

# TLE42694-2

Low Dropout Fixed Voltage Regulator

TLE42694-2EL

## Data Sheet

Rev. 1.0, 2012-07-03

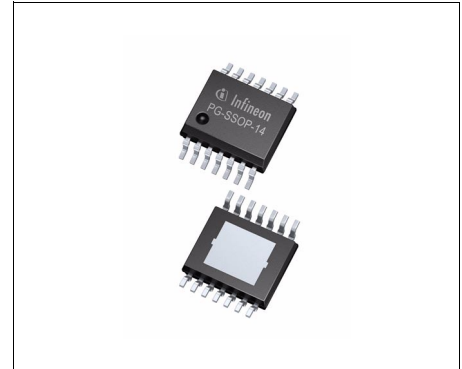
Automotive Power



## 1 Overview

### Features

- Output Voltage  $5\text{ V} \pm 2\%$
- Output Current up to 150 mA
- Very Low Current Consumption
- Power-on and Undervoltage Reset with Programmable Delay Time
- Reset Low Down to  $V_Q = 1\text{ V}$
- Adjustable Reset Threshold
- Very Low Dropout Voltage
- Output Current Limitation
- Reverse Polarity Protection
- Overtemperature Protection
- Suitable for Use in Automotive Electronics
- Wide Temperature Range  $-40\text{ }^\circ\text{C} \leq T_j \leq 150\text{ }^\circ\text{C}$
- Input Voltage Range from  $-42\text{ V}$  to  $45\text{ V}$
- Integrated Pull-Up Resistors at Logic Outputs
- Green Product (RoHS compliant)
- AEC Qualified



PG-SSOP-14 exposed pad

### Description

The TLE42694-2 is a monolithic integrated low dropout voltage regulator, especially designed for automotive applications. An input voltage up to 45 V (with reverse polarity protection) is regulated to an output voltage of 5.0 V. The component is able to drive loads up to 150 mA. Internal over-current and over-temperature features prevent damage of the part in over-load conditions. A reset signal is generated for an output voltage  $V_{Q,rt}$  of typically 4.65 V. This threshold can be decreased by an external resistor divider. The power-on reset delay time can be programmed by the external delay capacitor. The reset output is internally connected to the output Q via a pull-up resistor.

Type	Package	Marking
TLE42694-2EL	PG-SSOP-14 exposed pad	426942E

## 2 Block Diagram

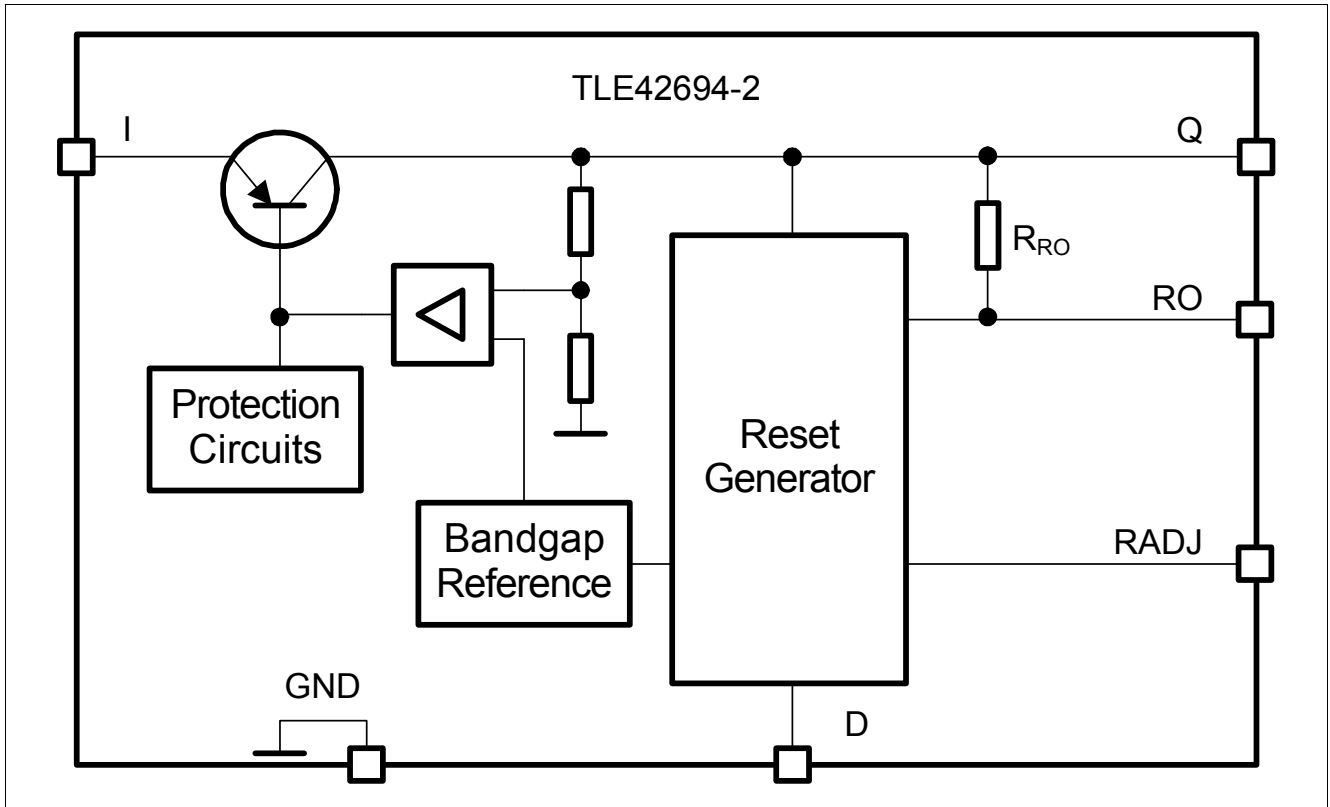


Figure 1 Block Diagram

## 2.1 Pin Assignment

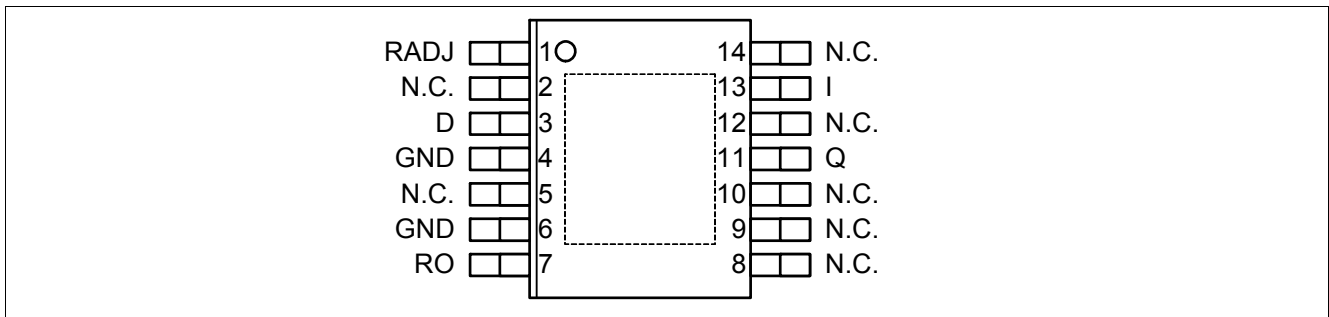


Figure 2 Pin Configuration (top view)

## 2.2 Pin Definitions and Functions

Table 1

Pin	Symbol	Function
1	RADJ	<b>Reset Threshold Adjust</b> connect an external voltage divider to adjust reset threshold; connect to GND for using internal threshold
2,5	n.c.	<b>not connected</b> No Internal Connection. Can be connected to I or GND (to improve heat dissipation).
3	D	<b>Reset Delay Timing</b> connect a ceramic capacitor to GND for adjusting the reset delay time; leave open if the reset function is not needed
4,6	GND	<b>Ground</b> all pins must be connected to GND
7	RO	<b>Reset Output</b> open collector output; internally linked to the output via a 20kΩ pull-up resistor; leave open if the reset function is not needed
8, 9, 10	n.c.	<b>not connected</b> No Internal Connection. Can be connected to I or GND (to improve heat dissipation).
11	Q	<b>Output</b> 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 <b>“Functional Range” on Page 6</b>
12	n.c.	<b>not connected</b> No Internal Connection. Can be connected to I or GND (to improve heat dissipation).
13	I	<b>Input</b> for compensating line influences, a capacitor to GND close to the IC terminals is recommended
14	n.c.	<b>not connected</b> No Internal Connection. Can be connected to I or GND (to improve heat dissipation).
Pad	-	<b>Exposed Pad</b> connect to heatsink area; connect to GND

### 3 General Product Characteristics

#### 3.1 Absolute Maximum Ratings

##### Absolute Maximum Ratings <sup>1)</sup>

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

Pos.	Parameter	Symbol	Limit Values		Unit	Conditions
			Min.	Max.		
<b>Input</b>						
3.1.1	Voltage	V <sub>I</sub>	-40	45	V	–
<b>Output, Reset Output, Reset Delay</b>						
3.1.2	Voltage	V <sub>Q</sub> , V <sub>RO</sub> , V <sub>D</sub>	-0.3	7	V	–
<b>Reset Threshold</b>						
3.1.3	Voltage	V <sub>RADJ</sub>	-0.3	7	V	–
3.1.4	Current	I <sub>RADJ</sub>	-10	10	mA	–
<b>Temperature</b>						
3.1.5	Junction Temperature	T <sub>j</sub>	-40	150	°C	–
3.1.6	Storage Temperature	T <sub>stg</sub>	-50	150	°C	–
<b>ESD Susceptibility</b>						
3.1.7	Human Body Model (HBM) <sup>2)</sup>	Voltage	-2	2	kV	–
3.1.8	Charged Device Model (CDM) <sup>3)</sup>	Voltage	-1	1	kV	–

1) not subject to production test, specified by design

2) ESD HBM Test according to AEC-Q100-002 - JESD22-A114 (1.5kOhm, 100pF)

3) ESD CDM Test according to ESDA ESD-STM5.3.1

*Note: Maximum ratings are absolute ratings; exceeding any one of these values may cause irreversible damage to the integrated circuit. Integrated protection functions are designed to prevent IC destruction under fault conditions. Fault conditions are considered as outside normal operating range. Protections functions are not designed for continuous repetitive operation.*

### 3.2 Functional Range

Pos.	Parameter	Symbol	Limit Values		Unit	Conditions
			Min.	Max.		
3.2.1	Input Voltage	$V_I$	5.5	45	V	–
3.2.2	Output Capacitor's Requirements for Stability	$C_Q$	10	–	$\mu\text{F}$	– <sup>1)</sup>
		$ESR(C_Q)$	–	3	$\Omega$	– <sup>2)</sup>
3.2.3	Output Capacitor's Requirements for Stability	$C_Q$	4.7	–	$\mu\text{F}$	– <sup>1)</sup>
		$ESR(C_Q)$	–	2.7	$\Omega$	– <sup>2)</sup>
3.2.4	Junction Temperature	$T_j$	-40	150	$^{\circ}\text{C}$	–

1) the minimum output capacitance requirement is applicable for a worst case capacitance tolerance of 40%

2) relevant ESR value at  $f = 10 \text{ kHz}$

*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.*

### 3.3 Thermal Resistance

Pos.	Parameter	Symbol	Limit Value			Unit	Conditions
			Min.	Typ.	Max.		
<b>TLE42694-2 (PG-SSOP-14 exposed pad)</b>							
3.3.5	Junction to Soldering Point <sup>1)</sup>	$R_{thJSP}$	–	10	–	K/W	measured to pin 5
3.3.6	Junction to Ambient <sup>1)</sup>	$R_{thJA}$	–	47	–	K/W	<sup>2)</sup>
3.3.7			–	145	–	K/W	Footprint only <sup>3)</sup>
3.3.8			–	63	–	K/W	300mm <sup>2</sup> heatsink area on PCB <sup>3)</sup>
3.3.9			–	53	–	K/W	600mm <sup>2</sup> heatsink area on PCB <sup>3)</sup>

1) not subject to production test, specified by design

2) Specified  $R_{thJA}$  value is according to Jedec JESD51-2,-5,-7 at natural convection on FR4 2s2p board; The Product (Chip+Package) was simulated on a 76.2 x 114.3 x 1.5 mm<sup>3</sup> board with 2 inner copper layers (2 x 70 $\mu\text{m}$  Cu, 2 x 35 $\mu\text{m}$  Cu). Where applicable a thermal via array under the exposed pad contacted the first inner copper layer.

3) Specified  $R_{thJA}$  value is according to JEDEC JESD 51-3 at natural convection on FR4 1s0p board; The Product (Chip+Package) was simulated on a 76.2 x 114.3 x 1.5 mm<sup>3</sup> board with 1 copper layer (1 x 70 $\mu\text{m}$  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 the table **“Functional Range” on Page 6** have to be maintained. For details see also the typical performance graph **“Output Capacitor Series Resistor ESR(CQ) versus Output Current IQ” on Page 10**. 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 prevents 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  $V_I = 22\text{ V}$ .

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  $150\text{ °C}$  are outside the maximum ratings and therefore significantly reduce the IC's lifetime.

The TLE42694-2 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.

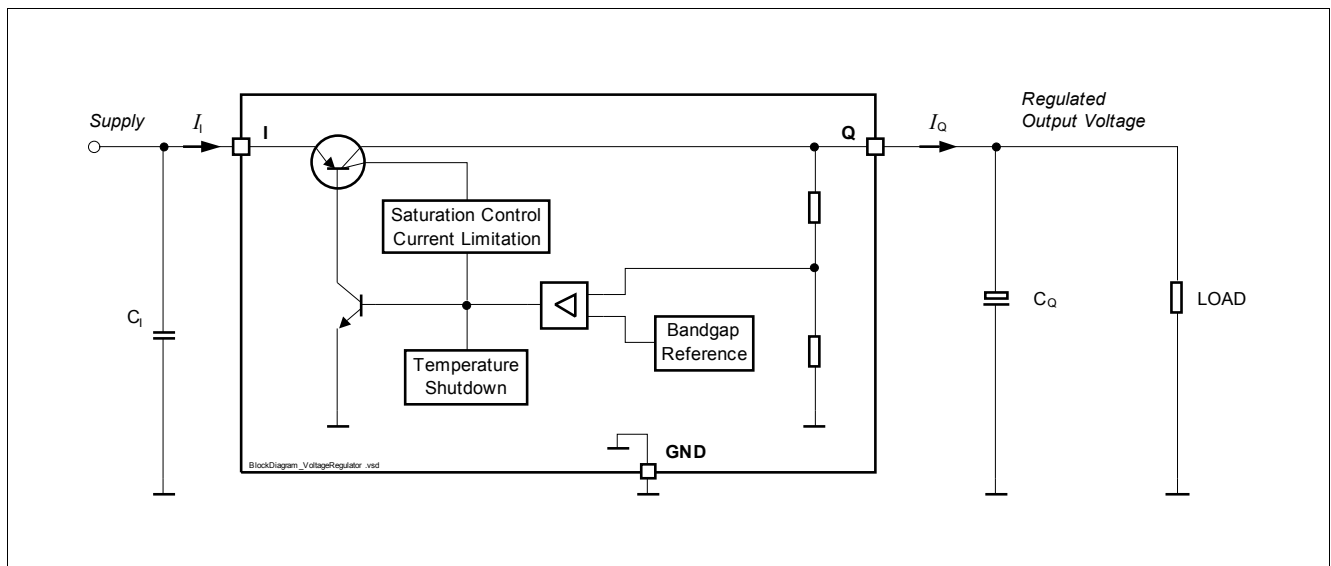


Figure 3 Voltage Regulator

## Block Description and Electrical Characteristics

**Electrical Characteristics Voltage Regulator**

$V_1 = 13.5 \text{ V}$ ,  $-40 \text{ }^\circ\text{C} \leq T_j \leq 150 \text{ }^\circ\text{C}$ , all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Pos.	Parameter	Symbol	Limit Values			Unit	Conditions
			Min.	Typ.	Max.		
4.1.1	Output Voltage	$V_Q$	4.9	5.0	5.1	V	$100 \mu\text{A} < I_Q < 100 \text{ mA}$ $6 \text{ V} < V_1 < 18 \text{ V}$
4.1.2	Output Current Limitation	$I_{Q,\text{max}}$	150	200	500	mA	$V_Q = 4.8\text{V}$
4.1.3	Load Regulation steady-state	$\Delta V_{Q,\text{load}}$	-30	-15	–	mV	$I_Q = 5 \text{ mA to } 100 \text{ mA}$ $V_1 = 6 \text{ V}$
4.1.4	Line Regulation steady-state	$\Delta V_{Q,\text{line}}$	–	10	40	mV	$V_1 = 6 \text{ V to } 32 \text{ V}$ $I_Q = 5 \text{ mA}$
4.1.5	Dropout Voltage <sup>1)</sup> $V_{\text{dr}} = V_1 - V_Q$	$V_{\text{dr}}$	–	200	330	mV	$I_Q = 100 \text{ mA}$
4.1.6	Overtemperature Shutdown Threshold	$T_{j,\text{sd}}$	151	–	200	°C	$T_j$ increasing <sup>2)</sup>
4.1.7	Overtemperature Shutdown Threshold Hysteresis	$T_{j,\text{sdh}}$	–	15	–	°C	$T_j$ decreasing <sup>2)</sup>
4.1.8	Power Supply Ripple Rejection <sup>2)</sup>	$PSRR$	–	70	–	dB	$f_{\text{ripple}} = 100 \text{ Hz}$ $V_{\text{ripple}} = 0.5 \text{ Vpp}$

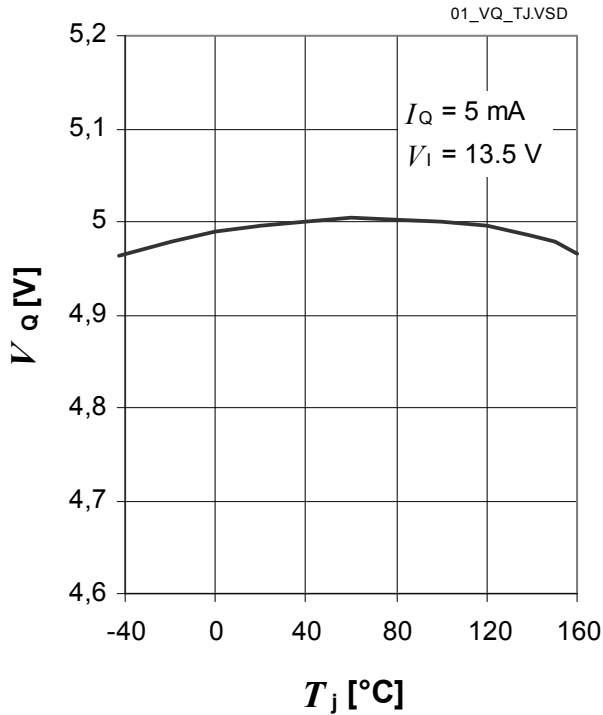
1) measured when the output voltage  $V_Q$  has dropped 100mV from the nominal value obtained at  $V_1 = 13.5\text{V}$

2) not subject to production test, specified by design

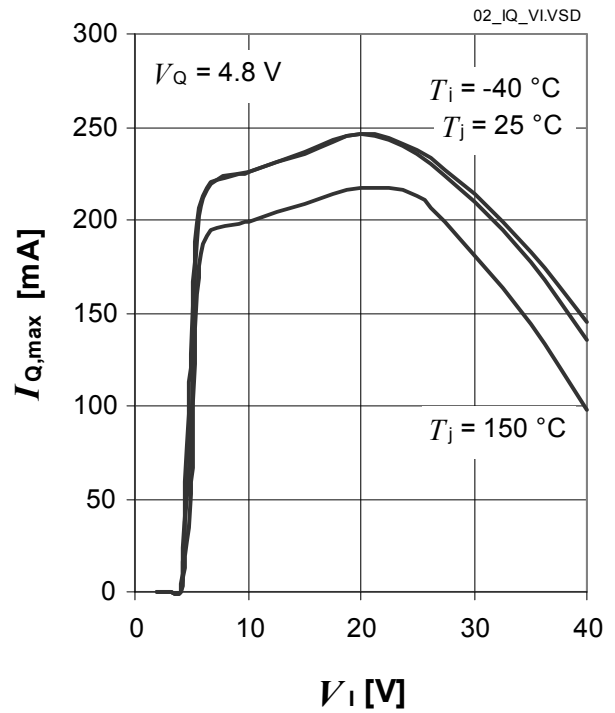


Typical Performance Characteristics Voltage Regulator

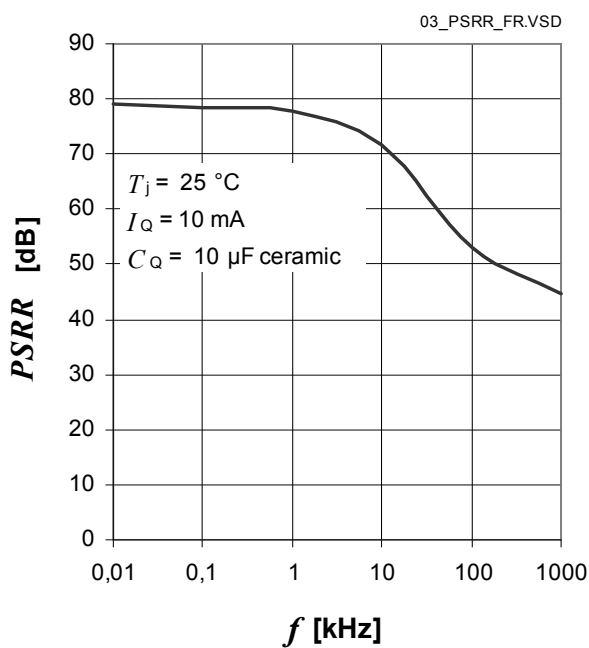
Output Voltage  $V_Q$  versus Junction Temperature  $T_j$



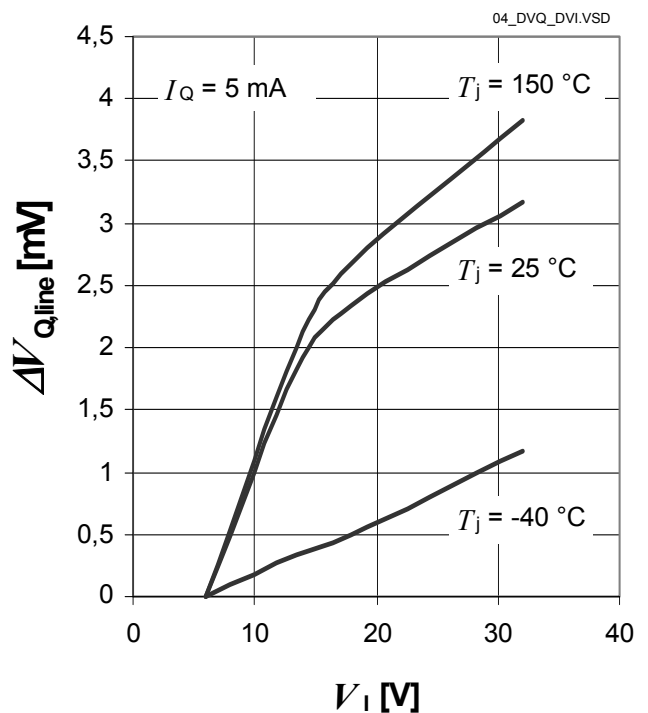
Output Current  $I_Q$  versus Input Voltage  $V_I$



Power Supply Ripple Rejection  $PSRR$  versus ripple frequency  $f_r$

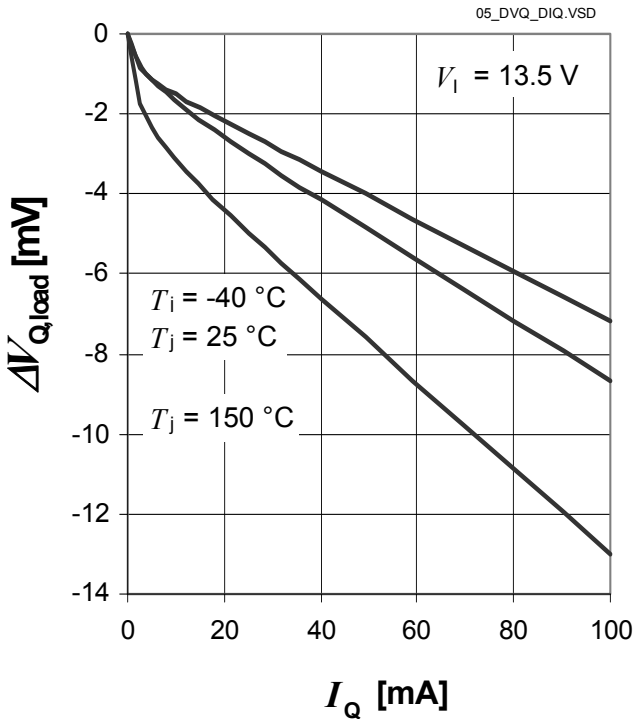


Line Regulation  $\Delta V_{Q,line}$  versus Input Voltage Change  $\Delta V_I$

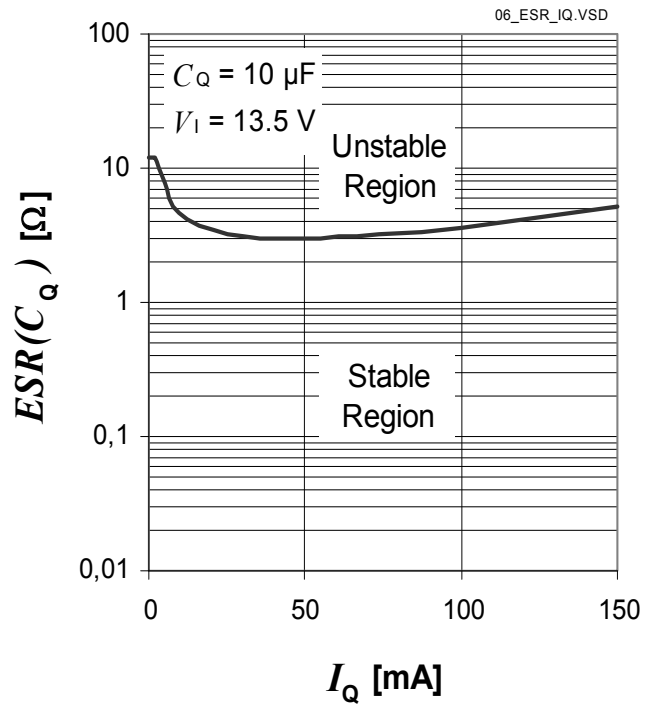


Typical Performance Characteristics Voltage Regulator

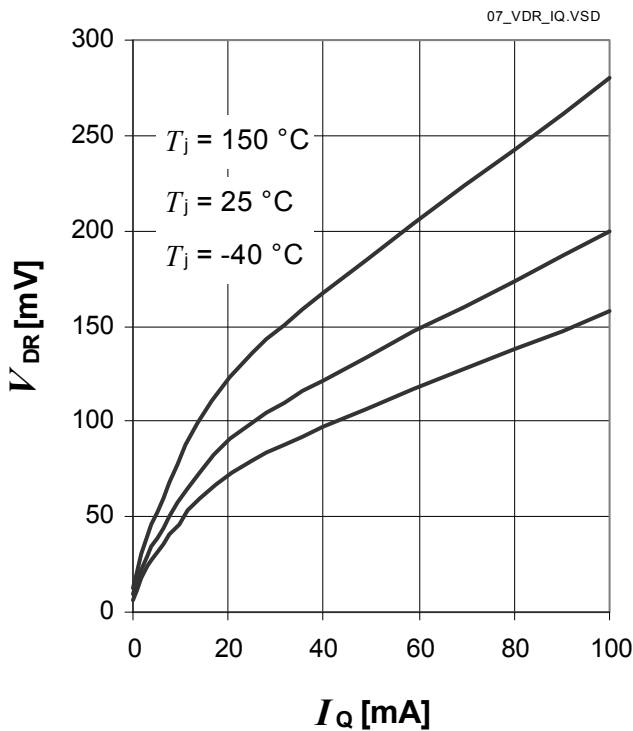
Load Regulation  $\Delta V_{Q,load}$  versus Output Current Change  $\Delta I_Q$



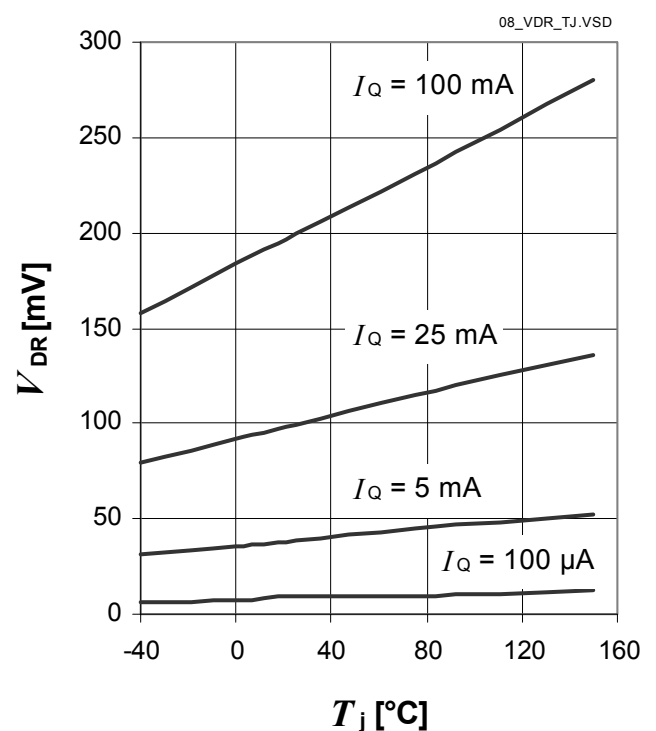
Output Capacitor Series Resistor  $ESR(C_Q)$  versus Output Current  $I_Q$



Dropout Voltage  $V_{dr}$  versus Output Current  $I_Q$



Dropout Voltage  $V_{dr}$  versus Junction Temperature  $T_j$



## 4.2 Current Consumption

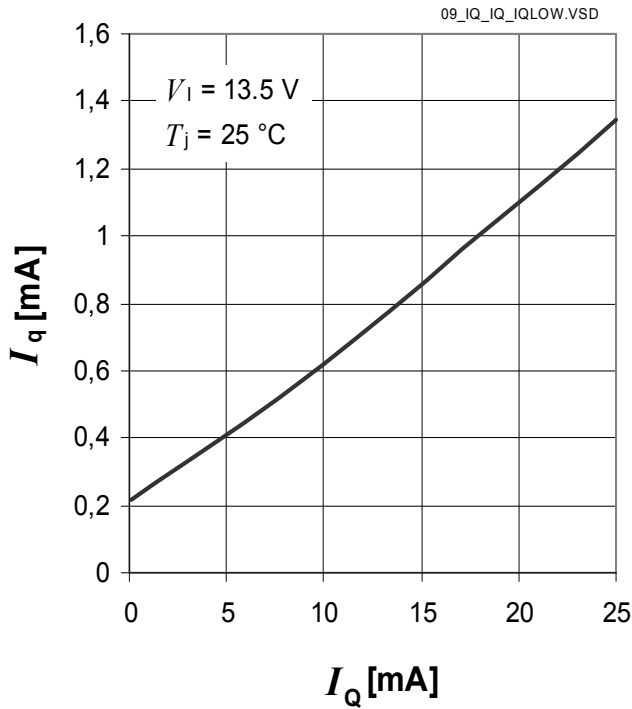
### Electrical Characteristics Current Consumption

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

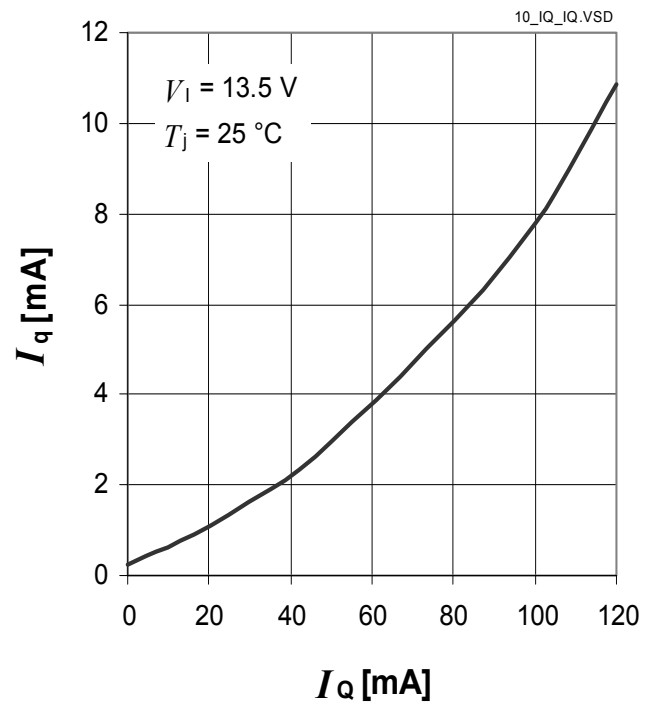
Pos.	Parameter	Symbol	Limit Values			Unit	Conditions
			Min.	Typ.	Max.		
4.2.1	Current Consumption $I_q = I_I - I_Q$	$I_q$	–	210	280	$\mu\text{A}$	$I_Q = 100\ \mu\text{A}$ $T_j = 25\text{ °C}$
4.2.2			–	240	300	$\mu\text{A}$	$I_Q = 100\ \mu\text{A}$ $T_j \leq 85\text{ °C}$
4.2.3			–	0.7	1	$\text{mA}$	$I_Q = 10\ \text{mA}$
4.2.4			–	3.5	8	$\text{mA}$	$I_Q = 50\ \text{mA}$

Typical Performance Characteristics Current Consumption

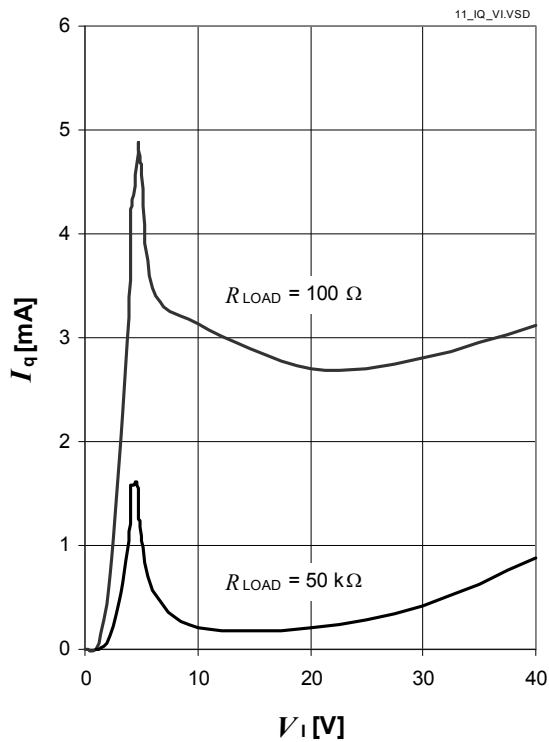
Current Consumption  $I_q$  versus Output Current  $I_Q$  ( $I_Q$  low)



Current Consumption  $I_q$  versus Output Current  $I_Q$



Current Consumption  $I_q$  versus Input Voltage  $V_1$



### 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 [Item 4.3.9](#), the delay capacitor’s value can be derived from the specified values in [Item 4.3.9](#) and the desired power-on delay time:

$$C_D = \frac{t_{rd,new}}{t_{rd}} \times 1,5\text{nF}$$

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:

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

with

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

#### Optional Reset Output Pull-Up Resistor $R_{RO,ext}$ :

The Reset Output RO is an open collector output with an integrated pull-up resistor. To improve the EMC behaviour of the component, an external pull-up resistor to the output  $V_Q$  can be added. In [Table “Electrical Characteristics Reset Function” on Page 16](#) a minimum value for the external resistor  $R_{RO,ext}$  is given.

**Reset Adjust Function**

The undervoltage reset switching threshold can be adjusted according to the application’s needs by connecting an external voltage divider ( $R_{ADJ1}$ ,  $R_{ADJ2}$ ) at pin RADJ. For selecting the default threshold connect pin RADJ to GND.

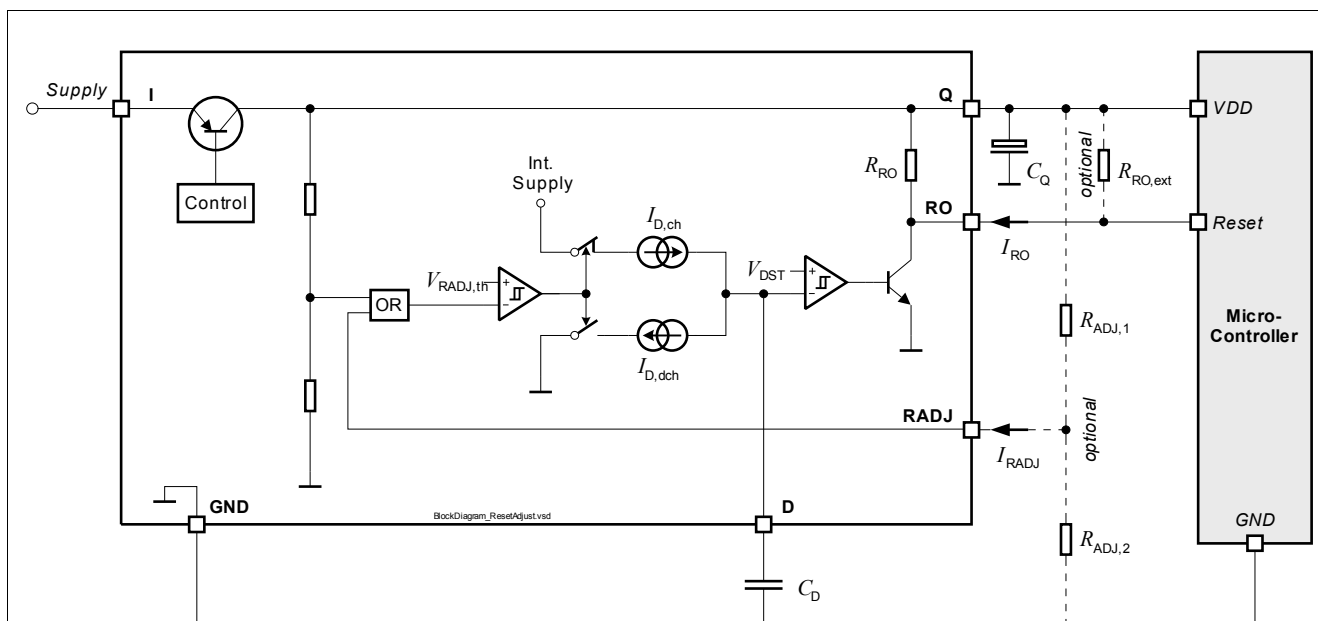
When dimensioning the voltage divider, take into consideration that there will be an additional current constantly flowing through the resistors.

With a voltage divider connected, the reset switching threshold  $V_{RT,new}$  is calculated as follows:

$$V_{RT,new} = \frac{R_{ADJ,1} + R_{ADJ,2}}{R_{ADJ,2}} \times V_{RADJ,th}$$

with

- $V_{RT,new}$ : the desired new reset switching threshold
- $R_{ADJ1}$ ,  $R_{ADJ2}$ : resistors of the external voltage divider
- $V_{RADJ,th}$ : reset adjust switching threshold given in [Table “Electrical Characteristics Reset Function” on Page 16](#)



**Figure 4** Block Diagram Reset Function

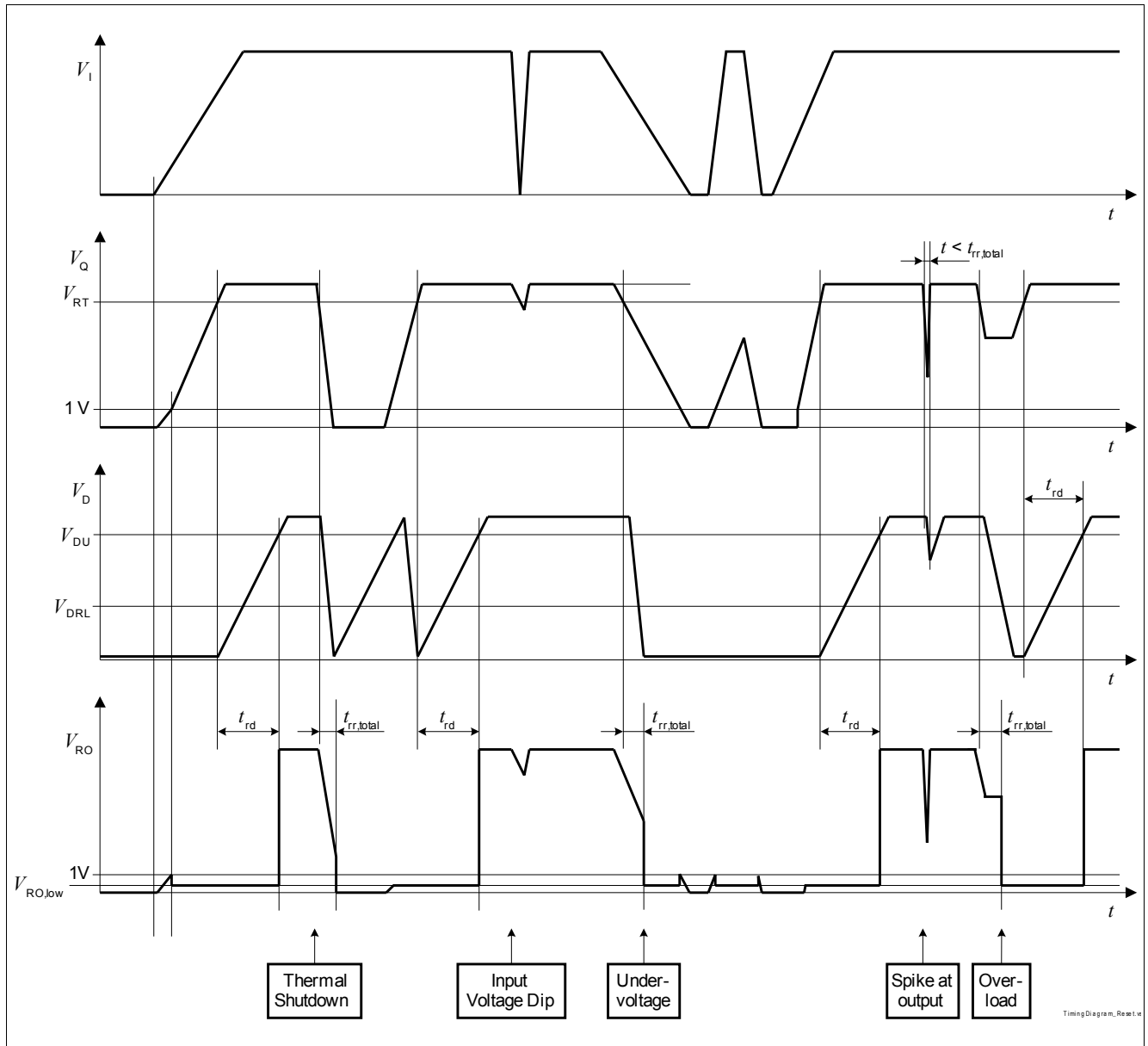


Figure 5 Timing Diagram Reset

## Block Description and Electrical Characteristics

**Electrical Characteristics Reset Function**

$V_1 = 13.5 \text{ V}$ ,  $-40 \text{ }^\circ\text{C} \leq T_j \leq 150 \text{ }^\circ\text{C}$ , all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Pos.	Parameter	Symbol	Limit Values			Unit	Conditions
			Min.	Typ.	Max.		
<b>Output Undervoltage Reset</b>							
4.3.1	Default Output Undervoltage Reset Switching Thresholds	$V_{RT}$	4.5	4.65	4.8	V	$V_Q$ decreasing
<b>Output Undervoltage Reset Threshold Adjustment</b>							
4.3.2	Reset Adjust Switching Threshold	$V_{RADJ,th}$	1.26	1.35	1.44	V	$3.5 \text{ V} \leq V_Q < 5 \text{ V}$
4.3.3	Reset Adjustment Range <sup>1)</sup>	$V_{RT,range}$	3.50	–	4.65	V	–
<b>Reset Output RO</b>							
4.3.4	Reset Output Low Voltage	$V_{RO,low}$	–	0.1	0.4	V	$1 \text{ V} \leq V_Q \leq V_{RT}$ no external $R_{RO,ext}$
4.3.5	Reset Output Internal Pull-Up Resistor to $V_Q$	$R_{RO}$	10	20	40	k $\Omega$	–
4.3.6	Optional Reset Output External Pull-up Resistor to $V_Q$	$R_{RO,ext}$	20	–	–	k $\Omega$	$1 \text{ V} \leq V_Q \leq V_{RT}$ ; $V_{RO} \leq 0.4 \text{ V}$
4.3.7	Optional Reset Output External Pull-up Resistor to $V_Q$	$R_{RO,ext}$	5	–	–	k $\Omega$	$2.5 \text{ V} \leq V_Q \leq V_{RT}$ ; $V_{RO} \leq 0.4 \text{ V}$
<b>Reset Delay Timing</b>							
4.3.8	Delay Pin Output Voltage	$V_D$	–	–	5	V	–
4.3.9	Power On Reset Delay Time	$t_{rd}$	100	400	700	$\mu\text{s}$	$C_D = 1.5 \text{ nF}$
4.3.10	Upper Delay Switching Threshold	$V_{DU}$	–	1.8	–	V	–
4.3.11	Lower Delay Switching Threshold	$V_{DL}$	–	0.45	–	V	–
4.3.12	Delay Capacitor Charge Current	$I_{D,ch}$	–	6.5	–	$\mu\text{A}$	$V_D = 1 \text{ V}$
4.3.13	Delay Capacitor Reset Discharge Current	$I_{D,dch}$	–	70	–	mA	$V_D = 1 \text{ V}$
4.3.14	Delay Capacitor Discharge Time	$t_{rr,d}$	–	30	100	ns	Calculated Value: $t_{rr,d} = C_D \cdot (V_{DU} - V_{DL}) / I_{D,dch}$ $C_D = 1.5 \text{ nF}$
4.3.15	Internal Reset Reaction Time	$t_{rr,int}$	–	3	7	$\mu\text{s}$	$C_D = 0 \text{ nF}$ <sup>2)</sup>
4.3.16	Reset Reaction Time	$t_{rr,total}$	–	3	7.1	$\mu\text{s}$	Calculated Value: $t_{rr,total} = t_{rr,int} + t_{rr,d}$ $C_D = 1.5 \text{ nF}$

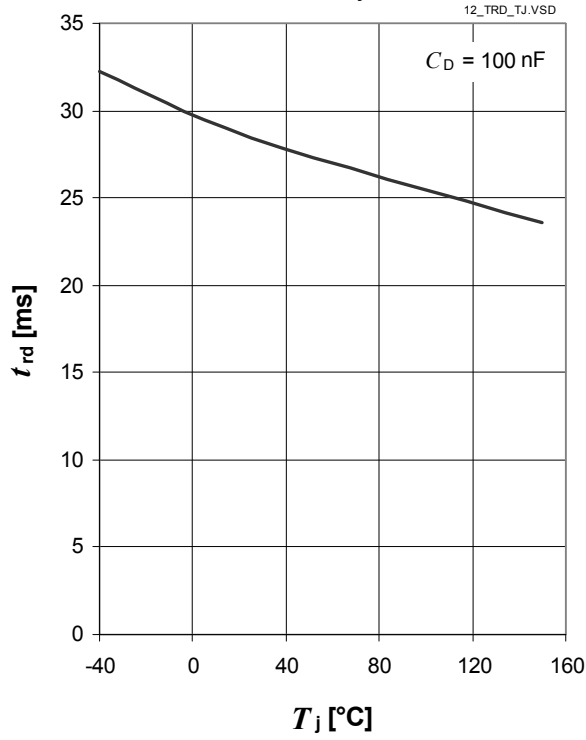
1)  $V_{RT}$  is scaled linearly, in case the Reset Switching Threshold is modified

2) parameter not subject to production test; specified by design

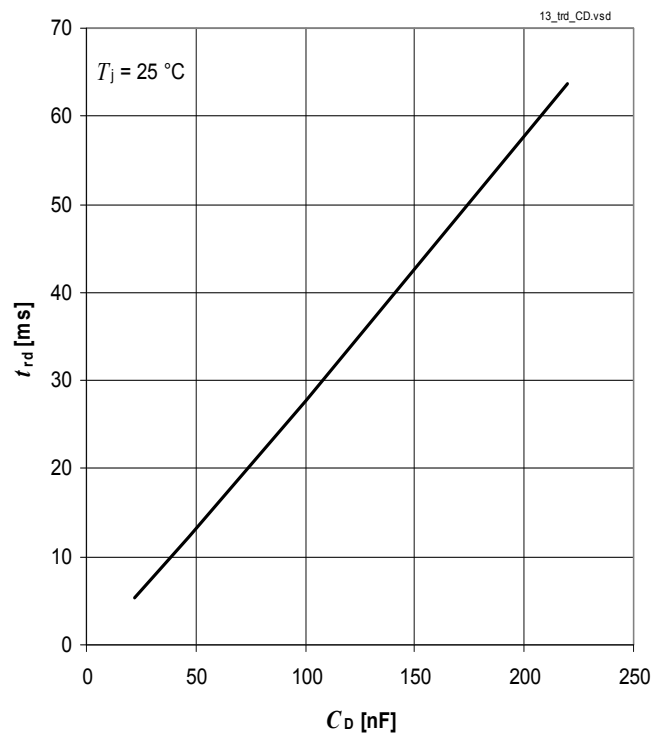


Typical Performance Characteristics

Power On Reset Delay Time  $t_{rd}$  versus Junction Temperature  $T_j$



Power On Reset Delay Time  $t_{rd}$  versus Capacitance  $C_D$





## 6 Revision History

Revision	Date	Changes
1.0	2012-07-03	Initial Data sheet

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