L9912, L9912L, L9924 and L9924L lamp handling

Introduction

A bulb lamp or a LED is connected between a battery and the L terminal and is switched on when the terminal is driven low by the relevant low-side driver.

During lamp activation the rush current can be high enough to trigger an undesired over-current event; for this reason the over-current detection circuit has a time filter to check the duration of the event.

If the condition duration is larger than tL_{OC} the driver is switched off and the relevant flag is set.

tL_{OC} value is a critical parameter because it has to be long enough to let the system withstand the rush phase but must not be too long to switch the LS driver off before it is damaged in case of short, either for 12 V or 24 V applications.

The value has been fixed to ~1.6 ms in order to withstand short to battery conditions with 24 V applications; as drawback an over-current event is very likely even for 12 V applications. In these cases a lamp switch on strategy is required.

The Purpose of this document is to show the system behavior and some strategy to correctly handle all possible conditions.
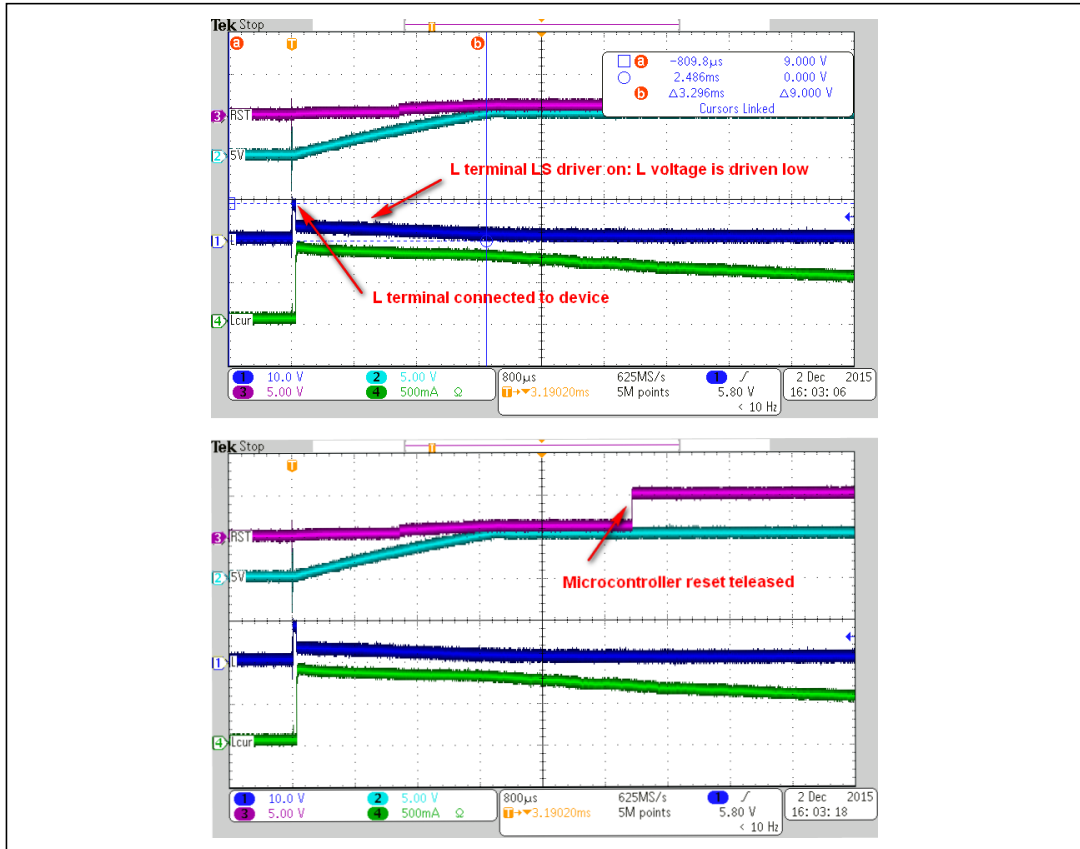
Contents

1 Wake-up by L

The following snapshots show a wake-up by L at two different battery voltages: once the system detects the transition at L terminal it switches the LS driver on and activates the voltage regulator to supply the microcontroller and then releases the reset signal.

Figure 1. Wake-up by L at 8 V

With an 8 V supply voltage the system is able to switch the lamp on without detecting any over-current event: L terminal is driven low and the lamp is on.

Figure 2. Wake-up by L at 12 V
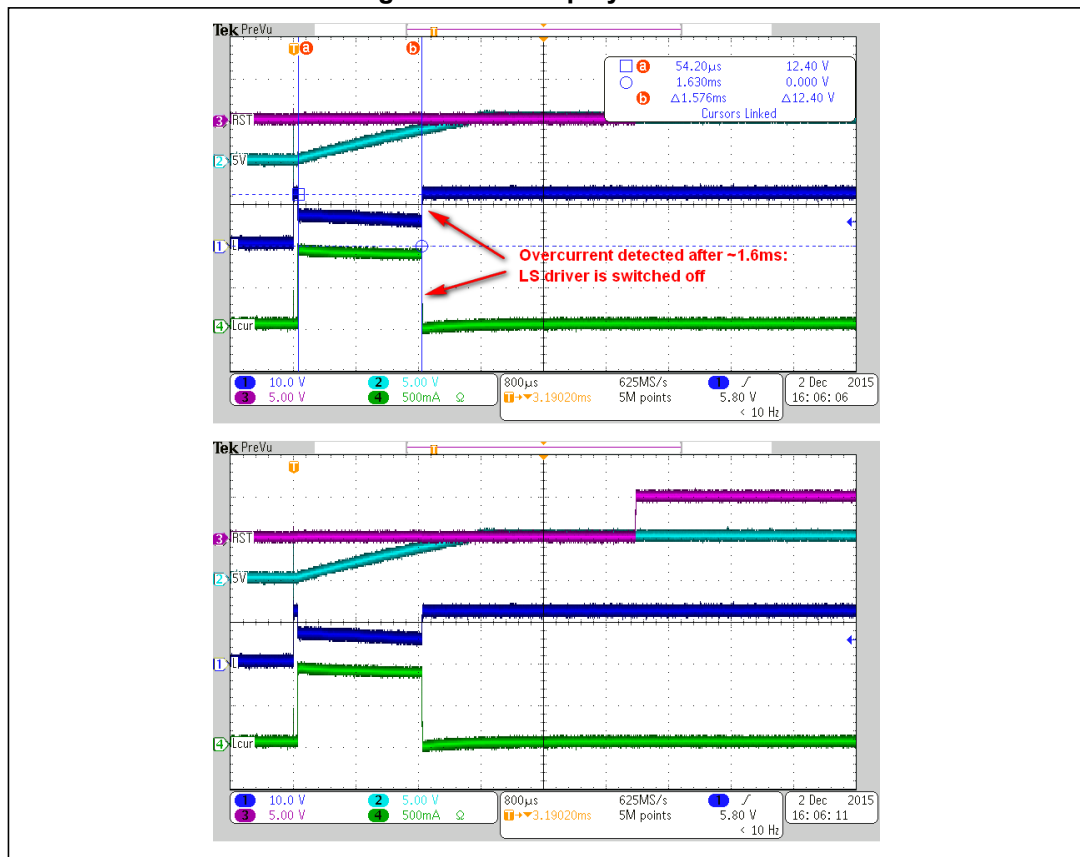
With a 12 V supply voltage the system is not able to switch the lamp and, because of the bulb rush current, an over-current event is generated: after the tL_{OC} time interval the L LS driver is switched off, the L terminal is released and the lamp is off.

1.1 Wake-up by short at L terminal

The following picture shows a wake-up generated by a short-to- battery condition at L terminal with an 8 V battery voltage: the system detects the short condition and switches the LS driver off after tL_{OC}

In case of short to battery at L terminal the system detects an over-current condition even at 8 V

Figure 3. Wake-up by L at 8 V in short conditions
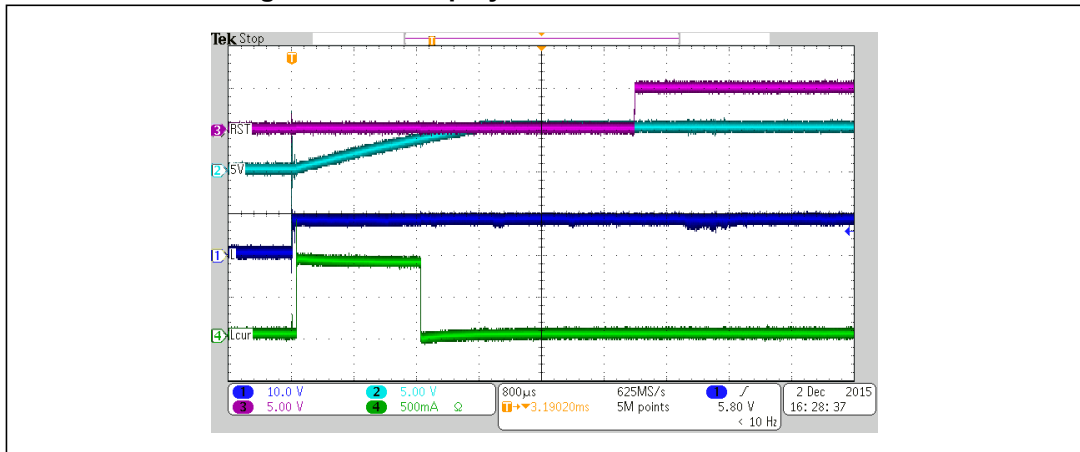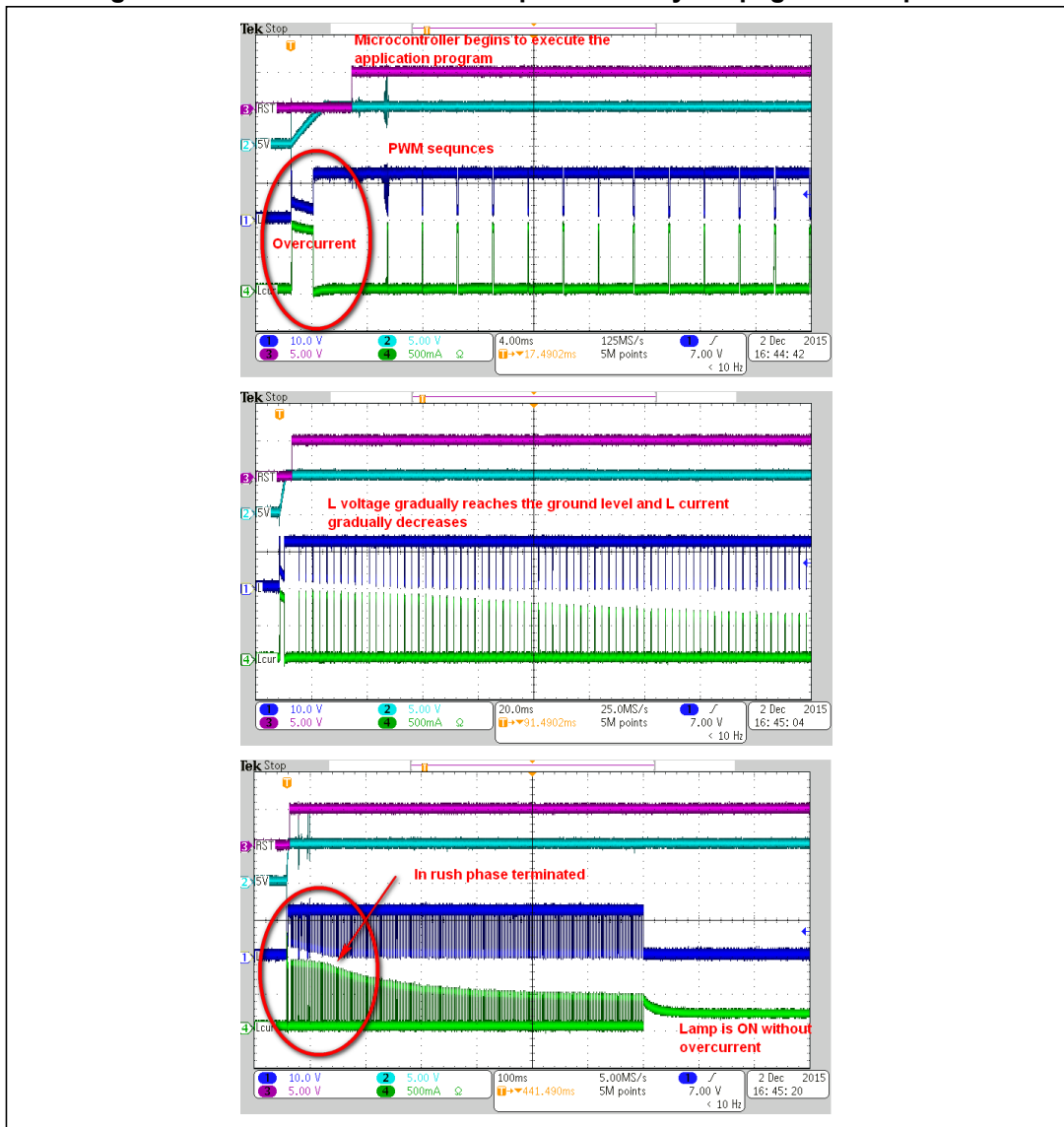
2 Lamp ignition sequence

The system has to ensure two opposite requisites:

- Overcome the bulb rush phase without switching the driver off;
- Withstand a short-to-battery condition at L terminal without damaging the LS driver.

To by-pass the rush current phase it is useful an ignition sequence based on a PWM L terminal switch on procedure with an on-time smaller than the tL_{OC}: in this condition no over-current detection is possible and the bulb lamp is gradually brought to steady conditions; at the end of the sequence the driver is left on and ready to detect a possible short.

The following snapshots show an example of the lamp switch on sequence; the number of PWM pulses is very high and can be drastically reduced depending on lamp characteristics.

Figure 4. Different views of wake-up followed by lamp ignition sequence

The sequence has to be used all times a lamp ignition is required.

Ignition parameters are the following:

- On time: this time period must be smaller than tL_{OC} to prevent any over-current occurrence.
- Off time: this time period allows the driver to cool down
- Number of pulses

Parameters' values depend on the type of lamp; as a general rule, it is suggested to keep the on time very small (100 µs in the above example) in order to avoid a fast driver heating in case of short conditions.

2.1 Lamp disable

To avoid an over-current detection on each key-on it is suggested to switch the lamp off before commanding the sleep status: in this condition the wake-up by L is guaranteed but the over-current no longer occurs then, when the microcontroller is working, it can implement the lamp ignition sequence.

The following picture shows an example where there is no overcurrent.

Figure 5. Wake-up by L with lamp LS driver disabled
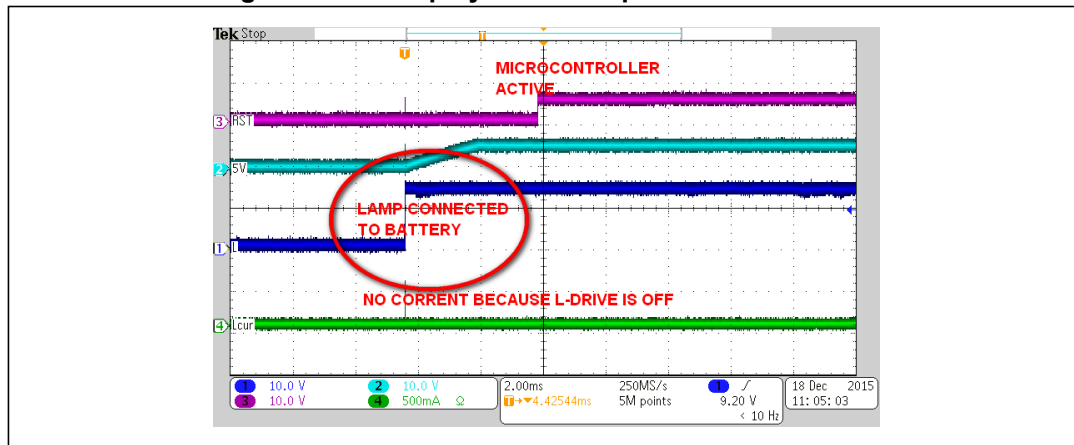
2.2 Lamp ignition sequence in short conditions

The following pictures show the system behavior in case of L terminal short conditions.

When a short is present an ignition retry strategy can be implemented: the retry time interval is a new parameter that needs to be tuned in order to let the driver cool down.

When a short is applied the over-current is immediately detected (tL_{OC} has already elapsed since the last L driver activation) and a new ignition attempt is performed after the retry time (200 ms in the example)

Figure 6. L terminal shorted to battery
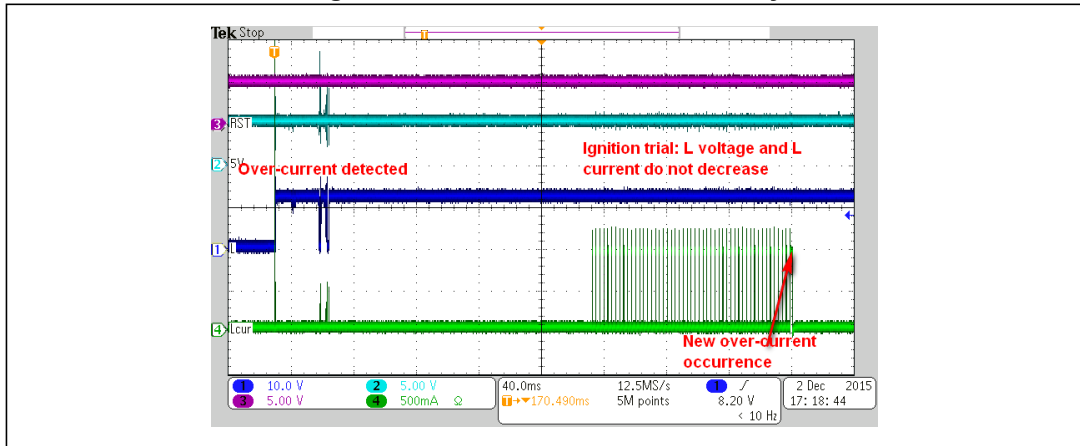
Figure 7 shows the case where the short condition is persistent and an ignition retry sequence is actuated.

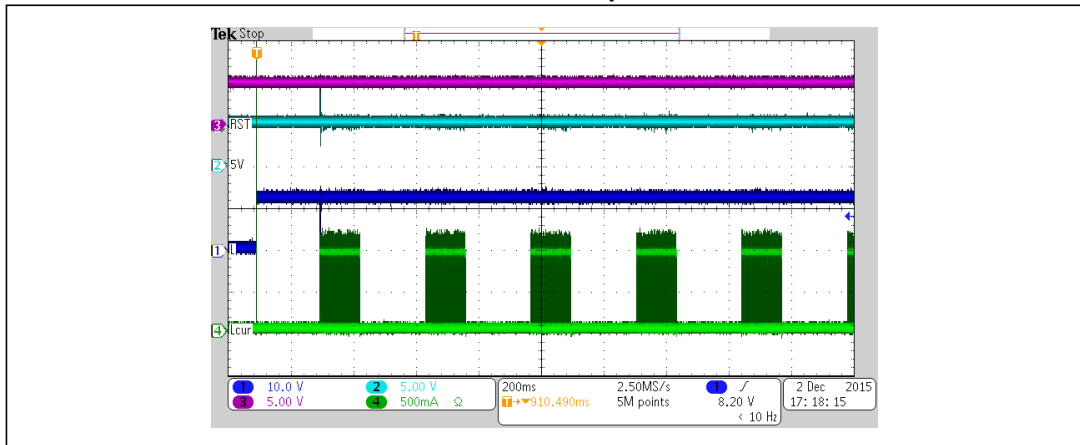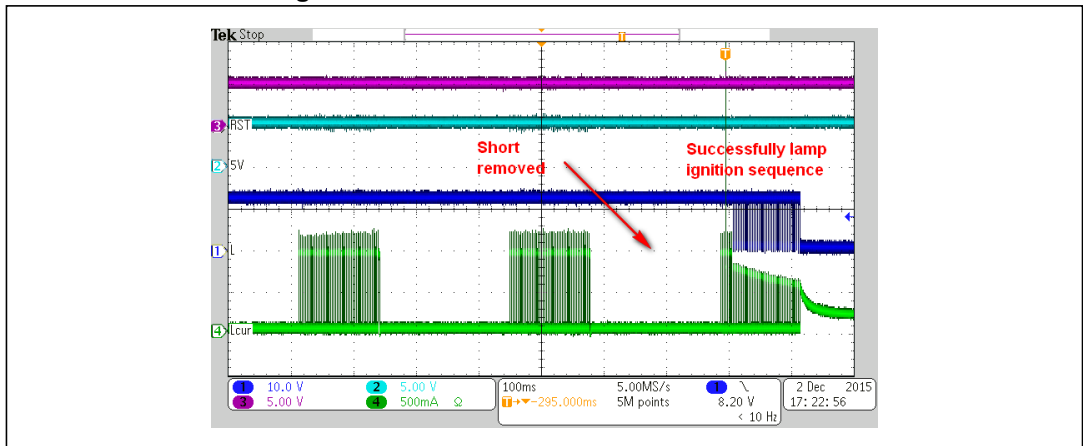**Figure 7. After some trials the short is removed and the system is again able to switch the lamp on**

Figure 8. Behavior in case of short removal

2.3 Lamp insertion

The following picture shows a lamp insertion example; an over-current condition is detected and a new successfully ignition is applied after the retry time interval.

Figure 9. Lamp insertion with the L LS driver on
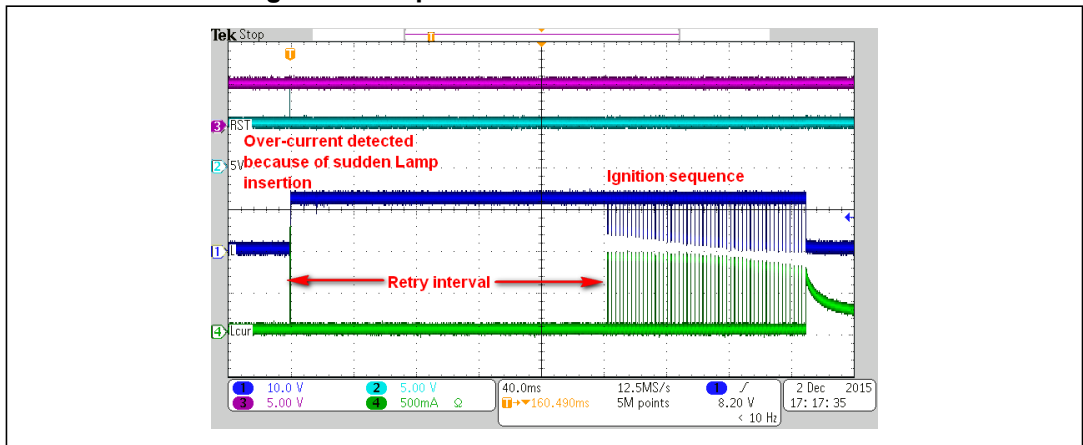
3 24 V applications

The lamp ignition sequence is also required for a 24 V application: the parameters are more critical because energy values are much larger and the system has to be preserved by excessive heating and needs more time to cool down. A further power dissipation is given by the internal regulator designed to extract the 5 V microcontroller supply voltage: at 24 V the current consumption is quite larger.

For this reason on-time has to be kept low and the retry time cannot be smaller than 1 ms.

The following pictures show the behavior.

Figure 10. Wake-up by L at 24 V
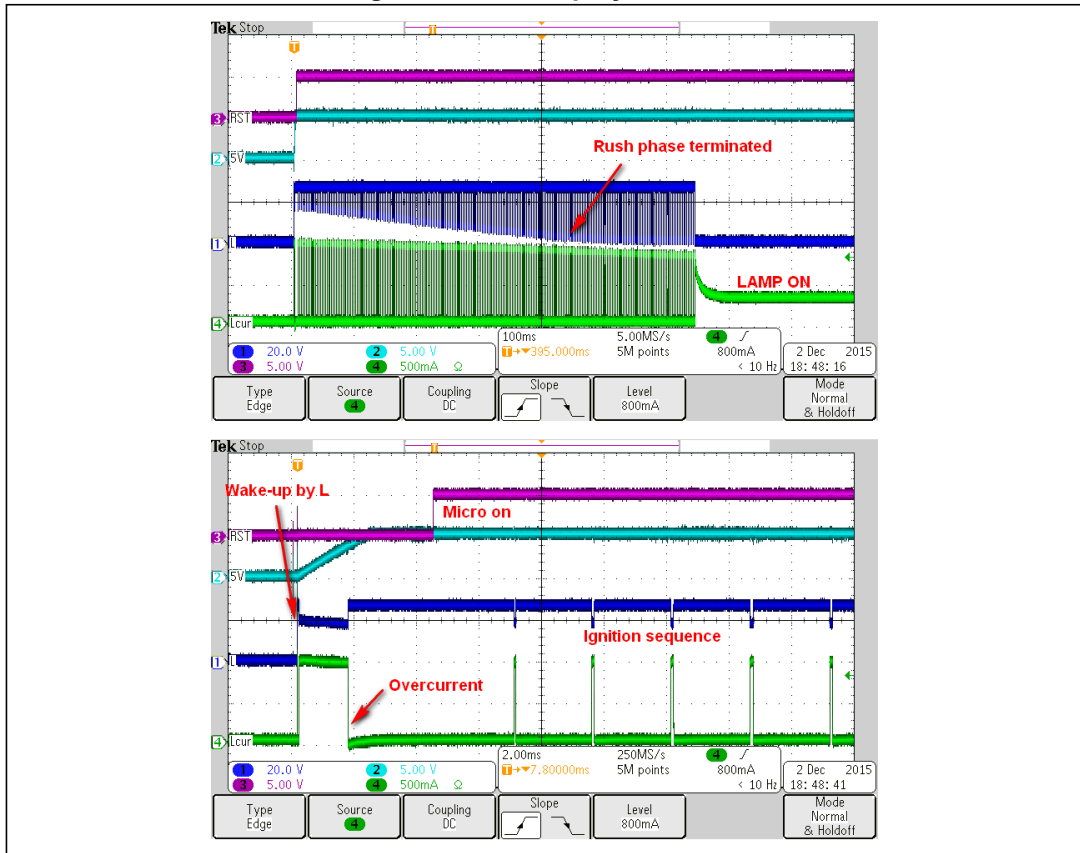
3.1 Lamp ignition sequence in short conditions

The following snapshots show the system behavior; refer to the 12 V examples for notes and comments.
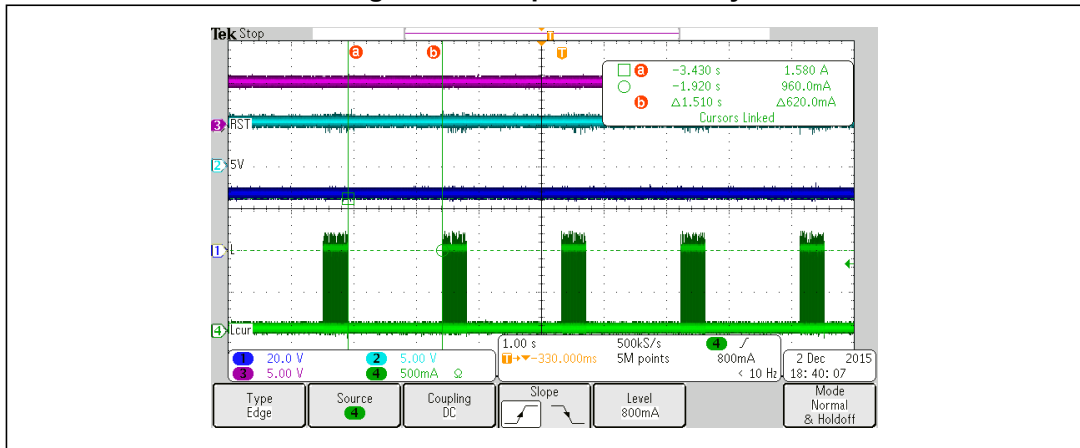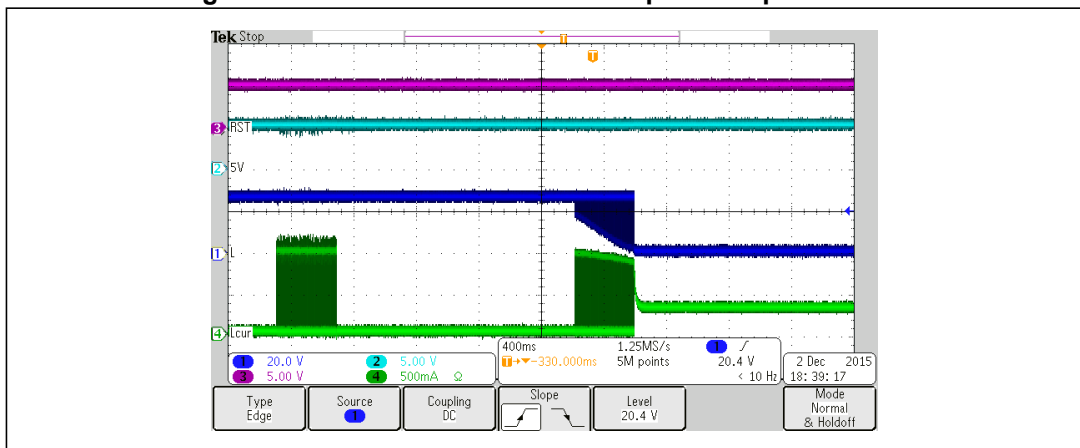
Figure 11. Lamp switch on retry

Figure 12. Short removal with consequent lamp activation

4 Low side driver protection

L terminal low side driver has to be preserved from excessive power contribution that could damage the device for thermal dissipation in case of short circuit.

The t_{LOC} time interval value is able to switch off the driver in case of high current consumption but is not able to keep under control the overall power dissipation.

To avoid system over heating the following strategies could be implemented:

- low duty cycle (e.g. $T_{on} \approx 0.1$ ms and $T_{off} \approx 2.4$ ms)
- low pulse number
- large retry interval (> 1 ms)
- change the pulse number according to the failed retries number: if a short is permanent the retry procedure could even be interrupted
- change the pulse number and/or the retry interval according to system temperature
- switch the driver off if the temperature exceeds a given value. Different approaches can be applied:
  - skip the current trial
  - skip the current PWM pulse

The following picture shows the system behavior with the following (very aggressive parameters):

- T_{on} = 200 µs
- T_{off} = 800 µs
- N pulse = 150
- Retry time = 1 s
- Driver switch off temperature threshold = 115° (Celsius)

Figure 13. Retry sequence with temperature acquisition
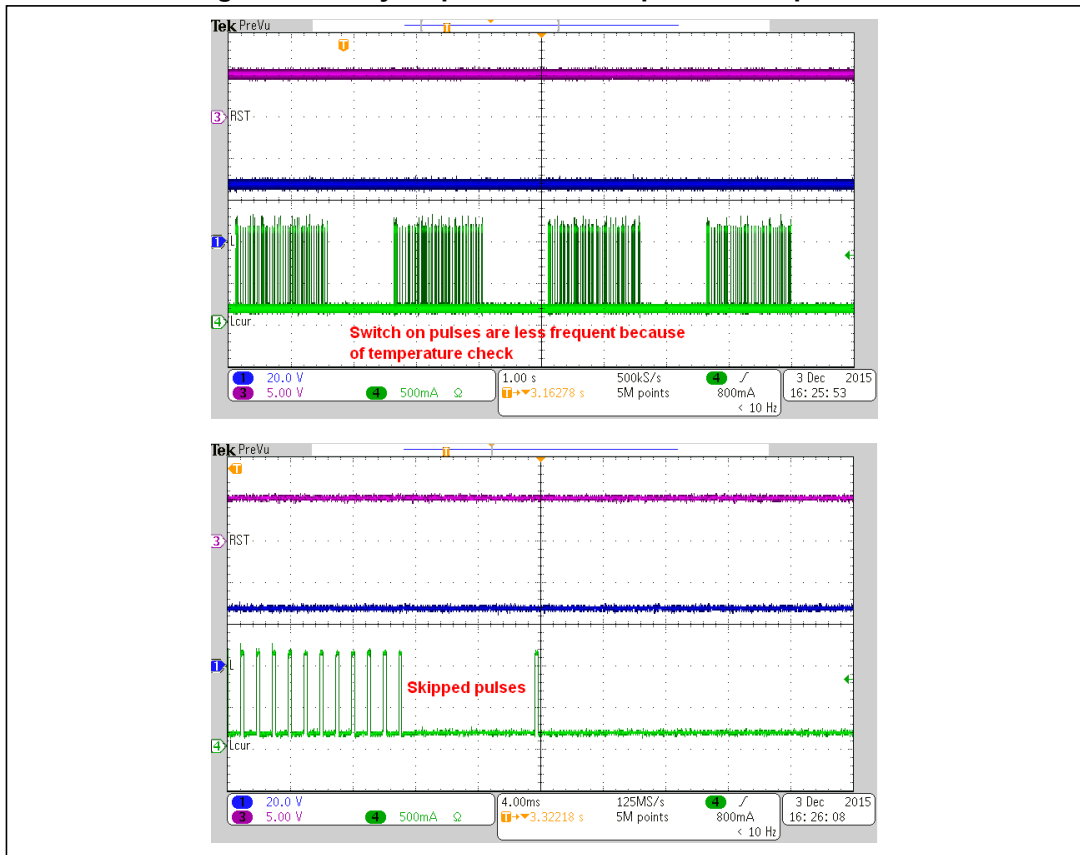
In the same conditions, without temperature control strategy, the device would be damaged.

4.1 Temperature sensor

The temperature sensor gives an estimation of the overall temperature: the temperature of the low side driver can be larger and a suitable margin must be taken.

The values returned by the ADC readout must be properly filtered in order to smooth noise effects.

5 Revision history

Table 1. Document revision history

Date	Revision	Changes
13-Jan-2016	1	Initial release.

IMPORTANT NOTICE – PLEASE READ CAREFULLY