

# Linear Voltage Regulator 3.3 V Fixed Output Voltage

TLE 4275 V33



## Feature Overview

- Output voltage  $3.3\text{ V} \pm 2\%$
- Current capability 400 mA
- Stable with ceramic output capacitor
- Reset circuit functional without supply voltage present
- Reset output active low down to  $V_Q = 1\text{ V}$
- Reset circuit sensing the output voltage with programmable delay time
- Maximum input voltage  $-42\text{ V} \leq V_I \leq +45\text{ V}$
- ESD Resistivity 4 kV (Human Body Model)
- Reverse polarity protection
- Short circuit protection
- Overtemperature shutdown
- Automotive temperature range  $-40\text{ }^\circ\text{C} \leq T_j \leq 150\text{ }^\circ\text{C}$
- Green Product (RoHS compliant)
- AEC qualified

The TLE 4275 V33 is a monolithic integrated low dropout fixed output voltage regulator for loads up to 400mA. An integrated reset generator with adjustable power-on delay time as well as several protection circuits predestine the IC for supplying microprocessor systems in an automotive environment.

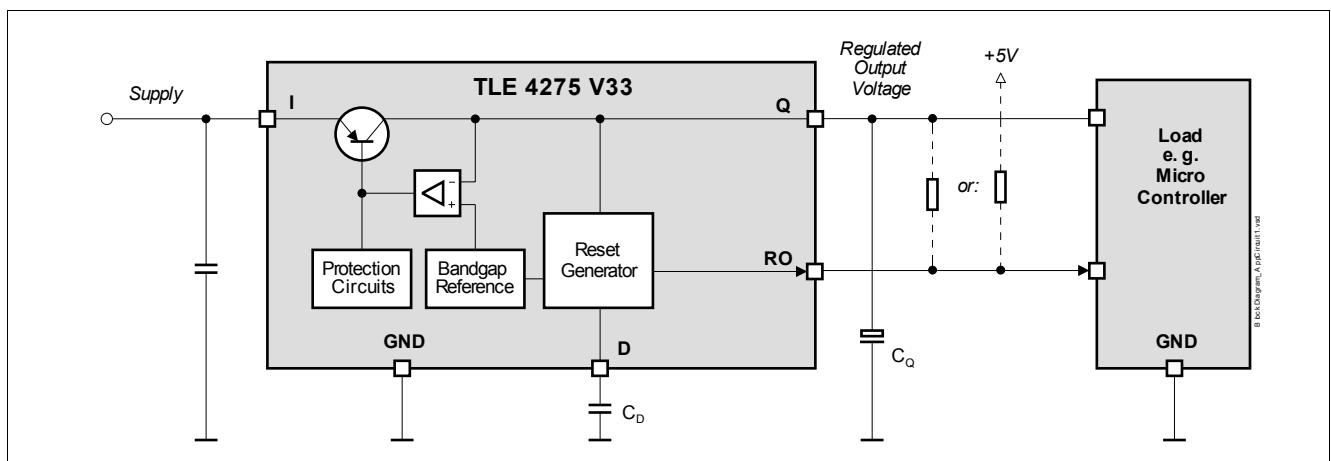
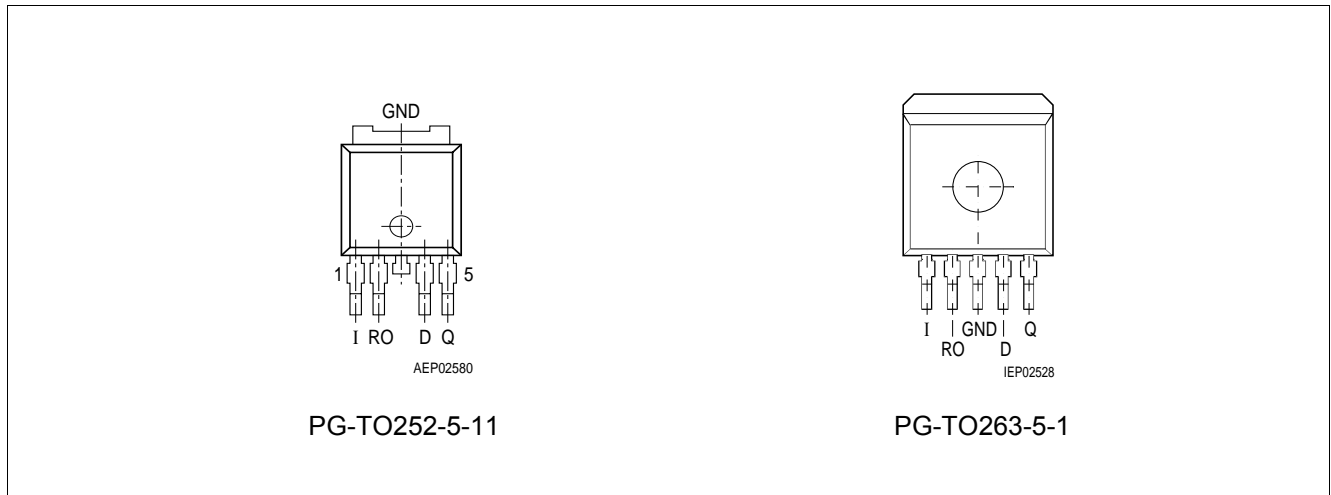


Figure 1 Simplified Block Diagram and Typical Application

Type	Package
TLE 4275 D V33	PG-TO252-5-11 (RoHS compliant)
TLE 4275 G V33	PG-TO263-5-1 (RoHS compliant)

# 1 Pin Definitions and Functions



**Figure 2 Pin Assignment**

Pin	Symbol	Function
1	I	<b>Regulator Input and IC Supply.</b> <ul style="list-style-type: none"> <li>For compensating line influences, a capacitor to GND close to the IC terminals is recommended.</li> </ul>
2	RO	<b>Reset Output.</b> <ul style="list-style-type: none"> <li>Open collector output. External pull-up resistor to a positive voltage rail required.</li> <li>Leave open if the reset function is not needed.</li> </ul>
3	GND	<b>PG-TO263-5-1 only: Ground Reference.</b> <ul style="list-style-type: none"> <li>Connect to TAB and heatsink area</li> </ul>
4	D	<b>Reset Delay Timing.</b> <ul style="list-style-type: none"> <li>Connect a ceramic capacitor to GND for reset delay timing adjustment.</li> <li>Leave open if the reset function is not needed.</li> </ul>
5	Q	<b>Regulator Output.</b> <ul style="list-style-type: none"> <li>Block to GND with a capacitor close to the IC terminals, respecting capacitance and ESR requirements given in the table “Functional Range”.</li> </ul>
TAB	GND	<b>PG-TO252-5-11 only: Ground Reference.</b> <ul style="list-style-type: none"> <li>Connect to heatsink area.</li> </ul>
TAB	–	<b>PG-TO263-5-1 only:</b> <ul style="list-style-type: none"> <li>Connect to heatsink area and ground reference (pin 3).</li> </ul>

## 2 Electrical Characteristics

### 2.1 Absolute Maximum Ratings

$-40\text{ °C} \leq T_j \leq 150\text{ °C}$ ; all voltages with respect to ground (unless otherwise specified)

Pos.	Parameter	Symbol	Limit Values		Unit	Conditions
			Min.	Max.		
<b>Regulator Input and IC Supply I</b>						
2.1.1	Voltage	$V_I$	-42	45	V	–
2.1.2	Current	$I_I$	–	–	mA	internally limited
<b>Regulator Output Q</b>						
2.1.3	Voltage	$V_Q$	-1	16	V	–
2.1.4	Current	$I_Q$	–	–	mA	internally limited
<b>Reset Output RO</b>						
2.1.5	Voltage	$V_{RO}$	-0.3	25	V	–
2.1.6	Current	$I_{RO}$	-5	5	mA	
<b>Reset Delay Timing D</b>						
2.1.7	Voltage	$V_D$	-0.3	7	V	–
2.1.8	Current	$I_D$	-2	2	mA	
<b>Ground GND</b>						
2.1.9	Current	$I_{GND}$	–	–	mA	internally limited
<b>Temperatures</b>						
2.1.10	Junction Temperature	$T_j$	-40	150	°C	–
2.1.11	Storage Temperature	$T_{stg}$	-50	150	°C	–
<b>ESD Susceptibility</b>						
2.1.12	ESD Resistivity	$V_{ESD,HBM}$	-4	4	kV	HBM <sup>1)</sup>
2.1.13		$V_{ESD,CDM}$	-500	500	V	CDM <sup>2)</sup>
<b>Moisture Level</b>						
2.1.14	Moisture Level	$MSL$	3		–	–

1) ESD susceptibility, Human Body Model “HBM” according to EIA/JESD 22-A114B.

2) ESD susceptibility, Charged Device Model “CDM” according to EIA/JESD22-C101 or ESDA STM5.3.1

*Note: 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.*

*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.*

## 2.2 Functional Range

Pos.	Parameter	Symbol	Limit Values		Unit	Conditions / Remarks
			Min.	Max.		
2.2.1	Input Voltage	$V_I$	4.4	42	V	$V_Q = V_I - V_{dr}$ <sup>1)</sup>
2.2.2	Junction Temperature	$T_j$	-40	150	°C	–
2.2.3	Output Capacitor	$C_Q$	22	–	µF	– <sup>2)</sup>
2.2.4		$ESR_{CQ}$	–	3	Ω	–

1) For details on max. output current vs. input voltage see Table 1: Electrical Characteristics Voltage Regulator

2) The minimum output capacitance requirement is applicable for a worst case capacitance tolerance of 30%

*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.*

## 2.3 Thermal Resistance

Pos.	Parameter	Symbol	Typ. Value	Unit	Conditions
<i>Package P-TO252-5:</i>					
2.3.1	Junction – Ambient	$R_{th,j-a}$	144	K/W	Footprint only <sup>1)</sup>
2.3.2	PG-TO252-5-11		78	K/W	300 mm <sup>2</sup> PCB heatsink area <sup>1)</sup>
2.3.3			55	K/W	600 mm <sup>2</sup> PCB heatsink area <sup>1)</sup>
2.3.4	Junction – Case PG-TO252-5-11	$R_{th,j-c}$	1.8	K/W	
<i>Package P-TO263-5:</i>					
2.3.1	Junction – Ambient	$R_{th,j-a}$	79	K/W	Footprint only <sup>1)</sup>
2.3.2	PG-TO263-5-1		53	K/W	300 mm <sup>2</sup> PCB heatsink area <sup>1)</sup>
2.3.3			39	K/W	600 mm <sup>2</sup> PCB heatsink area <sup>1)</sup>
2.3.4	Junction – Case PG-TO263-5-1	$R_{th,j-c}$	1.3	K/W	

1) EIA/JESD 52\_2, FR4, 80 × 80 × 1.5 mm; 35µ Cu, 5µ Sn; horizontal position; zero airflow.  
Not subject to production test; specified by design.

### 3 Block Description and Electrical Characteristics

#### 3.1 Voltage Regulator

The output voltage  $V_Q$  is controlled by comparing a portion of it to an internal reference and driving a PNP pass transistor accordingly. The control loop stability depends on the output capacitor  $C_Q$ , the load current, the chip temperature and the poles/zeros introduced by the integrated circuit. To ensure stable operation, the output capacitor's capacitance and its equivalent series resistor ESR requirements given in the table "Operating Range" have to be maintained. For details see also the typical performance graph "Output Capacitor Series Resistor  $ESR_{C_Q}$  vs. Output Current  $I_Q$ ". Also, the output capacitor shall be sized to buffer load transients.

An input capacitor  $C_I$  is strongly recommended to buffer line influences. Connect the capacitors close to the IC terminals.

Protection circuitry prevent the IC as well as the application from destruction in case of catastrophic events. These safeguards contain output current limitation, reverse polarity protection as well as thermal shutdown in case of overtemperature.

In order to avoid excessive power dissipation that could never be handled by the pass element and the package, the maximum output current is decreased at input voltages above  $V_I = 22\text{ V}$ .

The thermal shutdown circuit prevents the IC from immediate destruction under fault conditions (e.g. output continuously short-circuited) by switching off the power stage. After the chip has cooled down, the regulator restarts. This leads to an oscillatory behaviour of the output voltage until the fault is removed. However, junction temperatures above  $150\text{ }^\circ\text{C}$  are outside the maximum ratings and therefore significantly reduce the IC lifetime.

The TLE 4275 V33 allows a negative supply voltage. However, several small currents are flowing into the IC increasing its junction temperature. This has to be considered for the thermal design, respecting that the thermal protection circuit is not operating during reverse polarity conditions For details see typical performance graphs.

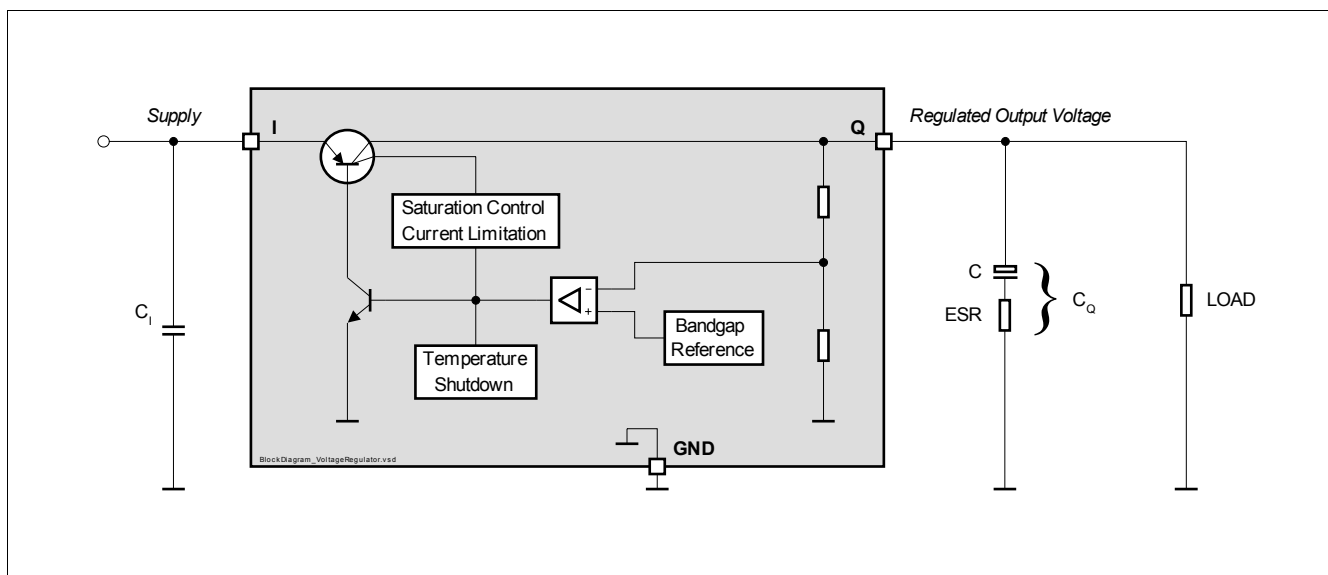


Figure 3 Block Diagram Voltage Regulator Circuit

**Table 1 Electrical Characteristics Voltage Regulator**
 $V_I = 13.5 \text{ V}; -40 \text{ }^\circ\text{C} \leq T_j \leq 150 \text{ }^\circ\text{C}$  (unless otherwise specified)

Pos.	Parameter	Symbol	Limit Values			Unit	Remark / Test Condition
			Min.	Typ.	Max.		
3.1.1	Output Voltage	$V_Q$	3.23	3.3	3.37	V	$1 \text{ mA} \leq I_Q \leq 400 \text{ mA};$ $5 \text{ V} \leq V_I \leq 28 \text{ V}$
3.1.1			3.23	3.3	3.37	V	$1 \text{ mA} \leq I_Q \leq 300 \text{ mA};$ $4.4 \text{ V} \leq V_I \leq 28 \text{ V}$
3.1.2			3.23	3.3	3.37	V	$1 \text{ mA} \leq I_Q \leq 200 \text{ mA};$ $4.4 \text{ V} \leq V_I \leq 40 \text{ V}$
3.1.3	Load Regulation steady-state	$dV_{Q,\text{load}}$	-30	-15	–	mV	$I_Q = 5 \text{ mA to } 400 \text{ mA};$ $V_I = 6 \text{ V}$
3.1.4	Line Regulation steady-state	$dV_{Q,\text{line}}$	–	5	15	mV	$V_I = 8 \text{ V to } 32 \text{ V};$ $I_Q = 5 \text{ mA}$
3.1.5	Power Supply Ripple Rejection	$PSRR$	–	60	–	dB	$f_{\text{ripple}} = 100 \text{ Hz};$ $V_{\text{ripple}} = 0.5 \text{ Vpp}$ <sup>1)</sup>
3.1.6	Output Current Limitation	$I_{Q,\text{max}}$	401	–	1000	mA	$V_Q = 3.0 \text{ V}$
3.1.7	Overtemperature Shutdown Threshold	$T_{j,\text{sd}}$	151	–	200	°C	$T_j$ increasing <sup>1)</sup>
3.1.8	Overtemperature Shutdown Threshold Hysteresis	$T_{j,\text{hy}}$	–	25	–	K	

1) Parameter not subject to production test; specified by design.

## 3.2 Current Consumption

**Table 2 Electrical Characteristics Current Consumption**
 $V_I = 13.5 \text{ V}; -40 \text{ }^\circ\text{C} \leq T_j \leq 150 \text{ }^\circ\text{C}$  (unless otherwise specified)

Pos.	Parameter	Symbol	Limit Values			Unit	Conditions
			Min.	Typ.	Max.		
3.2.1	Current Consumption $I_q = I_Q - I_I$	$I_q$	–	180	220	μA	$I_Q = 1 \text{ mA};$ $T_j = 25 \text{ }^\circ\text{C}$
3.2.2			–	180	240	μA	$I_Q = 1 \text{ mA};$ $T_j \leq 85 \text{ }^\circ\text{C}$
3.2.3			–	8	12	mA	$I_Q = 250 \text{ mA}$
3.2.4			–	20	30	mA	$I_Q = 400 \text{ mA}$

### 3.3 Reset Function

The reset function contains several features:

#### *Output Undervoltage Reset:*

An output undervoltage condition is indicated setting the Reset Output "RO" to low. This signal might be used to reset a microcontroller during low supply voltage.

In case the battery voltage is already lower than the buffered output voltage  $V_Q$  of the voltage regulator, the reset circuit is supplied from the output "Q", ensuring a defined reset switching threshold also at  $V_I = 0$  V. The Reset Output "RO" is held "low" down to an output voltage of  $V_Q = 1$  V, even if the input voltage  $V_I$  is 0 V.

#### *Power-On Reset Delay Time:*

The power-on reset delay time  $t_{d,PWR-ON}$  allows a microcontroller and oscillator to start up. This delay time is the time period from exceeding the reset switching threshold  $V_{RT}$  until the reset is released by switching the reset output "RO" from "low" to "high". The power-on reset delay time  $t_{d,PWR-ON}$  is defined by an external delay capacitor  $C_D$  connected to pin "D" which is charged up by the delay capacitor charge current  $I_{D,ch}$  starting from  $V_D = 0$  V.

For easy calculating the power-on reset delay time, a multiplier factor  $F_{d,PWR-ON} = t_{d,PWR-ON} / C_D$  is specified. Hence,  $t_{d,PWR-ON}$  becomes:

$$t_{d,PWR-ON} = F_{d,PWR-ON} / C_D \quad (1)$$

For a precise calculation consider also the delay capacitor's tolerance.

#### *Undervoltage Reset Delay Time:*

Unlike the power-on reset delay time, the undervoltage reset delay  $t_d$  time considers a short output undervoltage event where the delay capacitor  $C_D$  is assumed to be discharged to  $V_D = V_{DST,lo}$  only before the charging sequence restarts. Therefore, the undervoltage reset delay time  $t_d$  is defined by the delay capacitor charge current  $I_{D,ch}$  starting from  $V_D = V_{DST,lo}$  and the external delay capacitor  $C_D$ .

For easy calculating the undervoltage reset delay time, a multiplier factor  $F_d = t_d / C_D$  is specified. Hence,  $t_d$  becomes:

$$t_d = F_d / C_D \quad (2)$$

For a precise calculation consider also the delay capacitor's tolerance.

#### *Reset Reaction Time:*

The total reset reaction time  $t_{rr,total}$  considers the internal reaction time  $t_{rr,int}$  and the discharge time  $t_{rr,d}$  defined by the external delay capacitor  $C_D$  (see typical performance graph for details). Hence, the total reset reaction time becomes:

$$t_{rr,total} = t_{rr,int} + t_{rr,d} \quad (3)$$

#### *Reset Output "RO" Low for $V_Q \geq 1$ V:*

In case of an undervoltage reset condition reset output "RO" is held "low" for  $V_Q \geq 1$  V, even if the input voltage  $V_I$  is 0 V. This is achieved by supplying the reset circuit from the output capacitor.

Block Description and Electrical Characteristics

Reset Output "RO":

The Reset Output "RO" is an open collector output requiring an external pull-up resistor to a voltage rail  $V_{IO}$ . As the maximum Reset Output Sink Current  $I_{RO,max}$  is limited, the minimum external pull-up resistor calculates:

$$R_{RO,external,min} = V_{IO} / I_{RO,max} \tag{4}$$

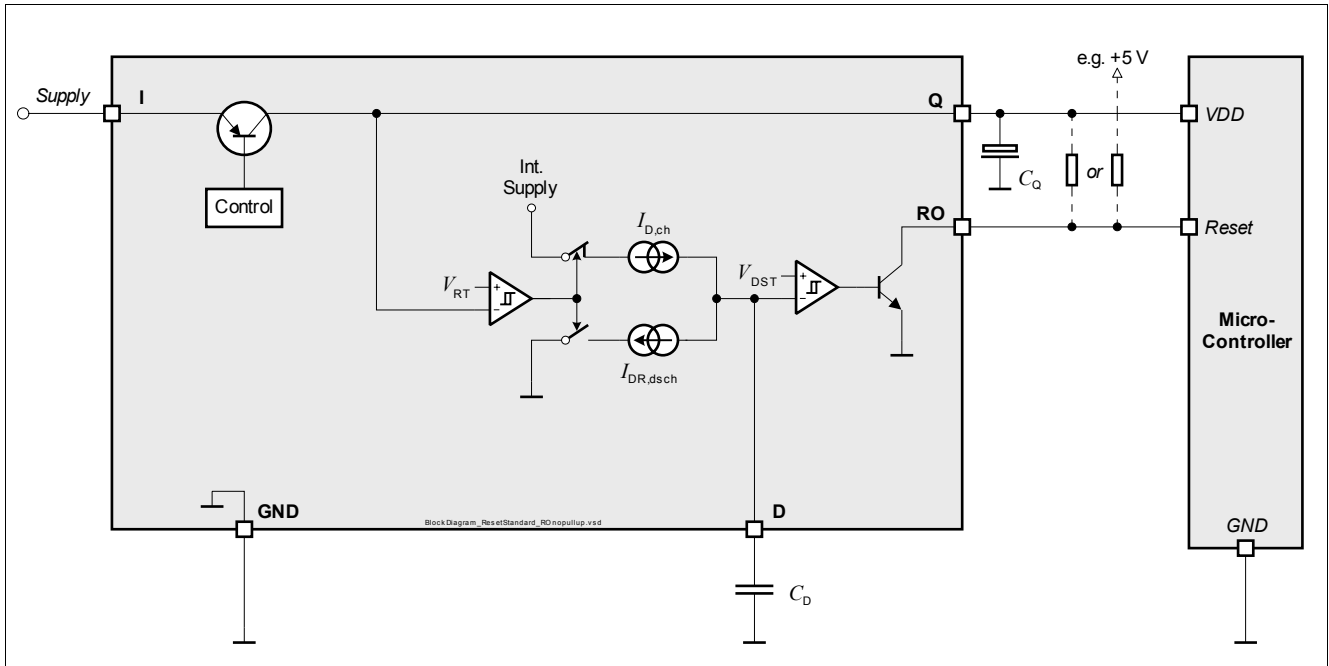


Figure 4 Block Diagram Reset Circuit

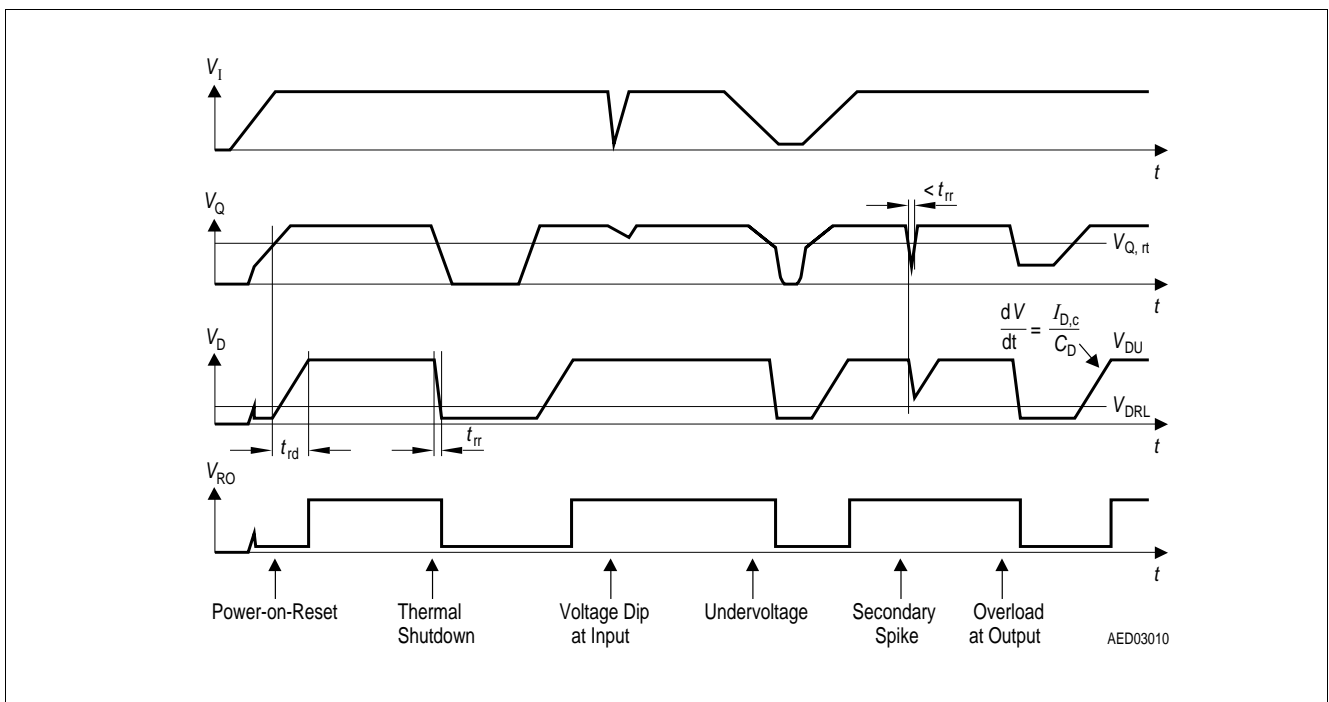


Figure 5 Timing Diagram Reset



**Table 3 Electrical Characteristics Reset Function**
 $V_I = 13.5 \text{ V}; -40 \text{ }^\circ\text{C} \leq T_j \leq 150 \text{ }^\circ\text{C}$  (unless otherwise specified)

Pos.	Parameter	Symbol	Limit Values			Unit	Conditions
			Min.	Typ.	Max.		
Pos.	Parameter	Symbol	Limit Values			Unit	Conditions / Remarks
			Min.	Typ.	Max.		
<i>Output Undervoltage Reset Comperator:</i>							
3.3.1	Output Undervoltage Reset Switching Threshold	$V_{RT1}$	3.06	3.13	3.2	V	$V_I \geq 4.4 \text{ V}$ $V_Q$ decreasing
3.3.2		$V_{RT2}$	2.5	2.9	$V_{RT1}$	V	$V_I = 0 \text{ V}$ $V_Q$ decreasing
3.3.3	Output Undervoltage Reset Headroom	$V_{RH}$	100	130	–	mV	Calculated Value: $V_{Q,nom} - V_{RT} \cdot V_I \geq 4.4 \text{ V}$
<i>Reset Output RO:</i>							
3.3.4	Reset Output Low Voltage	$V_{RO,low}$	–	0.2	0.4	V	$1 \text{ V} \leq V_Q \leq V_{RT}$ ; $I_{RO} = 0.3 \text{ mA}$
3.3.5	Reset Output Sink Current Limitation	$I_{RO,max}$	0.3	–	–	mA	$1 \text{ V} \leq V_Q < V_{RT}$ ; $V_{RO} = 3.3 \text{ V}$
3.3.6	Reset Output External Pull-up Resistor to $V_Q$	$R_{RO}$	3.3	–	–	k $\Omega$	$V_{RO} \leq 0.4 \text{ V}$ at reset condition
3.3.7	Reset Output Leakage Current	$I_{RO,leak}$	–	0	2	$\mu\text{A}$	$V_{RO} = 5 \text{ V}$
<i>Reset Delay Timing:</i>							
3.3.8	Upper Delay Switching Threshold	$V_{DST,hi}$	–	1.8	–	V	–
3.3.9	Lower Delay Switching Threshold	$V_{DST,lo}$	–	0.6	–	V	–
3.3.10	Delay Capacitor Charge Current	$I_{D,ch}$	–	6	–	$\mu\text{A}$	$V_D = 1 \text{ V}$
3.3.11	Delay Capacitor Reset Discharge Current	$I_{DR,dSCH}$	–	70	–	mA	$V_D = 1 \text{ V}$
3.3.12	Undervoltage Reset Delay Time Factor $F_d = t_d / C_D$	$F_d$	0.13	0.20	0.27	ms / nF	Calculated Value: $F_d = (V_{DST,hi} - V_{DST,lo}) / I_{D,ch}$ $C_D \geq 10 \text{ nF}^{1)}$
3.3.13	Power-on Reset Delay Time Factor $F_{d,PWR-ON} = t_{d,PWR-ON} / C_D$	$F_{d,PWR-ON}$	0.21	0.30	0.39	ms / nF	Calculated Value: $F_d = C_D * V_{DST,hi} / I_{D,ch}$ $C_D \geq 10 \text{ nF}^{1)}$
3.3.14	Delay Capacitor Discharge Time	$t_{rr,d}$	–	0.7	2	$\mu\text{s}$	Calculated Value: $t_{rr,d} = C_D * (V_{DST,hi} - V_{DST,lo}) / I_{D,dSCH}$ $C_D = 47 \text{ nF}$
3.3.15	Internal Reset Reaction Time	$t_{rr,int}$	–	2	6.5	$\mu\text{s}$	$C_D = 0 \text{ nF}^{2)}$

 1) For lower values of  $C_D$ , the accuracy given is not guaranteed; see typ. performance graph for details.

2) Parameter not subject to production test; specified by design.

## 4 Package Outlines

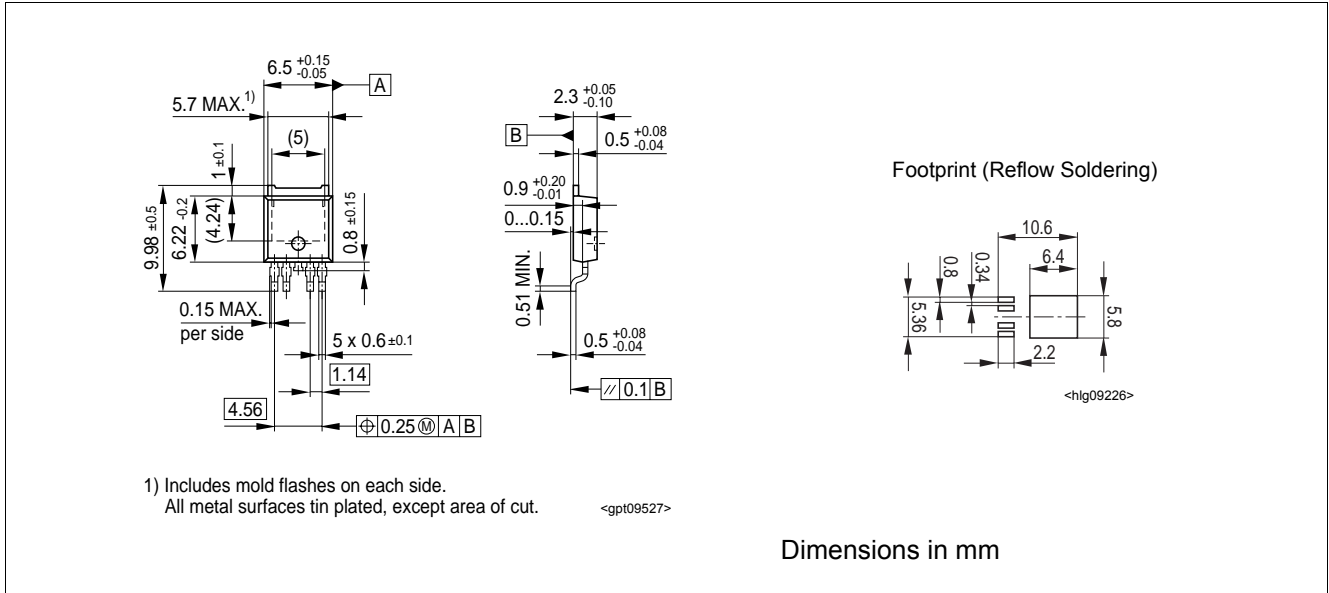


Figure 6 PG-T0252-5-11 Package Outline and Footprint

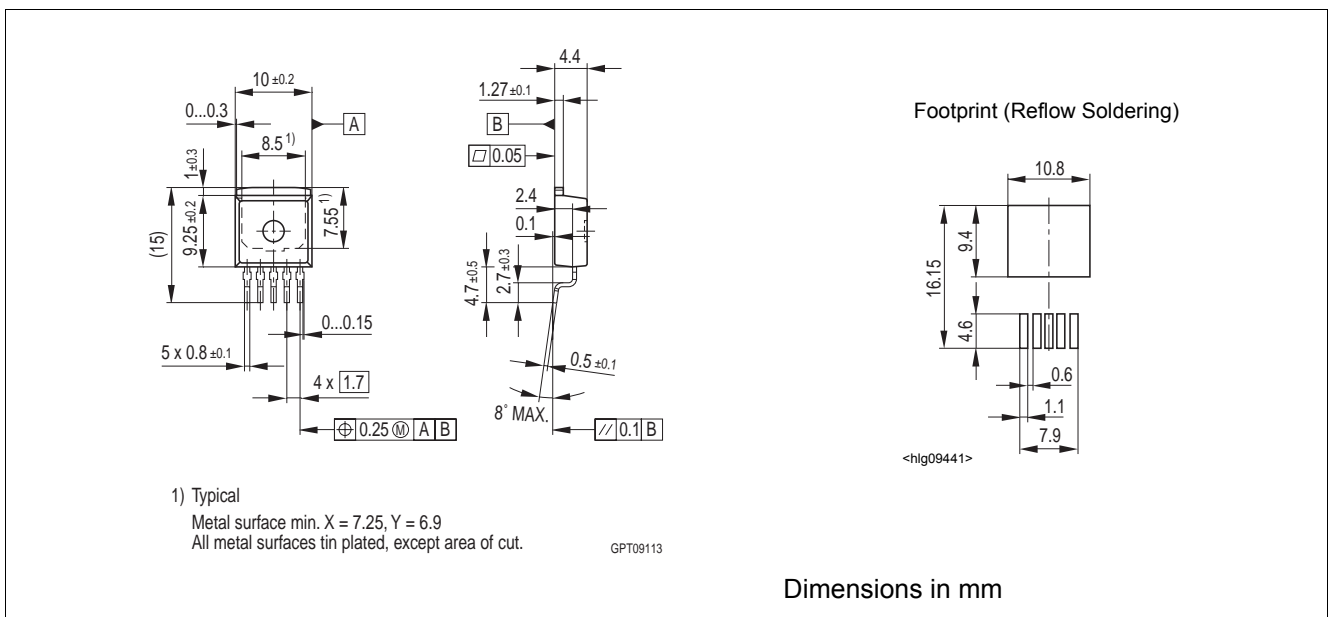


Figure 7 PG-T0263-5-1 Package Outline and Footprint

### 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).

Find more package information on the Infineon Internet Page: <http://www.infineon.com/packages>.

## 5 Revision History

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### TLE 4275 V33

<b>Revision History:</b>	<b>2006-09-22</b>	Rev. 1.0
Previous Version:	n/a	

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