Introduction to Simulation Model - Infineon Designer

LITIX™ Power Flex TLD5542-1QV

About this document

Scope and purpose

This document outlines the main features of LITIX™ Power Flex TLD5542-1QV by means of its digital twin, referred to as simulation model, in typical application setups aiming to be an easy, time efficient and cost reduction solution for exploring device capabilities and integration in complex applications.

Information covered in this document does not substitute datasheet content and shall be regarded as complementary to it. For a more precise description of the device and its features, please consult the datasheet.

Intended audience

This application note along with the simulation model itself offers an interactive solution targeted for anybody who aims to explore the functionality and "what if" scenarios for TLD5542-1QV device.

Table of contents

1 LITIX™ Power Flex TLD5542-1QV

The TLD5542-1QV is a synchronous MOSFET H-Bridge DC/DC controller with built in protection features and SPI interface. This concept is beneficial for driving high power LEDs with maximum system efficiency and minimum number of external components. The TLD5542-1QV offers both analog and digital (PWM) dimming.The switching frequency is adjustable in the range of 200 kHz to 700 kHz. It can be synchronized to an external clock source. A built in programable Spread Spectrum switching frequency modulation and the forced continuous current regulation mode improve the overall EMC behavior. Furthermore the current mode regulation scheme provides a stable regulation loop maintained by small external compensation components. The adjustable soft start feature limits the current peak as well as voltage overshoot at start-up.

The available online circuits are listed below:

- Automotive – LED Driver IC LITIX™ Power Flex TLD5542-1QV – Multi float switch
- Automotive – LED Driver IC LITIX™ Power Flex TLD5542-1QV – Input voltage ramping
- Automotive – LED Driver IC LITIX™ Power Flex TLD5542-1QV – Soft start, analog and digital dimming

Click here to open the circuits.

2 Simulation model features

- Perform transient simulations: observe and analyze transient device response to different stimuli. The number of stimuli and probes is unlimited.
- Measure the device electrical parameters in typical conditions with increased precision at small resolution (e.g. 100 ns/1 µV/1 µA).
- Integrate the simulation model in complex application and explore new possibilities.
- Explore main features of the real device (for more details consult the datasheet): shortest time to obtain results, zero error cost (no harm to physical components), can be done by anyone (engineers, students, etc.):
  - Regulation loops
  - Digital and analog PWM
  - Soft start behavior
  - Multi-float switch application
- Simulation model does not cover all features of the real device in order to keep the usability and simulation speed in a reasonable range:
  - No SPI interface (MFS SPI related registers controlled via model parameters)
  - BST1,2 and SWN1,2 pins not available (no real external MOSFETs, only ideal switches)
  - LDO output (no IVCC/IVCC_ext pins available)
  - Thermal network and self-heating not available
  - Fault reporting and handling not available (except short 2 ground detection possible via S2G virtual pin)
  - External clock sync (no FREQ_SYNC pin, frequency controlled via model parameter)
  - Limp Home not implemented
  - Spread Spectrum not implemented
  - Current consumption of the IC not considered (no realistic power efficiency calculation possible)
  - No ESD, EMC, AC, DC and Monte Carlo analysis simulation capability
  - Possible convergence issues for using DC sources, steep ramps or high frequency sources within the setup.

Details on the implementation

Gate Drivers controlling the four external MOSFETs in H-Bridge configuration are providing ideal 0 V-5 V logic signals independent of switching nodes levels SWN1,2. Due to this, it is only possible to drive ideal switches instead of real MOSFETs . This in turn reduces the number of calculations per cycle and highly improves the total simulation time. Therefore, bootstrap pins BST1,2 and SWN1,2 are not present on the symbol. Dead time between low side and high side switching is implemented. For the ideal switches the ON threshold, RDSON and body diode have been considered.

Internal oscillator has not been modeled as in the real device. Hence the FREQ_SYNC pin is not present on the symbol. The main reason is to reduce the complexity of the model and have the speed performance under control. Instead, the frequency of the controller is specified directly in [Hz] units via the model parameter {frequency} available on the test bench. External clock synchronization is not possible as well.

Internal LDO has not been modeled therefore IVCC and IVCC_EXT pins are not present on the symbol. The control of Multi Float Switch routine is performed via the four model parameters available on the test bench emulating the internal SPI registers (for more details check Table 1 and Model performance section).

Table 1 Model parameter list

Parameter name	Description
frequency	specify directly the controller frequency in the range [200kHz to 700kHz]
LED_initial	number of LEDs before performing the jump; this number must be the same with the number of LEDs connected at the output; the range is between 2 and 16
LED_after	number of LEDs after the jump; this number must be the same with the number of LEDs that will remain connect at the output; the range is between 1 and 15
t_PREP	time until Ccomp is discharged; give the compensation capacitors enough time to discharge, otherwise spikes will still appear at the output
t_SOMFS	time when MFS routine will start; for other test benches, keep this parameter higher than simulation time to deactivate the feature

3 Model performance

3.1 Multi float switch – transient

This test bench shows the Multi Float Switch (MFS) feature for $t_{PREP}>t_{DISCHARGE\_COUT}$. That means the controller performs special routines in order to minimize the current overshoots in dynamic load applications when the number of LEDs is decreased (i.e. High Beam to Low Beam front light change).

With the right settings of the timing parameters, the overshoot of the output current will be minimized. The setup is configured for a jump from 8 LEDs to 5 LEDs.

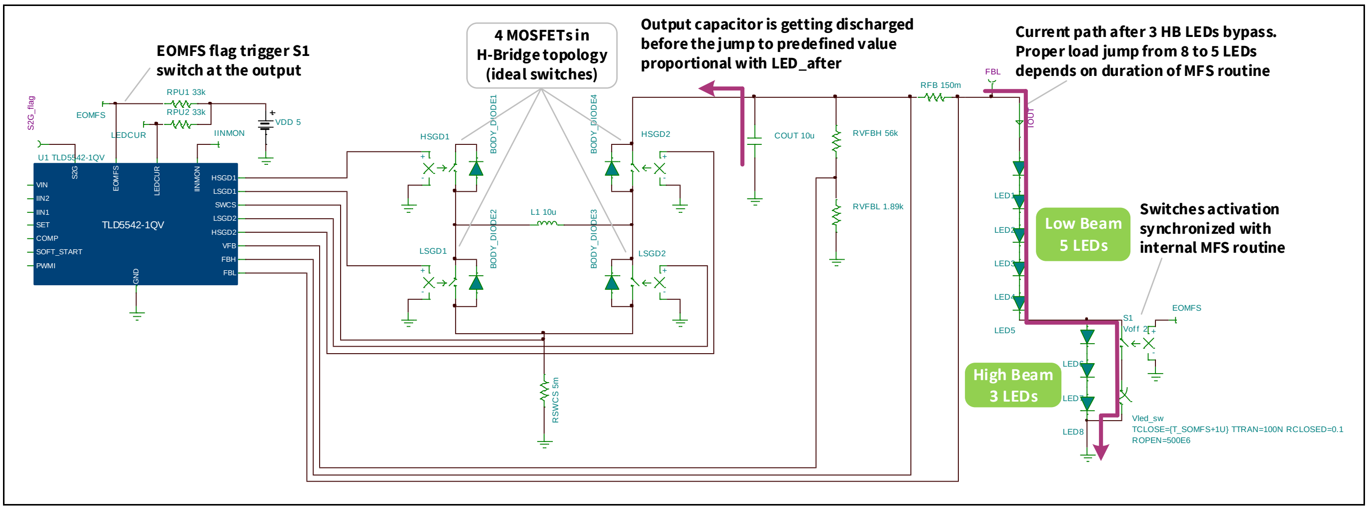

Figure 1 Test setup for multi float switch click to open

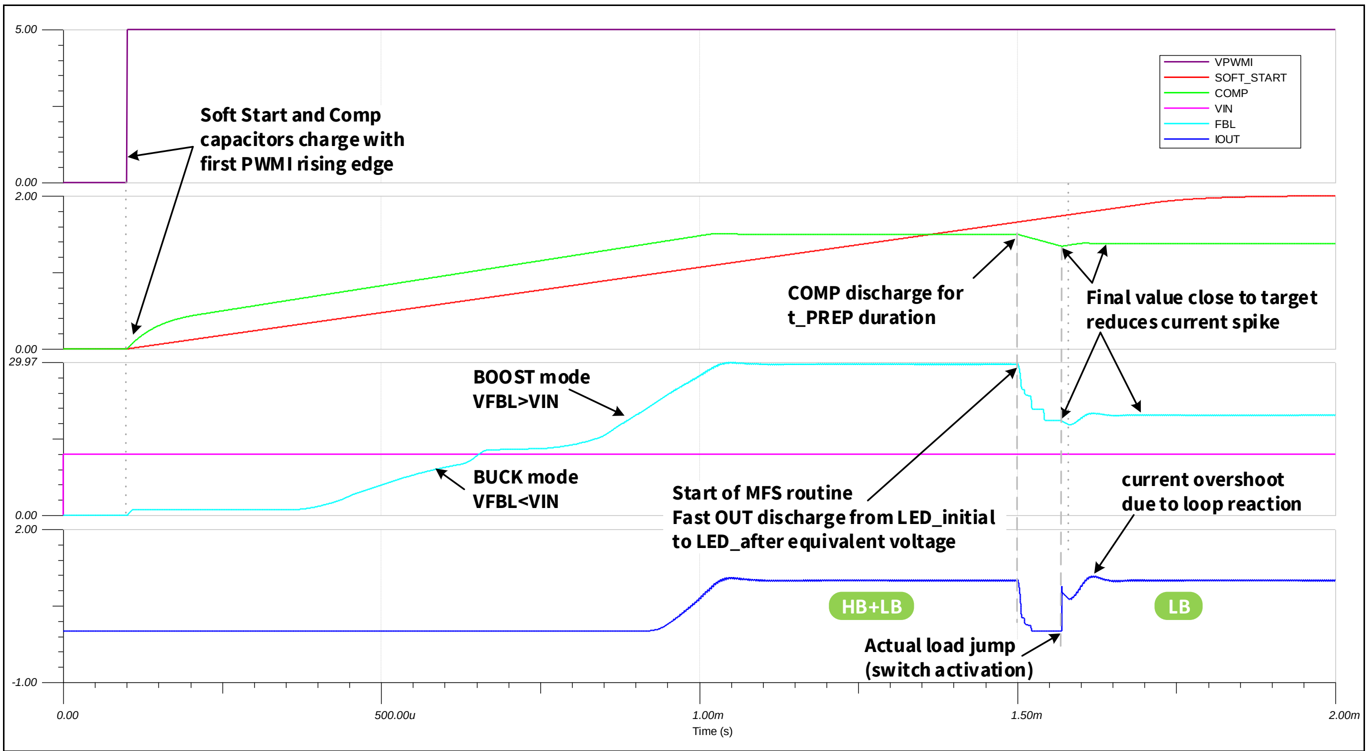

Figure 2 Simulation results

3.2 Input voltage ramping – transient

This test bench shows how the regulator reacts to changes in the input voltage (VIN) while the circuit is in steady state. Output current is monitored while the regulator is trying to compensate for input voltage variaton below or above the nominal output voltage. The load is fixed formed by 4 LEDs driven by 1 A average current.

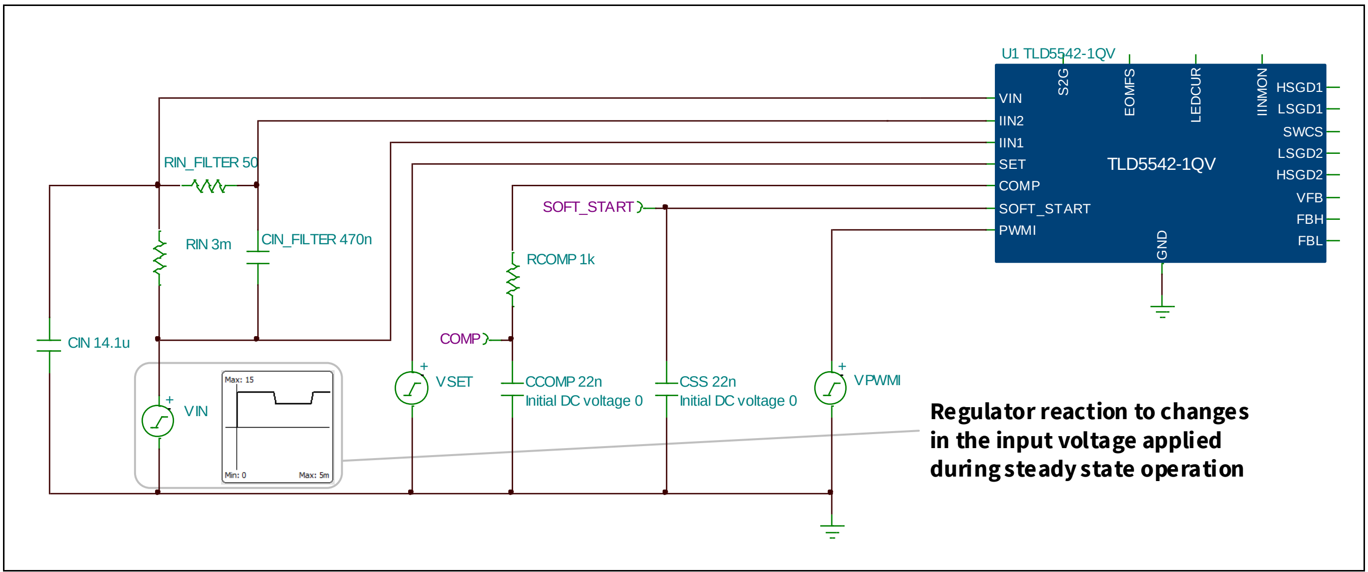

Figure 3 Test setup for input voltage ramping [click to open]

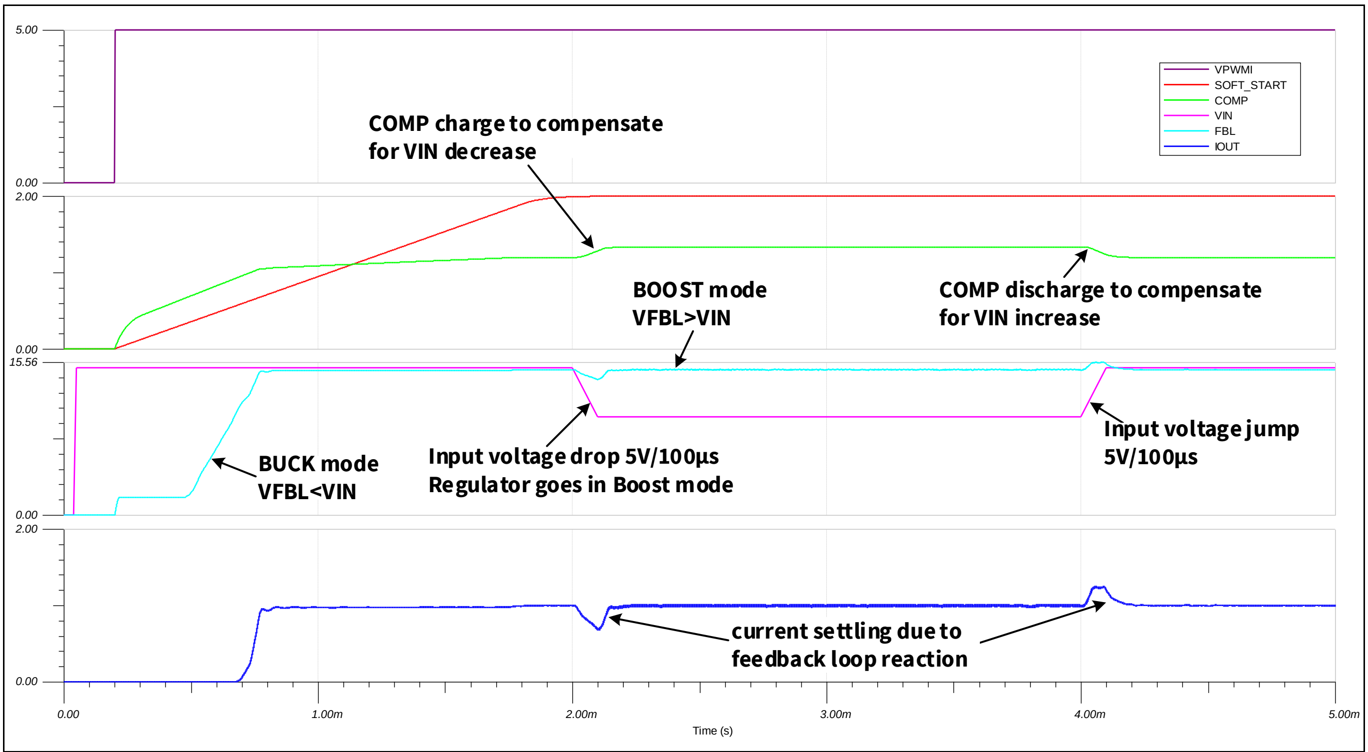

Figure 4 Simulation results

3.3 Soft start, analog and digital dimming – transient

This test bench shows soft start, output current control via analog dimming and digital dimming via PWMI pin features.

- SOFT_START and COMP capacitor values are chosen in order to see the impact of SOFT_START in the start-up until the circuit is reaching steady-state. If COMP ramp is faster than SOFT_START ramp and exceeds SOFT_START by more than 0.7 V, then COMP ramp will be limited by SOFT_START.
- RFB is set to 150 mΩ in order to have 1 A at the output. SET pin is decreased from 1.4 V (100% analog dimming) to 0.8 V (50% analog dimming).
- When PWMI is in logic low, the output current will drop to 0 A and the output capacitor is starting to discharge (digital dimming).

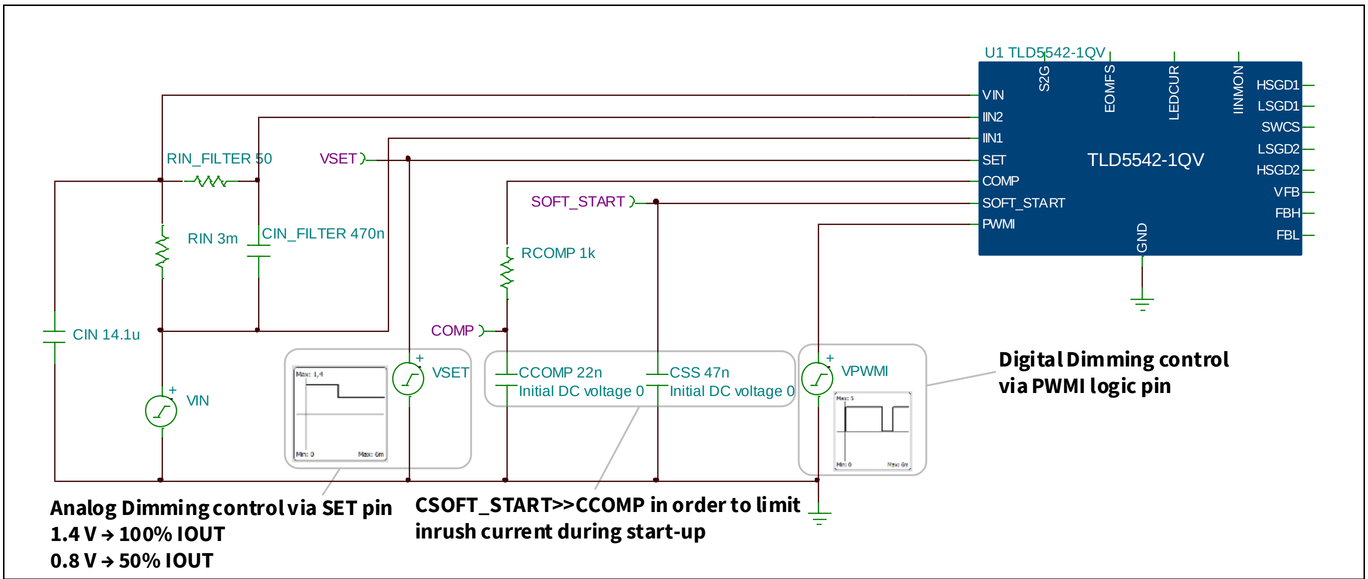

Figure 5 Test setup for soft start, analog and digital dimming [click to open]

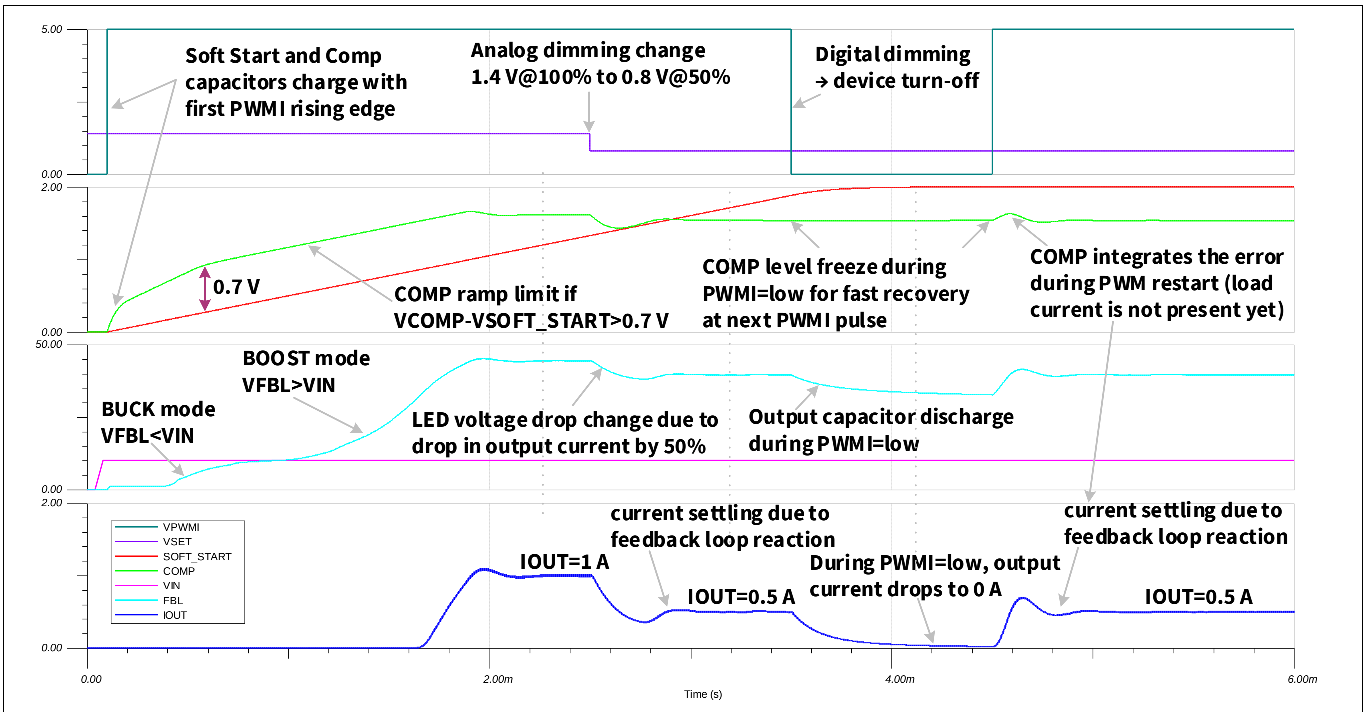

Figure 6 Simulation results

4 Revision history

Document version	Date of release	Description of changes
Rev.1.00	2020-09-01	Initial version created

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