TLD7002-16SHIELD

User guide

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About this document

Scope and purpose

The TLD7002-16SHIELD is an LED driver shield compatible with Arduino UNO. The TLD7002-16ES is a 16 independent-channel-LED driver with individual output current from 5 mA to 76 mA and UART over CAN interface.

The scope of this user manual is to provide instructions on use of the TLD7002-16SHIELD for a jump-start on the TLD7002-16ES programming with the simple Arduino IDE.

This user guide describes the TLD7002-16SHIELD with PCB version P03 and P04 in which, only thermal vias are changed. Additionally, schematic version S03 is described.

This board will be used during design-in, for evaluation and proof of concepts for new projects adopting the TLD7002-16ES.
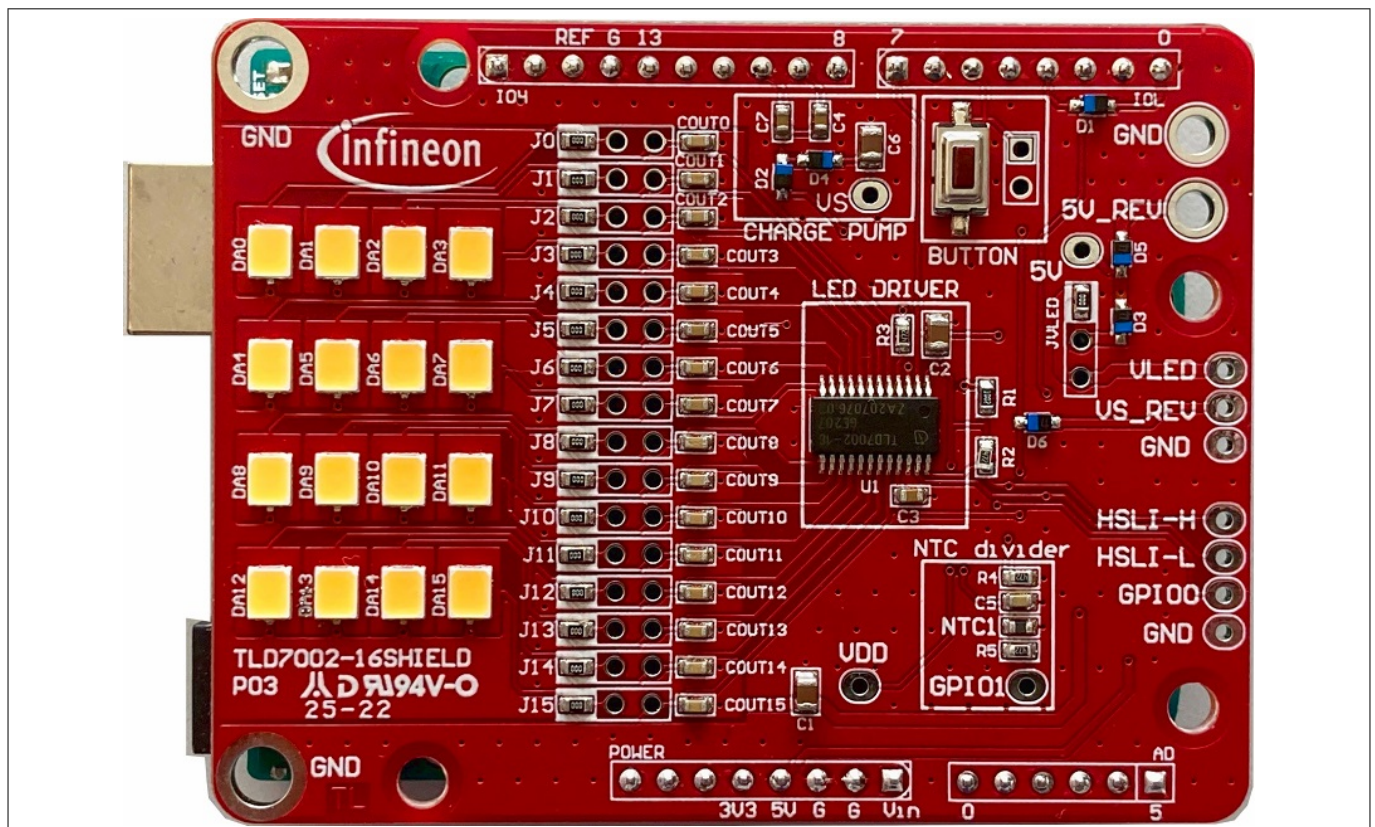

Figure 1   **TLD7002-16SHIELD**

Intended audience

Hardware engineers and software engineers

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1 Description

The core of the shields is the TLD7002-16ES which features:

- Output current up to 16 x 76.5 mA
- UART over CAN interface up to 2 Mbit/s compliant with ISO11898-2 (2016) CAN physical layer
- 16 independent 14-bit PWM engines from 100 Hz up to 2 kHz
- Integrated diagnostics for load monitoring and device fault monitor
- ISO26262 compliant development up to ASIL B

The only needed connection from Arduino to drive 16 mid power LEDs is an UART interface and optionally the TLD7002-16ES GPIN0 pin, which acts as a chip-select during the TLD7002-16ES one time programmable (OTP) memory programming/emulation.

1.1 UART over CAN interface connections

The TLD7002-16ES has an UART over CAN physical layer interface called HSLI (High Speed Lighting Interface) which is a differential BUS. The HSLIL output pin it is an open drain with a diode in series, and it can be connected directly to a standard UART with a simple workaround without the need for a transceiver. The resulting logic levels on the RX and TX pins are not CMOS or TTL compliant, and they will have slightly reduced noise margin compared to standard CMOS gates.
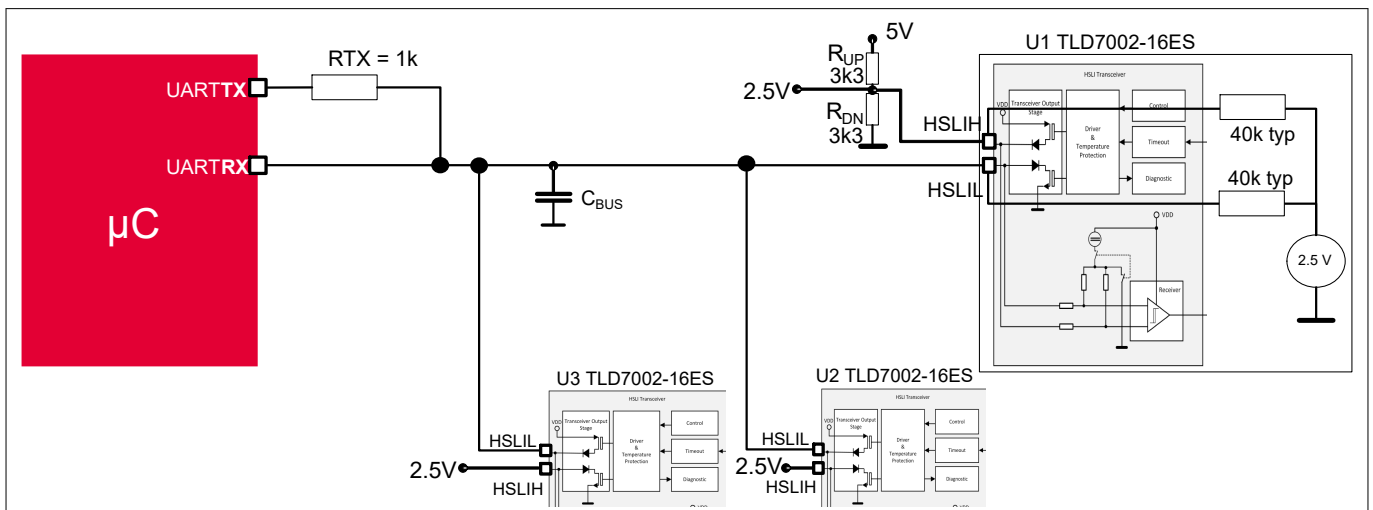

Figure 2   **TLD7002-16ES direct UART connection**

Arduino has an internal pull up on the RX pin therefore, instead of the resistor on the TX pin, a diode is placed on the TX pin. See Figure 3.
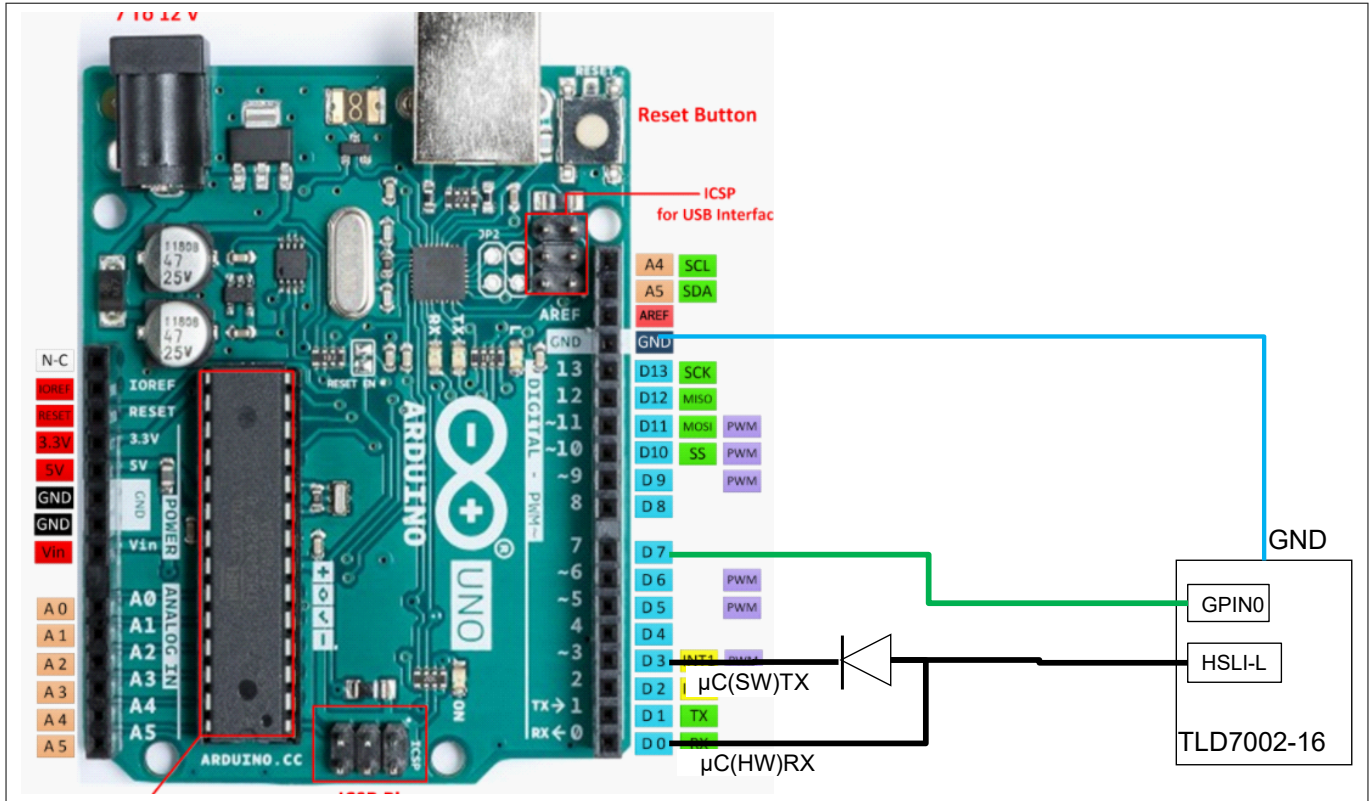
Figure 3   TLD7002-16SHIELD HSLI interface and GPIN0 connections

The TLD7002-16ES UART has a 200 kbps minimum speed. In order to have the serial monitor prints available for debugging, the TLD7002-16ES has been connected to a soft serial port for the Arduino TX, and a hardware serial port for the Arduino RX signal. UART speed has been set to a standard 230400 bps.

This soft/hard serial division is needed because the soft serial cannot handle 230 kbps in reception, and therefore it is not possible to have both soft serial for TX and RX connected to TLD7002-16ES UART. The soft serial library has been slightly modified in order to handle the 230 kbps with reduced delay on adjacent bytes.

The Arduino UNO can be programmed even if the TLD7002-16SHIELD is plugged into the Arduino.

1.2   TLD7002-16ES Power supply options

The TLD7002-16ES applications has 2 supply rails:

- V_S to power TLD7002-16ES device (VS pin, 6 V to 20 V functional range)
- V_{LED} to power the LEDs

Since its outputs are linear current sources, when possible is better to keep V_{LED} voltage close to the LED load voltage plus the TLD7002-16ES dropout, to limit the power dissipation on the LED driver. Since the load is only 1 LED per output, the recommended V_{LED} is approximately 4 V, while the V_S must be higher than 6 V.

In order to avoid 2 power supplies connected to the TLD7002-16ES shield, and to supply the board directly by the Arduino USB, a charge pump has been designed on Arduino pin 9 and 10. The power supply connections are illustrated below.
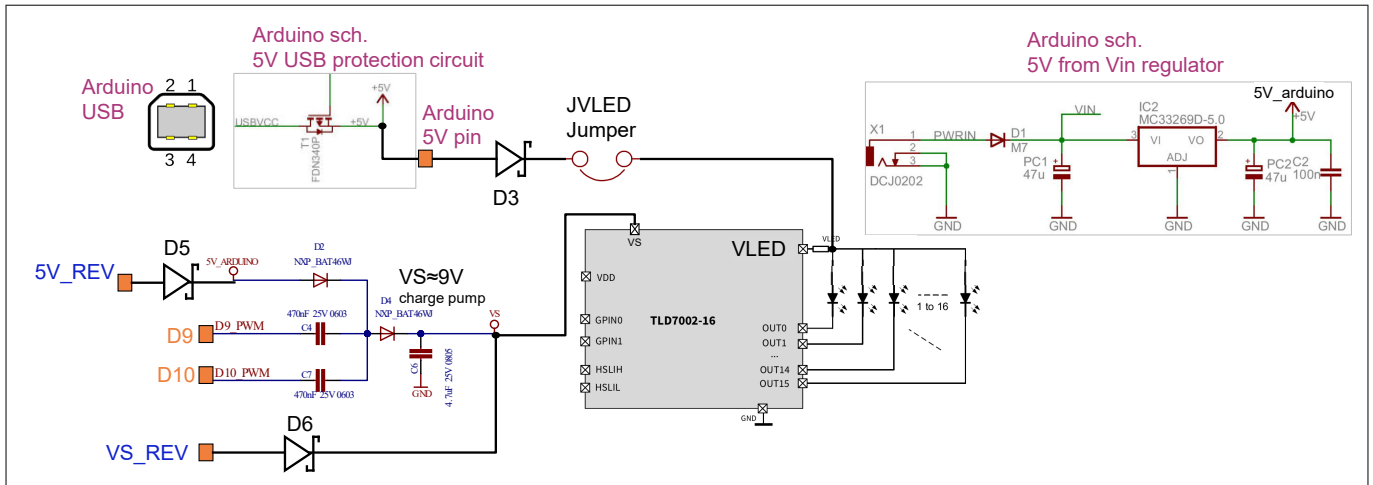
1 Description

Figure 4   **TLD7002-16SHIELD power supply connections with Arduino UNO R3**

The TLD7002-16ES output currents can be as high as 76.5 mA per channel, for a total current of 1224 mA in case all outputs are on @100% duty. The current setting on the TLD7002-16ES outputs must be adjusted in order to avoid damages to the Arduino UNO circuitry.

In the provided sketch, the LED current has been set to 20 mA for a total LED current of 320 mA.

The board can be powered in several ways:

- Arduino USB B connector
  - Keep total LED current below 400 mA to avoid damages to Arduino T1 transistor, see Figure 4
- Powering the Arduino VIN port with 7 V to keep power on the Arduino LDO (IC2) low
  - Keep total LED current below 400 mA
- Providing external 5 V to the Arduino 5V_REV test point with an external power supply
  - Keep total LED current below 800 mA to avoid damages to D5 and D3
  - Do not exceed 5.5 V or the the Arduino UNO board will be damaged
- Powering the Arduino with one power supply (Either at VIN or USB) while VLED is powered by an external power supply (4 V to 6 V is recommended). Remove JVLED Jumper for this option
  - Total LED current can go up to 1224 mA

2 Quick start procedure

A step-by-step procedure is laid out for setting up and running the shield.

1.   Download the TLD7002SHIELD_DEMO sketch from the TLD7002SHIELD webpage
2.   Plug the TLD7002SHIELD on the Arduino UNO board
3.   Connect the TLD7002SHIELD to the PC with a USB cable
4.   Download and open the Arduino IDE [1]
5.   Select the correct COM PORT on the **Tools** > **Port** menu
6.   Upload the TLD7002SHIELD_DEMO sketch in the Arduino UNO
7.   Press **BUTTON** on TLD7002-16SHIELD to change the animation
8.   Optional: open **Tools** > **Serial Monitor** and set the speed to 230400 bps to see diagnostic printf
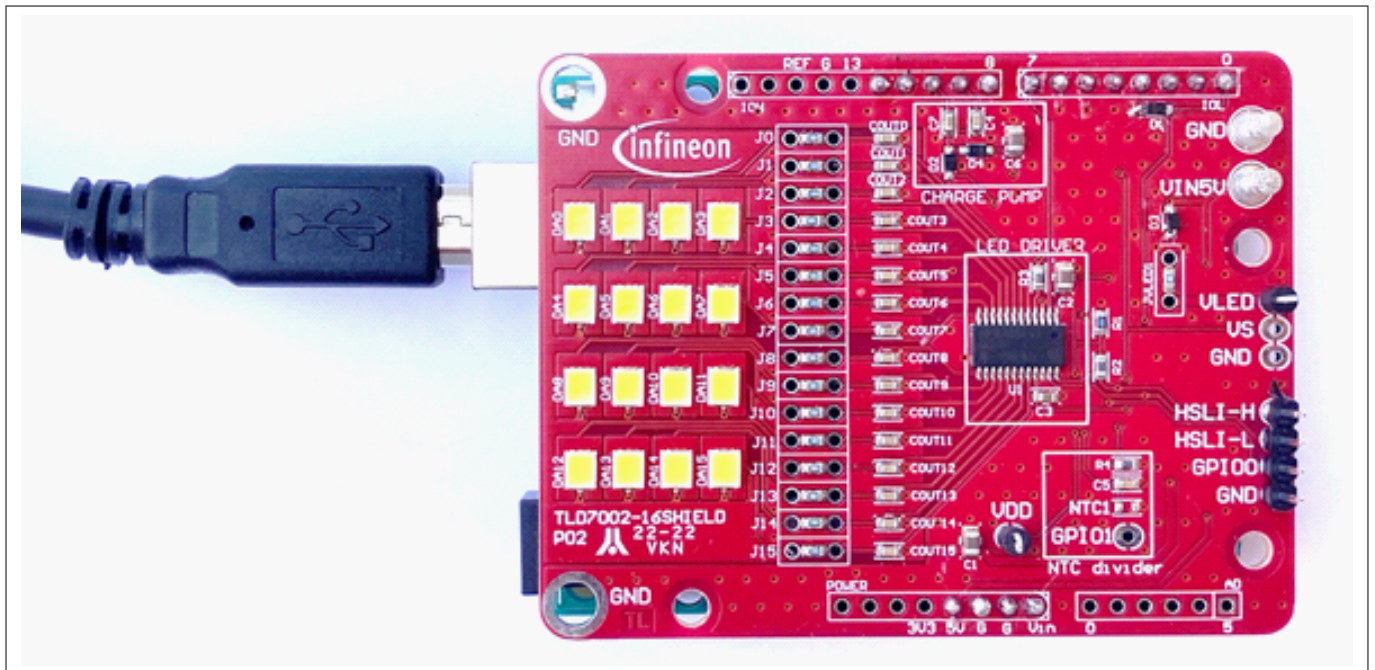

Figure 5   **TLD7002-16SHIELD plugged in the Arduino UNO with USB cable**

The TLD7002-16SHIELD is equipped with efficient white LEDs, therefore in order to keep the glare low, a duty cycle is set to 10% on the TLD7002-16DEMO sketch V.1.0. The brightness can be easily increased by modifying the provided sketch.

2.1 OTP configuration array and OTP wizard tool

The TLD7002-16SHIELD is assembled with a TLD7002-16ES device with unwritten OTP.

The TLD7002SHIELD_DEMO sketch V.1 initialize the TLD7002-16ES device by emulating the LED driver OTP with a hard-coded configuration array:

```
const uint16 OTP_hex_cfg[] = {0x0000, 0x0000, 0x0000, 0x0000, 0x4D4D...};
```

This is needed because the TLD7002-16ES cannot be in ACTIVE mode if the OTP has not been written or emulated.

A different configuration array can be easily generated by the OTP wizard tool. The OTP wizard is a GUI/tool used to easily configure the OTP memory of the TLD7002-16ES device.

The OTP configuration array is prepared in advance. This can be easily achieved by clicking save configuration in the OTP wizard tool. The configuration array is located at the end of the .ocfg saved file: in the HEX_DATA_16BIT field. The file is of txt format and can be opened with a text editor.

The OTP wizard GUI is installed via the Infineon Developer Center Launcher (IDC) [2] following one of the 2 installation paths:

Infineon Developer Center [3]: online repository listing all available tools, software and services

Launcher [4]: offline utility to manage and update all tools after downloading from the IDC online repository

Once IDC is installed, run it and click on **Manage Tools**.

Figure 6   **Manage Tools**

Then search for **OTP Wizard** (point 1) and click on **Install** (point 2).
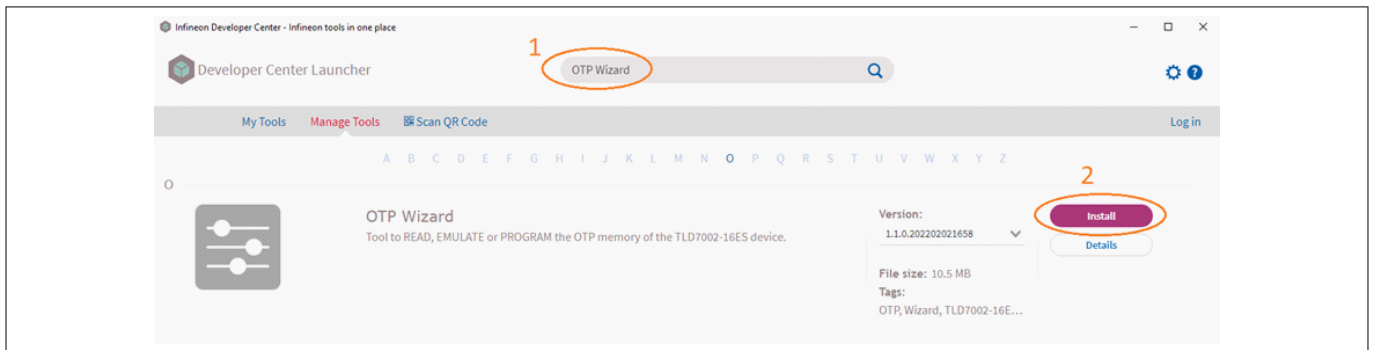
Figure 7   **Searching Tools**

Once OTP wizard installation has completed, select **My Tools tab** (point 3) in Infineon Toolbox, then click on **Start** (point 4) in OTP Wizard to start the tool.
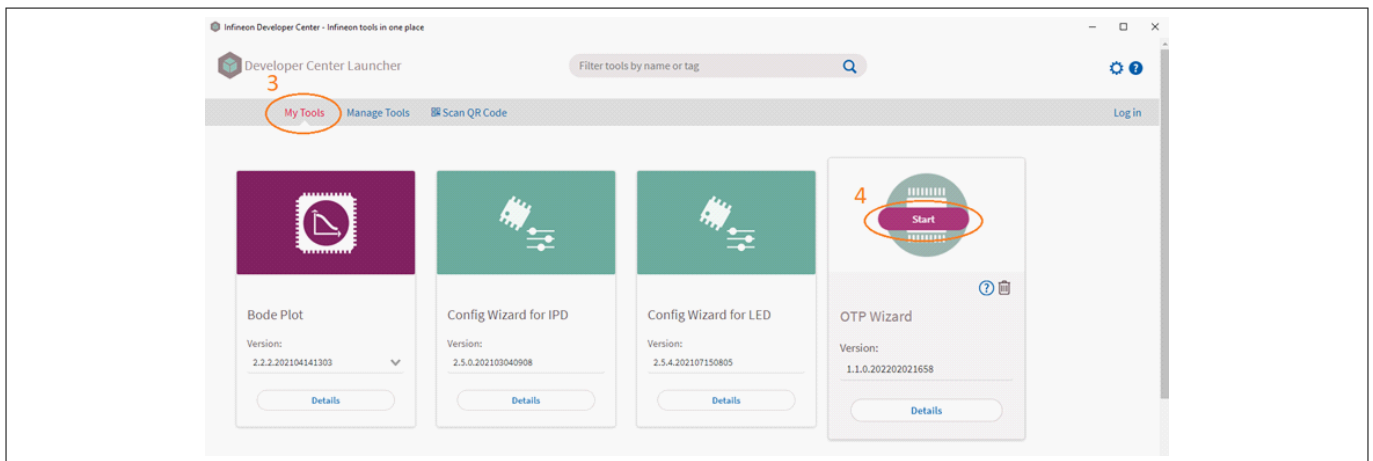
Figure 8   **Starting the OTP Wizard GUI**

3 Electrical characteristics

Table 1 **Electrical characteristics**

Parameter	Symbol	Values			Unit	Note or test condition
		Min.	**Typ.**	**Max.**		
Input voltage	V_{IN_5V}	4.5	5	5.5	V	V_{IN_5V} is directly connected to Arduino 5 V, voltage higher than 5.5 V will damage your Arduino UNO
Input current	I_{IN_5V}	50	470	1300	mA	TLD7002SHIELD_DEMO sketch sets OUT current to 25 mA per channel. If duty cycle is modified to 100% and all outputs are ON, then the 5 V current will be approximately 470 mA
LED power supply	V_{LED}	4.5	–	35	V	V_{LED} can be as low as 0 V if JVLED jumper is open and JVLED resistor not populated
TLD7002-16ES power supply	V_S	6	–	20	V	–
Output voltage	V_{OUT_n}	0	–	20	V	Diagnostic setting has to be adapted in the OTP configuration file for the shield to be used with different loads
Output current	I_{OUT_n}	5.6	–	76.5	mA	TLD7002SHIELD_DEMO V1 is set to 25 mA
PWM frequency	f_{PWM}	99.9	–	1997	Hz	–

The input current on the TLD7002-16SHIELD is equal to the sum of all of the following:

• The LED currents multiplied by their duty cycle
• The TLD7002-16ES supply current (VS pin) multiplied by 2, due to the charge pump
• The Arduino UNO supply current

In the provided sketch the output current is set to 20 mA per channel, if duty cycle is set to 100% and all outputs are ON, the current consumption would be approximately:

$$I_{5V\_REF} = I_{OUT\_n} \cdot 16 + I_{VS\_typ} + I_{ArduinoUNO\_typ} = 25mA \cdot 16 + 15mA \cdot 2 + 40mA = 470mA \qquad (1)$$

4 Bill of material

Table 2 **Bill of material**

Designator	Description	Footprint	Quantity
5V, GND3, GND4, GPIO0, GPIO1, HSLI-H, HSLI-L, VDD, VLED, VS, VS_REV	NO_POP_KEYSTONE 5117-1	TESTPAD KEYSTONE 5117-1	11
AD	NO_POP_Head 6	STRIP 6V P2.54 MD	1
BUTTON	PTS636 SK25F SMTR LFS	PULS 6,1X3,5 SMD C&K PTS636 F	1
C1, C2, C6	4.7uF 25V 0805	C0805	3
C3, C4, C7	470nF 25V 0603	C0603	3
C5	100nF 16V 0603	C0603	1
COUT0, COUT1, COUT2, COUT3, COUT4, COUT5, COUT6, COUT7, COUT8, COUT9, COUT10, COUT11, COUT12, COUT13, COUT14, COUT15	10nF	C0603	16
D1, D2, D3, D4, D5, D6	BAS3010A-03W	SOD323F	6
DA0, DA1, DA2, DA3, DA4, DA5, DA6, DA7, DA8, DA9, DA10, DA11, DA12, DA13, DA14, DA15	JB2835AWT-W-H30	LED SMD 2835 CREE JE2835AWTE	16
IOH	NO_POP_Head 10	STRIP 10V P2.54 MD	1
IOL, POWER	NO_POP_Head 8	STRIP P2.54	2
J0, J1, J2, J3, J4, J5, J6, J7, J8, J9, J10, J11, J12, J13, J14, J15, JVLED	0R	0603	17
JBUT	NO_POP TSW-102-08-G-S	STRIP P2.54	1
NTC1	Mitsubishi TD11-3H103F NTC(0603 10K 3370K)	R0603	1
R1	10k 1% 0603	R0603	1
R2, R3, R4, R5	4k7 1% 0603	R0603	4
U1	TLD7002-16ES	PG-TSDSO-24	1

5 PCB layout
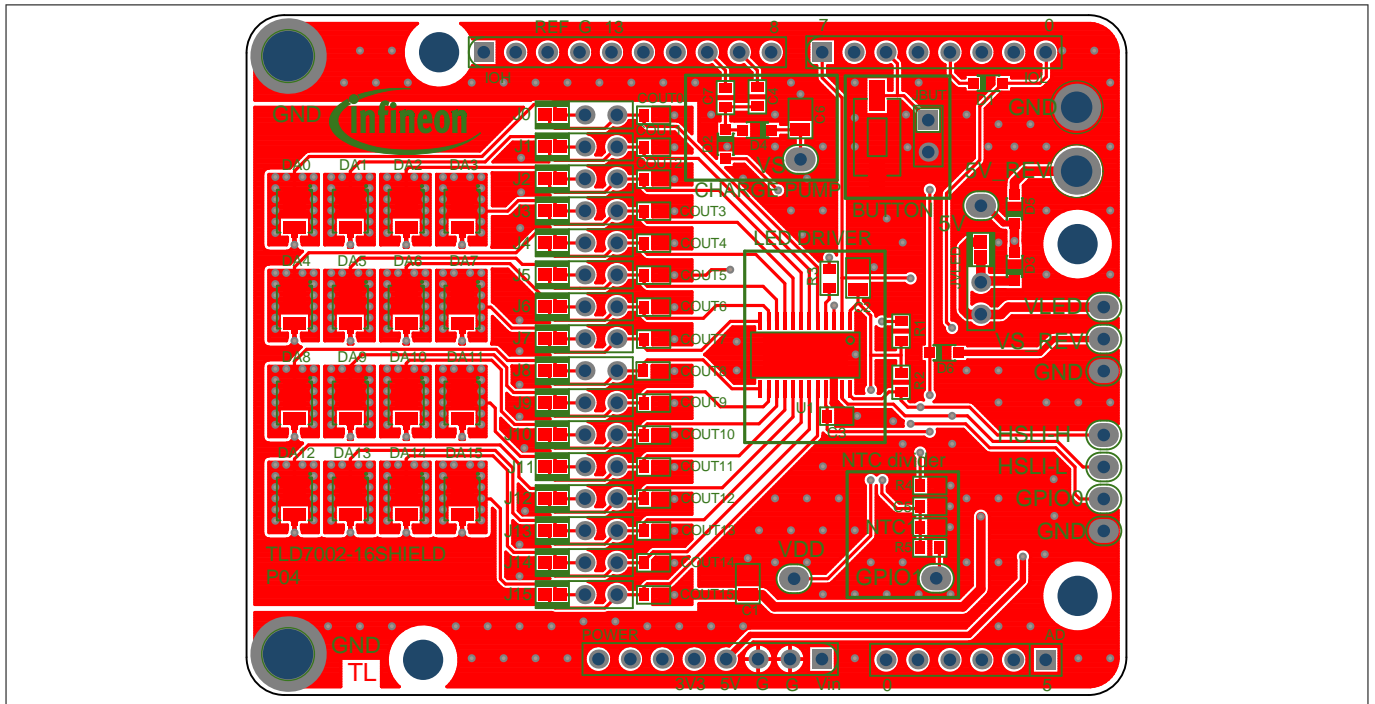
Figure 9 PCB layout top
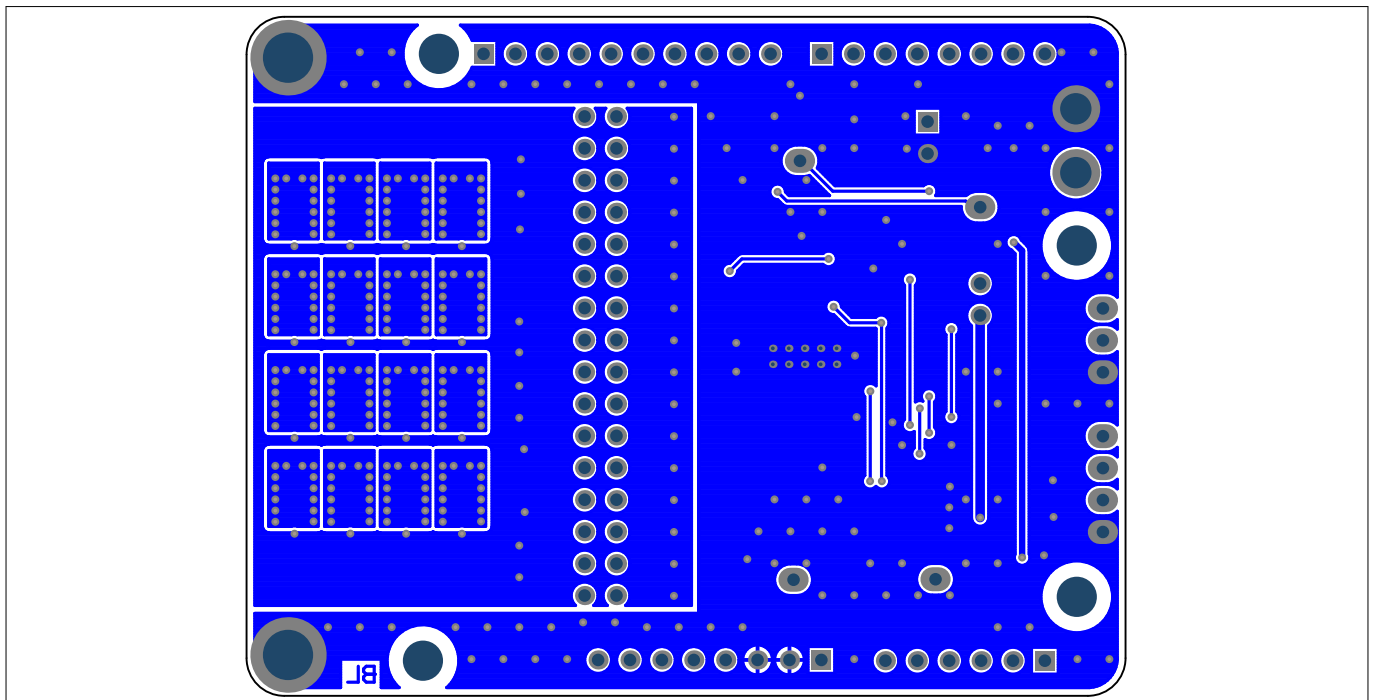
Figure 10 PCB layout bottom

6 Schematics
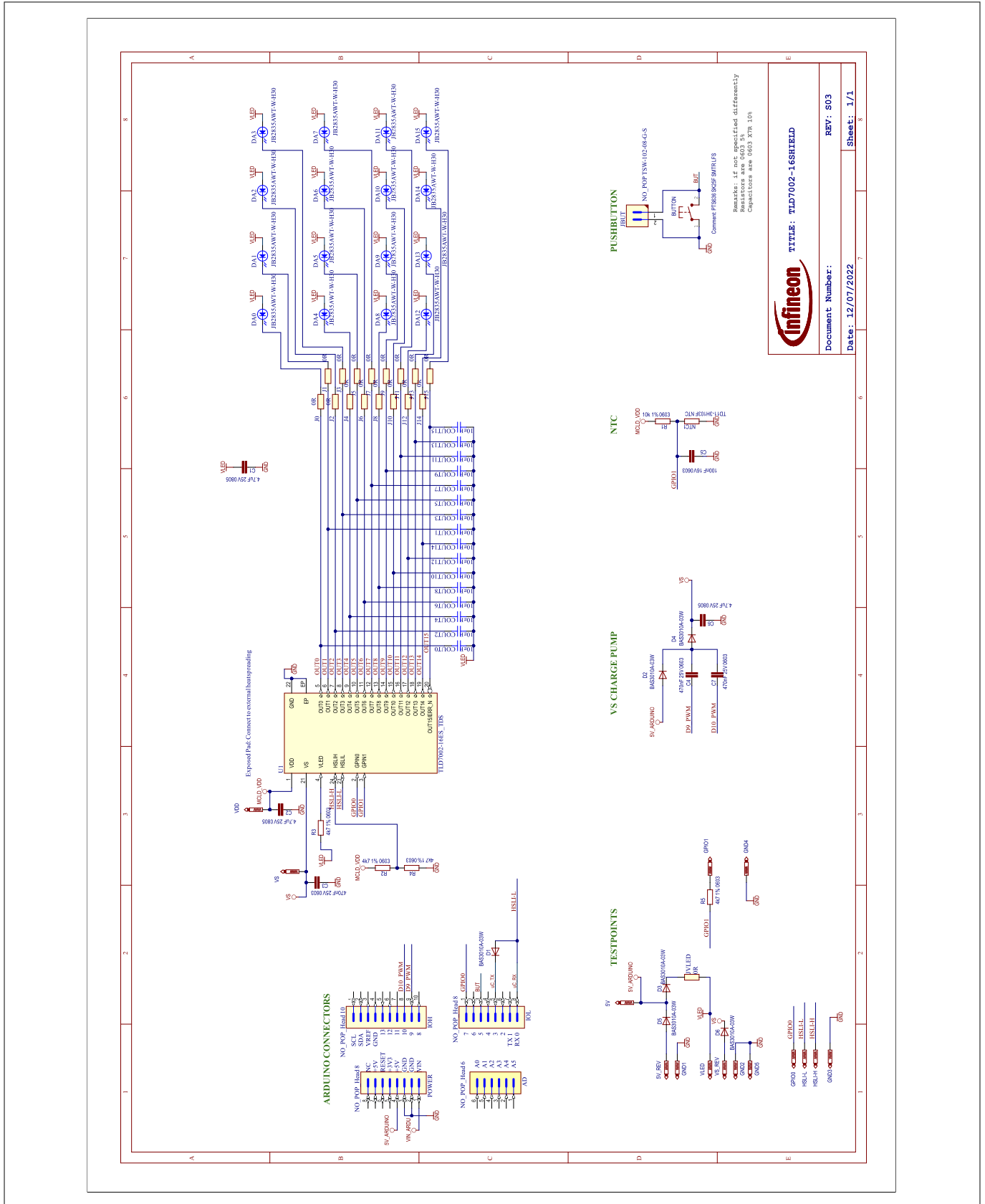
Figure 11 **TLD7002-16ES schematic**

References

[1]   *Arduino IDE downloads*; https://www.arduino.cc/en/software

[2]   *Infineon Developer Center Launcher* ; https://www.infineon.com/cms/en/design-support/tools/utilities/infineon-developer-center-idc-launcher/

[3]   *Infineon Developer Center*; https://softwaretools.infineon.com/welcome?_ga=2.13126193.788892259.1654090253-547430173.1617093564

[4]   *Launcher*https://softwaretools.infineon.com/tools/com.ifx.tb.launcher2

Revision history

Document version	Date of release	Description of changes
Rev.1.00	2022-07-26	• Initial release

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