

# Infineon® LITIX™ Power

Multitopology LITIX™ Power DC/DC Controller IC

TLD5097EL

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### Data Sheet

Revision 1.0

2015-03-12

Automotive Power

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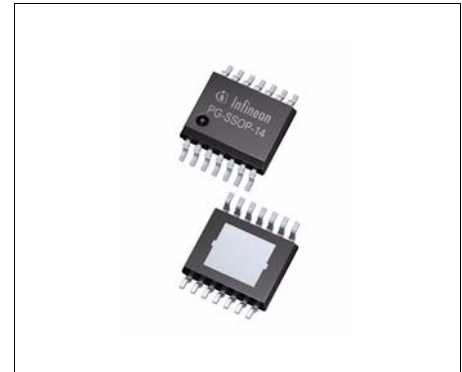
## TLD5097EL

Infineon® LITIX™ Power



### 1 Overview

- Wide Input Voltage Range from 4.5 V to 45 V
- Constant Current or Constant Voltage Regulation
- Drives LEDs in Boost, Buck, Buck-Boost, SEPIC and Flyback Topology
- Very Low Shutdown Current:  $I_{q\_OFF} < 10 \mu A$
- Flexible Switching Frequency Range, 100 kHz to 500 kHz
- Synchronization with external clock source
- PWM Dimming
- Analog Dimming feature to adjust average LED current
- Internal 5 V Low Drop Out Voltage Regulator
- Open Circuit Detection
- Output Overvoltage Protection
- Internal Soft Start
- Over Temperature Shutdown
- Wide LED current range via simple adaptation of external components
- 300mV High Side Current Sense to ensure highest flexibility and LED current accuracy
- Available in a small thermally enhanced PG-SSOP-14 package
- Automotive AEC Qualified
- Green Product (RoHS) Compliant



PG-SSOP-14

### Description

The TLD5097EL is a LED boost controller with built in protection features. The main function of this device is to regulate a constant LED current. The constant current regulation is especially beneficial for LED color accuracy and longer lifetime. The controller concept of the TLD5097EL allows multiple configurations such as Boost, Buck, Buck-Boost, SEPIC and Flyback by simply adjusting the external components. The TLD5097EL offers the most flexible dimming options. Dimming can be achieved with analog or PWM input. The switching frequency is adjustable in the range of 100 kHz to 500 kHz and can be synchronized to an external clock source. The TLD5097EL features an enable function reducing the shut-down current consumption to  $I_{q\_OFF} < 10 \mu A$ . The current mode regulation scheme of this device provides a stable regulation loop maintained by small external compensation components. The integrated soft start feature limits the current peak as well as voltage overshoot at start-up. This IC is suited for use in the harsh automotive environments and provides output overvoltage protection and device overtemperature shutdown.

### Application

- Automotive Exterior and Interior Lighting

Type	Package	Marking
TLD5097EL	PG-SSOP-14	TLD5097

Block Diagram

2 Block Diagram

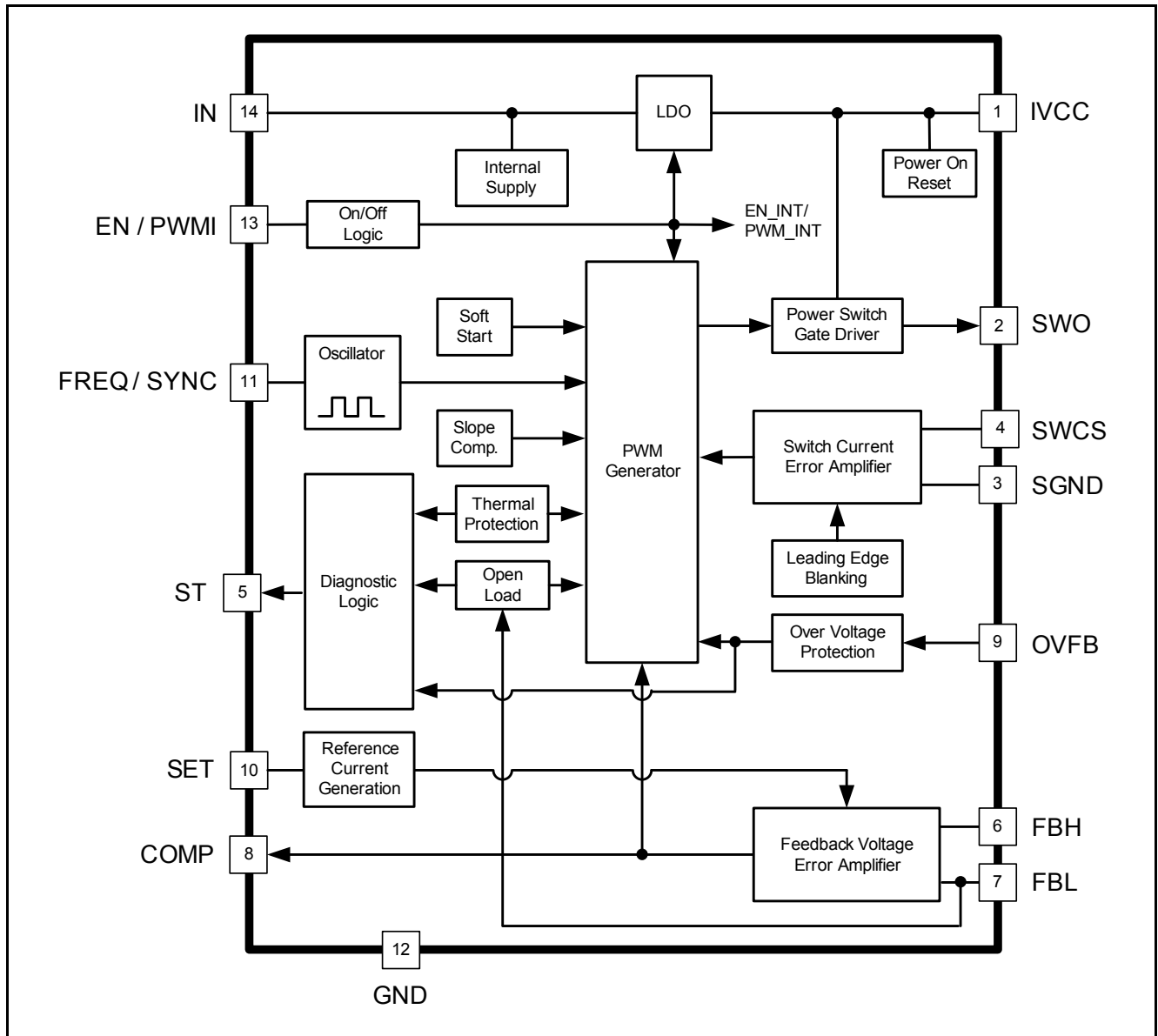


Figure 2-1 Block Diagram TLD5097EL

Pin Configuration

### 3 Pin Configuration

#### 3.1 Pin Assignment

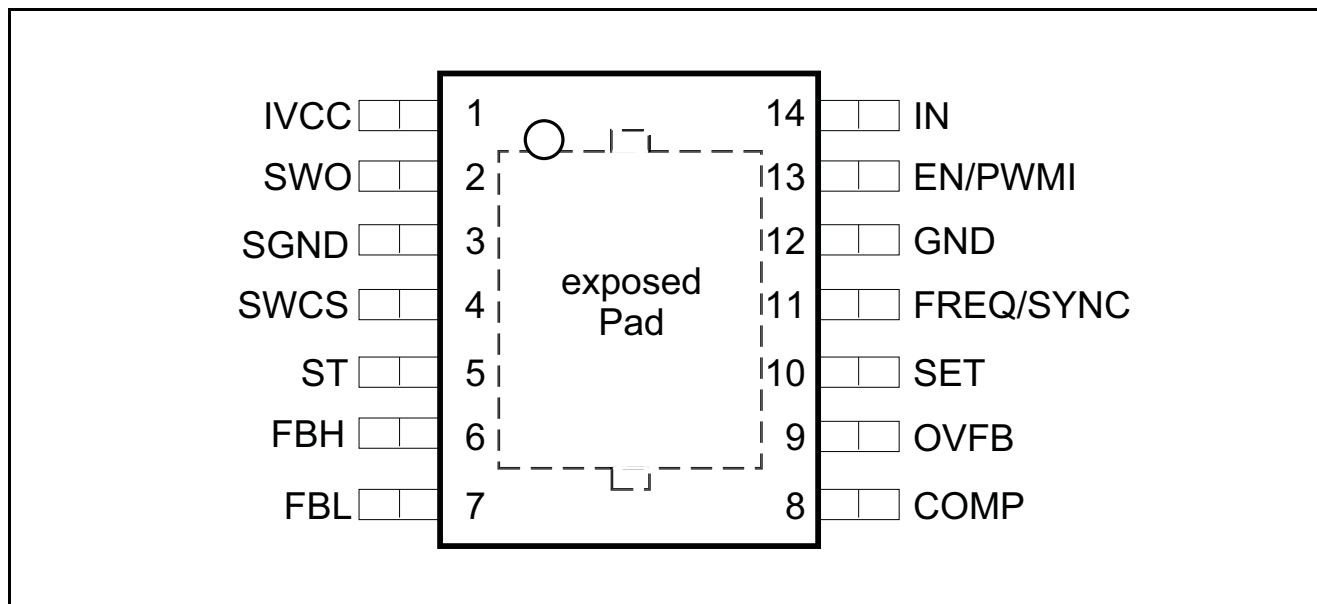


Figure 3-1 Pin Configuration TLD5097EL

#### 3.2 Pin Definitions and Functions

Table 3-1 Pin Definition and Function

#	Symbol	Direction	Type	Function
1	IVCC			<b>Internal LDO Output;</b> Used for internal biasing and gate drive. Bypass with external capacitor. Pin must not be left open.
2	SWO			<b>Switch Output;</b> Connect to gate of external switching MOSFET
3	SGND			<b>Current Sense Ground;</b> Ground return for current sense switch
4	SWCS			<b>Current Sense Input;</b> Detects the peak current through switch
5	ST			<b>Status Output;</b> to indicate fault conditions
6	FBH			<b>Voltage Feedback Positive;</b> Non inverting Input (+)
7	FBL			<b>Voltage Feedback Negative;</b> Inverting Input (-)
8	COMP			<b>Compensation Input;</b> Connect R and C network to pin for stability

**Pin Configuration**

**Table 3-1 Pin Definition and Function**

#	Symbol	Direction	Type	Function
9	OVFB			<b>Output Overvoltage Protection Feedback;</b> Connect to resistive voltage divider to set overvoltage threshold.
10	SET			<b>Analog Dimming Input;</b> Load current adjustment Pin. Pin must not be left open. If analog dimming feature is not used connect to IVCC pin.
11	FREQ / SYNC			<b>Frequency Select or Synchronization Input;</b> Connect external resistor to GND to set frequency. Or apply external clock signal for synchronization within frequency capture range.
12	GND			<b>Ground;</b> Connect to system ground.
13	EN / PWMI			<b>Enable or PWM Input;</b> Apply logic HIGH signal to enable device or PWM signal for dimming LED.
14	IN			<b>Supply Input;</b> Supply for internal biasing.
	EP			<b>Exposed Pad;</b> Connect to external heat spreading GND Cu area (e.g. inner GND layer of multilayer PCB with thermal vias)

General Product Characteristics

## 4 General Product Characteristics

### 4.1 Absolute Maximum Ratings

$T_j = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ; all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

**Table 4-1 Absolute Maximum Ratings<sup>1)</sup>**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
<b>Voltages</b>							
IN Supply Input	$V_{IN}$	-0.3		45	V		P_4.1.1
EN / PWMI Enable or PWM Input	$V_{EN}$	-40		45	V		P_4.1.2
FBH-FBL; Feedback Error Amplifier Differential	$V_{FBH}-V_{FBL}$	-40		61	V	The maximum delta must not exceed 61V	P_4.1.3
FBH; Feedback Error Amplifier Positive Input	$V_{FBH}$	-40		61	V	The difference between $V_{FBH}$ and $V_{FBL}$ must not exceed 61V, refer to Parameter 4.1.3	P_4.1.4
FBL Feedback Error Amplifier Negative Input	$V_{FBL}$	-40		61	V	The difference between $V_{FBH}$ and $V_{FBL}$ must not exceed 61V, refer to Parameter 4.1.3	P_4.1.5
FBH and FBL Current	$I_{FBL,FBH}$		1		mA	$t < 100\text{ms}$ , $V_{FBH}-V_{FBL}=0.3\text{V}$	P_4.1.6
OVFB Over Voltage Feedback Input	$V_{OVP}$	-0.3		5.5	V		P_4.1.7
OVFB Over Voltage Feedback Input	$V_{OVP}$	-0.3		6.2	V	$t < 10\text{s}$	P_4.1.8
SWCS Switch Current Sense Input	$V_{SWCS}$	-0.3		5.5	V		P_4.1.9
SWCS Switch Current Sense Input	$V_{SWCS}$	-0.3		6.2	V	$t < 10\text{s}$	P_4.1.10

**General Product Characteristics**

**Table 4-1 Absolute Maximum Ratings<sup>1)</sup>**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
SWO Switch Gate Drive Output	$V_{SWO}$	-0.3		5.5	V		P_4.1.11
SWO Switch Gate Drive Output	$V_{SWO}$	-0.3		6.2	V	t < 10s	P_4.1.12
SGND Current Sense Switch GND	$V_{SGND}$	-0.3		0.3	V		P_4.1.13
COMP Compensation Input	$V_{COMP}$	-0.3		5.5	V		P_4.1.14
COMP Compensation Input	$V_{COMP}$	-0.3		6.2	V	t < 10s	P_4.1.15
FREQ / SYNC; Frequency and Synchronization Input	$V_{FREQ/SYNC}$	-0.3		5.5	V		P_4.1.16
FREQ / SYNC; Frequency and Synchronization Input	$V_{FREQ/SYNC}$	-0.3		6.2	V	t < 10s	P_4.1.17
PWMO PWM Dimming Output	$V_{PWMO}$	-0.3		5.5	V		P_4.1.18
PWMO PWM Dimming Output	$V_{PWMO}$	-0.3		6.2	V	t < 10s	P_4.1.19
ST	$V_{ST}$	-0.3		5.5	V		P_4.1.20
ST	$V_{ST}$	-0.3		6.2	V	t < 10s	P_4.1.21
ST current	$I_{ST}$	-2		2	mA		P_4.1.22
SET	$V_{SET}$	-0.3		45	V		P_4.1.23
IVCC Internal Linear Voltage Regulator Output	$V_{IVCC}$	-0.3		5.5	V		P_4.1.24
IVCC Internal Linear Voltage Regulator Output	$V_{IVCC}$	-0.3		6.2	V	t < 10s	P_4.1.25

**Temperatures**

Junction Temperature	$T_j$	-40		150	°C		P_4.1.26
Storage Temperature	$T_{stg}$	-55		150	°C		P_4.1.27

**ESD Susceptibility**

ESD Resistivity of all pins	$V_{ESD,HBM}$	-2		2	kV	HBM <sup>2)</sup>	P_4.1.28
ESD Resistivity of IN, EN/PWMI, FBH, FBL and SET pin to GND	$V_{ESD,HBM}$	-4		4	kV	HBM <sup>2)</sup>	P_4.1.29

1) Not subject to production test, specified by design.

2) ESD susceptibility, Human Body Model "HBM" according to ANSI/ESDA/JEDEC JS-001 (1.5kΩ, 100pF)



**General Product Characteristics**

Note:

1. Stresses above the ones listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
2. Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as “outside” normal operating range. Protection functions are not designed for continuous repetitive operation.

**4.2 Functional Range**

**Table 4-2 Functional Range**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Extended Supply Voltage Range	$V_{IN}$	4.5		45 <sup>1)</sup>	V	$V_{IVCC} > V_{IVCC,RTH,d}$ ; Parameter deviations possible	P_4.2.1
Nominal Supply Voltage Range	$V_{IN}$	8		34	V		P_4.2.2
Feedback Voltage Input	$V_{FBH}$ ; $V_{FBL}$	3		60	V		P_4.2.3
Junction Temperature	$T_j$	-40		150	°C		P_4.2.4

1) Not subject to production test, specified by design

Note: Within the functional range the IC operates as described in the circuit description. The electrical characteristics are specified within the conditions given in the related electrical characteristics table.

**General Product Characteristics**

**4.3 Thermal Resistance**

*Note: This thermal data was generated in accordance with JEDEC JESD51 standards.  
 For more information, go to [www.jedec.org](http://www.jedec.org).*

**Table 4-3 Thermal Resistance**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Junction to Case <sup>1)2)</sup>	$R_{thJC}$		10		K/W		P_4.3.1
Junction to Ambient <sup>3)</sup>	$R_{thJA}$		47		K/W	2s2p	P_4.3.2
Junction to Ambient	$R_{thJA}$		54		K/W	1s0p + 600mm <sup>2</sup>	P_4.3.3
Junction to Ambient	$R_{thJA}$		64		K/W	1s0p + 300mm <sup>2</sup>	P_4.3.4

- 1) Not subject to production test, specified by design.
- 2) Specified  $R_{thJC}$  value is simulated at natural convection on a cold plate setup (all pins and the exposed pad are fixed to ambient temperature). Ta=25°C is dissipating 1W.
- 3) Specified  $R_{thJA}$  value is according to JEDEC 2s2p (JESD 51-7) + (JESD 51-5) and JEDEC 1s0p (JESD 51-3) + heatsink area at natural convection on FR4 board; The device was simulated on a 76.2 x 114.3 x 1.5mm board. The 2s2p board has 2 outer copper layers (2 x 70µm Cu) and 2 inner copper layers (2 x 35µm Cu), A thermal via (diameter = 0.3mm and 25µm plating) array was applied under the exposed pad and connected the first outer layer (top) to the first inner layer and second outer layer (bottom) of the JEDEC PCB. Ta=25°C, IC is dissipating 1W

**Switching Regulator**

## 5 Switching Regulator

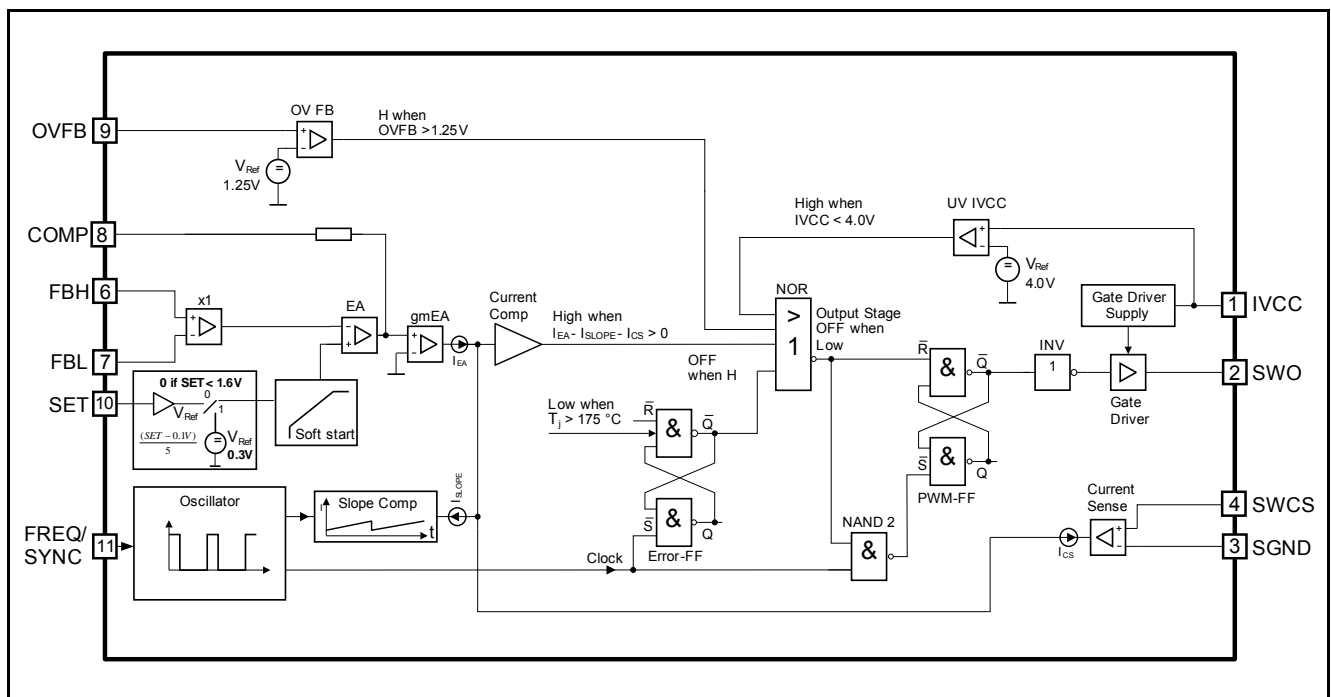
### 5.1 Description

The TLD5097EL regulator is suitable for Boost, Buck, Buck-Boost, SEPIC and Flyback configurations. The constant output current is especially useful for light emitting diode (LED) applications. The switching regulator function is implemented by a pulse width modulated (PWM) current mode controller.

The PWM current mode controller uses the peak current through the external power switch and error in the output current to determine the appropriate pulse width duty cycle (on time) for constant output current. The current mode controller provides a PWM signal to an internal gate driver which then outputs to an external n-channel enhancement mode metal oxide field effect transistor (MOSFET) power switch.

The current mode controller also has built-in slope compensation to prevent sub-harmonic oscillations which is a characteristic of current mode controllers operating at high duty cycles (>50% duty).

An additional built-in feature is an integrated soft start that limits the current through the inductor and external power switch during initialization. The soft start function gradually increases the inductor and switch current over  $t_{SS}$  (Parameter 5.2.9) to minimize potential overvoltage at the output.



**Figure 5-1 Switching Regulator Block Diagram**

**Switching Regulator**

**5.2 Electrical Characteristics**

$V_{IN} = 8\text{ V to }34\text{ V}$ ;  $T_j = -40^\circ\text{C to }+150^\circ\text{C}$ , all voltages with respect to ground, positive current flowing into pin; (unless otherwise specified)

**Table 5-1 Electrical Characteristics: Switching Regulator**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
<b>Regulator</b>							
Feedback Reference Voltage	$V_{REF}$	0.29	0.30	0.31	V	refer to <a href="#">Figure 11-11</a> $V_{REF} = V_{FBH} - V_{FBL}$ $V_{SET} = 5\text{V}$ $I_{LED} = 350\text{ mA}$	P_5.2.1
Feedback Reference Voltage	$V_{REF}$	0.057	0.06	0.063	V	refer to <a href="#">Figure 11-11</a> $V_{REF} = V_{FBH} - V_{FBL}$ $V_{SET} = 0.4\text{V}$ $I_{LED} = 70\text{mA}$	P_5.2.2
Feedback Reference Voltage Offset	$V_{REF\_offset}$	–	–	5	mV	refer to <a href="#">Figure 10-2</a> and <a href="#">Figure 11-11</a> $V_{REF} = V_{FBH} - V_{FBL}$ $V_{SET} = 0.1\text{V}$ $V_{OUT} > V_{IN}$	P_5.2.3
Voltage Line Regulation	$(\Delta V_{REF} / V_{REF}) / \Delta V_{IN}$	–	–	0.15	%/V	refer to <a href="#">Figure 11-11</a> $V_{IN} = 8\text{V to }19\text{V}$ ; $V_{SET} = 5\text{V}$ ; $I_{LED} = 350\text{mA}$	P_5.2.4
Voltage Load Regulation	$(\Delta V_{REF} / V_{REF}) / \Delta I_{BO}$	–	–	5	%/A	refer to <a href="#">Figure 11-11</a> $V_{SET} = 5\text{V}$ ; $I_{LED} = 100\text{ to }500\text{mA}$	P_5.2.5
Switch Peak Over Current Threshold	$V_{SWCS}$	130	150	170	mV	$V_{FBH} = V_{FBL} = 5\text{ V}$ $V_{COMP} = 3.5\text{V}$	P_5.2.6
Maximum Duty Cycle	$D_{MAX, fixed}$	91	93	95	%	Fixed frequency mode	P_5.2.7
Maximum Duty Cycle	$D_{MAX, sync}$	88	–	–	%	Synchronization mode	P_5.2.8
Soft Start Ramp	$t_{SS}$	350	1000	1500	$\mu\text{s}$	$V_{FB}$ rising from 5% to 95% of $V_{FB}$ , typ.	P_5.2.9
IFBH Feedback High Input Current	$I_{FBH}$	38	46	54	$\mu\text{A}$	$V_{FBH} - V_{FBL} = 0.3\text{ V}$	P_5.2.10

Switching Regulator

Table 5-1 Electrical Characteristics: Switching Regulator

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
IFBL Feedback Low Input Current	$I_{FBL}$	15	21	27	$\mu A$	$V_{FBH} - V_{FBL} = 0.3 V$	P_5.2.11
Switch Current Sense Input Current	$I_{SWCS}$	10	50	100	$\mu A$	$V_{SWCS} = 150 mV$	P_5.2.12
Input Undervoltage Shutdown	$V_{IN,off}$	3.5	–	4.5	V	$V_{IN}$ decreasing	P_5.2.13
Input Voltage Startup	$V_{IN,on}$	–	–	4.85	V	$V_{IN}$ increasing	P_5.2.14
<b>Gate Driver for External Switch</b>							
Gate Driver Peak Sourcing Current	$I_{SWO,src}$	–	380	–	mA	<sup>1)</sup> $V_{SWO} = 1 V$ to 4 V	P_5.2.15
Gate Driver Peak Sinking Current	$I_{SWO,snk}$	–	550	–	mA	<sup>1)</sup> $V_{SWO} = 4 V$ to 1 V	P_5.2.16
Gate Driver Output Rise Time	$t_{R,SWO}$	–	30	60	ns	<sup>1)</sup> $CL,SWO = 3.3 nF$ ; $V_{SWO} = 1 V$ to 4 V	P_5.2.17
Gate Driver Output Fall Time	$t_{F,SWO}$	–	20	40	ns	<sup>1)</sup> $CL,SWO = 3.3 nF$ ; $V_{SWO} = 4 V$ to 1 V	P_5.2.18
Gate Driver Output Voltage	$V_{SWO}$	4.5	–	5.5	V	<sup>1)</sup> $CL,SWO = 3.3 nF$	P_5.2.19

1) Not subject to production test, specified by design

## 6 Oscillator and Synchronisation

### 6.1 Description

#### R\_ OSC vs. switching frequency

The internal oscillator is used to determine the switching frequency of the boost regulator. The switching frequency can be selected from 100 kHz to 500 kHz with an external resistor to GND. To set the switching frequency with an external resistor the following formula can be applied.

(6.1)

$$R_{FREQ} = \frac{1}{(141 \cdot 10^{-12} \left[ \frac{s}{\Omega} \right]) \cdot \left( f_{FREQ} \left[ \frac{1}{s} \right] \right)} - (3.5 \cdot 10^3 [\Omega]) [\Omega]$$

In addition, the oscillator is capable of changing from the frequency set by the external resistor to a synchronized frequency from an external clock source. If an external clock source is provided on the pin FREQ/SYNC, then the internal oscillator synchronizes to this external clock frequency and the boost regulator switches at the synchronized frequency. The synchronization frequency capture range is 250 kHz to 500 kHz.

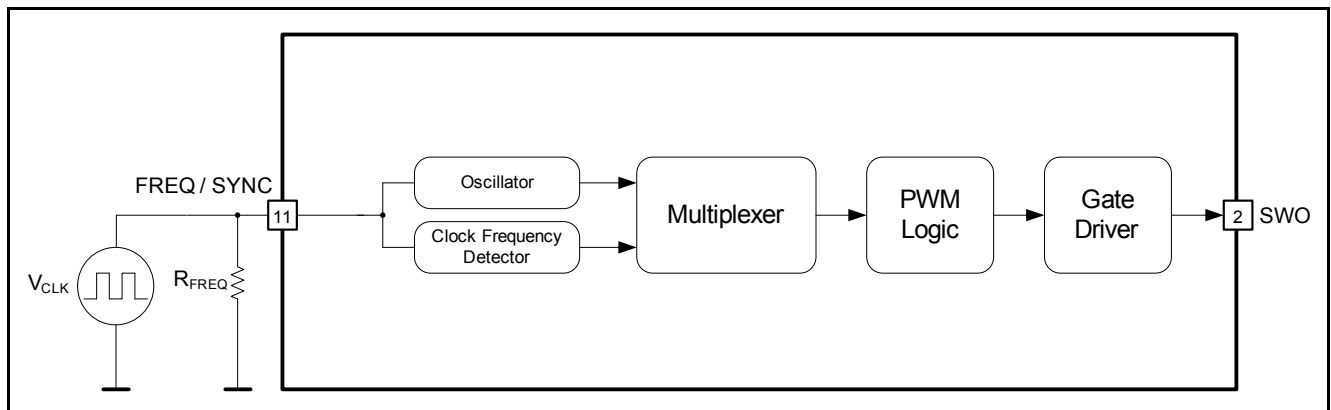


Figure 6-1 Oscillator and Synchronization Block Diagram and Simplified Application Circuit

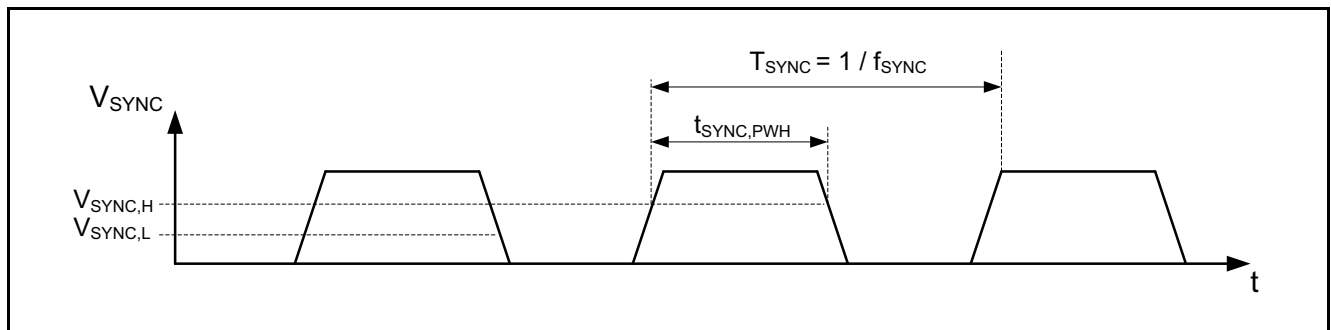


Figure 6-2 Synchronization Timing Diagram

**Oscillator and Synchronisation**

**6.2 Electrical Characteristics**

$V_{IN} = 8\text{ V to }34\text{ V}$ ;  $T_j = -40^\circ\text{C to }+150^\circ\text{C}$ , all voltages with respect to ground, positive current flowing into pin; (unless otherwise specified)

**Table 6-1 Electrical Characteristics: Oscillator and Synchronisation**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
<b>Oscillator</b>							
Oscillator Frequency	$f_{FREQ}$	250	300	350	kHz	$R_{FREQ} = 20\text{k}\Omega$	P_6.2.1
Oscillator Frequency Adjustment Range	$f_{FREQ}$	100	–	500	kHz		P_6.2.2
FREQ / SYNC Supply Current	$I_{FREQ}$	–	–	-700	$\mu\text{A}$	$V_{FREQ} = 0\text{ V}$	P_6.2.3
Frequency Voltage	$V_{FREQ}$	1.16	1.24	1.32	V	$f_{FREQ} = 100\text{ kHz}$	P_6.2.4
<b>Synchronisation</b>							
Synchronization Frequency Capture Range	$f_{SYNC}$	250	–	500	kHz		P_6.2.5
Synchronization Signal High Logic Level Valid	$V_{SYNC,H}$	3.0	–	–	V	1)2)	P_6.2.6
Synchronization Signal Low Logic Level Valid	$V_{SYNC,L}$	–	–	0.8	V	1)2)	P_6.2.7
Synchronization Signal Logic High Pulse Width	$t_{SYNC,PWH}$	200	–	–	ns	1)2)	P_6.2.8

1) Synchronization of external PWM ON signal to falling edge

2) Not subject to production test, specified by design

### 6.3 Typical Performance Characteristics of Oscillator

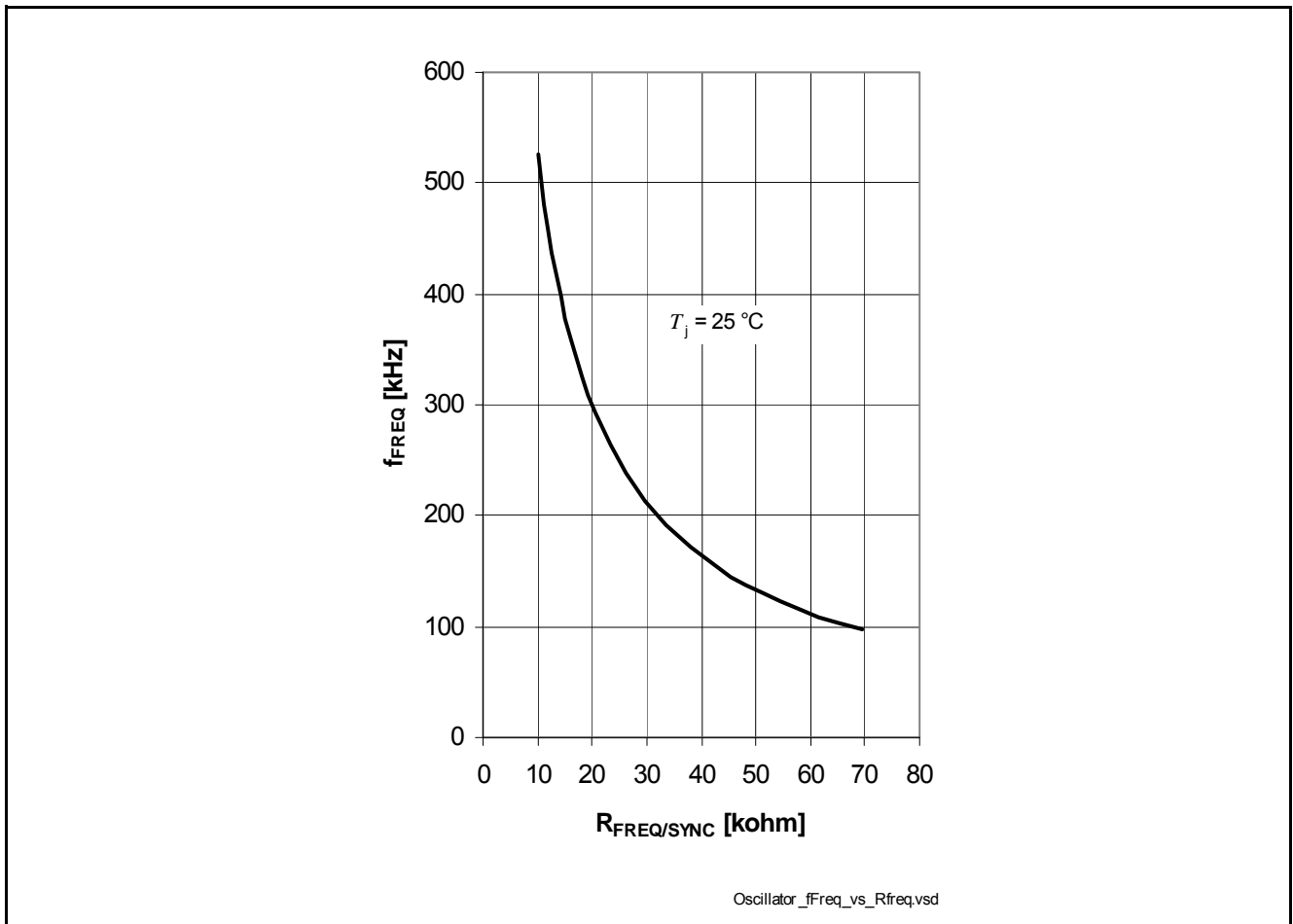


Figure 6-3 Switching Frequency  $f_{\text{SW}}$  versus Frequency Select Resistor to GND  $R_{\text{FREQ/SYNC}}$



## 7 Enable and Dimming Function

### Description

The enable function powers ON or OFF the device. A valid logic LOW signal on enable pin EN/PWMI powers OFF the device and current consumption is less than  $I_{Q\_OFF}$  (Parameter 7.2.8). A valid logic HIGH enable signal on enable pin EN/PWMI powers on the device. The enable function features an integrated pull down resistor which ensures that the IC is shut down and the power switch is OFF in case the enable pin EN is left open.

In addition to the enable function described above, the EN/PWMI pin detects a pulse width modulated (PWM) input signal that is fed through to the internal gate driver. The EN/PWMI enables and disables the gate driver for the main switch during PWM operation. PWM dimming an LED is a commonly practiced dimming method and can prevent color shift in an LED light source.

The enable and PWM input function share the same pin. Therefore a valid logic LOW signal at the EN/PWMI pin needs to differentiate between an enable power OFF or an PWM dimming LOW signal. The device differentiates between enable OFF and PWM dimming signal by requiring the enable OFF at the EN/PWMI pin to stay LOW for the Enable Turn OFF Delay Time ( $t_{EN,OFF,DEL}$  Parameter 7.2.6).

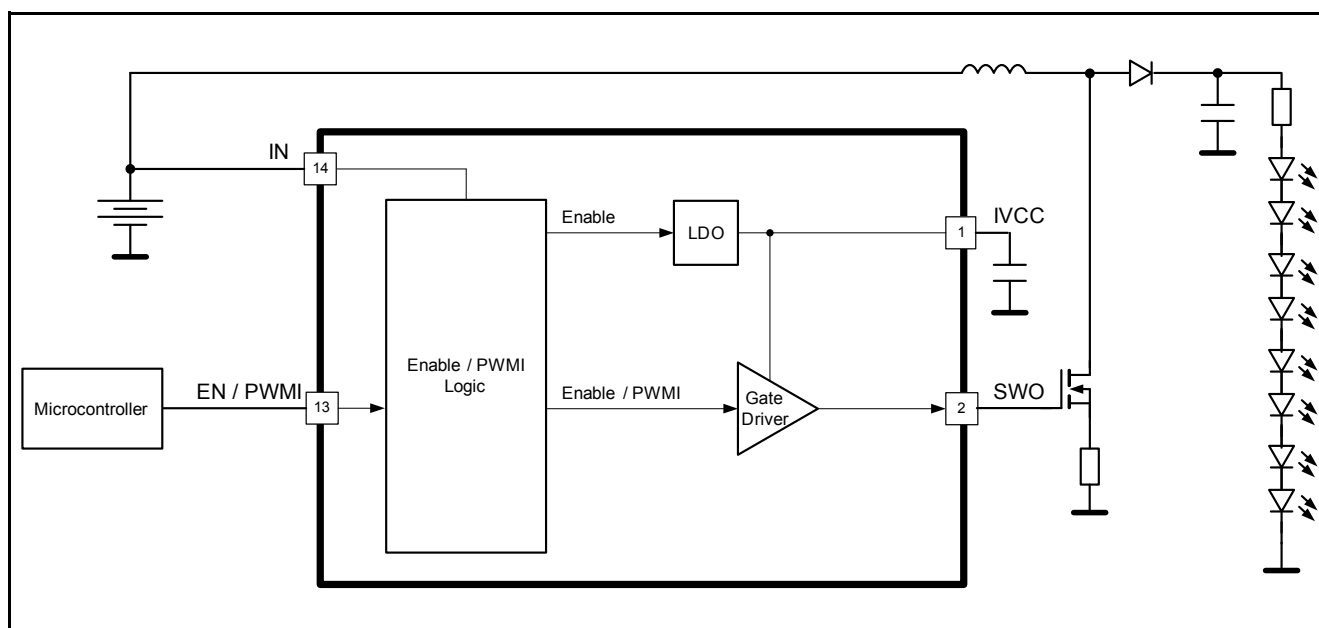


Figure 7-1 Block Diagram and Simplified Application Circuit Enable and LED Dimming

Enable and Dimming Function

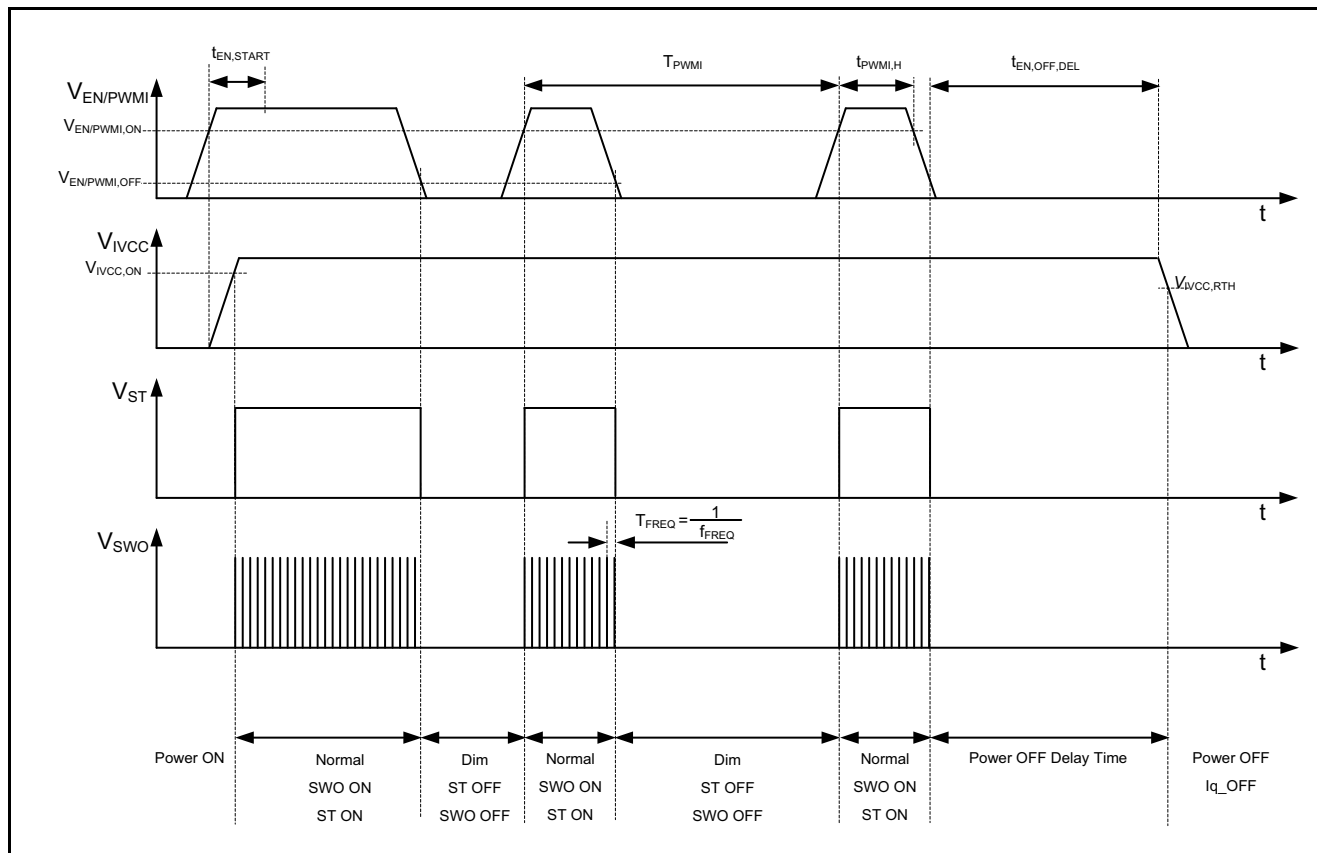


Figure 7-2 Timing Diagram Enable and LED Dimming

Note: The ST signal is LOW during soft-start.

7.1 Electrical Characteristics

V<sub>IN</sub> = 8V to 34V; T<sub>J</sub> = -40°C to +150°C, all voltages with respect to ground, positive current flowing into pin; (unless otherwise specified)

Table 7-1 Electrical Characteristics: Enable and Dimming

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
<b>Enable / PWM Input</b>							
Enable/PWMI Turn On Threshold	V <sub>EN/PWMI,ON</sub>	3.0	-		V		P_7.1.1
Enable/PWMI Turn Off Threshold	V <sub>EN/PWMI,OFF</sub>	-	-	0.8	V		P_7.1.2
Enable/PWMI Hysteresis	V <sub>EN/PWMI,HYS</sub>	50	200	400	mV	<sup>1)</sup>	P_7.1.3
Enable/PWMI High Input Current	I <sub>EN/PWMI,H</sub>	-	-	30	µA	V <sub>EN/PWMI</sub> = 16.0 V	P_7.1.4
Enable/PWMI Low Input Current	I <sub>EN/PWMI,L</sub>	-	0.1	1	µA	V <sub>EN/PWMI</sub> = 0.5 V	P_7.1.5

**Enable and Dimming Function**

**Table 7-1 Electrical Characteristics: Enable and Dimming**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Enable Turn Off Delay Time	$t_{EN,OFF,DEL}$	8	10	12	ms		P_7.1.6
Enable Startup Time	$t_{EN,START}$	100	–	–	μs		P_7.1.7

**Current Consumption**

Current Consumption, Shutdown Mode	$I_{q\_OFF}$	–	–	10	μA	$V_{EN/PWMI} = 0.8\text{ V};$ $T_j \leq 105^\circ\text{C};$ $V_{IN} = 16\text{V}$	P_7.1.8
Current Consumption, Active Mode <sup>2)</sup>	$I_{q\_ON}$	–	–	7	mA	$V_{EN/PWMI} \geq 4.75\text{ V};$ $I_{BO} = 0\text{ mA};$ $V_{SWO} = 0\% \text{ Duty Cycle}$	P_7.1.9

1) Not subject to production test, specified by design

2) Dependency on switching frequency and gate charge of external switches.

## 8 Linear Regulator

### Description

The internal linear voltage regulator supplies the internal gate drivers with a typical voltage of 5 V and current up to  $I_{LIM,min}$  (parameter [P\\_8.1.2](#)). An external output capacitor with ESR lower than  $R_{IVCC,ESR}$  (parameter [P\\_8.1.5](#)) is required on pin IVCC for stability and buffering transient load currents. During normal operation the external MOSFET switches will draw transient currents from the linear regulator and its output capacitor. Proper sizing of the output capacitor must be considered to supply sufficient peak current to the gate of the external MOSFET switches.

### Integrated Undervoltage Protection for the External Switching MOSFET

An integrated undervoltage reset threshold circuit monitors the linear regulator output voltage ( $V_{IVCC}$ ) and resets the device in case the output voltage falls below the IVCC undervoltage reset switch OFF threshold ( $V_{IVCC,RTH,d}$ ). The undervoltage reset threshold for the IVCC pin helps to protect the external switches from excessive power dissipation by ensuring the gate drive voltage is sufficient to enhance the gate of an external logic level n-channel MOSFET.

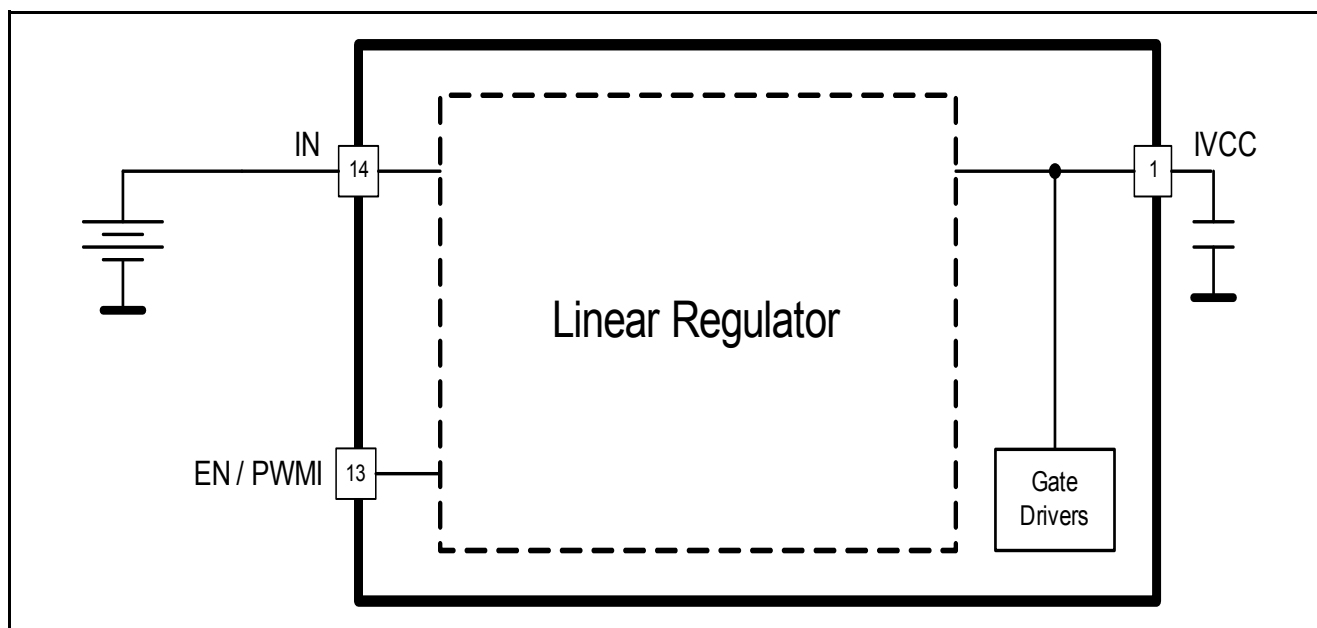


Figure 8-1 Voltage Regulator Block Diagram and Simplified Application Circuit

**Linear Regulator**

**8.1 Electrical Characteristics**

$V_{IN} = 8V$  to  $34V$ ;  $T_j = -40^{\circ}C$  to  $+150^{\circ}C$ , all voltages with respect to ground, positive current flowing into pin; (unless otherwise specified)

**Table 8-1 Electrical Characteristics:Line Regulator**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Output Voltage	$V_{IVCC}$	4.85	5	5.15	V	$6V \leq V_{IN} \leq 45V$ $0.1mA \leq I_{IVCC} \leq 40mA$	P_8.1.1
Output Current Limitation	$I_{LIM}$	51		90	mA	$V_{IN} = 13.5V$ $V_{IVCC} = 4.5V$	P_8.1.2
Drop out Voltage	$V_{DR}$			0.5	V	$V_{IN} = 4.5V$ $I_{IVCC} = 25mA$	P_8.1.3
IVCC Buffer Capacitor	$C_{IVCC}$	0.47	1	100	$\mu F$	<sup>1)2)</sup>	P_8.1.4
IVCC Buffer Capacitor ESR	$R_{IVCC,ESR}$	–	–	0.5	$\Omega$	<sup>1)</sup>	P_8.1.5
Undervoltage Reset Headroom	$V_{IVCC,HDRM}$	100	–	–	mV	$V_{IVCC}$ decreasing $V_{IVCC} - V_{IVCC,RTH,d}$	P_8.1.6
IVCC Undervoltage Reset switch OFF Threshold	$V_{IVCC,RTH,d}$	3.6	–	4.0	V	<sup>3)</sup> $V_{IVCC}$ decreasing	P_8.1.7
IVCC Undervoltage Reset switch ON Threshold	$V_{IVCC,RTH,i}$	–	–	4.5	V	$V_{IVCC}$ increasing	P_8.1.8

- 1) Minimum value given is needed for regulator stability; application might need higher capacitance than the minimum.
- 2) Minimum value given is needed for regulator stability; application might need higher capacitance than the minimum.
- 3) Selection of external switching MOSFET is crucial and the  $V_{IVCC,RTH,d}$  min. as worst case  $V_{GS}$  must be considered.

## 9 Protection and Diagnostic Functions

### 9.1 Description

The TLD5097EL has integrated circuits to diagnose and protect against output overvoltage, open load, open feedback and overtemperature faults. In case of a fault condition, the SWO signal stops operation. The ST signal will change to an active logic LOW signal to communicate that a fault has occurred (detailed overview in [Figure 9-1](#) and [Figure 9-2](#) below). [Figure 9-3](#) illustrates the various open load and open feedback conditions. In case of an overtemperature condition the integrated thermal shutdown function turns off the gate driver and internal linear voltage regulator. The typical junction shutdown temperature is 175°C ( $T_{j,SD}$  Parameter 9.2.3). After cooling down the IC will automatically restart. Thermal shutdown is an integrated protection function designed to prevent IC destruction and is not intended for continuous use in normal operation ([Figure 9-5](#)). To calculate the proper overvoltage protection resistor values an example is given in [Figure 9-6](#).

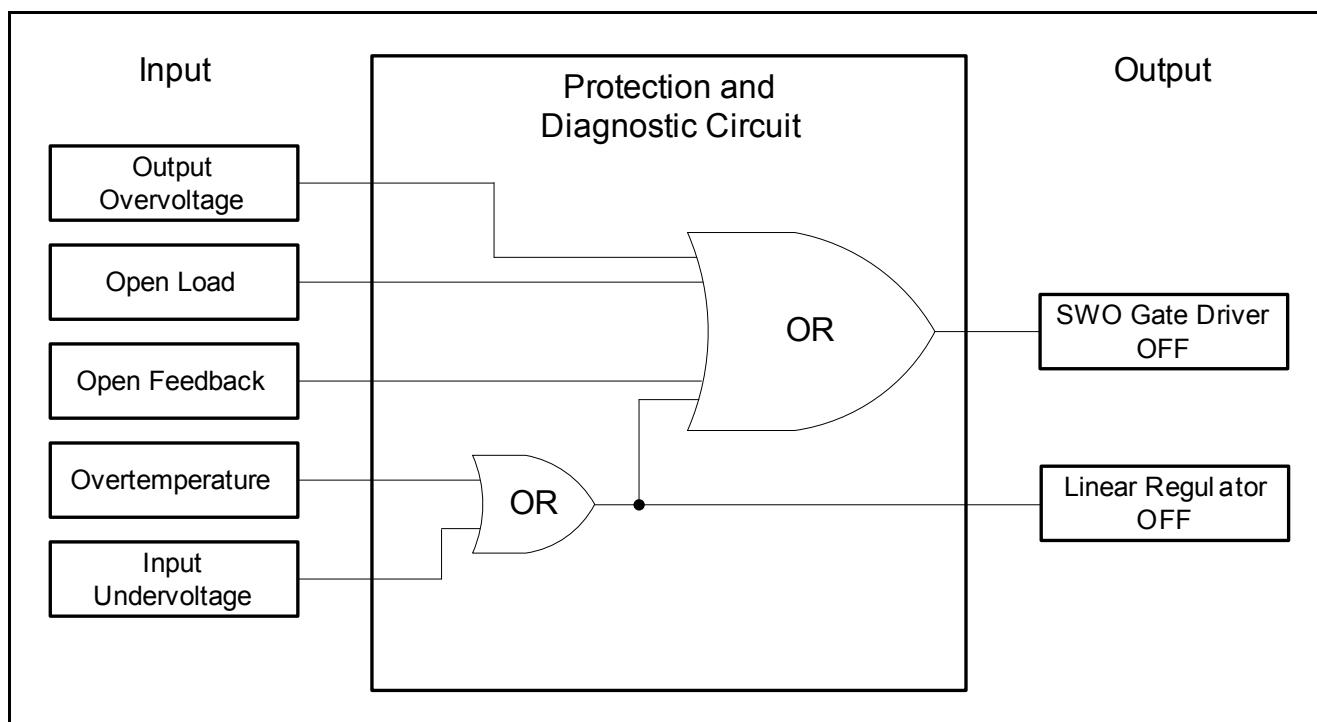


Figure 9-1 Protection and Diagnostic Function Block Diagram

Protection and Diagnostic Functions

Input		Output		
Condition	Level*	ST	SWO	IVCC
Overvoltage @ Output	False	H or Sw*	Sw*	Active
	True	L	L	Active
Open Load	False	H or Sw*	Sw*	Active
	True	L	L	Active
Open Feedback	False	H or Sw*	Sw*	Active
	True	L	L	Active
Overtemperature	False	H or Sw*	Sw*	Active
	True	L	L	Shutdown
Undervoltage @ Input	False	H or Sw*	Sw*	Active
	True	L	L	Shutdown

\*Note:  
Sw = Switching  
False = Condition does not exist  
True = Condition does exist

Figure 9-2 Diagnosis Truth Table

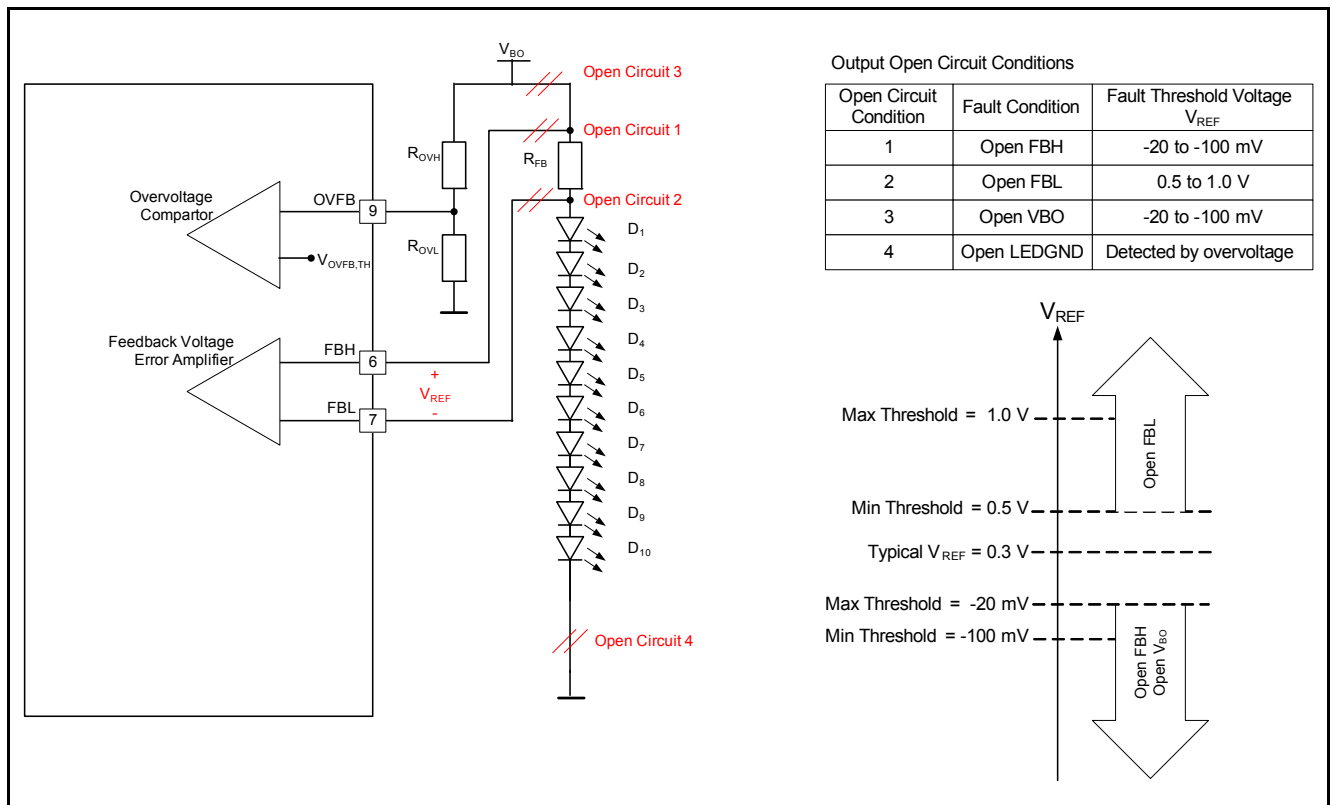


Figure 9-3 Open Load and Open Feedback Conditions

Protection and Diagnostic Functions

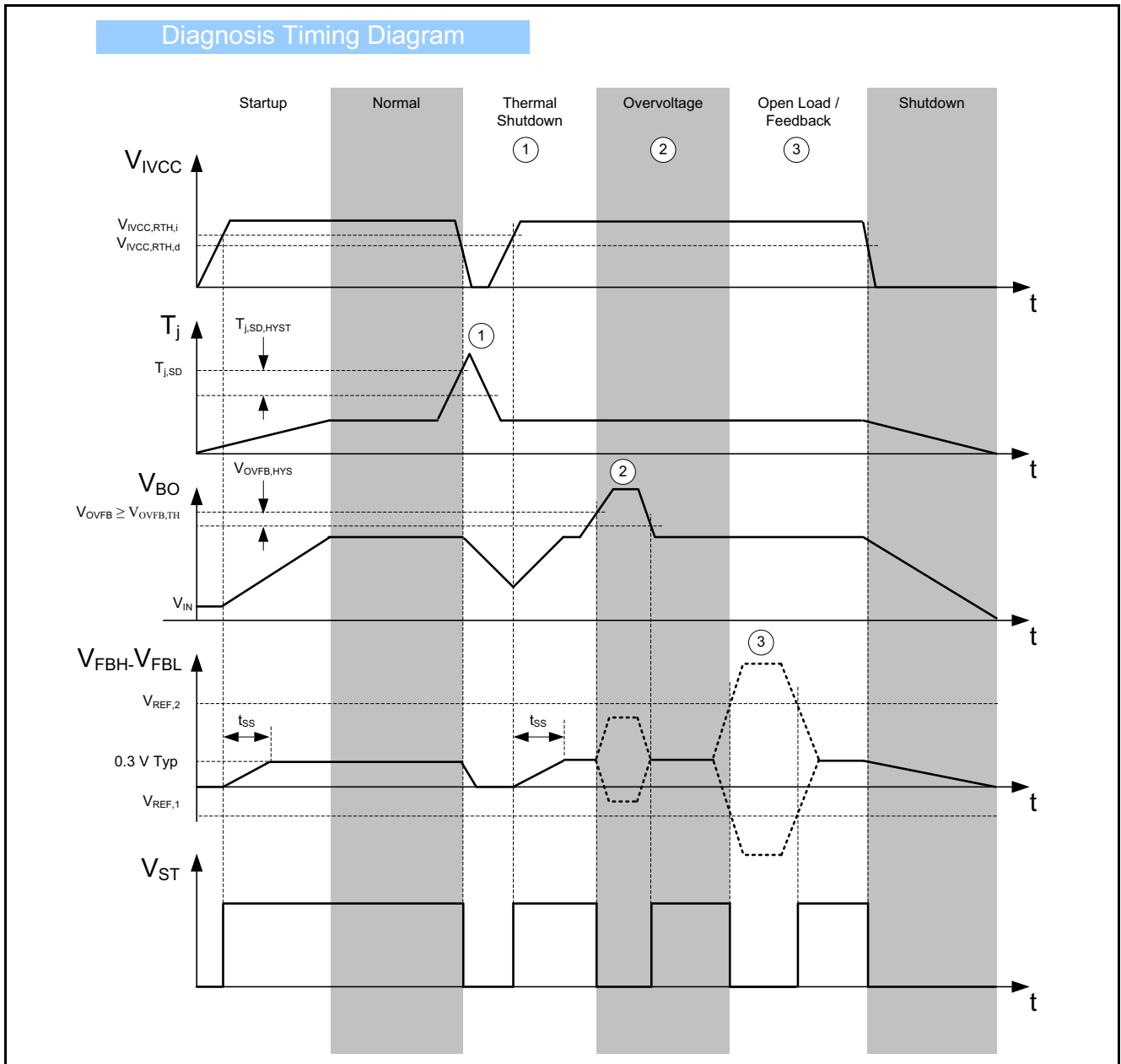


Figure 9-4 Open load, Overvoltage and Overtemperature Timing Diagram



Protection and Diagnostic Functions

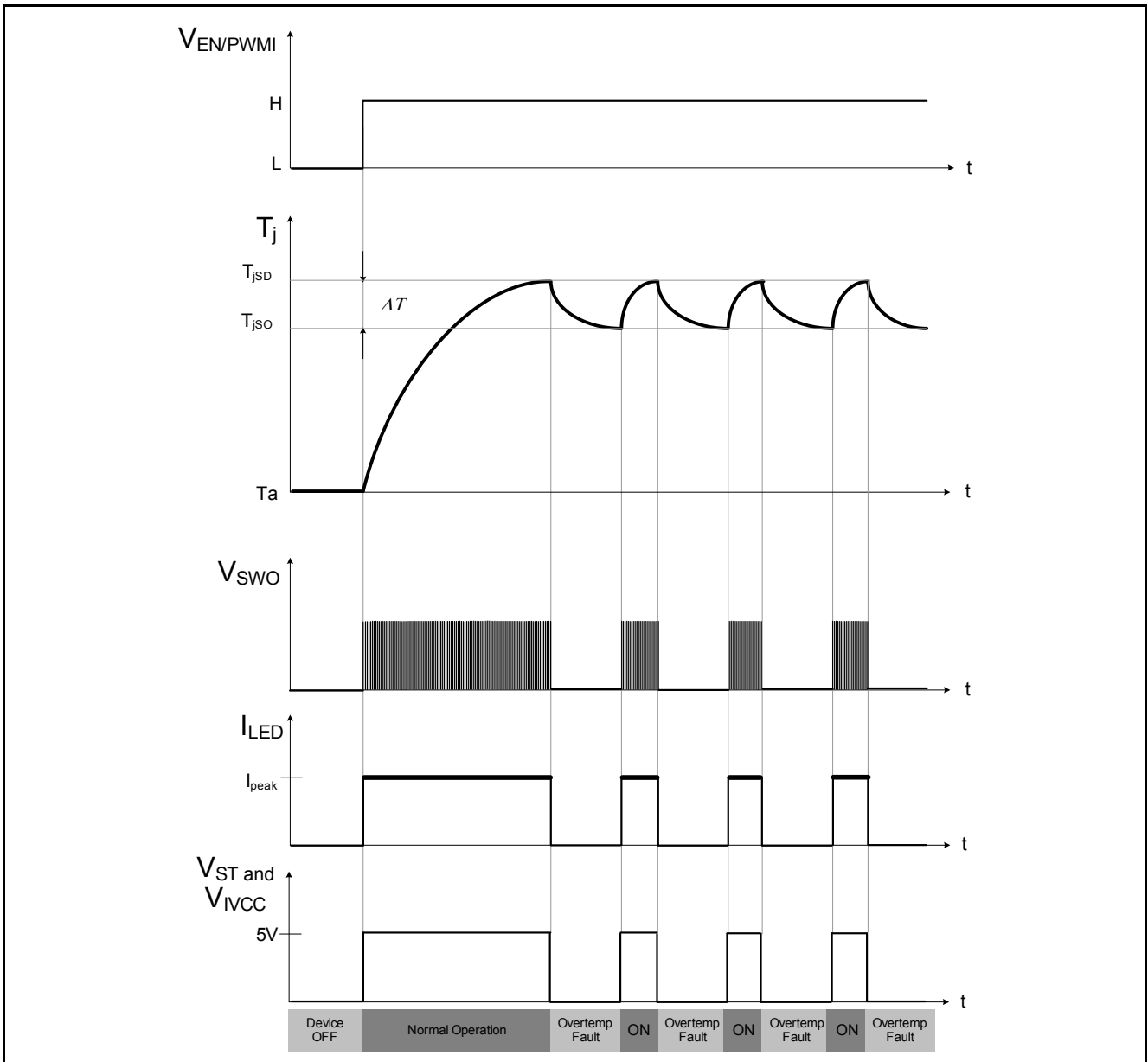


Figure 9-5 Device Overtemperature Protection Behavior

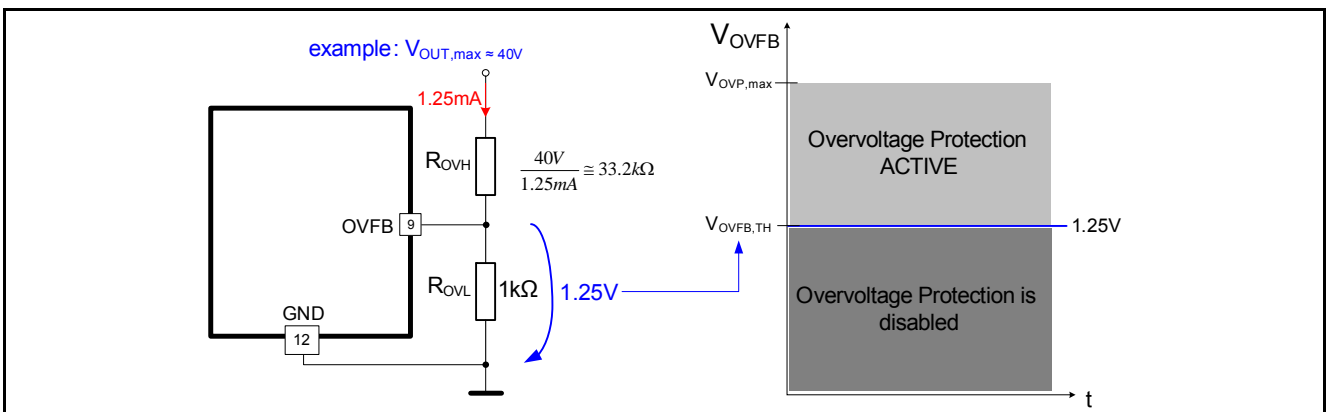


Figure 9-6 Overvoltage Protection Description

**Protection and Diagnostic Functions**

**9.2 Electrical Characteristics**

V<sub>IN</sub> = 8V to 34V; T<sub>j</sub> = -40°C to +150°C, all voltages with respect to ground, positive current flowing into pin; (unless otherwise specified)

**Table 9-1 Electrical Characteristics: Protection and Diagnosis**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
<b>Status Output</b>							
Status Output Voltage Low	V <sub>ST,LOW</sub>	–	–	0.4	V	<sup>1)</sup> I <sub>ST</sub> = 1mA	P_9.2.1
Status Output Voltage High	V <sub>ST,HIGH</sub>	V <sub>IVCC</sub> - 0.4	–	V <sub>IVCC</sub>	V	<sup>1)</sup> I <sub>ST</sub> = -1mA	P_9.2.2
<b>Temperature Protection</b>							
Overtemperature Shutdown	T <sub>j,SD</sub>	160	175	190	°C	<sup>1)</sup> refer to <b>Figure 9-5</b>	P_9.2.3
Overtemperature Shutdown Hysteresis	T <sub>j,SD,HYST</sub>	–	15	–	°C	<sup>1)</sup>	P_9.2.4
<b>Overvoltage Protection</b>							
Output Over Voltage Feedback Threshold Increasing	V <sub>OVFB,TH</sub>	1.21	1.25	1.29	V	refer to <b>Figure 9-6</b>	P_9.2.5
Output Over Voltage Feedback Hysteresis	V <sub>OVFB,HYS</sub>	50	–	150	mV	<sup>1)</sup> Output Voltage decreasing	P_9.2.6
Over Voltage Reaction Time	t <sub>OVPRR</sub>	2	–	10	μs	<sup>1)</sup> Output Voltage decreasing	P_9.2.7
Over Voltage Feedback Input Current	I <sub>OVFB</sub>	-1	0.1	1	μA	V <sub>OVFB</sub> = 1.25 V	P_9.2.8
<b>Open Load and Open Feedback Diagnostics</b>							
Open Load/Feedback Threshold	V <sub>REF,1,3</sub>	-100	–	-20	mV	refer to <b>Figure 9-3</b> V <sub>REF</sub> = V <sub>FBH</sub> - V <sub>FBL</sub> Open Circuit 1 or 3	P_9.2.9
Open Feedback Threshold	V <sub>REF,2</sub>	0.5	–	1	V	V <sub>REF</sub> = V <sub>FBH</sub> - V <sub>FBL</sub> Open Circuit 2	P_9.2.10

<sup>1)</sup> Specified by design; not subject to production test.

*Note: Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as “outside” normal operating range. Protection functions are not designed for continuous repetitive operation.*

## 10 Analog Dimming

This pin is influencing the Feedback Voltage Error Amplifier by generating an internal current accordingly to an external reference voltage (VSET). If the analog dimming feature is not needed this pin must be connected to IVCC or external > 1.6V supply. Different application scenarios are described in **Figure 10-3**. This pin can also go outside of the ECU for instance if a thermistor is connected on a separated LED Module and the Analog Dimming Input is used to thermally protect the LEDs. For reverse battery protection of this pin an external series resistor should be placed to limit the current.

### 10.1 Purpose of Analog Dimming

1. It is difficult for LED manufacturers to deliver LEDs which have the same Brightness, Colorpoint and Forward Voltage Class. Due to this relatively wide spread of the crucial LED parameters automotive customers order LEDs from one or maximum two different colorpoint classes. The LED manufacturer must preselect the LEDs to deliver the requested colorpoint class. Those preselected LEDs are matched in terms of the colorpoint but a variation of the brightness remains. To correct the brightness deviation an analog dimming feature is needed. The mean LED current can be adjusted by applying an external voltage VSET at the SET pin.
2. If the DC/DC application is separated from the LED loads the ECU manufacturers aim is to develop one hardware which should be able to handle different load current conditions (e.g. 80mA to 400mA) to cover different applications. To achieve this average LED current adjustment the analog dimming is a crucial feature.

### 10.2 Description

#### Application Example

Desired LED current = 400mA. For the calculation of the correct Feedback Resistor  $R_{FB}$  the following equation can be used: This formula is valid if the analog dimming feature is disabled and  $V_{SET} > 1.6V$ .

(10.1)

$$I_{LED} = \frac{V_{REF}}{R_{FB}} \rightarrow R_{FB} = \frac{V_{REF}}{I_{LED}} \rightarrow R_{FB} = \frac{0.3V}{400mA} = 750m\Omega$$

A decrease of the average LED current can be achieved by controlling the voltage at the SET pin ( $V_{SET}$ ) between 0V and 1.6V. The mathematical relation is given in the formula below:

(10.2)

$$I_{LED} = \frac{V_{SET} - 0.1V}{5 \cdot R_{FB}}$$

If  $V_{SET}$  is 100mV the LED current is only determined by the internal offset voltages of the comparators. For this example  $I_{LED} = 0A$  if  $V_{SET} < 100mV$ . Refer to the concept drawing in **Figure 10-2**.

Analog Dimming

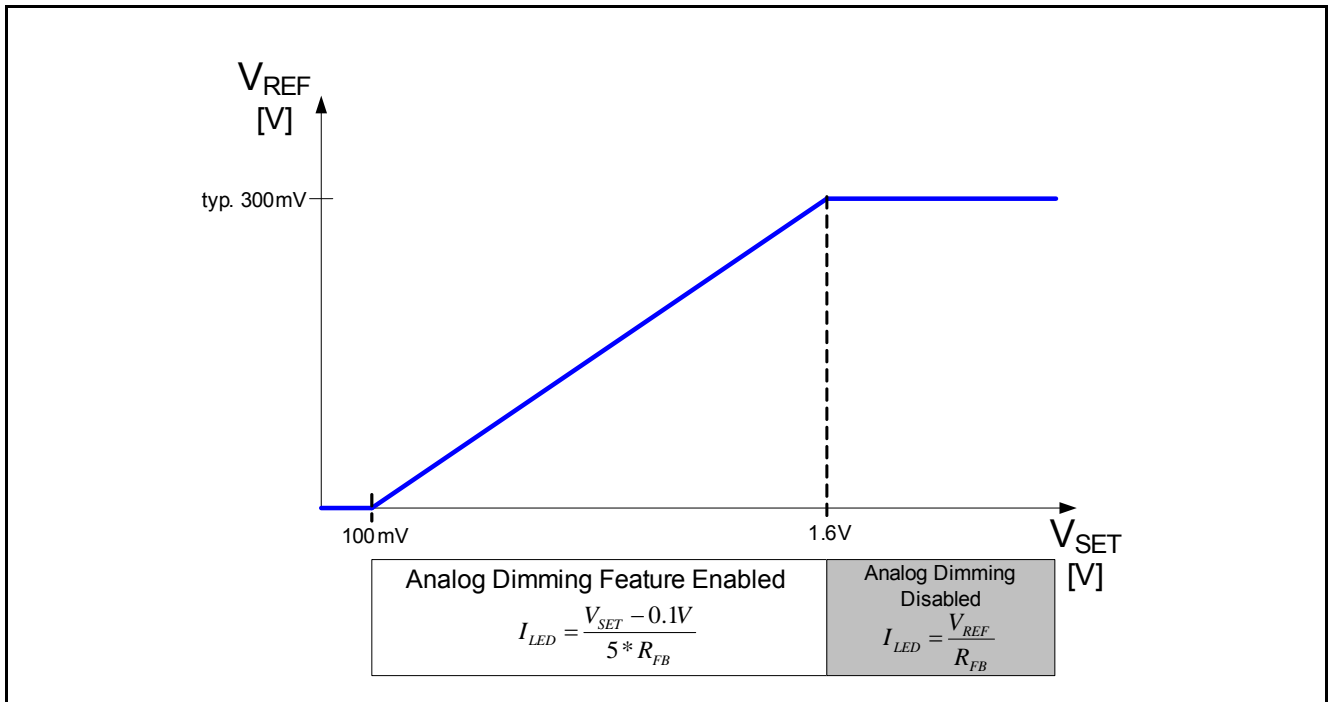


Figure 10-1 Basic relationship between  $V_{REF}$  and  $V_{SET}$  Voltage

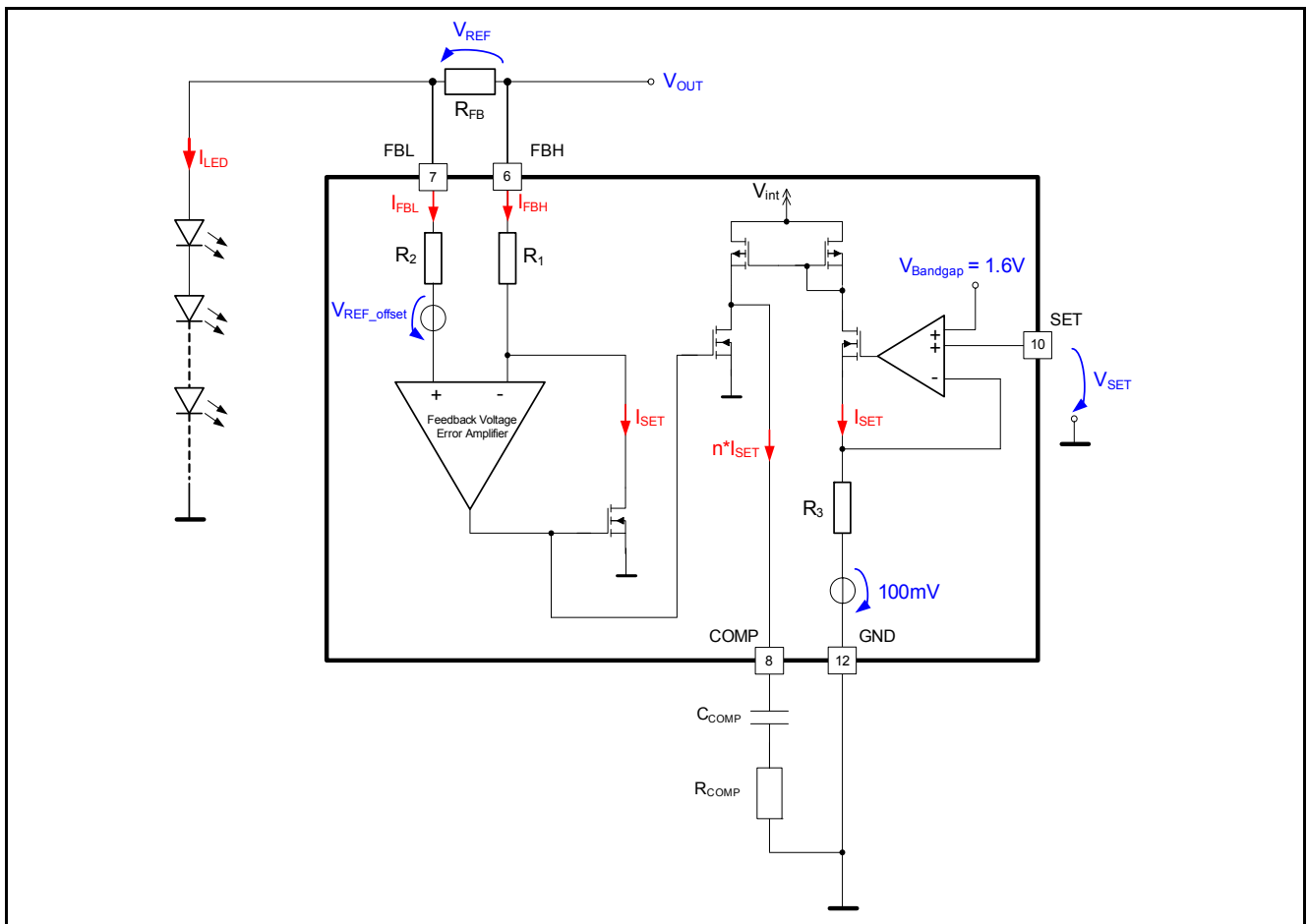


Figure 10-2 Concept Drawing Analog Dimming

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## **Analog Dimming**

### **Multi-purpose usage of the Analog dimming feature**

1. A  $\mu\text{C}$  integrated digital analog converter (DAC) output or a stand alone DAC can be used to supply the SET pin of the TLD5097EL. The integrated voltage Regulator (VIVCC) can be used to supply the  $\mu\text{C}$  or external components if the current consumption does not exceed 20mA.
2. The analog dimming feature is directly connected to the input voltage of the system. In this configuration the LED current is reduced if the input voltage  $V_{\text{IN}}$  is decreasing. The DC/DC boost converter is changing (increasing) the switching duty cycle if  $V_{\text{IN}}$  drops to a lower potential. This is causing an increase of the input current consumption. If applications require a decrease of the LED current in respect to  $V_{\text{IN}}$  variations this setup can be chosen.
3. The usage of an external resistor divider connected between IVCC (integrated 5V regulator output and gate buffer pin) SET and GND can be chosen for systems without  $\mu\text{C}$  on board. The concept allows to control the LED current via placing cheap low power resistors. Furthermore a temperature sensitive resistor (Thermistor) to protect the LED loads from thermal destruction can be connected additionally.
4. If the analog dimming feature is not needed the SET pin must be connected directly to  $>1.6\text{V}$  potential (e.g. IVCC potential)
5. Instead of an DAC the  $\mu\text{C}$  can provide a PWM signal and an external R-C filter is producing a constant voltage for the analog dimming. The voltage level is depending on the PWM frequency (fPWM) and duty cycle (DC) which can be controlled by the  $\mu\text{C}$  software after reading the coding resistor placed at the LED module.

Analog Dimming

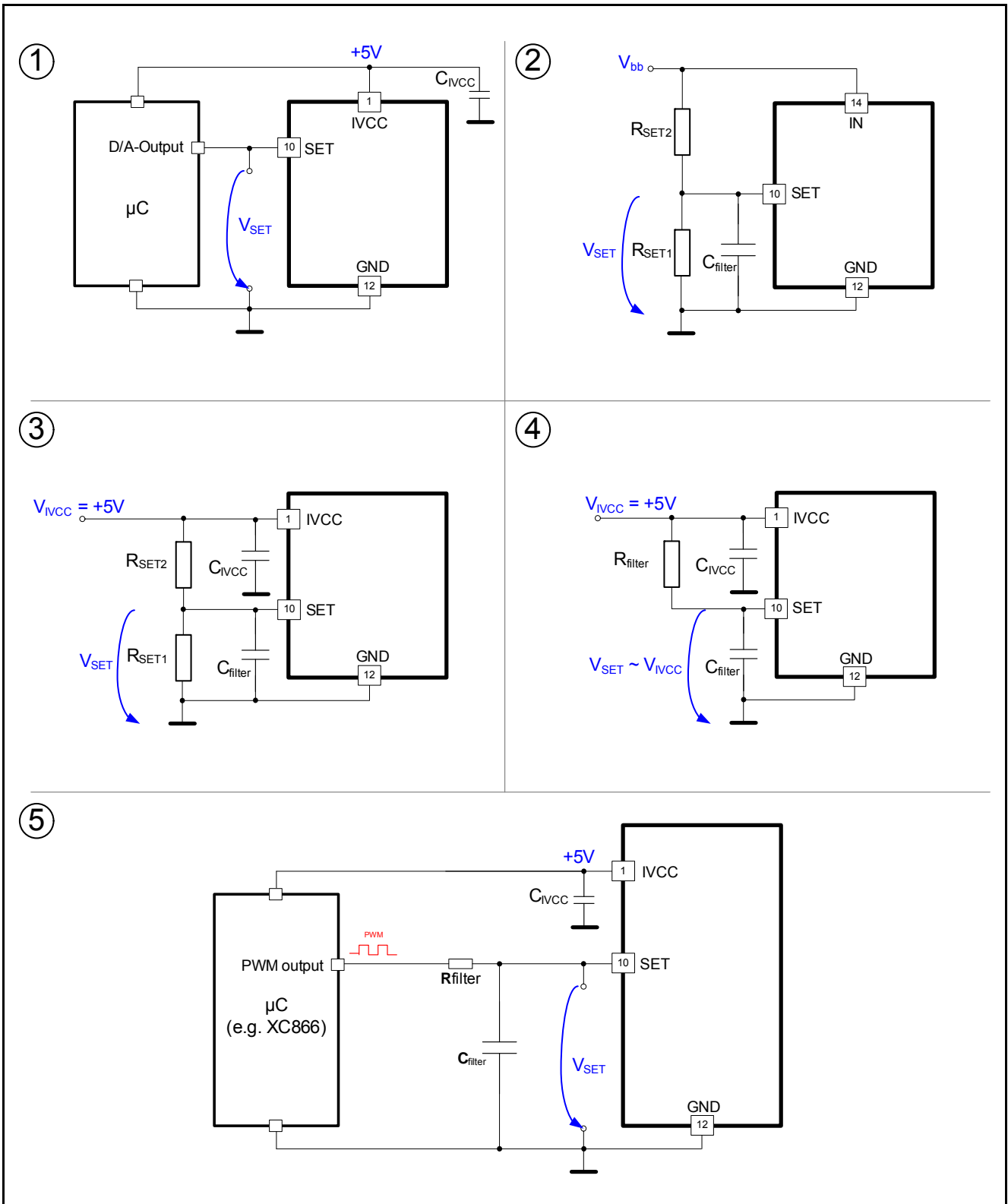


Figure 10-3 Analog Dimming in various applications

**Analog Dimming**

**10.3 Electrical Characteristics**

V<sub>IN</sub> = 8V to 34V; T<sub>j</sub> = -40°C to +150°C, all voltages with respect to ground, positive current flowing into pin; (unless otherwise specified)

**Table 10-1 Electrical Characteristics: Protection and Diagnosis**

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
SET programming range	V <sub>SET</sub>	0	–	1.6	V	<sup>1)</sup> refer to <a href="#">Figure 10-1</a>	P_10.3.1

1) Specified by design; not subject to production test.

Application Information

## 11 Application Information

Note: The following information is given as a hint for the implementation of the device only and shall not be regarded as a description or warranty of a certain functionality, condition or quality of the device.

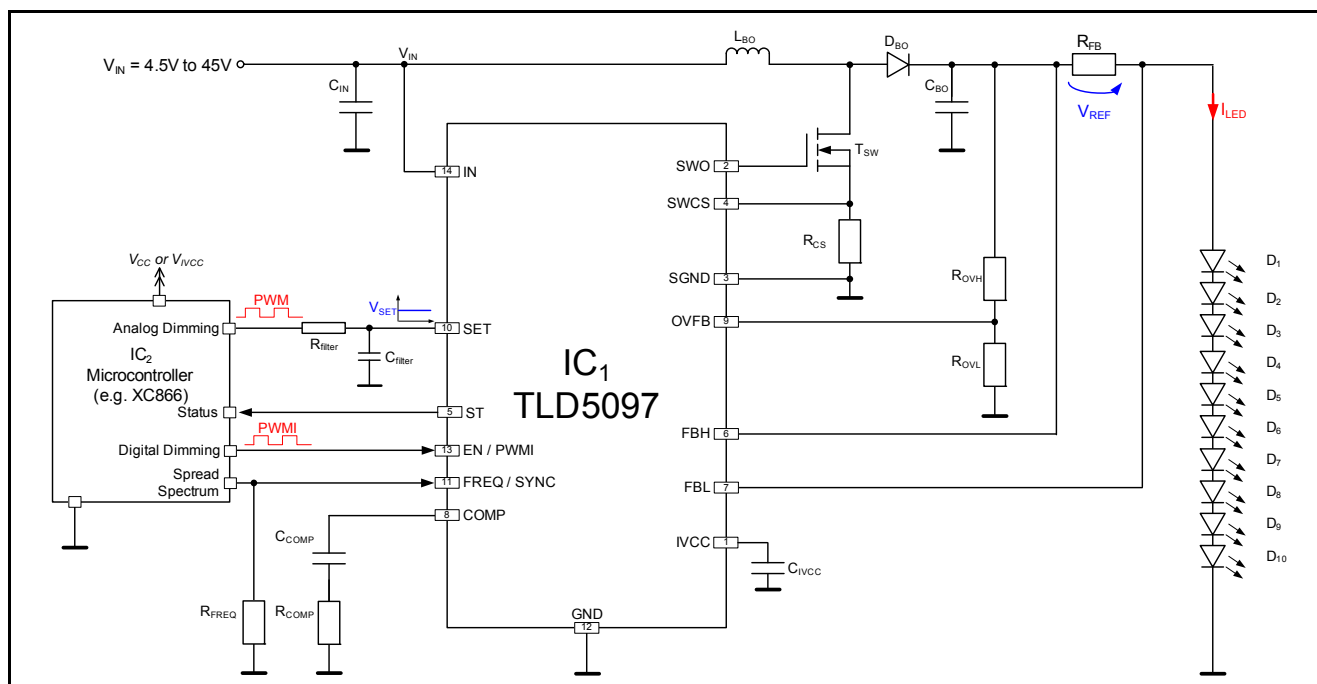


Figure 11-1 Boost to Ground Application Circuit - B2G (Boost configuration)

Reference Designator	Value	Manufacturer	Part Number	Type	Quantity
D <sub>1-10</sub>	White	Osram	LUW H9GP	LED	10
D <sub>BO</sub>	Schottky, 3 A, 100 V <sub>R</sub>	Vishay	SS3H10	Diode	1
C <sub>IN</sub>	100 uF, 50V	Panasonic	EEEFK1H101GP	Capacitor	1
C <sub>BO</sub>	10 uF, 50V	Panasonic	Electrolytic or Ceramic Bank	Capacitor	1
C <sub>COMP</sub>	100 nF	EPCOS	X7R	Capacitor	1
C <sub>IVCC</sub>	1uF , 6.3V	EPCOS	MLCC CCNPZC105KBW X7R	Capacitor	1
IC <sub>1</sub>	--	Infineon	TLD5097	IC	1
IC <sub>2</sub>	--	Infineon	XC866	IC	1
L <sub>BO</sub>	100 uH	Coilcraft	MSS1278T-104ML	Inductor	1
R <sub>COMP</sub>	10 kΩ, 1%	Panasonic	ERJ3EKF 1002V	Resistor	1
R <sub>FB</sub>	820 mΩ, 1%	Panasonic	ERJ14BQFR82U	Resistor	1
R <sub>FREQ</sub>	20 kΩ, 1%	Panasonic	ERJ3EKF 2002V	Resistor	1
R <sub>OVH</sub>	33.2 kΩ, 1%	Panasonic	ERJ3EKF 3322V	Resistor	1
R <sub>OVL</sub>	1 kΩ, 1%	Panasonic	ERJ3EKF 1001V	Resistor	1
R <sub>CS</sub>	50 mΩ, 1%	Panasonic	ERJB 1CFR05U	Resistor	1
T <sub>SW</sub>	100V N-ch, 35A	Infineon	IPG20N10S4L-22	Transistor	1
	alternativ: 60V N-ch, 30A	Infineon	IPD30N06S4L-23	Transistor	1

Figure 11-2 Bill of Materials for B2G Application Circuit



Application Information

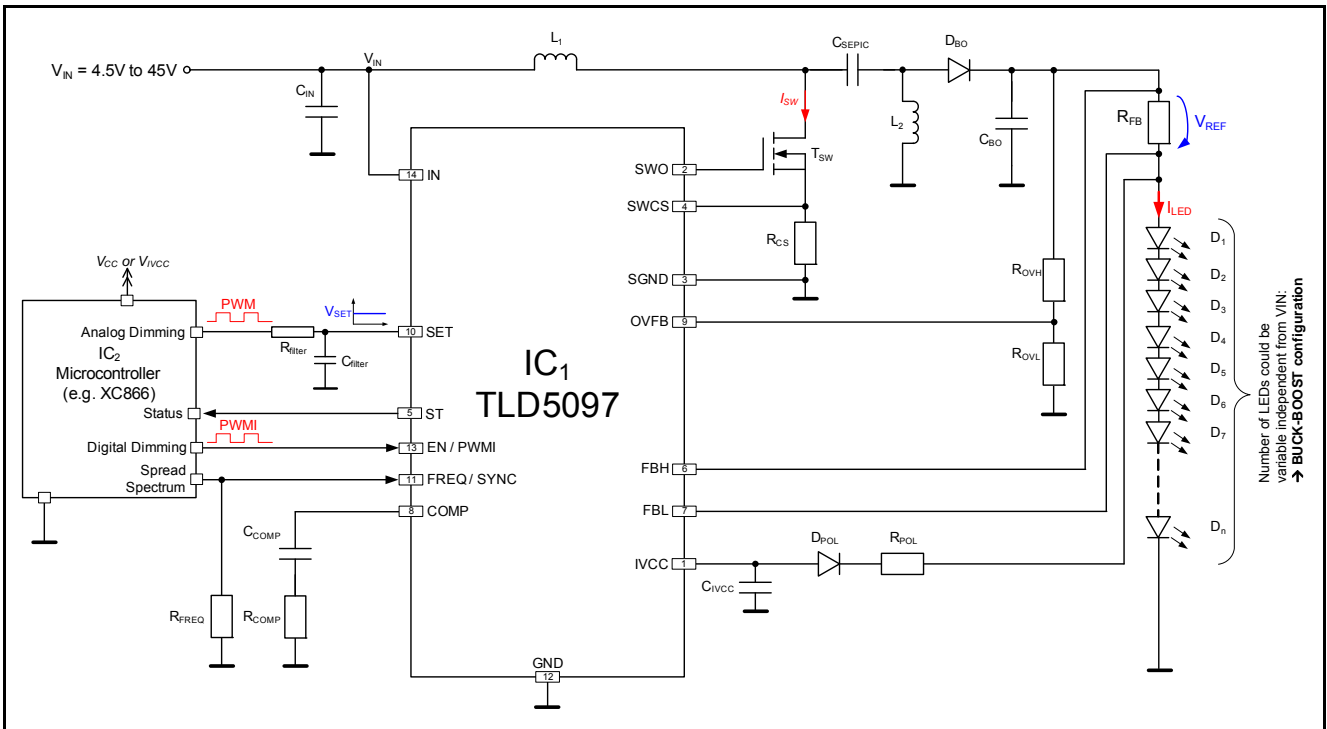


Figure 11-3 SEPIC Application Circuit (Buck-Boost configuration)

Reference Designator	Value	Manufacturer	Part Number	Type	Quantity
D <sub>1 - n</sub>	White	Osram	LUW H9GP	LED	variable
D <sub>BO</sub>	Schottky, 3 A, 100 V <sub>R</sub>	Vishay	SS3H10	Diode	1
D <sub>POL</sub>	80V Diode	Infineon	BAS 1603W	Diode	1
C <sub>SEPIC</sub>	3.3 uF, 20V	EPCOS	X7R, Low ESR	Capacitor	1
C <sub>IN</sub>	100 uF, 50V	Panasonic	EEEFK1H101GP	Capacitor	1
C <sub>BO</sub>	10 uF, 50V	Panasonic	EEEFK1H100P	Capacitor	1
C <sub>COMP</sub>	100 nF	EPCOS	X7R	Capacitor	1
C <sub>IVCC</sub>	1uF, 6.3V	EPCOS	X7R	Capacitor	1
IC <sub>1</sub>	--	Infineon	TLD5097	IC	1
IC <sub>2</sub>	--	Infineon	XC866	IC	1
L <sub>1, L2</sub>	47 uH	Coilcraft	MSS1278T-473ML	Inductor	2
	alternativ: 22uH coupled inductor	Coilcraft	MSD1278-223MLD	Inductor	1
R <sub>COMP, R<sub>POL</sub></sub>	10 kΩ, 1%	Panasonic	ERJ3EKF 1002V	Resistor	2
R <sub>FB</sub>	820 mΩ, 1%	Panasonic	ERJ14BQFR82U	Resistor	1
R <sub>FREQ</sub>	20 kΩ, 1%	Panasonic	ERJ3EKF 2002V	Resistor	1
R <sub>OVH</sub>	33.2 kΩ, 1%	Panasonic	ERJ3EKF 3322V	Resistor	1
R <sub>OVL</sub>	1 kΩ, 1%	Panasonic	ERJ3EKF 1001V	Resistor	1
R <sub>CS</sub>	50 mΩ, 1%	Panasonic	ERJB1CFR05U	Resistor	1
T <sub>SW</sub>	100V N-ch, 35A	Infineon	IPD35N10S3L-26	Transistor	1
	alternativ: 60V N-ch, 30A	Infineon	IPD30N06S4L-23	Transistor	1

Figure 11-4 Bill of Materials for SEPIC Application Circuit



Application Information

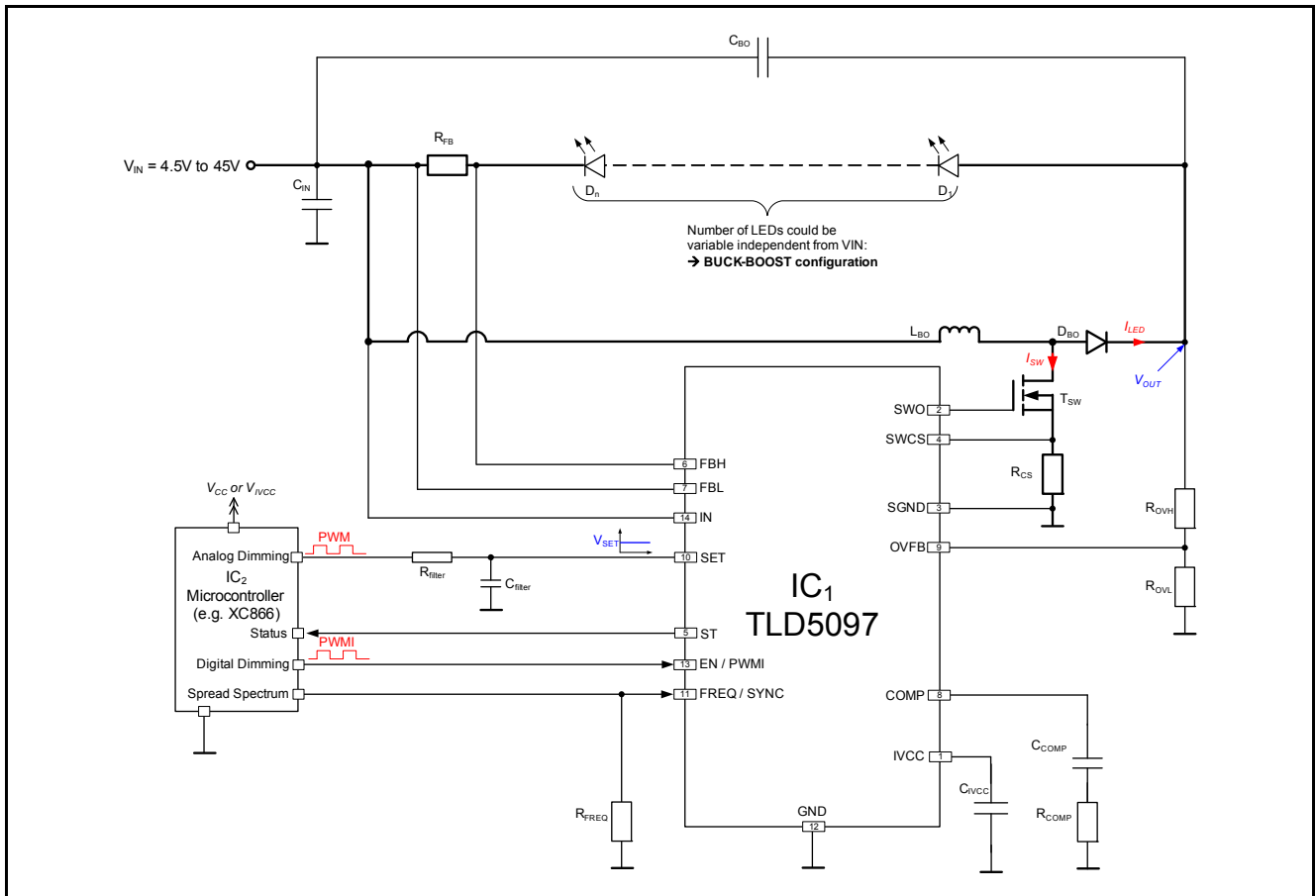


Figure 11-7 Boost to Battery Application Circuit - B2B (Buck-Boost configuration)

Reference Designator	Value	Manufacturer	Part Number	Type	Quantity
D <sub>1 - n</sub>	White	Osram	LUW H9GP	Diode	variable
D <sub>BO</sub>	Schottky, 3 A, 100 V <sub>R</sub>	Vishay	SS3H10	Diode	1
C <sub>BO</sub>	10 uF, 80V	Panasonic	EEEFK1K100P	Capacitor	1
C <sub>IN</sub>	100 uF, 50V	Panasonic	EEEFK1H101GP	Capacitor	1
C <sub>COMP</sub>	100 nF	EPCOS	X7R	Capacitor	1
C <sub>IVCC</sub>	1 uF, 6.3V	EPCOS	MLCC CCNPZC105KBW X7R	Capacitor	1
IC <sub>1</sub>	--	Infineon	TLD5097	IC	1
IC <sub>2</sub>	--	Infineon	XC866	IC	1
L <sub>BO</sub>	100 uH	Coilcraft	MSS1278T-104ML_	Inductor	1
R <sub>COMP</sub>	10 kΩ, 1%	Panasonic	ERJ3EKF1002V	Resistor	1
R <sub>FB</sub>	820 mΩ, 1%	Panasonic	ERJ14BQFR82U	Resistor	1
R <sub>FREQ</sub>	20 kΩ, 1%	Panasonic	ERJ3EKF2002V	Resistor	1
R <sub>OVH</sub>	33.2 kΩ, 1%	Panasonic	ERJP06F5102V	Resistor	1
R <sub>OVL</sub>	1 kΩ, 1%	Panasonic	ERJ3EKF1001V	Resistor	1
R <sub>CS</sub>	50 mΩ, 1%	Panasonic	ERJB1CFR05U	Resistor	1
T <sub>SW</sub>	N-ch, OptiMOS-T2 100V, 35A	Infineon	IPD35N10S3L-26	Transistor	1
	alternativ: 60V N-ch, 30A	Infineon	IPD30N06S4L-23	Transistor	1

Figure 11-8 Bill of Materials for B2B Application Circuit

Application Information

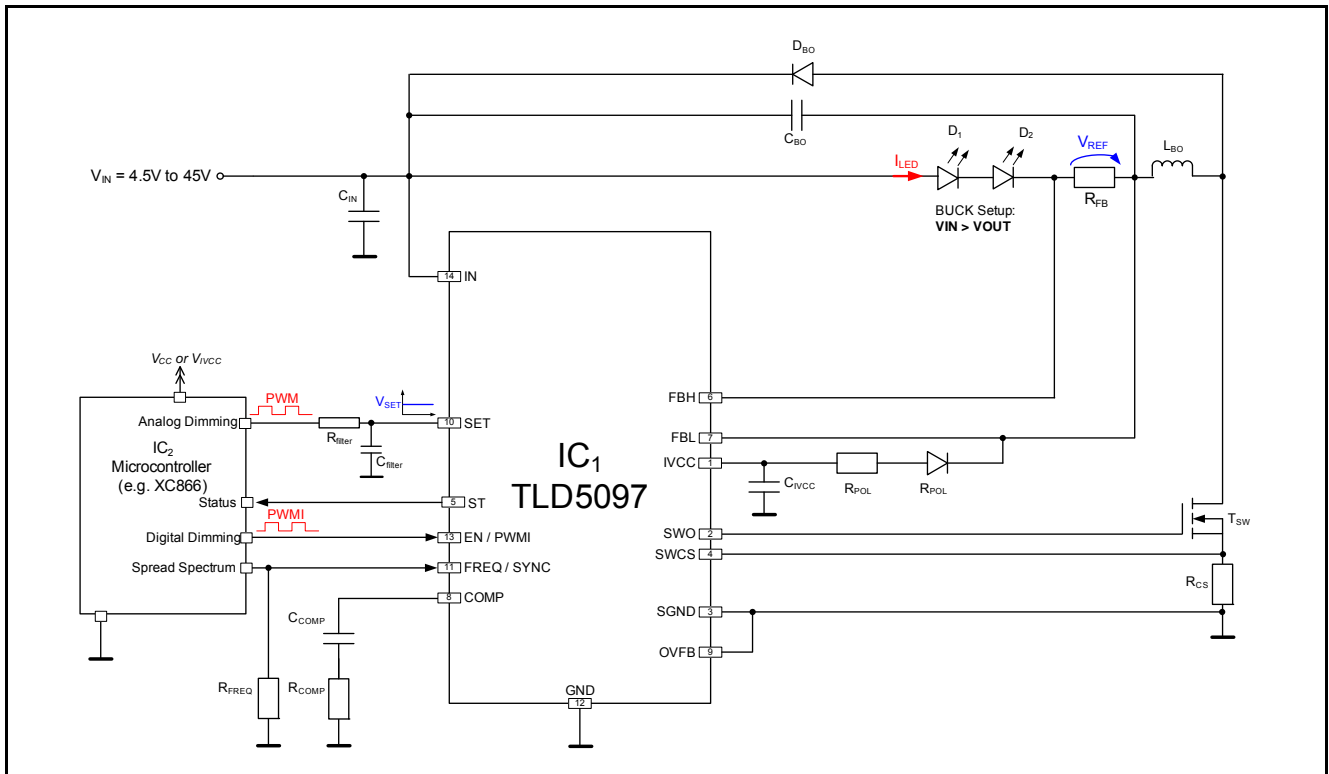


Figure 11-9 Buck Application Circuit

Reference Designator	Value	Manufacturer	Part Number	Type	Quantity
D <sub>1-2</sub>	White	Osram	LE UW Q9WP	LED	2
D <sub>BO</sub>	Schottky, 3 A, 100 V <sub>R</sub>	Vishay	SS3H10	Diode	1
D <sub>POL</sub>	80V Diode	Infineon	BAS1603W	Diode	1
C <sub>BO</sub>	4.7 uF, 50V	EPCOS	X7R	Capacitor	1
C <sub>IN</sub>	100 uF, 50V	Panasonic	EEEFK1H101GP	Capacitor	1
C <sub>COMP</sub>	47 nF	EPCOS	X7R	Capacitor	1
C <sub>IVCC</sub>	1 uF, 6.3V	EPCOS	MLCC CCNPZC105KBW X7R	Capacitor	1
IC <sub>1</sub>	--	Infineon	TLD5097	IC	1
IC <sub>2</sub>	--	Infineon	XC866	IC	1
L <sub>1</sub>	22 uH	Coilcraft	MSS1278T	Inductor	1
R <sub>POL</sub>	10 kΩ, 1%	Panasonic	ERJ3EKF1002V	Resistor	1
R <sub>FB</sub>	820 mΩ, 1%	Isabellenhütte	SMS – Power Resistor	Resistor	1
R <sub>FREQ</sub>	20 kΩ, 1%	Panasonic	ERJ3EKF2002V	Resistor	1
R <sub>CS</sub>	50 mΩ, 1%	Isabellenhütte	SMS - Power Resistor	Resistor	1
T <sub>SW</sub>	100V N-ch, 35A	Infineon	IPG20N10S4L-22	Transistor	1
	alternativ: 60V N-ch, 30A	Infineon	IPD30N06S4L-23	Transistor	1

Figure 11-10 Bill of Materials for Buck Application Circuit

Application Information

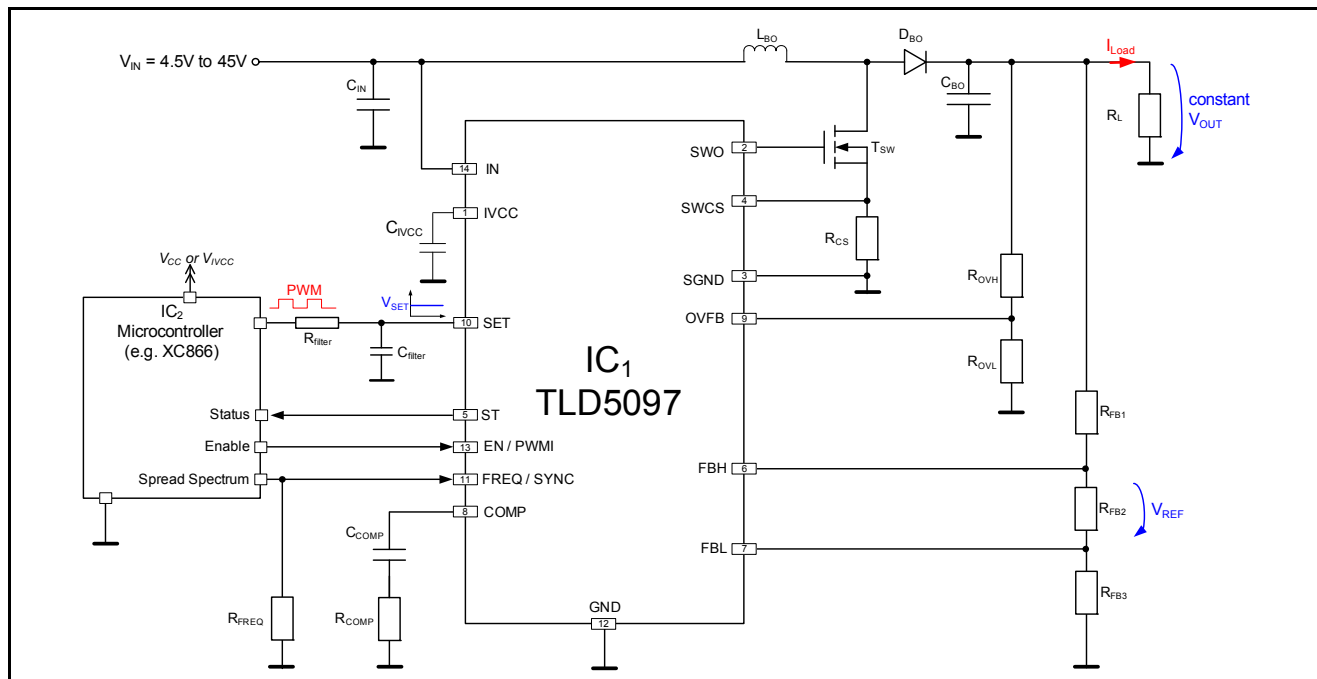


Figure 11-11 Boost Voltage Application Circuit

Reference Designator	Value	Manufacturer	Part Number	Type	Quantity
$D_{BO}$	Schottky, 3 A, 100 V <sub>R</sub>	Vishay	SS3H10	Diode	1
$C_{BO}$	100 uF, 80V	Panasonic	EEVFK1K101Q	Capacitor	1
$C_{IN}$	100 uF, 50V	Panasonic	EEEFK1H101GP	Capacitor	1
$C_{COMP}$	10 nF, 16V	EPCOS	X7R	Capacitor	1
$C_{IVCC}$	1 uF, 6.3V	Panasonic	X7R	Capacitor	1
IC <sub>1</sub>	--	Infineon	TLD5097	IC	1
IC <sub>2</sub>	--	Infineon	XC866	IC	1
$L_{BO}$	100 uH	Coilcraft	MSS1278T-104ML_	Inductor	1
$R_{COMP}$	10 kohms, 1%	Panasonic	ERJ3EKF 1002V	Resistor	1
$R_{FB1}, R_{FB3}$	51 kohms, 1%	Panasonic	ERJ3EKF 5102V	Resistor	1
$R_{FB2}$	1 kohms, 1%	Panasonic	ERJ3EKF 1001V	Resistor	1
$R_{FREQ}$	20 kohms, 1%	Panasonic	ERJ3EKF 2002V	Resistor	1
$R_{OVH}$	33.2 kohms, 1%	Panasonic	ERJ3EKF 3322V	Resistor	1
$R_{OVL}$	1 kohms, 1%	Panasonic	ERJ3EKF 1001V	Resistor	1
$R_{CS}$	50 mohms, 1%	Panasonic	ERJB 1CFR05U	Resistor	1
$T_{SW}$	N-ch, OptiMOS-T2 100V	Infineon	IPG20N10S4L-22	Transistor	1

Figure 11-12 Bill of Materials for Boost Voltage Application Circuit

Note: The application drawings and corresponding bill of materials are simplified examples. Optimization of the external components must be done accordingly to specific application requirements.

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**Application Information**

**11.1 Further Application Information**

- For further information you may contact <http://www.infineon.com/>
- Application Note: TLD509x DC-DC Multitopology Controller IC “Dimensioning and Stability Guideline - Theory and Practice”

Package Outlines

12 Package Outlines

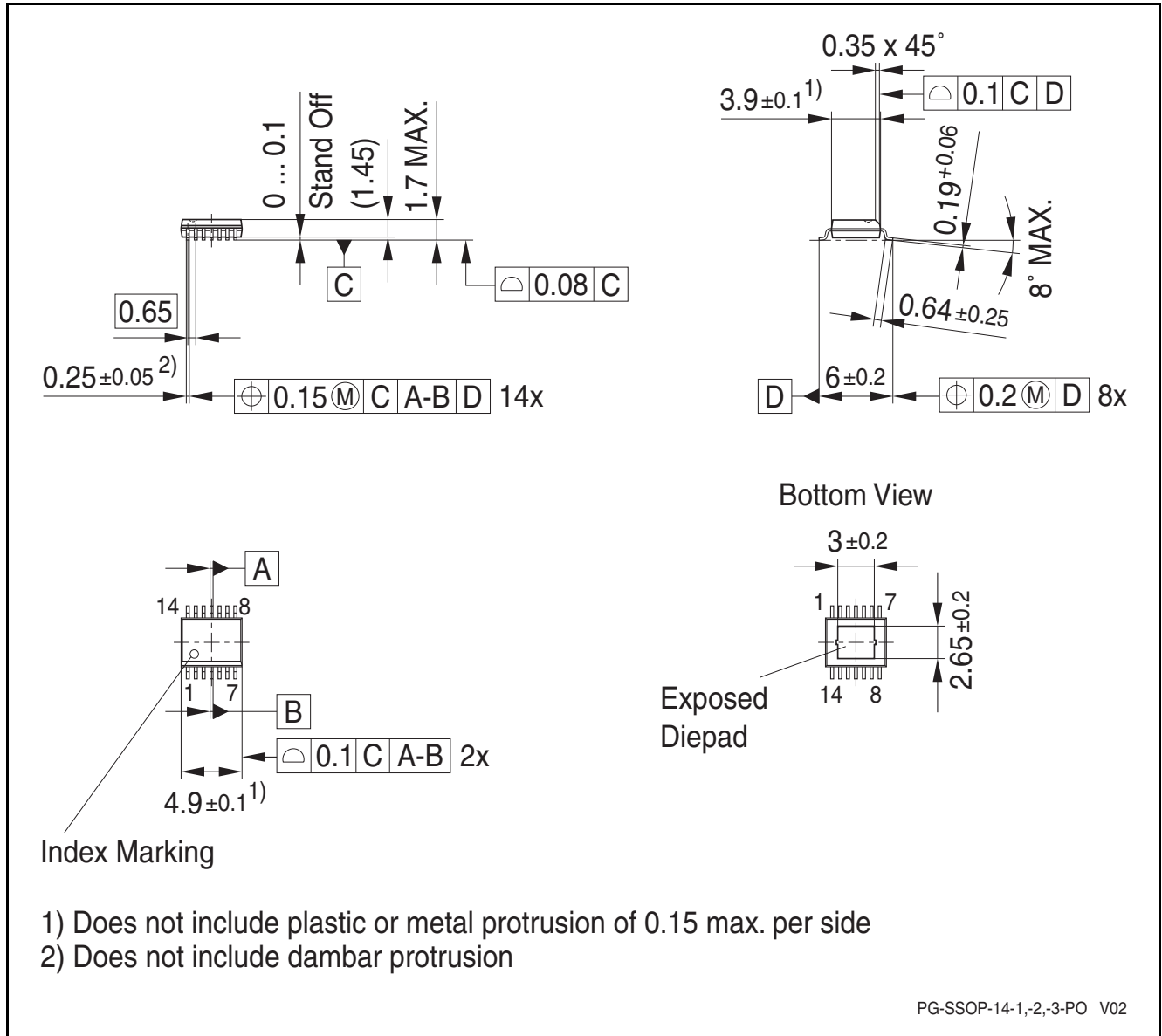


Figure 12-1 Outline PG-SSOP-14 Dimensions in mm

Green Product (RoHS Compliant)

To meet the world-wide customer requirements for environmentally friendly products and to be compliant with government regulations the device is available as a green product. Green products are RoHS-Compliant (i.e Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

Note: For further package information, please visit our website: <http://www.infineon.com/packages>.



<b>Revision History</b>			
<b>Revision 1.0, 2015-03-12</b>			
<b>Page or Item</b>	<b>Subjects (major changes since previous revision)</b>	<b>Responsible</b>	<b>Date</b>
Rev1.0	Initial Data Sheet for TLD5097EL		2013-11-12



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**Edition 2015-03-12**

**Published by**

**Infineon Technologies AG**

**81726 Munich, Germany**

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