Getting started with the STEVAL-QUADV01 evaluation board based on L6981, L7983 and ST1PS03 DC-DC converter buck regulators, and ST730 LDO

Introduction

The STEVAL-QUADV01 evaluation board features four different step-down regulators.

The board provides four different means of providing an output voltage of 5 V. The output voltages can be easily set to other values by changing the resistors in resistive dividers of the feedback networks.

The evaluation board is based on the L6981, L7983, and ST1PS03 synchronous step-down converters. It also features the ST730 LDO, which offers various benefits for voltage conversion from multiple input levels.

The L6981 synchronous monolithic step-down regulator is capable of delivering up to 1.5 A DC. Its wide input voltage range makes the device suitable for a broad range of applications. The device implements peak current mode architecture in an SO 8L package with internal compensation to minimize design complexity and size. The L6981 is available in low consumption mode (LCM) and low noise mode (LNM) versions. LCM maximizes efficiency at light load with controlled output voltage ripple, making the device extremely suitable for battery-powered applications. LNM makes the switching frequency constant and minimizes the output voltage ripple overload current range, meeting the specifications for noise sensitive applications. The EN pin manages the enable/disable function. The typical shutdown current is 2 µA when disabled. When the EN pin is pulled up, the device is enabled and the internal 1.3 ms soft-start takes place. Pulse-by-pulse current sensing on both power elements implements effective constant current protection while thermal shutdown prevents thermal run-away.

The L7983 regulator is a step-down monolithic switching regulator that can deliver up to 300 mA DC, based on peak current mode architecture. The wide input voltage range and adjustable UVLO threshold meet the specification for 12 V, 24 V, and 48 V industrial bus standards. The selected switching frequency is 1 MHz. It can be adjusted by applying an external clock on the LNM/LCM pin or by changing the frequency programming resistor. L7983 supports dynamic low consumption mode (LCM) to low noise mode (LNM) transition. LCM is designed for applications with active idle mode to maximize the efficiency at light load with controlled output voltage ripple, while LNM keeps the switching frequency constant over the load current range for low noise applications. The soft start time is internally fixed and the output voltage supervisor manages the reset phase for any digital load (MCU, FPGA, etc.). The internal compensation network features high noise immunity, simple design, and component cost savings. The RST open collector output can also implement output voltage sequencing during the power-up phase. The synchronous rectification, designed for high efficiency at medium to heavy loads, and the high switching frequency capability contribute to size reduction in final application designs. Pulse-by-pulse current sensing on both power elements implements effective constant current protection.

The ST1PS03 is a step-down converter able to deliver up to 400 mA output current from a 1.8 to 5.5 V input, with a 1.6 to 3.3 V dynamically adjustable output voltage. The board features the ST1PS03AQTR nano-quiescent miniaturized synchronous step-down converter, which implements enhanced peak current control (PCC) and advanced design circuitry to minimize quiescent current. The device embeds a controlled load switch to supply a subsystem with VIN_AUX voltage rail. The design demonstrates how high efficient conversion can be achieved thanks to the ST1PS03AQTR (in a thin TQFN12 package of 2.0x1.7 mm), a 2.2 µH inductor, and two small capacitors.

The ST730 is a low-quiescence medium input voltage (28 V) LDO able to deliver up to 300 mA output current from a 2.5 V to 28 V input. Thanks to its low quiescence, it is suitable in always-on applications. The ST730 features an SOA-type protection that clamps the output current to a safe value in case of overload or short-circuit.

All regulators feature thermal protections that disable the device in case it reaches critical temperatures that might damage the devices.

You can use the eDesignSuite and eDSim software tools to simulate and configure the L6981, L7983, and ST1PS03 buck converters before verifying the simulation results on the evaluation board.

Figure 1. **STEVAL-QUADV01 evaluation board (top view)**

1 Getting started

1.1 Safety instructions

Caution: This board has to be used only by skilled technical personnel who are suitably qualified and familiar with the installation, use, and maintenance of power electronic systems. The same personnel must be aware of and must apply national accident prevention rules. The electrical installation has to be completed in accordance with the appropriate requirements (that is, cross-sectional areas of conductors, fusing, and GND connections).

1.2 Features

- L6981
  - 3.5 to 38 V wide input voltage range
  - Output voltage adjustable from 0.85 V to VIN
  - 400 kHz switching frequency
  - Pulse skipping or forced PWM operation at light load depending on version
  - Synchronization from 200 to 500 kHz
  - Constant current protection with hiccup mode
  - Current sensing on rds-on low-side
  - Improved line-transient response
  - Thermal protection
  - Operating junction temperature range: -40 to 150°C
- L7983
  - 3.5 V to 60 V input voltage range
  - Output voltage adjustable from 0.85 V to VIN
  - Switching frequency settable from 200 kHz to 2.2 MHz
  - Selectable pulse skipping or forced PWM operation at light load
  - Synchronization from 180 kHz to 2.4 MHz
  - Constant current protection with hiccup mode
  - Current sensing on rds-on low-side
  - Improved line-transient response
  - Input voltage undervoltage lockout
  - Thermal protection
  - Operating junction temperature range: -40 to 150°C
- ST1PS03
  - 1.8 to 5.5 V input operating range
  - Up to 400 mA output current capability
  - Tiny external components: L = 2.2 µH typical
  - Dynamically selectable output voltages from 1.6 to 3.3 V
  - Independent load switch (AUX control input)
  - Operating junction temperature range: -40 to 150°C

- ST730
  - Wide input voltage range of 2.5 V to 28 V
  - Ultra-low quiescent current: typ. 5 µA at no-load, 10 µA max. across full temperature range, 1 µA max. in shutdown
  - High output voltage accuracy: ± 0.5% @ 25 °C, ± 2.5% across temperature range
  - Output current up to 300 mA
  - Output voltage adjustable from 1.2 V to VIN - VDROP
  - Stable with low ESR capacitors (0.47 µF min.)
  - Thermal shutdown protection
  - Current limit and SOA protection
  - -40 °C to +125 °C operating temperature range

2 How to use the board

All four regulators on the STEVAL-QUADV01 feature an adjustable V_{OUT}. Each circuit output voltage can be set freely by adjusting the resistor values.

To use the board, follow the procedure below.

Step 1. Connect the voltage supply between V_{IN} and GND pins of the regulator(s) you intend to use.

Step 2. Connect the load (power resistor or active load) between V_{OUT} and GND connectors of the regulator(s) you intend to use.

Step 3. Set the supply voltage V_{IN} to a level suitable for the selected regulator(s) before enabling their output.

Step 4. Connect the EN pin to Vin in order to activate regulator output. This step is not needed for STEVAL$QUADV01B.

3 Connectors and test points

3.1 V_{IN}

Each regulator has a unique V_{IN} connector. To use it, connect a supply voltage within the voltage range of the regulator to be used.

V_{IN} should be connected to the power source with a short wire to avoid oscillations between the cable parasitic inductance and the input ceramic capacitor.

3.2 GND

This is the return of the terminal of the input and output capacitors. Each regulator has a unique GND connector.

We suggest using a short wire to avoid oscillations between the cable parasitic inductance and the input capacitor.

3.3 V_{OUT}

This is the V_{OUT} connector and test point. Connect the active load or power resistor between V_{OUT} and GND test point. We suggest using short wires for the connection.

3.4 EN

This is the EN connector and is used to enable the relevant device. It can be shorted to the input voltage with a resistor or a solder bridge, or connected to the V_{IN} voltage.

Note: There are two versions of board STEVAL-QUADV01 handling EN pin differently:

- *STEVAL$QUADV01A need to have the EN pin connected to Vin in order to activate selected regulator.*
- *STEVAL$QUADV01B does have the pullup resistors assembled therefore no need to drive EN pin externally. Regulator will be automatically turned on.*

3.5 AUXIN

The AUXIN connector is used to supply the auxiliary power path of the ST1PS03. To use it, connect a supply voltage within the allowed voltage range. The input voltage should be connected to the power source with a short wire.

3.6 AUXOUT

The AUXOUT connector is used to supply any loads and to measure the auxiliary output voltage. We suggest using a short wire.

4 eDesignSuite and eDSim SW design tools

The eDesignSuite suite and eDSim software tools help you to configure ST products for power conversion applications.

You can use them to customize the regulators for specific applications. Start by entering the main specifications for your design. Then, generate an automatic design or follow a sequential process to build a highly customized design.

Then, you can simulte your circuit in the time and in the frequency domain with eDSim simulator, reaching from 10 to 50 times faster simulation time.

Figure 2. eDesignSuite devices selection

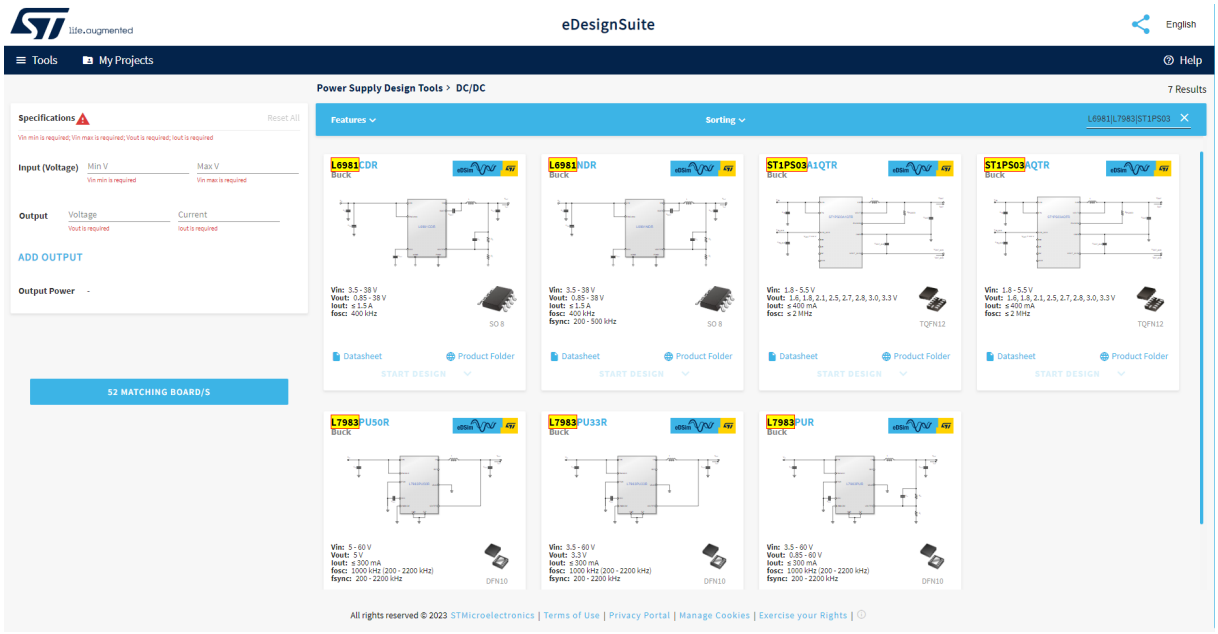
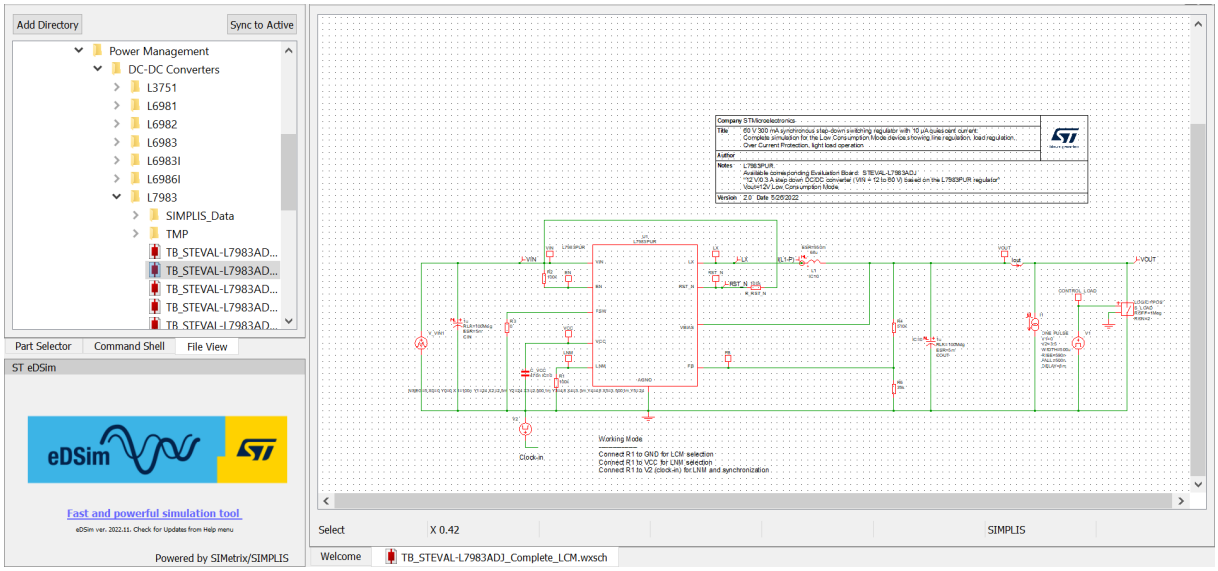


Figure 3. eDSim workspace



5 PCB layout

The STEVAL-QUADV01 is a two-layer PCB with 1-oz copper thickness.

Figure 4. STEVAL-QUADV01 PCB layout (1 of 2)

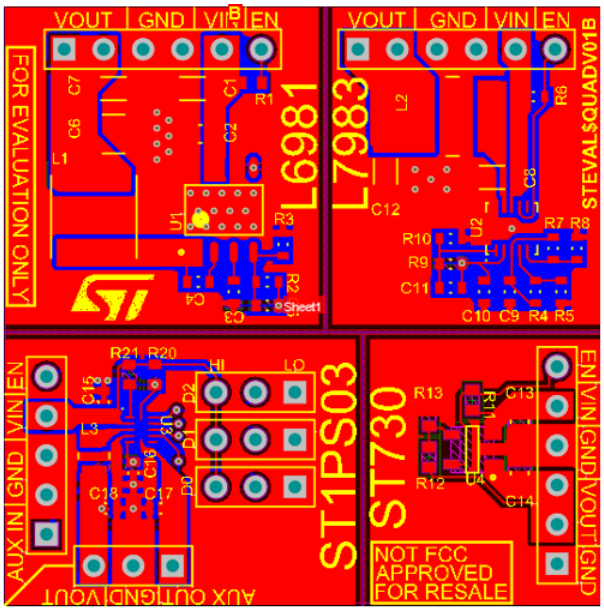
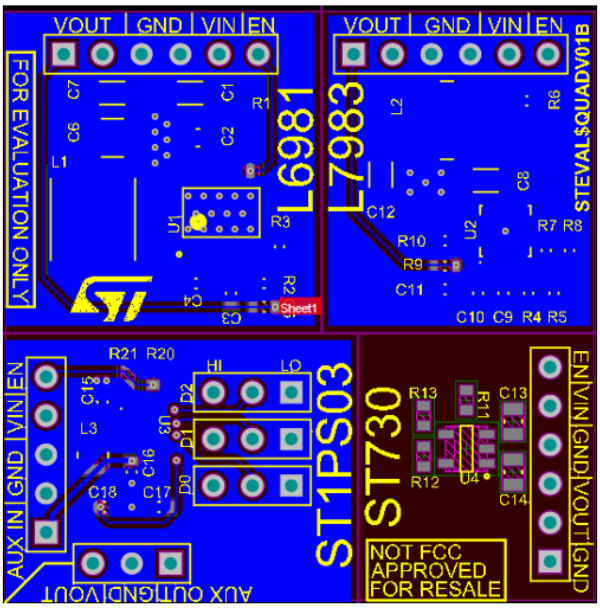


Figure 5. STEVAL-QUADV01 PCB layout (2 of 2)



6 Bill of materials

Table 1. **STEVAL-QUADV01 bill of materials**

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
1	1	C1	10uF, 1206, 50 V	Input capacitor	TDK	C3216X7R1H106K160AC
2	1	C2	1uF, 0805, 50 V	Input capacitor	TDK	CGA4J3X7R1H105K125AB
3	1	C3	1uF, 0603, 10 V	VCC capacitor	TDK	C1608X7R1A105K080AC
4	1	C4	100nF, 0603, 50 V	Bootstrap capacitor	KEMET	C0603C104K5RAC3121
5	1	C5 DNM	10pF, 0603, 50 V	Feedforward capacitor	Kyocera	06035C100KAT2A
6	1	C6	22uF, 1210, 25 V	Output capacitor	Murata	GRJ32EC71E226KE11
7	1	C7	10uF, 1206, 25 V	Output capacitor	TDK	C3216X7R1E106K160AE
8	1	R1	100k	EN resistor	Panasonic	ERJ-3EKF1002V (DNM for STEVAL$QUADV01A, Mounted for STEVAL$QUADV01B)
9	1	R2	330k, 0603	FB HS resistor	Panasonic	ERJ-3EKF3303V
10	1	R3	68k, 0603	FB LS resistor	Panasonic	ERJ-3EKF6802V
11	1	L1	22uH, 5030	Inductor	Coilcraft	XGL5030-223
12	1	U1	L6981CDR, SO8, 1.5 A	38 V, 1.5 A synchronous step-down converter with low quiescent current	ST	L6981CDR
13	1	P6	6x1, through hole, 2.54mm pitch, HDR1X6	Male SIL connector	Harwin	M20-9990645
14	2	C8, C12	10uF, 1206, 100 V	Input capacitor	TDK	C3216X7R2A105K
15	1	C9	470nF, 0603, 10 V	VCC capacitor	TDK	C1608X7R1A105K080AC
16	1	C10	100nF, 0603	Vbias capacitor	TDK	C0603C104K5RAC3121
17	1	C11 DNM	10pF, 0603	Feedforward capacitor	Kyocera	06035C100KAT2A
18	1	R4	5.6k, 0603	Upper FSW resistor	Panasonic	ERJ-3EKF5601V
19	1	R5 DNM	100k, 0603	Lower FSW resistor	Panasonic	ERJ-3EKF5601V
20	1	R6, R8	100k, 0603	EN resistor, LCM resistor	Panasonic	ERJ-3EKF5601V (DNM for STEVAL$QUADV01A, Mounted for STEVAL$QUADV01B)
21	1	R7 DNM	10k, 0603	LNM Resistor	Panasonic	ERJ-3EKF1002V
22	1	R9	330k, 0603	FB HS resistor	Panasonic	ERJ-3EKF3303V

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
23	1	R10	68k, 0603	FB LS resistor	Panasonic	ERJ-3EKF6802V
24	1	L2	22uH, 4040	Inductor	Coilcraft	MSS5131H-473
25	1	U2	L7983, DFN 3X3X0.8 10L PITCH 0.5	60 V 300 mA synchronous step-down switching regulator with 10 µA quiescent current	ST	L7983PUR
26	1	P8	6x1, through hole, 2.54mm pitch, HDR1X6	Male SIL connector	Harwin	M20-9990645
27	4	C15, C16, C17, C18	10uF, 0603, 16 V	Input, Output and aux capacitor	TDK	C1608X5R1C106M080AB
28	1	L3	2,2uH, 0603	Inductor	Coilcraft	XFL2010-222
29	1	R20	100k, 0603	EN resistor	Panasonic	ERJ-3EKF1002V (DNM for STEVAL$QUADV01A, Mounted for STEVAL$QUADV01B)
30	1	R21	10k, 0603	AUX resistor	Panasonic	ERJ-3EKF1002V
31	1	U4	ST1PS03AQTR , MLPQ/QFN 1.7x2.0x0.55 12L P0.4	DC-DC regulator, ST1PS03	ST	ST1PS03AQTR
32	1	P4	5x1, through hole, 2.54mm pitch, HDR1X5	Male SIL connector	Harwin	M20-9990645
33	3	P1, P2, P3	3x1, thorugh hole, 2.54mm pitch, HDR1X3	Male SIL connector	Harwin	M20-9990645
34	2	C13, C14	1uF, 0805, 50 V	Input, Output capacitor	TDK	C2012X7R1H105K125AB
35	1	R11	100k, 0603	Enable resistor	Panasonic	ERJ-3EKF1002V (DNM for STEVAL$QUADV01A, Mounted for STEVAL$QUADV01B)
36	1	R12	150k, 0603	FB HS resistor	Panasonic	ERJ-3EKF1503V
37	1	R13	47k, 0603	FB LS resistor	Panasonic	ERJ-3EKF4702V
38	1	U3	ST730, SOT23-5L, 0.3 A	Low dropout regulator	ST	ST730MR
39	1	P9	6x1, through hole, 2.54mm, HDR1X6,	Male SIL connector	Harwin	M20-9990645

7 Schematic diagrams

Figure 6. **STEVAL-QUADV01 circuit schematic (1 of 4)**

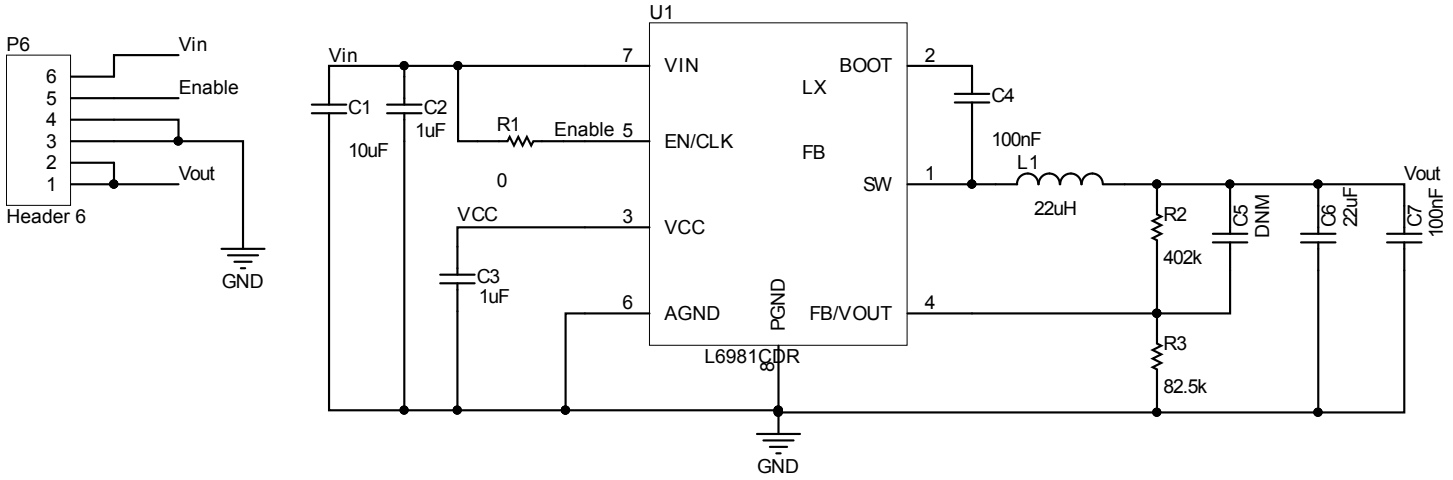


Figure 7. **STEVAL-QUADV01 circuit schematic (2 of 4)**

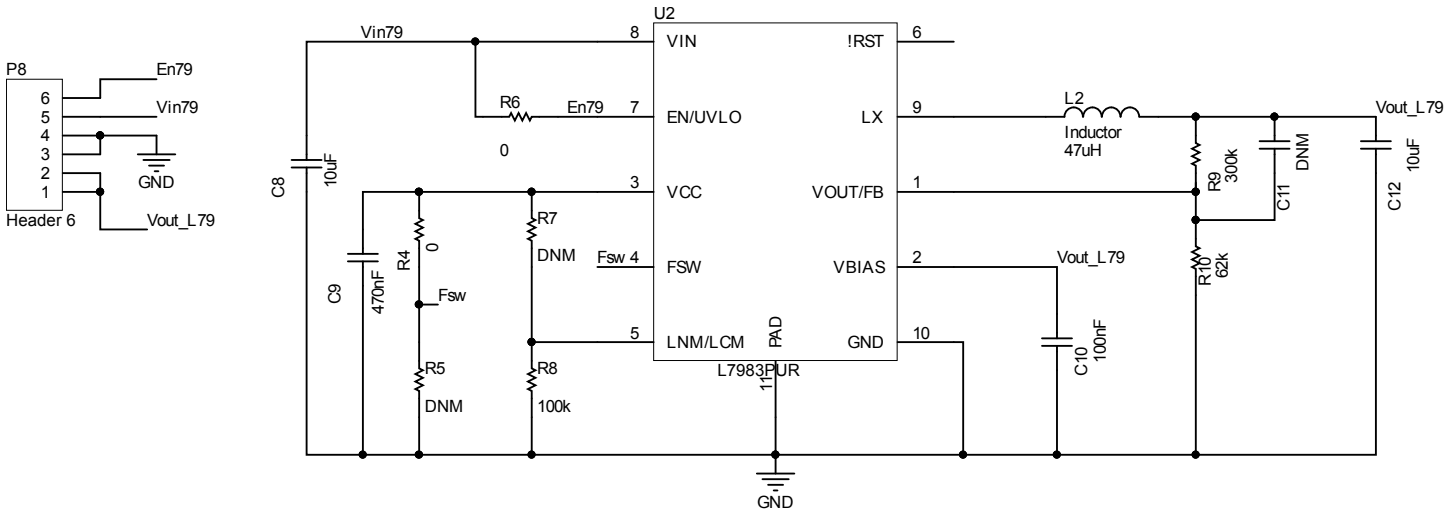


Figure 8. **STEVAL-QUADV01 circuit schematic (3 of 4)**

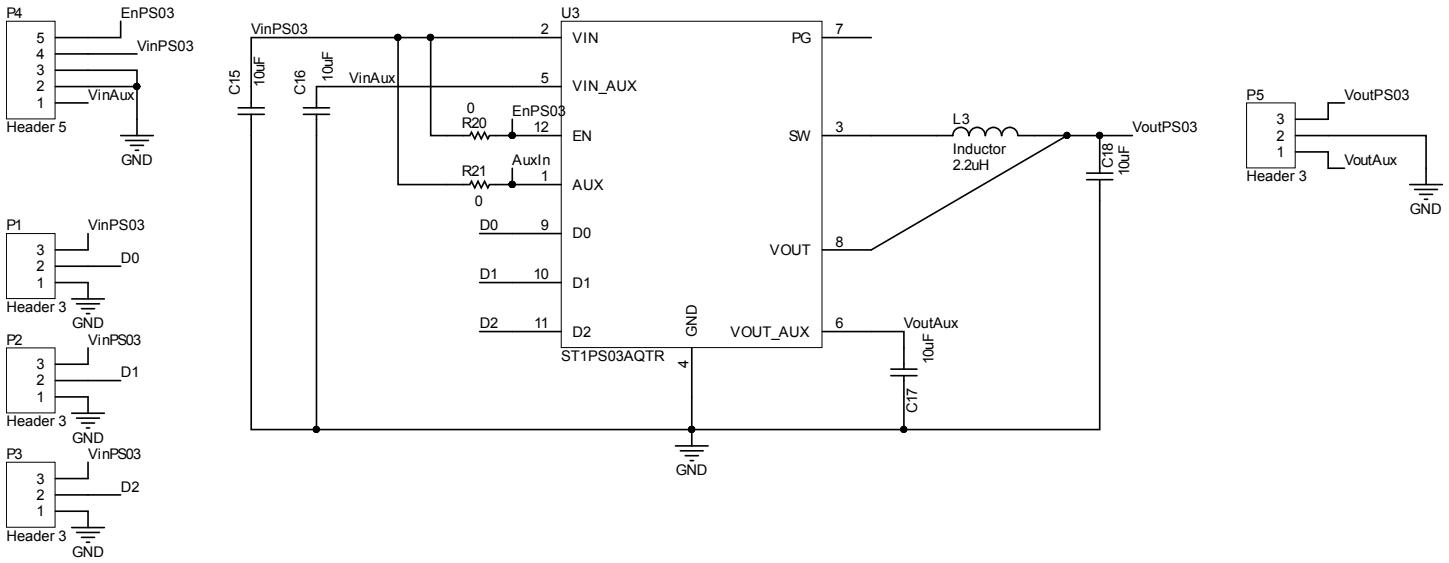
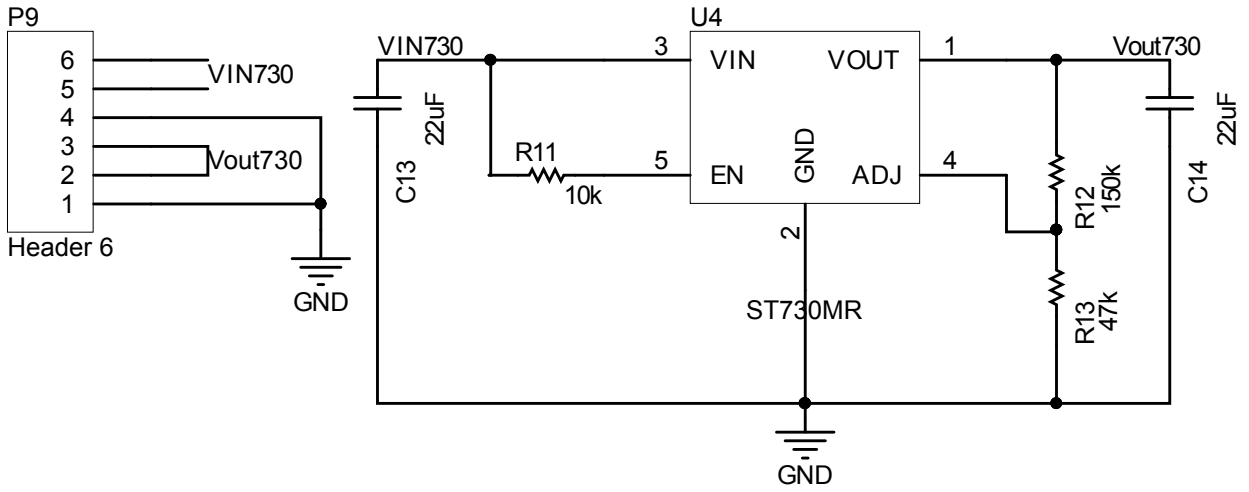


Figure 9. **STEVAL-QUADV01 circuit schematic (4 of 4)**



8 Regulatory compliance

Notice for US Federal Communication Commission (FCC)

For evaluation only; not FCC approved for resale

FCC NOTICE - This kit is designed to allow:

(1) Product developers to evaluate electronic components, circuitry, or software associated with the kit to determine

whether to incorporate such items in a finished product and

(2) Software developers to write software applications for use with the end product.

This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter 3.1.2.

Notice for Innovation, Science and Economic Development Canada (ISED)

For evaluation purposes only. This kit generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to Industry Canada (IC) rules.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

Notice for European Union

This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2015/863/EU (RoHS).

Notice for United Kingdom

This device is in compliance with the UK Electromagnetic Compatibility Regulations 2016 (UK S.I. 2016 No. 1091) and with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (UK S.I. 2012 No. 3032).

9 Board versions

Table 2. **STEVAL-QUADV01 versions**

PCB version	Schematic diagrams	Bill of materials
STEVAL$QUADV01A (1)	STEVAL$QUADV01A schematic diagrams	STEVAL$QUADV01A bill of materials
STEVAL$QUADV01B (2)	STEVAL$QUADV01B schematic diagrams	STEVAL$QUADV01B bill of materials

1. *This code identifies the STEVAL-QUADV01 evaluation board first version. It is printed on the board PCB.*
2. *This code identifies the STEVAL-QUADV01 evaluation board second version. It is printed on the board PCB.*

Note: The two versions of board STEVAL-QUADV01 handling EN pin differently:

- *STEVAL$QUADV01A need to have the EN pin connected externally to Vin in order to activate selected regulator*
- *STEVAL$QUADV01B does have the pullup resistors assembled therefore no need to drive EN pin externally. Regulator will be automatically turned on.*

Revision history

Table 3. **Document revision history**

Date	Revision	Changes
26-Apr-2023	1	Initial release.
23-Jan-2024	2	Updated Section 9: Board versions, Section 7: Schematic diagrams and Section 6: Bill of materials.

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