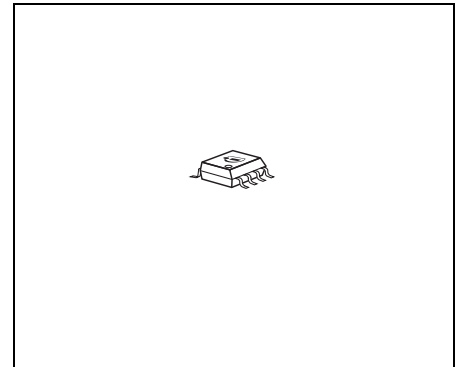




## Features

- Step down converter
- Supply Over- and Under-Voltage-Lockout
- Low Output voltage tolerance
- Output Overvoltage Lockout
- Output Under-Voltage-Reset with delay
- Overtemperature Shutdown
- Wide Ambient operation range -40 °C to 125 °C
- Wide Supply voltage operation range
- Very low current consumption
- Very small PG-DSO-8 SMD package
- Green Product (RoHS compliant)
- AEC Qualified



## Functional Description

The **TLE 6365 G** is a power supply circuit especially designed for automotive applications.

The device is based on Infineon's power technology SPT<sup>®</sup> which allows bipolar and CMOS control circuitry to be integrated with DMOS power devices on the same monolithic circuitry.

The **TLE 6365 G** contains a buck converter and a power on reset feature to start up the system

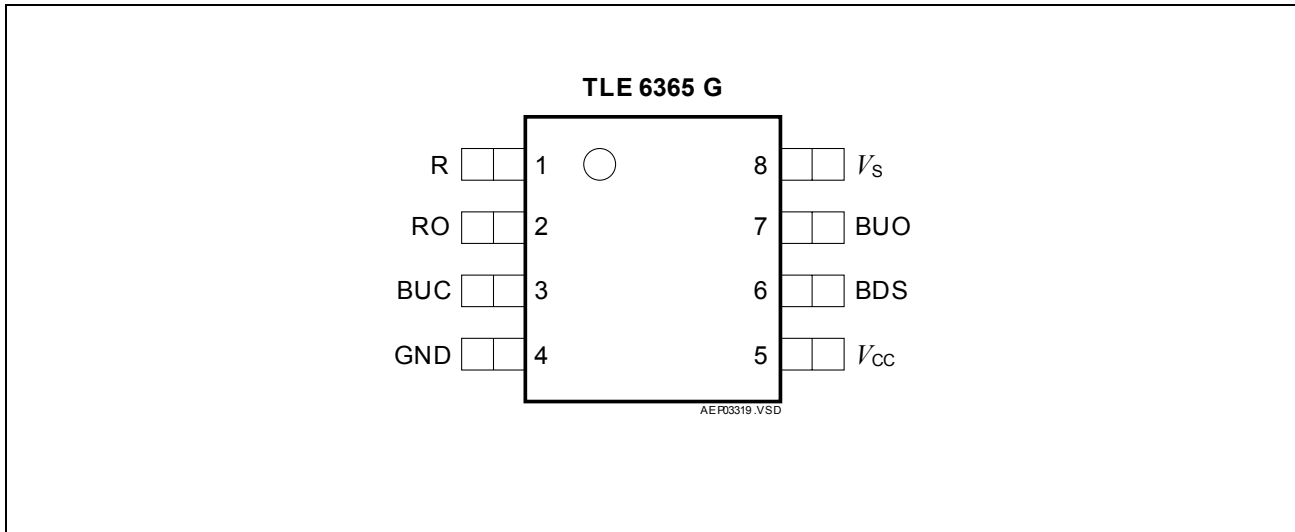
The very small **PG-DSO-8** SMD package meets the application requirements.

It delivers a precise 5 V fully short circuit protected output voltage.

Furthermore, the build-in features like under- and overvoltage lockout for supply- and output-voltage and the overtemperature shutdown feature increase the reliability of the **TLE 6365 G** supply system.

Type	Package	Marking
TLE 6365 G	PG-DSO-8	6365G

### Pin Configuration

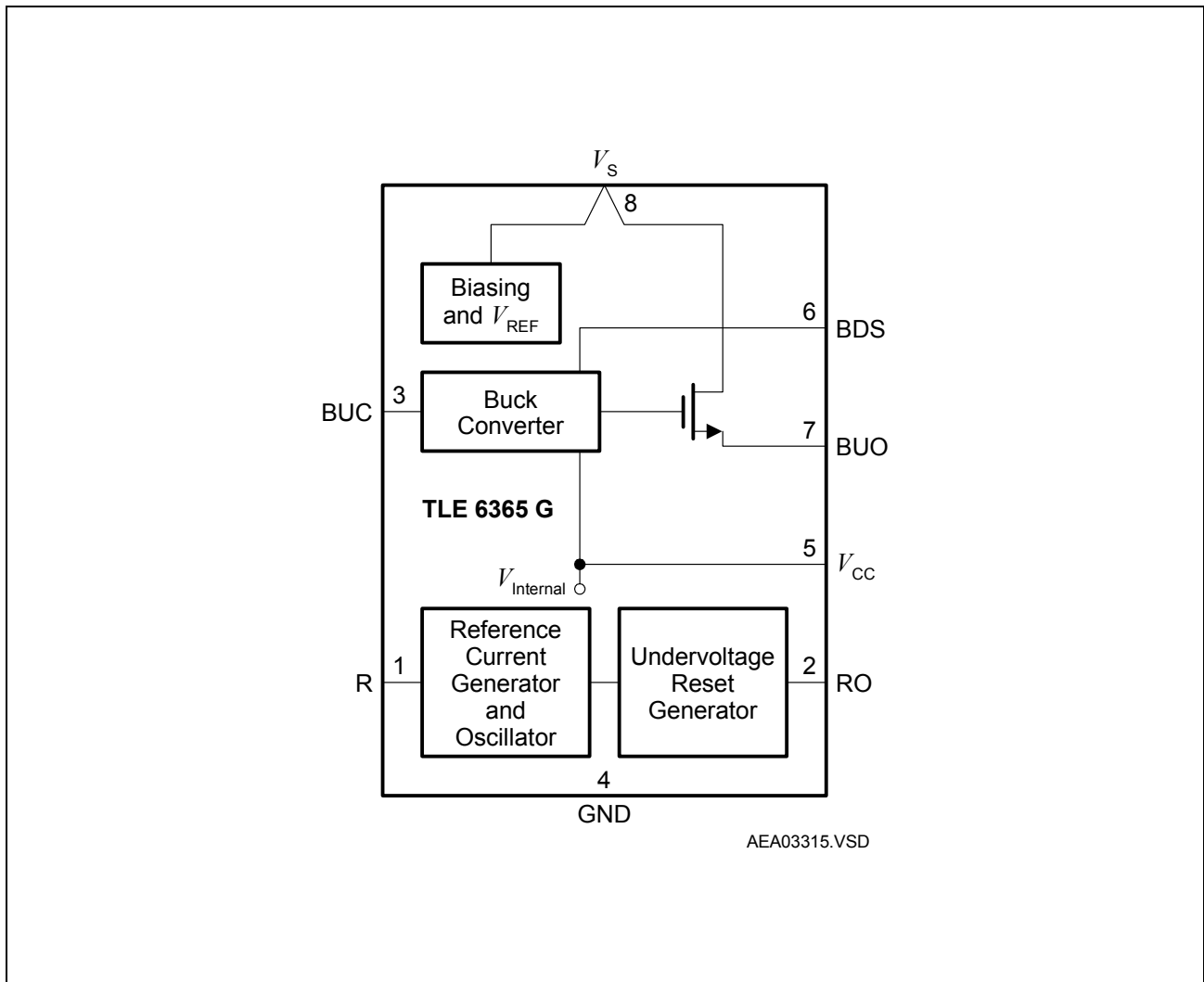


**Figure 1** Pin Configuration (top view)

**Table 1** Pin Definitions and Functions

Pin No.	Symbol	Function
1	R	<b>Reference Input;</b> an external resistor from this pin to GND determines the reference current and so the oscillator / switching frequency.
2	RO	<b>Reset Output;</b> open drain output from reset comparator with an internal pull-up resistor
3	BUC	<b>Buck-Converter Compensation Input;</b> output of internal error amplifier; for loop-compensation and therefore stability connect an external <i>R-C</i> -series combination to GND.
4	GND	<b>Ground;</b> analog signal ground
5	$V_{CC}$	<b>Output Voltage Input;</b> feedback input (with integrated resistor divider) and logic supply input; external blocking capacitor necessary
7	BUO	<b>Buck Converter Output;</b> source of the integrated power-DMOS
6	BDS	<b>Buck Driver Supply Input;</b> voltage to drive the buck converter powerstage
8	$V_S$	<b>Supply Voltage Input;</b> buck converter input voltage; external blocking capacitor necessary.

### Block Diagram



**Figure 2**      **Block Diagram**

**Table 2 Absolute Maximum Ratings**

Parameter	Symbol	Limit Values		Unit	Remarks
		Min.	Max.		
<b>Voltages</b>					
Supply voltage	$V_S$	-0.3	46	V	–
Buck output voltage	$V_{BUO}$	-1	46	V	–
Buck driver supply voltage	$V_{BDS}$	-0.3	48	V	$0^{\circ}\text{C} \leq T_j \leq 150^{\circ}\text{C}$
		-0.3	47	V	$-40^{\circ}\text{C} \leq T_j < 0^{\circ}\text{C}$
Buck compensation input voltage	$V_{BUC}$	-0.3	6.8	V	–
Logic supply voltage	$V_{CC}$	-0.3	6.8	V	–
Reset output voltage	$V_{RO}$	-0.3	6.8	V	–
Current reference voltage	$V_R$	-0.3	6.8	V	–
<b>ESD-Protection (Human Body Model; <math>R = 1.5 \text{ k}\Omega</math>; <math>C = 100 \text{ pF}</math>)</b>					
All pins to GND	$V_{HBM}$	-2	2	kV	–
<b>Temperatures</b>					
Junction temperature	$T_j$	-40	150	$^{\circ}\text{C}$	–
Storage temperature	$T_{stg}$	-50	150	$^{\circ}\text{C}$	–

*Note: Stresses above those listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

**Table 3 Operating Range**

Parameter	Symbol	Limit Values		Unit	Remarks
		Min.	Max.		
Supply voltage	$V_S$	-0.3	40	V	–
Supply voltage	$V_S$	5	35	V	$V_S$ increasing
Supply voltage	$V_S$	4.5	36	V	$V_S$ decreasing
Supply voltage	$V_S$	-0.3	4.5	V	Buck-Converter OFF
Buck output voltage	$V_{BUO}$	-0.6	40	V	–
Buck driver supply voltage	$V_{BDS}$	-0.3	48	V	$0^{\circ}\text{C} \leq T_j \leq 150^{\circ}\text{C}$
		-0.3	47	V	$-40^{\circ}\text{C} \leq T_j < 0^{\circ}\text{C}$
Buck compensation input voltage	$V_{BUC}$	0	3.0	V	–
Logic supply voltage	$V_{CC}$	4.0	6.2	V	–
Reset output voltage	$V_{RO}$	-0.3	$V_{CC} + 0.3$	V	–
Current reference voltage	$V_{CREF}$	0	1.23	V	–
Junction temperature	$T_j$	-40	150	$^{\circ}\text{C}$	–
<b>Thermal Resistance</b>					
Junction ambient	$R_{thj-a}$	–	180	K/W	–

**Table 4 Electrical Characteristics**

8 V <  $V_S$  < 35 V; 4.75 V <  $V_{CC}$  < 5.25 V; -40 °C <  $T_j$  < 150 °C;  $R_R = 47$  kΩ; all voltages with respect to ground; positive current defined flowing into the pin; unless otherwise specified

Parameter	Symbol	Limit Values			Unit	Test Condition
		Min.	Typ.	Max.		
<b>Current Consumption</b>						
Current consumption; see <a href="#">Figure 6</a>	$I_S$	–	1.5	4	mA	$I_{CC} = 0$ mA
Current consumption; see <a href="#">Figure 6</a>	$I_S$	–	5	10	mA	$I_{CC} = 400$ mA
<b>Under- and Over-Voltage Lockout at <math>V_S</math></b>						
UV ON voltage; buck conv. ON	$V_{SUVON}$	4.0	4.5	5.0	V	$V_S$ increasing
UV OFF voltage; buck conv. OFF	$V_{SUVOFF}$	3.5	4.0	4.5	V	$V_S$ decreasing
UV Hysteresis voltage	$V_{SUVHY}$	0.2	0.5	1.0	V	HY = ON - OFF
OV OFF voltage; buck conv. OFF	$V_{SOVOFF}$	34	37	40	V	$V_S$ increasing
OV ON voltage; buck conv. ON	$V_{SOVON}$	30	33	36	V	$V_S$ decreasing
OV Hysteresis voltage	$V_{SUVHY}$	1.5	4	10	V	HY = OFF - ON
<b>Over-Voltage Lockout at <math>V_{CC}</math></b>						
OV OFF voltage; buck conv. OFF	$V_{CCOVOFF}$	5.5	6.0	6.5	V	$V_{CC}$ increasing
OV ON voltage; buck conv. ON	$V_{CCOVON}$	5.25	5.75	6.25	V	$V_{CC}$ decreasing
OV Hysteresis voltage	$V_{CCOVHY}$	0.10	0.25	0.50	V	HY = OFF - ON

**Table 4 Electrical Characteristics (cont'd)**

8 V <  $V_S$  < 35 V; 4.75 V <  $V_{CC}$  < 5.25 V; -40 °C <  $T_j$  < 150 °C;  $R_R = 47$  k $\Omega$ ; all voltages with respect to ground; positive current defined flowing into the pin; unless otherwise specified

Parameter	Symbol	Limit Values			Unit	Test Condition
		Min.	Typ.	Max.		
<b>Buck-Converter; BUO, BDS, BUC and <math>V_{CC}</math></b>						
Logic supply voltage	$V_{CC}$	4.9	–	5.1	V	1 mA < $I_{CC}$ < 400 mA; see <b>Figure 6</b>
Efficiency; see <b>Figure 6</b>	$\eta$	–	85	–	%	$I_{CC} = 400$ mA; $V_S = 14$ V
Power-Stage ON resistance	$R_{BUON}$	–	0.38	0.5	$\Omega$	$T_j = 25$ °C; $I_{BUO} = 0.6$ A
Power-Stage ON resistance	$R_{BUON}$	–	–	1.0	$\Omega$	$I_{BUO} = 0.6$ A
Buck overcurrent threshold	$I_{BUOC}$	0.7	0.9	1.2	A	–
Input current on pin $V_{CC}$	$I_{CC}$	–	–	500	$\mu$ A	$V_{CC} = 5$ V
Buck Gate supply voltage; $V_{BGS} = V_S - V_{BDS}$	$V_{BGS}$	5	7.2	10	V	–
<b>Reference Input; R (Oscillator; Timebase for Buck-Converter and Reset)</b>						
Voltage on pin R	$V_R$	–	1.4	–	V	$R_R = 100$ k $\Omega$
Oscillator frequency	$f_{OSC}$	85	95	105	kHz	$T_j = 25$ °C
Oscillator frequency	$f_{OSC}$	75	–	115	kHz	–
Cycle time for reset timing	$t_{CYL}$	–	1	–	ms	$t_{CYL} = 100 / f_{OSC}$

**Table 4 Electrical Characteristics (cont'd)**

8 V <  $V_S$  < 35 V; 4.75 V <  $V_{CC}$  < 5.25 V; -40 °C <  $T_j$  < 150 °C;  $R_R = 47$  kΩ; all voltages with respect to ground; positive current defined flowing into the pin; unless otherwise specified

Parameter	Symbol	Limit Values			Unit	Test Condition
		Min.	Typ.	Max.		
<b>Reset Generator; RO</b>						
Reset threshold; $V_{CC}$ decreasing	$V_{RT}$	4.50	4.65	4.75	V	$V_{RO}$ H to L or L to H transition; $V_{RO}$ remains low down to $V_{CC} > 1$ V
Reset low voltage	$V_{ROL}$	–	0.2	0.4	V	$I_{ROL} = 1$ mA; $2.5$ V < $V_{CC} < V_{RT}$
Reset low voltage	$V_{ROL}$	–	0.2	0.4	V	$I_{ROL} = 0.2$ mA; $1$ V < $V_{CC} < V_{RT}$
Reset high voltage	$V_{ROH}$	$V_{CC} - 0.1$	–	$V_{CC} + 0.1$	V	$I_{ROH} = 0$ mA
Reset pull-up current	$I_{RO}$	–	240	–	μA	$0$ V < $V_{RO} < 4$ V
Reset Reaction time	$t_{RR}$	10	40	90	μs	$V_{CC} < V_{RT}$
Power-up reset delay time	$t_{RD}$	–	128	–	$t_{CYL}$	$V_{CC} \geq 4.8$ V
<b>Thermal Shutdown (Boost and Buck-Converter OFF)</b>						
Thermal shutdown junction temperature	$T_{jSD}$	150	175	200	°C	–
Thermal switch-on junction temperature	$T_{jSO}$	120	–	170	°C	–
Temperature hysteresis	$\Delta T$	–	30	–	K	–



### Circuit Description

Below some important sections of the TLE 6365 are described in more detail.

### Power On Reset

In order to avoid any system failure, a sequence of several conditions has to be passed. In case of  $V_{CC}$  power down ( $V_{CC} < V_{RT}$  for  $t > t_{RR}$ ) a logic LOW signal is generated at the pin RO to reset an external microcontroller. When the level of  $V_{CC}$  reaches the reset threshold  $V_{RT}$ , the signal at RO remains LOW for the Power-up reset delay time  $t_{RD}$  before switching to HIGH. If  $V_{CC}$  drops below the reset threshold  $V_{RT}$  for a time extending the reset reaction time  $t_{RR}$ , the reset circuit is activated and a power down sequence of period  $t_{RD}$  is initiated. The reset reaction time  $t_{RR}$  avoids wrong triggering caused by short “glitches” on the  $V_{CC}$ -line.

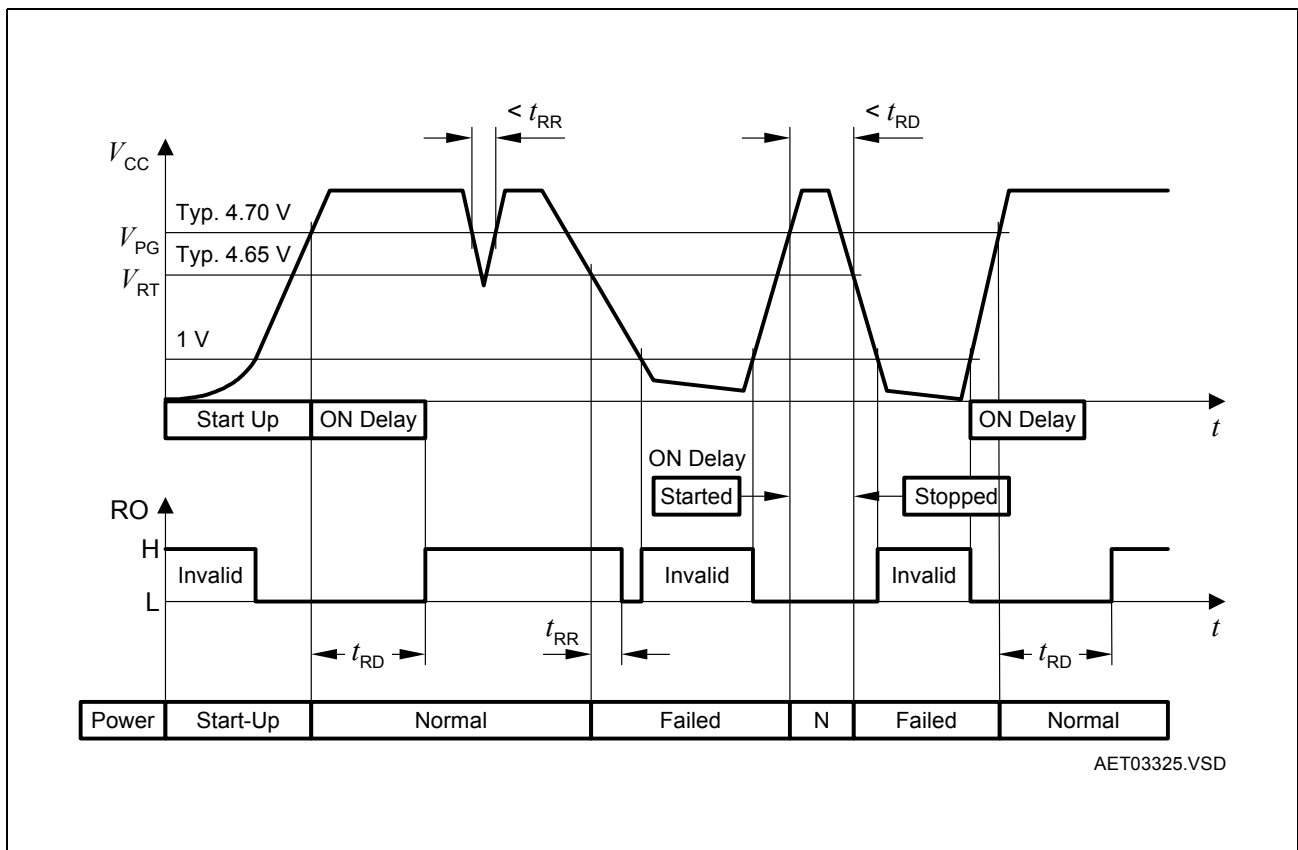


Figure 3 Reset Function

## Buck Converter

A stabilized logic supply voltage (typ. 5 V) for general purpose is realized in the system by a buck converter. An external buck-inductance  $L_{BU}$  is PWM switched by a high side DMOS power transistor with the programmed frequency (pin R).

The buck converter uses the temperature compensated bandgap reference voltage (typ. 2.8 V) for its regulation loop.

This reference voltage is connected to the non-inverting input of the error amplifier and an internal voltage divider supplies the inverting input. Therefore the output voltage  $V_{CC}$  is fixed due to the internal resistor ratio to typ. 5.0 V.

The output of the error amplifier goes to the inverting input of the PWM comparator as well as to the buck compensation output BUC.

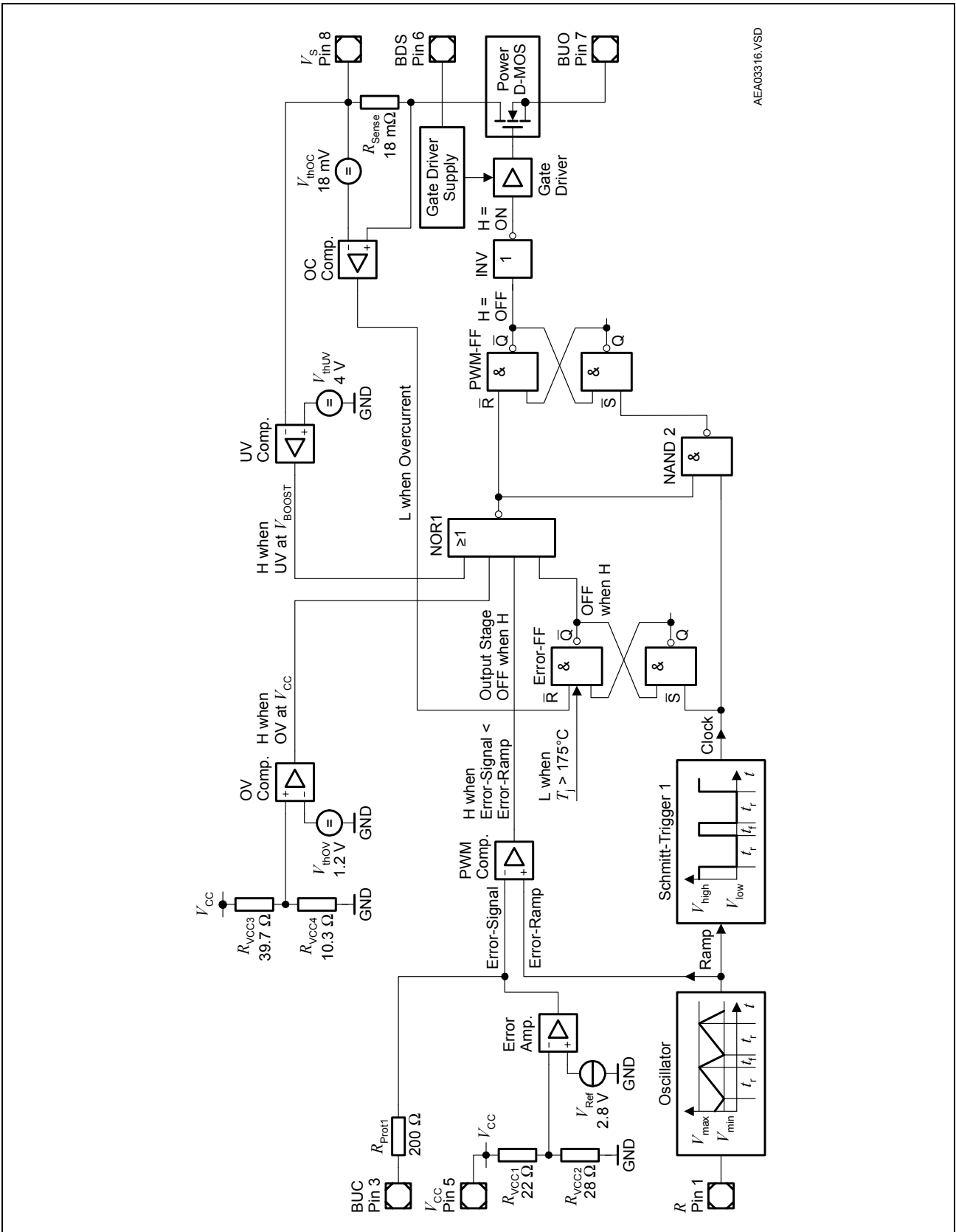
When the error amplifier output voltage exceeds the sawtooth voltage the output power MOS-transistor is switched on. So the duration of the output transistor conduction phase depends on the  $V_{CC}$  level. A logic signal PWM with variable pulse width is generated.

External loop compensation is required for converter stability, and is formed by connecting a compensation resistor-capacitor series-network ( $R_{BUC}$ ,  $C_{BUC}$ ) between pin BUC and GND.

In the case of overload or short-circuit at  $V_{CC}$  (the output current exceeds the buck overcurrent threshold  $I_{BUOC}$ ) the DMOS output transistor is switched off by the overcurrent comparator immediately.

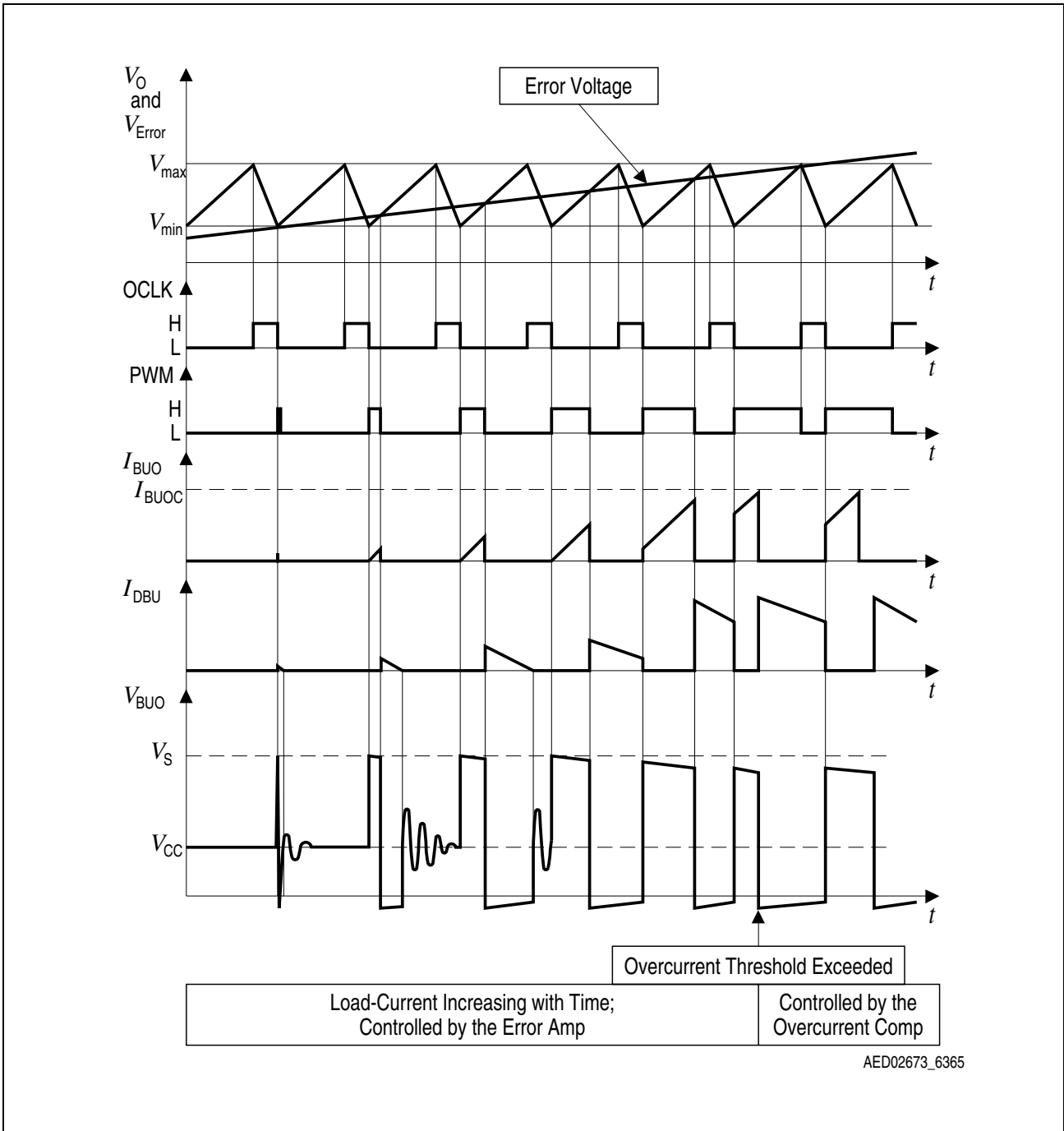
In order to protect the  $V_{CC}$  input as well as the external load against catastrophic failures, an overvoltage protection is provided which switches off the output transistor as soon as the voltage at pin  $V_{CC}$  exceeds the internal fixed overvoltage threshold  $V_{CCOV\ OFF} = \text{typ. } 6.0 \text{ V}$ .

Also a battery undervoltage protection is implemented in the **TLE 6365** to avoid wrong operation of the following supplied devices, the typical threshold when decreasing the battery voltage is at  $V_{SU\ V\ OFF} = \text{typ. } 4.0 \text{ V}$ .



AEA03316.VSD

Figure 4 Buck Converter Block Diagram



**Figure 5 Most Important Waveforms of the Buck Converter Circuit**

Application Circuit

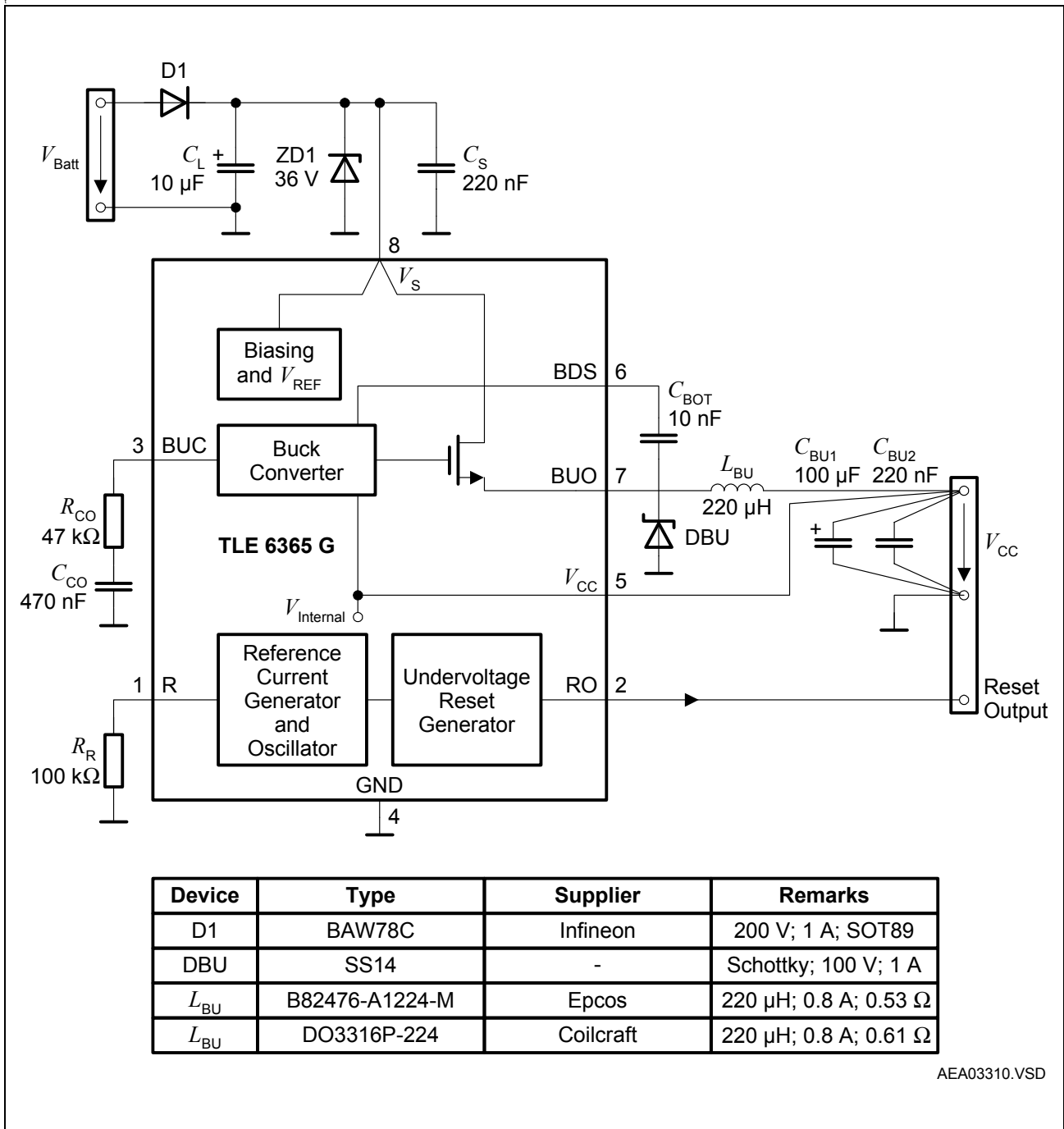
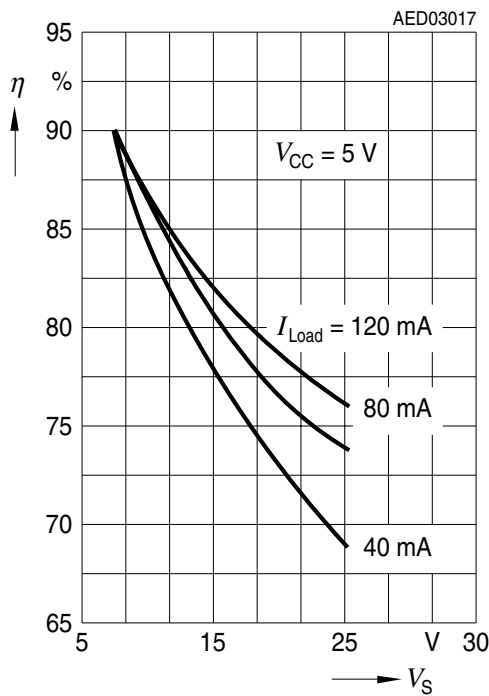


Figure 6 Application Circuit

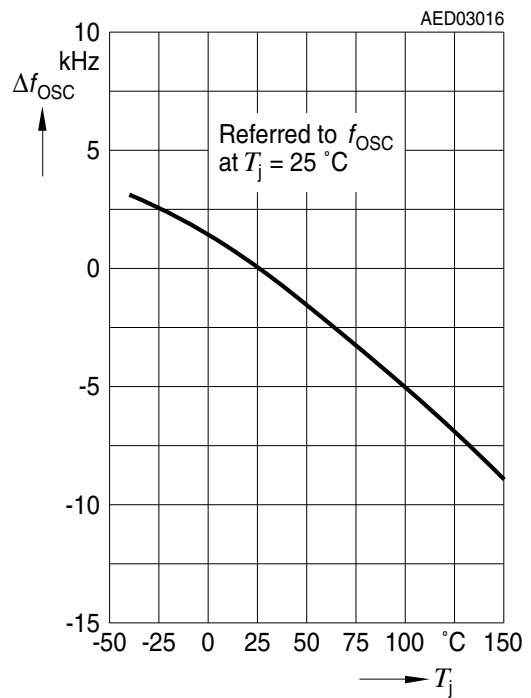
### Diagrams: Oscillator and Boost/Buck-Converter Performance

In the following the behaviour of the Boost/Buck-converter and the oscillator is shown.

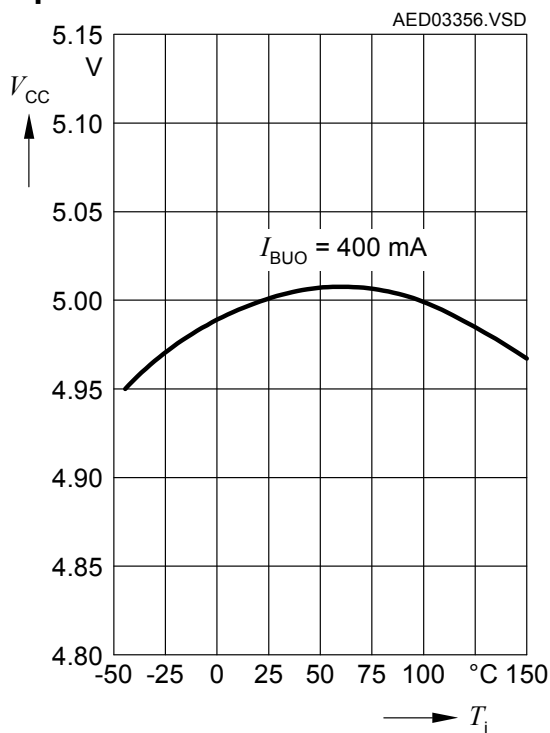
#### Efficiency Buck vs. Boost Voltage



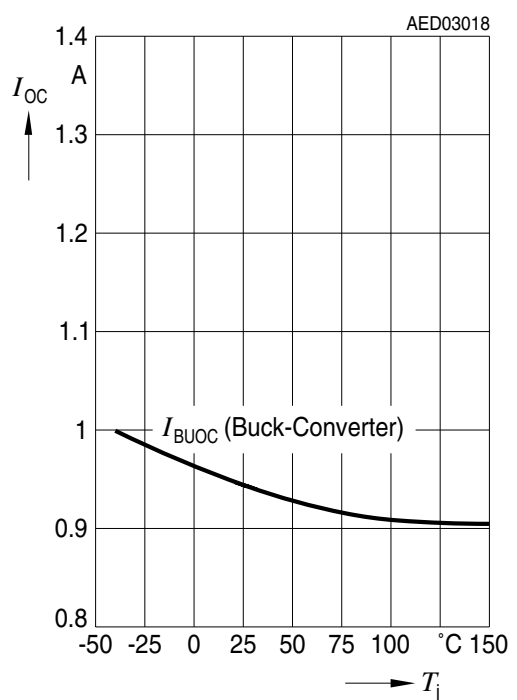
#### Oscillator Frequency Deviation vs. Junction Temperature



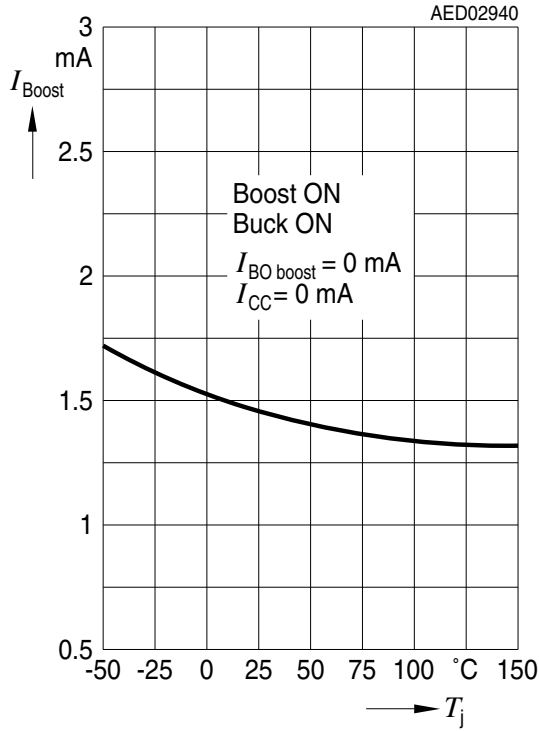
#### Feedback Voltage vs. Junction Temperature



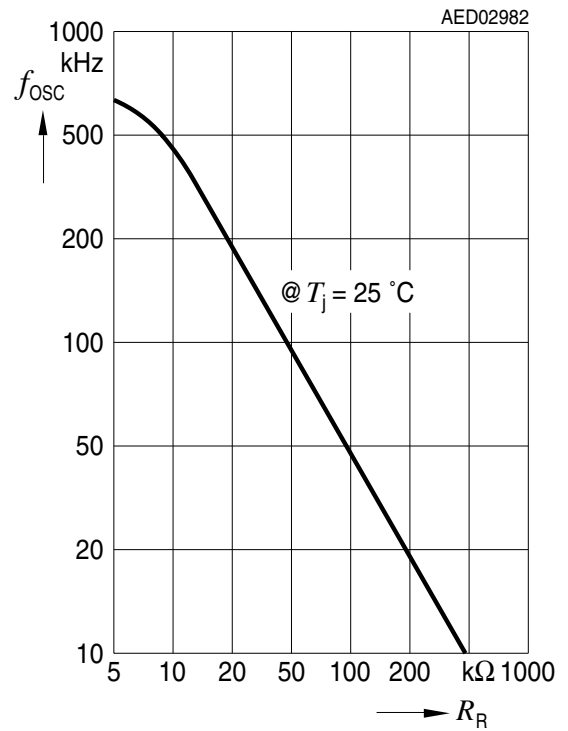
#### Buck Overcurrent Threshold vs. Junction Temperature



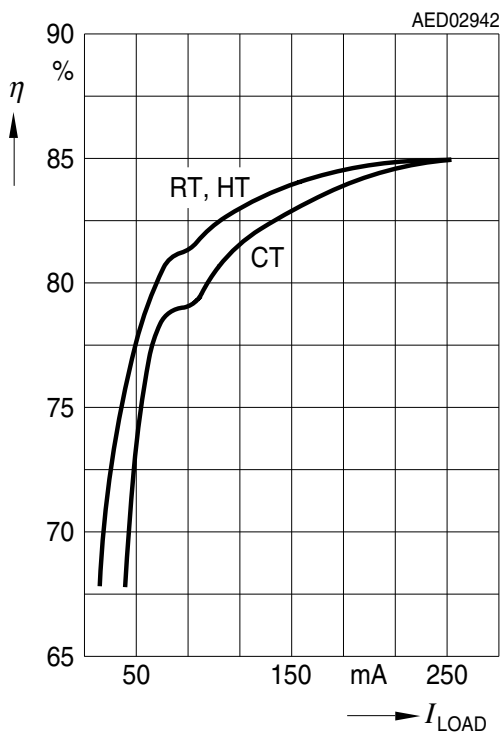
**Current Consumption vs. Junction Temperature**



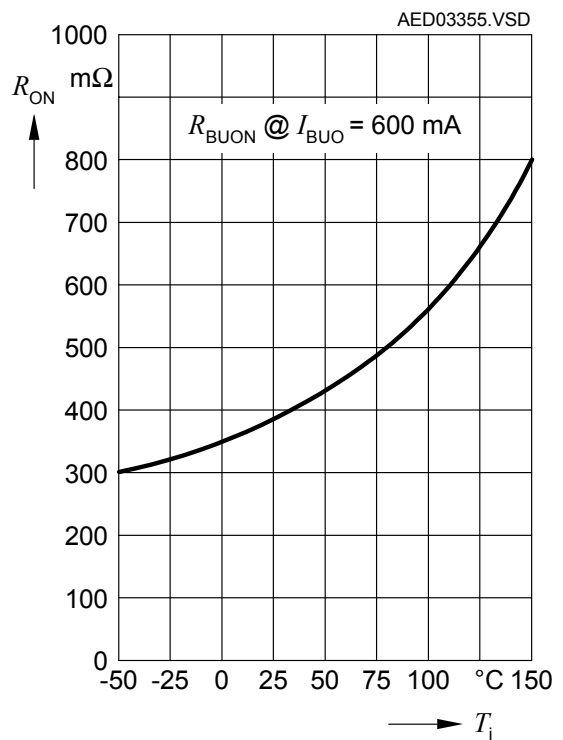
**Oscillator Frequency vs. Resistor between R and GND**



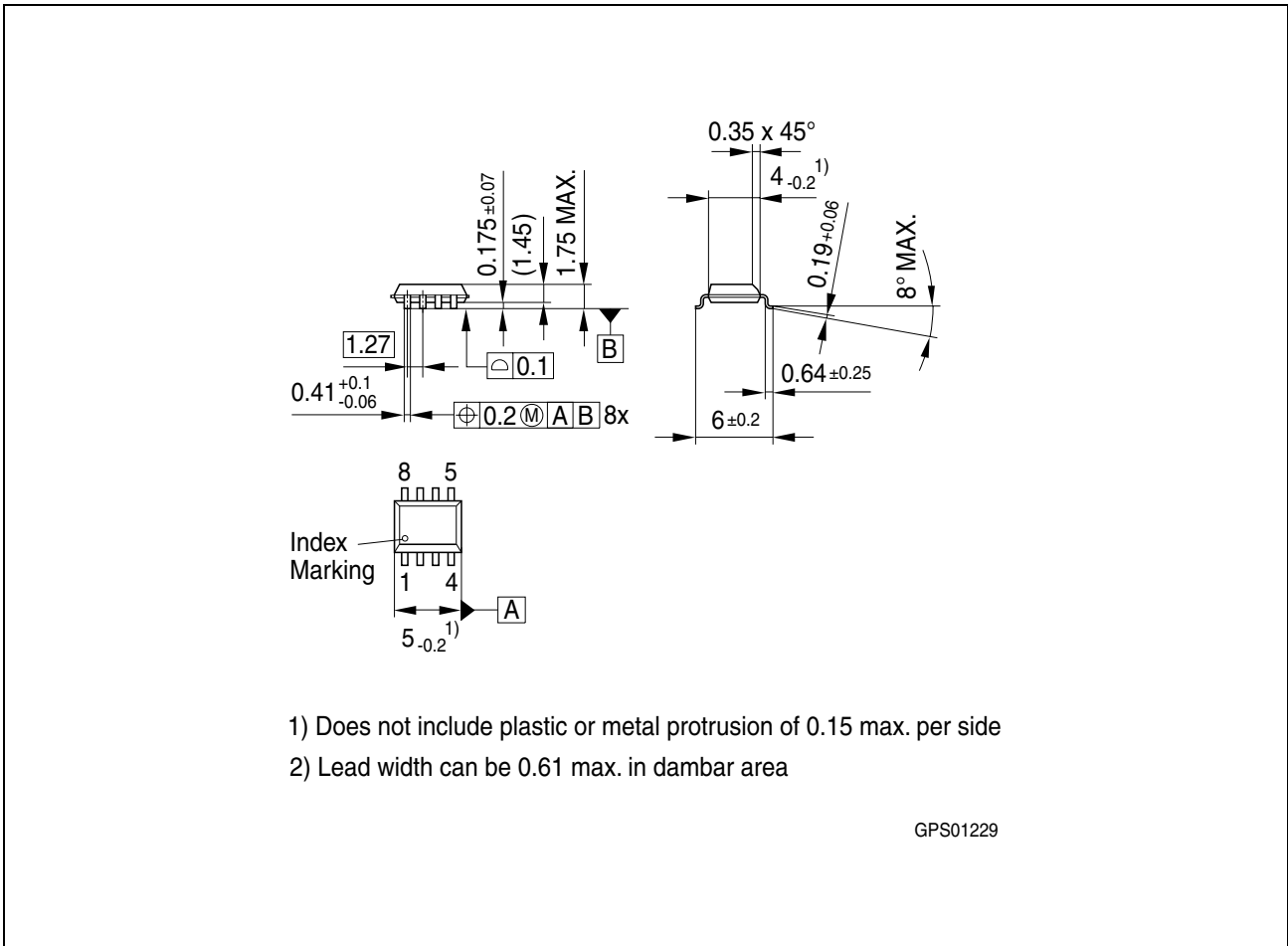
**Efficiency Buck vs. Load**



**Buck ON Resistance vs. Junction Temperature**



### Package Outlines



**Figure 7 PG-DSO-8-16 (Plastic Dual Small Outline)**

### 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).

You can find all of our packages, sorts of packing and others in our Infineon Internet Page "Products": <http://www.infineon.com/products>.

SMD = Surface Mounted Device

Dimensions in mm



## Revision History

Version	Date	Changes
Rev. 1.9	2007-07-30	Initial version of RoHS-compliant derivate of TLE 6365 <b>Page 1</b> : AEC certified statement added <b>Page 1</b> and <b>Page 16</b> :RoHS compliance statement and Green product feature added <b>Page 1</b> and <b>Page 16</b> : Package changed to RoHS compliant version Legal Disclaimer and Infineon Logo updated

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