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Low Dropout Linear Voltage Regulator

TLS850F0TAV50

TLS850F0TAV50

Linear Voltage Regulator

Data Sheet

Rev. 1.0, 2015-07-24

Automotive Power

Table of Contents

1 Overview . . . 3

2 Block Diagram . . . 5

3 Pin Configuration . . . 6
3.1 Pin Assignment TLS850F0TAV50 . . . 6
3.2 Pin Definitions and Functions TLS850F0TAV50 . . . 6

4 General Product Characteristics . . . 7
4.1 Absolute Maximum Ratings . . . 7
4.2 Functional Range . . . 8
4.3 Thermal Resistance . . . 9

5 Block Description and Electrical Characteristics . . . 10
5.1 Voltage Regulation . . . 10
5.2 Typical Performance Characteristics Voltage Regulator . . . 12
5.3 Current Consumption . . . 15
5.4 Typical Performance Characteristics Current Consumption . . . 16
5.5 Enable . . . 17
5.6 Typical Performance Characteristics Enable . . . 18
5.7 Reset . . . 19
5.8 Typical Performance Characteristics Reset . . . 23
5.9 Standard Watchdog . . . 24
5.10 Typical Performance Characteristics Standard Watchdog . . . 30

6 Application Information . . . 31
6.1 Application Diagram . . . 31
6.2 Selection of External Components . . . 31
6.2.1 Input Pin . . . 31
6.2.2 Output Pin . . . 31
6.3 Thermal Considerations . . . 32
6.4 Reverse Polarity Protection . . . 33
6.5 Further Application Information . . . 33

7 Package Outlines . . . 34

8 Revision History . . . 35

1 Overview

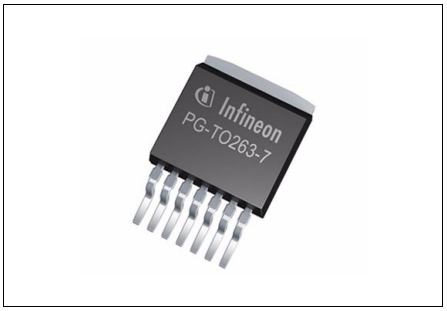


Figure 1 PG-TO263-7

Features

- Wide Input Voltage Range from 3.0 V to 40 V
- Fixed Output Voltage 5 V
- Output Voltage Precision ≤ ±2 %
- Output Current Capability up to 500 mA
- Ultra Low Current Consumption typ. 40 µA
- Very Low Dropout Voltage typ. 70 mV@100 mA
- Stable with Ceramic Output Capacitor of 1 µF
- Delayed Reset at Power-On: 16.5 ms
- Adjustable Reset Threshold down to 2.50V
- Watchdog with fixed timing and current dependent deactivation: 96 ms, Activated at I_Q > 5.5 mA
- Enable, Undervoltage Reset,Overtemperature Shutdown
- Output Current Limitation
- Wide Temperature Range
- Green Product (RoHS compliant)
- AEC Qualified

Functional Description

The TLS850F0TAV50 is a high performance very low dropout linear voltage regulator for 5 V supply in a PG-TO263-7 package.

With an input voltage range of 3 V to 40 V and very low quiescent of only 40 µA, these regulators are perfectly suitable for automotive or any other supply systems connected to the battery permanently. The TLS850F0TAV50 provides an output voltage accuracy of 2 % and a maximum output current up to 500 mA.

The new loop concept combines fast regulation and very good stability while requiring only one small ceramic capacitor of 1 µF at the output. At currents below 100 mA the device will have a very low typical dropout voltage of only 70 mV. The operating range starts already at input voltages of only 3 V (extended operating range). This makes the TLS850F0TAV50 also suitable to supply automotive systems that need to operate during cranking condition.

The device can be switched on and off by the Enable feature as described in **Chapter 5.5**.

The output voltage is supervised by the Reset feature, including Undervoltage Reset, delayed Reset at Power-On and an adjustable lower Reset Threshold, more details can be found in **Chapter 5.7**.

In addition, a Watchdog circuit with fixed timing is integrated to monitor the microcontroller‘s operation.

Internal protection features like output current limitation and overtemperature shutdown are implemented to protect the device against immediate damage due to failures like output short circuit to GND, over-current and over-temperatures.

Choosing External Components

An input capacitor C_{I} is recommended to compensate line influences. The output capacitor C_{Q} is necessary for the stability of the regulating circuit. TLS850F0TAV50 is designed to be also stable with low ESR ceramic capacitors.

Type	Package	Marking
TLS850F0TAV50	PG-TO263-7	850F0V50

2 Block Diagram

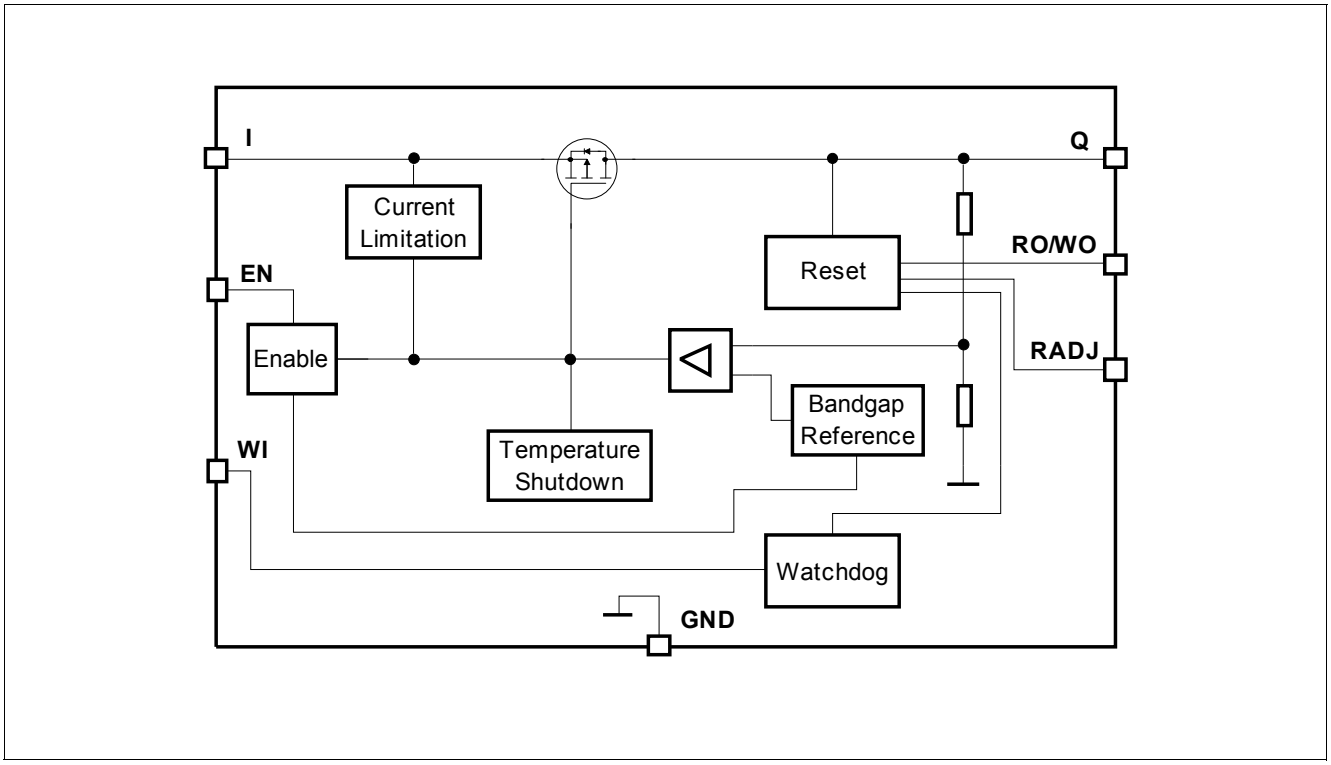


Figure 2 Block Diagram TLS850F0TAV50

3 Pin Configuration

3.1 Pin Assignment TLS850F0TAV50

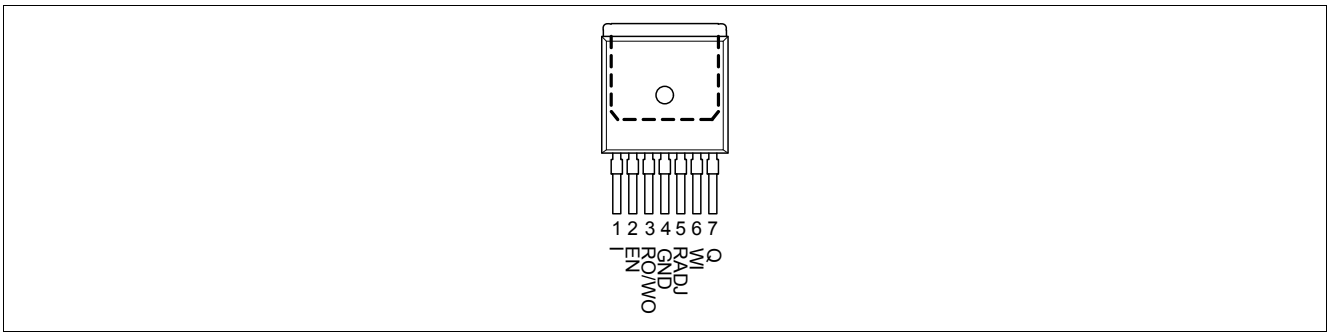


Figure 3 Pin Configuration

3.2 Pin Definitions and Functions TLS850F0TAV50

Pin	Symbol	Function
1	I	**Input** It is recommended to place a small ceramic capacitor (e.g. 100 nF) to GND, close to the IC terminals, in order to compensate line influences. See also **Chapter 6.2.1**
2	EN	**Enable** (integrated pull-down resistor) Enable the IC with high level input signal; Disable the IC with low level input signal;
3	RO/WO	**Reset Output / Watchdog Output** (intergrated pull-up resistor to Q) Open collector output; Leave open if the reset and watchdog function are not needed
4	GND	**Ground**
5	RADJ	**Reset Threshold Adjustment** Connect to GND to use standard value; Connect an external voltage divider to adjust reset threshold
6	WI	**Watchdog Input** (integrated pull-down resistor) Serve Watchdog with trigger input signal (usable for microcontroller monitoring)
7	Q	**Output Voltage** Connect output capacitor C_Q to GND close to the IC's terminals, respecting the values specified for its capacitance and ESR in **"Functional Range" on Page 8**
Heat Slug	–	**Heat Slug** Connect to heatsink area; Connect to GND

4 General Product Characteristics

4.1 Absolute Maximum Ratings

Table 1 Absolute Maximum Ratings[1)]

T_j = -40 °C to +150 °C; all voltages with respect to ground (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Input I, Enable EN							
Voltage	V_I, V_{EN}	-0.3	–	45	V	–	P_4.1.1
Output Q, Reset/Watchdog Output RO/WO							
Voltage	V_Q, $V_{RO/WO}$	-0.3	–	7	V	–	P_4.1.3
Watchdog Input WI, Reset Threshold Adjustment RADJ							
Voltage	V_{WI}, V_{RADJ}	-0.3	–	7	V	–	P_4.1.5
Temperatures							
Junction Temperature	T_j	-40	–	150	°C	–	P_4.1.7
Storage Temperature	T_{stg}	-55	–	150	°C	–	P_4.1.8
ESD Absorption							
ESD Susceptibility to GND	V_{ESD}	-2	–	2	kV	2) HBM	P_4.1.9
ESD Susceptibility to GND	V_{ESD}	-500	–	500	V	3) CDM	P_4.1.10
ESD Susceptibility Pin 1, 7 (corner pins) to GND	$V_{ESD1,7}$	-750	–	750	V	3) CDM	P_4.1.12

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

2) ESD susceptibility, HBM according to ANSI/ESDA/JEDEC JS001 (1.5 kΩ, 100 pF)

3) ESD susceptibility, Charged Device Model “CDM” according JEDEC JESD22-C101

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 2 Functional Range

T_j = -40 °C to +150 °C; all voltages with respect to ground (unless otherwise specified)

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Input Voltage Range	V_I	$V_{Q,nom}$ + V_{dr}	–	40	V	1) –	P_4.2.1
Extended Input Voltage Range	$V_{I,ext}$	3.0	–	40	V	2) –	P_4.2.3
Enable Voltage Range	V_{EN}	0	–	40	V	–	P_4.2.5
Output Capacitor's Requirements for Stability	C_Q	1	–	–	µF	3)4) –	P_4.2.6
ESR	$ESR(C_Q)$	–	–	100	Ω	3) –	P_4.2.7
Junction Temperature	T_j	-40	–	150	°C	–	P_4.2.9

1) Output current is limited internaly and depends on the input voltage, see Electrical Characteristics for more details.

2) When V_I is between $V_{I,ext,min}$ and $V_{Q,nom}$ + V_{dr}, V_Q = V_I - V_{dr}. When V_I is below $V_{I,ext,min}$, V_Q can drop down to 0 V.

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

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

Note: Within the functional or operating range, the IC operates as described in the circuit description. The electrical characteristics are specified within the conditions given in the Electrical Characteristics table.

4.3 Thermal Resistance

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

Table 3 Thermal Resistance

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Package Version PG-TO263-7							
Junction to Case	R_{thJC}	–	3	–	K/W	1) –	P_4.3.6
Junction to Ambient	R_{thJA}	–	21	–	K/W	1)2) 2s2p board	P_4.3.7
Junction to Ambient	R_{thJA}	–	75	–	K/W	1)3) 1s0p board, footprint only	P_4.3.8
Junction to Ambient	R_{thJA}	–	42	–	K/W	1)3) 1s0p board, 300 mm^2 heatsink area on PCB	P_4.3.9
Junction to Ambient	R_{thJA}	–	34	–	K/W	1)3) 1s0p board, 600 mm^2 heatsink area on PCB	P_4.3.10

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 mm³ board with 2 inner copper layers (2 x 70µm Cu, 2 x 35µm 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 × 114.3 × 1.5 mm^3 board with 1 copper layer (1 x 70µm Cu).

5 Block Description and Electrical Characteristics

5.1 Voltage Regulation

The output voltage V_Q is divided by a resistor network. This fractional voltage is compared to an internal voltage reference and the pass transistor is driven accordingly.

The control loop stability depends on the output capacitor C_Q, the load current, the chip temperature and the internal circuit design. To ensure stable operation, the output capacitor's capacitance and its equivalent series resistor (ESR) requirements given in **"Functional Range" on Page 8** have to be maintained. For details, also see the typical performance graph **"Output Capacitor Series Resistor ESR(CQ) versus Output Current IQ" on Page 13**. 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 recommended to compensate line influences. In order to block influences like pulses and HF distortion at input side, an additional reverse polarity protection diode and a combination of several capacitors for filtering should be used. Connect the capacitors close to the component's terminals.

In order to prevent overshoots during start-up, a smooth ramp up function is implemented. This ensures almost no output voltage overshoots during start-up, mostly independent from load and output capacitance.

Whenever the load current exceeds the specified limit, e.g. in case of a short circuit, the output current is limited and the output voltage decreases.

The overtemperature shutdown circuit prevents the IC from immediate destruction under fault conditions (e.g. output continuously short-circuit) 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.

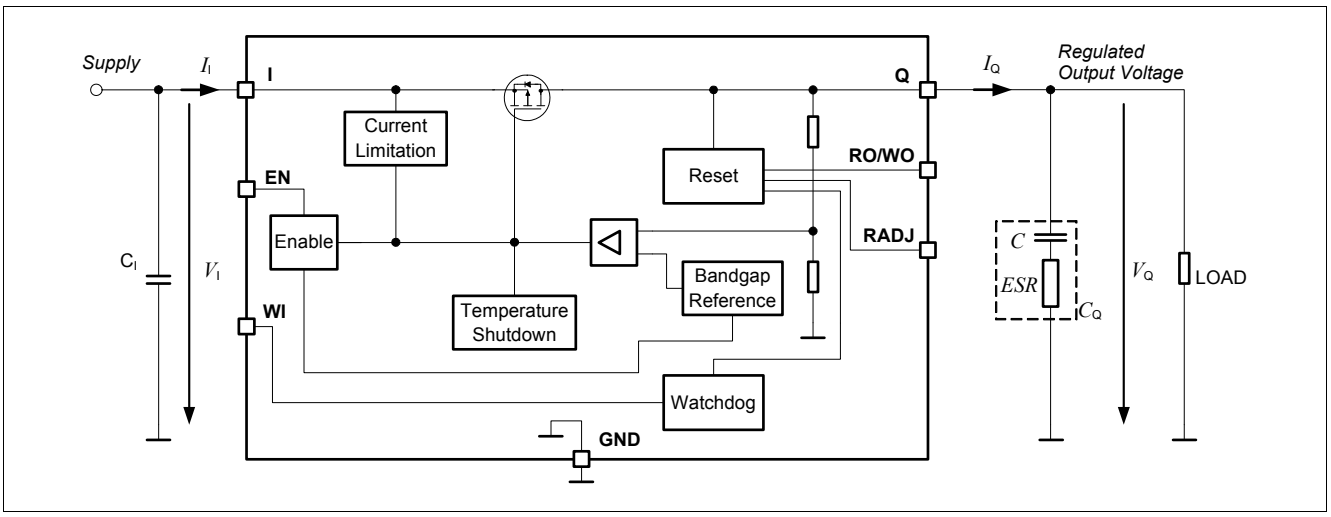


Figure 4 Voltage Regulation

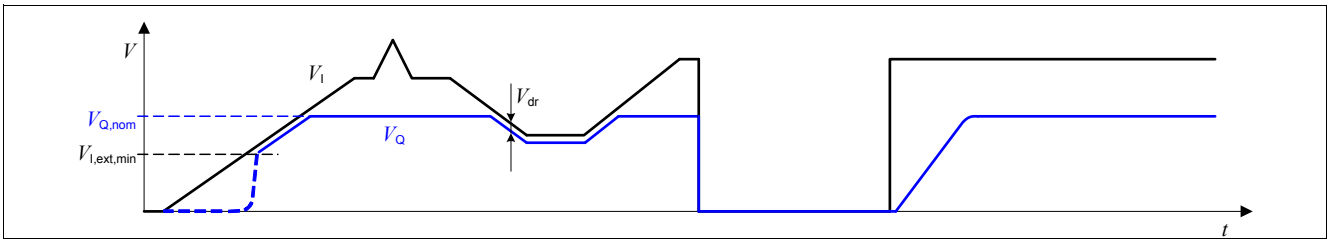


Figure 5 Output Voltage vs. Input Voltage

Table 4 Electrical Characteristics Voltage Regulator 5 V version

T_j = -40 °C to +150 °C, V_I = 13.5 V, all voltages with respect to ground (unless otherwise specified)
Typical values are given at T_j = 25 °C

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Output Voltage Precision	V_Q	4.9	5.0	5.1	V	0.05 mA < I_Q < 500 mA 5.95 V < V_I < 28 V	P_5.1.3
Output Voltage Precision	V_Q	4.9	5.0	5.1	V	0.05 mA < I_Q < 200 mA 5.44 V < V_I < 40 V	P_5.1.4
Output Voltage Start-up slew rate	dV_Q/dt	3.0	7.5	18	V/ms	V_I > 18 V/ms C_Q = 1 µF 0.5 V < V_Q < 4.5 V	P_5.1.7
Output Current Limitation	$I_{Q,max}$	501	650	1100	mA	0 V < V_Q < 4.8 V	P_5.1.9
Load Regulation steady-state	$\Delta V_{Q,load}$	-20	-1.5	5	mV	I_Q = 0.05 mA to 500 mA V_I = 6 V	P_5.1.11
Line Regulation steady-state	$\Delta V_{Q,line}$	-20	0	20	mV	V_I = 8 V to 32 V I_Q = 5 mA	P_5.1.13
Dropout Voltage V_{dr} = V_I - V_Q	V_{dr}	–	175	425	mV	1) I_Q = 250 mA	P_5.1.16
Dropout Voltage V_{dr} = V_I - V_Q	V_{dr}	–	70	170	mV	1) I_Q = 100 mA	P_5.1.17
Power Supply Ripple Rejection	$PSRR$	–	59	–	dB	2) f_{ripple} = 100 Hz V_{ripple} = 0.5 Vpp	P_5.1.18
Overtemperature Shutdown Threshold	$T_{j,sd}$	151	–	200	°C	2) T_j increasing	P_5.1.19
Overtemperature Shutdown Threshold Hysteresis	$T_{j,sdh}$	–	15	–	K	2) T_j decreasing	P_5.1.20

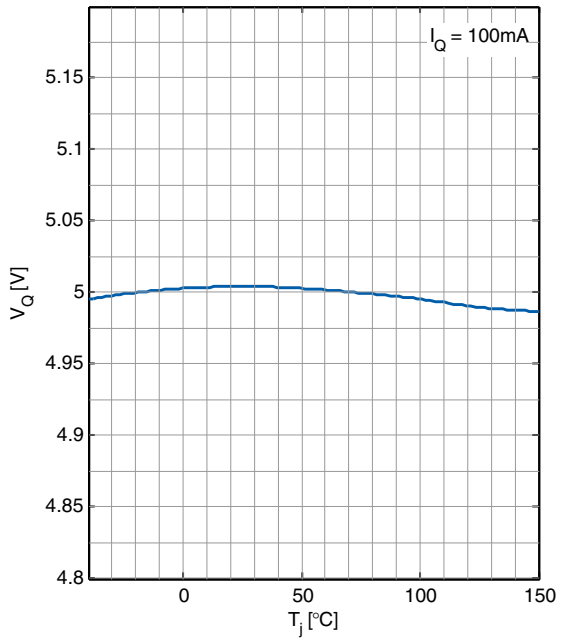
1) Measured when the output voltage V_Q has dropped 100 mV from the nominal value obtained at V_I = 13.5V

2) Not subject to production test, specified by design

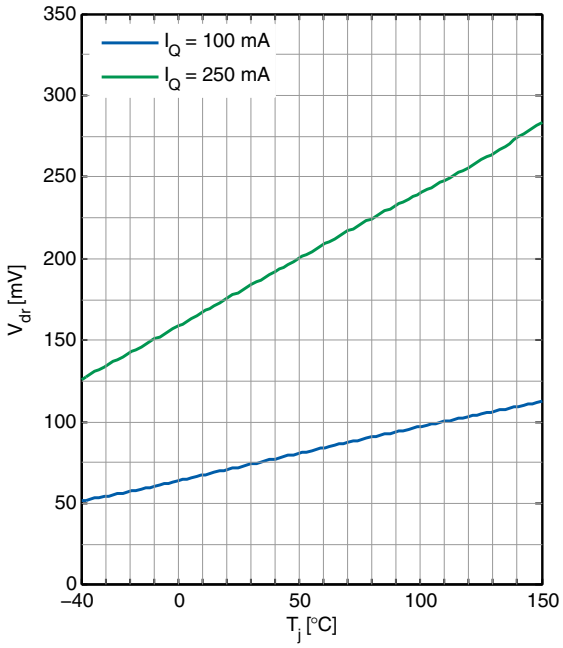
5.2 Typical Performance Characteristics Voltage Regulator

Typical Performance Characteristics

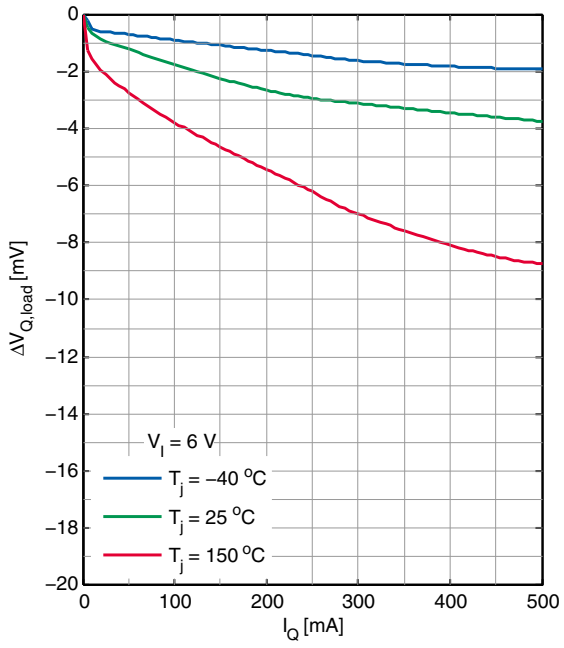
Output Voltage V_Q versus Junction Temperature T_j



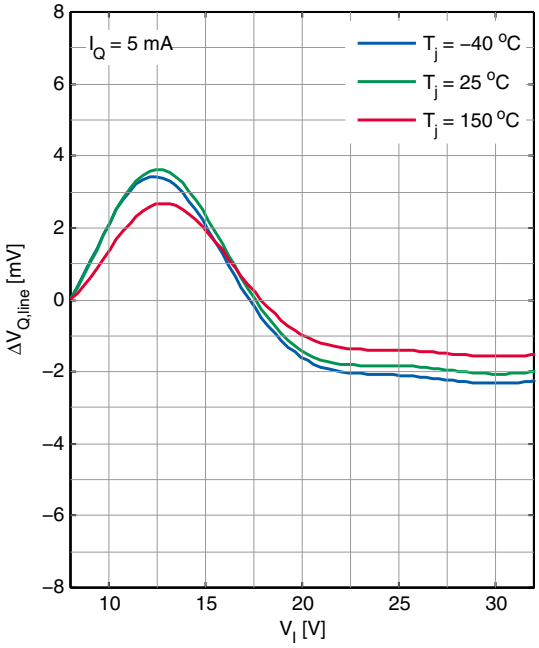
Dropout Voltage V_{dr} versus Junction Temperature T_j



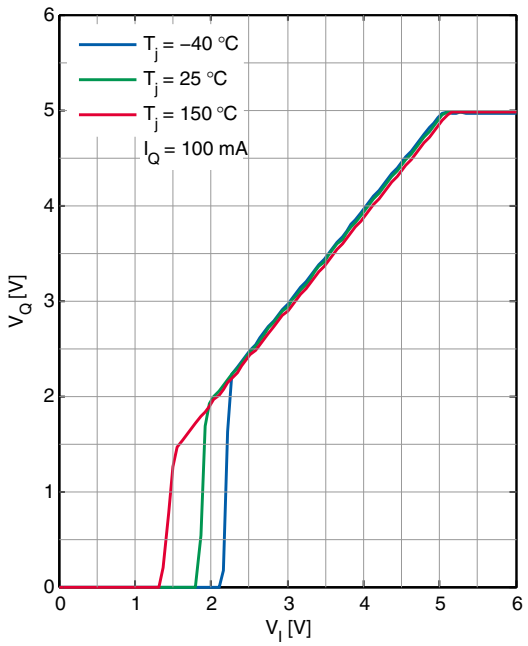
Load Regulation $\Delta V_{Q,load}$ versus Output Current Change I_Q



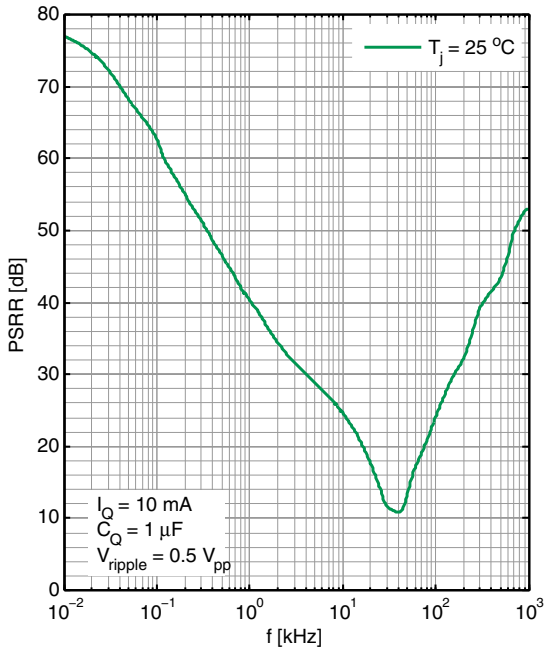
Line Regulation $\Delta V_{Q,line}$ versus Input Voltage V_I



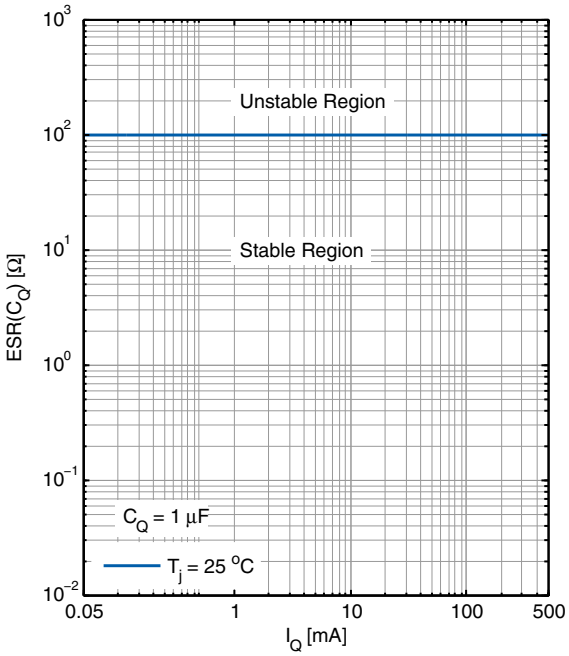
Output Voltage V_Q versus Input Voltage V_I



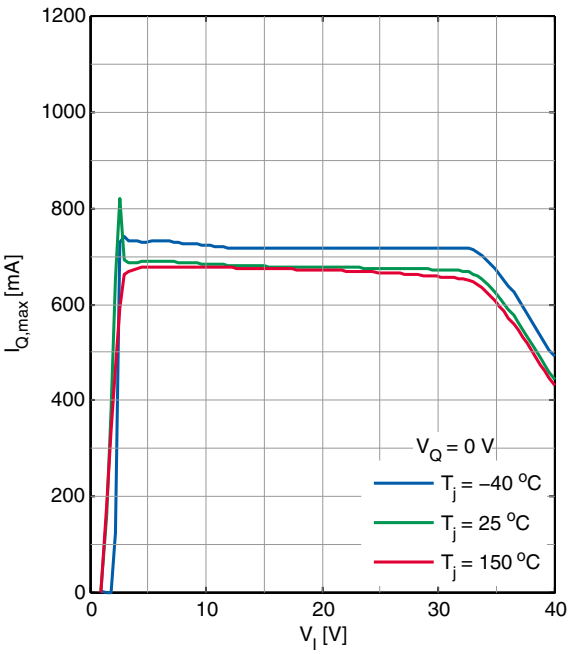
Power Supply Ripple Rejection $PSRR$ versus ripple frequency f



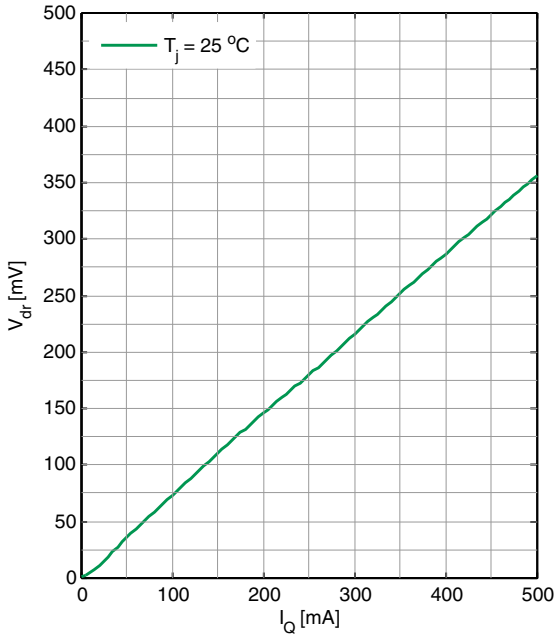
Output Capacitor Series Resistor $ESR(C_Q)$ versus Output Current I_Q



Maximum Output Current I_Q versus Input Voltage V_I



Dropout Voltage V_{dr} versus Output Current I_Q



5.3 Current Consumption

Table 5 Electrical Characteristics Current Consumption

T_j = -40 °C to +150 °C, V_I = 13.5 V (unless otherwise specified)
Typical values are given at T_j = 25 °C
Conditions of other pins: WI = GND

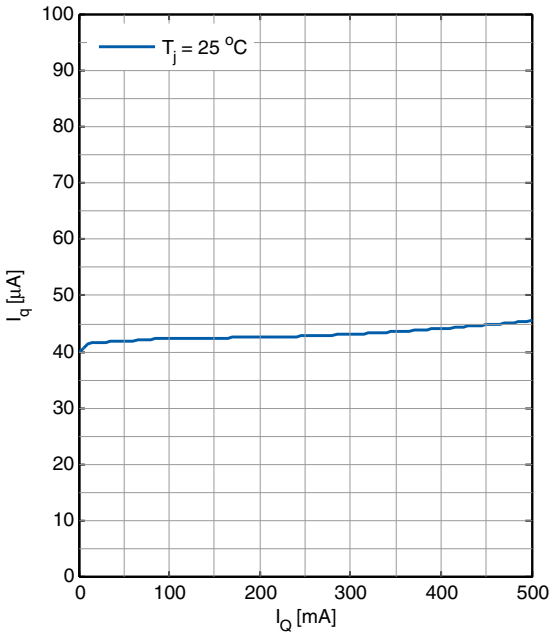
Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Current Consumption $I_q = I_I$	$I_{q,off}$	–	1.3	5	µA	V_{EN} = 0 V; T_j < 105 °C	P_5.3.1
Current Consumption $I_q = I_I$	$I_{q,off}$	–	–	8	µA	V_{EN} = 0.4 V; T_j < 125 °C	P_5.3.3
Current Consumption $I_q = I_I - I_Q$	I_q	–	40	52	µA	I_Q = 0.05 mA T_j = 25 °C	P_5.3.4
Current Consumption $I_q = I_I - I_Q$	I_q	–	62	77	µA	I_Q = 0.05 mA T_j < 125 °C	P_5.3.7
Current Consumption $I_q = I_I - I_Q$	I_q	–	62	82	µA	[1] I_Q = 500 mA T_j < 125 °C	P_5.3.11

1) Not subject to production test, specified by design

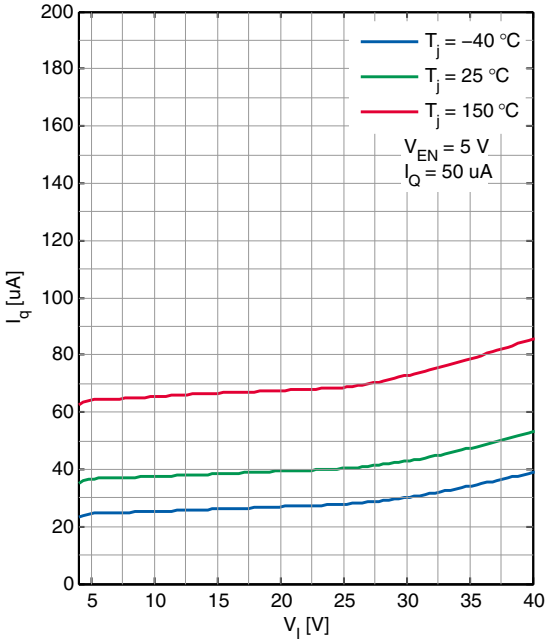
5.4 Typical Performance Characteristics Current Consumption

Typical Performance Characteristics

Current Consumption I_q versus Output Current I_Q



Current Consumption I_q versus Input Voltage V_I



5.5 Enable

The TLS850F0TAV50 can be switched on and off by the Enable feature: Connect a HIGH level as specified below (e.g. the battery voltage) to pin EN to enable the device; connect a LOW level as specified below (e.g. GND) to shut it down. The enable has a built in hysteresis to avoid toggling between ON/OFF state, if signals with slow slopes are applied to the EN input.

Table 6 Electrical Characteristics Enable

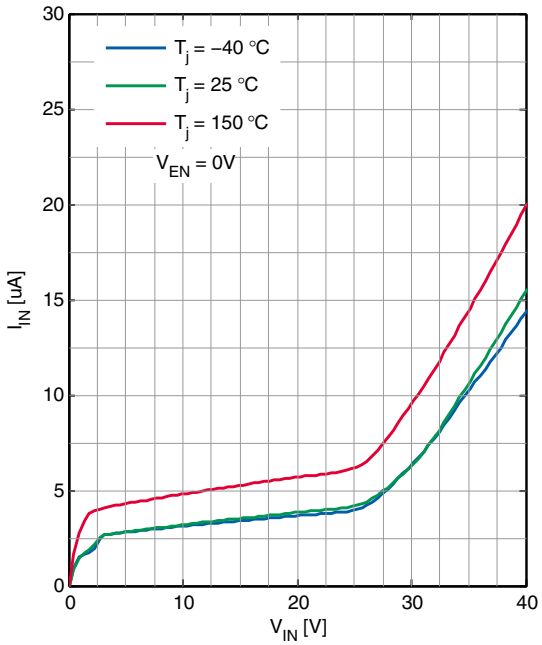
T_j = -40 °C to +150 °C, V_I = 13.5 V, all voltages with respect to ground (unless otherwise specified)
Typical values are given at T_j = 25 °C

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
High Level Input Voltage	$V_{EN,H}$	2	–	–	V	V_Q settled	P_5.5.1
Low Level Input Voltage	$V_{EN,L}$	–	–	0.8	V	V_Q ≤ 0.1 V	P_5.5.2
Enable Threshold Hysteresis	$V_{EN,Hy}$	100	–	–	mV	–	P_5.5.3
High Level Input Current	$I_{EN,H}$	–	–	3.5	µA	V_{EN} = 3.3 V	P_5.5.4
High Level Input Current	$I_{EN,H}$	–	–	22	µA	V_{EN} ≤ 18 V	P_5.5.6
Enable internal pull-down resistor	R_{EN}	0.95	1.5	2.6	MΩ	–	P_5.5.7

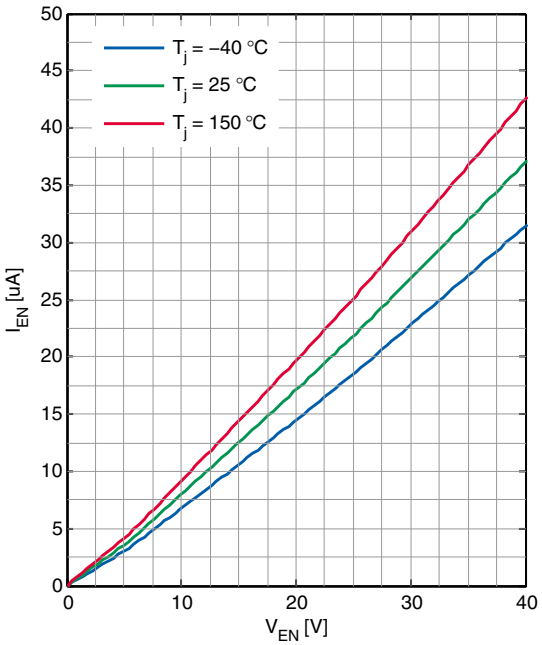
5.6 Typical Performance Characteristics Enable

Typical Performance Characteristics

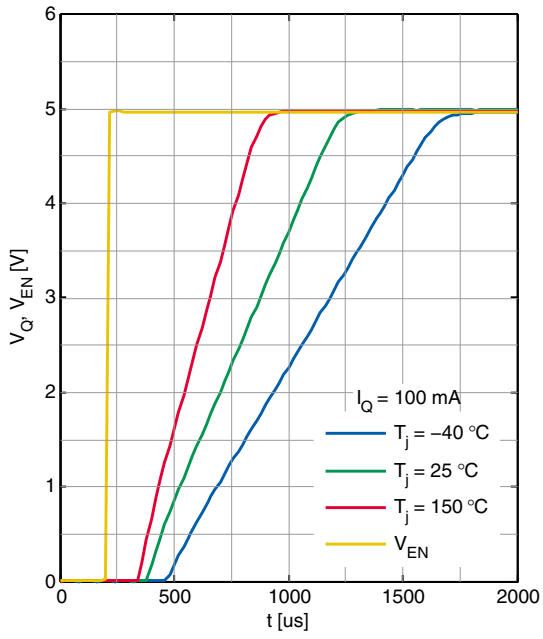
Input Current I_{IN} versus Input Voltage V_{IN} (condition: V_{EN} = 0 V)



Enabled Input Current I_{EN} versus Enabled Input Voltage V_{EN}



Output Voltage V_Q versus time (EN switched ON)



5.7 Reset

The TLS850F0TAV50's output voltage is supervised by the Reset feature, including Undervoltage Reset, delayed Reset at Power-On and an adjustable Reset Threshold.

The Undervoltage Reset function sets the pin RO/WO to LOW, in case V_Q is falling for any reason below the Reset Threshold $V_{RT,low}$.

When the regulator is powered on, the pin RO/WO is held at LOW for the duration of the Power-On Reset Delay Time t_{rd}.

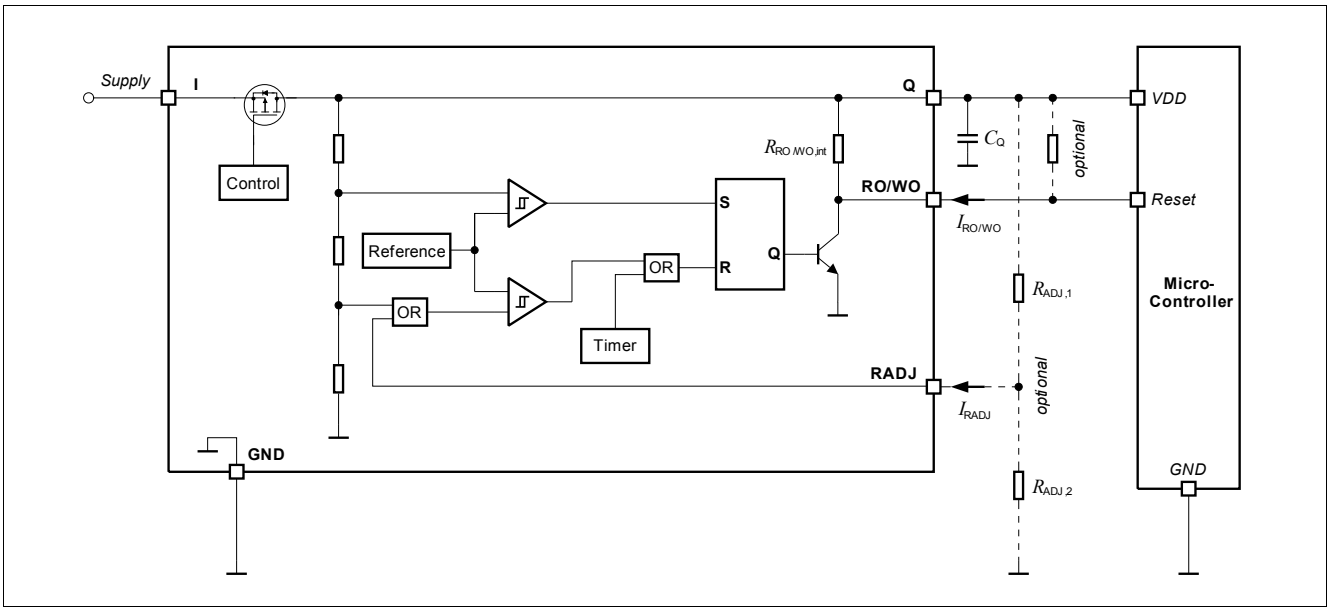


Figure 6 Block Diagram Reset Circuit

Reset Delay Time

The Reset Delay Time t_{rd} is fix defined according to **Table 7**.

Table 7 Reset DelayTime

Reset delay timing	t_{rd}
fix	16.5 ms

Power-On Reset Delay Time

The power-on reset delay time is defined by the parameter t_{rd} and allows a microcontroller and oscillator to start up. This delay time is the time period from exceeding the upper reset switching threshold $V_{RT,high}$ until the reset is released by switching the reset output "RO/WO" from "LOW" to "HIGH".

Undervoltage Reset Delay Time

Unlike the power-on reset delay time, the undervoltage reset delay time is defined by the parameter t_{rd} and considers an output undervoltage event where the output voltage V_Q trigger the $V_{RT,low}$ threshold.

Reset Blanking Time

The reset blanking time $t_{rr,blank}$ avoids that short undervoltage spikes trigger an unwanted reset "low" signal.

Reset Reaction Time

In case the output voltage of the regulator drops below the output undervoltage lower reset threshold $V_{RT,low}$, the reset output “RO/WO” is set to low, after the delay of the internal reset reaction time $t_{rr,int}$. The reset blanking time $t_{rr,blank}$ is part of the reset reaction time $t_{rr,int}$.

Reset Output “RO/WO”

The reset output “RO/WO” is an open collector output with an integrated pull-up resistor. In case a lower-ohmic “RO/WO” signal is desired, an external pull-up resistor can be connected to the output “Q”. Since the maximum “RO/WO” sink current is limited, the minimum value of the optional external resistor “$R_{RO/WO,ext}$” is given in **Table “Reset Output / Watchdog Output RO/WO” on Page 22**.

Reset Output “RO/WO” Low for VQ ≥ 1 V

In case of an undervoltage reset condition reset output “RO/WO” 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.

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. The reset adjustment range for the TLS850F0TAV50 is given in **Reset Threshold Adjustment Range**.

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 (neglecting the Reset Adjust Pin Current I_{RADJ}):

$$V_{RT,lo,new} = V_{RADJ,th} \times (R_{ADJ,1} + R_{ADJ,2}) / R_{ADJ,2} \quad (1)$$

with

- $V_{RT,lo,new}$: Desired undervoltage reset switching threshold.
- $R_{ADJ,1}$, $R_{ADJ,2}$: Resistors of the external voltage divider, see **Figure 6**.
- $V_{RADJ,th}$: Reset adjust switching threshold given in **Reset Adjustment Switching Threshold**.

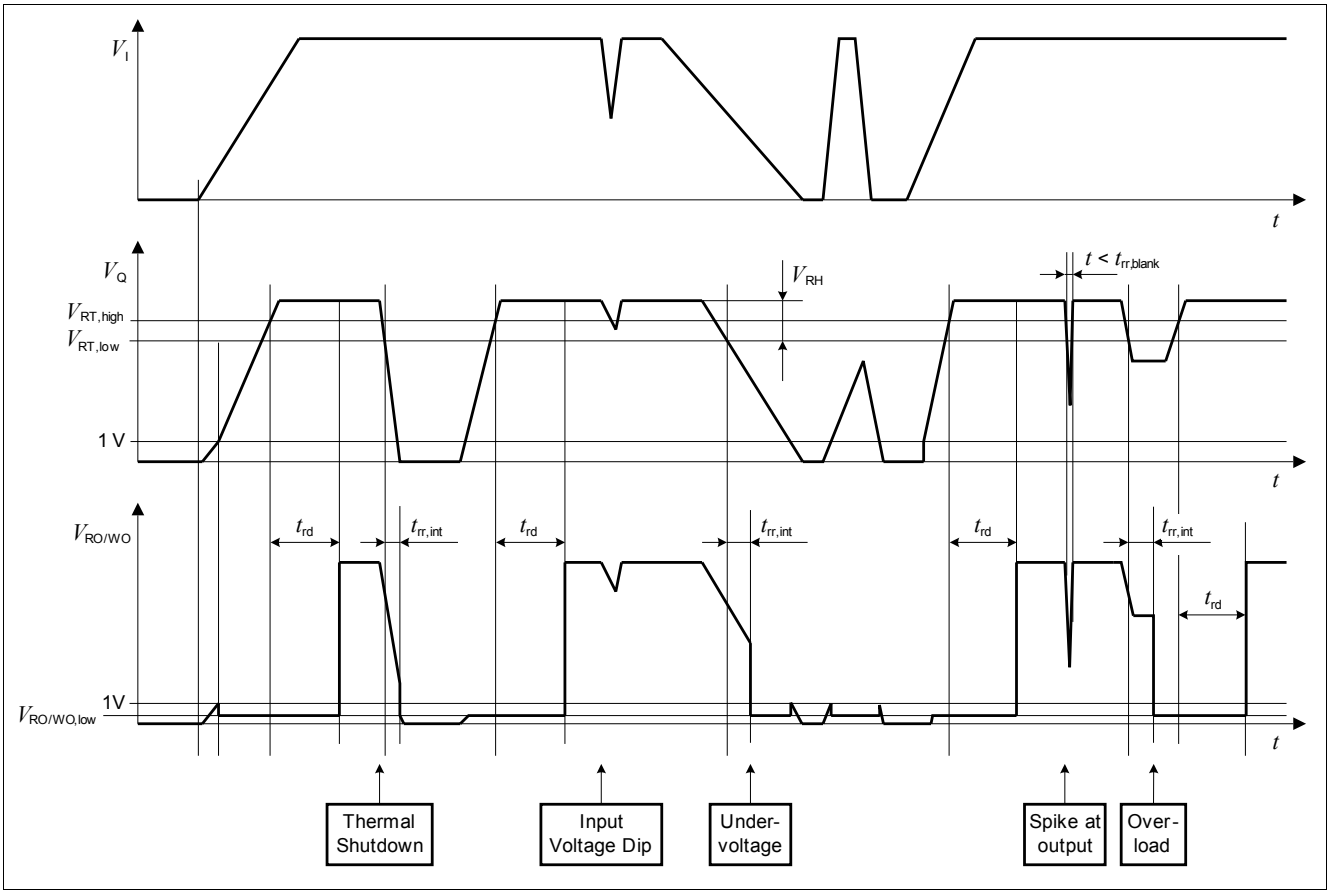


Figure 7 Typical Timing Diagram Reset

Table 8 Electrical Characteristics Reset

T_j = -40 °C to +150 °C, V_I = 13.5 V, all voltages with respect to ground (unless otherwise specified)
Typical values are given at T_j = 25 °C

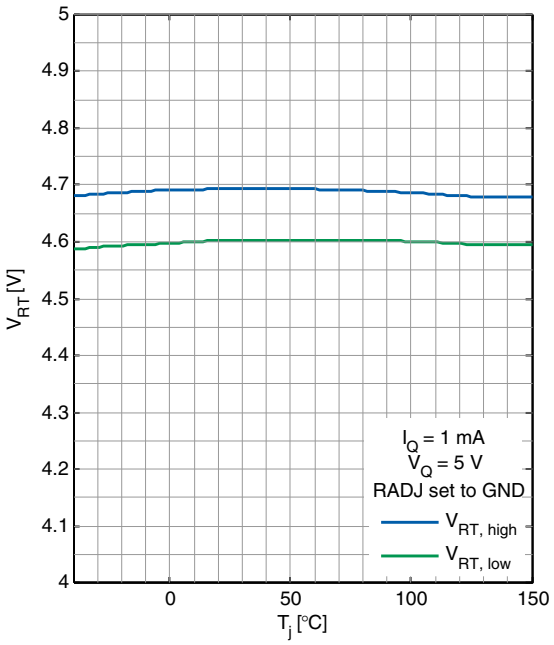
Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Output Undervoltage Reset 5V Version only							
Output Undervoltage Reset Upper Switching Threshold	$V_{RT,high}$	4.6	4.7	4.8	V	V_Q increasing	P_5.7.1
Output Undervoltage Reset Lower Switching Threshold - Default	$V_{RT,low}$	4.5	4.6	4.7	V	V_Q decreasing RADJ = GND	P_5.7.2
Output Undervoltage Reset Switching Hysteresis	$V_{RT,hy}$	60	100	–	mV	RADJ connected to GND	P_5.7.3
Output Undervoltage Reset Headroom V_Q - V_{RT}	V_{RH}	200	400	–	mV	RADJ = GND	P_5.7.4
Reset Threshold Adjustment							
Reset Adjustment Switching Threshold	$V_{RADJ,th}$	1.15	1.20	1.25	V	–	P_5.7.9
Reset Threshold Adjustment Range	$V_{RT,range}$	2.5	–	4.4	V	for $V_{Q,nom}$ = 5 V	P_5.7.10
Reset Output / Watchdog Output RO/WO							
Reset Output Watchdog Output Low Voltage	$V_{RO/WO,low}$	–	0.2	0.4	V	1 V ≤ V_Q ≤ V_{RT}; $R_{RO/WO}$ ≥ 5.1 kΩ	P_5.7.16
Reset Output Watchdog Output Internal Pull-Up Resistor	$R_{RO/WO,int}$	13	20	36	kΩ	internally connected to Q	P_5.7.17
Reset Output Watchdog Output External Pull-up Resistor to V_Q	$R_{RO/WO,ext}$	5.1	–	–	kΩ	1 V ≤ V_Q ≤ V_{RT}; $V_{RO/WO}$ ≤ 0.4 V	P_5.7.18
Reset Delay Timing							
Reset Delay Time	t_{rd}	13.2	16.5	19.8	ms	Fixed Timing	P_5.7.39
Reset blanking time	$t_{rr,blank}$	–	7	–	µs	1) for $V_{Q,nom}$ = 5 V	P_5.7.46
Internal Reset Reaction Time	$t_{rr,int}$	–	10	33	µs	for $V_{Q,nom}$ = 5 V	P_5.7.36

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

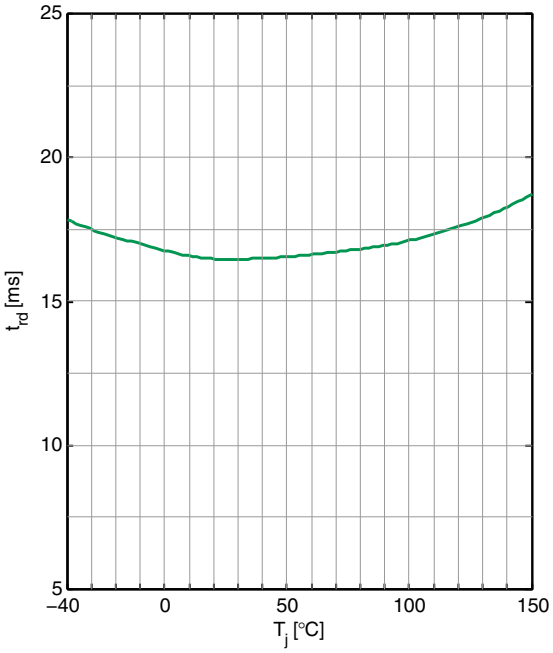
5.8 Typical Performance Characteristics Reset

Typical Performance Characteristics

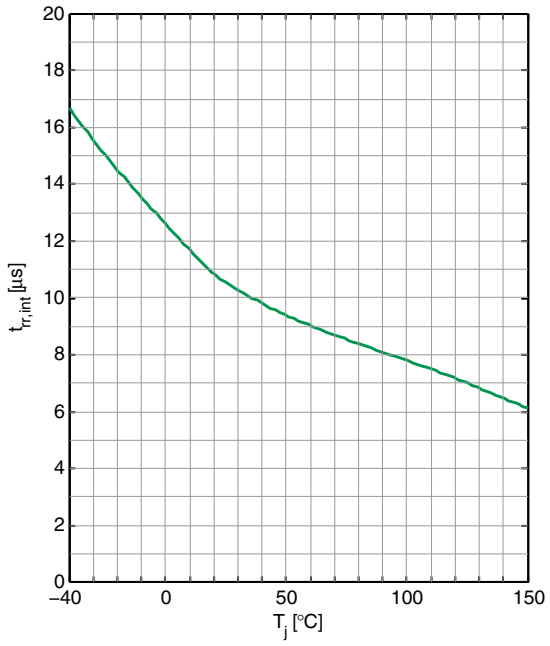
Undervoltage Reset Threshold V_{RT} versus Junction Temperature T_j



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



Internal Reset Reaction Time $t_{rr,int}$ versus Junction Temperature T_j



5.9 Standard Watchdog

The TLS850F0TAV50 features a load dependent watchdog function. The watchdog function monitors a microcontroller, including time base failures. In case of a missing falling edge within a certain pulse repetition time, the watchdog output “RO/WO” is set to “low”.

The watchdog uses an internal oscillator as timebase. The effective trigger window is derived from the watchdog timebase.

The watchdog output signal is provided by a combined Reset Output / Watchdog Output “RO/WO” pin.

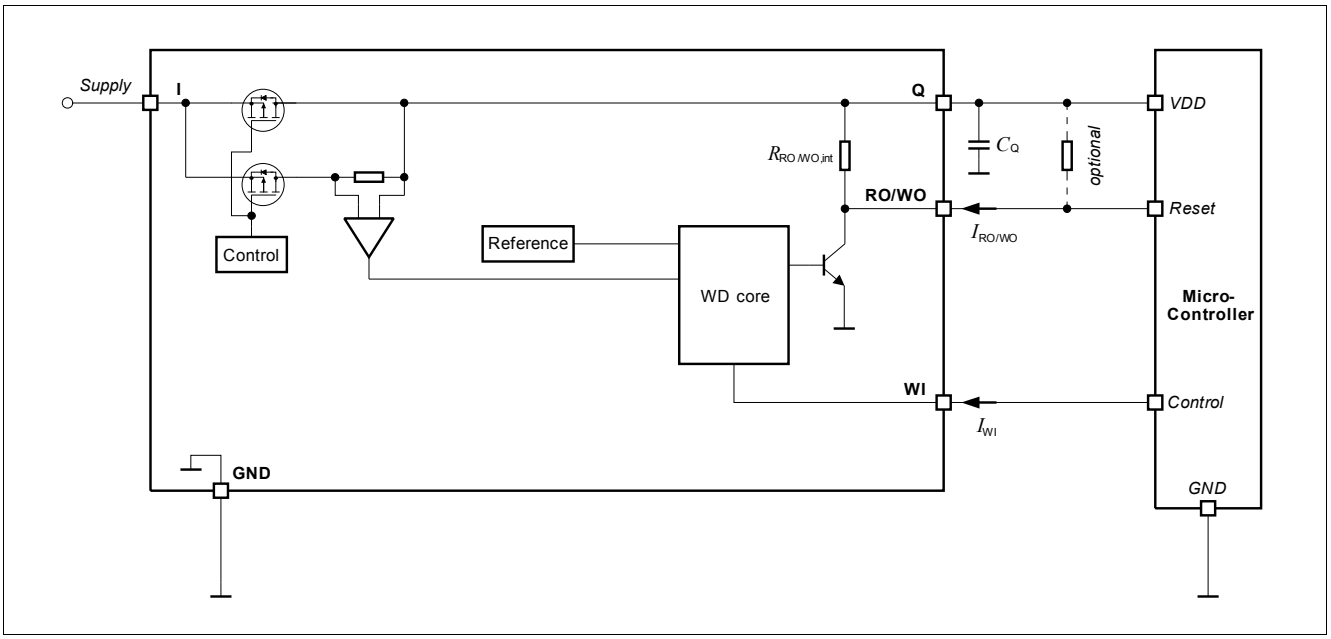


Figure 8 Block Diagram Watchdog Circuit

Watchdog Timing

Figure 9 shows the state diagram of the watchdog (WD) and the mode selection. After power-on, the reset output signal at the “RO/WO” pin (microcontroller reset) is kept LOW for the reset delay time t_{rd}. With the LOW to HIGH transition of the signal at “RO/WO” the device starts the watchdog ignore time $t_{WI,i}$. Next, the WD starts the watchdog trigger time (time frame within a trigger at WI must occur).

From now on, the timing of the signal on WI from the microcontroller must fit to the WD-trigger time $t_{WI,tr}$. A Re-Trigger of the WD-trigger time is done with a HIGH-to-LOW transient at the WI-pin within the active $t_{WI,tr}$.

Watchdog Output “RO/WO”

The watchdog output “RO/WO” is an open collector output with an integrated pull-up resistor. In case a lower-ohmic “RO/WO” signal is desired, an external pull-up resistor can be connected to the output “Q”. Since the maximum “RO/WO” sink current is limited, the minimum value of the optional external resistor “$R_{RO/WO,ext}$” is given in **Table “Reset Output / Watchdog Output RO/WO” on Page 22**. A HIGH to LOW transition of the watchdog trigger signal on pin WI is taken as a trigger. A watchdog signal is generated (“RO/WO” goes LOW), if there is no trigger pulse during the Watchdog trigger time.

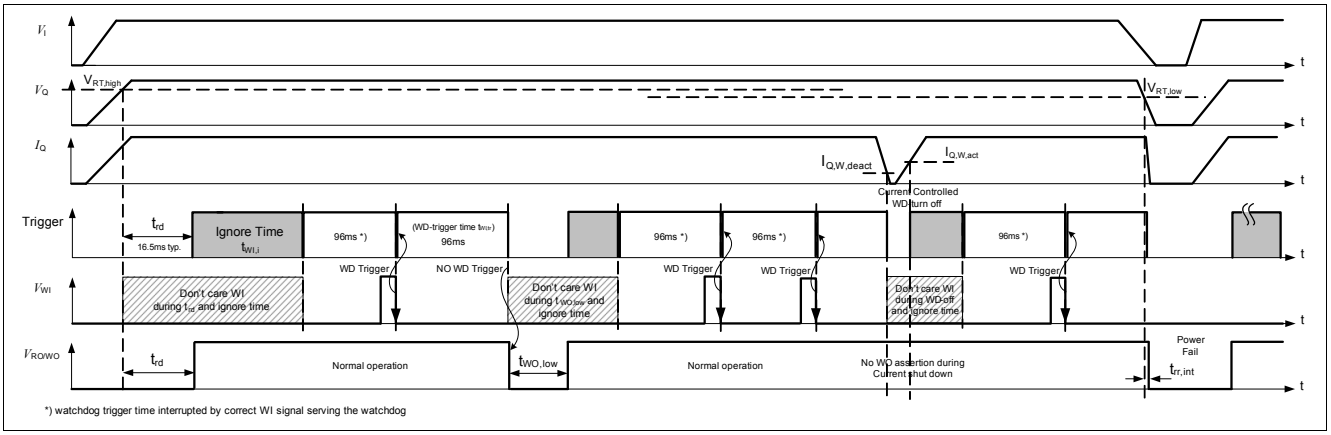


Figure 9 Typical Watchdog Timing Diagram, Watchdog and Reset Modes

Watchdog Input "WI"

The watchdog is triggered by a falling edge at the watchdog input pin "WI". The amplitude and slope of this signal has to comply with the specification (**Table "Watchdog Input WI" on Page 26**). For details regarding test pulses, see **Figure 10 "Test Pulses Watchdog Input WI" on Page 25**.

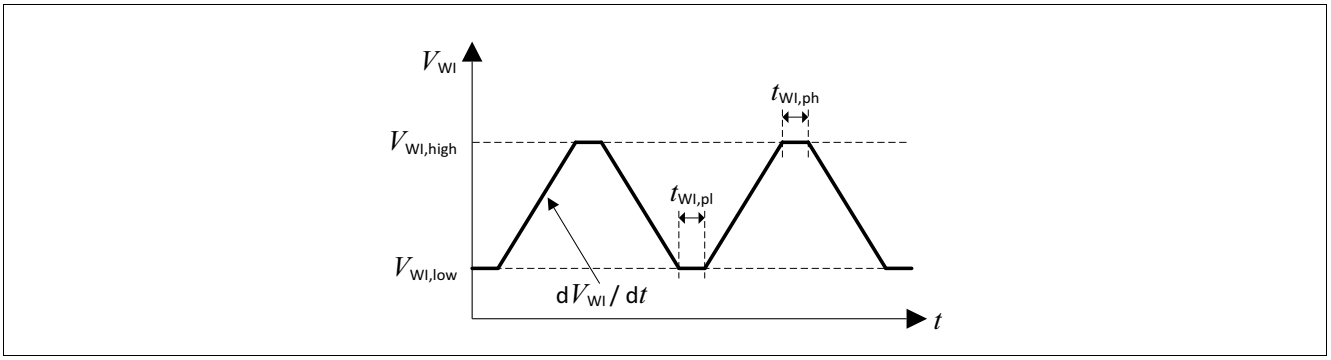


Figure 10 Test Pulses Watchdog Input WI