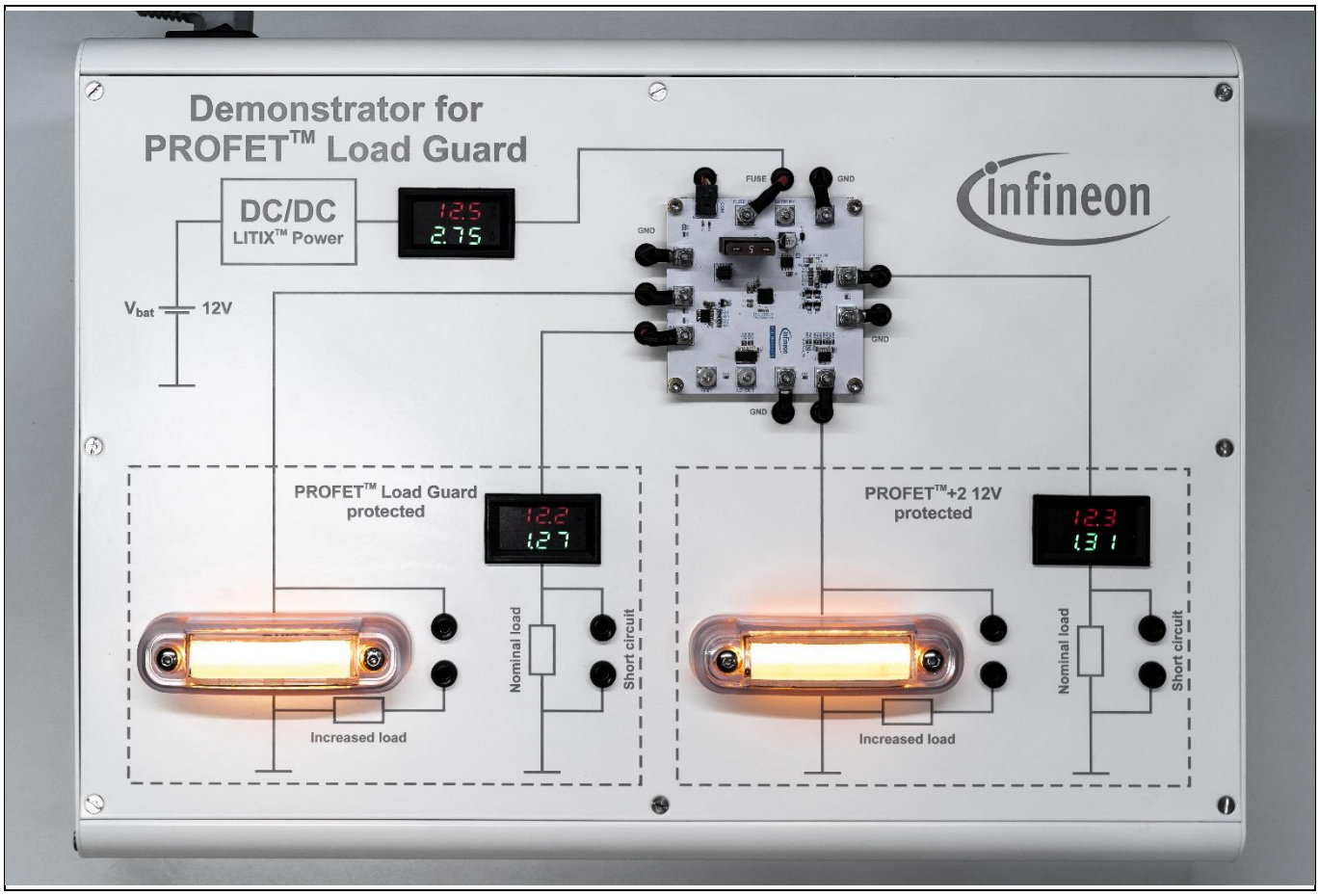
Demonstrator for PROFET™ Load Guard

User guide

About this document

Scope and purpose

This User guide provides all necessary information and instructions to understand and operate the PROFET™ Load Guard demonstrator. Furthermore, this document can also be used as training material.



Intended audience

This document is intended for all people who deal with the PROFET™ product family. Especially for those who are interested in PROFET™ Load Guard and PROFET™ +2 smart power switches and want to understand how to operate the demonstrator.

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1 Introduction

The Load Guard demonstrator, depicted in Figure 1, promotes the main features of the PROFET™ Load Guard portfolio. This demonstrator platform represents a simplified snippet of an automotive power distribution architecture.

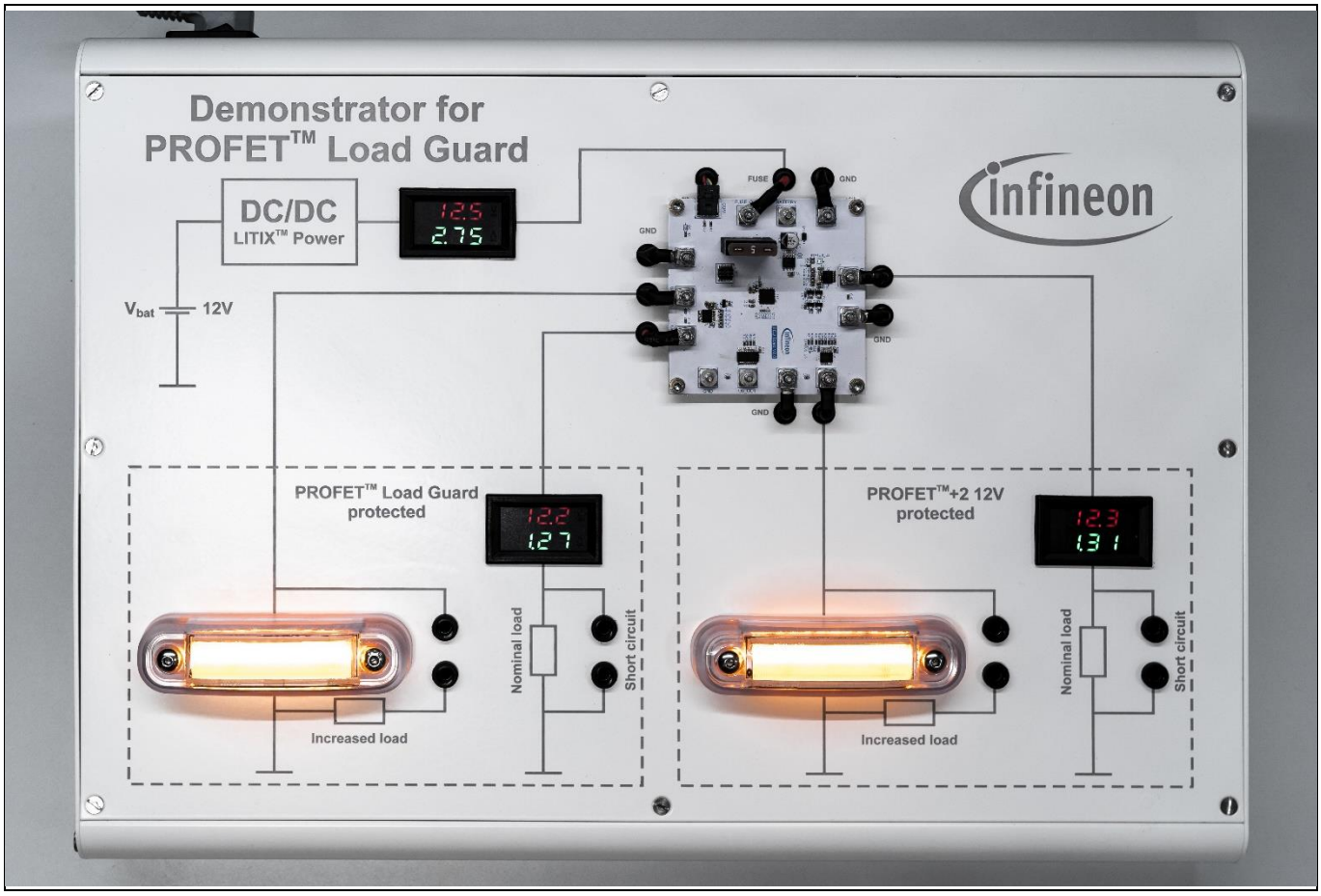

Figure 1 Load Guard demonstrator

The main benefits promoted by the Load Guard demonstrator are:

- Wire harness protection against overheating
- System supply protection
- Load control and self-protection
- Fast channel shut-off in case of short circuit
- Resettable in case of a fault

1.1 PROFET™ Load Guard demonstrator hardware

Figure 2 shows the front panel of the demonstrator. One printed circuit board (PCB), which acts in this application as the Electrical Control Unit (ECU), hosts the PROFET™ smart power switches and the microcontroller. The microcontroller, a Cypress PSoC™ 4100S automotive controller (CY8C4124LQE-S423) and the embedded software control the two PROFET™ +2 BTS7040-1EPA and the PROFET™ Load Guard BTG7090- 2EPL. To demonstrate and compare the use case results of the PROFET™ Load Guard to the PROFET™ +2, two different loads are connected, an indicator light on one channel and a resistive load in series

with a V/I multimeter display on the other. Loads of same type are connected to two 1-channel PROFET™ devices. In addition, a V/I multimeter display is placed between the LITIX™ Power DC-DC controller and the ECU, which gives information about the power consumption of the whole application.

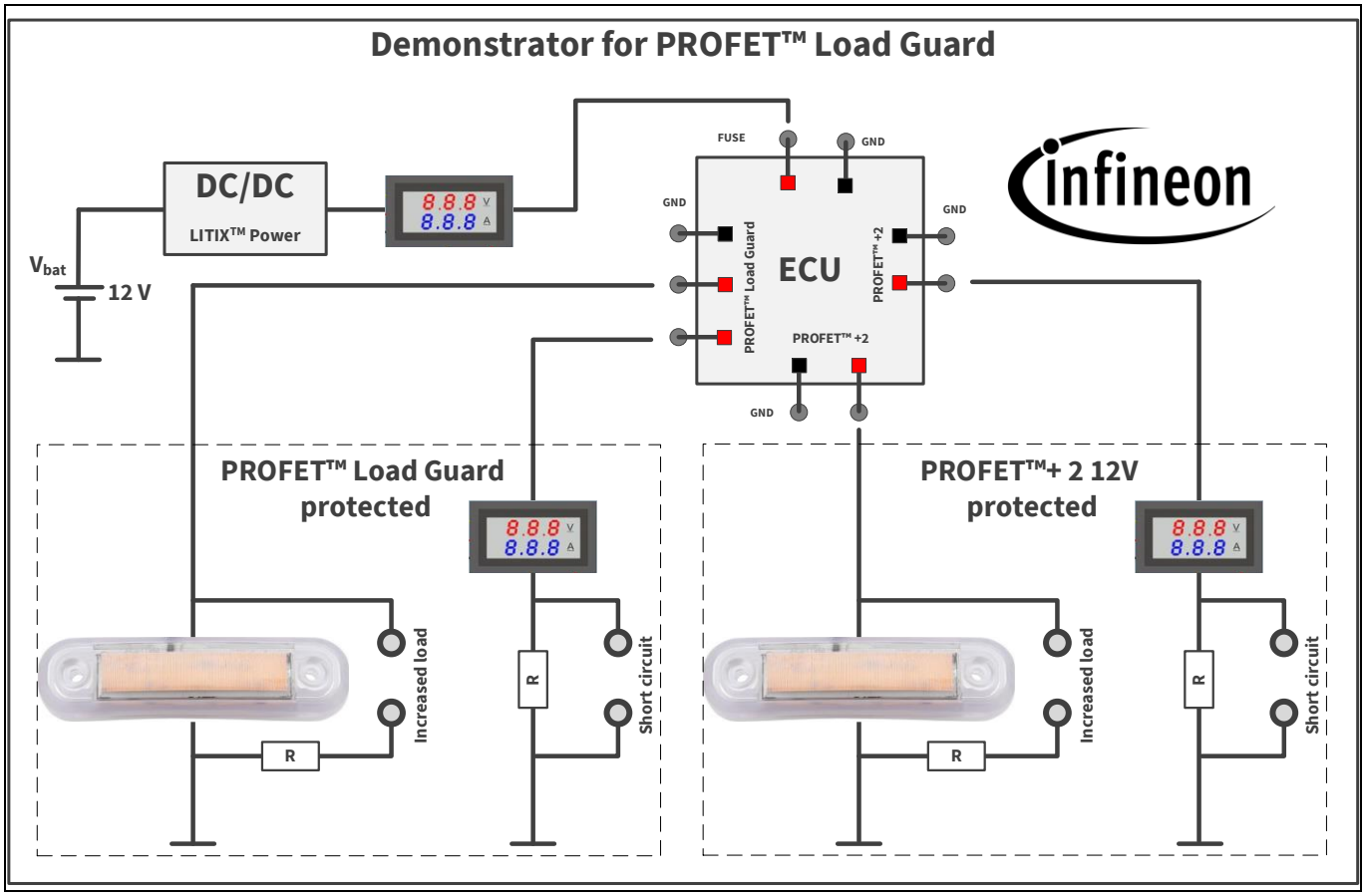

Figure 2 Load Guard demonstrator top-view

1.1.1 LITIX™ Power

The LITIX™ Power family consists of a buck converter, low-side switch controllers and 4-switch buck-boost controllers. The LITIX™ Power TLD5190QV is a synchronous MOSFET H-Bridge DC-DC controller with built in protection features. It embeds synchronous and seamless buck-boost regulation and is suitable not only for LED applications but even for mobile wireless charging or battery management systems. For this application the LITIX™ Power TLD5190QV is configured to manage a maximum output power of 60 W (12 V and 5 A).

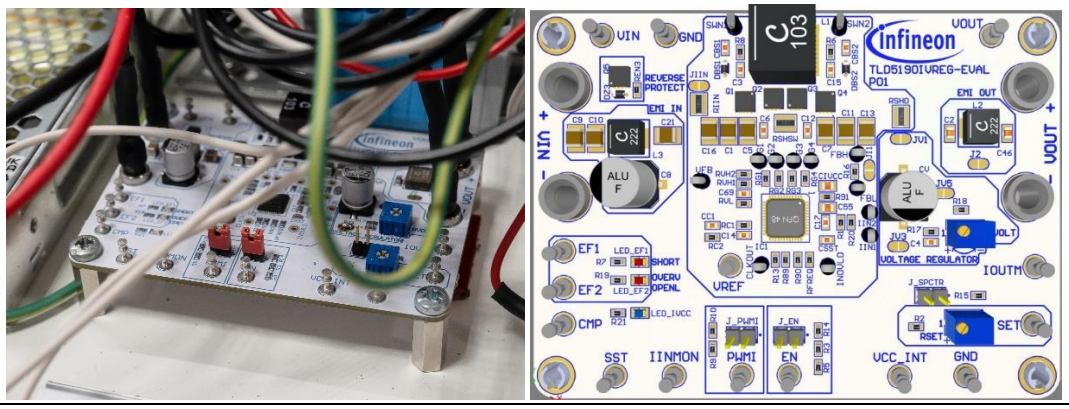

Figure 3 LITIX™ Power TLD5190QV evaluation board

1.1.2 ECU board

The Electronic Control Unit (ECU) board acts in this setup like a body control module with integrated fuse box and diagnosis functionality. The chosen fuse is limited to an output current of 5 A. It is equipped with a Cypress PSoC™ 4100S automotive controller (CY8C4124LQE-S423), a PROFET™ Load Guard BTG7090-2EPL and two PROFET™ +2 BTS7040-1EPA devices.

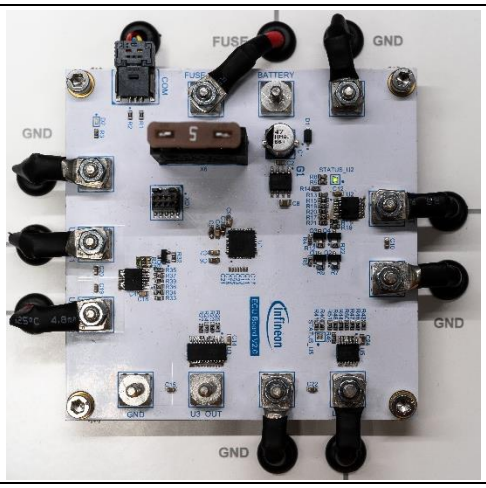

Figure 4 ECU board

1.1.3 Connected load

Two types of load are used:

1. Indicator lights which are connected to one channel of the PROFET™ Load Guard and to one of the PROFET™ BTS7040-1EPA devices. This type of load was chosen to give the user a feeling of the working principle of the current limitation feature. When the "increased load" jumper is connected, the output current is increased. Since the current limitation of the Load Guard is set at 1.5 A, the LED gets dimmed.
2. When there is a nominal current in the application, resistors; in combination with the V/I multimeter display, provide vital parameters. When the increased load is connected to the PROFET™, the voltage and the current drops on all 4 output channels. This is due to the limited DC-DC power supply. The "short circuit" jumper causes channel 0 of the Load Guard to turn OFF.

Attention: Only one jumper is included for the demonstrator setup and intended for use. This jumper is placed, according to the application cases which are described in more detail in Chapter 2.

Attention: For the melting fuse socket, use only ATOF blade fuse rated 5 A 32 V by Littelfuse (MPN: 0287005.PXCN) because different producers have different max ratings for their fuses. This could lead to an unwanted behavior in the application.

1.2 Included equipment for setup

- Power supply
- Power plug: single, 100 to 240 VAC, 50 Hz to 60 Hz
- Power cable with IEC-C13 connector

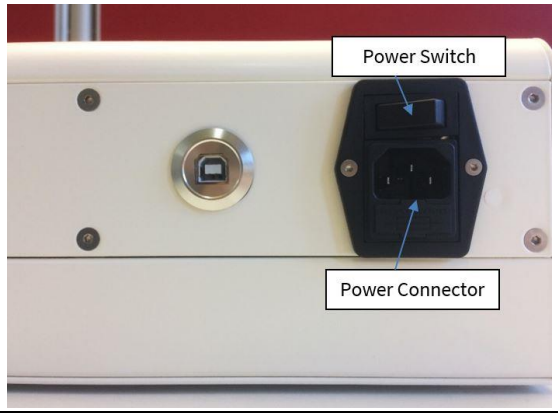

Figure 5 Power connector and USB-B socket on the backside of the demonstrator

1.3 Additional information

- Dimensions (LxHxW): 480 x 340 x 130 mm
- Weight: ~9 kg
- Dimensions Stormcase (LxHxW): 625 x 500 x 297 mm (PELI - SKU IM2720-01001)
- HS-Codes Stormcase: 42021250
- Weight Stormcase: ~10 kg
- Weight total: ~19 kg
- Export Classification: AL = N ECCN = N
- Country of Origin: Austria

2 Application cases

2.1 Overview

The different application cases demonstrated by the PROFET™ Load Guard demonstrator are described in this chapter.

2.1.1 Basic behavior after turn ON

When the power switch is turned ON and no jumper is connected, the display between the LITIX™ Power DC-DC controller and the ECU indicates the supply line range which is approximately at V = 12.5 V and I = 2.75 A (this is load dependent). The voltage, 12.5 V, is given by the DC-DC output. The current, 2.75 A, is the sum of the two indicator lights (~50 mA each), the two resistive loads (~1.2 A each) and what is consumed by the ECU board itself (remaining 80 mA).

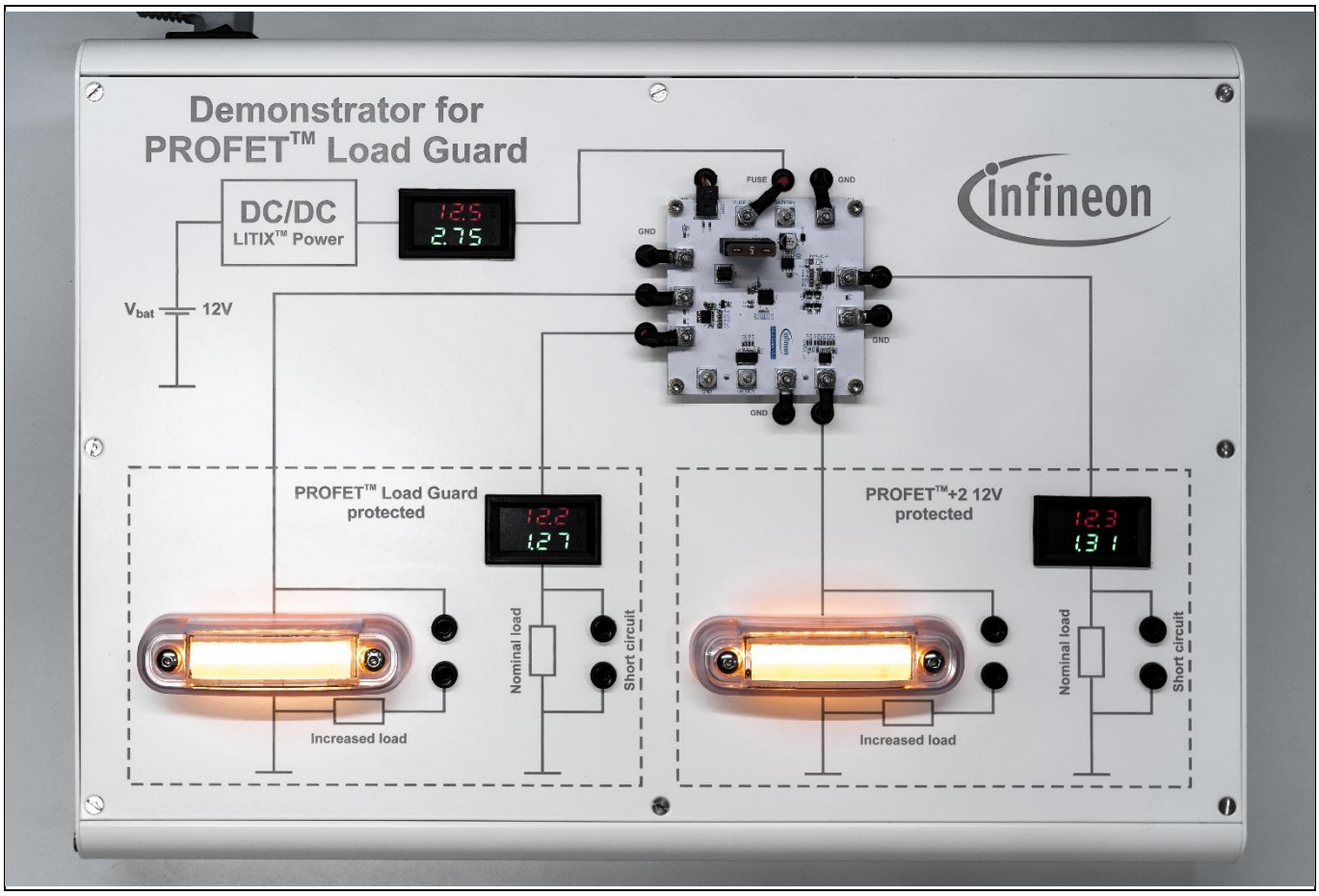

Figure 6 Use case: Basic behavior after turn ON

2.1.2 Increased load via PROFET™ Load Guard

This application case demonstrates the performance of the PROFET™ Load Guard adjustable current limitation feature. Due to the chosen current limitation, 1.5 A per channel, the PROFET™ Load Guard limits the increased load current. Due to this, the increased load does not lead to a significantly higher current and therefore the LITIX™ Power DC-DC controller works properly.

In order to demonstrate this application case, place the jumper as shown in Figure 7. This results in a higher current which is indicated on the display between the DC-DC and the ECU board. In addition, the LED on the left

side (connected to the PROFET™ Load Guard channel 1) is dimmed. Dimming is caused partly by the current that flows through the increased load resistor and also by the PROFET™ Load Guard current limitation.

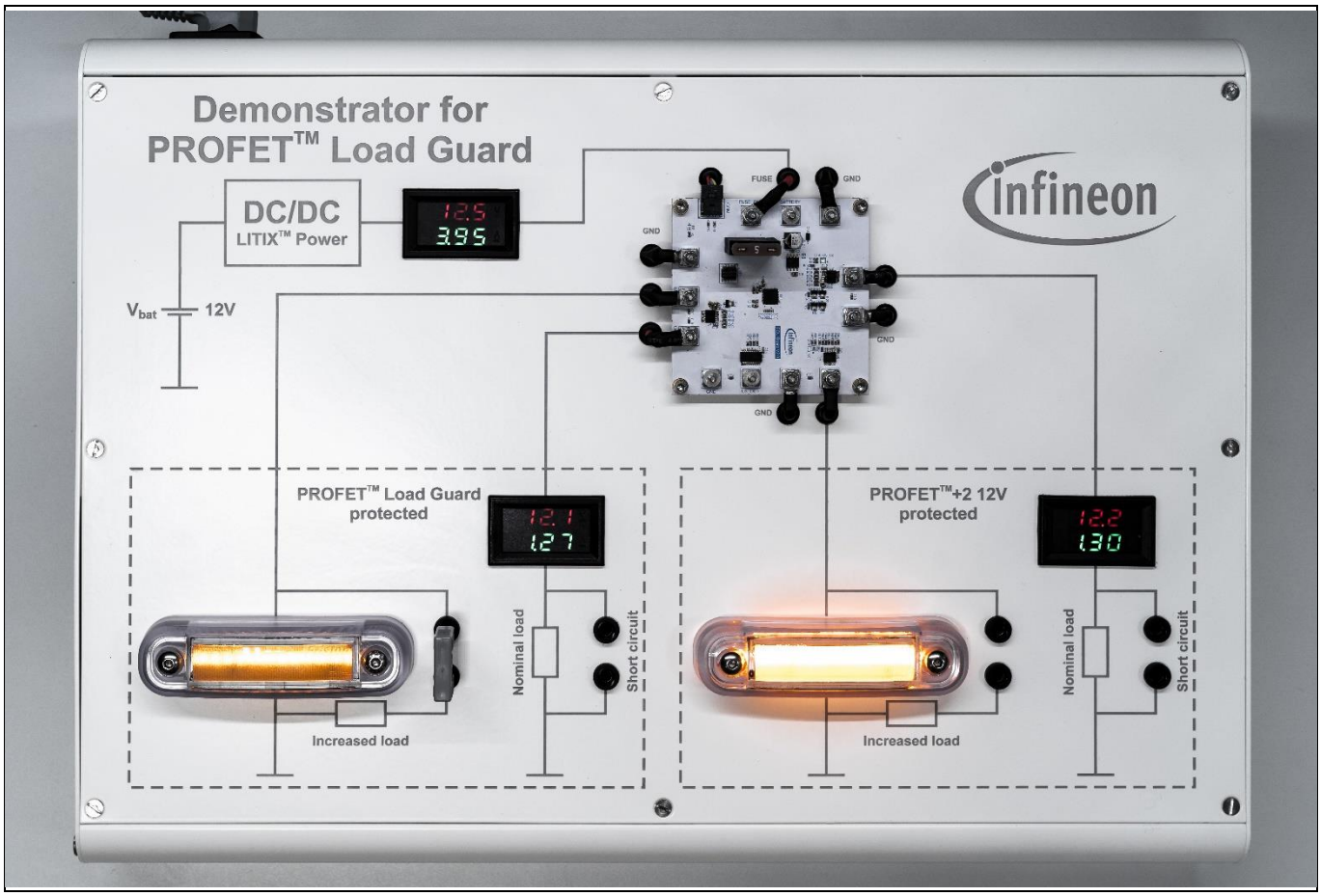

Figure 7 Use case: Increased load via PROFET™ Load Guard - Jumper setting

2.1.3 Increased load via PROFET™ +2

This application case compares the behavior of the PROFET™ +2 to the PROFET™ Load Guard when an increased load condition is present. Since the PROFET™ +2 device has no adjustable current limitation, more current than the LITIX™ Power DC-DC controller can offer, is consumed. Since the LITIX™ Power can only offer up to 5 A, the increased current leads to the collapse of the DC-DC. Furthermore, this leads to a dimming of the indicator lights and a lower load current on the two output channels with the V/I measurement display. This application also highlights that the 5 A fuse is not as accurate as the adjustable current limitation feature of the PROFET™ Load Guard.

To apply this application case, place the jumper as shown in Figure 8. This jumper leads to an increased load current as described above.

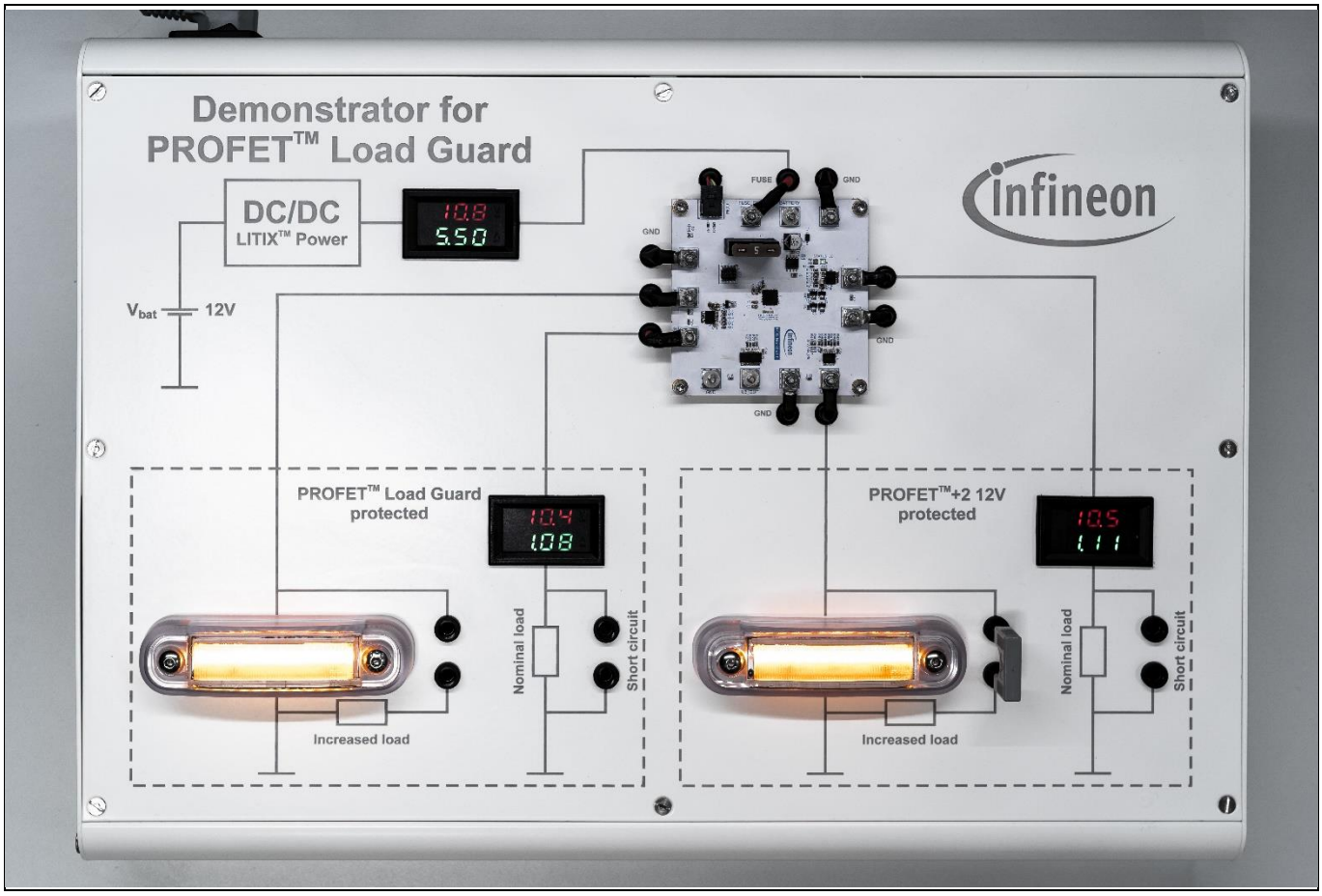

Figure 8 Use case: Increased load via PROFET™ +2 - Jumper setting

2.1.4 Short circuit via PROFET™ Load Guard

This application case demonstrates the short circuit protection with adjustable current limitation feature of the PROFET™ Load Guard. Due to the chosen current limitation, 1.5 A per channel, the 5 A fuse does not get destroyed. Since the short circuit current is much higher than the chosen current limitation, the PROFET™ Load Guard turns the channel 0 OFF to protect the power supply. In order to reset this fault mode, the 5 A fuse has to be removed and plugged in again. Typically, the fault can be reset by pulling the input, INx, of the PROFET™ Load Guard to 0 V.

In order to demonstrate this application case, place the "short circuit" jumper as shown in Figure 9. This jumper leads to a short circuit to ground.

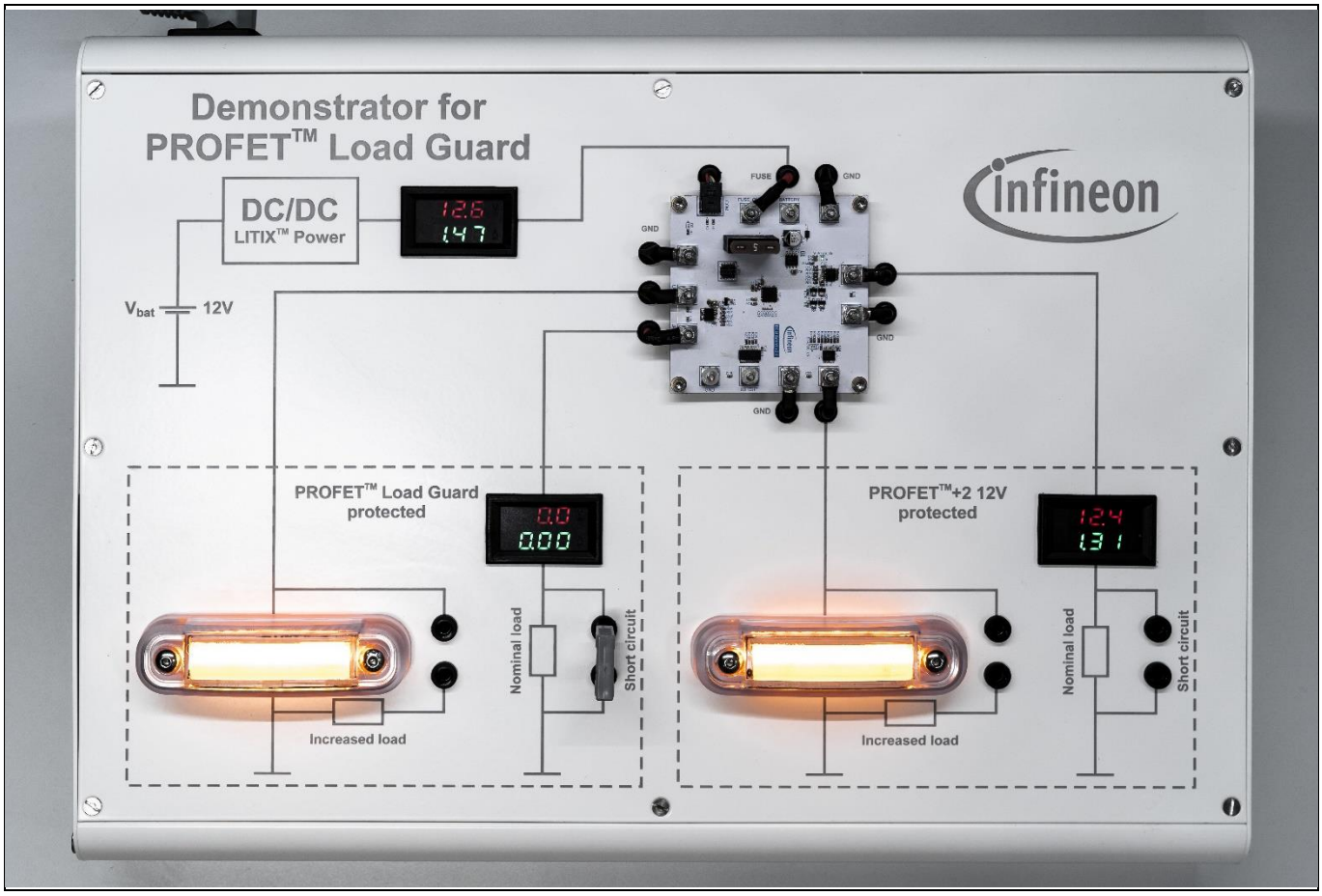

Figure 9 Use case: Short circuit via PROFET™ Load Guard - Jumper setting

2.1.5 Short circuit via PROFET™ +2

This application case demonstrates the behavior of the PROFET™ +2 when a short circuit condition is present. The PROFET™ +2 overload detection current is much higher than the current that the DC-DC offers. Therefore, the device does not turn OFF. This leads to the 5 A fuse to blow as the short circuit current is much higher than what the fuse can manage.

To apply this application case, place the "short circuit" jumper as shown in Figure 10. This jumper applied a short circuit to ground condition.

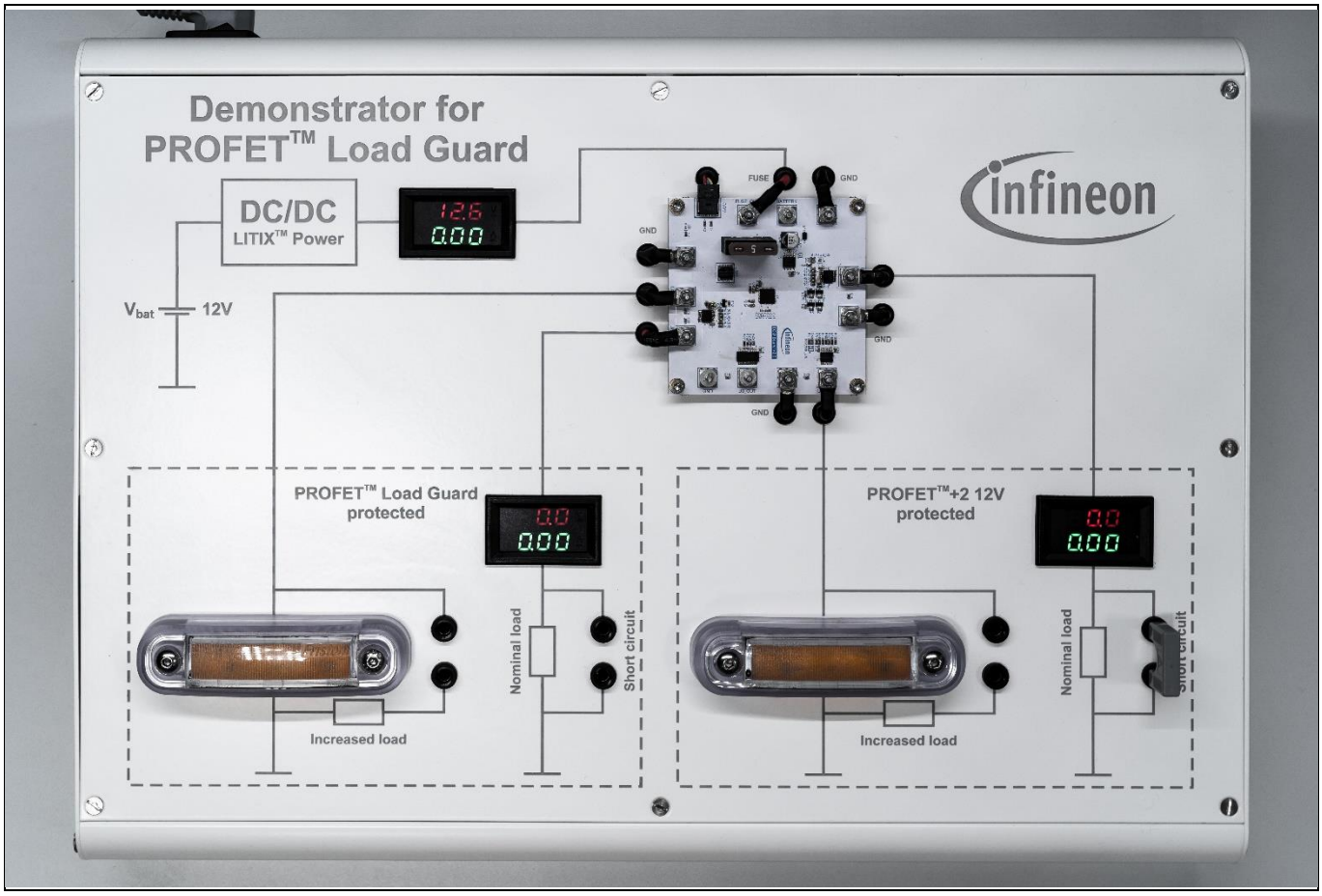

Figure 10 Use case: Short circuit via PROFET™ +2 - Jumper setting

3 Load Guard demonstrator - Digital twin

This chapter outlines the Load Guard demonstrator features by means of its digital twin, referred as simulation model, aiming to be an easy, time efficient solution to explore the demonstrator as well as the PROFET™ Load Guard device benefits.

3.1 Digital twin of Load Guard demonstrator that shows the difference between the PROFET™ Load Guard and PROFET™ +2 devices

Figure 11 shows the digital twin of the PROFET™ Load Guard demonstrator.

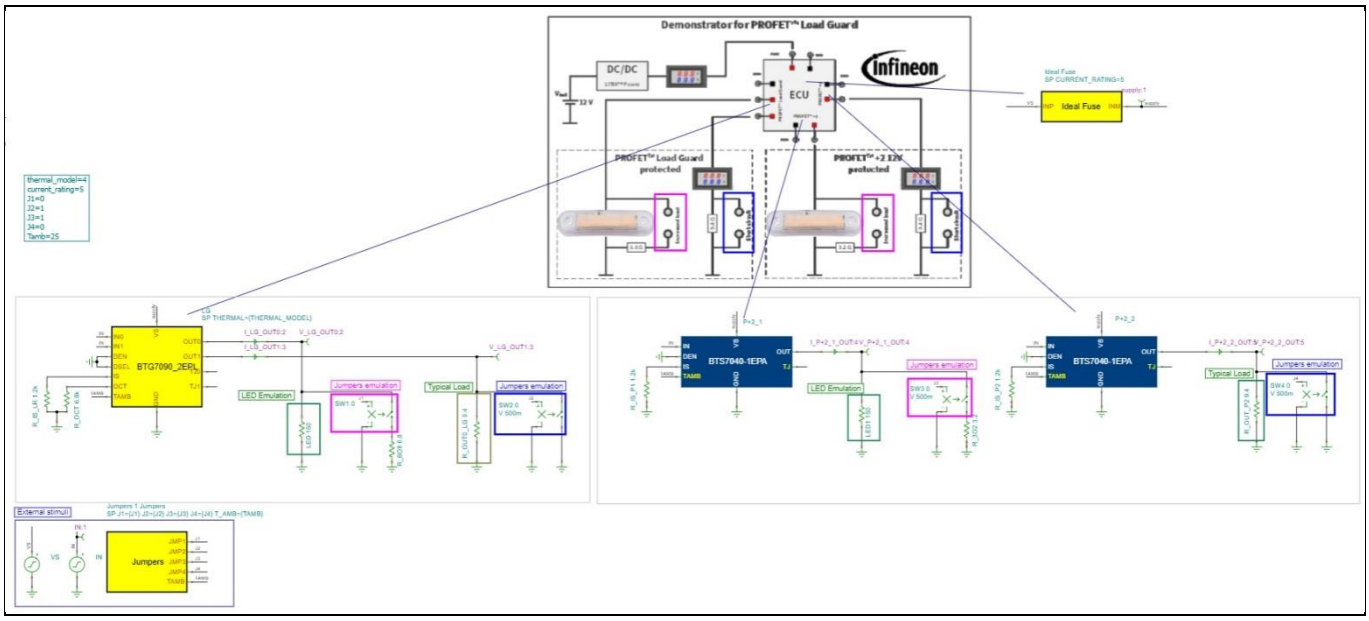

Figure 11 Load Guard demonstrator digital twin

In the digital twin, the LITIX™ Power TLD5190QV simulation model has been replaced by a constant voltage source, V_S, shown in Figure 12. This is due to the long simulation time required by the DC-DC controller model during startup.

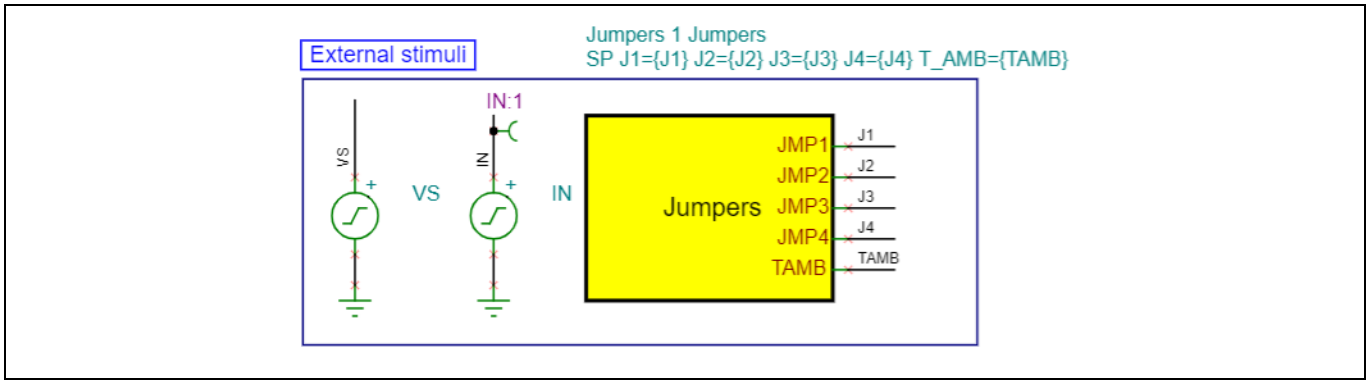

Figure 12 External stimuli circuit including supply and jumpers

The fuse is emulated with the use of an ideal model to avoid the long simulation time of a real fuse emulation. Once the current has reached the current rating, the ideal fuse disconnects the supply voltage of all the switches from the application.

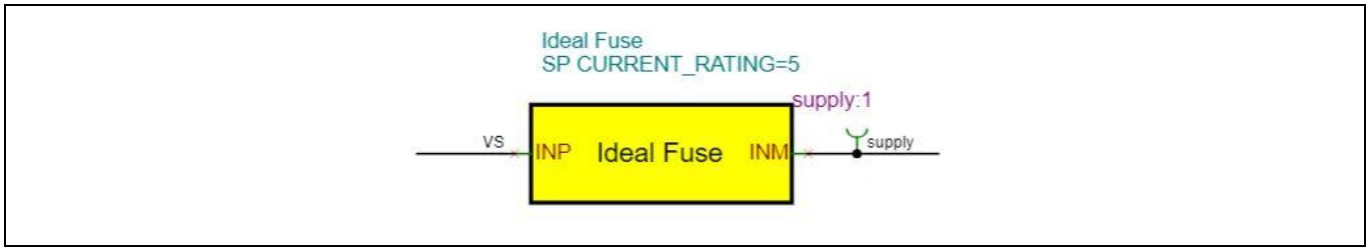

Figure 13 Ideal fuse

Figure 14 and Figure 15 show the PROFET™ Load Guard BTG7090-2EPL and the PROFET™ +2 BTS7040-1EPA circuit, respectively.

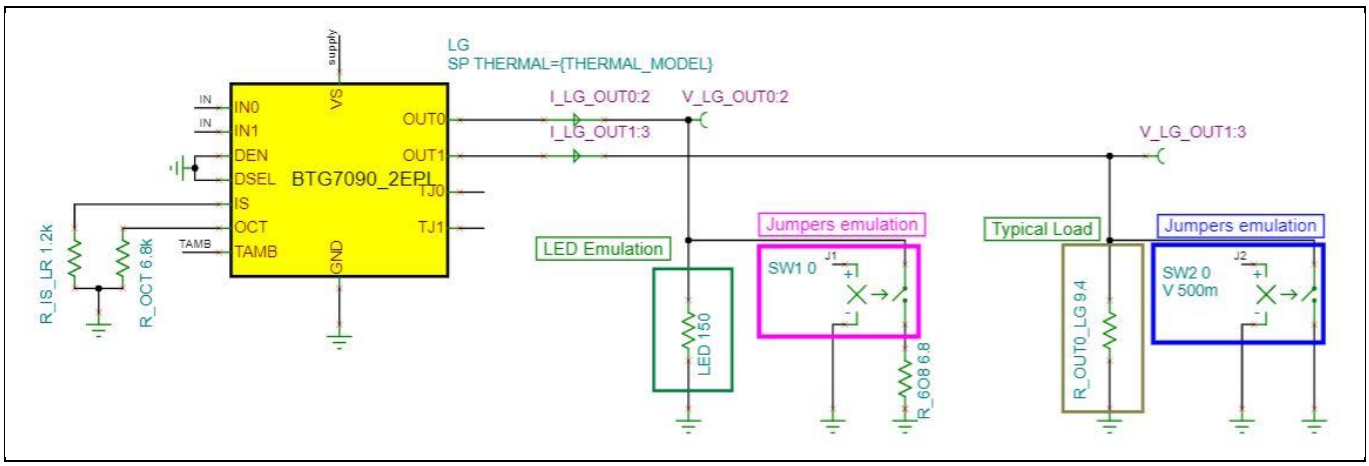

Figure 14 PROFET™ Load Guard BTG7090-2EPL circuit

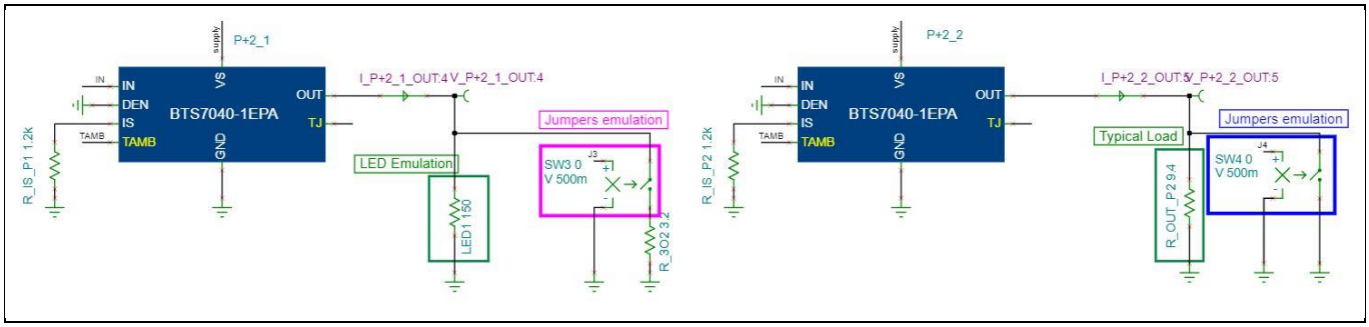

Figure 15 PROFET™ +2 BTS7040-1EPA circuit

In the actual hardware, each application case is selected with the use of a jumper. The digital twin gives the user the possibility to try all the application cases available on the Load Guard demonstrator. To do so, the "increased load" and "short circuit" jumpers are reflected in the digital twin as J1 to J4 jumpers, part of the external stimuli circuit shown in Figure 12. To simulate an application case, other than the normal operation, the user can select one from the "Failure Testcases" list, shown in Figure 16.

Figure 16 Simulation options: "Normal operation" and "Failure Testcases" list

3.1.1 Normal operation

In normal operation the demonstrator is powered ON (Chapter 2.1.1) and no jumpers are connected. Each channel operates in normal/typical conditions. Figure 17 shows the simulation results of normal operation.

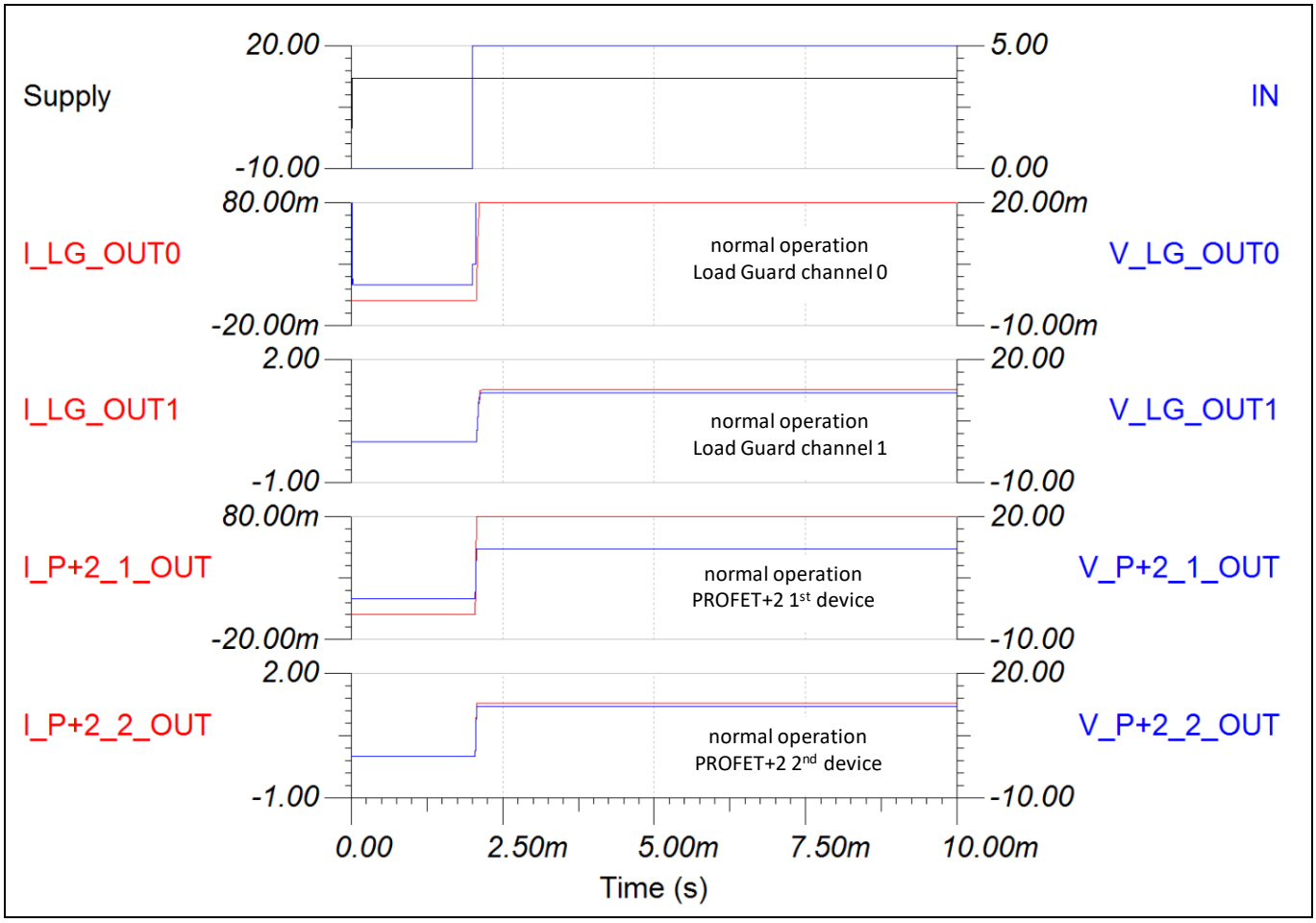

Figure 17 Simulation results - normal operation

3.1.2 Test case 1 - Overload on PROFET™ Load Guard channel 0

Test case 1 emulates the behavior of the PROFET™ Load Guard and PROFET™ +2 devices when an overload condition is present on PROFET™ Load Guard channel 0. In the hardware, this condition is achieved by connecting the "Increase load" jumper. Here, this condition is achieved by connecting jumper J1, refer to Chapter 2.1.2. Under this condition, the load on PROFET™ Load Guard channel 0 is increased while the PROFET™ Load Guard channel 1 and the PROFET™ +2 devices are not affected, as shown in Figure 18.

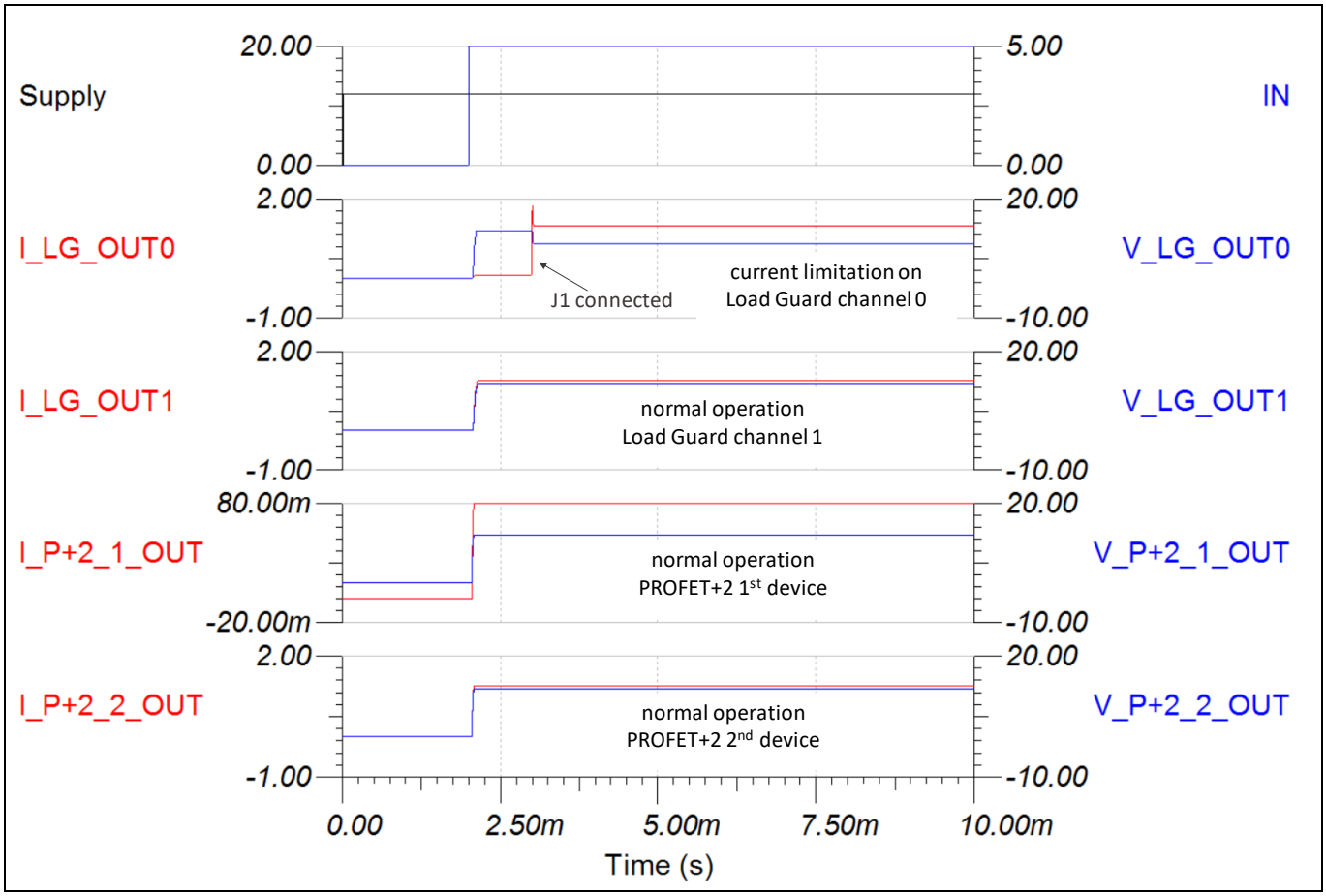

Figure 18 Simulation results – Test case 1, overload on PROFET™ Load Guard channel 0

3.1.3 Test case 2 - Short circuit to ground on PROFET™ Load Guard channel 1

Test case 2 emulates the behavior of the PROFET™ Load Guard and PROFET™ +2 devices when a short circuit to ground condition is present on PROFET™ Load Guard channel 1. In the hardware this condition is achieved by connecting the "short circuit" jumper. Here, this condition is achieved by connecting jumper-J2, refer to Chapter 2.1.4. Under this condition, the PROFET™ Load Guard channel 0 and the PROFET™ +2 devices are not affected, as shown in the figure below.

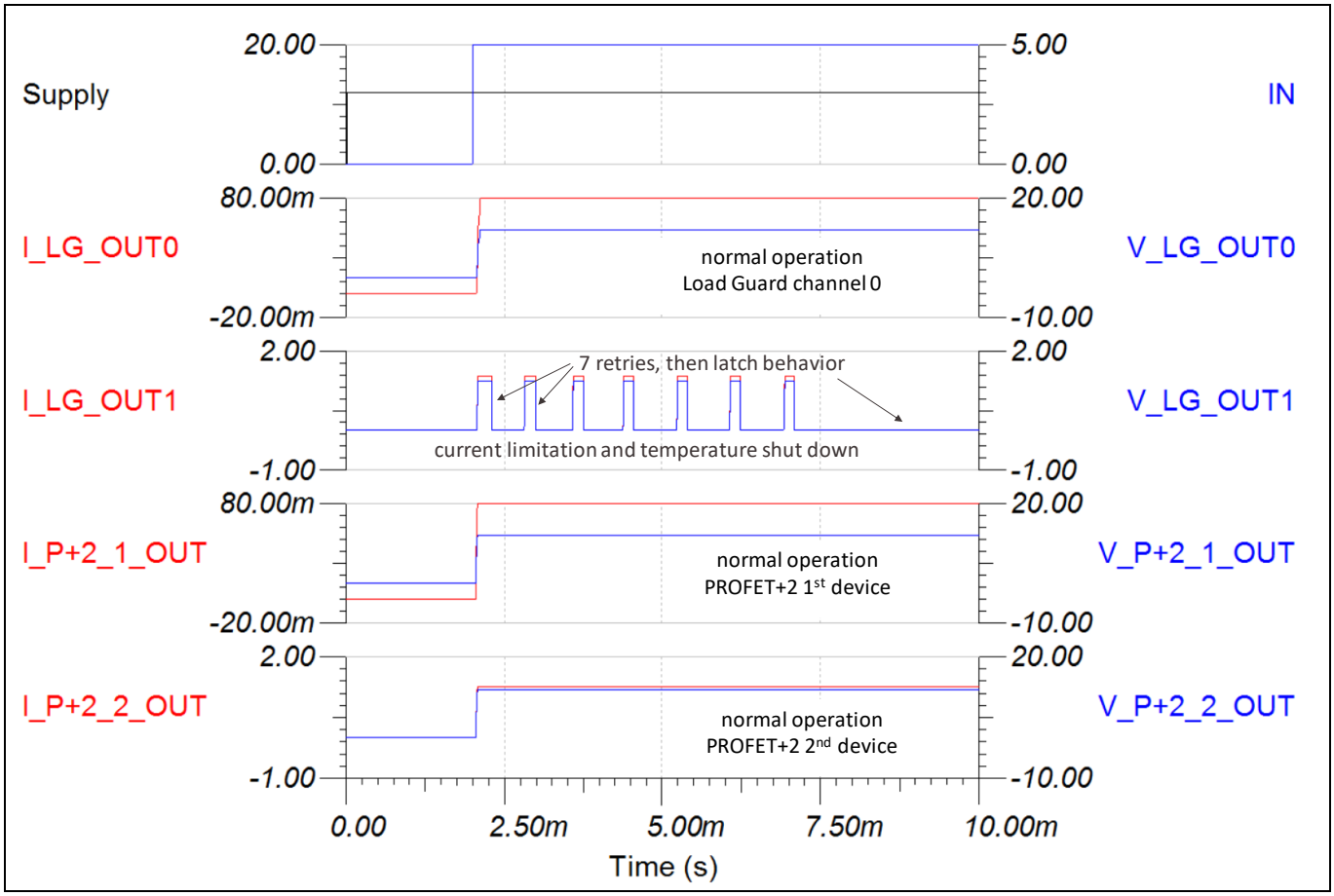

Figure 19 Simulation results - Short circuit to ground on PROFET™ Load Guard channel 1

3.1.4 Test case 3 - Overload on PROFET™ +2

Test case 3 emulates the behavior of the PROFET™ Load Guard and PROFET™ +2 devices when an overload condition is present on PROFET™ +2 BTS7040-1EPA. In the hardware, this condition is achieved by connecting the "Increase load" jumper. Here, this condition is achieved by connecting jumper J3, refer to Chapter 2.1.3. Under this condition, the load on PROFET™ +2 BTS7040-1EPA is increased and causes the current to exceed 5 A. This results in the ideal fuse to break and therefore disconnects the supply voltage for all the devices. Simulation results are depicted in the figure below.

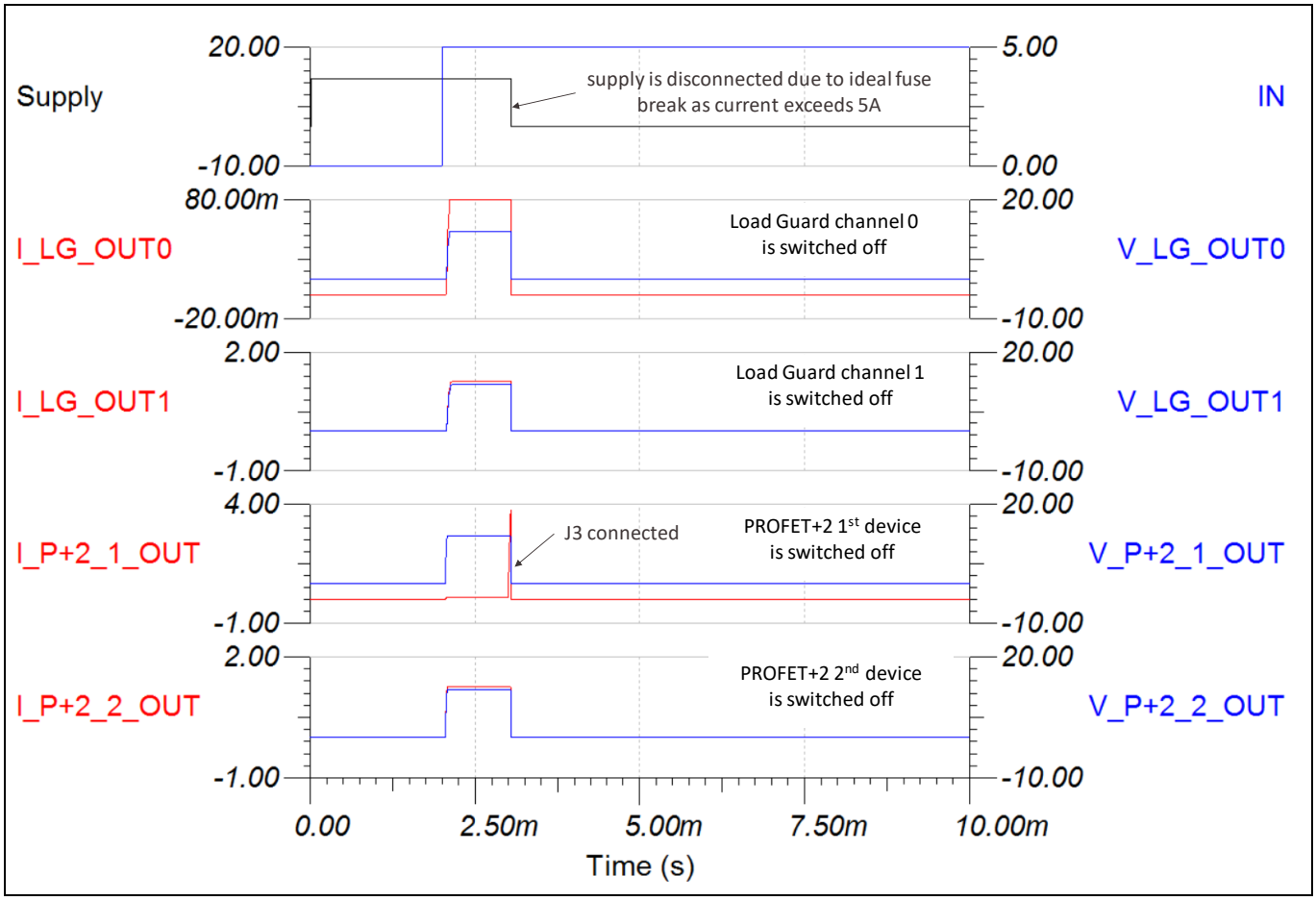

Figure 20 Test case 3 - Overload on PROFET™ +2 BTS7040-1EPA

3.1.5 Test case 4 - Short circuit to ground on PROFET™ +2 BTS7040-1EPA

Test case 4 emulates the behavior of the PROFET™ Load Guard and PROFET™ +2 devices when a short circuit to ground condition is present on PROFET™ +2 BTS7040-1EPA. In the hardware, this condition is achieved by connecting the "short circuit" jumper. Here, this condition is achieved by connecting jumper J4, refer to Chapter 2.1.5. Under this condition, all the devices are switched off, as shown in the figure below.

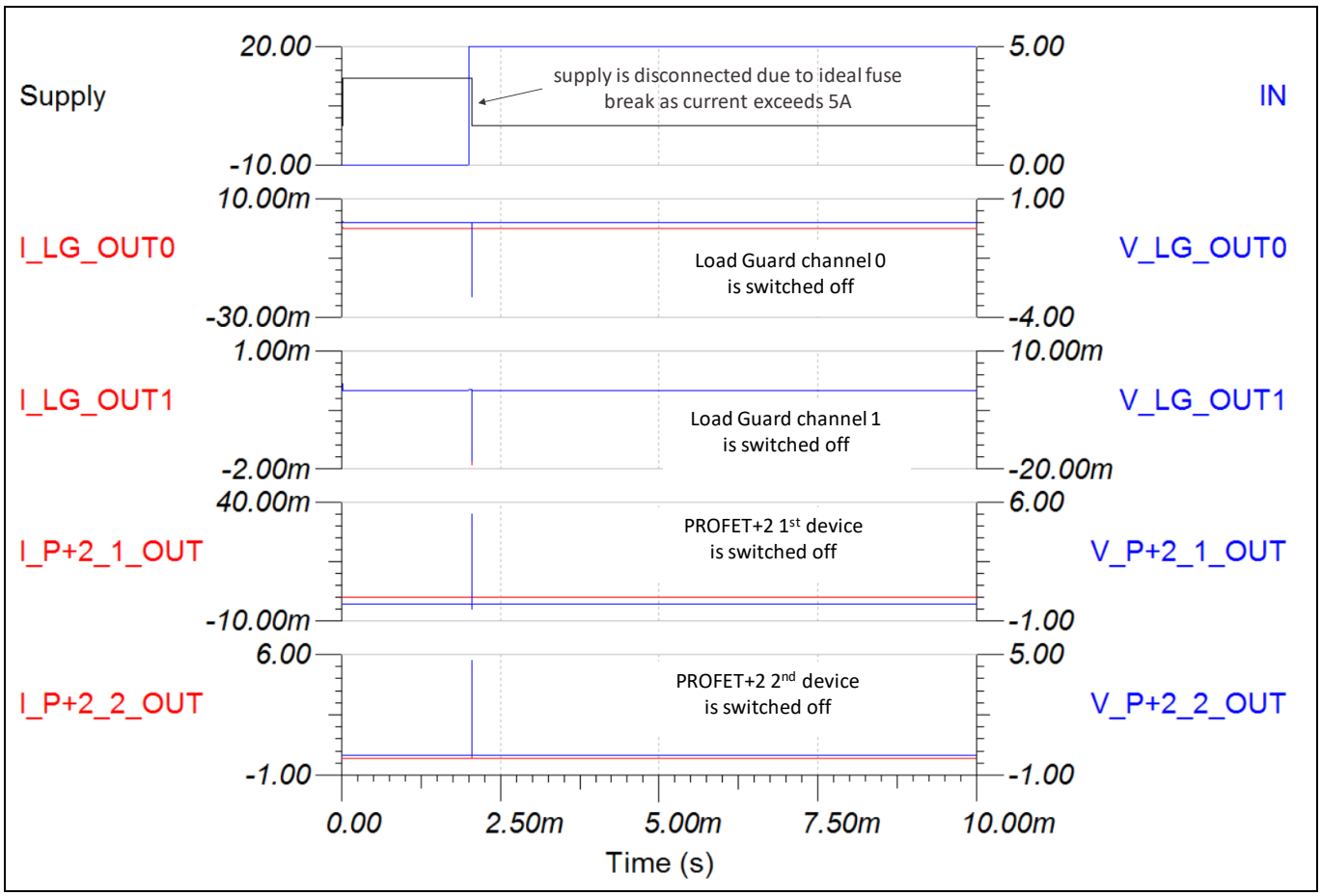

Figure 21 Simulation results - Short circuit to ground on PROFET™ BTS7040-1EPA

4 Help guide

4.1 Troubleshooting

Table 1 shows the potential issues that may occur when using the PROFET™ Load Guard demonstrator, the possible root cause and respective solution.

Table 1 PROFET™ Load Guard demonstrator - potential issues and solutions

Issue	Possible root cause	Solution
The selected application case does not behave as expected	Wrong jumper or melting fuse	Check jumper setting as shown in Chapter 2
Indicator lights are OFF and no current is visible on the V/I measurement displays	Power cable is not connected to the demonstrator	Use a power cable and connect it at the backside of the demonstrator, refer to Figure 5
	5 A fuse is already broken	Remove the already broken 5 A fuse and insert a new one
	Power cable is broken	Exchange the power cable and use a new one
The selected application case does not behave as expected	Wrong jumper or melting fuse	Check jumper setting as shown in Chapter 2

5 List of References

[1] Infineon PROFET™ Load Guard 12V | Automotive Smart High-Side Switch; https://www.infineon.com/cms/en/product/power/smart-low-side-high-side-switches/high-side-switches/profet-load-guard-12v-automotive-smart-high-side-switch/

[2] Infineon BTG7090-2EPL; https://www.infineon.com/cms/en/product/power/smart-low-side-high-side-switches/high-side-switches/profet-load-guard-12v-automotive-smart-high-side-switch/btg7090-2epl/

[3] Infineon Designer – Online SPICE simulator; https://www.infineon.com/cms/en/tools/landing/ifxdesigner.html?search=true&keyword=load%20guard

[4] Infineon PROFET™ +2 12V | Automotive Smart High-Side Switch; https://www.infineon.com/cms/en/product/power/smart-low-side-high-side-switches/high-side-switches/profet-plus-2-12v-automotive-smart-high-side-switch/

[5] Infineon BTS7040-1EPA; https://www.infineon.com/cms/en/product/power/smart-low-side-high-side-switches/high-side-switches/profet-plus-2-12v-automotive-smart-high-side-switch/bts7040-1epa/

[6] Infineon LITIX™ Power TLD5190QV; https://www.infineon.com/cms/en/product/power/lighting-ics/litix-automotive-led-driver-ic/litix-power/tld5190qv/

[7] Infineon CY8C4124LQE-S423; https://www.infineon.com/cms/en/product/microcontroller/32-bit-psoc-arm-cortex-microcontroller/psoc-4-32-bit-arm-cortex-m0-mcu/cy8c4124lqe-s423/

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