TLD1173-1STD_EVAL

User guide

Z8F80490877

About this document

Scope and purpose

The TLD1173-1ET device used in this evaluation board, is an AEC qualified one channel linear current sink, especially designed to be used as a current regulator (low-side LED driver). The main features of this evaluation board are:

- Output current capability up to 400 mA
- Possibility to offload power consumption via low-cost external resistor to allow maximum current driving capability (power shift feature)
- Analog and digital dimming supported via output current control input to adjust the output current of the LEDs
- Configurable fault management (1-fail-all-OFF/1-fail-all-ON), open load (OL), short to battery (SC) and thermal shutdown protections
- Thermal derating function via external NTC resistor
- Sharing a common error network, compatible with other evaluation boards of LITIX™ Basic+ extension and LITIX™ Basic+ families

The scope of this user guide is to provide instructions on the use of the TLD1173-1ET evaluation board.

Intended audience

This document is intended for engineers who need to perform measurements and check performances with TLD1173-1ET evaluation board.

Evaluation board

This board is to be used during the design-in process for evaluating and measuring characteristic curves, and for checking datasheet specifications.

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

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Safety precautions

Safety precautions

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

Table 1 Safety precautions

	**Warning:** *The evaluation or reference board contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the drive system, wait five minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.*
	**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:** *Only personnel familiar with the drive, power electronics and associated machinery should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.*
	**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.*
	**Caution:** *A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.*
	**Caution:** *The evaluation or reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.*

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1 The board at a glance

The TLD1173-1STD_EVAL is a one-channel constant current regulator that, under nominal conditions, is designed to deliver high current up to 400 mA. The high current capability is allowed because of its power shift feature, that offload the power consumption via an external resistor.

The range of the input supply voltage that can be supported by TLD1173-1STD_EVAL board is between 8 V to 21 V. The input supply circuit is followed by a fuse and reverse polarity diode. The load is 1 x 3 white LEDs placed on the bottom side of the evaluation board. Depending on the connection of jumpers, it is possible to bypass the LEDs. It is also feasible to connect an off-board LED load, if desired.

The user of this evaluation board is able to implement analog and digital dimming.

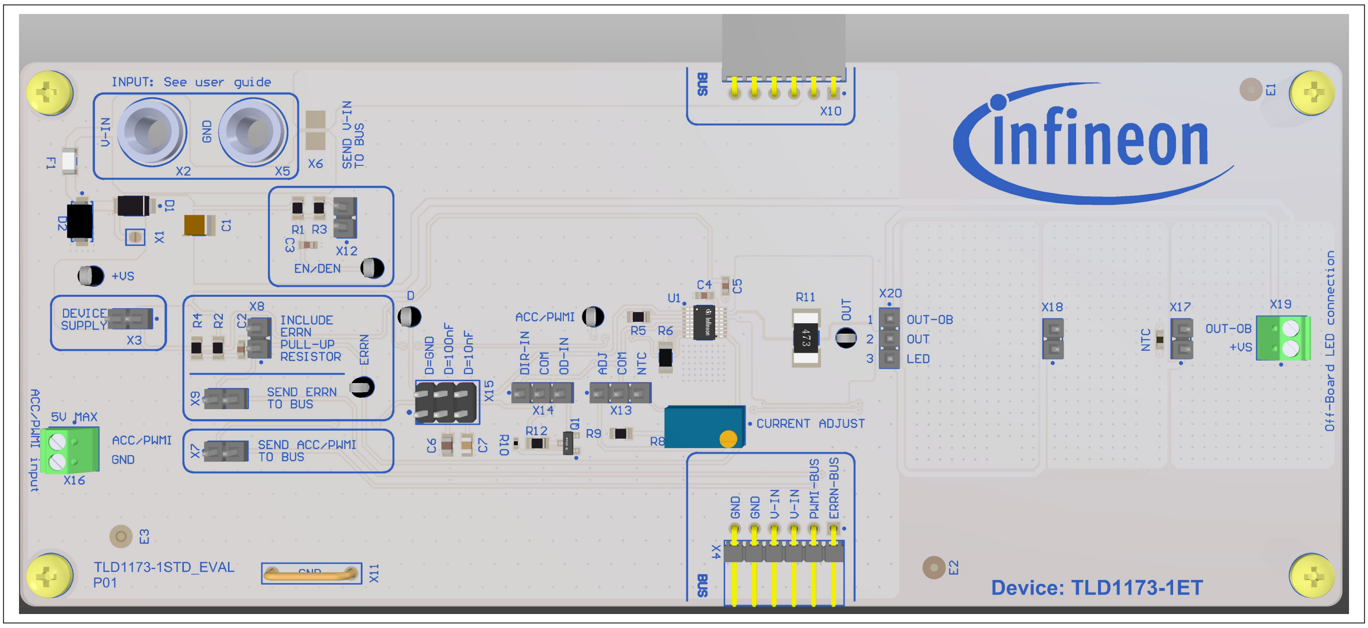

Figure 1 **TLD1173-1STD_EVAL**

1.1 Main features

- Power shift feature
- Output current capability up to 400 mA
- Analog and digital dimming supported via output current control input to adjust the output current of the LEDs
- Configurable fault management (1-fail-all-OFF/1-fail-all-ON), Open Load (OL), Short to battery (SC) and thermal shutdown protections
- Thermal derating function via external NTC resistor
- Sharing a common error network, compatible with other evaluation boards of LITIX™ Basic+ extension and LITIX™ Basic+ families

1.2 Board parameters

Table 2 Board parameters

Parameter	Symbol	Conditions	Value
Input supply voltage	V-IN	For 1 channel x 3 LED string For 1 channel x 2 LED string For 1 channel x 1 LED string	8 V to 21 V 8 to 18 V 8 to 15 V
Peak input supply voltage	$V\text{-}IN_{peak}$	Less than 1 s	27 V
Forward voltage of on-board LEDs	V_F	–	2.8 V (min.) 3.15 V (typ.) 3.4 V (max.)
Forward voltage of off-board LEDs	$V_{LED\_STRING\_OB}$	When • V_{IN} = 8 V to 21 V • $V_{SENSEx(reg)}$= 400 mV	6.5 V to 18.5 V
Maximum ambient temperature	T_A	–	40°C

2 Quick setup

The purpose of this “Quick setup”chapter is to indicate a quick way of turning on the device and to explain some basic functions, step-by-step.

2.1 Supply connection

The board is equipped with a banana type connector for the supply voltage. The supply voltage depends on the connected load and the maximum temperature allowed by the junction. For example, the 1 output channel with 3 white LEDs attached, the recommended supply voltage range is 8 V to 21 V.

More information can be found in Table 2 and in the schematics of the TLD1173-1STD_EVAL in Chapter 7.1.

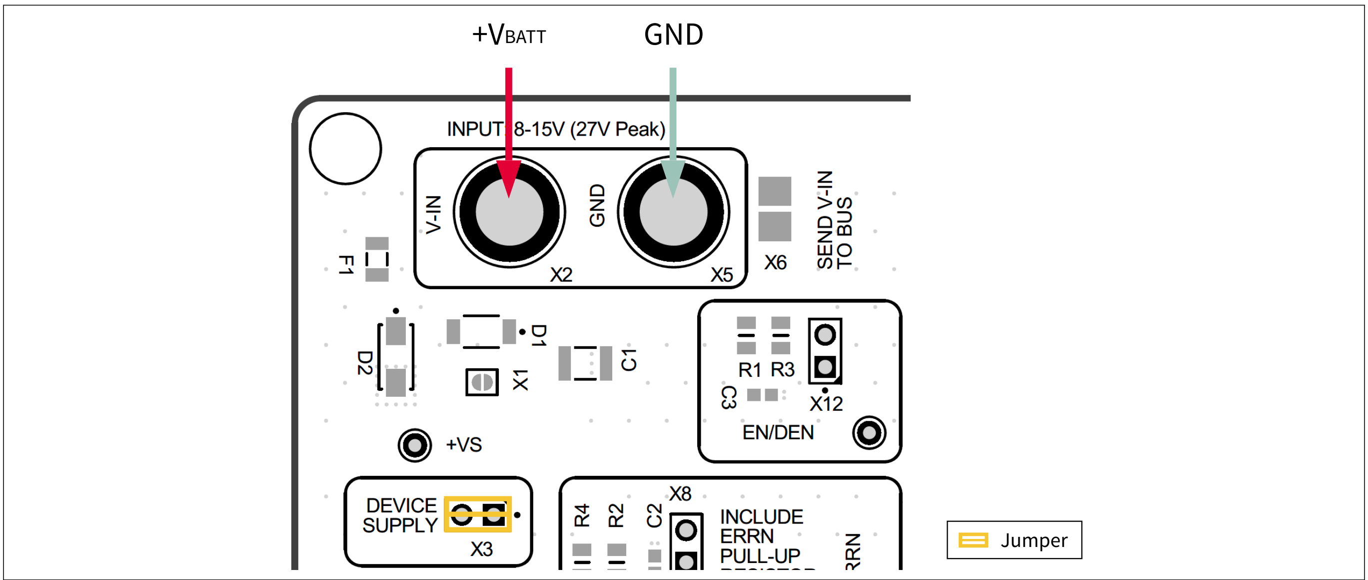

Figure 2 **Supply connection**

As shown in Figure 2, when connecting the board on the power supply to supply the device, it is necessary to close the X3 jumper to supply the device. The supply circuitry contains a fuse and a diode so the supply voltage V_S on the device is reduced by around 500 mV.

2.2 ERRN/DEN connection

The ERRN/DEN pin has two functionalities:

1. By connecting a pull-up resistor, the device can report a detected failure in a shared error network
2. By connecting a resistor divider, keeps the reporting feature, and in addition it is possible to decouple the $V_{DEN(th)}$ from the EN/DEN pin and control through the ERRN/DEN pin when the diagnosis is required to be enabled

More details about the ERRN/DEN functionalities are found in Chapter 5.3.

Close the X8 connector with a jumper, as shown in Figure 3. In this way, a pull-up resistor is connected to ERRN/DEN pin.

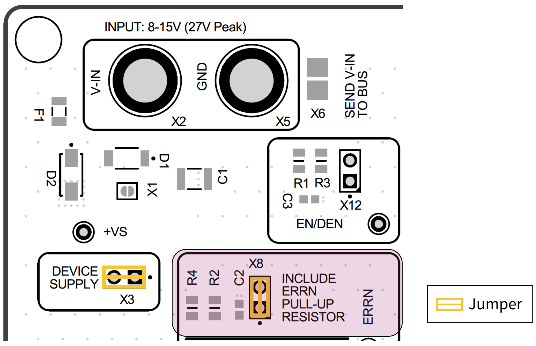

Figure 3 **ERRN/DEN connection**

2.3 EN/DEN connection

The EN/DEN pin has four functionalities:

1. Enables the device, when the voltage on EN/DEN-pin is above $V_{DEN(th)}$
2. Enables the diagnosis, when the voltage on EN/DEN-pin is above $V_{DEN(th)}$. This means that the device is ready to detect and report fault conditions via ERRN/DEN pin. As mentioned before, the diagnostics enable can be decoupled from EN/DEN-pin and implemented via the ERRN/DEN-pin
3. Provides the possibility of applying digital dimming on the output channel
4. If the voltage applied at all the EN/DEN pin is below $V_{DEN(th)}$ for more than t_{SLEEP}, the device enters sleep mode. The change of the state is in both directions from low consumption state “sleep”to the normal consumption state “active”

More details about the PWM control via EN/DEN-pin can be found in Chapter 4.3 and Chapter 5.2.

According to the datasheet [1], as soon as the voltage supply on the device is above $V_{SUV(th)}$ (4.5 V) and the voltage applied at the EN/DEN-pin is above $V_{EN(th)}$ (> 1.8 V), the device is ready to deliver output current.

By default, on the TLD1173-1STD_EVAL, the EN/DEN-pin is connected on voltage supply, V_S through a pullup resistor. There is a possibility to connect a resistor divider as described in Chapter 5.2, by closing the X12 connector, as shown in the figure below. If diagnosis threshold is not needed, leave X12 open.

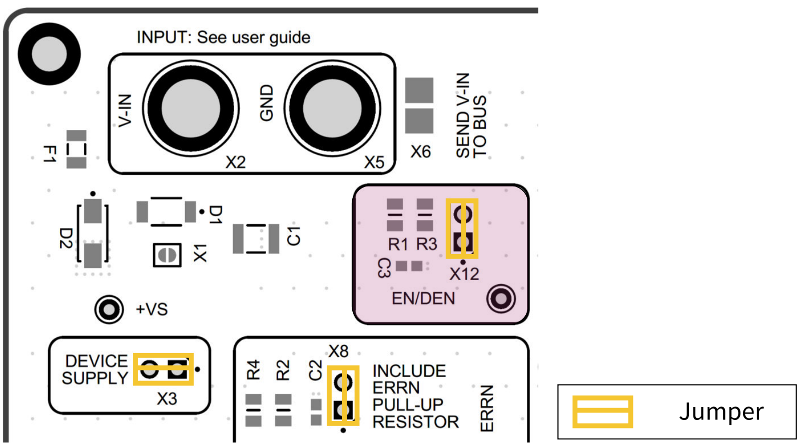

Figure 4 **EN/DEN connection**

2.4 Load connection

The last step to complete the quick setup of this evaluation board, is to connect the load. Connections on the TLD1173-1STD_EVAL in two possible ways:

1. Connect the LEDs mounted on the bottom of the board
2. Connect external load

These two connection methods are explained below in Chapter 2.4.1 and Chapter 2.4.2

The output current of each channel is regulated completely by the SENSE pin. The provided output current by default for both possible ways is 400 mA. More information about the output current regulation on this board is in Chapter 3.

2.4.1 Load on-board

Connect the white LEDs that are mounted on the bottom of the PCB.

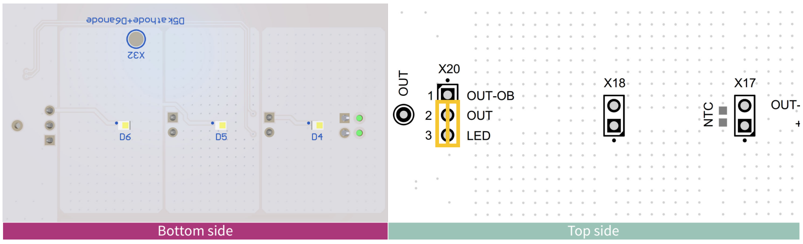

Figure 5 Load on-board connection

To connect the on-board LEDs, close the X20 connector as shown in the figure, above.

2.4.2 Load off-board

Connect an external load as is shown in the configuration figure below.

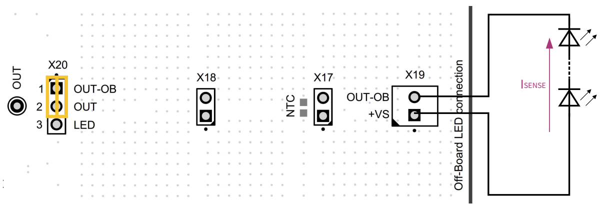

Figure 6 Load off-board connection –external load connected to X19 connector

2.5 Power shift feature

According to the datasheet [1], the device manages high power dissipation by separating the LED current into two current branches:

- One current sink path through an external drop element (power resistor) and the internal power shift
- One current sink path through the internal power stage

For this purpose, the PS-pin is a double function pin found on TLD1173-1ET:

1. Provides the regulated power shift current in combination with SENSE- and OUT-pins
2. Provides the diagnostic input for short to VS-pin

The figure below illustrates a simplified diagram of power shift configuration.

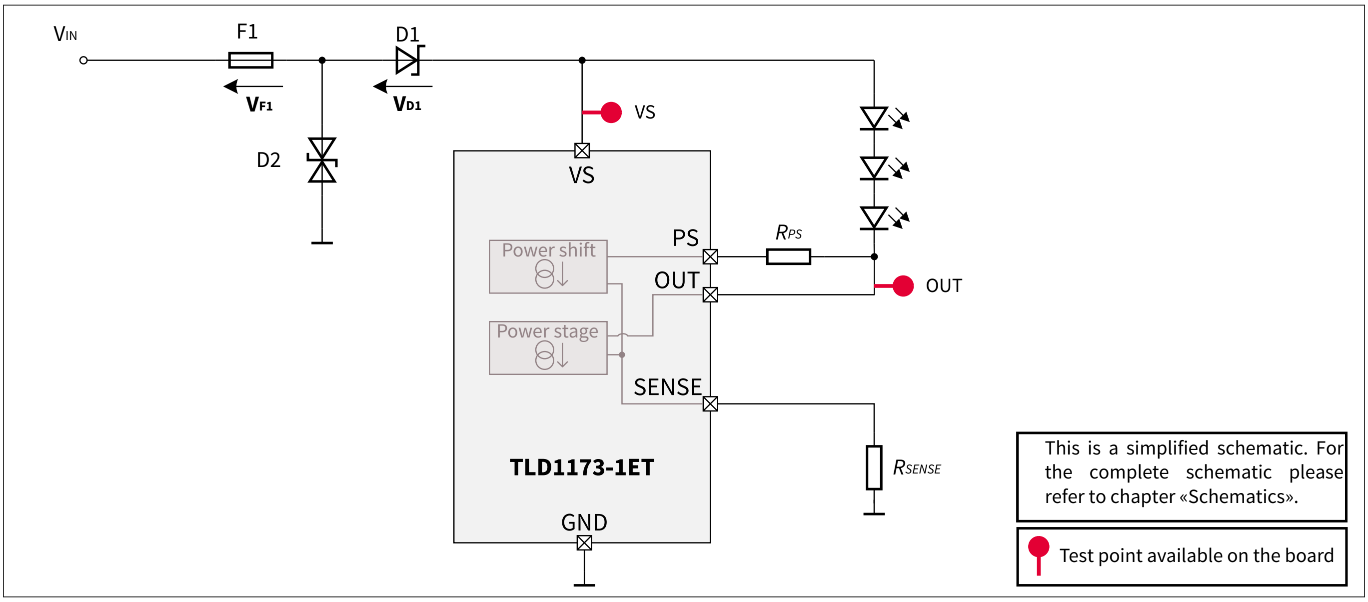

Figure 7 **Power shift configuration**

Resistor, R_{SENSE} equal to 1 Ω, results in 400 mA of current provided to the LEDs, when $V_{ACC/PWMI}$ ≥ 2.4 V. The power resistor used on the PS pin is equal to 47 Ω.

***Note**: For dimensioning the power shift resistor Infineon Technologies has developed a dedicated tool "Power Shift Dimensioning Tool" available on Infineon Developer Center [2]. Please contact Infineon for more information [3].*

3 Output current regulation

As mentioned in Chapter 2.4, the output current regulation block controls the LEDs current by regulating the voltage drop $V_{SENSE(reg)}$ on the external low-side current-sense resistor R_{SENSE} placed between SENSE pin and GND. Place R_{SENSE} as close as possible to the SENSE pin to avoid current regulation instability.

According to the datasheet [1], the output current I_{SENSE} of the LEDs branch is calculated by the following formula:

$$I_{SENSE} = \frac{V_{\mathrm{SENSE(reg)}}}{R_{SENSE}} \tag{1}$$

According to the datasheet [1], $V_{SENSE(reg)}$ is equal to 400 mV.

According to the datasheet [1], comply with the following equation for proper control of the output current on the evaluation board:

$$\begin{aligned} &V_{IN} \geq V_{SENSE(reg)} + V_{DR,CS} + V_{LED\_STRING} + V_{D1} + V_{F1} \Longrightarrow \\ &V_S \geq \; V_{SENSE(reg)} + V_{DR,CS} + V_{LED\_STRING} \end{aligned} \tag{2}$$

Where,

V_{IN}	Input voltage supplied on the evaluation board
V_S	Supply voltage on the device
$V_{SENSE(reg)}$	SENSE voltage regulation accuracy
$V_{DR,CS}$	Power stage dropout voltage
V_{LED_STRING}	Total forward voltage of LEDs
V_{D1}	Forward voltage of reverse polarity protection diode
V_{F1}	Voltage drop on the protection fuse

4 PWM control

According to the datasheet [1], PWM dimming is adopted to vary brightness of the LED with greatly reduced chromaticity shift. Brightness reduction is achieved because PWM dimming varies the duty cycle of a constant current in the LED string.

The PWM control can be performed in two ways:

1. ACC/PWMI pin
2. EN/DEN pin

In this chapter, the purpose of each pin and its potential is described.

4.1 ACC/PWMI pin

The ACC/PWMI pin is a double function pin:

1. Analog dimming
2. Digital dimming, by providing PWM signal

The voltage applied on the ACC/PWMI affects the current of all the output channels.

Below, some examples of applications using this evaluation board are given.

4.1.1 Analog current control and PWM inputs

This chapter describes how to implement analog or digital dimming through ACC/PWMI-pin with this evaluation board. For analog dimming, implement either from an external signal or from the mounted components on the board such as the trimmer or NTC. For digital dimming, apply an external PWM signal of a timer/LITIX™ Basic+ TLD214x-xEP/microcontroller such as a PSoC™ 4 to the evaluation board.

Refer to the schematics **Analog current control and PWM inputs** area of the schematic , Main schematic Figure 25 in Schematics.

4.1.1.1 Analog dimming via external reference

To have 400 mA output current passing through LEDs, follow the configuration in the PCB configuration figure, below, by applying a voltage level $V_{ACC/PWMI)100\%}$ which is equal to 2.4 V. The maximum applied $V_{ACC/PWMI)}$ is 5 V. In case lower than the maximum current capability of the device is required, it is sufficient that the applied voltage $V_{ACC/PWMI)}$ is less than 2.4 V.

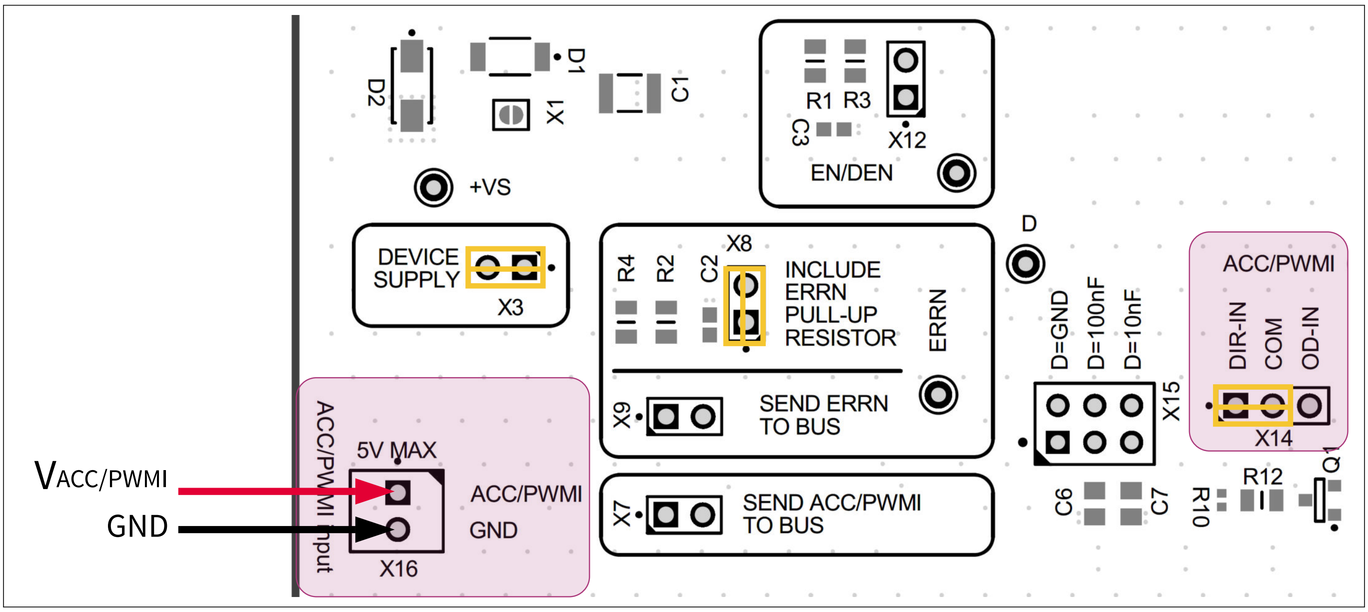

Figure 8 **PCB configuration - direct external signal input**

The output current will be I_{SENSE} as described in the formula below:

$$I_{SENSE} = \frac{0.2 \times V_{ACC/PWMI} - 0.08\ V}{R_{SENSE}} \tag{3}$$

When $V_{ACC/PWMI} < 2.4$ V

$$I_{SENSE} = \frac{V_{SENSE(100\%)}}{R_{SENSE}} \tag{4}$$

When $V_{ACC/PWMI} \geq 2.4\ V$

If the voltage $V_{ACC/PWMI}$ applied at ACC/PWMI pin is between 0.5 V and 2.4 V, it is possible to reduce linearly the sense current, while maintain the same sense resistor value R_{SENSE}, as shown in the graph below.

Therefore,

$$I_{SENSE} = \frac{V'_{SENSE}}{R_{SENSE}} \tag{5}$$

Where the V'_{SENSE} is equal to

$$V'_{SENSE} = 0.2 \times V'_{ACC/PWMI} - 0.08\ V \tag{6}$$

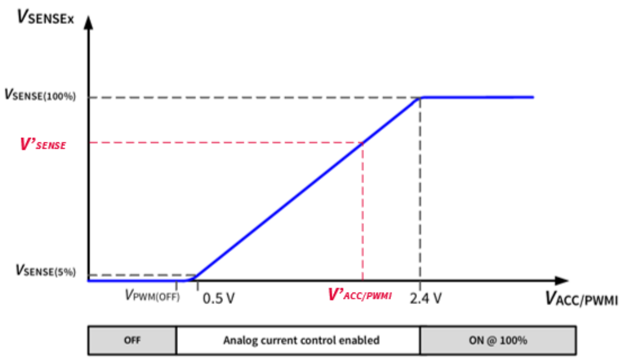

Figure 9 **Graphical relation of V_{SENSE} and $V_{ACC/PWMI}$**

The ACC/PWMI-pin sources a current regulated by the IREF-pin. When a resistor is placed between the ACC/PWMI-pin and the GND, then a voltage $V_{ACC/PWMI}$ on ACC/PWMI-pin will appear. More information can be found in Chapter 4.1.3.

4.1.1.2 PWM input

Another use case is for applications such as rear combination lamp (RCL). Two levels of current are required, one higher than the other. To achieve this, apply a PWM signal on the ACC/PWMI-pin. The MOSFET (Q1) in series with a resistor R_{TAIL} (R12 with 0 Ω placeholder on the PCB) connected to the ACC/PWMI-pin create two levels of output current and can be seen in the example depicted in Figure 12 and 13.

When R12 is does not equal 0 Ω, the tail current is calculated:

$$V_{ACC/PWMI} = R12 * I_{ACC/PWMI} \tag{7}$$

$$I_{TAIL} = \frac{0.2*R12*I_{ACC/PWMI} - 0.08}{R_{SENSE}} \quad (8)$$

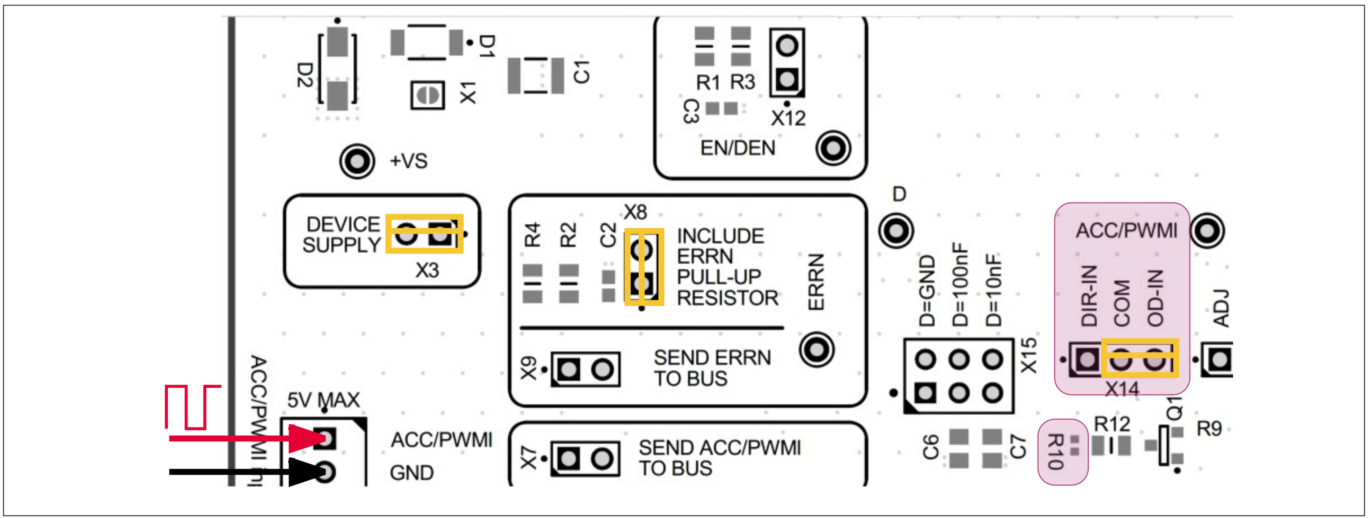

Figure 10 PCB configuration - direct PWM signal input and analog dimming implemented

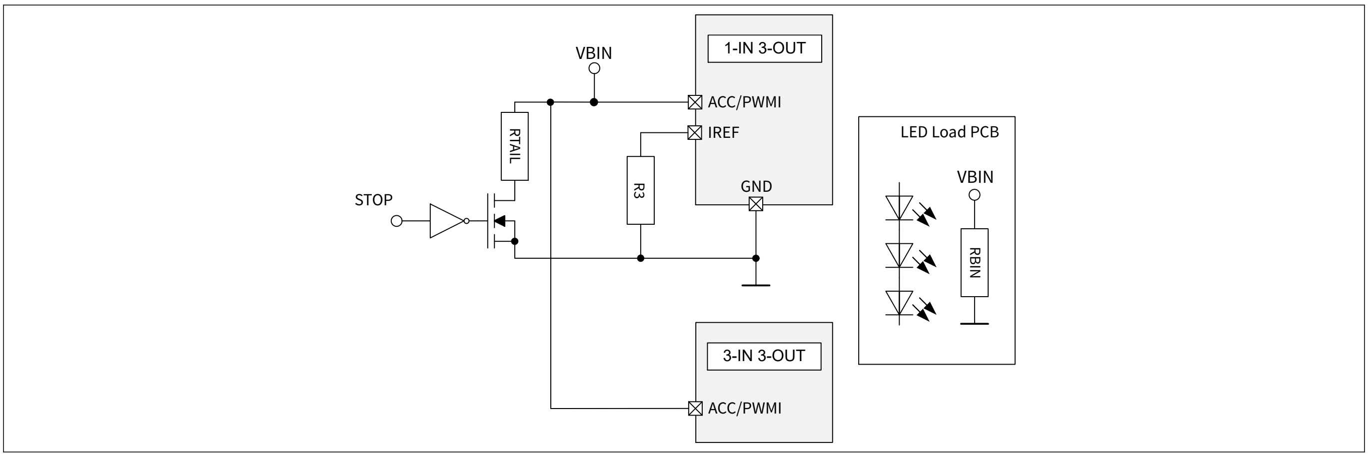

Figure 11 Rear combination lamp - implementing analog dimming via an R_{TAIL} resistor

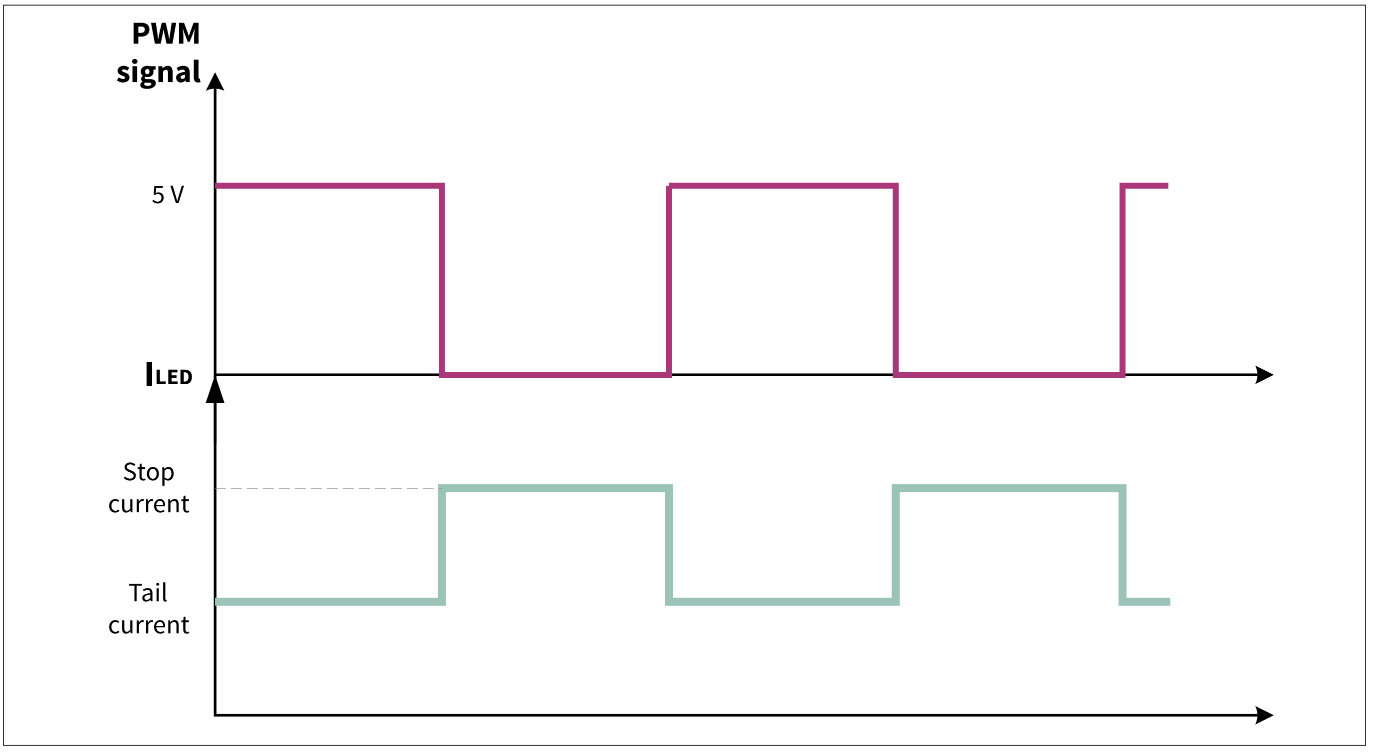

Figure 12 **Tail/stop function current levels using a MOSFET in series with the R12**

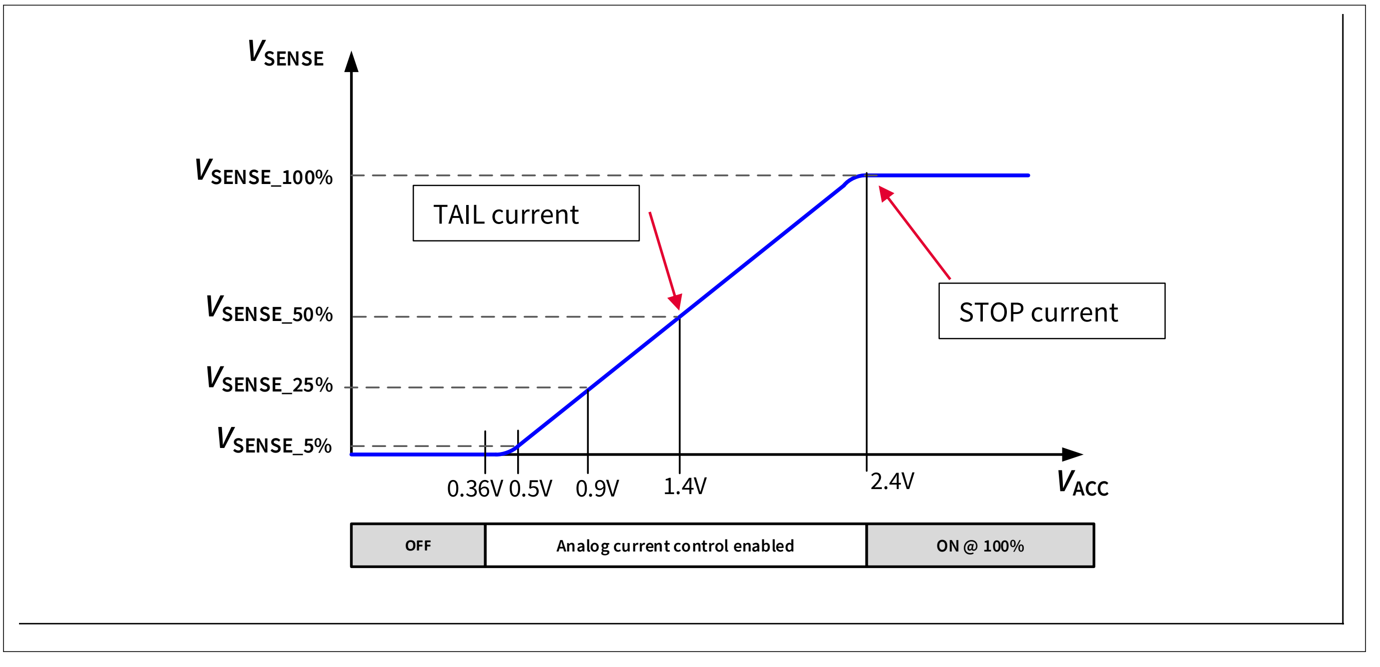

Figure 13 **Example of current levels on TAIL/STOP lighting application**

4.1.2 Embedded regulation

The ACC/PWMI-pin sources current and is regulated by the IREF-pin. When a resistor is placed between the ACC/PWMI-pin and the GND, then a voltage $V_{ACC/PWMI}$ on this pin will appear.

4.1.2.1 Trimmer

One way to adjust the voltage applied on the ACC/PWMI-pin is by using the trimmer mounted on the board. The trimmer is connected to the ACC/PWMI-pin and it is used to adjust the output current by allowing a current range between 0 mA to 400 mA. Use the trimmer to achieve analog dimming which can be implemented in combination with digital dimming, if needed, by additionally applying an external PWM signal to the ACC/PWMI-pin.

The lower the value of the trimmer resistor, the lower the voltage on ACC/PWMI pin. As a consequence, the lower the current sunk by the 1 output channel.

The configuration to connect the trimmer on the ACC/PWMI-pin is illustrated in the figure below.

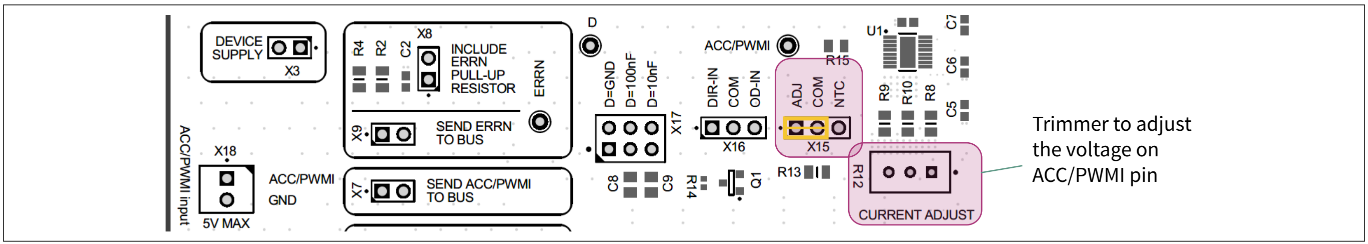

Figure 14 **PCB configuration –connecting the trimmer on the ACC/PWMI pin**

4.1.2.2 Thermal derating - NTC

An NTC resistor is placed on the on-board LED area and is connected to the ACC/PWMI pin. The NTC resistor senses the temperature around the on-board LED load. When the resistor reaches a temperature of 40°C, the output current of each output channel decreases respectively. The NTC resistor connection on the ACC/PWMI pin is optional and it is applied in case thermal derating is needed. The use of the NTC resistor achieves analog dimming which can be implemented in combination with digital dimming, if needed, by applying additionally an external PWM signal to the ACC/PWMI, as shown in the figure below.

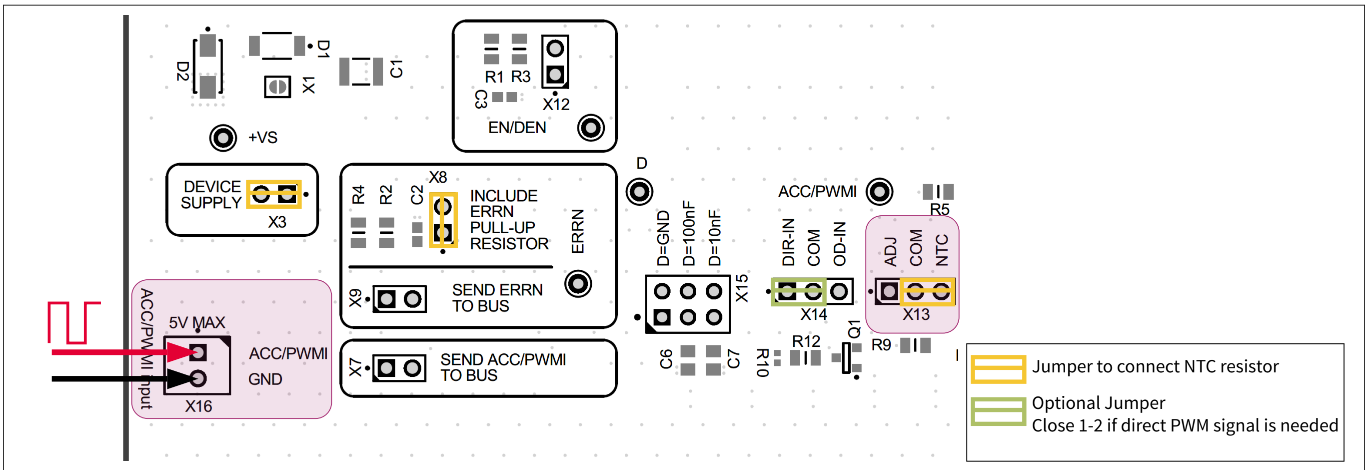

Figure 15 **PCB configuration –connecting the NTC on the ACC/PWMI pin**

4.1.3 Open ACC/PWMI pin

If there is no need to apply digital dimming nor analog dimming, then do not connect any jumper used for the ACC/PWMI pin. Hereby, the ACC/PWMI stays open.

The functionality of the IREF pin and how it is related to ACC/PWMI pin will be explained.

4.2 IREF pin

A summary of the possible configurations using the ACC/PWMI pin are the following, as mentioned in the datasheet [1].

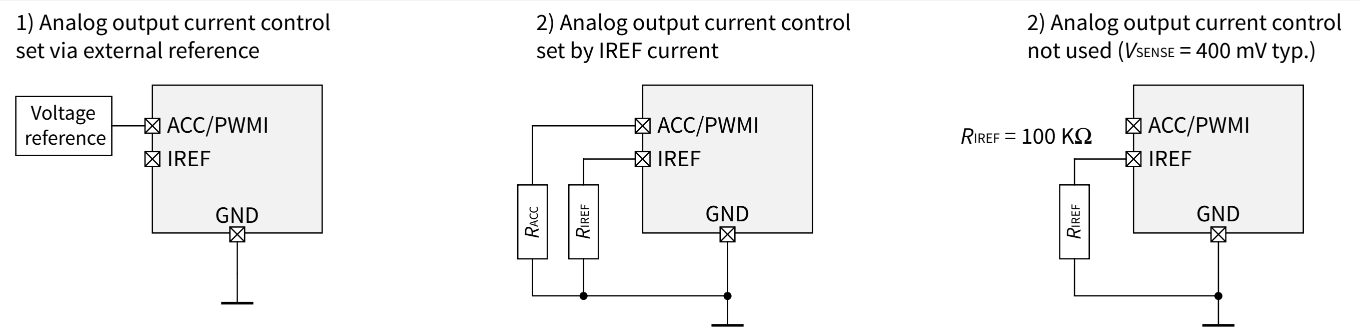

Figure 16 **Analog output current control configurations**

The IREF pin provides a constant voltage of about 1.2 V. The current at this pin is mirrored on the ACC/PWMI pin with a factor of 5. Regarding the datasheet [1], the ratio between these currents is:

$$\frac{I_{ACC}}{I_{IREF}} = 5 \tag{9}$$

***Note**: This ratio is valid when the I_{IREF} is between 20 µA and 250 µA.*

The current reference generation block, outputs an accurate output reference current with low temperature drift. The resistor must be placed as close as possible to the IREF pin.
On this board, a resistor R_{IREF} (R5) equal to 14.3 kΩ is used.

***Note**: The resistance R15 shown in the schematics is different to these placed on the board. It has been modified manually to be equal to 14.3 kΩ.*

This means that the current on the IREF pin is:

$$I_{IREF} = \frac{V_{IREF}}{R_{IREF}} = \frac{1.22[V]}{14.3[k\Omega]} = 85\ uA \tag{10}$$

Therefore, the current on the ACC/PWMI pin is

$$I_{ACC/PWMI} = 5 \times 85[uA] \cong 425\ uA \tag{11}$$

- If the ACC is connected to a voltage reference with low output impedance, as shown in Figure 16(1), the voltage VACC, is equal to the voltage reference. As it is expected, in this case it is not necessary to connect a resistor to the IREF pin
- If the ACC is connected to digital/analog dimming, as shown in Figure 16(2), the IREF pin provides current to the ACC/PWMI pin set by a resistor. The voltage on the VACC/PWMI on this board is equal to:

$$V_{ACC/PWMI} = I_{ACC} \times R_{ACC} \tag{12}$$

Where I_{ACC} is equal to 5 × I_{IREF}. Simultaneously, the resistor, R_{ACC} is placed on the ACC/PWMI pin for analog current control.

- If the analog or digital current control is not needed, the ACC/PWMI pin stays open, as shown in Figure 16(3), then connect a high resistance to the IREF pin. In this way, the voltage on the ACC/PWMI pin reaches its maximum possible voltage

$$V_{ACC/PWMI} \cong 5\ V \tag{13}$$

4.3 EN/DEN pin for PWM control

Chapter EN/DEN connection, covers two of the functionalities of EN/DEN pin, concerning enable and diagnosis enable. As mentioned in Chapter 2.3, in point 3., the pin provides the possibility of applying digital dimming on the output channel.

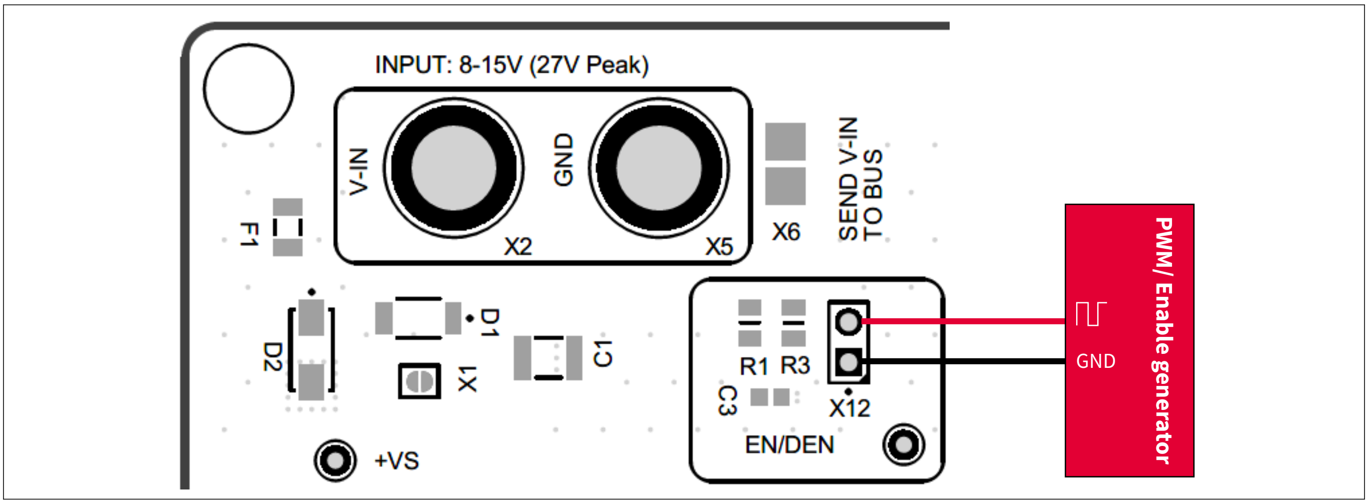

Figure 17 Applying PWM signal via EN/DEN pins for individual dimming of each channel

On the evaluation board the resistor divider is connected. This means that the amplitude of the applied PWM signal is going to be reduced. Please remove and short the resistors' placeholders R1 and R3 if a pure PWM signal is needed

5 Load diagnostics

The TLD1173-1ET device provides flexible fault management. Several diagnosis features are integrated:

- Open load detection (OL)
- Short to supply detection (SC)
- Power shift short to supply detection (SC)
- Overtemperature thermal detection (OT)

Find more information in the TLD1173-1ET datasheet [1]

5.1 D pin

The D pin is designed for two main purposes:

1. For the configured device to react to error conditions in LED arrays according to the implementation fault management policy, in systems where multiple LED chains are used for a given function
2. To extend the channel's deactivation delay time of a value t_D, adding a small signal capacitor from the D pin to GND

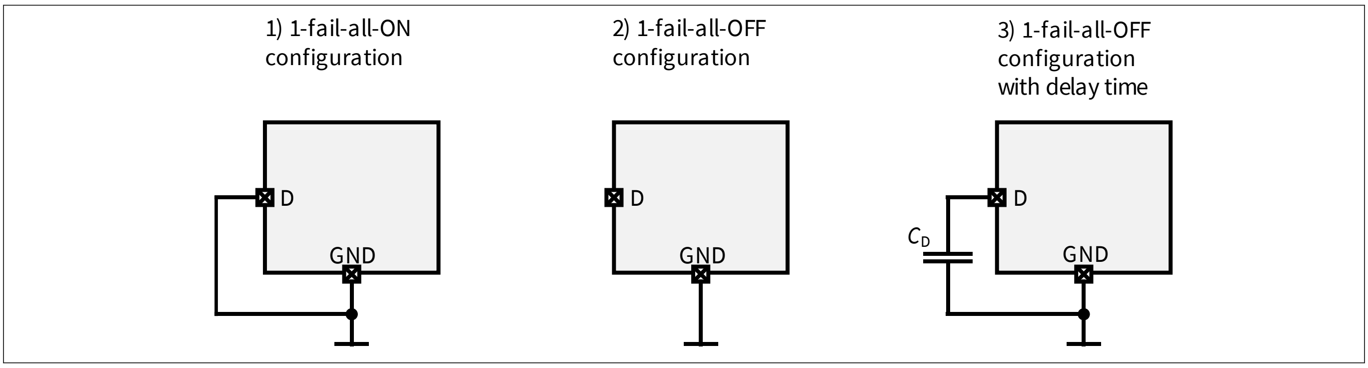

Figure 18 D pin configuration

The device reacts to the fault depending on the fault configuration chosen. The configuration on the board is depicted below, in Figure 19.

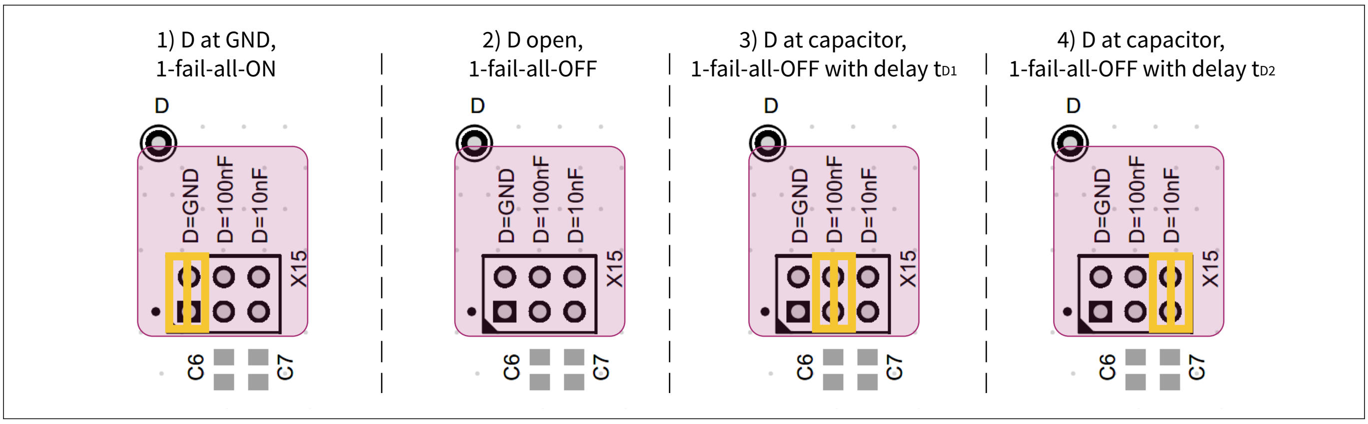

Figure 19 PCB configuration - D pin

If a fault occurs on TLD1173-1ET or on other devices connected on the same error network:

- When the D pin is connected to the GND, the voltage on the ERRN pin drops and the output channel of TLD1173-1ET remains ON (1-fail-all-ON)
- When D pin is left open, the voltage on the ERRN pin drops and output channel is turned OFF (1-fail-all-OFF)
- When D pin is connected to the capacitor C_1 = 100 nF, the voltage on the ERRN pin drops and output channel is turned OFF after t_{D1} delay time (1-fail-all-OFF)

$$t_{D1} = 4.86\ \text{ms} \tag{14}$$

When D pin is connected to the capacitor C_2 = 10 nF, the voltage on the ERRN pin drops and output channel is turned OFF after t_{D2} delay time (1-fail-all-OFF).

$$t_{D2} = 486\ \mu\text{s} \tag{15}$$

More information about D pin can be found in Chapter 9.3 of the datasheet [1].

***Note**: The devices that share a common error network will behave according to the fault management configured for each of these devices.*

5.2 Diagnostics enable (EN/DEN)

According the datasheet[1], as soon as the voltage supply at the VS pin of the device is above $V_{SUV(th)}$ and the voltage applied at the EN/DEN pin is above $V_{EN(th)}$, the device is ready to deliver output current.

$V_{SUV(th)}$ is equal to 4.5 V and $V_{EN(th)}$ is between 0.6 V and 1.8 V.

As soon as the voltage applied at the VS pin of the device is above $V_{SUV(th)}$ and the voltage applied at the EN/DEN pin is above $V_{DEN(th)}$, the device is ready to detect and report fault conditions via ERRN/DEN pin.

$V_{DEN(th)}$ is between 2.3 V and 2.7 V.

By default, on the TLD1173-1STD_EVAL the EN/DEN pin connected on VS through a pull-up resistor, R1. In addition, there is a possibility to connect a resistor divider, R3 by closing the jumper X12. By closing X12 we are setting at which threshold the diagnosis will be enabled.

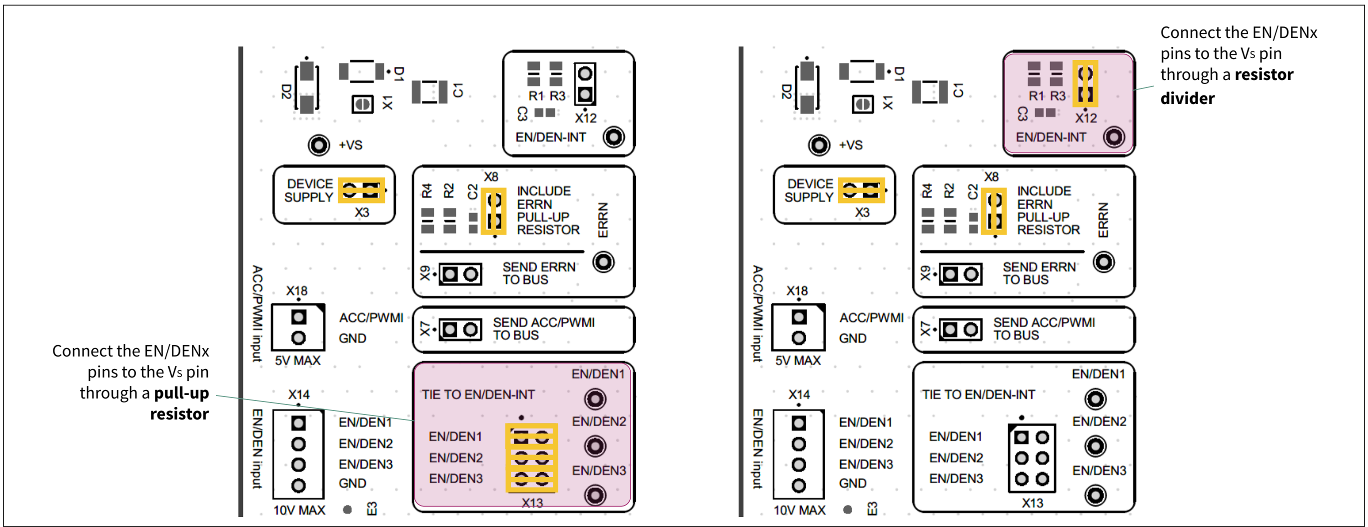

Figure 20 **PCB configuration – EN/DEN through pull-up resistor (on the left), EN/DEN through resistor divider (on the right)**

Table 3 **EN/DEN configuration - example**

Connection to V_S	Supply voltage V_S [V]	$V_{EN/DEN}$ [V]	Diagnosis enabled
Pull-up resistor	V_S	$\approx V_S$	Yes
Resistor divider	5	1.97	No
	6	2.36	No
	7	2.76	Yes

(table continues...)

Table 3 (continued) EN/DEN configuration - example

Connection to V_S	Supply voltage V_S [V]	$V_{EN/DEN}$ [V]	Diagnosis enabled
	8	3.15	Yes
	9	3.55	Yes
	10	3.94	Yes

In Table above, various voltage supply values, V_S and their corresponding $V_{EN/DEN}$ as well as whether the diagnosis is enabled on this evaluation board is depicted. As described above the diagnosis is enabled when the $V_{EN/DEN}$ is greater than $V_{DEN(th)}$.

It is also possible by connecting the EN/DEN pin directly to the supply line, to keep the device enabled as much as possible and disable the diagnosis from the ERRN/DEN pin by applying a resistor divider on it. More information can be found in the following Chapter 5.3.

5.3 ERRN/DEN pin

As mentioned in Chapter 2.3, the ERRN/DEN has two functionalities:

1. Reports an error in case of fault
2. Provides the diagnostic enable/disable function

In this chapter, the focus is on the second function.

When a PWM signal is applied to the EN/DEN pin, as shown in Chapter 4.3, the channel turns ON and OFF depending on the applied PWM signal. Therefore, it is not possible to enable/disable the diagnostic function.

For this reason, the extension of LITIX™ Basic+ family introduces the ERRN/DEN pin. This pin decouples the $V_{DEN(th)}$ threshold from the $V_{EN(th)}$ threshold to turn on the device as soon as needed, independent of the diagnostic enable threshold, $V_{DEN(th)}$. The DEN function is duplicated on the ERRN/DEN pin.

The fault is now detected when the $V_{ERRN/DEN}$ is above $V_{ERRN(DEN)}$.

$V_{ERRN(DEN)}$ is between 2.1 V and 2.3 V.

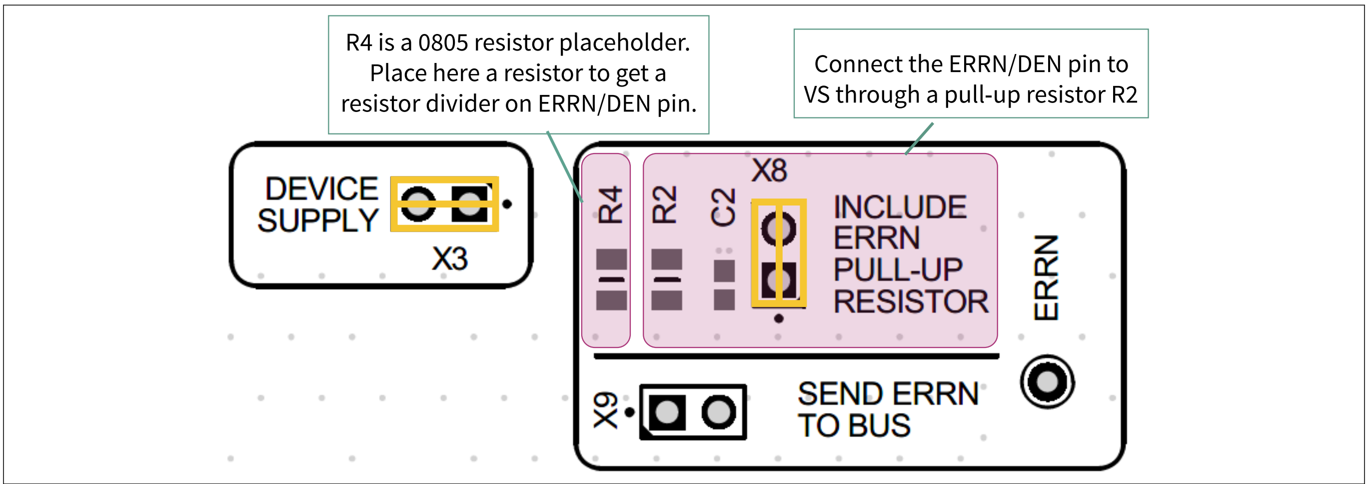

Figure 21 PCB configuration – ERRN/DEN connection

The ERRN/DEN pin is already connected through a pull-up resistor R2 to the supply voltage. To activate the diagnosis-enable (DEN function of the ERRN/DEN-pin), connect a resistor divider on the ERRN/DEN by mounting a resistor on the placeholder R4 on the board as shown in Figure 21, above.

For example, by mounting a resistor 15 kΩ on the R4 placeholder of the evaluation board the behavior of the device in case of a fault is shown in the table below:

Table 4 ERRN/DEN configuration – Fault condition example

Connection to V_S	Supply voltage V_S [V]	$V_{ERRN/DEN}$ [V]	Meaning
Pull-up resistor	$V_S > V_{SUV(th)}$	$V_{ERRN/DEN} < V_{ERRN(fault)}$	Error reported
Resistor divider	5	1.21	No error reported, Diagnosis disabled
	6	1.45	No error reported, Diagnosis disabled
	7	1.69	No error reported, Diagnosis disabled
	8	1.94	No error reported, Diagnosis disabled
	9	2.18	No error reported, Diagnosis disabled
	10	2.42	Error reported, Diagnosis enabled

6 Bus connection

The available evaluation boards of the extended LITIX™ Basic+ family are:

- TLD2362-3STD_EVAL
- TLD1173-1STD_EVAL
- TLD23x2-3STD_EVAL

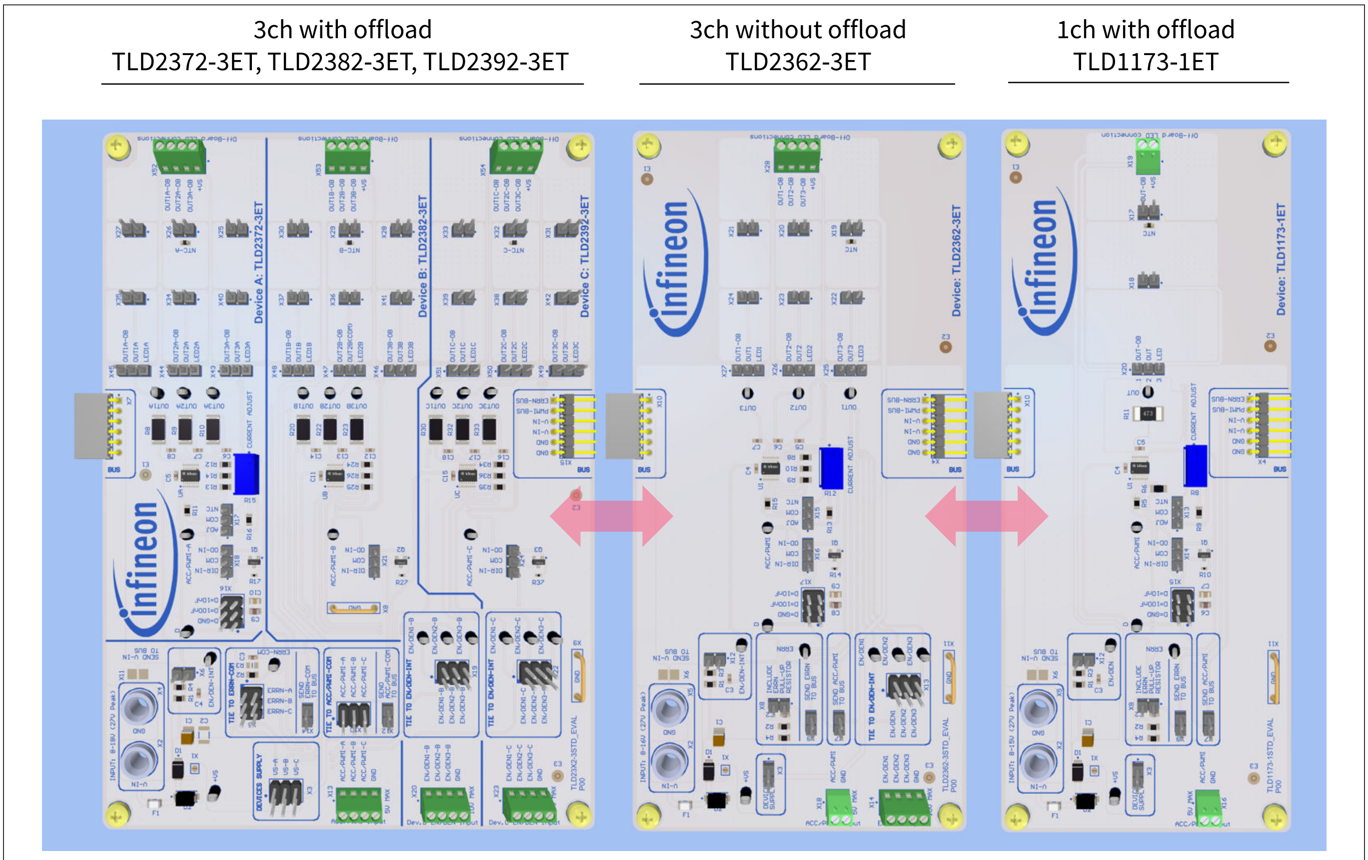

Figure 22 Bus connection between the evaluation boards

It is possible to connect all the boards of this family without using additional cables. The signals that are shared between boards by means of a bus connection are:

- Input voltage VIN
- ERRN/DEN
- ACC/PWMI
- GND

Each device it is supplied by the V_{IN} input voltage which is followed by a diode and fuse as shown in Chapter 2

Connect the battery voltage V_{IN} to the bus line and the boards are connected in chain, see Figure 23:

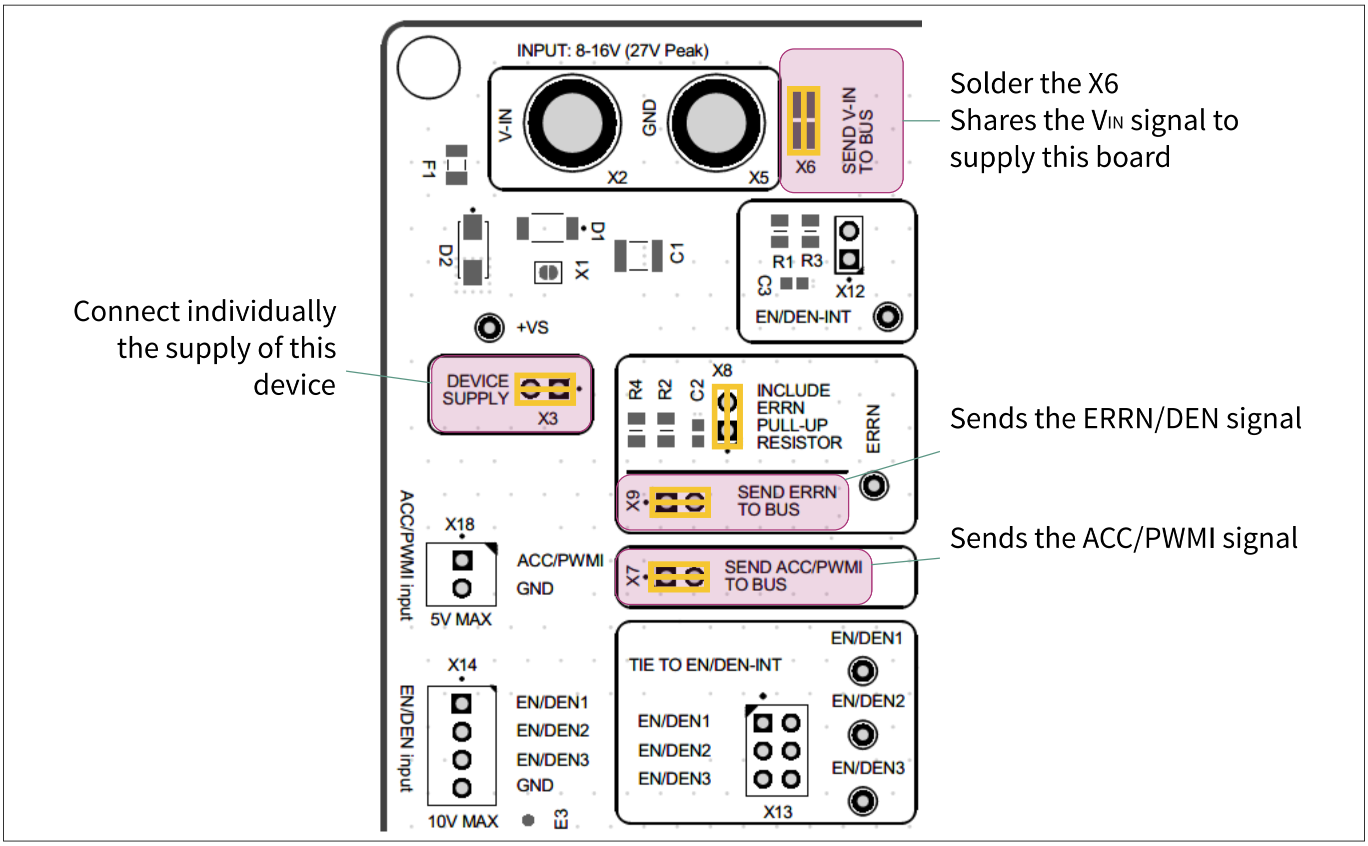

Figure 23 **PCB configuration – Bus connection**

While supplying the evaluation boards at typically 12 V, the supply current limitation should be at least the total amount of the output current of all the boards.

For example,

Table 5 **Supply instrument – Current limitation**

Evaluation board	Max. output current capability	Suggested supply current
TLD1173-1STD_EVAL	400 mA	0.5 A
TLD23x2-3STD_EVAL	150 mA/channel	0.16 A
TLD2362-3STD_EVAL	(Ch 1) 5 mA – (Ch 2) 30 mA – (Ch 3) 150 mA	0.16 A
All 3 above (interconnected)	–	0.9 A

***Note**:* *The configuration in Figure 23 above should be followed by all the connected in chain (via BUS connectors) boards.*

7 System design

7.1 Schematics

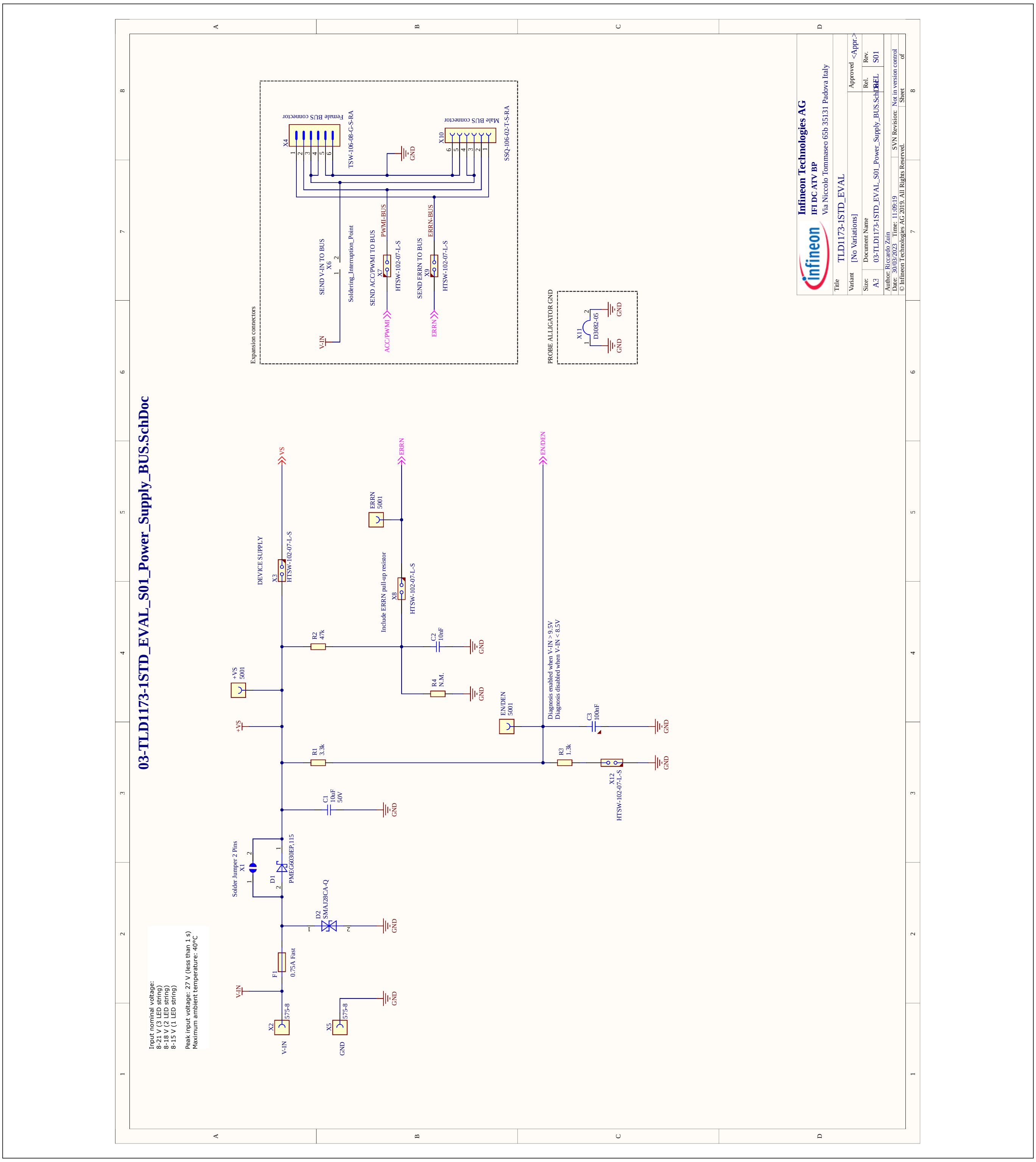

Figure 24 Power supply schematic

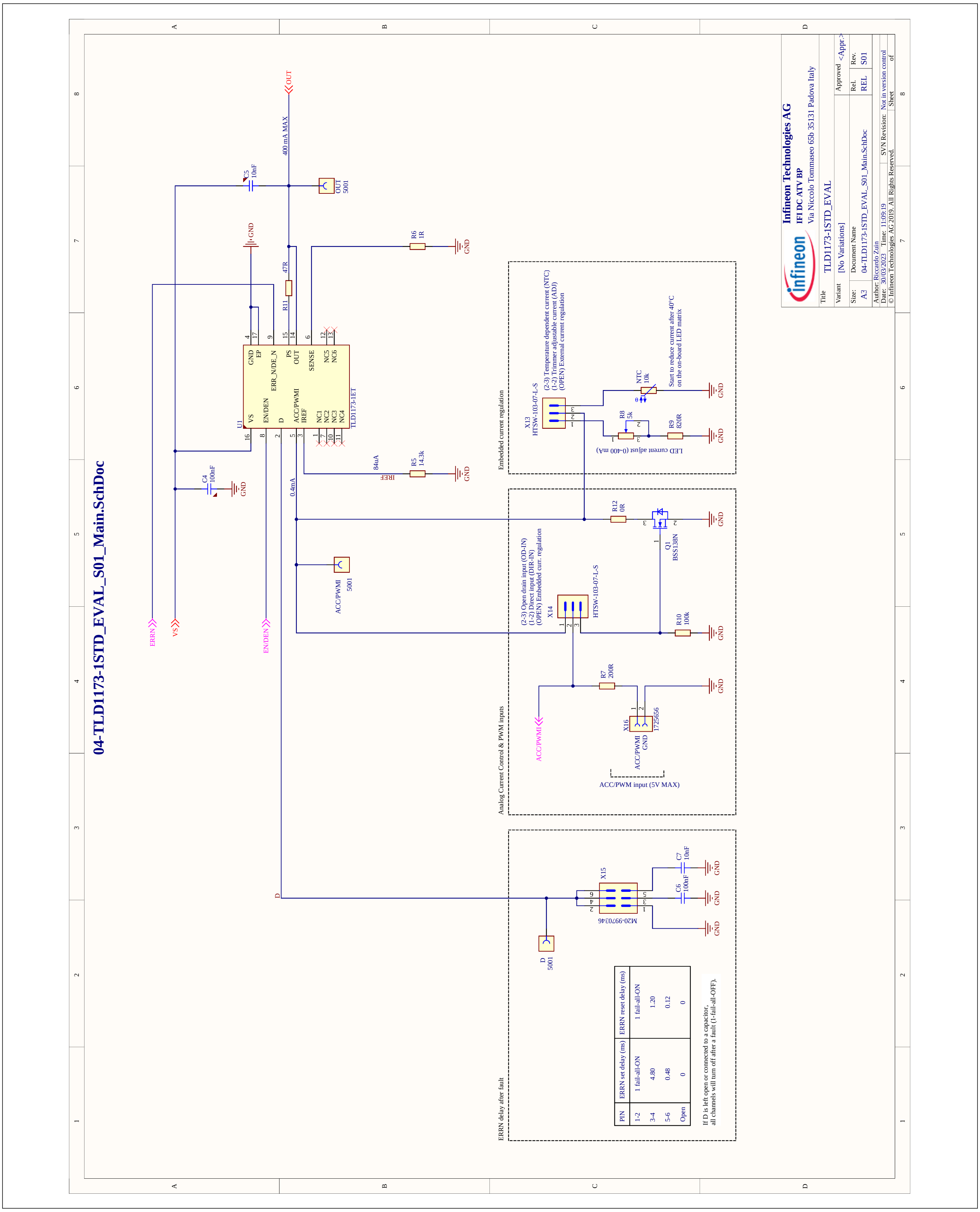

Figure 25 Main schematic

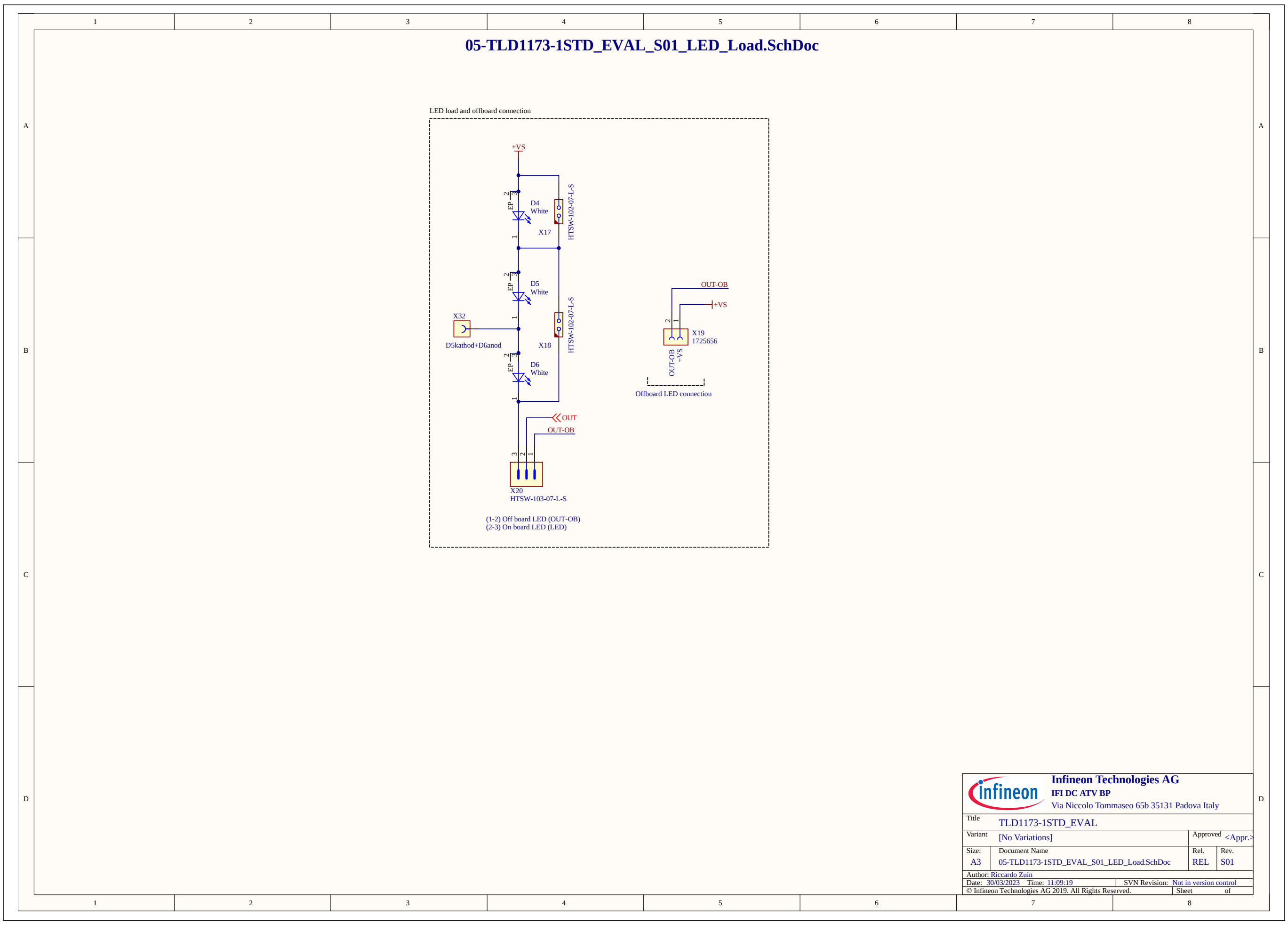

Figure 26 LED load schematic

7.2 PCB layout

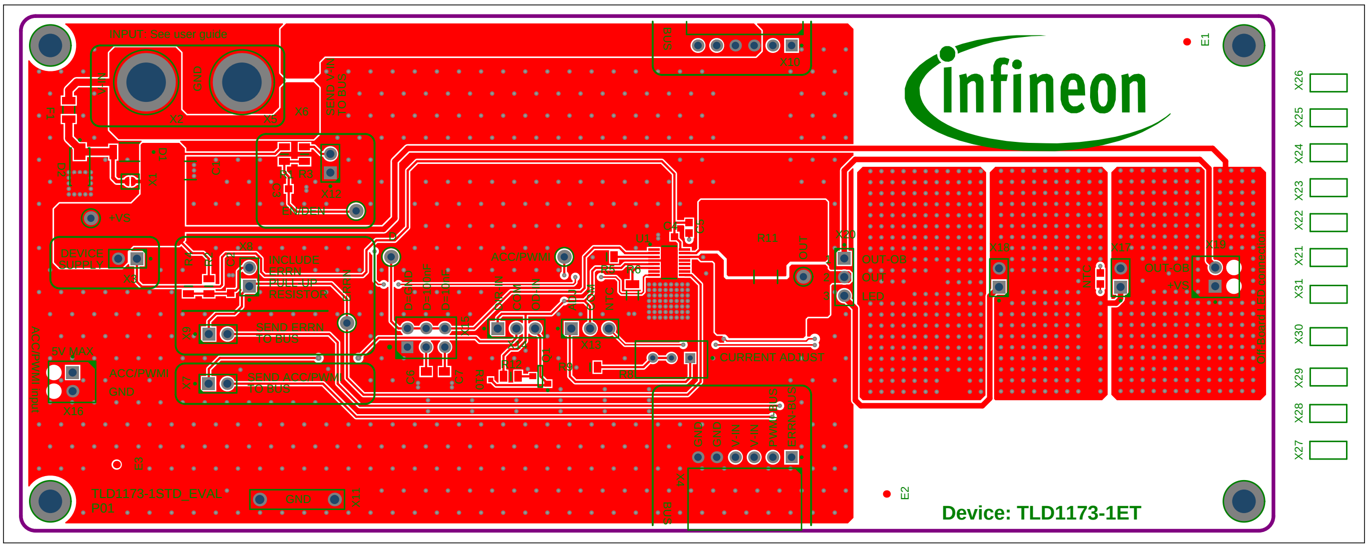

Figure 27 Top overlay

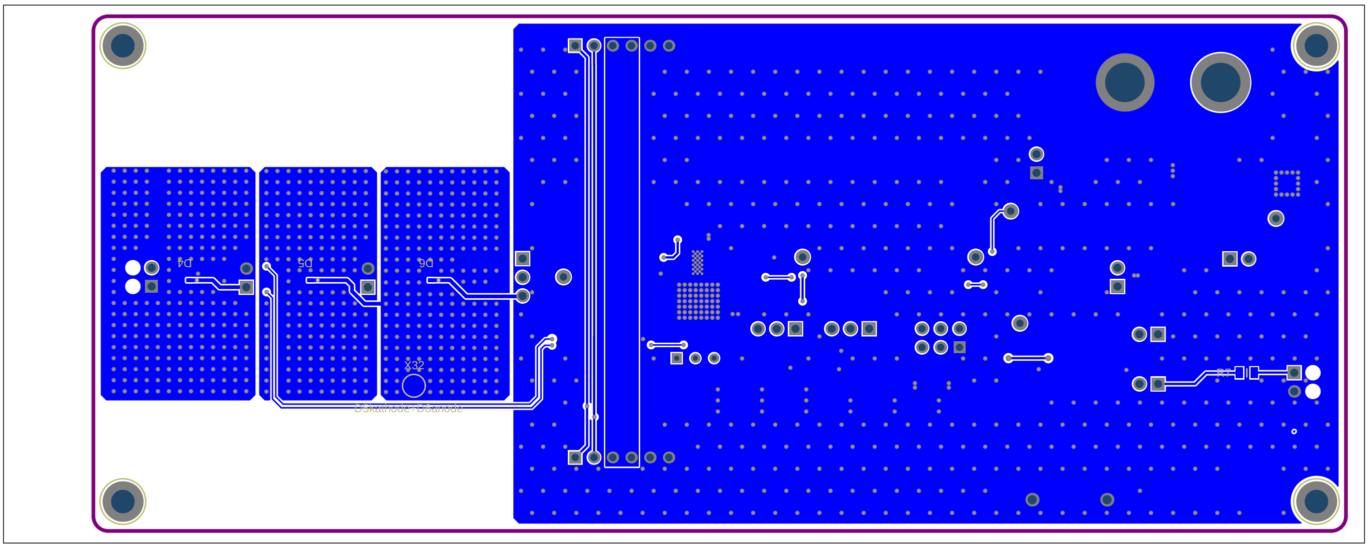

Figure 28 **Bottom overlay**

7.3 Bill of material

Ref Designator	Value	Manufacturer	Manufacturer P/N
+VS, ACC/PWMI, D, EN/ DEN, ERRN, OUT	5001	Keystone Electronics Corp.	5001
C1	10uF	MuRata	GRM32ER71H106MA12
C2, C5	10nF	TDK Corporation	CGA3E2X8R1H103K080AA
C3, C4	100nF	TDK Corporation	CGA3E3X8R1H104K080AB
C6	100nF	AVX	08055F104K4T2A
C7	10nF	Kemet	C0805C103K5RACAUTO
D1	PMEG6030EP,115	Nexperia	PMEG6030EP,115
D2	SMAJ28CA-Q	Bourns	SMAJ28CA-Q
D4, D5, D6	White	OSRAM Opto Semiconductors	KW CELNM2.TK-S2S8-4L07M0-2686
F1	540mR	Bussmann	3216FF750-R
MP1, MP2, MP3, MP4	970250321	Wurth Elektronik	970250321
MP5, MP6, MP7, MP8	MP006555	Multicomp	MP006555
NTC	10k	Vishay	NTCS0603E3103JLT
Q1	BSS138N	Infineon Technologies	BSS138N
R1	3.3k	Vishay	CRCW08053K30FK
R2	47k	Vishay	CRCW080547K0FK
R3	1.3k	Vishay	CRCW08051K30FK
R4	47k	Vishay	CRCW080547K0FK
R5	14.3k	Vishay	CRCW080514K3FK
R6	1R	Vishay	CRCW12061R00FKEA
R7	200R	Vishay	CRCW0805200RFK

Ref Designator	Value	Manufacturer	Manufacturer P/N
R8	5k	Vishay	T93YA502KT20
R9	820R	Vishay	CRCW0805820RFK
R10	100k	Vishay	CRCW0402100KFK
R11	47R	Bourns	CHP2512AFX-47R0ELF
R12	0R	Vishay	CRCW08050000Z0EA
U1		Infineon Technologies	TLD1173-1ET
X1	Solder Jumper 2 Pins	Infineon Technologies	Solder Jumper 2 Pins
X2, X5	575-8	Keystone Electronics Corp.	575-8
X3, X7, X8, X9, X12, X17, X18	HTSW-102-07-L-S	Samtec	HTSW-102-07-L-S
X4	TSW-106-08-G-S-RA	Samtec	TSW-106-08-G-S-RA
X10	SSQ-106-02-T-S-RA	Samtec	SSQ-106-02-T-S-RA
X11	D3082-05	Harwin	D3082-05
X13, X14, X20	HTSW-103-07-L-S	Samtec	HTSW-103-07-L-S
X15	M20-9970346	Harwin	M20-9970346
X16, X19	1725656	Phoenix Contact	1725656
X21, X22, X23, X24, X25, X26, X27, X28, X29, X30, X31	M7583-05	Harwin	M7583-05
X32	IFX-TestPad	Infineon Technologies	IFX-TestPad

References

[1] Infineon: *TLD1173-1ET* datasheet

[2] Infineon *Developer Center*; https://www.infineon.com/cms/en/product/power/lighting-ics/litix-automotive-led-driver-ic/#!support

[3] Infineon *LITIX™ Automotive LED Driver IC* https://www.infineon.com/cms/en/product/power/lighting-ics/litix-automotive-led-driver-ic/#!support

Revision history

Document version	Date of release	Description of changes
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Rev.1.00	2024-01-30	• Initial user guide release

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