TLD5542-1CHG_SHIELD

User guide

About this document

Product description

The TLD5542-1CHG_SHIELD it is a battery charger shield compatible with Arduino UNO. It can charge up to 6 lithium cells in series and up to 5 A of output current to a maximum of 65 W.
The shield can be powered either by a USB-PD adapter, or by a standard 12 V power supply, and it can be configured as:

- Battery charger
- Adjustable voltage regulator
- LED driver

A graphical OLED 128x64 and 4 push-buttons are present to set parameters and check charge status.
The TLD5542-1 is an LED driver, so the charge algorithm is implemented in the Arduino, therefore it is highly customizable.

Scope and purpose

The scope of this user manual is to provide the reader with instructions on the usage of the TLD5542-1CHG_SHIELD shield for Arduino.

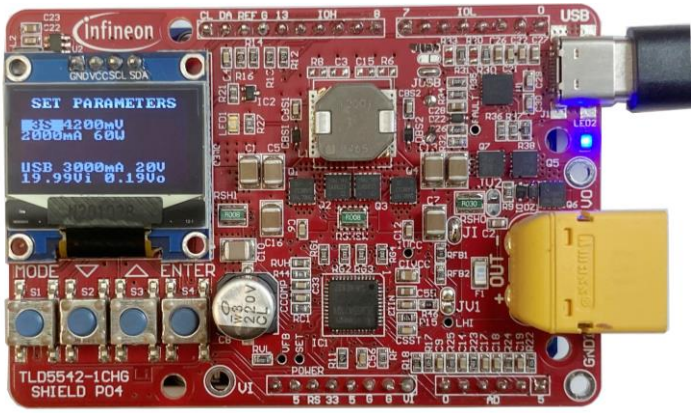


Figure 1 TLD5542-1CHG_SHIELD

Intended audience

Hardware engineers, software engineers, system architects, Makers

Evaluation Board

This board will be used during design-in, for evaluation and measurement of characteristics, and proof of data sheet specifications.

Note: PCB and auxiliary circuits are NOT optimized for final customer design.

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Safety precautions

Note: Please note the following warnings regarding the hazards associated with development systems.

Table 1 Safety precautions

	***Caution:** Lithium batteries may explode if not treated correctly. Special care has to be taken if the TLD5542-1CHG_SHIELD is used as battery charger for Lithium batteries*
	**Caution:** *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	**Caution:** *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*

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2 Description

Core of the shields is the TLD5542-1, a 4-switch buck-boost converter, which is among the most efficient buck-boost topologies for high current applications. The device has an SPI interface and an analog input current monitor, therefore it is suitable for an Arduino DC-DC application.

A CYPD3177 barrel cable replacement IC, which requests the maximum power profile available at the USB-PD adapter, is present on the board. The Arduino microcontroller can easily read the USB PDO (Power Data Objects) values via I2C from the CYPD3177.

The battery charger algorithm is implemented in the Arduino, therefore it is highly customizable. The output voltage is monitored by Arduino ADCs with an external reference voltage with 0.2% accuracy.

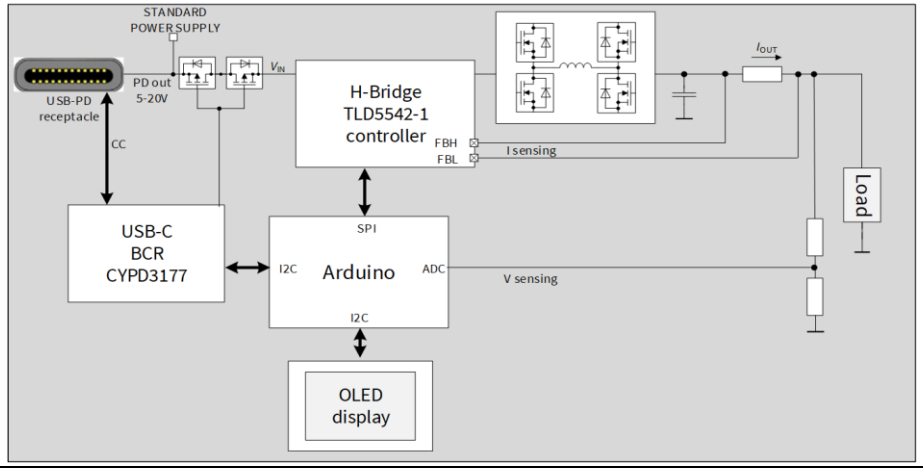


Figure 2 TLD5542-1CHG_SHIELD block diagram

The shield can be powered either by a USB-PD adapter, or by a standard 12 V power supply, and it can be configured as:

- Battery charger
- Adjustable voltage regulator
- LED driver

Upload the relevant sketch to the Arduino UNO board and apply the correct solder jump configuration.

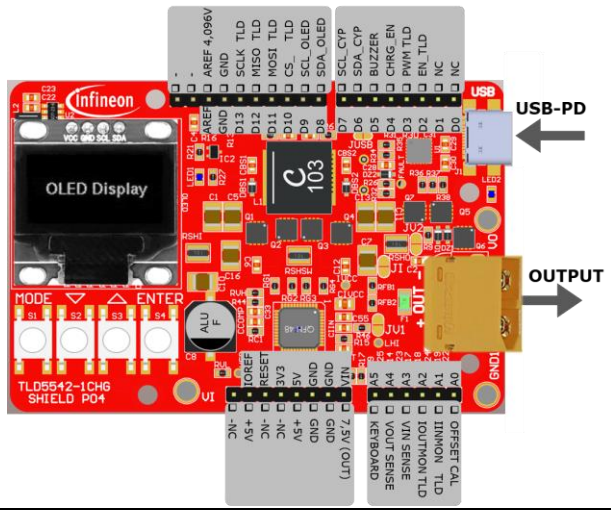


Figure 3 TLD5542-1CHG_SHIELD pinout configuration

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2.1 Special attention when using as charger

Lithium batteries may explode if not treated correctly. Special care has to be taken if the TLD5542-1CHG_SHIELD is used as battery charger:

- Use only with a charger sketch specific for the battery chemistry installed
- Use only if the shield solder jumpers are set for battery charger and NOT for voltage regulator
- Use only to charge protected batteries[1)]
- Never charge batteries without supervision
- Set proper charging parameters before operating. Setting the parameters incorrectly will result in damage to the product, personal property and may cause serious injury as well.
- Check if the voltage/current values are read correctly by the shield, comparing the ADC readings with a multimeter

The user assumes all responsibility and liability for proper and safe handling of the materials. Furthermore, the user indemnifies Infineon from all claims arising from the handling or use of the materials. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

1) Even when using protected batteries, pay attention, output voltage may reach 32 V for a short time in case the battery is overcharged because the protection disconnects the battery from the charger. This could damage some protection PCBs making them ineffective. The safest approach would be to change the overvoltage setting (R_{VH} and R_{VL} resistor) to remain just few volts above the selected battery maximum voltage.

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3 Quick start procedure

In the following paragraphs, step by step procedures are laid out for setting up and running the shield in all available configurations.

All through-hole components are provided but due to cost reduction, may not be attached to the shield for example, pin-headers, XT60 connector and buzzer, they have to be soldered by the end user.

Place the buzzer on the bottom-side of the PCB, see Figure 7.

Both battery charger and LED driver are current regulators, so they use the same hardware configuration. Please upload only the appropriate sketch for the desired functionality, see Chapter 4 for details on the 2 sketches.

3.1 Battery charger or LED driver - powered by USB-PD

1. Set solder jumpers for current regulator and USB-PD supply: see Figure 4
2. Upload the desired sketch (TLD5542-1CHARGER for battery charger or TLD5542-1LED_DRV for LED driver)
3. Plug the TLD5542-1CHG_SHIELD on the Arduino UNO board

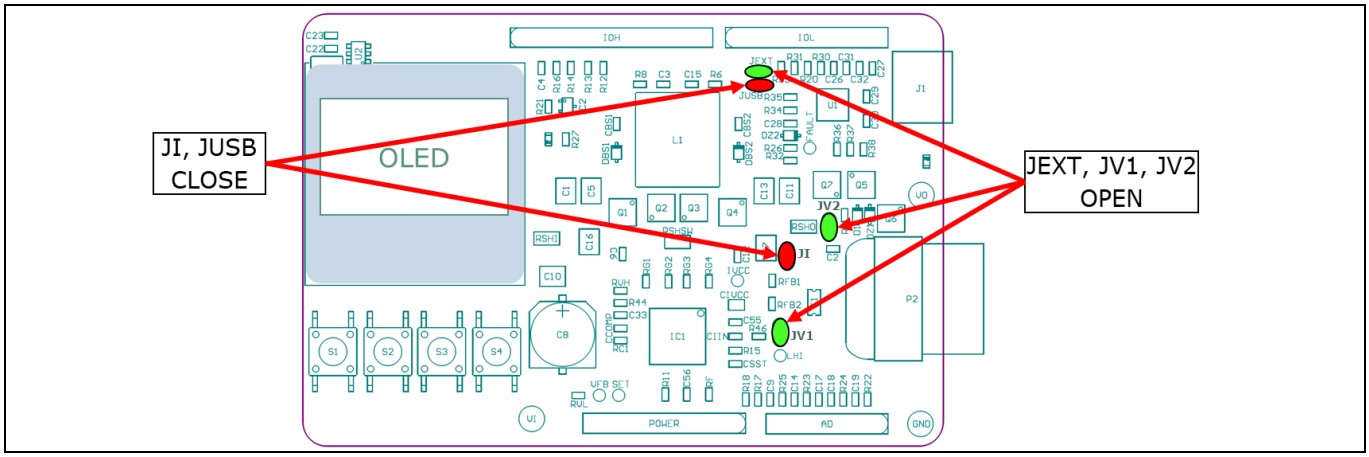


Figure 4 Set jumpers for charger mode powered by USB-PD

4. Connect a USB-PD adapter (recommended ≥ 18W) to J1 USB connector
5. Connect the load (LED or battery) depending on the installed sketch to the OUT connector P2

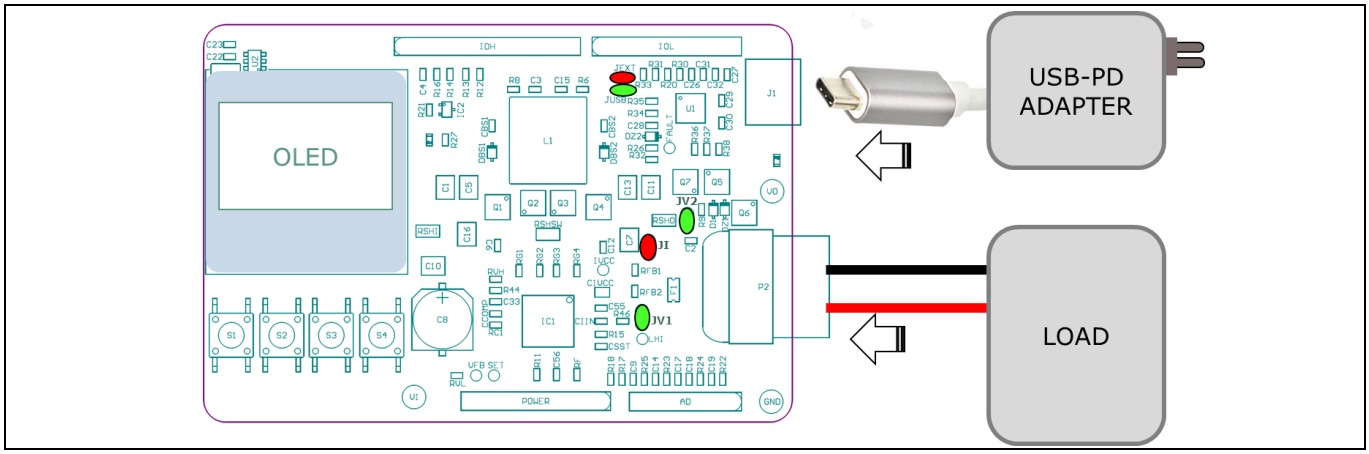


Figure 5 Connect power supply and the load (battery or LED depending on the installed sketch)

6. Set charge or LED driver parameters and start charging (see chapter 4)

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3.2 Battery charger or LED driver - powered by standard power supply

1. Configure solder jumper for battery charger and external standard power supply: see Figure 6
2. Upload the desired sketch (TLD5542-1CHARGER for battery charger or TLD5542-1LED_DRV for LED driver)
3. Plug the TLD5542-1CHG_SHIELD on the Arduino UNO board

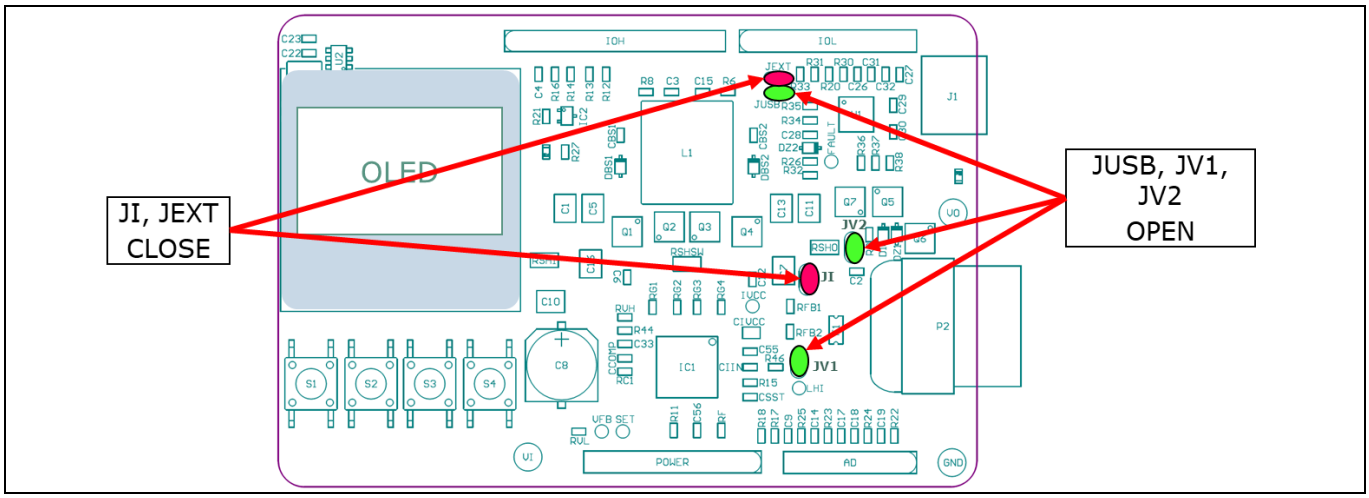


Figure 6 Set jumpers for charger mode powered by standard power supply

4. Solder 2 wires at the bottom of the PCB at the EXT power supply pads: see Figure 7
5. Connect a POWER supply 9 V to 30 V (see power derating profile): see Figure 15
6. Connect the load (LED or battery) depending on the installed sketch to the OUT connector P2
7. Set charge or LED driver parameters and start charging (see Chapter 4)

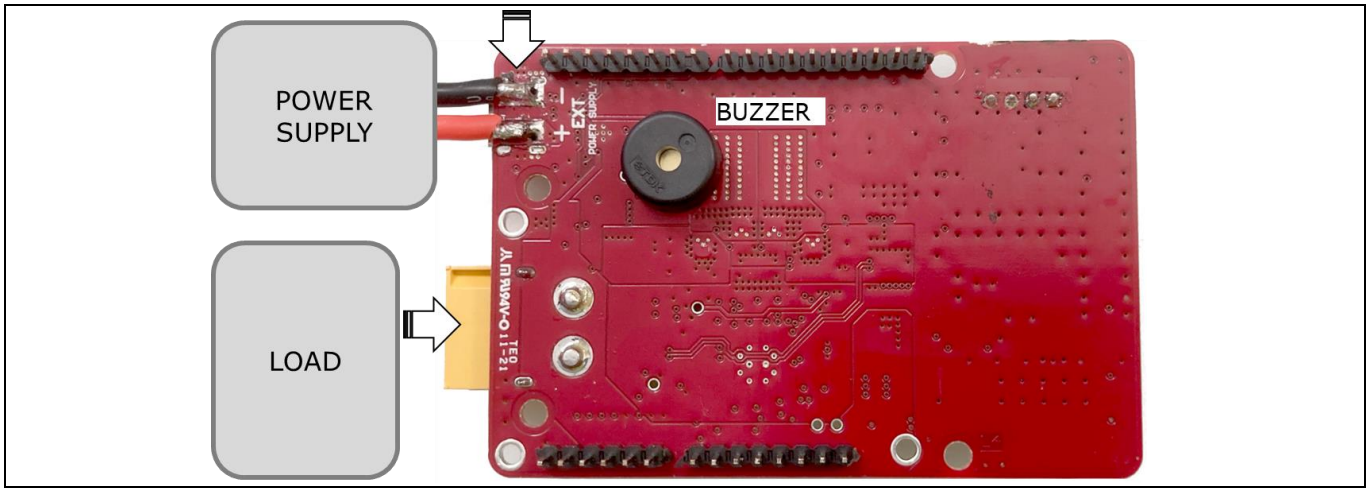


Figure 7 Solder power supply wires at the shield EXT pads

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3.3 Voltage regulator - powered by USB-PD

1. Configure solder jumpers for voltage regulator and external standard power supply: Figure 8
   Upload the TLD5542-1VREG sketch to Arduino UNO board and plug in the TLD5542-1CHG_SHIELD

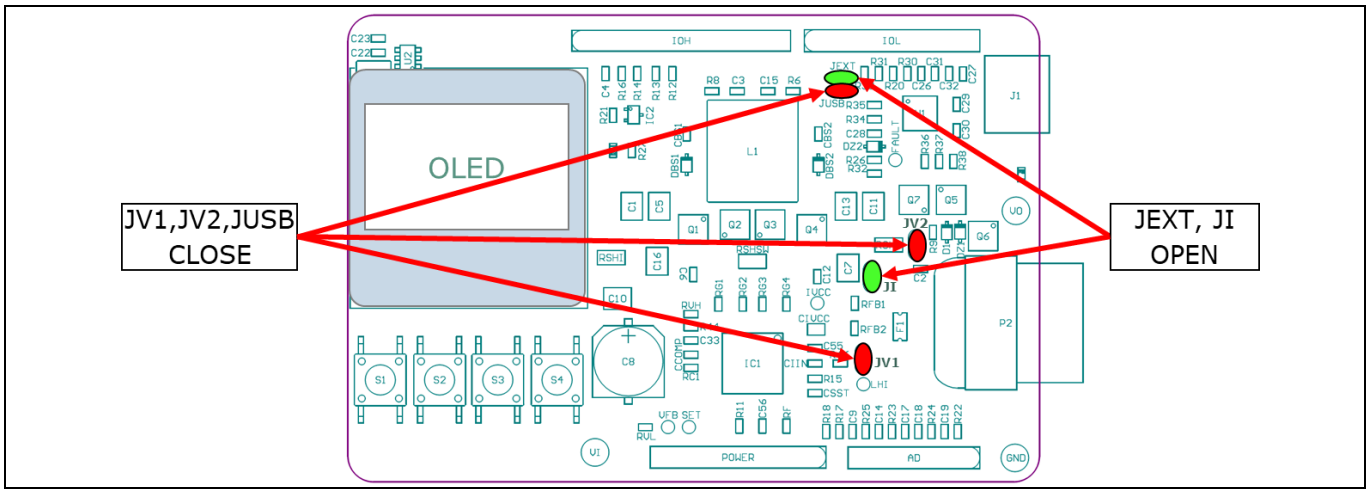


Figure 8 Jumpers set for voltage regulator mode powered by USB-PD

2. Connect a USB-PD adapter (recommended ≥ 18 W)
3. Connect the load
4. Set the desired voltage regulator parameters(see Chapter 4)

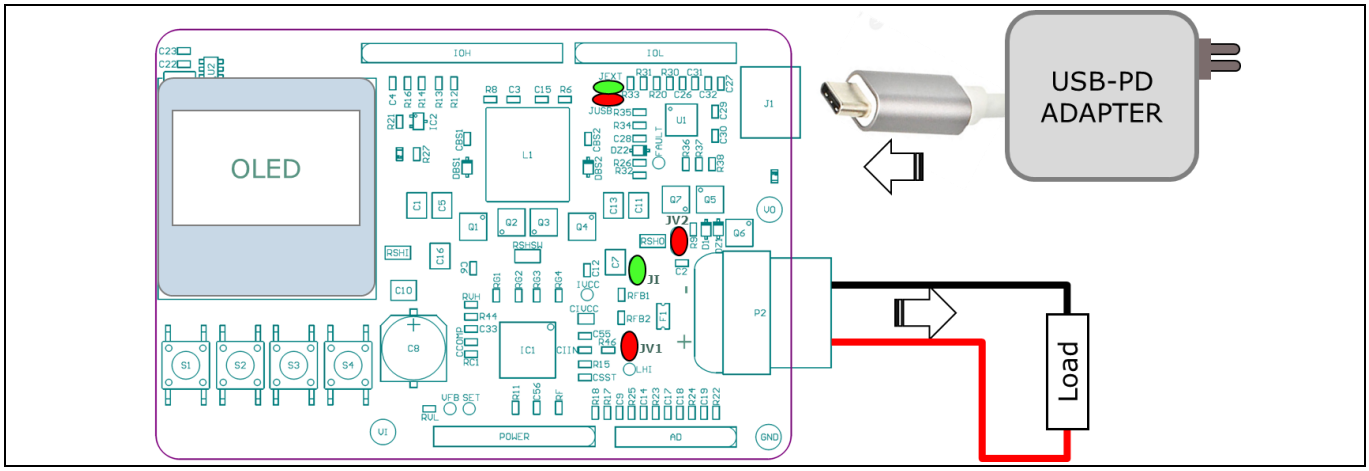


Figure 9 Connect power supply and the load

Note: *Load for the voltage regulator cannot be a battery because the shield could be damaged*

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3.4 Voltage regulator - powered by standard power supply

1. Configure jumpers for voltage regulator and external standard power supply, see Figure 10

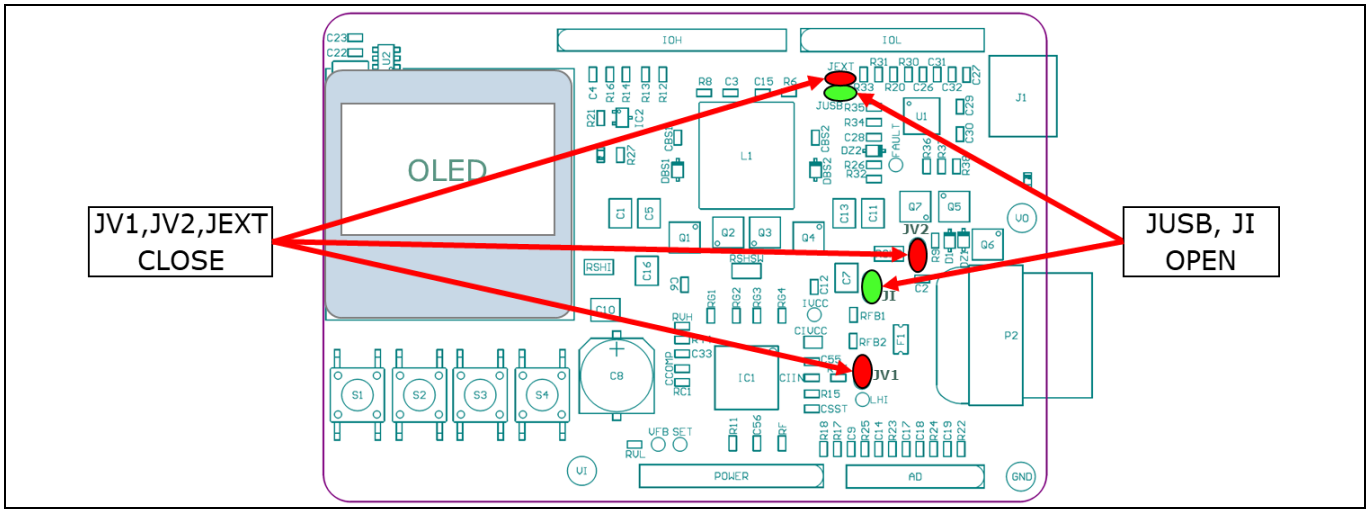


Figure 10 Jumper set for voltage regulator mode powered by standard power supply

2. Upload the TLD5542-1VREG sketch to Arduino UNO board and plug in the shield
3. Solder 2 wires at the bottom of the PCB at the EXT power supply pads: Figure 7
4. Connect the load.
5. Set the desired voltage regulator parameters(see Chapter 4)

Note: *Load for the voltage regulator cannot be a battery or the shield could be damaged*

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4 Quick start procedure software

This section provides a short description of the 3 main sketches for the TLD5542-1CHG_SHIELD.

Every sketch implements basic protection functions such as:

- Short circuit protection
- Input maximum power limiter
- Input under voltage

The user can set the maximum input power sink by the shield, the sketch will automatically lower the output current/voltage with the aim of keeping the input power below the selected power.

4.1 Charger sketch

The TLD5542-1CHARGER sketch transforms the shield into a lithium battery charger.

The first displayed screen allows the user to set several battery charging parameters: cell count, final cell voltage, charge current, maximum input power limit. The charger algorithm will automatically lower the output current to remain below the selected maximum power.

The cell count can be set from 1 to 6 cells. Depleted cells below 3 V will not be charged and therefore it is important to set the correct cell count on the parameter. There is no balance plug, so the sketch cannot detect unbalanced cells.

The push-button functionalities are:

- MODE button: switch from a parameter to another one, the selected parameter is highlighted
- ARROW buttons: the selected parameter increases or decreases
- ENTER button: battery starts charging with the chosen values

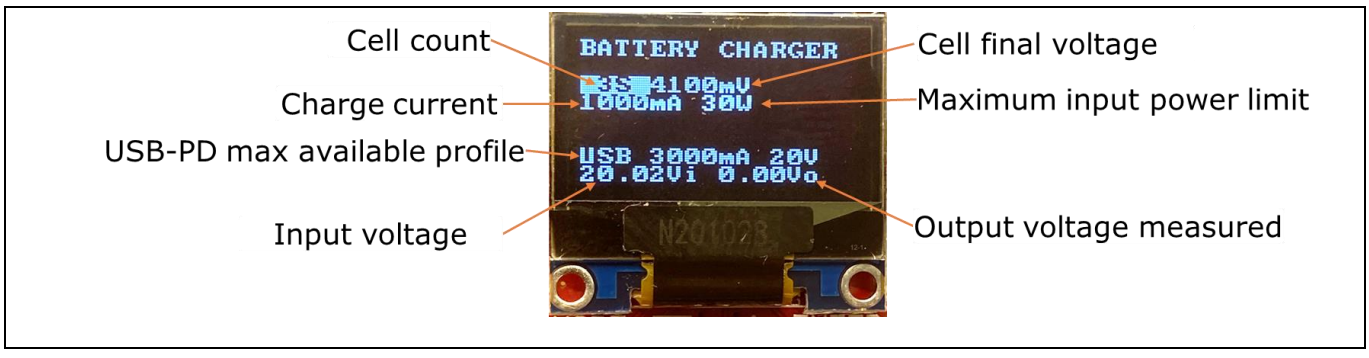


Figure 11 TLD5542-1CHARGER sketch, set parameters screen

The last 2 rows of the screen present measured parameters.

If a USB-PD adapter is connected to the shield, the software will request the highest available power profile, and this will be reported on the screen. While charging, the display shows charging variables as shown in Figure 12.

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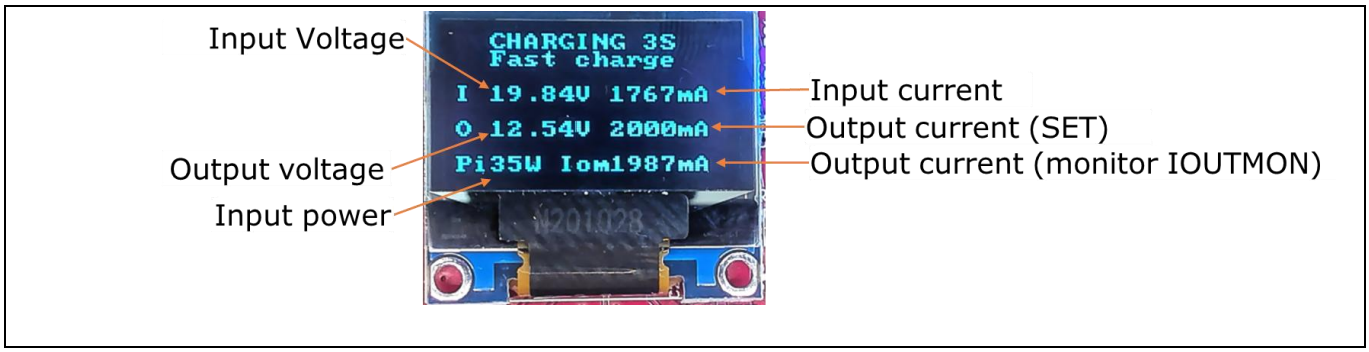


Figure 12 TLD5542-1CHARGER sketch, charging screen

Any button pressed during the charging phase interrupts the charging process.

4.2 Voltage regulator sketch

The TLD5542-1VREG sketch transforms the shield into an adjustable voltage regulator.

The first displayed screen allows the user to set several voltage regulator parameters: V_{OUT}, and maximum input power limit. The voltage regulator algorithm will automatically lower the output voltage to remain below the selected maximum power.

The push-button functionalities are:

- MODE button: switch from a parameter to another one, the selected parameter is highlighted
- ARROW buttons: the selected parameter increases or decreases
- ENTER button: turns ON/OFF the output voltage

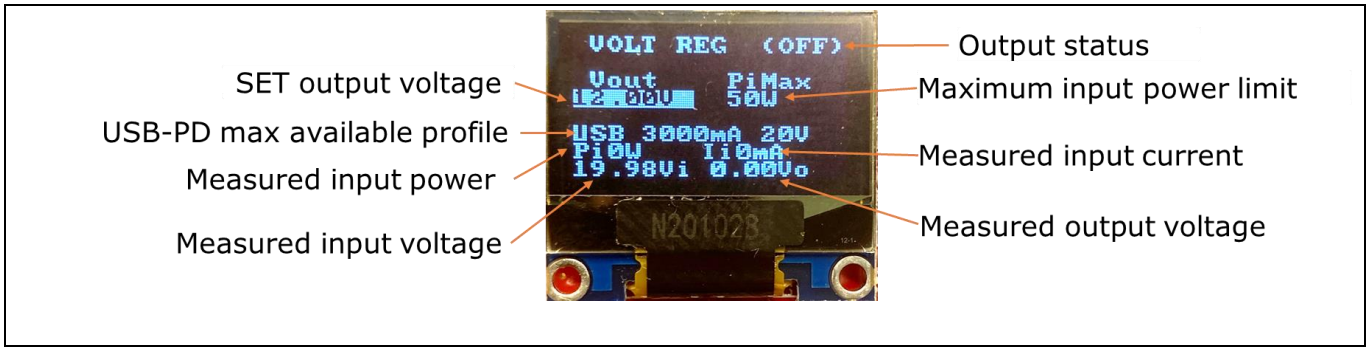


Figure 13 TLD5542-1VOLTAGE sketch, main screen

The last 3 rows of the screen present measured parameters.

If a USB-PD adapter is connected to the shield, the software will request the highest available power profile, and this will be reported on the screen.

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4.3 LED driver sketch

The TLD5542-1LED sketch transforms the shield into an LED driver, where the user can set output current and PWMI duty cycle.

The shield has X7R ceramic capacitors for automotive applications, these capacitors have strong piezoelectric effect, so if a PWM, smaller than 100% is applied, a buzzing noise will be produced because of the V_{OUT} variations. For ambient lighting application, the best dimming method is the analog dimming, achieved by reducing the driving current while keeping PWM to 100%. This method is flicker free, and also good for video recording.

The first displayed screen allows the user to set several LED driver parameters: output current, maximum input power limit and PWM Duty cycle. The LED driver algorithm will automatically lower the output current to remain below the selected maximum power.

The push-button functionalities are:

- MODE button: switch from a parameter to another one, the selected parameter is highlighted
- ARROW buttons: the selected parameter increases or decreases
- ENTER button: turns ON/OFF the output current

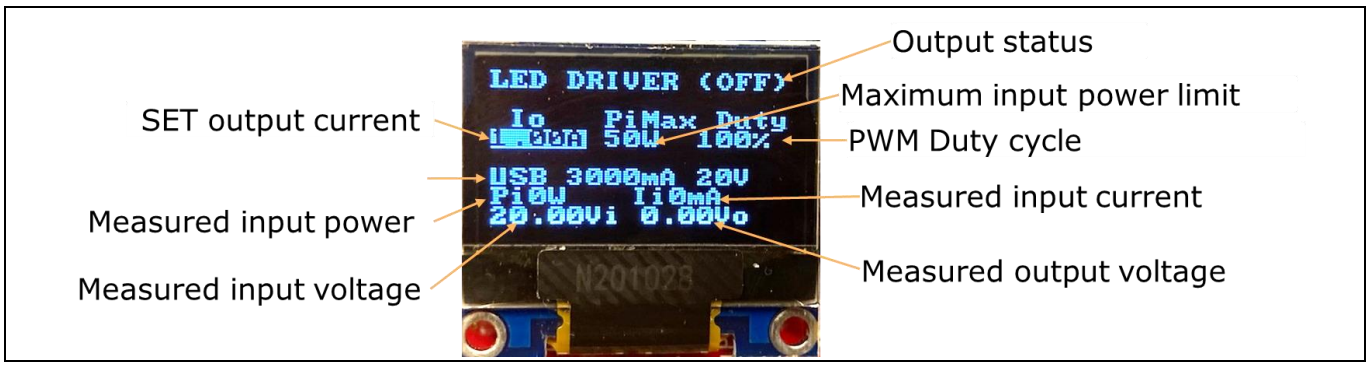


Figure 14 TLD5542-1LED sketch, main screen

The last 3 rows of the screen present measured parameters.

If a USB-PD adapter is connected to the shield, the software will request the highest available power profile, and this will be reported in the screen. The user can then limit the maximum input power sink by the shield to avoid exceeding the power capability of the adapter or the external power supply.

The LED driver sketch detects a short circuit at the output and shuts down the regulator if a voltage below 3 V is measured at the output.

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5 Operating range and power derating

The TLD5542-1CHG_SHIELD has very high efficiency, so it can deliver up to 65 W at the output without a heat sink at T_A = 25°C, V_{IN} = 20 V (see Figure 15 for power-derating curve).

Note: *The module does not implement thermal protection, so ensure proper cooling or software power derating if an enclosure is applied, or if ambient temperature is higher than 25°C.*

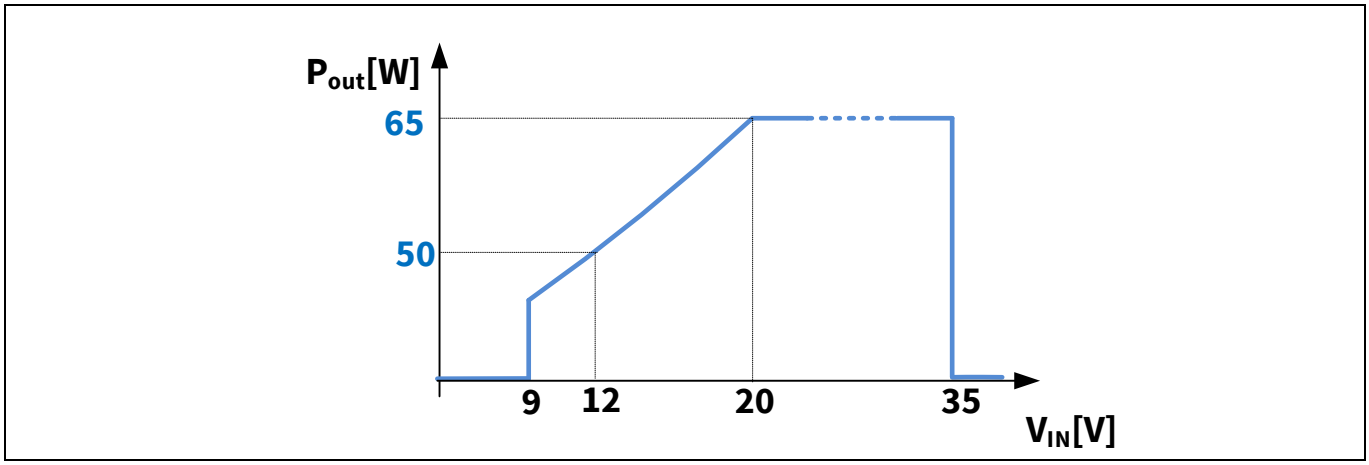


Figure 15 Output power derating curve (T_A = 25°C)

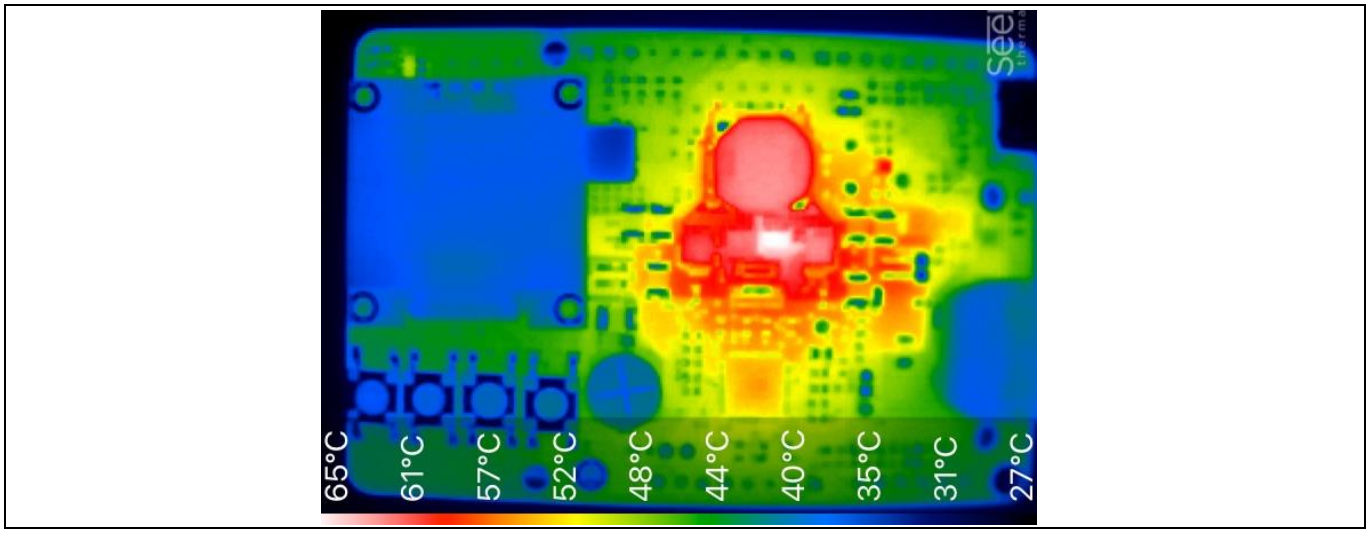


Figure 16 Thermal, P_{OUT} = 64 W, T_A = 25°C, V_{IN} = 20 V, V_{OUT} = 20 V, I_{OUT}= 3.2 A

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6 Electrical characteristics

Table 2 TLD5542-1IVREG-EVAL version S01 P01 – electrical characteristics

Parameter	Symbol	Value			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Input voltage	V_{IN}	7	–	35	V	Power derating may occur for V_{IN} < 9 V
Outout voltage	V_{OUT}	3.2 3.5	–	30 25	V	Current mode Voltage mode
Output current	I_{OUT}	0	–	5	A	
Output power	P_{OUT}	–	–	65	W	V_{IN} 20 V, T_A = 25°C No Enclosure
Switching frequency	Switching frequency	–	385	–	kHz	Spread spectrum deviation is present
System efficiency	η	–	95	–	%	
Accuracy voltage	Acc_V	1			%	V_{OUT} = 30 V
Accuracy current	Acc_I	3			%	I_{OUT} = 5 A

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7 Bill of material, PCB layout and schematic

Table 3 Bill of material P05 S05

Designator	Value	Footprint	Quantity
C1, C5, C7, C10, C11, C13, C16	10uF 50V X7R 1210	C1210	7
C2, C23, C25, C26, C27, C28, C55,CIIN	1uF 35V	C0603	8
C3, C15	560pF 50V	C0603	2
C4, C6, C9, C12, C14, C17, C19, C20, C22, C24, C31, C32, C56, CBS1, CBS2	100nF 50V 0603	C0603	15
C8	220uF 35V(Nichicon UCL1V221MNL1GS)	CE D8 CASE F	1
C21, C33, CSST	10nF 50V 0603	C0603	3
C29, C30	390pF 50V	C0603	2
CCOMP	22nF 25V X7R 5% 0603	C0603	1
CIVCC	10uF 16V 0805 X7R	C0805	1
D1, DBS1, DBS2	NXP_BAT46WJ	SOD323F	3
DZ1, DZ2	ZENER 15V(MM3Z15VT1G)	SOD323	2
F1	Belfuse 8A 0685T8000-01	FUSE S1206	1
IC1	TLD5542-1QV	VQFN48 7X7 P05	1
IC2	ADR5044AKSZ	SC70	1
J1	USB4110-GF-A	GCT_USB4110-GF-A_revA	1
L1	TDK SPM10065VT-100M-D (10uH)	IND SMD XAL1010	1
L2	10uH Tayo NR4018T100M	IND SMD XAL4030	1
LED1, LED2	BLUE WURTH 150080BS75000	LED 0603 ROSSO	2
Q1, Q2, Q3, Q4, Q6	IAUZ30N06S5L140	PG-TSDSON-8-32	5
Q5, Q7	BSZ086P03NS3	PG-TSDSON-8 SGD	2
R1	3k 1%	R0603	1
R2, R3, R4, R5, R27, R29	1k5 1%	R0603	6
R7, R17, R22,R23	100k 0.1%	R0603	4
R9	220k 1%	R0603	1
R10, R19, R25, R26, R28, R30, R31, R34, R35, R38, RVL	10k 1%	R0603	11
R11, R12, R13, R14, R15, R16	470 5%	R0603	6
R18, R24	10k 0.1%	R0603	2
R21, R32, RC1	1k 1%	R0603	3
R36, R37	3k3 1%	R0603	2
R40, R41	0 Ohm	R0603	2
R44	1k5 1% 0603	R0603	1
RG1, RG2, RG3, RG4	10 Ohm	R0603	4

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Bill of material, PCB layout and schematic

Designator	Value	Footprint	Quantity
R46,R47 ,R8,R6	4.7 Ohm	R0603	4
RF, RFB2	27k 1% 0603	R0603	2
RFB1	150 0603	R0603	1
RSHI, RSHSW	8mOhm 0612 1% susumu PRL1632-R008-F-T1	R0612-4P	2
RSHO	30mOhm 0612 1% susumu PRL1632-R030-F-T1	R0612-4P	1
RVH	220k 1% 0603	R0603	1
S1, S2, S3, S4	TE 1571563-8	PULS 6X6 TE 1571563-8	4
U1	CYPD3177-24LQXQ	QFN24 4x4 P0.5	1
U2	TPS560430YFQDBVRQ1	SOT23-6	1
R20, R33,R39, R42 ,C18	NOT POPULATED	0603	4
OLED	OLED128x64 MDOB128064V2V-YI	LCD 128X64	1
BUZ	PS1240P02BT	BUZZER D12.2 p5 h6.5	1
p2	XT60PW M	XT60PW-F	1

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8 Appendix – schematic and layout

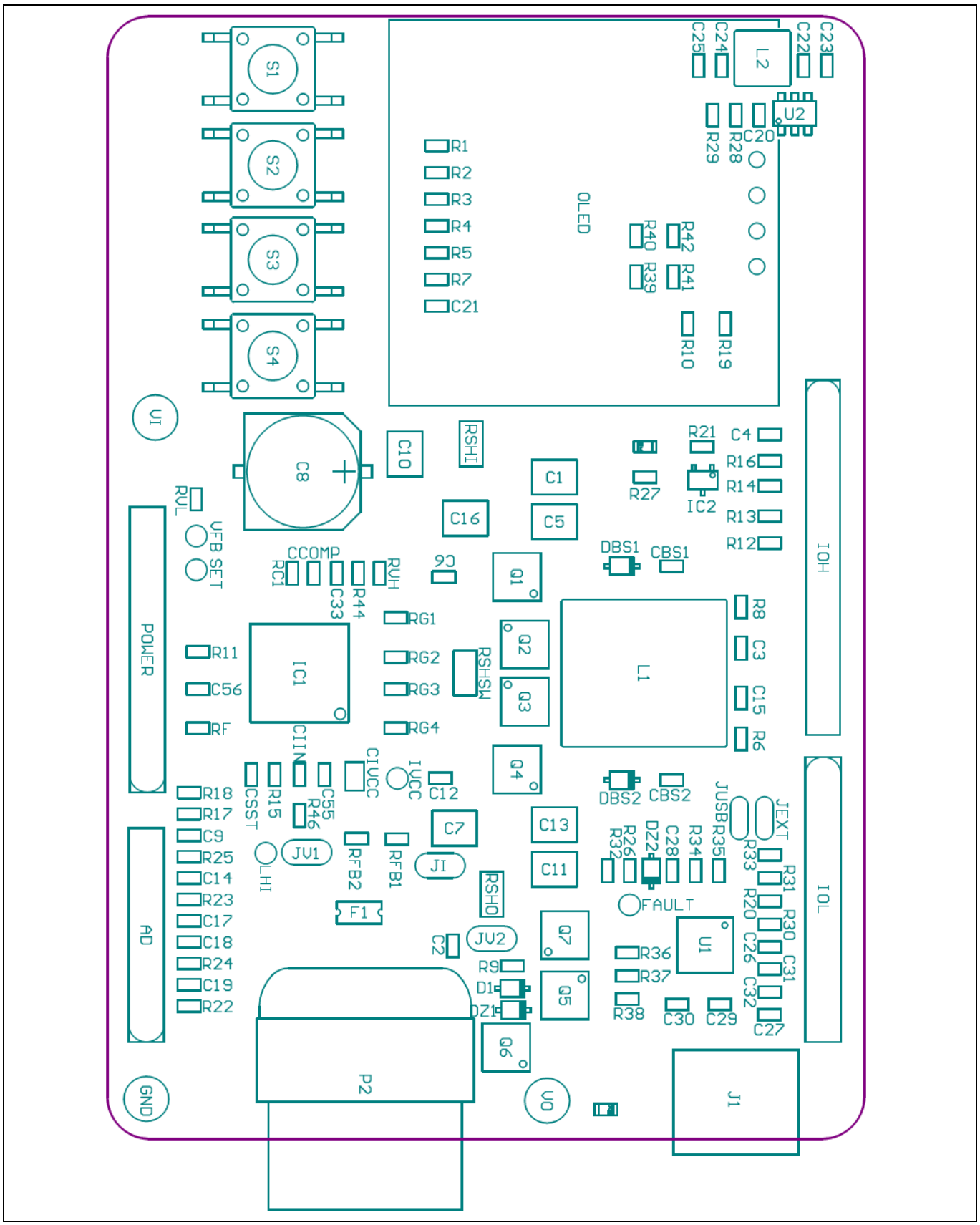


Figure 17 Component positioning

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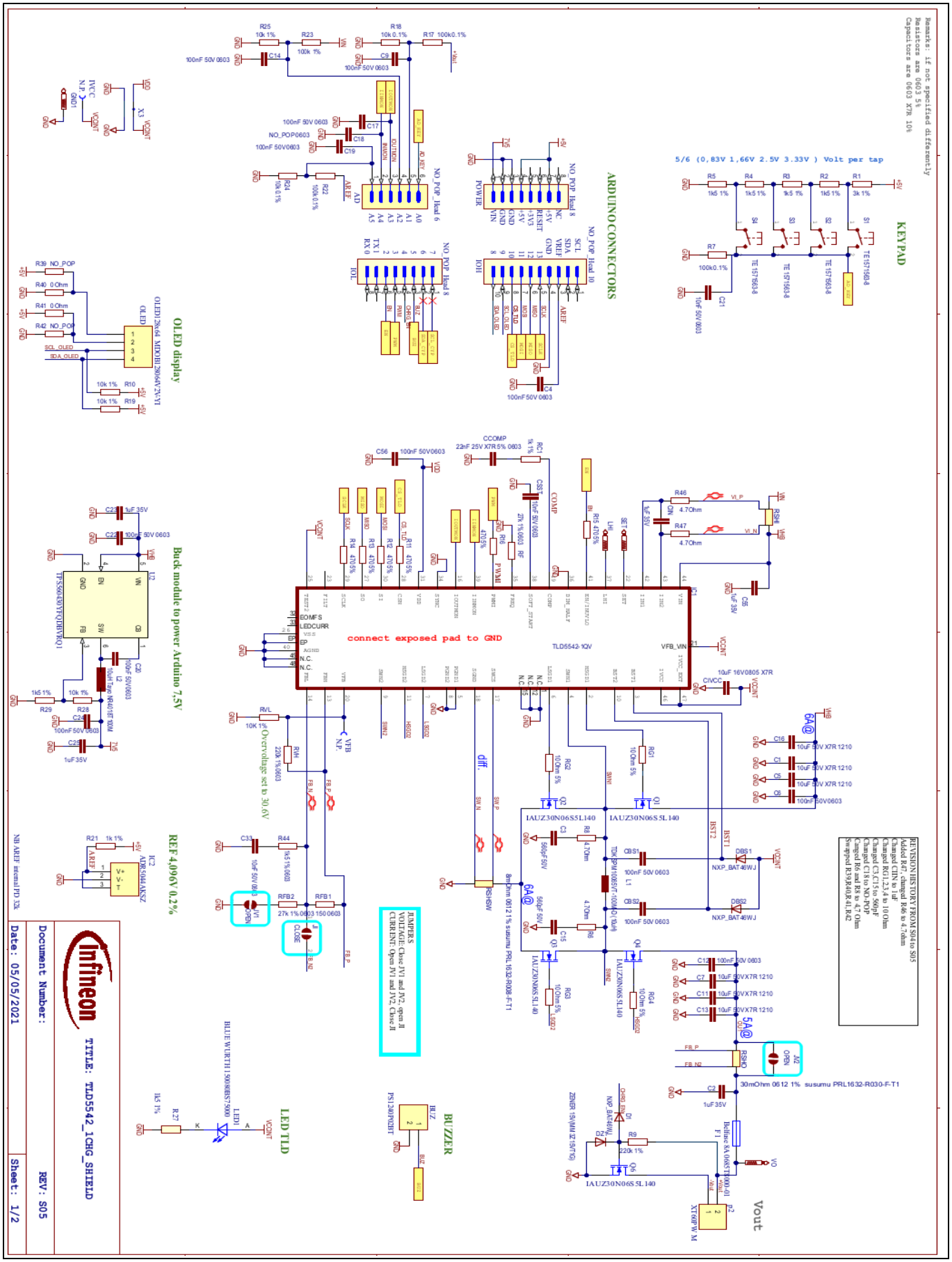


Figure 18 Schematic 1/2

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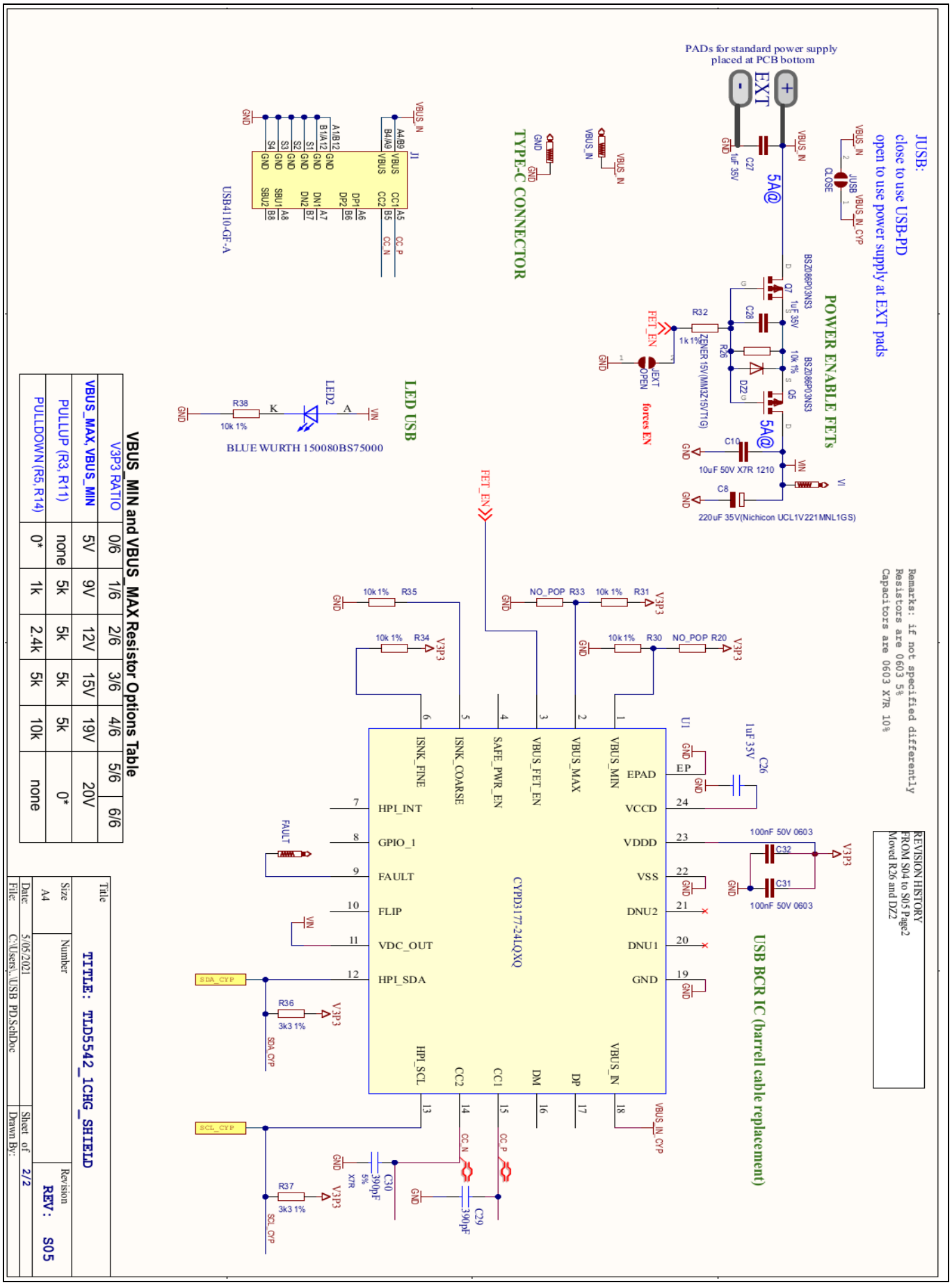


Figure 19 Schematic 2/2

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Revision history

Document version	Date of release	Description of changes
Rev. 1.00	2021-05-17	Initial User guide

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