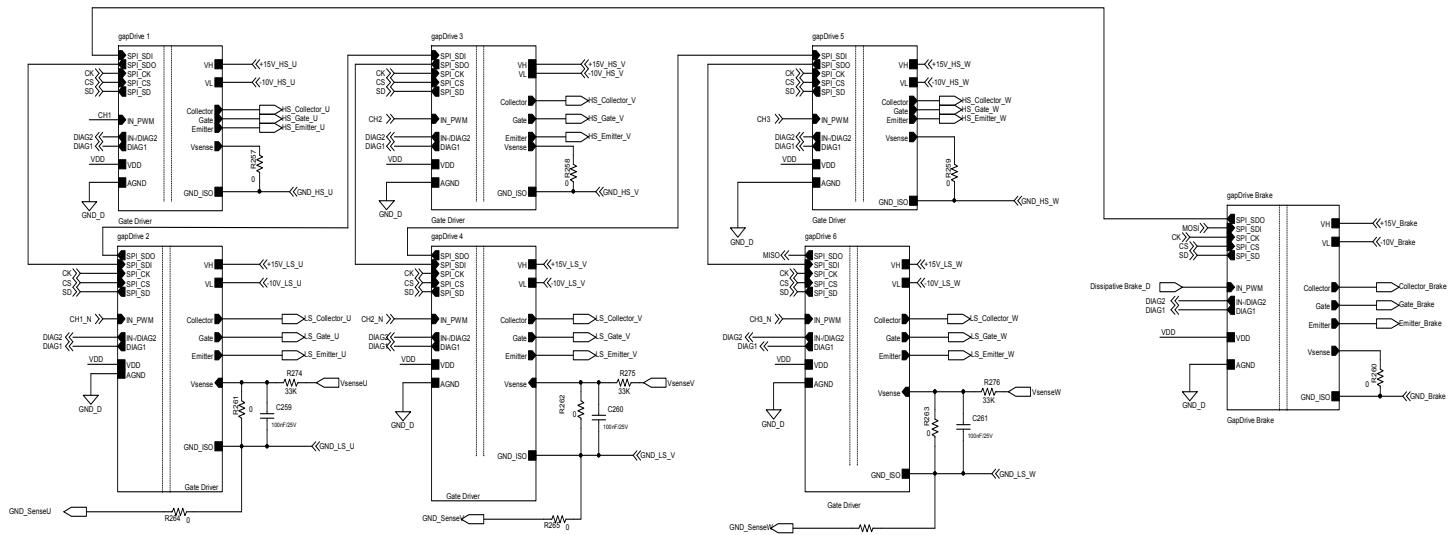


Figure 36. STEVAL-CTM001V2D circuit schematic (8 of 14)

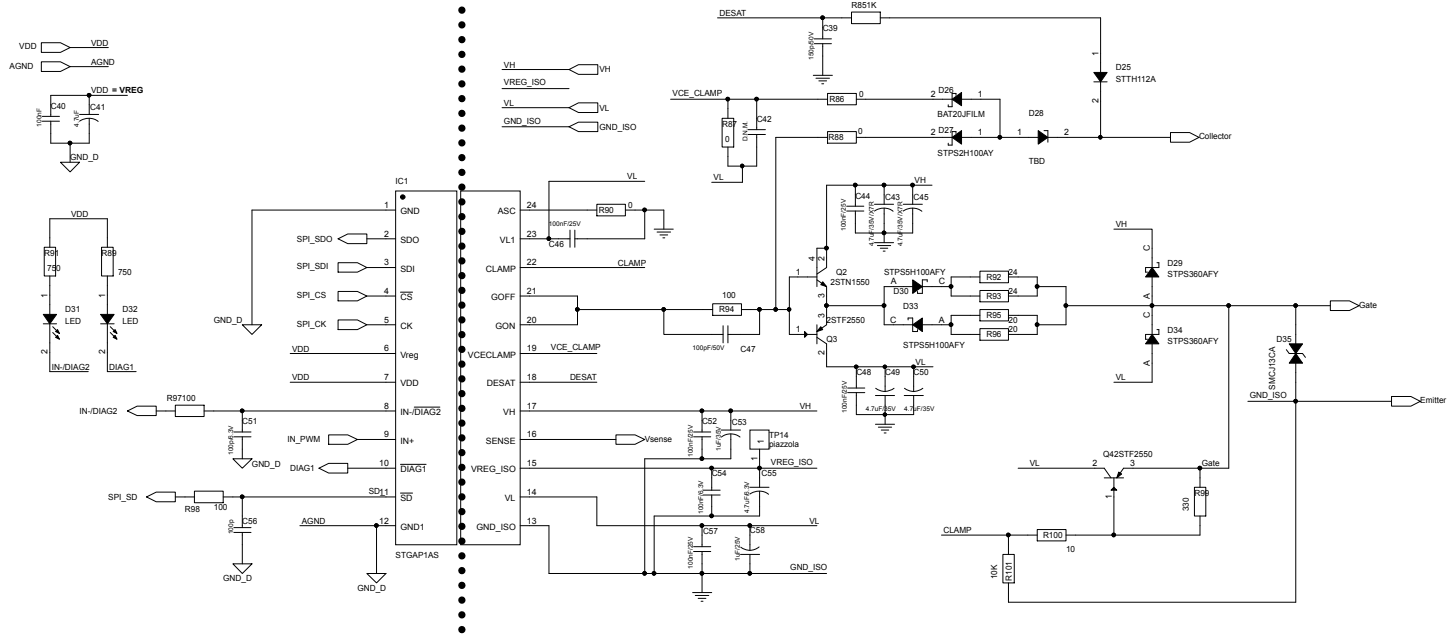


Figure 37. STEVAL-CTM001V2D circuit schematic (9 of 14)

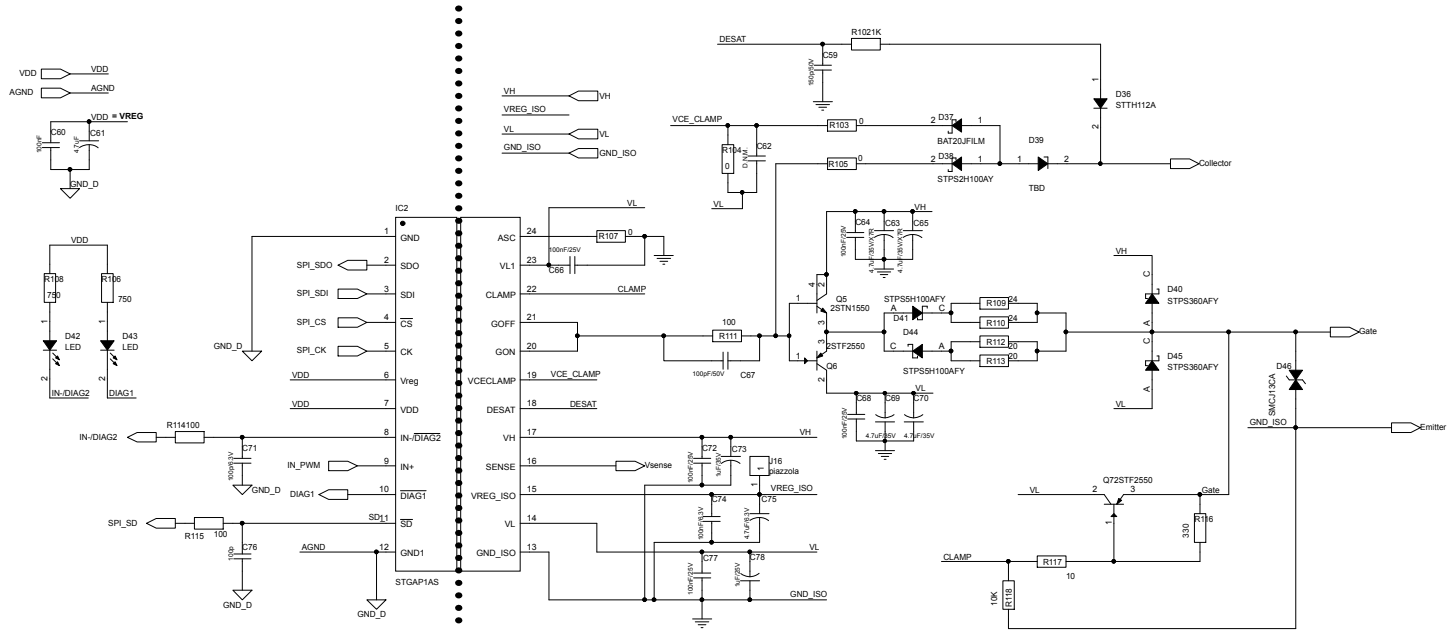


Figure 38. STEVAL-CTM001V2D circuit schematic (10 of 14)

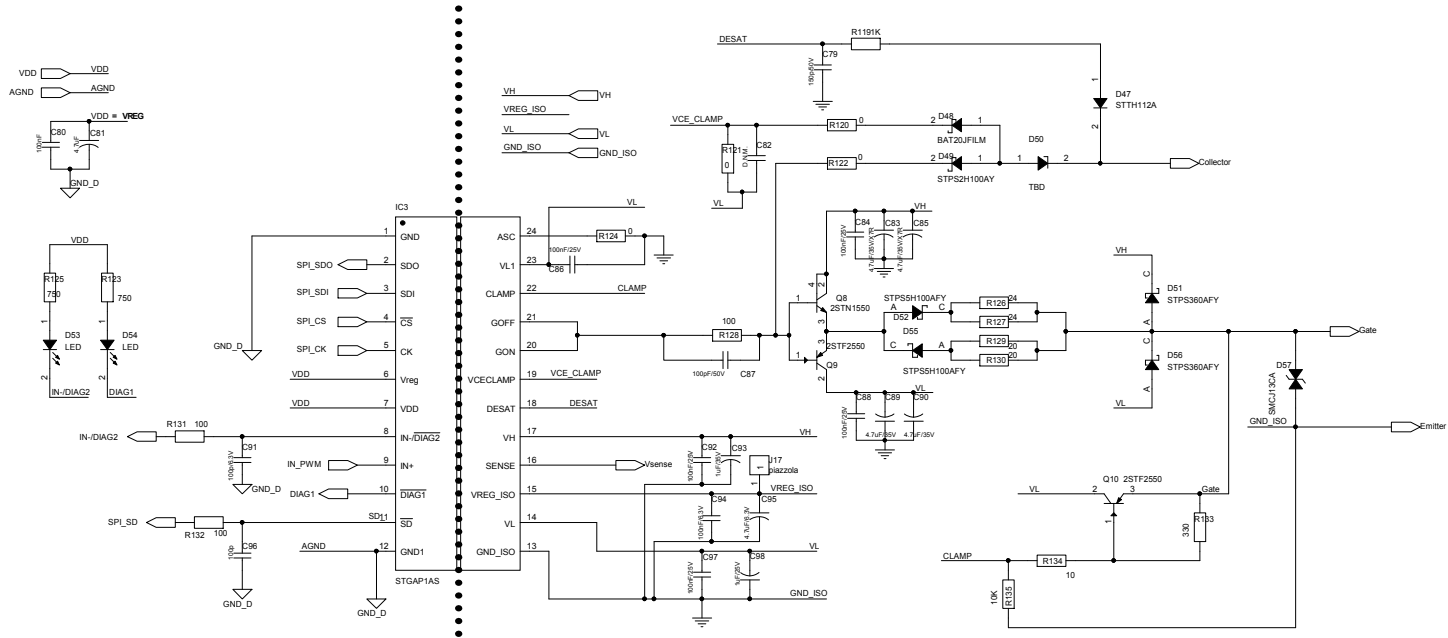


Figure 39. STEVAL-CTM001V2D circuit schematic (11 of 14)

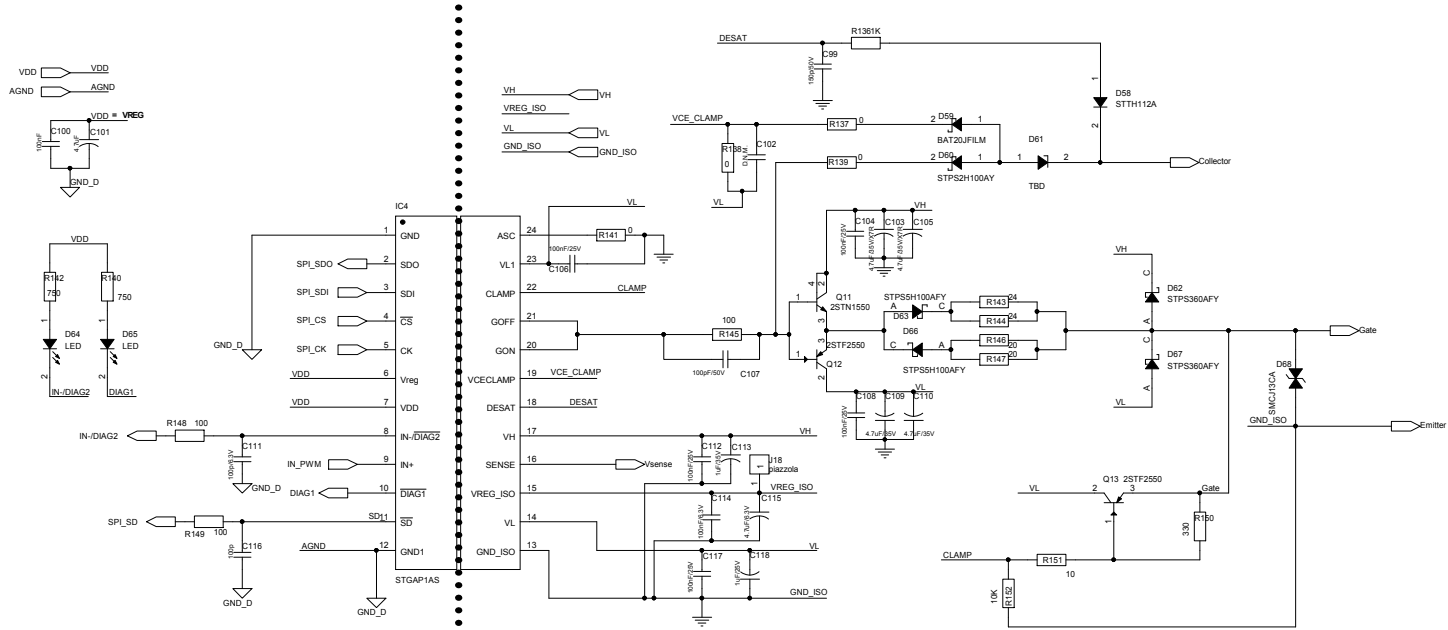


Figure 40. STEVAL-CTM001V2D circuit schematic (12 of 14)

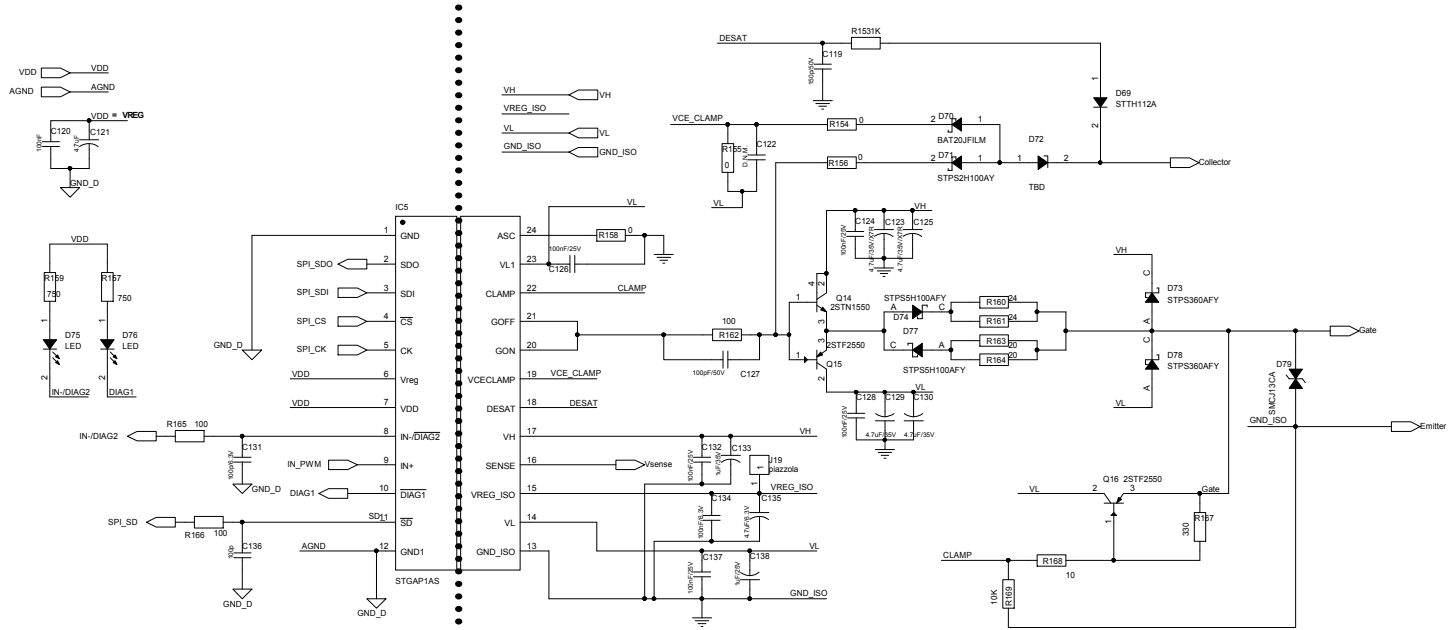


Figure 41. STEVAL-CTM001V2D circuit schematic (13 of 14)

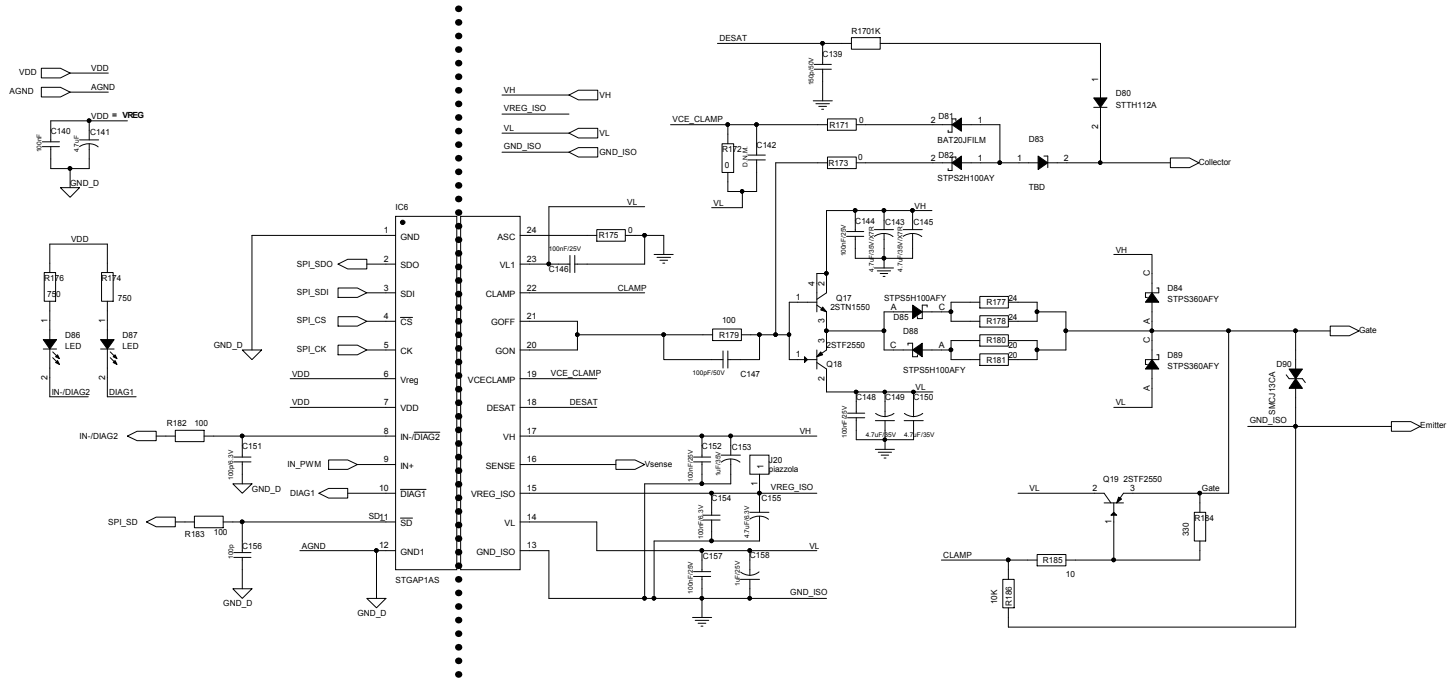
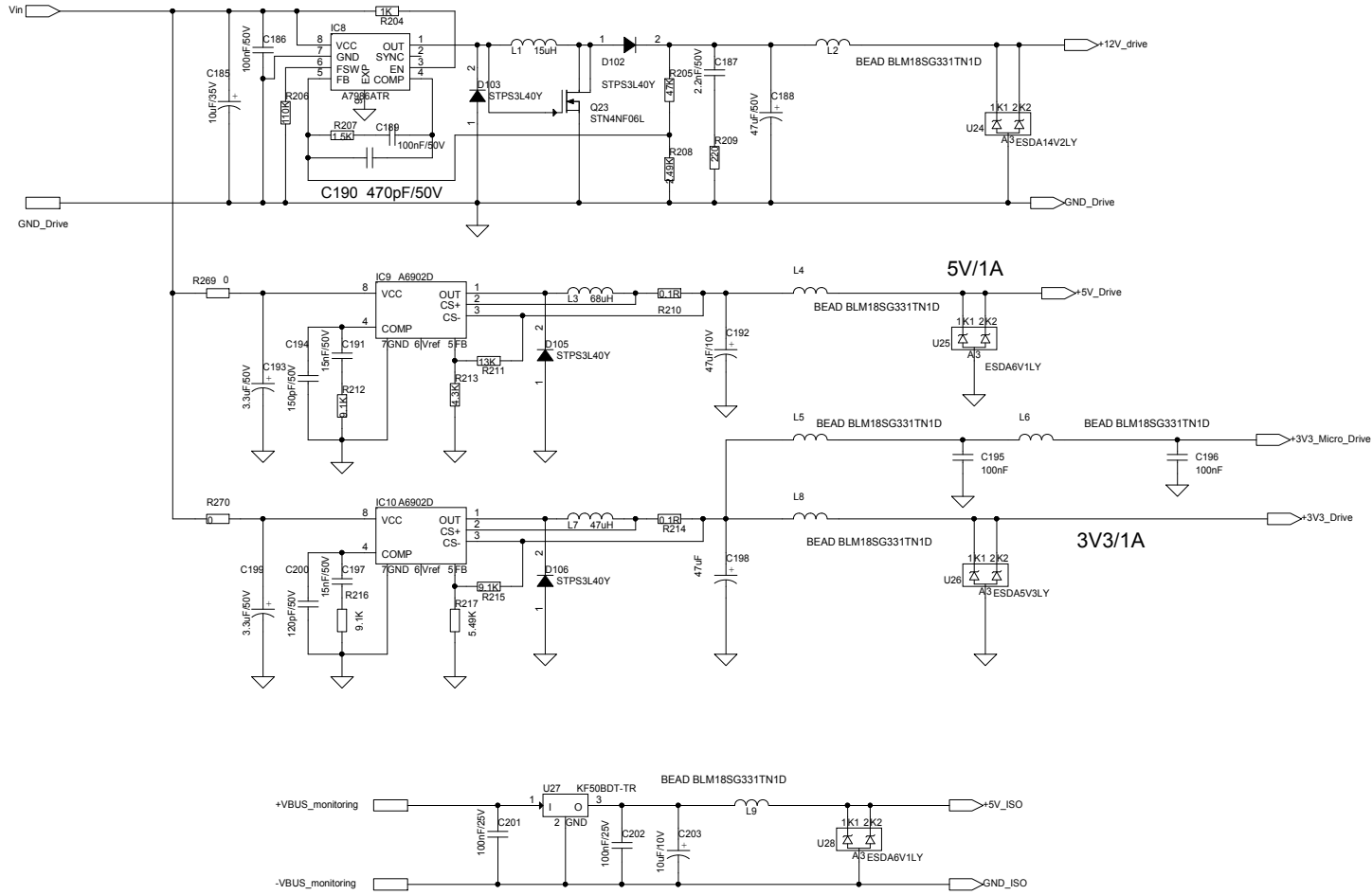


Figure 42. STEVAL-CTM001V2D circuit schematic (14 of 14)



4 Bill of material

Table 9. STEVAL-HKI001V2 bill of materials

| Item | Q.ty | Ref. | Part/Value | Description | Manufacturer | Order code |
|------|------|----------|------------------|---------------|--------------|---------------------------------|
| 1 | 1 | Table 10 | STEVAL-CTM001V1C | Control board | ST | Not available for separate sale |
| 2 | 1 | Table 11 | STEVAL-CTM002V2 | Power stage | ST | Not available for separate sale |
| 3 | 1 | Table 12 | STEVAL-CTM001V2D | Driving board | ST | Not available for separate sale |

Table 10. STEVAL-CTM001V1C bill of materials

| Item | Q.ty | Reference | Part / Value | Description | Manufacturer | Order code |
|------|------|--|-------------------------------|---|----------------------------|----------------------|
| 1 | 1 | CON1 | blkcon100vhtm2oew20014 | SPI connector | Sullins Connector Solution | SFH11-PBPC-D07-ST-BK |
| 2 | 1 | CON2 | blkcon100vhtm2oew20010 | Enc/Hall connector | Any | Any |
| 3 | 1 | CON3 | blkcon100vhtm2oew20034 | MC SPI connector | Sullins Connector Solution | SFH11-PBPC-D17-ST-BK |
| 4 | 1 | CON5 | walcon100vhtm2oew32534 | MC Connector | Sullins Connector Solution | SBH11-PBPC-D17-ST-BK |
| 5 | 2 | CON4, CON8 | walcon100vhtm2oew32514 | SPI-Power module interface | Sullins Connector Solution | SBH11-PBPC-D07-ST-BK |
| 6 | 2 | CON10, CON11 | blkcon100vhtm2oew2008 | Analog input-digital output-ext encoder | Any | Any |
| 7 | 1 | CON13 | blkcon100vhtm2oew2006 | Digital input | Any | Any |
| 8 | 1 | CON14 | walcon100vhtm2oew32520 | JTAG connector | Sullins Connector Solution | SBH11-PBPC-D10-ST-BK |
| 9 | 1 | CON16 | | Connector | Sullins Connector Solution | SBH11-PBPC-D05-ST-BK |
| 10 | 80 | C2, C10, C11, C12, C25, C40, C44, C46, C48, C52, C54, C57, C60, C64, C66, C68, C72, C74, C77, C80, C84, C86, C88, C92, C94, C97, C100, C104, C106, C108, C112, C114, C117, C120, C124, C126, C128, C132, C134, C137, C140, C144, C146, C148, C152, C154, C157, C160, C164, | 100 nF 50 V ±10% SMC 0603 X7R | Capacitors | Any | Any |

| Item | Q.ty | Reference | Part / Value | Description | Manufacturer | Order code |
|------|------|--|-------------------------------|----------------------------|-----------------|----------------------|
| | | C166, C168, C172, C174, C177, C186, C195, C196, C201, C202, C206, C214, C215, C216, C222, C223, C229, C230, C231, C232, C233, C234, C237, C255, C256, C259, C260, C261, C262 | | | | |
| 11 | 10 | C9, C14, C39, C59, C79, C99, C119, C139, C159, C194 | 150 pF 50 V ±10% SMC 0603 X7R | Capacitors | Any | Any |
| 12 | 2 | C13, C226 | 10 nF 50 V ±10% SMC 0603 X7R | Capacitors | Any | Any |
| 13 | 8 | C15, C16, C17, C18, C19, C26, C31, C32 | 47 pF 50 V ±10% SMC 0603 X7R | Capacitors | Any | Any |
| 14 | 3 | C33, C34, C35 | 10 pF 50 V ±10% SMC 0603 X7R | Capacitors (not assembled) | Any | Any |
| 15 | 14 | C41, C55, C61, C75, C81, C95, C101, C115, C121, C135, C141, C155, C161, C175 | 4.7 μF 25 V ±10% SMC 0603 X5R | X5R | Samsung Electro | CL10A475KA8NQNC |
| 16 | 13 | C42, C62, C82, C102, C217, C218, C220, C122, C235, C236, C240, C142, C162 | SMC 0603 | Capacitors (not assembled) | | |
| 17 | 28 | C43, C45, C49, C50, C63, C65, C69, C70, C83, C85, C89, C90, C103, C105, C109, C110, C123, C125, C129, C130, C143, C145, C149, C150, C163, C165, C169, C170 | 4.7 μF 35 V ±10% SMC 0805 X7R | Capacitors | TDK | CGA4J3X5R1H475K125AB |
| 18 | 21 | C47, C51, C56, C67, C71, C76, C87, C91, C96, C107, C111, C116, C127, C131, C136, C147, C151, C156, C167, C171, C176 | 100 pF 50 V ±10% SMC 0603 X7R | Capacitors | Any | Any |

| Item | Q.ty | Reference | Part / Value | Description | Manufacturer | Order code |
|------|------|--|--|---|--------------|------------------------------|
| 19 | 14 | C53, C58, C73, C78, C93, C98, C113, C118, C133, C138, C153, C158, C173, C178 | 1 µF 50 V ±10% SMC 0603 X7R | Capacitors | Any | Any |
| 20 | 1 | C185 | 10 µF 35 V ±10% tantalioc | Capacitor | Kemet | T491C106K035AT |
| 21 | 1 | C187 | 2.2 nF 50 V ±10% SMC 0603 X7R | Capacitor | Any | Any |
| 22 | 2 | C188, C258 | 47 µF 25 V ±10% tantaliode | Capacitors | Kemet | T491D476K025AT |
| 23 | 1 | C190 | 470 pF 50 V ±10% SMC 0603 X7R | Capacitors | Any | Any |
| 24 | 2 | C191, C197 | 15 nF 50 V ±10% SMC 0603 X7R | Capacitors | Any | Any |
| 25 | 2 | C192, C198 | 47 µF 16 V ±10% tantalioc | Capacitors | AVX | TPSC476K016R0110 |
| 26 | 2 | C193, C199 | 3.3 µF 50 V ±10% tantalioc | Capacitors | AVX | TAJC335K050R |
| 27 | 1 | C200 | 120 pF 50 V ±5% SMC 0603 | Capacitors | Any | Any |
| 28 | 2 | C203, C225, | 10 µF 10 V ±10% tantaliob | Capacitors | AVX | TAJB106K010RNJ |
| 29 | 2 | C204, C207 | 22 pF 50 V ±5% SMC 0603 C0G | Capacitors | Any | Any |
| 30 | 1 | C221 | 1 nF 50 V ±10% SMC 0603 X7R | Capacitor | Any | Any |
| 31 | 1 | C224 | 470 nF 50 V ±10% SMC 0603 X7R | Capacitor | Any | Any |
| 32 | 1 | C257 | 220 nF 25 V ±10% SMC 0603 X7R | Capacitor | Any | Any |
| 33 | 18 | D5, D18, D19, D20, D31, D32, D42, D43, D53, D54, D64, D65, D75, D76, D86, D87, D97, D98, 110 | SMD SMR0603 | Red LEDs | Osram Opto | LR Q396 |
| 34 | 1 | D3 | TZMC13-GS08 13 V/0.5 W ±5% smdo213ac21 | Zener diode | Vishay | TZMC13-GS08 |
| 35 | 1 | D4 | TZMB2V7-GS08 2.7 V/0.5 W ±2% smdo213ac21 | Zener diode | Vishay | TZMB2V7-GS08 |
| 36 | 5 | D6, D7, D8, D11, D13 | ESDLIN1524BJ SOD323f | Transil™, transient voltage surge suppressor diode for ESD protection | ST | ESDLIN1524BJ |
| 37 | 7 | D10, D12, D107, D108, D109, D111, D114 | BAT48ZFilm SOD123 | 40 V, 350 mA axial general purpose signal Schottky diode | ST | BAT48ZFILM |
| 38 | 4 | D14, D15, D23, D24 | SMD 0603 | Green LEDs | Osram Opto | LT Q39G-Q1S2-25-1 |
| 39 | 7 | D25, D36, D47, D58, D69, D80, D91 | STTH112A SMA | 1200 V, 1 A ultrafast Diode | ST | STTH112A |

| Item | Q.ty | Reference | Part / Value | Description | Manufacturer | Order code |
|------|------|---|---|--|-----------------|-------------------------------|
| 40 | 7 | D26, D37, D48, D59, D70, D81, D92 | BAT20JFILM SOD323f | 23 V, 1 A general purpose signal Schottky diode | ST | BAT20JFILM |
| 41 | 7 | D27, D38, D49, D60, D71, D82, D93 | STPS2H100AY 100 V/2 A SMA | 100 V, 2 A SMA SMB automotive power Schottky rectifier | ST | STPS2H100AY |
| 42 | 7 | D28, D39, D50, D61, D72, D83, D94 | SMB | Diode (not assembled) | ST | |
| 43 | 18 | D29, D34, D40, D45, D51, D56, D62, D67, D73, D78, D84, D89, D95, D100, D102, D103, D105, D106 | STPS3L40SY 40 V/3 A SMC | 40 V, 3 A automotive low drop power Schottky rectifier | ST | STPS3L40SY |
| 44 | 12 | D30, D33, D41, D44, D52, D55, D63, D66, D74, D77, D85, D88 | STPS5L60Y 60 V/5 A SMC | 60 V, 5 A SMC automotive low drop power Schottky rectifier | ST | STPS5L60-Y |
| 45 | 7 | D35, D46, D57, D68, D79, D90, D101 | SMCJ13CA SMDO214AB21 | 1500 W, TVS in SMC | ST | SMCJ13CA |
| 46 | 1 | D113 | ESDCAN24-2BLY smsot23123 | Automotive dual-line TVS in SOT23-3L for CAN bus (12 V system) | ST | ESDCAN24-2BLY |
| 47 | 12 | F4, F5, F6, F7, F8, F9, F12, F13, F14, F15, F20, F21 | MPZ1608S121A sml0603 | Filters | Wurth | 742 792 625 |
| | | | | | TDK | MPZ1608S121A |
| 48 | 7 | IC1, IC2, IC3, IC4, IC5, IC6, IC7 | STGAP1S sog05024wg425l650 | Automotive galvanically isolated single gate driver | ST | STGAP1S |
| 49 | 1 | IC8 | A7986ATR sog0508wg244l200exposure | 3 A step-down switching regulator for automotive applications | ST | A7986ATR |
| 50 | 2 | IC9, IC10 | A6902D sog0508wg244l200 | Up to 1 A switch step down regulator with adjustable current limit for automotive applications | ST | A6902D |
| 51 | 1 | JMP1 | Strip line male 1X3 pitch 2.54 mm siptm3003 | Jumper | Any | Any |
| 52 | 1 | JP1 | Vin low voltage 36 V/2 A mor2X3812204822 | Jumper | Phoenix Contact | 1803426 |
| 53 | 3 | JP2, JP3, JP4 | conwurth61302015721 | Jumpers | Wurth | 61301015721 |
| 54 | 3 | JP5, JP6, JP7 | conwurth61300415721 | Jumpers | Wurth | 61300415721 |

| Item | Q.ty | Reference | Part / Value | Description | Manufacturer | Order code |
|------|------|--|---|---|--------------------|---------------------------|
| 55 | 2 | JP14, JP15 | Strip line male 1X2 pitch 2.54 mm siptm2002 | Jumper | Any | Any |
| 56 | 1 | J22 | DAC blkcon100vhtm2oew2004 | Double strip line male 2X2 pitch 2.54mm | Any | Any |
| 57 | 1 | J23 | Vdc in mor2X254 | Supply connector | Phoenix Contact | 1725656 |
| 58 | 1 | L1 | 15 µH indnrs5040t150m | Inductor | Wurth Elektronik | 74404054150 |
| 59 | 1 | L3 | 68 µH INDLMAXSJM680FTAS | Inductor | Wurth Elektronik | 744771168 |
| 60 | 6 | L2, L4, L5, L6, L8, L9 | sml 0603 | Filters | Murata | BLM18SG331TN1D |
| 61 | 1 | L7 | 47 µH indBOURNSSRR1240470M | Fixed inductor | Wurth Elektronik | 7447715470 |
| 62 | 1 | L10 | smr0603 | Power line ferrite bead | Murata | BLM18SG700TN1D |
| 63 | 2 | MT2, MT4 | M3X10 mm Nylon MTHOLE3 | Tower | Keyston electronic | 25501 |
| 64 | 7 | PS1, PS2, PS3, PS4, PS5, PS6, PS7 | 15 V/-10 V | Power supply | Any | Any |
| 65 | 2 | P1, P2 | DB9-male connector dsubrp318tm9mcon | D-Sub connector | Amphenol | L717TSEH09POL2RM5 |
| 66 | 7 | Q2, Q5, Q8, Q11, Q14, Q17, Q20 | 2STN1550 sot223 | Low voltage high performance NPN power transistors | ST | 2STN1550 |
| 67 | 13 | Q3, Q4, Q6, Q7, Q9, Q10, Q12, Q13, Q15, Q16, Q18, Q19, Q21 | 2STF2550 smsot89 | Low voltage high performance NPN power transistors | ST | 2STF2550 |
| 68 | 1 | Q23 | STN4NF06L sot223 | Automotive-grade N-channel 60 V, 0.07 Ohm typ., 4 A STripFET II Power MOSFET in SOT-223 package | ST | STN4NF06L |
| 69 | 71 | R32, R34, R35, R36, R37, R38, R39, R40, R45, R50, R57, R61, R62, R63, R64, R86, R87, R88, R90, R103, R104, R105, R107, R120, R121, R122, R124, R137, R138, R139, R141, R154, R155, R156, R158, R171, R172, R173, R175, R188, | 0.1/16 W ±1% smr0603 | Thick film resistors | Any | Any |

| Item | Q.ty | Reference | Part / Value | Description | Manufacturer | Order code |
|------|------|--|---------------------------|--------------------------------------|--------------|--------------|
| | | R189, R190, R192, R219, R220, R221, R226, R227, R228, R229, R230, R232, R234, R237, R238, R240, R243, R257, R258, R259, R260, R261, R262, R263, R264, R265, R266, R269, R270, R273, R277 | | | | |
| 70 | 17 | R68, R69, R70, R71, R72, R74, R75, R76, R101, R118, R135, R152, R169, R186, R218, R241, R242 | 10 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 71 | 1 | R79 | 3.5 7K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 72 | 3 | R65, R66, R77 | 820 R 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 73 | 4 | R18, R19, R21, R22 | 392 K 1/2 W ±5 %smr1210 | Thick film resistors | Panasonic | ERJP14F3923U |
| 74 | 3 | R20, R23, R26 | 68K 1W ±5% smr2512 | Thick film resistors | TE Connector | 352068KJT |
| 75 | 1 | R24 | 7.87 KK 1/4 W ±1% smr1206 | Thick film resistors | Any | Any |
| 76 | 2 | R25, R31 | 4.02 k 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 77 | 1 | R27 | 39 R 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 78 | 2 | R28, R29 | 2 k 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 79 | 1 | R30 | 120 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 80 | 1 | R33 | 3.3 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 81 | 5 | R35, R38, R61, R63, R64 | 0 Ohm 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 82 | 3 | R48, R49, R73 | 1/16 W ±1% smr0603 | Thick film resistors (not assembled) | Any | Any |
| 83 | 5 | R58, R59, R60, R249, R271 | 4.7 k 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 84 | 1 | R78 | 1.3 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 85 | | R79 | 3.57 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |

| Item | Q.ty | Reference | Part / Value | Description | Manufacturer | Order code |
|------|------|---|---------------------------------|----------------------|--------------|------------|
| 86 | 11 | R80, R81, R84, R85, R102, R119, R136, R153, R170, R187, R204 | 1 K 1/16 W $\pm 1\%$ smr0603 | Thick film resistors | Any | Any |
| 87 | 1 | R82 | 680 1/16 W $\pm 1\%$ smr0603 | Thick film resistors | Any | Any |
| 88 | 14 | R89, R91, R106, R108, R123, R125, R140, R142, R157, R159, R174, R176, R191, R193 | 750 1/16 W $\pm 1\%$ smr0603 | Thick film resistors | Any | Any |
| 89 | 13 | R92, R93, R109, R110, R126, R127, R143, R144, R160, R161, R177, R178, R194 | 24 1 W $\pm 5\%$ smr2512 | Thick film resistors | Any | Any |
| 90 | 21 | R94, R97, R98, R111, R114, R115, R128, R131, R132, R145, R148, R149, R162, R165, R166, R179, R182, R183, R196, R199, R200 | 100 1/16 W $\pm 1\%$ smr0603 | Thick film resistors | Any | Any |
| 91 | 12 | R95, R96, R112, R113, R129, R130, R146, R147, R163, R164, R180, R181 | 20 1 W smr2512 | Thick film resistors | Any | Any |
| 92 | 6 | R99, R116, R133, R150, R167, R184 | 330 1/16 W $\pm 1\%$ smr0603 | Thick film resistors | Any | Any |
| 93 | 6 | R100, R117, R134, R151, R168, R185 | 10 1/16 W $\pm 1\%$ smr0603 | Thick film resistors | Any | Any |
| 94 | 1 | R205 | 47 K 1/16 W $\pm 1\%$ smr0603 | Thick film resistors | Any | Any |
| 95 | 1 | R206 | 110 K 1/16 W $\pm 1\%$ smr0603 | Thick film resistors | Any | Any |
| 96 | 1 | R207 | 1.5 K 1/16 W $\pm 1\%$ sMr0603 | Thick film resistors | Any | Any |
| 97 | 1 | R208 | 2.49 K 1/16 W $\pm 1\%$ sMr0603 | Thick film resistors | Any | Any |
| 98 | 1 | R209 | 220 1/16 W $\pm 1\%$ sMr0603 | Thick film resistors | Any | Any |
| 99 | 2 | R210, R214 | 0.1 R 1/16 W $\pm 1\%$ smr0603 | Thick film resistors | Any | Any |
| 100 | 1 | R211 | 13 K 1/16 W $\pm 1\%$ smr0603 | Thick film resistors | Any | Any |

| Item | Q.ty | Reference | Part / Value | Description | Manufacturer | Order code |
|------|------|------------------------------|---|--|-----------------|-----------------------------|
| 101 | 3 | R212, R215, R216 | 9.1 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 102 | 1 | R213 | 4.3 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 103 | 1 | R217 | 5.49 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 104 | 1 | R225 | 5.6 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 105 | 1 | R235 | 47 R 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 106 | 1 | R239 | 18 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 107 | 2 | R245, R246 | 60R4 1/16W ±1% smr0603 | Thick film resistors | Any | Any |
| 108 | 5 | R250, R251, R252, R253, R254 | 100 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 109 | 1 | R255 | 1K5 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 110 | 4 | R274, R275, R276, R272 | 33 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 111 | 1 | SW1 | SWITCHMULT | Multiple switch | TE Connectivity | 1-1825010-4 |
| 112 | 1 | SW5 | Strip Line Male 1X3 pitch 2.54 mm siptm3003 | Jumper | Any | Any |
| 113 | 2 | SW6, SW7, | 0.05 A-12 V SMDPULSE4 | Push button | APEM | DTSMW69RW |
| 114 | 2 | S7, S8 | Strip Line Male 1X2 pitch 2.54 mm siptm2002 | Jumpers | Any | Any |
| 115 | 1 | T1 | B82789-C104 indB82789C104 | Common mode choke dual | EPCOS | B82789-C104 |
| 116 | 1 | U1 | TSZ121ILT SOT23L5 | Very high accuracy (5 µV) zero drift 5 V CMOS Op-Amp, single, GBP=400kHz | ST | TSZ121ILT |
| 117 | 1 | U2 | ACPL-782T SWG1008WG387L430 | Opto-Isolator | Avago | ACPL-782T-500E |
| 118 | 1 | U24 | ESDA14V2LY smsot23123 | Automotive dual Transil™ array for ESD protection | ST | ESDA14V2LY |
| 119 | 2 | U25, U28 | ESDA6V1LY smsot23123 | Automotive dual Transil™ array for ESD protection | ST | ESDA6V1LY |
| 120 | 1 | U26 | ESDA5V3LY smsot23123 | Automotive dual Transil™ array for ESD protection | ST | ESDA5V3LY |
| 121 | 1 | U27 | LF50CDT-TRY smdpak | Very low drop voltage regulator with inhibit | ST | LF50CDT-TRY |

| Item | Q.ty | Reference | Part / Value | Description | Manufacturer | Order code |
|------|------|-----------|----------------------------------|--|-----------------|---------------|
| 122 | 1 | U29 | ST32F303RBT7 quad50m64wg1200 | Mainstream Mixed signals MCUs ARM Cortex-M4 core comparators | ST | STM32F303RBT7 |
| 123 | 1 | U30 | ST3232EBTR sog065m16wg820l635 | 15 KV ESD protected, RS232 drivers and receivers | ST | ST3232EBTR |
| 124 | 1 | U31 | L9615D sog0508wg244l200 | High speed Can bus transceiver | ST | L9615D |
| 125 | 1 | Y1 | | Crystal | Fox Electronics | SDLF/080-20 |

Table 11. STEVAL-CTM002V2 bill of materials

| Item | Q.ty | Ref. | Part/Value | Description | Manufacturer | Order code |
|------|------|---------------------|--|--------------------------------------|----------------------------------|---------------------------------|
| 1 | 1 | CON1 | walcon100vhtm2oew32514 | Power module Interface | Sullins Connector Solution | SBH11-PBPC-D07-ST-BK |
| 2 | 3 | J7, J8, J9 | Out connector 40 A PowerTerm40A | Connectors | ERNI | 214786 |
| 3 | 3 | C5, C7, C9 | 100 nF 25 V ±20% smc0603 | Capacitors | Any | Any |
| 4 | 1 | C1 | 470 nF 630 V DC ±5% rad1000x425ls750H39 | Polyfilm capacitor | EPCOS | B32653A6474J000 |
| 5 | 3 | C2, C3, C4 | STPS1L30A 30V/1A SMA | Capacitors | EPCOS | B81123C1222M000 |
| 6 | 3 | C6, C8, C10 | 10 nF 25 V ±20% smc0603 | Capacitors | Any | |
| 7 | 1 | D1 | STPS1L30A 30 V/1 A SMA | Low drop power Schottky rectifier | ST | STPS1L30A |
| 8 | 3 | D2, D3, D4 | red led Led SMR0603 | LED | Osram Opto | LR Q396 |
| 9 | 3 | F1, F2, F3 | 20 A-500 V 500V/25A fuse10X38M + Clip Bussman | Clips+FUSE | SIBA + Bussmann | 60-033-05 25A + 1A3400-09 |
| 10 | 1 | F10 | MPZ1608S121A sml0603 | Filter | Würth (TDK) | 742 792 625 (MPZ1608S121A) |
| 11 | 3 | JP8, JP9, JP10 | 1X10 pitch 2.54 mm High 13.5 mm blkcon100vhtm1sqw100X10 | Strip line male | FCI | 77311-462K10LF |
| 12 | 3 | JP11, JP12, JP13 | 1X4 pitch 2.54 mm High 13.5 mm siptm4004 | Strip line male | FCI | 77311-462K04LF |
| 13 | 5 | J4 and other 4 | M3X10 mm MTHole3 | Tower | RS Pro | 606-686 |
| 14 | 1 | J6 | | Testpoint | NOT ASSEMBLY | |
| 15 | 2 | J2, J3 | VBUS mthole5 | Screw M5 + Nut M5 | RS Pro | 482-8739+483-0546 |
| 16 | 1 | J1 | 30 A/400 V mors2x9X52 | Brake connector | Phonex contact | 1714971 |
| 17 | 1 | J5 | 300 V 25 A 25A/300V mors4x9X52 | EXT_Brake | Phonex contact | 1906129 |
| 18 | 1 | LS1 | SPST 12VDC SPST releTE112H2MG | Relay | TE CONNECTIVIT Y / OEG | PCFN-112H2MG,000 |

| Item | Q.ty | Ref. | Part/Value | Description | Manufacturer | Order code |
|------|------|-----------------------------|----------------------------|---|--------------|------------------------------|
| 19 | 1 | Q1 | 3STF1640 sot89 | Low voltage high performance NPN power transistor | ST | 3STF1640 |
| 20 | 1 | RT1 | NTC-10 Ohm NTC-10 rad26NTC | | EPCOS | B57464S0100M00 |
| 21 | 4 | R2, R3, R4, R14 | 0 ¼ W ±1% SMR1206 | Thick film resistors | Any | Any |
| 22 | 1 | R1 | 4.7 1/8 W ±1% smr805 | Thick film resistors | Any | Any |
| 23 | 1 | R8 | 1.8 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 24 | 6 | R7, R10, R11, R12, R13, R17 | 100 K 1 W ±5% smr2512 | Thick film resistors | Any | Any |
| 25 | 1 | R5 | 3.9 K 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 26 | 1 | R6 | 820 R 1/16 W ±1% smr0603 | Thick film resistors | Any | Any |
| 27 | 1 | SP! | | ACEPACK 2 converter inverter brake | ST | A2C35S12M3-F |
| 28 | 3 | U1, U2, U3 | SenseACS755XCB | | Allegro | ACS759LCB-050B-PFF-T |

Table 12. STEVAL-CTM001V2D bill of materials

| Item | Q.ty | Ref. | Part/Value | Description | Manufacturer | Order code |
|------|------|---|------------------------------|-------------|--------------|--------------------|
| 1 | 61 | C10, C11, C12, C25, C40, C44, C46, C48, C52, C54, C57, C60, C64, C66, C68, C72, C74, C77, C80, C84, C86, C88, C92, C94, C97, C100, C104, C106, C108, C112, C114, C117, C120, C124, C126, C128, C132, C134, C137, C140, C144, C146, C148, C152, C154, C157, C160, C164, C166, C168, C172, C174, C177, C186, C195, C196, C201, C202, C259, C260, C261 | 100 nF smc0603 50 V ±10% X7R | Capacitors | AVX | 06035C104KAT2A |
| 2 | 1 | C13 | 10 nF smc0603 50 V ±10% X7R | Capacitor | Murata | GRM188R71H103KA01D |
| 3 | 1 | C185 | 10 µF tantalioC 35 V ±10% | Capacitor | Kemet | T491C106K035AT |

| Item | Q.ty | Ref. | Part/Value | Description | Manufacturer | Order code |
|------|------|--|------------------------------|----------------------------|----------------------------|----------------------|
| 4 | 1 | C187 | 2.2 nF smc0603 50 V ±10% X7R | Capacitor | Vishay | VJ0603Y222KXACW1BC |
| 5 | 2 | C188, C258 | 47 µF tantalioc 25 V ±10% | Capacitors | Kemet | T491D476K025AT |
| 6 | 1 | C190 | 470 pF smc0603 50 V ±10% X7R | Capacitor | Yageo | CC0603KRX7R9BB471 |
| 7 | 2 | C191, C197 | 15 nF smc0603 50 V ±10% X7R | Capacitors | Samsung | CL10B153KB8NNNC |
| 8 | 2 | C192, C198 | 47 µF tantalioc 16 V ±10% | Capacitors | AVX | TPSC476K016R0110 |
| 9 | 2 | C193, C199 | 3.3 µF tantalioc 50 V ±10% | Capacitors | AVX | TAJC335K050R |
| 10 | 1 | C200 | 120 pF SMC0603 50 V ±5% | Capacitor | Murata | GRM1885C1H121JA01D |
| 11 | 1 | C203 | 10 µF tantalioc 10 V ±10% | Capacitor | AVX | TAJB106K010RNJ |
| 12 | 1 | C257 | 220 nF smc0603 25 V ±10% X7R | Capacitor | Murata | GCM188R71E224KA55D |
| 13 | 14 | C41, C55, C61, C75, C81, C95, C101, C115, C121, C135, C141, C155, C161, C175 | 4.7µF smc0603 25V ±10% X5R | Capacitors | Samsung Electro | CL10A475KA8NQNC |
| 14 | 9 | C42, C62, C82, C102, C122, C142, C162 | smc0603 | Capacitors (not assembled) | | |
| 15 | 28 | C43, C45, C49, C50, C63, C65, C69, C70, C83, C85, C89, C90, C103, C105, C109, C110, C123, C125, C129, C130, C143, C145, C149, C150, C163, C165, C169, C170 | 4.7 µF smc0805 35 V ±10% X7R | Capacitors | TDK | CGA4J3X5R1H475K125AB |
| 16 | 21 | C47, C51, C56, C67, C71, C76, C87, C91, C96, C107, C111, C116, C127, C131, C136, C147, C151, C156, C167, C171, C176 | 100 pF smc0603 50 V ±10% X7R | Capacitors | Yageo | CC0603KRX7R9BB101 |
| 17 | 14 | C53, C58, C73, C78, C93, C98, C113, C118, C133, C138, C153, C158, C173, C178 | 1 µF smc0603 50 V ±10% X7R | Capacitors | Taiyo Yuden | UMK107AB7105KA-T |
| 18 | 10 | C9, C14, C39, C59, C79, C99, C119, C139, C159, C194 | 150 pF smc0603 50 V ±10% X7R | Capacitors | Wurth | 885012206078 |
| 19 | 1 | CON1 | blkcon100vhtm2oew20014 | SPI Connector | Sullins Connector Solution | SFH11-PBPC-D07-ST-BK |

| Item | Q.ty | Ref. | Part/Value | Description | Manufacturer | Order code |
|------|------|---|---|---|----------------------------|------------------------------|
| 20 | 1 | CON16 | CON10 male | Connector | Sullins Connector Solution | SBH11-PBPC-D05-ST-BK |
| 21 | 1 | CON2 | blkcon100vhtm2oew20010 | Enc/Hall connector | AMTEK | PH1S25-2x40GB6/3-L |
| 22 | 1 | CON3 | blkcon100vhtm2oew20034 | Connector | Sullins Connector Solution | SFH11-PBPC-D17-ST-BK |
| 23 | 2 | CON4, CON8 | walcon100vhtm2oew32514 | SPI-Power module interface | Sullins Connector Solution | SBH11-PBPC-D07-ST-BK |
| 24 | 1 | CON5 | walcon100vhtm2oew32534 | Connector | Sullins Connector Solution | SBH11-PBPC-D17-ST-BK |
| 25 | 2 | D23, D24 | smd0603 | Green LED | Osram Opto | LT Q39G-Q1S2-25-1 |
| 26 | 7 | D25, D36, D47, D58, D69, D80, D91 | STTH112A SMA | 1200 V, 1A ultrafast diode | ST | STTH112A |
| 27 | 7 | D26, D37, D48, D59, D70, D81, D92 | BAT20JFILM SOD323f | 23 V, 1 A general purpose signal Schottky diode | ST | BAT20JFILM |
| 28 | 7 | D27, D38, D49, D60, D71, D82, D93 | STPS2H100AY SMA 100V/2A | 100 V, 2 A SMA SMB automotive power Schottky rectifier | ST | STPS2H100AY |
| 29 | 7 | D28, D39, D50, D61, D72, D83, D94 | TBD smb | Diode (not assembled) | ST | |
| 30 | 14 | D29, D34, D40, D45, D51, D56, D62, D67, D73, D78, D84, D89, D95, D100 | STPS360AFY SOD128 60V/3A | Automotive 60 V, 3 A power Schottky rectifier | ST | STPS360AFY |
| 31 | 4 | D102, D103, D105, D106 | STPS3L40SY SMC 3A/40V | Automotive 40 V, 3 A low drop power Schottky rectifier | ST | STPS3L40SY |
| 32 | 1 | D3 | TZMC13-GS08 smdo213ac21 13V/0, 5W 5% | Zener diode | Vishay | TZMC13-GS08 |
| 33 | 12 | D30, D33, D41, D44, D52, D55, D63, D66, D74, D77, D85, D88 | STPS5H100AFY SOD128 100V/5A | Automotive 100 V, 5 A SOD128Flat power Schottky rectifier | ST | STPS5H100AFY |
| 34 | 7 | D35, D46, D57, D68, D79, D90, D101 | SMCJ13CA SMD0214AB21 | 1500 W, TVS in SMC | ST | SMCJ13CA |
| 35 | 1 | D4 | TZMB2V7-GS08 smdo213ac21 2, 7V/0, 5W 2% | Zener diode | Vishay | TZMB2V7-GS08 |
| 36 | 17 | D5, D18, D19, D20, D31, D32, D42, D43, D53, D54, D64, D65, D75, D76, D86, D87, D97, D98 | SMR0603 | Red LED | Osram Opto | LS Q976 |

| Item | Q.ty | Ref. | Part/Value | Description | Manufacturer | Order code |
|------|------|--|--|---|------------------|---------------------------|
| 37 | 7 | IC1, IC2, IC3, IC4, IC5, IC6, IC7 | STGAP1S sog05024wg425l650 | Automotive galvanically isolated single gate driver | ST | STGAP1S |
| 38 | 1 | IC8 | A7986ATR sog0508wg244l200exposure | 3 A step-down switching regulator for automotive applications | ST | A7986ATR |
| 39 | 2 | IC9, IC10 | A6902D sog0508wg244l200 | Up to 1 A switch step down regulator with adjustable current limit for automotive applications | ST | A6902D |
| 40 | 1 | J22 | DAC blkcon100vhtm2oew2004 | Jumper | AMTEK | PH1S25-2x40GB6/3-L |
| 41 | 1 | JP1 | Vin Low Voltage mor2X3812204822 36V-2A | Jumper | Phoenix Contact | 1803426 |
| 42 | 3 | JP2, JP3, JP4 | conwurth61302015721 | Jumpers | Würth Elektronik | 61301015721 |
| 43 | 3 | JP5, JP6, JP7 | conwurth61300415721 | Jumpers | Würth Elektronik | 61300415721 |
| 44 | 1 | L1 | 15 µH indnrs5040t150m | Inductor | Würth Elektronik | 74404054150 |
| 45 | 6 | L2, L4, L5, L6, L8, L9 | BLM18SG331TN1D sml0603 | Filters | Murata | BLM18SG331TN1D |
| 46 | 1 | L3 | 68 µH INDLMAXSJM680FTAS | Inductor | Würth Elektronik | 744771168 |
| 47 | 1 | L7 | 47 µH indBOURNSSRR1240470M | Inductor | Würth Elektronik | 7447715470 |
| 48 | 7 | PS1, PS2, PS3, PS4, PS5, PS6, PS7 | 15 V/-10 V | DC-DC power converter | Murata | MGJ3T12150505MC |
| 49 | 7 | Q2, Q5, Q8, Q11, Q14, Q17, Q20 | 2STN1550 sot223 | Low voltage high performance NPN power transistors | ST | 2STN1550 |
| 50 | 1 | Q23 | STN4NF06L sot223 | Automotive-grade N-channel 60 V, 0.07 Ohm typ., 4 A STripFET II Power MOSFET in SOT-223 package | ST | STN4NF06L |
| 51 | 13 | Q3, Q4, Q6, Q7, Q9, Q10, Q12, Q13, Q15, Q16, Q18, Q19, Q21 | 2STF2550 smsot89 | Low voltage high performance NPN power transistors | ST | 2STF2550 |
| 52 | 6 | R100, R117, R134, R151, R168, R185 | 10 SMR0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW060310R0FKEA |
| 53 | 6 | R101, R118, R135, R152, R169, R186, | 10 K smr0603 1/16 W ±1% | Thick film resistors | RS Pro | 804-8921 |

| Item | Q.ty | Ref. | Part/Value | Description | Manufacturer | Order code |
|------|------|--|---------------------------|----------------------|--------------|--------------------|
| 54 | 4 | R18, R19, R21, R22 | 392 K smr1210 1/2 W ±5% | Thick film resistors | Panasonic | ERJP14F3923U |
| 55 | 3 | R20, R23, R26 | 68 K smr2512 1 W ±5% | Thick film resistors | TE Connector | 352068KJT |
| 56 | 1 | R205 | 47 K sMr0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW060347K0FKEA |
| 57 | 1 | R206 | 110 K sMr0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW0603110KFKEA |
| 58 | 1 | R207 | 1.5 K sMr0603 1/16 W ±1% | Thick film resistors | Panasonic | ERJP03F1501V |
| 59 | 1 | R208 | 2.49 K sMr0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW06032K49FKEA |
| 60 | 1 | R209 | 220 sMr0603 1/16 W ±1% | Thick film resistors | Panasonic | ERJP03F2200V |
| 61 | 2 | R210, R214 | 0.1 R smr0603 1/16 W ±1% | Thick film resistors | Bourns | CRL0603-FW-R100ELF |
| 62 | 1 | R211 | 13 K SMR0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW060313K0FKEA |
| 63 | 3 | R212, R215, R216 | 9.1 K smr0603 1/16 W ±1% | Thick film resistors | Yageo | RC0603FR-079K1L |
| 64 | 1 | R213 | 4.3 K smr0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW06034K30FKEA |
| 65 | 1 | R217 | 5.49 K smr0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW06035K49FKEA |
| 66 | 1 | R24 | 7.87 K smr1206 1/4 W ±1% | Thick film resistors | Panasonic | ERJP08F7871V |
| 67 | 2 | R25, R31 | 4.02 k smr0603 1/16 W ±1% | Thick film resistors | Panasonic | ERA3AEB4021V |
| 68 | 1 | R255 | 1K5 SMR0603 1/16 W ±1% | Thick film resistors | Panasonic | ERJP03F1501V |
| 69 | 1 | R27 | 39 R smr0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW060339R0FKEA |
| 70 | 3 | R274, R275, R276 | 33 K SMR0603 1/16 W ±1% | Thick film resistors | Yageo | RC0603FR-0733KL |
| 71 | 2 | R28, R29 | 2 k smr0603 1/16 W ±1% | Thick film resistors | Bourns | CR0603-FX-2001ELF |
| 72 | 1 | R30 | 120 smr0603 1/16 W ±1% | Thick film resistors | Yageo | RC0603FR-07120RL |
| 73 | 1 | R77 | 820 R smr0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW0603820RFKEA |
| 74 | 1 | R78 | 1.3 K smr0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW06031K30FKEA |
| 75 | 1 | R79 | 3.57 K smr0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW06033K57FKEA |
| 76 | 11 | R80, R81, R84, R85, R102, R119, R136, R153, R170, R187, R204 | 1 K sMr0603 1/16 W ±1% | Thick film resistors | Yageo | RC0603FR-071KL |
| 77 | 1 | R82 | 680 SMR0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW0603680RFKEA |

| Item | Q.ty | Ref. | Part/Value | Description | Manufacturer | Order code |
|------|------|--|---|----------------------|-----------------|--------------------|
| 78 | 41 | R86, R87, R88, R90, R103, R104, R105, R107, R120, R121, R122, R124, R137, R138, R139, R141, R154, R155, R156, R158, R171, R172, R173, R175, R188, R189, R190, R192, R257, R258, R259, R260, R261, R262, R263, R264, R265, R266, R269, R270, R273, | 0 smr0603 1/16 W ±1% | Thick film resistors | Vishay | CRCW06030000Z0EB |
| 79 | 14 | R89, R91, R106, R108, R123, R125, R140, R142, R157, R159, R174, R176, R191, R193 | 750 smr0603 1/16 W ±1% | Thick film resistors | Panasonic | ERJ3GEYJ751V |
| 80 | 13 | R92, R93, R109, R110, R126, R127, R143, R144, R160, R161, R177, R178, R194 | 24 SMR2512 1 W ±5% | Thick film resistors | TE Connectivity | 352056RJT |
| 81 | 21 | R94, R97, R98, R111, R114, R115, R128, R131, R132, R145, R148, R149, R162, R165, R166, R179, R182, R183, R196, R199, R200 | 100 smr0603 1/16 W ±1% | Thick film resistors | RS PRO | 804-8760 |
| 82 | 12 | R95, R96, R112, R113, R129, R130, R146, R147, R163, R164, R180, R181 | 20 smr2512 1 W ±1% | Thick film resistors | Panasonic | ERJ-1TNF20R0U |
| 83 | 6 | R99, R116, R133, R150, R167, R184 | 330 smr0603 1/16 W ±1% | Thick film resistors | Panasonic | ERJ3EKF3300V |
| 84 | 1 | S7 | Strip Line Male 1X2 pitch 2.54 mm siptm2002 | Jumper | AMTEK | PH1S25-1x40GB6/3-L |
| 85 | 1 | SW1 | SWITCHMULT | Multiple Switch | TE Connectivity | 1-1825010-4 |
| 86 | 1 | U1 | TSZ121ILT SOT23L5 | | ST | TSZ121ILT |
| 87 | 1 | U2 | ACPL-782T SWG1008WG387L430 | Opto-Isolator | Avago | ACPL-782T-500E |

| Item | Q.ty | Ref. | Part/Value | Description | Manufacturer | Order code |
|------|------|----------|----------------------------------|---|--------------|-----------------------------|
| 88 | 1 | U24 | ESDA14V2LY smsot23123 | Automotive dual Transil™ array for ESD protection | ST | ESDA14V2LY |
| 89 | 2 | U25, U28 | ESDA6V1LY smsot23123 | Automotive dual Transil™ array for ESD protection | ST | ESDA6V1LY |
| 90 | 1 | U26 | ESDA5V3LY smsot23123 | Automotive dual Transil™ array for ESD protection | ST | ESDA5V3LY |
| 91 | 1 | U27 | LF50CDT-TRY smdpak | Very low drop voltage regulator with inhibit | ST | LF50CDT-TRY |
| 92 | 1 | PCB | FR4-283x92x1.6mm 283x92x1.6mm | PCB | Any | Any |

Revision history

Table 13. Document revision history

| Date | Version | Changes |
|-------------|---------|------------------|
| 12-Dec-2019 | 1 | Initial release. |

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