

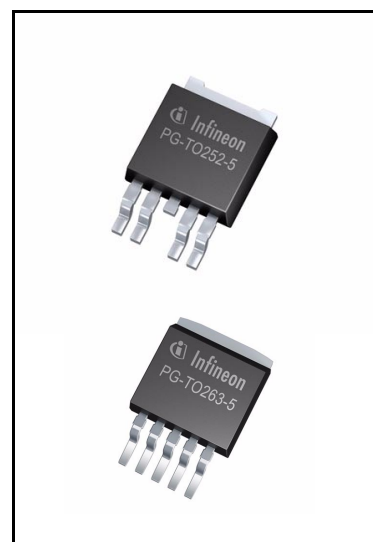
OPTIREG™ linear TLE42754

Low dropout linear voltage regulator



Features

- Output voltage $5\text{ V} \pm 2\%$
- Output current up to 450 mA
- Very low current consumption
- Power-on and undervoltage reset with programmable delay time
- Reset low down to $V_Q = 1\text{ V}$
- Very low dropout voltage
- Output current limitation
- Reverse polarity protection
- Overtemperature protection
- Suitable for use in automotive electronics
- Wide temperature range from -40°C up to 150°C
- Input voltage range from -42 V to 45 V
- Green Product (RoHS-compliant)



Potential applications

General automotive applications.

Product validation

Qualified for automotive applications. Product validation according to AEC-Q100.

Description

The OPTIREG™ linear TLE42754 is a monolithic integrated low-dropout voltage regulator in a 5-pin TO-package, especially designed for automotive applications. An input voltage up to 42 V is regulated to an output voltage of 5.0 V. The component is able to drive loads up to 450 mA. It is short-circuit proof by the implemented current limitation and has an integrated overtemperature shutdown. A reset signal is generated for an output voltage $V_{Q,rt}$ of typically 4.65 V. The power-on reset delay time can be programmed by the external delay capacitor.

Type	Package	Marking
TLE42754D	PG-TO252-5	42754D
TLE42754G	PG-TO263-5	TLE42754

Dimensioning information on external components

An input capacitor C_I is recommended for compensation of line influences. An output capacitor C_O is necessary for the stability of the control loop.

Circuit description

The control amplifier compares a reference voltage to a voltage that is proportional to the output voltage and drives the base of the series transistor via a buffer. Saturation control as a function of the load current prevents any oversaturation of the power element. The component also has a number of internal circuits for protection against:

- Overload
- Overtemperature
- Reverse polarity

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Block diagram

1 Block diagram

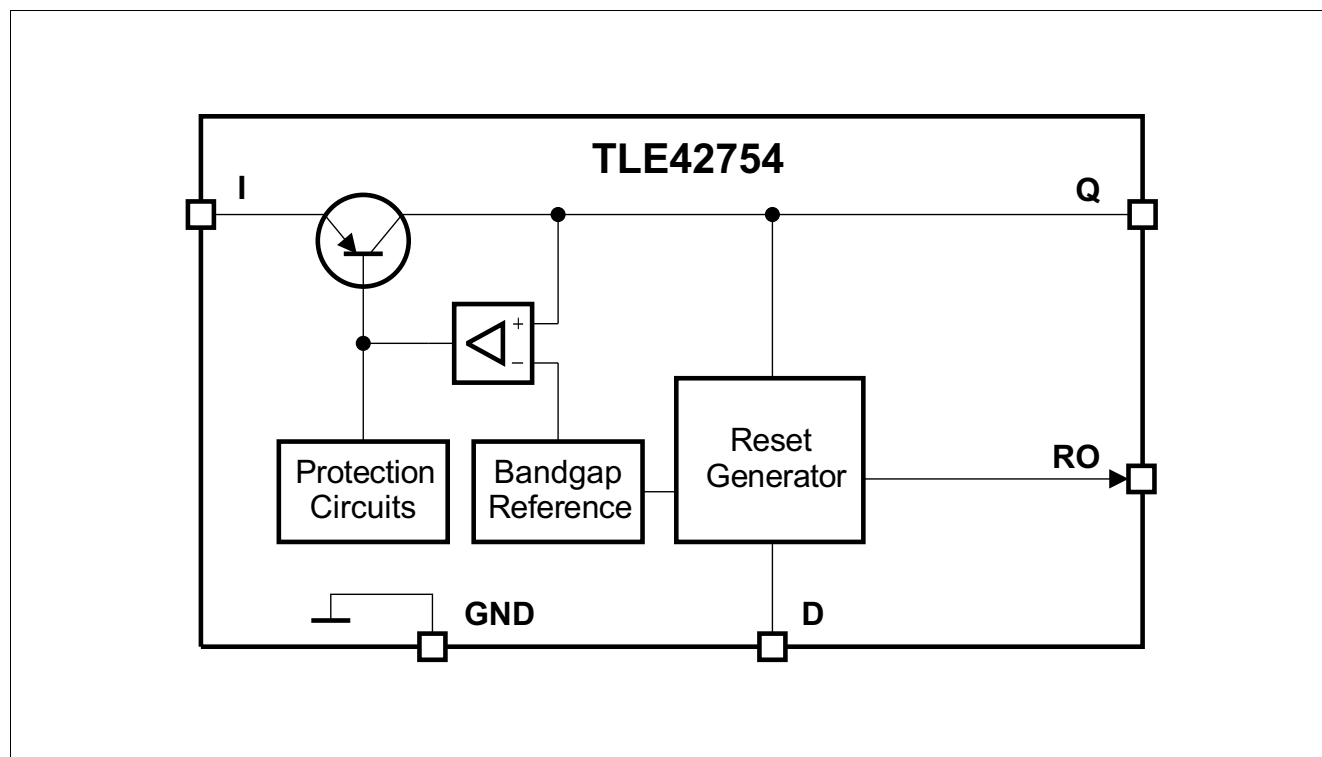


Figure 1 Block diagram

Pin configuration

2 Pin configuration

2.1 Pin assignment TLE42754D (PG-TO252-5) and TLE42754G (PG-TO263-5)

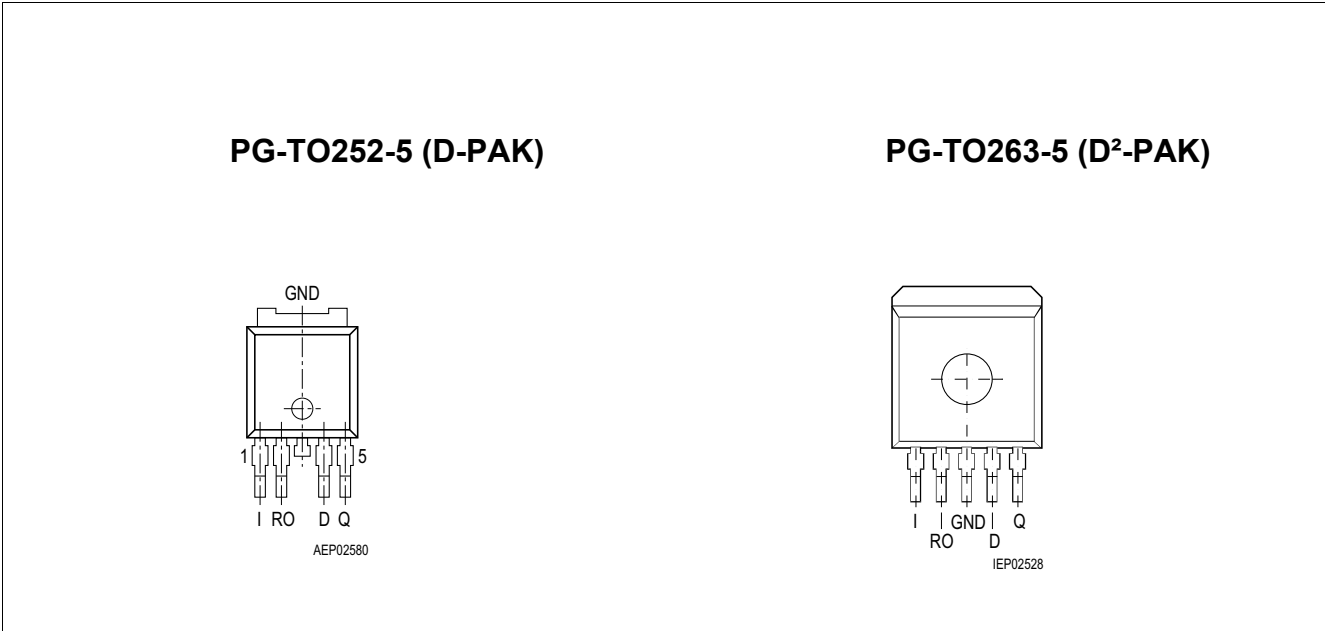


Figure 2 Pin configuration (top view)

2.2 Pin definitions and functions TLE42754D (PG-TO252-5) and TLE42754G (PG-TO263-5)

Table 1 Pin definitions and functions

Pin	Symbol	Function
1	I	Input For compensating line influences, a capacitor to GND close to the IC terminals is recommended.
2	RO	Reset output Open collector output; external pull-up resistor to a positive potential required; leave open if the reset function is not needed.
3	GND	TLE42754G (PG-TO263-5) only: ground Internally connected to tab.
4	D	Reset delay timing Connect a ceramic capacitor to GND for adjusting the reset delay time; leave open if the reset function is not needed.
5	Q	Output Block to GND with a capacitor close to the IC terminals, respecting the values given for its capacitance C_Q and ESR in the table Functional range .
TAB	GND	Ground Connect to heatsink area.

General product characteristics

3 General product characteristics

3.1 Absolute maximum ratings

Table 2 Absolute maximum ratings¹⁾

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

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Input							
Voltage	V_I	-42	–	45	V	–	P_4.1.1
Output							
Voltage	V_Q	-0.3	–	7	V	–	P_4.1.2
Reset output							
Voltage	V_{RO}	-0.3	–	25	V	–	P_4.1.3
Reset delay							
Voltage	V_D	-0.3	–	7	V	–	P_4.1.4
Temperature							
Junction temperature	T_j	-40	–	150	°C	–	P_4.1.5
Storage temperature	T_{stg}	-50	–	150	°C	–	P_4.1.6
ESD absorption							
ESD absorption	$V_{ESD,HBM}$	-2	–	2	kV	²⁾ Human body model (HBM)	P_4.1.7
ESD absorption	$V_{ESD,CDM}$	-500	–	500	V	³⁾ Charge device model (CDM)	P_4.1.8
ESD absorption	$V_{ESD,CDM}$	-750	–	750	V	³⁾ Charge device model (CDM) at corner pins	P_4.1.9

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

2) ESD HBM test according AEC-Q100-002 - JESD22-A114.

3) ESD CDM test according ESDA STM5.3.1.

Notes

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 datasheet. Fault conditions are considered as “outside” normal operating range. Protection functions are not designed for continuous repetitive operation.

General product characteristics

3.2 Functional range

Table 3 Functional range

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Input voltage	V_I	5.5	–	42	V	–	P_4.2.1
Output capacitor's requirements for stability	C_Q	22	–	–	μF	¹⁾	P_4.2.2
Output capacitor's requirements for stability	$ESR(C_Q)$	–	–	3	Ω	²⁾	P_4.2.3
Junction temperature	T_j	-40	–	150	°C	–	P_4.2.4

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

2) Relevant ESR value at $f = 10$ kHz.

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

3.3 Thermal resistance

Table 4 Thermal resistance¹⁾

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
TLE42754D (PG-TO252-5)							
Junction to case	R_{thJC}	–	3.7	–	K/W	–	P_4.3.1
Junction to ambient	R_{thJA}	–	27	–	K/W	²⁾ FR4 2s2p board	P_4.3.2
Junction to ambient	R_{thJA}	–	110	–	K/W	³⁾ FR4 1s0p board, footprint only	P_4.3.3
Junction to ambient	R_{thJA}	–	57	–	K/W	³⁾ FR4 1s0p board, 300 mm ² heatsink area on PCB	P_4.3.4
Junction to ambient	R_{thJA}	–	42	–	K/W	³⁾ FR4 1s0p board, 600 mm ² heatsink area on PCB	P_4.3.5
TLE42754G (PG-TO263-5)							
Junction to case	R_{thJC}	–	3.7	–	K/W	–	P_4.3.6
Junction to ambient	R_{thJA}	–	22	–	K/W	²⁾ FR4 2s2p board	P_4.3.7
Junction to ambient	R_{thJA}	–	70	–	K/W	³⁾ FR4 1s0p board, footprint only	P_4.3.8
Junction to ambient	R_{thJA}	–	42	–	K/W	³⁾ FR4 1s0p board, 300 mm ² heatsink area on PCB	P_4.3.9
Junction to ambient	R_{thJA}	–	33	–	K/W	³⁾ FR4 1s0p board, 600 mm ² heatsink area on PCB	P_4.3.10

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

2) The specified R_{thJA} value is according to JEDEC JESD51-2,-5,-7 at natural convection on FR4 2s2p board. The product (chip and package) was simulated on a 76.2 × 114.3 × 1.5 mm³ board with 2 inner copper layers (2 × 70 μm Cu, 2 × 35 μm Cu). Where applicable a thermal via array under the exposed pad contacted the first inner copper layer.

3) The specified R_{thJA} value is according to JEDEC JESD 51-3 at natural convection on FR4 1s0p board. The product (chip and package) was simulated on a 76.2 × 114.3 × 1.5 mm³ board with 1 copper layer (1 × 70 μm Cu).

4 Block description and electrical characteristics

4.1 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 [Table 3](#) have to be maintained. For details see also the typical performance graph [Output capacitor series resistor ESR\(\$C_Q\$ \) versus output current \$I_Q\$](#) . As the output capacitor also has to buffer load steps it should be sized according to the application's needs.

An input capacitor C_I is strongly recommended to compensate line influences. Connect the capacitors close to the component's terminals.

A protection circuitry prevent the IC as well as the application from destruction in case of catastrophic events. These safeguards contain an output current limitation, a reverse polarity protection as well as a 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 $V_I = 28$ V.

The thermal shutdown circuit prevents the IC from immediate destruction under fault conditions (for example, output continuously short-circuited) by switching off the power stage. After the chip has cooled down, the regulator restarts. This leads to an oscillatory behavior of the output voltage until the fault is removed. However, junction temperatures above 150°C are outside the maximum ratings and therefore significantly reduce the IC's lifetime.

The TLE42754 allows a negative supply voltage. In this fault condition, 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.

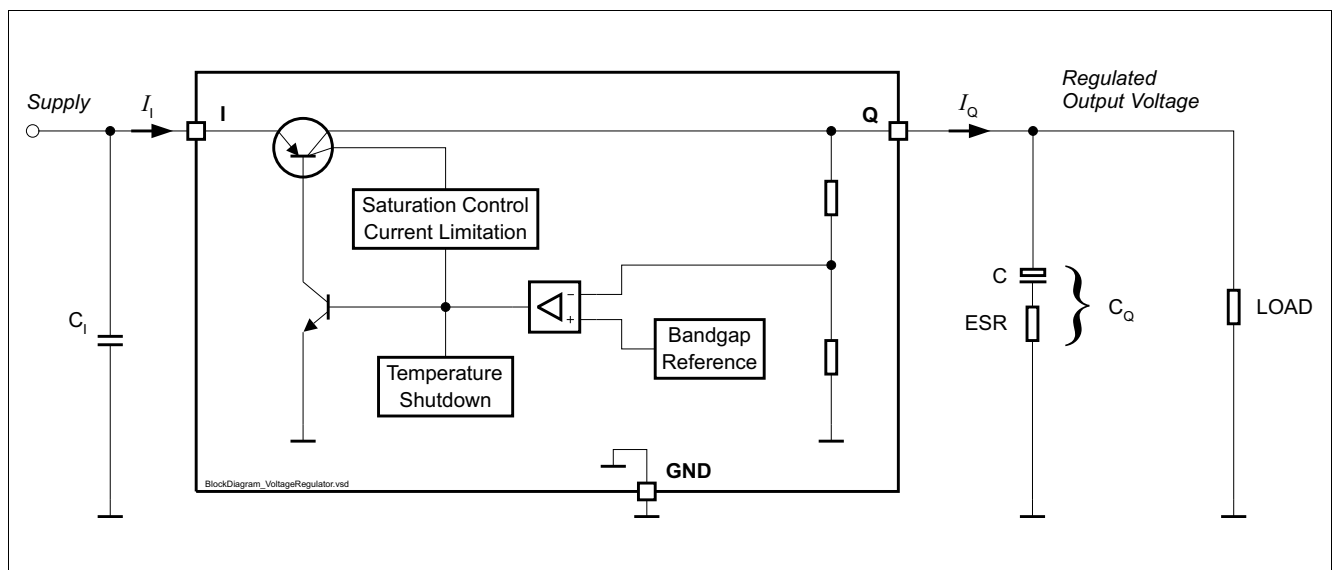


Figure 3 Voltage regulator

Block description and electrical characteristics

Table 5 Electrical characteristics voltage regulator

$V_I = 13.5 \text{ V}$, $T_j = -40^\circ\text{C}$ to 150°C , all voltages with respect to ground, positive current flowing into pin
(unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Output voltage	V_Q	4.9	5.0	5.1	V	$1 \text{ mA} < I_Q < 450 \text{ mA}$ $9 \text{ V} < V_I < 28 \text{ V}$	P_5.1.1
Output voltage	V_Q	4.9	5.0	5.1	V	$1 \text{ mA} < I_Q < 400 \text{ mA}$ $6 \text{ V} < V_I < 28 \text{ V}$	P_5.1.2
Output voltage	V_Q	4.9	5.0	5.1	V	$1 \text{ mA} < I_Q < 200 \text{ mA}$ $6 \text{ V} < V_I < 40 \text{ V}$	P_5.1.3
Output current limitation	$I_{Q,max}$	450	–	1100	mA	$V_Q = 4.8 \text{ V}$	P_5.1.4
Load regulation steady-state	$\Delta V_{Q,load}$	-30	-15	–	mV	$I_Q = 5 \text{ mA}$ to 400 mA $V_I = 8 \text{ V}$	P_5.1.5
Line regulation steady-state	$\Delta V_{Q,line}$	–	5	15	mV	$V_I = 8 \text{ V}$ to 32 V $I_Q = 5 \text{ mA}$	P_5.1.6
Dropout voltage $V_{dr} = V_I - V_Q$	V_{dr}	–	250	500	mV	¹⁾ $I_Q = 300 \text{ mA}$	P_5.1.7
Power supply ripple rejection	$PSRR$	–	60	–	dB	²⁾ $f_{ripple} = 100 \text{ Hz}$ $V_{ripple} = 0.5 \text{ Vpp}$	P_5.1.8
Temperature output voltage drift	$\Delta V_Q / \Delta T$	–	0.5	–	mV/K	–	P_5.1.9
Overtemperature shutdown threshold	$T_{j,sd}$	151	–	200	°C	²⁾ T_j increasing	P_5.1.10
Overtemperature shutdown threshold hysteresis	$T_{j,sdh}$	–	20	–	°C	²⁾ T_j decreasing	P_5.1.11

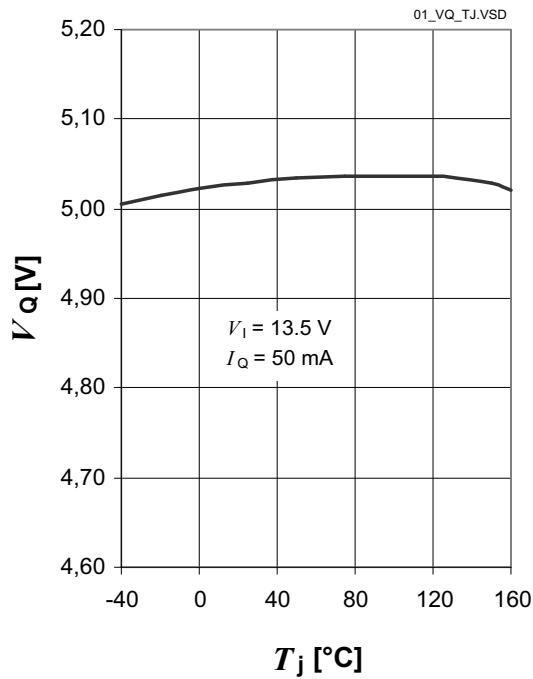
1) Measured when the output voltage V_Q has dropped 100 mV from the nominal value obtained at $V_I = 13.5 \text{ V}$.

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

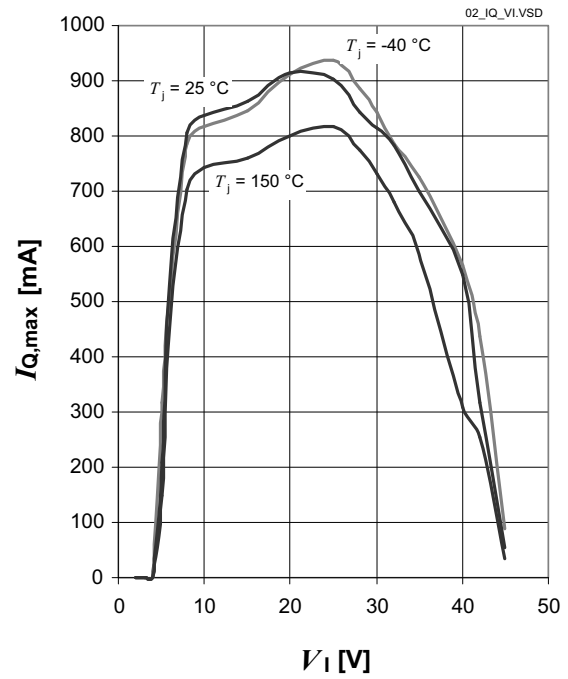
Block description and electrical characteristics

Typical performance characteristics voltage regulator

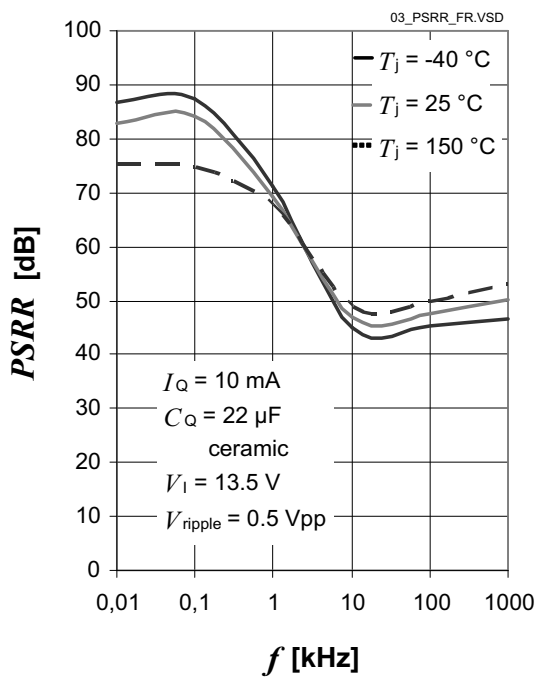
Output voltage V_Q versus junction temperature T_j



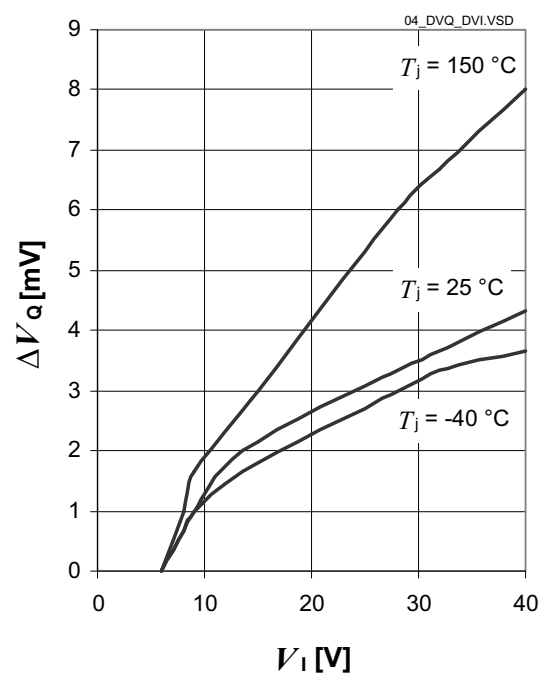
Output current limitation $I_{Q,max}$ versus input voltage V_I



Power supply ripple rejection $PSRR$ versus ripple frequency f_r

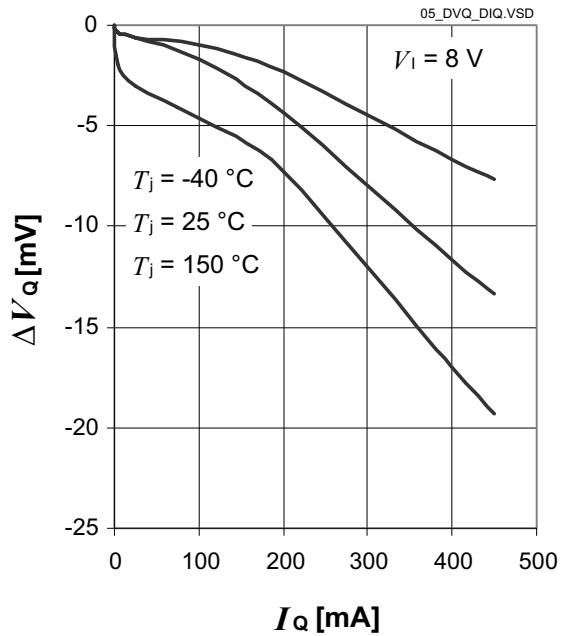


Line regulation $\Delta V_{Q,line}$ versus input voltage change ΔV_I

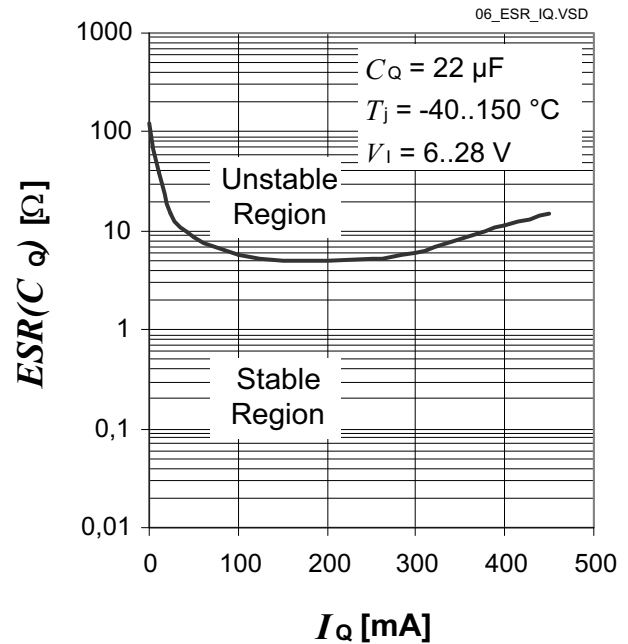


Block description and electrical characteristics

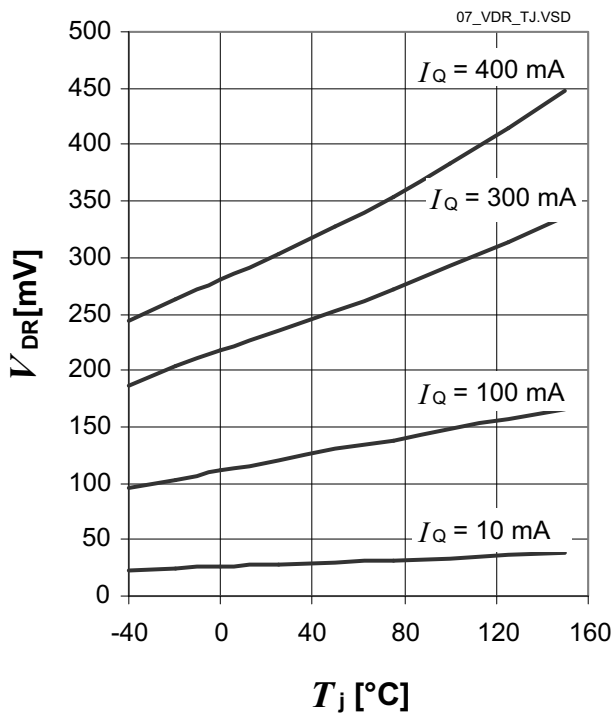
Load regulation $\Delta V_{Q,load}$ versus output current change ΔI_Q



Output capacitor series resistor $ESR(C_Q)$ versus output current I_Q



Dropout voltage V_{dr} versus junction temperature T_j



Block description and electrical characteristics

4.2 Current consumption

Table 6 Electrical characteristics current consumption

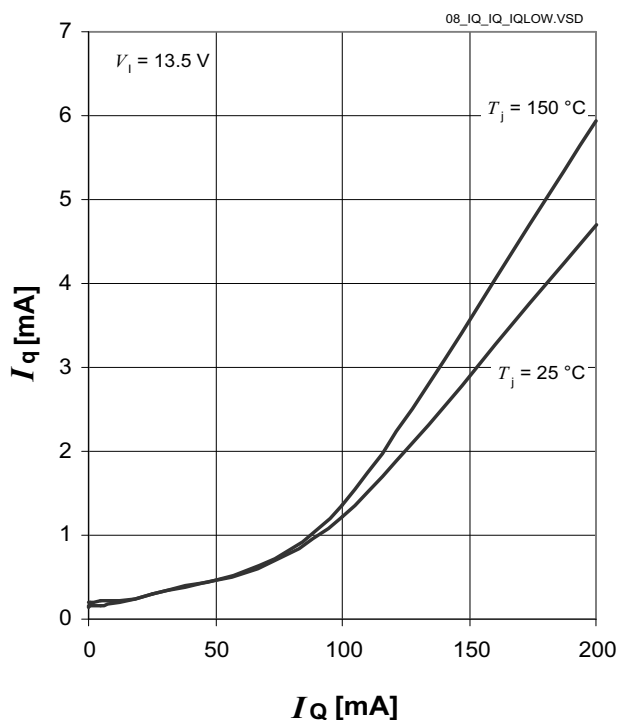
$V_I = 13.5\text{ V}$, $T_j = -40^\circ\text{C}$ to 150°C , positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Current consumption $I_q = I_I - I_Q$	I_q	–	150	200	μA	$I_Q = 1\text{ mA}$ $T_j = 25^\circ\text{C}$	P_5.2.1
Current consumption $I_q = I_I - I_Q$	I_q	–	150	220	μA	$I_Q = 1\text{ mA}$ $T_j = 85^\circ\text{C}$	P_5.2.2
Current consumption $I_q = I_I - I_Q$	I_q	–	5	10	mA	$I_Q = 250\text{ mA}$	P_5.2.3
Current consumption $I_q = I_I - I_Q$	I_q	–	15	25	mA	$I_Q = 400\text{ mA}$	P_5.2.4

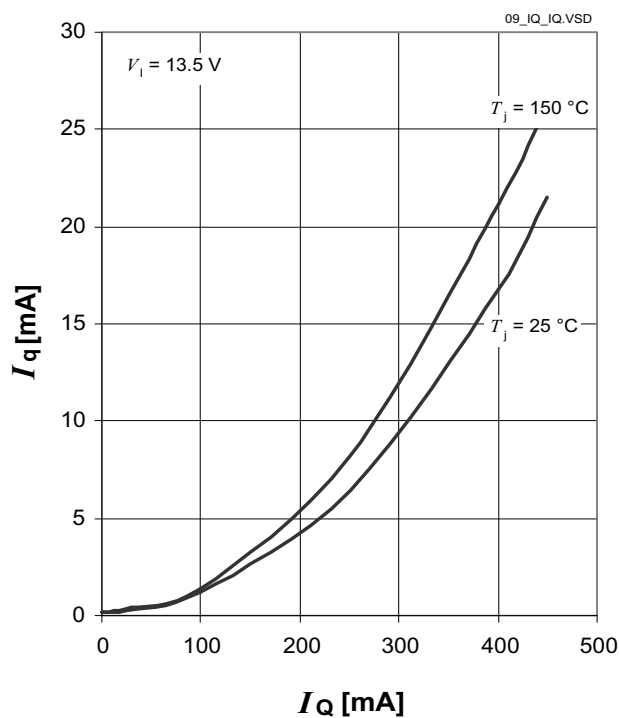
Block description and electrical characteristics

Typical performance characteristics current consumption

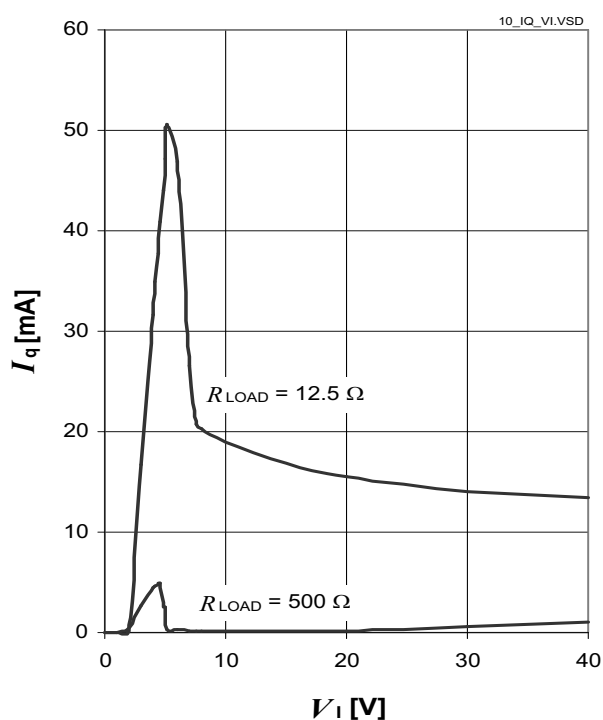
Current consumption I_q versus output current I_Q (I_Q low)



Current consumption I_q versus output current I_Q



Current consumption I_q versus input voltage V_i



Block description and electrical characteristics

4.3 Reset function

The reset function provides several features:

Output undervoltage reset

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

Power-on reset delay time

The power-on reset delay time t_{rd} allows a microcontroller and oscillator to start up. This delay time is the time frame 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_{rd} is defined by an external delay capacitor C_D connected to pin D charged by the delay capacitor charge current $I_{D,ch}$ starting from $V_D = 0$ V.

If the application needs a power-on reset delay time t_{rd} different from the value given in [Reset delay timing](#), the delay capacitor's value can be derived from the specified values for [Power on reset delay time](#) and the desired power-on delay time:

(4.1)

$$C_D = \frac{t_{rd,new}}{t_{rd}} \times 47\text{nF}$$

with

- C_D : capacitance of the delay capacitor to be chosen
- $t_{rd,new}$: desired power-on reset delay time
- t_{rd} : power-on reset delay time specified in this datasheet

For a precise calculation also take the delay capacitor's tolerance into consideration.

Reset reaction time

The reset reaction time avoids that short undervoltage spikes trigger an unwanted reset “low” signal. The reset reaction time t_{rr} 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:

(4.2)

$$t_{rr} = t_{rd,int} + t_{rr,d}$$

with

- t_{rr} : reset reaction time
- $t_{rr,int}$: internal reset reaction time
- $t_{rr,d}$: reset discharge

Block description and electrical characteristics

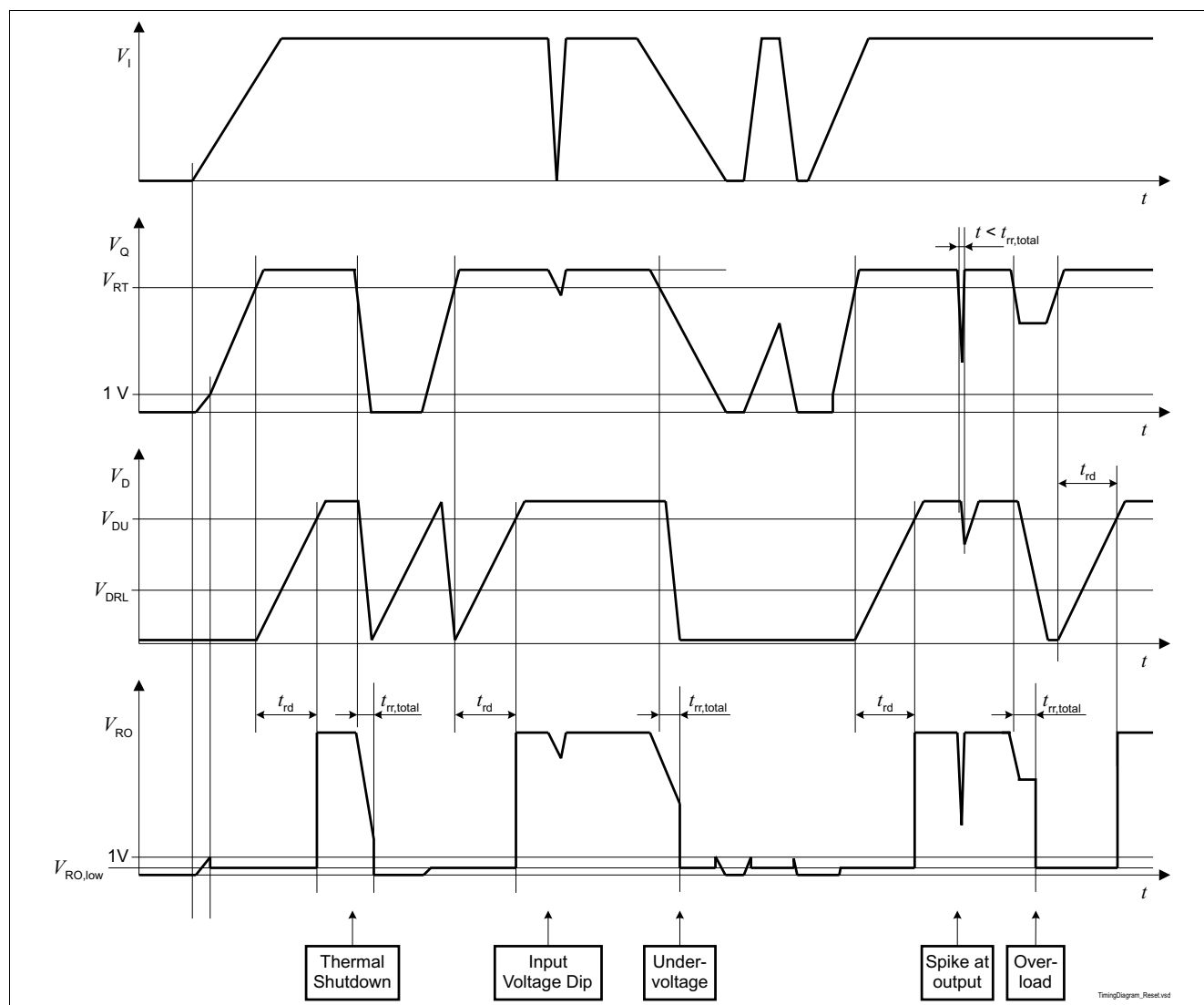


Figure 5 Timing diagram reset

Block description and electrical characteristics

Table 7 Electrical characteristics reset function

$V_I = 13.5 \text{ V}$, $T_j = -40^\circ\text{C}$ to 150°C , all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

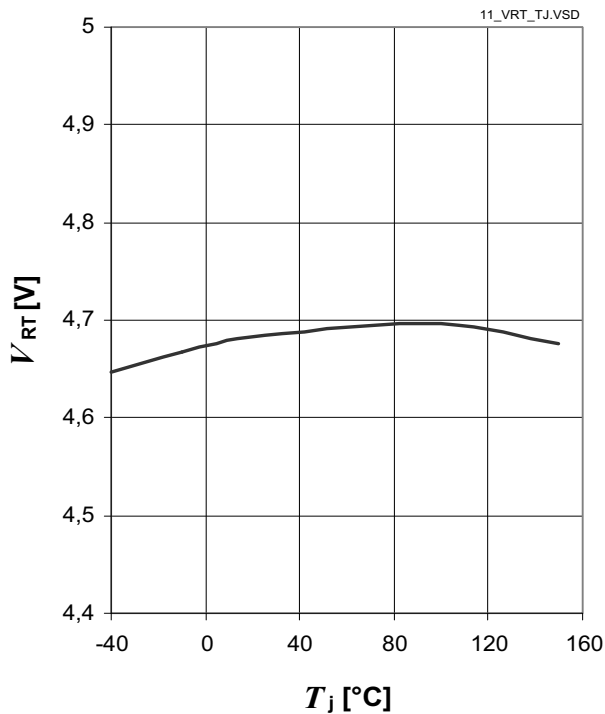
Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Output undervoltage reset							
Output undervoltage reset switching thresholds	V_{RT}	4.5	4.65	4.8	V	V_Q decreasing	P_5.3.1
Reset output RO							
Reset output low voltage	$V_{RO,low}$	–	0.2	0.4	V	$V_Q = 1\text{ V}$ to V_{RT} ; $I_{RO} = 0.2\text{ mA}$	P_5.3.2
Reset output sink current capability	$I_{RO,max}$	0.2	–	–	mA	$V_Q = 1\text{ V}$ to V_{RT} ; $V_{RO} = 5\text{ V}$	P_5.3.3
Reset output leakage current	$I_{RO,leak}$	–	0	10	μA	$V_{RO} = 5\text{ V}$	P_5.3.4
Reset output external pull-up resistor to V_Q	R_{RO}	5	–	–	k Ω	$V_Q = 1\text{ V}$ to V_{RT} ; $V_{RO} \leq 0.4\text{ V}$	P_5.3.5
Reset delay timing							
Power on reset delay time	t_{rd}	10	16	22	ms	$C_D = 47\text{ nF}$	P_5.3.6
Upper delay switching threshold	V_{DU}	–	1.8	–	V	–	P_5.3.7
Lower delay switching threshold	V_{DRL}	–	0.65	–	V	–	P_5.3.8
Delay capacitor charge current	$I_{D,ch}$	–	5.5	–	μA	$V_D = 1\text{ V}$	P_5.3.9
Delay capacitor reset discharge current	$I_{D,dch}$	–	100	–	mA	$V_D = 1\text{ V}$	P_5.3.10
Delay capacitor discharge time	$t_{rr,d}$	–	0.5	1	μs	Calculated value: $t_{rr,d} = C_D \times (V_{DU} - V_{DRL}) / I_{D,dch}$ $C_D = 47\text{ nF}$	P_5.3.11
Internal reset reaction time	$t_{rr,int}$	–	4	7	μs	¹⁾ $C_D = 0\text{ nF}$	P_5.3.12
Reset reaction time	$t_{rr,total}$	–	4.5	8	μs	Calculated value: $t_{rr,total} = t_{rr,int} + t_{rr,d}$ $C_D = 47\text{ nF}$	P_5.3.13

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

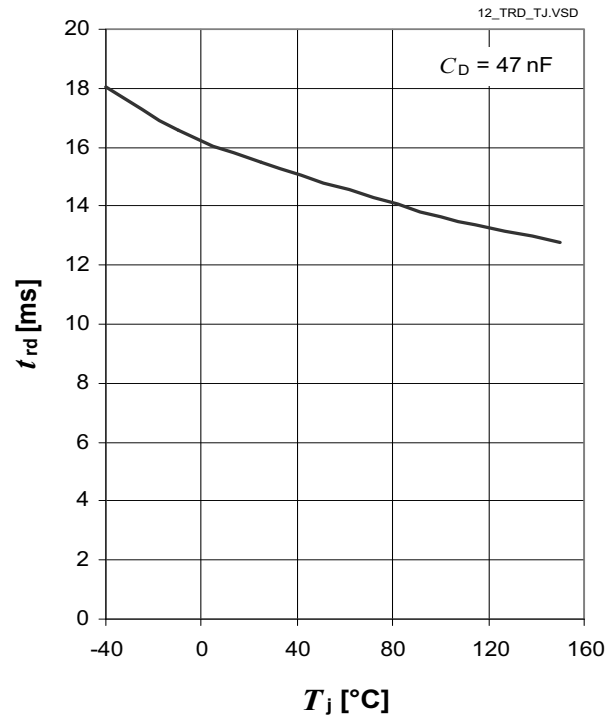
Block description and electrical characteristics

Typical performance characteristics

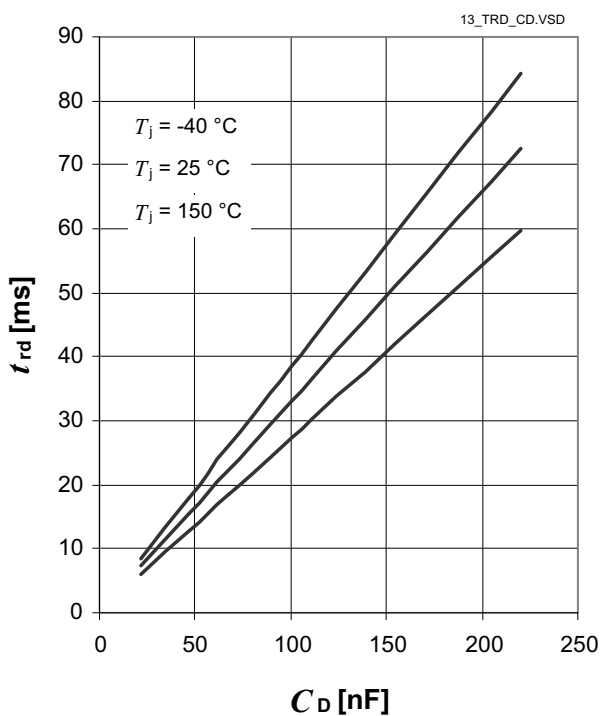
Undervoltage reset switching threshold V_{RT} versus junction temperature T_j



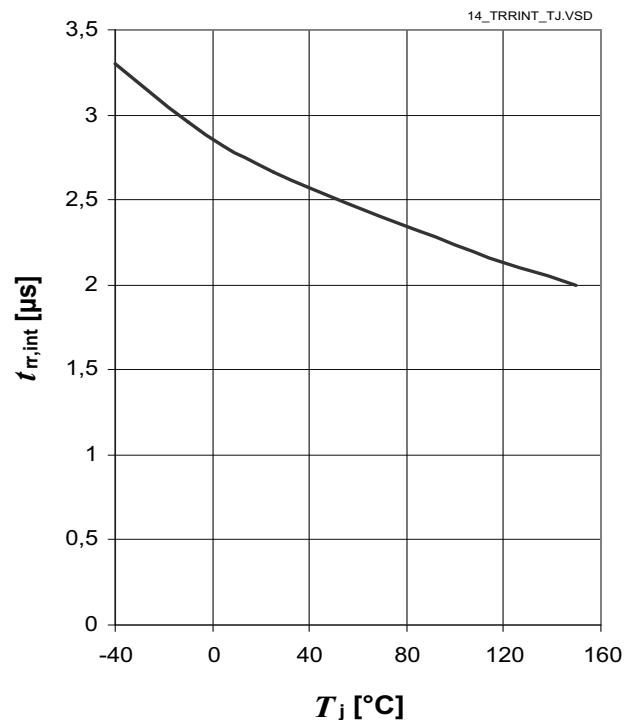
Power on reset delay time t_{rd} versus junction temperature T_j



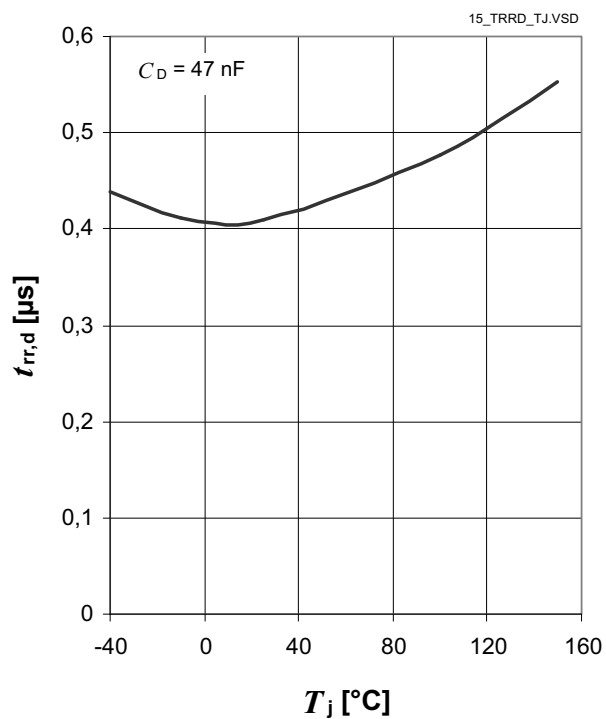
Power on reset delay time t_{rd} versus capacitance C_D



Internal reset reaction time $t_{rr,int}$ versus junction temperature T_j



**Delay capacitor discharge time $t_{rr,d}$ versus
junction temperature T_j**



Application information

5 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.

5.1 Application diagram

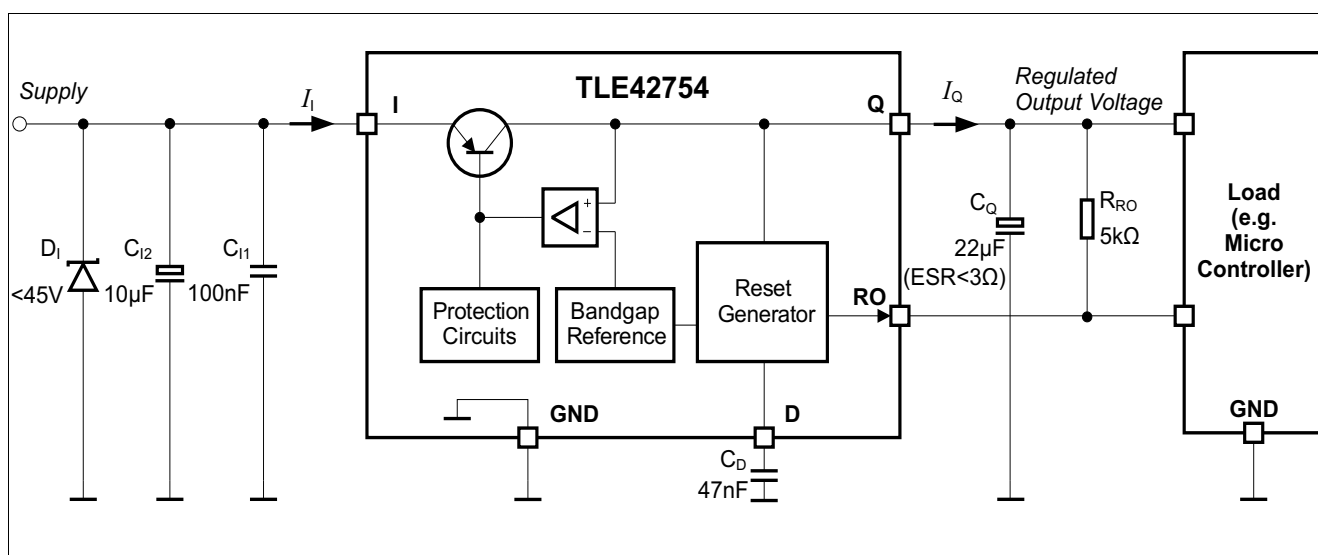


Figure 6 Application diagram

5.2 Selection of external components

5.2.1 Input pin

The typical input circuitry for a linear voltage regulator is shown in [Figure 6](#).

A ceramic capacitor at the input, in the range of 100 nF to 470 nF, is recommended to filter out the high frequency disturbances imposed by the line, for example, ISO pulses 3a/b. This capacitor must be placed very close to the input pin of the linear voltage regulator on the PCB.

An aluminum electrolytic capacitor in the range of 10 µF to 470 µF is recommended as an input buffer to smooth out high energy pulses, such as ISO pulse 2a. This capacitor should be placed close to the input pin of the linear voltage regulator on the PCB.

An overvoltage suppressor diode can be used to further suppress any high voltage beyond the maximum rating of the linear voltage regulator and protect the device against any damage due to overvoltage.

The external components at the input are not mandatory for the operation of the voltage regulator, but they are recommended in case of possible external disturbances.

5.2.2 Output pin

An output capacitor is mandatory for the stability of linear voltage regulators.

The requirement to the output capacitor is given in [Table 3](#). The graph [Output capacitor series resistor ESR\(CQ\) versus output current IQ](#) shows the stable operation range of the device.

TLE42754 is designed to be stable with extremely low ESR capacitors. According to the automotive environment, ceramic capacitors with X5R or X7R dielectrics are recommended.

Application information

The output capacitor should be placed as close as possible to the regulator's output and GND pins and on the same side of the PCB as the regulator itself.

In case of rapid transients of input voltage or load current, the capacitance should be dimensioned in accordance and verified in the real application that the output stability requirements are fulfilled.

5.3 Thermal considerations

Knowing the input voltage, the output voltage and the load profile of the application, the total power dissipation can be calculated:

$$P_D = (V_I - V_Q) \times I_Q + V_I \times I_q \quad (5.1)$$

with

- P_D : continuous power dissipation
- V_I : input voltage
- V_Q : output voltage
- I_Q : output current
- I_q : quiescent current

The maximum acceptable thermal resistance R_{thJA} can then be calculated:

$$R_{thJA, \max} = \frac{T_{j, \max} - T_a}{P_D} \quad (5.2)$$

with

- $T_{j, \max}$: maximum allowed junction temperature
- T_a : ambient temperature

Based on the above calculation the proper PCB type and the necessary heat sink area can be determined with reference to the thermal specification in [Table 4](#).

Example

Application conditions:

$$V_I = 13.5 \text{ V}$$

$$V_Q = 5 \text{ V}$$

$$I_Q = 250 \text{ mA}$$

$$T_a = 85^\circ\text{C}$$

Calculation of $R_{thJA, \max}$:

$$\begin{aligned} P_D &= (V_I - V_Q) \times I_Q + V_I \times I_q \\ &= (13.5 \text{ V} - 5 \text{ V}) \times 250 \text{ mA} + 13.5 \text{ V} \times 10 \text{ mA} \\ &= 2.125 \text{ W} + 0.135 \text{ W} \\ &= 2.26 \text{ W} \end{aligned}$$

Application information

$$\begin{aligned} R_{thJA,max} &= (T_{j,max} - T_a) / P_D \\ &= (150^{\circ}\text{C} - 85^{\circ}\text{C}) / 2.26 \text{ W} \\ &= 28.76 \text{ K/W} \end{aligned}$$

As a result, the PCB design must ensure a thermal resistance R_{thJA} lower than 28.76 K/W. By considering TLE42754G and according to [Table 4](#), only the FR4 2s2p board is applicable.

5.4 Reverse polarity protection

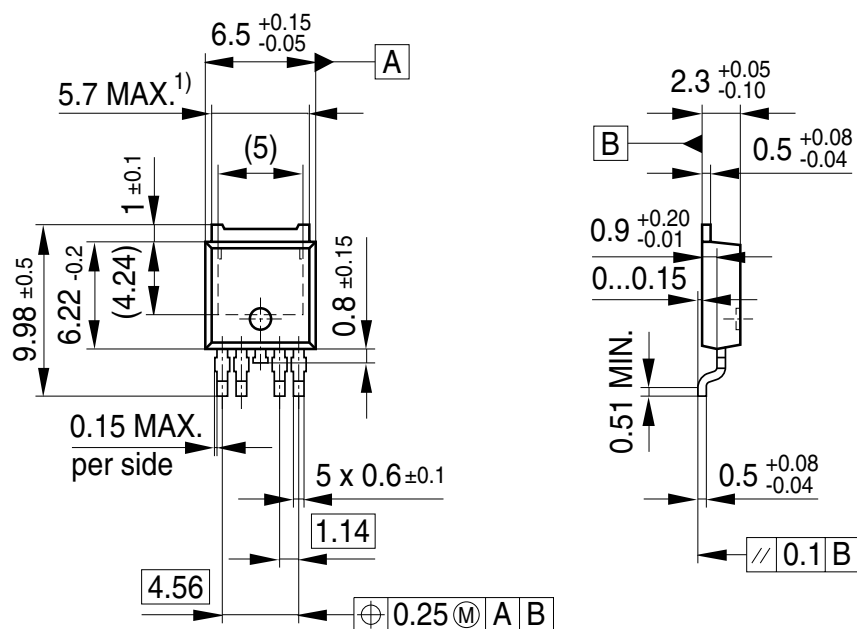
TLE42754 is self protected against reverse polarity faults and allows negative supply voltage. External reverse polarity diode is not needed. However, the absolute maximum ratings of the device as specified in [Table 2](#) must be kept.

The reverse voltage causes several small currents to flow into the IC hence increasing its junction temperature. As the thermal shut down circuitry does not work in the reverse polarity condition, designers have to consider this in their thermal design.

5.5 Further application information

For further information you may contact <https://www.infineon.com>.

6 Package outlines



1) Includes mold flashes on each side.
 All metal surfaces tin plated, except area of cut.

Figure 7 PG-T0252-5¹⁾

1) Dimensions in mm

Package outlines

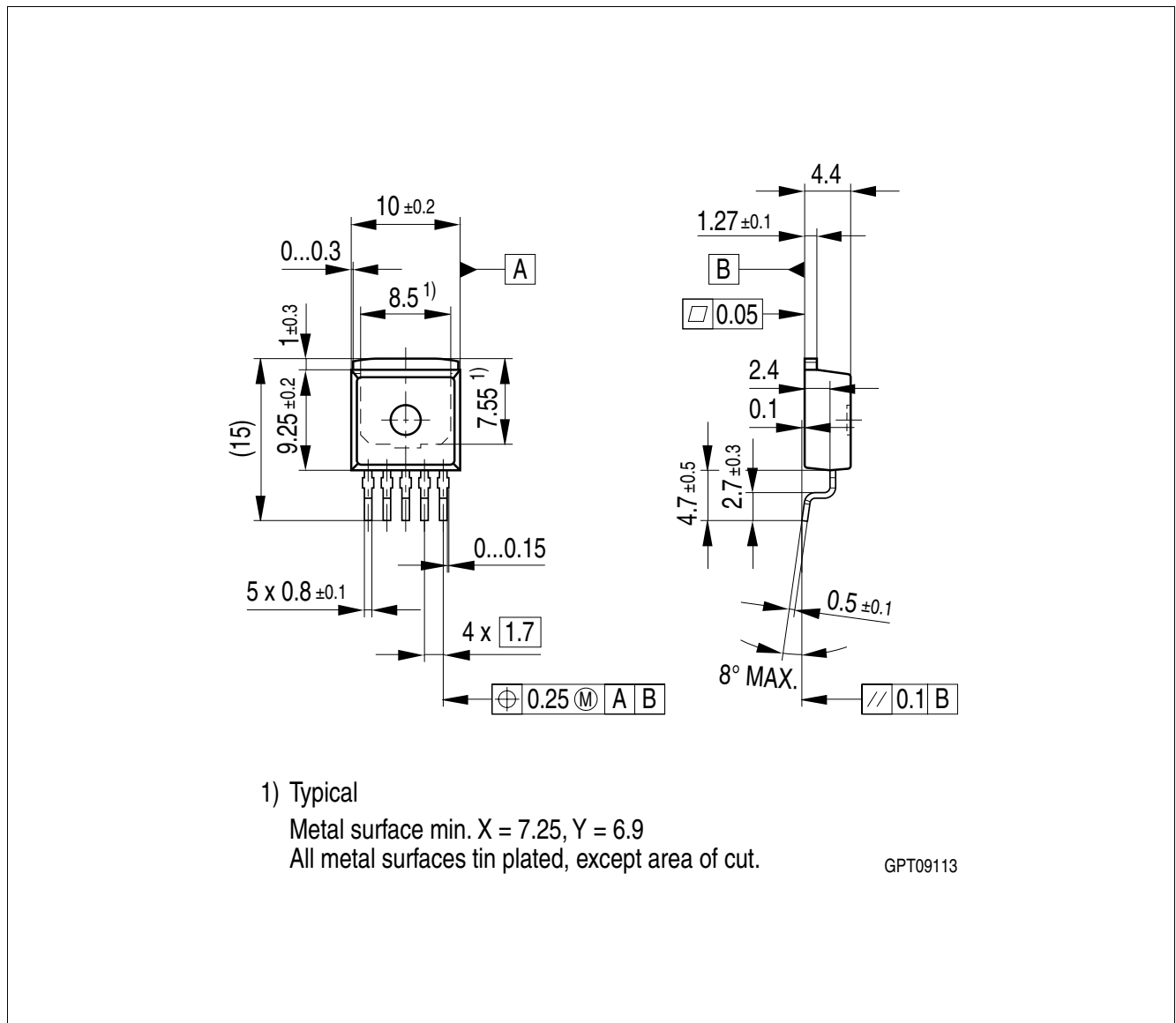


Figure 8 PG-T0263-5¹⁾

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 (Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

Further information on packages

<https://www.infineon.com/packages>

1) Dimensions in mm

Revision history

7 Revision history

Revision	Date	Changes
1.31	2023-11-27	Editorial changes Discontinued package variant TLE42754E removed
1.3	2021-11-25	Marking changes from TLE42754G to TLE42754 Updated layout and structure Editorial changes
1.2	2014-07-03	“Application Information” added PG-SSOP-14 EP package outline updated
1.11	2012-01-20	Condition of Parameter Delay Capacitor Discharge Time, Internal Reset Reaction Time and Reset Reaction Time corrected. Parameters are valid for all package variants. No need to limit the Measurement conditions Coverpage updated
1.1	2008-09-24	Datasheet updated with new package variant in PG-SSOP-14 exposed pad: In “FrontCover” package graphic and sales name with marking added In Table “Thermal Resistance” values for package PG-SSOP-14 exposed pad added In “Package Outlines” Outlines for package PG-SSOP-14 exposed pad added
1.0	2008-05-29	Initial version

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