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# OPTIREG™ Linear TLS102B0MB

## High Precision Voltage Tracker

AEC Qualified RoHS

## Features



- 20 mA current capability
- Very high accuracy tracking
- Output voltage adjustable down to 2.0 V
- Stable with ceramic output capacitors
- Very low dropout voltage of typically 120 mV at 20 mA
- Very low current consumption of typically 3 µA in off mode
- Wide input voltage range -16 V ≤ $V_{IN}$ ≤ 45 V
- Wide temperature range: -40°C ≤ $T_j$ ≤ 150°C
- Short circuit protected output (to GND and to battery)
- Reverse polarity protected input
- Overtemperature protection
- Green Product (RoHS compliant)

## Potential applications

- Automotive sensor supply
- Protected sensor supply for off-board sensors
- Secondary voltage supply for automotive ECU
- High precision voltage tracking
- Precision voltage replication
- Power switch for off-board load

## Product validation

Qualified for Automotive Applications.
Product validation according to AEC-Q100/101.

## Description

The OPTIREG™ Linear TLS102B0MB is a monolithic integrated low-dropout voltage tracking regulator with high accuracy in small PG-SCT595-5 package. The TLS102B0MB is designed to supply off-board systems, for example sensors in powertrain management systems under the severe conditions of automotive applications. Therefore, the TLS102B0MB is equipped with additional protection functions against reverse polarity as well as short circuit to GND and battery. Up to a supply voltage of 40 V and up to an output current of 20 mA the output voltage follows the reference voltage applied to the EN/ADJ input with very high accuracy. The required minimum reference voltage at EN/ADJ is 2.0 V.

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## Description

| Type | Package | Marking |
|---|---|---|
| TLS102B0MB | PG-SCT595-5 | 02 |

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# Table of contents


**Features** . . . 1
**Potential applications** . . . 1
**Product validation** . . . 1
**Description** . . . 1
**Table of contents** . . . 3
**1 Block diagram** . . . 4
**2 Pin configuration** . . . 5
2.1 Pin assignment TLS102B0MB in PG-SCT595-5 package . . . 5
2.2 Pin definitions and functions PG-SCT595-5 . . . 5
**3 General product characteristics** . . . 6
3.1 Absolute maximum ratings . . . 6
3.2 Functional range . . . 7
3.3 Thermal resistance . . . 7
**4 Block description and electrical characteristics** . . . 8
4.1 Tracking regulator . . . 8
4.2 Typical performance characteristics tracking regulator . . . 11
4.3 Current consumption . . . 14
4.4 Typical performance characteristics current consumption . . . 15
4.5 Enable/Adjust input . . . 17
4.6 Typical performance characteristics Enable/Adjust input . . . 17
**5 Application information** . . . 18
5.1 Application diagram . . . 18
5.2 Selection of external components . . . 18
5.2.1 Input pin . . . 18
5.2.2 Output pin . . . 19
5.2.3 Enable/Adjust pin . . . 19
5.3 Thermal considerations . . . 19
**6 Package information** . . . 21
**Revision history** . . . 22
**Disclaimer** . . . 23

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# 1 Block diagram

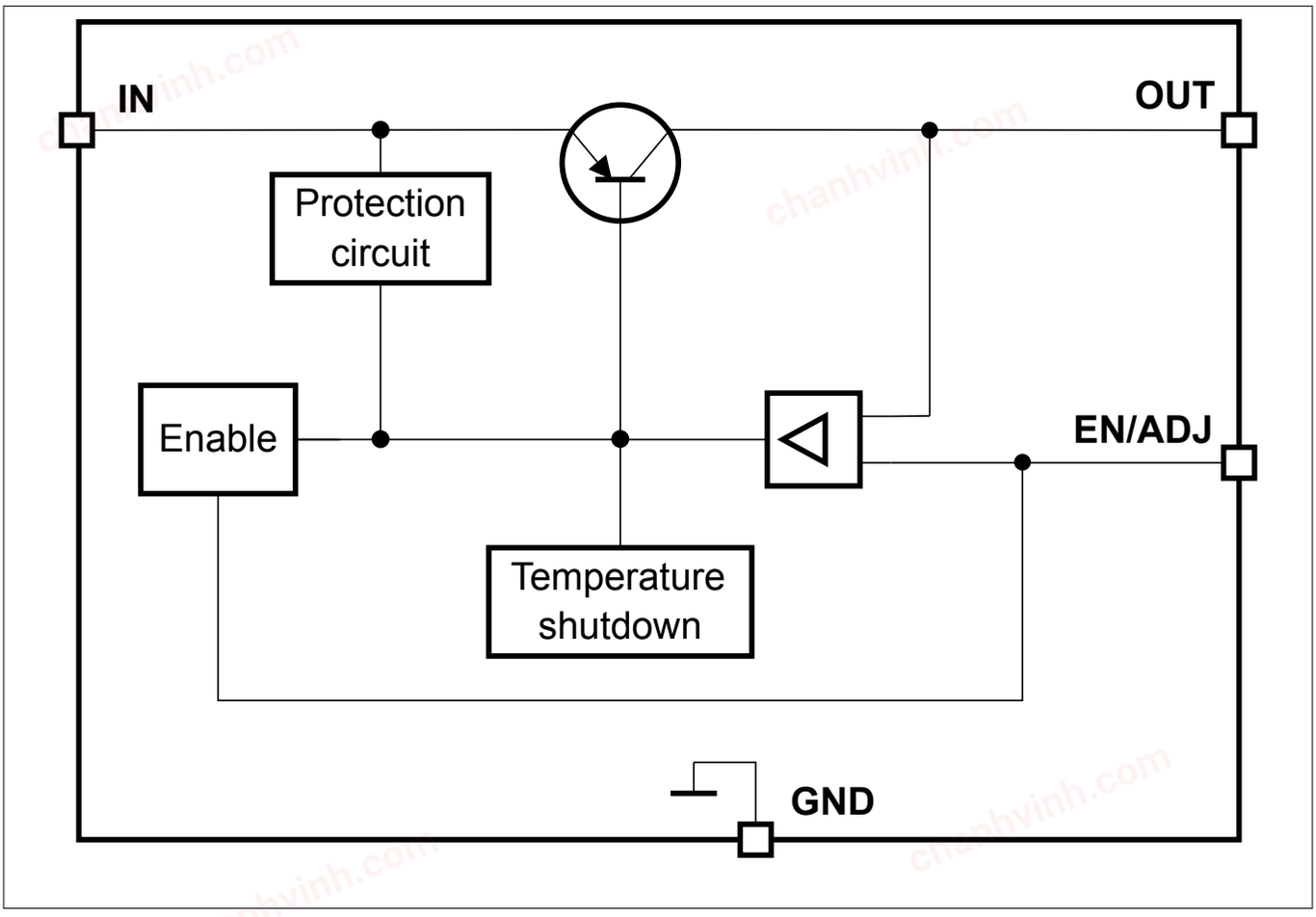



**Figure 1 Block diagram**

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# 2 Pin configuration

## 2.1 Pin assignment TLS102B0MB in PG-SCT595-5 package

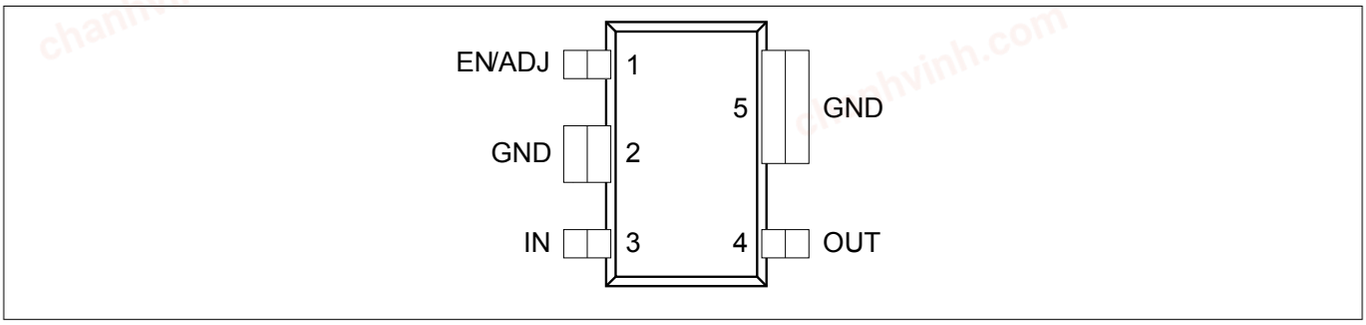



**Figure 2 Pin configuration**

## 2.2 Pin definitions and functions PG-SCT595-5

**Table 1 Pin definitions and functions**

| Pin | Symbol | Function |
|---|---|---|
| 1 | EN/ADJ | **Enable / Adjust**<br>Connect the reference voltage to this pin. The reference voltage can be connected directly or via a voltage divider for lower output voltages. For the compensation of disturbances on the line, a capacitor close to the IC pins is recommended.<br>"low" signal disables the device<br>"high" signal enables the device |
| 2 | GND | **Ground**<br>Internally connected to pin 5. Connect to heatsink area. |
| 3 | IN | **Input**<br>Compensating line disturbances with a small ceramic capacitor to GND close to the IC terminals is recommended. |
| 4 | OUT | **Tracker output**<br>20 mA output current capability<br>Connect a capacitor to GND close to the pin, in accordance with capacitance and ESR requirements described in ***Table 3***. |
| 5 | GND | **Ground**<br>Internally connected to pin 2. Connect to heatsink area. |

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# 3 General product characteristics

## 3.1 Absolute maximum ratings

**Table 2 Absolute maximum ratings[1)]**

$T_j$ = -40°C to 150°C; all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

| Parameter | Symbol | Values | | | Unit | Note or condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| **Voltages** | | | | | | | |
| Input voltage | $V_{IN}$ | -16 | – | 45 | V | – | P_3.1.1 |
| Enable/Adjust voltage | $V_{EN/ADJ}$ | -0.3 | – | 45 | V | – | P_3.1.2 |
| Output voltage | $V_{OUT}$ | -5 | – | 45 | V | – | P_3.1.3 |
| Input output voltage difference | $V_{IN}$-$V_{OUT}$ | -30 | – | 45 | V | – | P_3.1.4 |
| **Temperatures** | | | | | | | |
| Junction temperature | $T_j$ | -40 | – | 150 | °C | – | P_3.1.5 |
| Storage temperature | $T_{stg}$ | -55 | – | 150 | °C | – | P_3.1.6 |
| **ESD absorption** | | | | | | | |
| ESD absorption | $V_{ESD,HBM}$ | -2 | – | 2 | kV | Human Body Model (HBM)[2)] | P_3.1.7 |
| ESD absorption | $V_{ESD,CDM}$ | -1 | – | 1 | kV | Charged Device Model (CDM)[3)] | P_3.1.8 |
| ESD absorption | $V_{ESD,CDM}$ | -1 | – | 1 | kV | Charged Device Model (CDM) at corner pins[3)] | P_3.1.9 |

*Notes:*

1. *Stresses above the ones listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods of time 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” the normal operating range. Protection functions are not designed for continuous repetitive operation.*

1 Not subject to production test, specified by design.
2 ESD susceptibility, HBM according to ANSI/ESDA/JEDEC JS001 (1.5k Ω, 100 pF)
3 ESD susceptibility, Charged Device Model “CDM” ESDA STM5.3.1 or ANSI/ESD S.5.3.1

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## 3.2 Functional range

**Table 3 Functional range**

| Parameter | Symbol | Values | | | Unit | Note or condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| Input voltage range | $V_{IN}$ | 4 | – | 40 | V | – | P_3.2.1 |
| Adjust input voltage range (Voltage tracking range) | $V_{ADJ}$ | 2 | – | 20 | V | – | P_3.2.2 |
| Output capacitor's capacitance required for stability | $C_{OUT}$ | 1 | – | – | µF | –[4] | P_3.2.3 |
| Output capacitor's ESR required for stability | $ESR_{C_{OUT}}$ | – | – | 3 | Ω | –[5] | P_3.2.4 |
| Junction temperature | $T_j$ | -40 | – | 150 | °C | – | P_3.2.5 |

*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.*

## 3.3 Thermal resistance

**Table 4 Thermal resistance[6]**

| Parameter | Symbol | Values | | | Unit | Note or condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| Junction to ambient | $R_{thJA}$ | – | 84 | – | K/W | [7] | P_3.3.1 |
| Junction to ambient | $R_{thJA}$ | – | 228 | – | K/W | Footprint only[8] | P_3.3.2 |
| Junction to ambient | $R_{thJA}$ | – | 123 | – | K/W | 300 mm² PCB heatsink area[8] | P_3.3.3 |
| Junction to ambient | $R_{thJA}$ | – | 109 | – | K/W | 600 mm² PCB heatsink area[8] | P_3.3.4 |
| Junction to soldering point | $R_{thJSP}$ | – | 32 | – | K/W | Pins 2, 5 fixed to $T_A$ | P_3.3.5 |

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

4 The minimum output capacitance requirement is applicable for a worst case capacitance tolerance of 30%
5 Relevant ESR value at $f$ = 10 kHz.
6 Not subject to production test, specified by design.
7 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 two inner copper layers (2 × 70 µm Cu, 2 × 35 µm Cu). Where applicable, a thermal via array next to the package contacted the first inner copper layer.
8 Package mounted on PCB FR4; 80 × 80 × 1.5 mm³; 35 µm Cu, 5 µm Sn; horizontal position; zero airflow.

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# 4 Block description and electrical characteristics

## 4.1 Tracking regulator

The regulator controls the output voltage $V_{OUT}$ by comparing it to the reference voltage applied to the EN/ADJ pin and driving a PNP pass transistor accordingly. The stability of the control loop depends on the following parameters:

- output capacitor $C_{OUT}$
- load current
- IC temperature
- poles and zeroes in the frequency response of the circuit including TLS102B0MB
- external circuitry

To ensure stable operation, the output capacitor's capacitance and its equivalent series resistance *ESR* must meet the requirements given in ***Table 3***. Also the output capacitor must be sized suitably to buffer load transients.

An input capacitor $C_{IN}$ is strongly recommended to buffer disturbances on the line.

Connect each capacitor close to the pins.

Protection circuitry prevents the TLS102B0MB itself as well as the application from destruction in case of catastrophic events. These safeguards contain the following:

- output current limitation
- reverse polarity protection
- thermal shutdown

### Output current limitation

In order to protect the pass element and the package from excessive power dissipation the TLS102B0MB limits the maximum output current at high input voltage.

### Reverse polarity protection

The TLS102B0MB allows a negative supply voltage. However, in reverse polarity condition several small currents flow into the TLS102B0MB causing an increase in the junction temperature. Thermal design must consider this effect, as the overtemperature protection circuit does not operate in reverse polarity condition.

### Thermal shutdown

The overtemperature protection circuit prevents immediate destruction of the TLS102B0MB in certain fault conditions (for example a continuous short circuit at output) by switching off the power stage. As soon as the IC cools down sufficiently, the regulator restarts. If the fault is not removed, this then leads to an oscillatory behavior of the output voltage. Please note, that a junction temperature above 150°C is outside the maximum ratings and reduces the lifetime of the TLS102B0MB.

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### Table 5 Electrical characteristics tracking regulator

$V_{IN}$ = 13.5 V, 2.0 V ≤ $V_{EN/ADJ}$ ≤ 20 V, $T_j$ = -40°C to 150°C, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified).

| Parameter | Symbol | Values | | | Unit | Note or condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| **Tracking output** | | | | | | | |
| Output voltage tracking accuracy<br>$\Delta V_{OUT} = V_{ADJ} - V_{OUT}$ | $\Delta V_{OUT}$ | -5 | – | 5 | mV | 4 V ≤ $V_{IN}$ ≤ 32 V;<br>0.1 mA ≤ $I_{OUT}$ ≤ 20 mA;<br>2 V ≤ $V_{EN/ADJ}$ ≤ $V_{IN}$ - 0.5 V; $V_{EN/ADJ}$ ≤ 20 V | P_4.1.2 |
| Output voltage tracking accuracy<br>$\Delta V_{OUT} = V_{ADJ} - V_{OUT}$ | $\Delta V_{OUT}$ | -5 | – | 5 | mV | 4 V ≤ $V_{IN}$ ≤ 40 V;<br>0.1 mA ≤ $I_{OUT}$ ≤ 10 mA;<br>2 V ≤ $V_{EN/ADJ}$ ≤ $V_{IN}$ - 0.5 V; $V_{EN/ADJ}$ ≤ 20 V | P_4.1.3 |
| Load regulation<br>steady-state | $\Delta V_{OUT,load}$ | -3 | – | – | mV | $I_{OUT}$ = 0.1 mA to 20 mA;<br>$V_{EN/ADJ}$ = 5 V | P_4.1.4 |
| Line regulation<br>steady-state | $\Delta V_{OUT,line}$ | – | – | 3 | mV | $V_{IN}$ = 5.5 V to 32 V;<br>$I_{OUT}$ = 10 mA;<br>$V_{EN/ADJ}$ = 5 V | P_4.1.5 |
| Power supply ripple rejection[1)] | *PSRR* | – | 100 | – | dB | $f_{ripple}$ = 100 Hz;<br>$V_{ripple}$ = 1 $V_{pp}$;<br>$I_{OUT}$ = 10 mA;<br>$C_{OUT}$ = 10 µF, ceramic type | P_4.1.6 |
| Output current limitation | $I_{OUT,max}$ | 21 | 75 | 120 | mA | $V_{OUT}$ = $V_{ADJ}$ - 0.1 V;<br>$V_{EN/ADJ}$ = 5 V | P_4.1.7 |
| Reverse current | $I_{OUT,rev}$ | -1 | -0.3 | – | mA | $V_{IN}$ = 0 V;<br>$V_{OUT}$ = 16 V;<br>$V_{EN/ADJ}$ = 5 V | P_4.1.10 |
| Reverse current at negative input voltage | $I_{IN,rev}$ | -8 | -4 | – | mA | $V_{IN}$ = -16 V;<br>$V_{OUT}$ = 0 V;<br>$V_{EN/ADJ}$ = 5 V | P_4.1.11 |
| Dropout voltage[2)]<br>$V_{dr} = V_{IN} - V_{OUT}$ | $V_{dr}$ | – | 120 | 300 | mV | $I_{OUT}$ = 20 mA;<br>$V_{EN/ADJ}$ = 5 V | P_4.1.12 |

1 Not subject to production test, specified by design.
2 Measured when the output voltage $V_Q$ has dropped 100 mV from the nominal value obtained at $V_I$ = 13.5 V.

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**Table 6 Electrical characteristics tracking regulator**

$V_{IN}$ = 13.5 V, 2.0 V ≤ $V_{EN/ADJ}$ ≤ 20 V, $T_j$ = -40°C to 150°C, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified).

| Parameter | Symbol | Values | | | Unit | Note or condition | Number |
|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | | |
| **Overtemperature protection**[1)] | | | | | | | |
| Overtemperature shutdown threshold | $T_{j,sd}$ | – | 175 | – | °C | $T_j$ increasing due to power dissipation generated by the device | P_4.1.16 |
| Overtemperature shutdown threshold hysteresis | $T_{j,sdh}$ | – | 15 | – | °C | | P_4.1.17 |

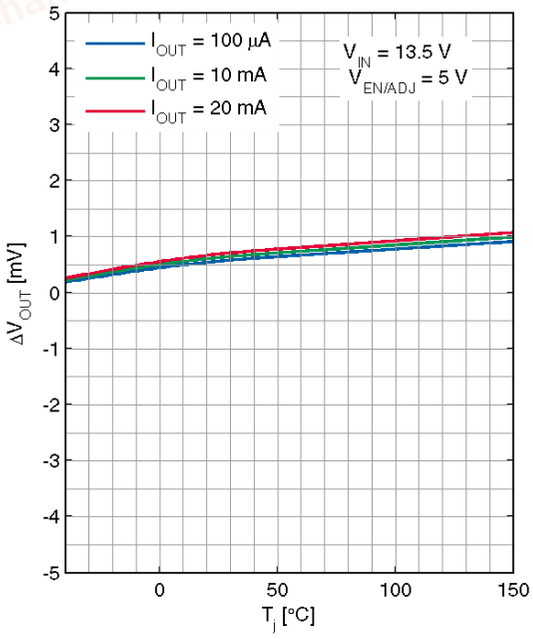
1 Not subject to production test, specified by design.

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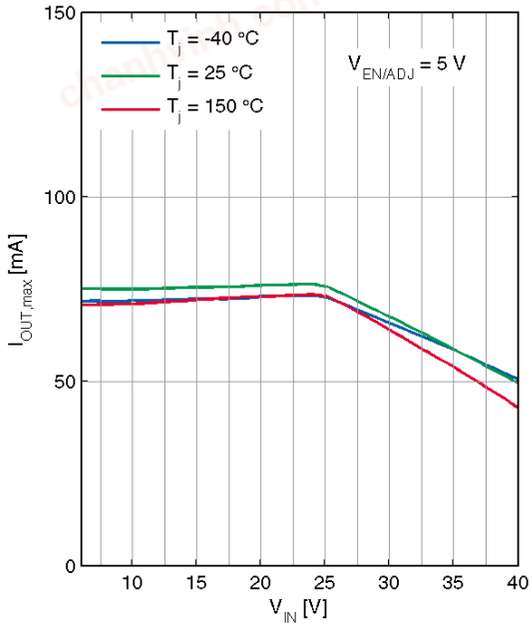


## 4.2 Typical performance characteristics tracking regulator

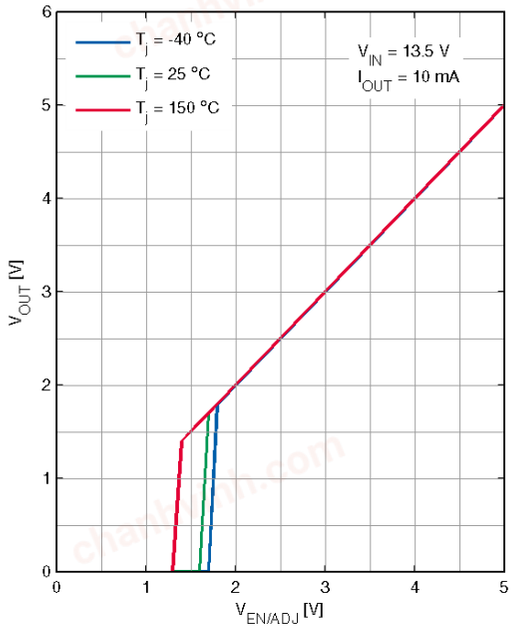
Tracking accuracy $\Delta V_{OUT}$ versus junction temperature $T_j$



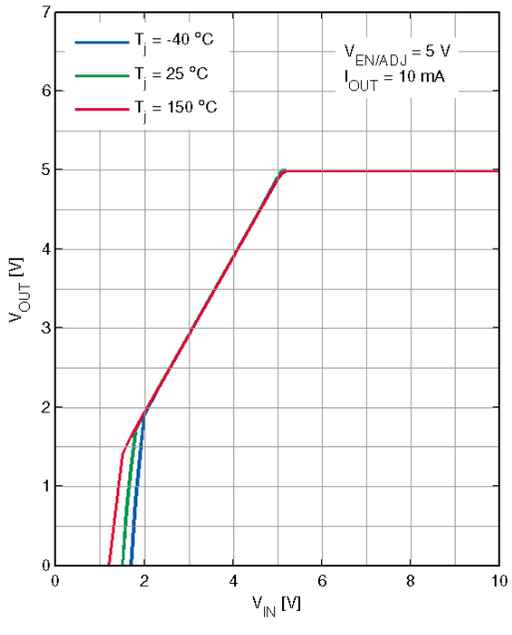

Output current limitation $I_{OUT,max}$ versus input voltage $V_{IN}$




Output voltage $V_{OUT}$ versus Enable/Adjust voltage $V_{EN/ADJ}$



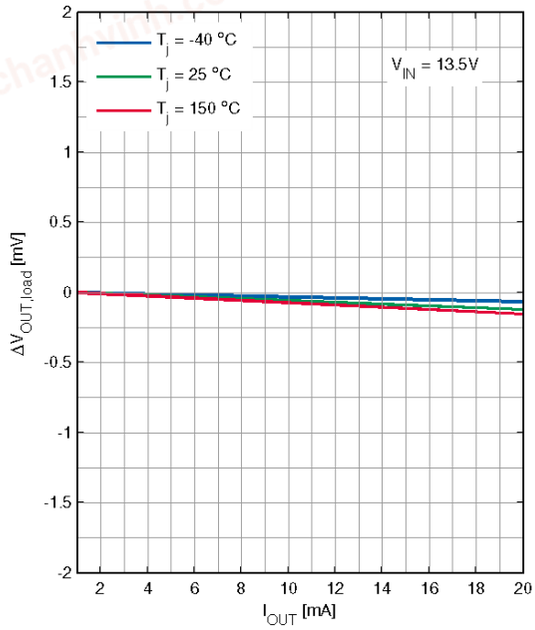

Output voltage $V_{OUT}$ versus input voltage $V_{IN}$



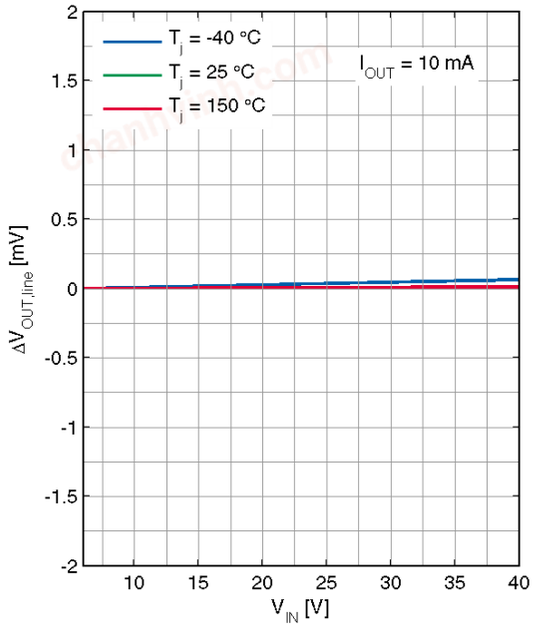
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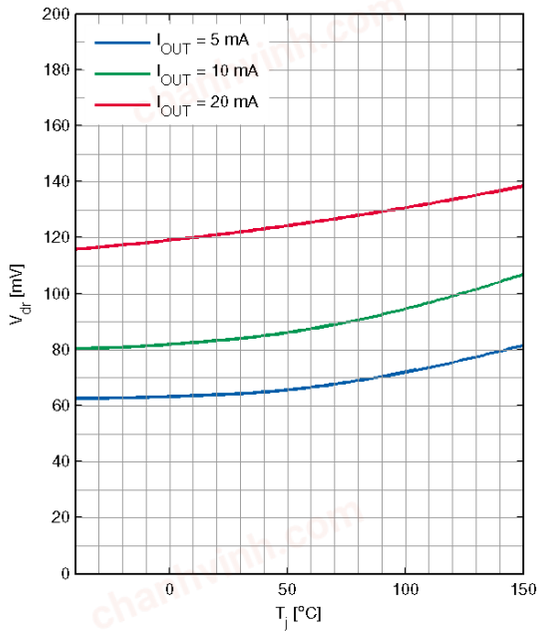
Load regulation $\Delta V_{OUT,load}$ versus output current $I_{OUT}$



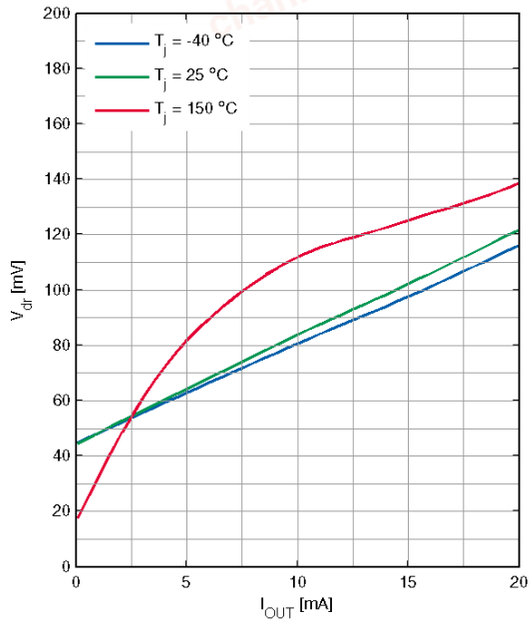

Line regulation $\Delta V_{OUT,line}$ versus input voltage $V_{IN}$




Dropout voltage $V_{dr}$ versus junction temperature $T_j$



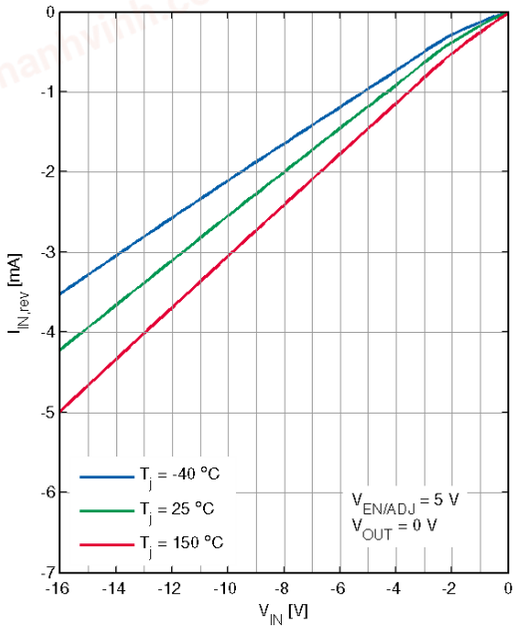

Dropout voltage $V_{dr}$ versus output current $I_{OUT}$



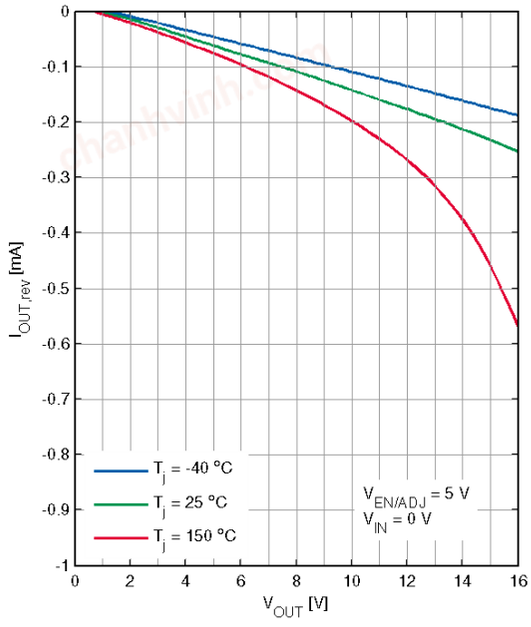
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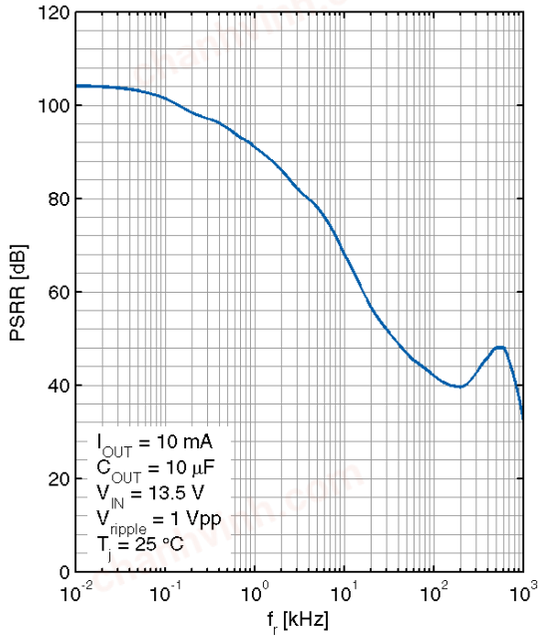
Reverse input current $I_{IN,rev}$ versus input voltage $V_{IN}$



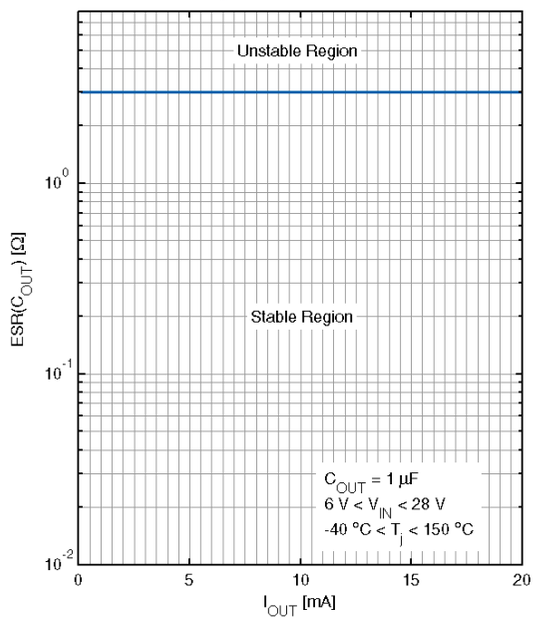

Reverse output current $I_{OUT,rev}$ versus output voltage $V_{OUT}$




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




Output capacitor Equivalent Series Resistance $ESR_{C_{OUT}}$ versus output current $I_{OUT}$



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## 4.3 Current consumption

**Table 7 Electrical Characteristics Current Consumption**

$V_{IN}$ = 13.5 V, 2.0 V ≤ $V_{EN/ADJ}$ ≤ 20 V,$T_j$ = -40°C to 150°C, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified).

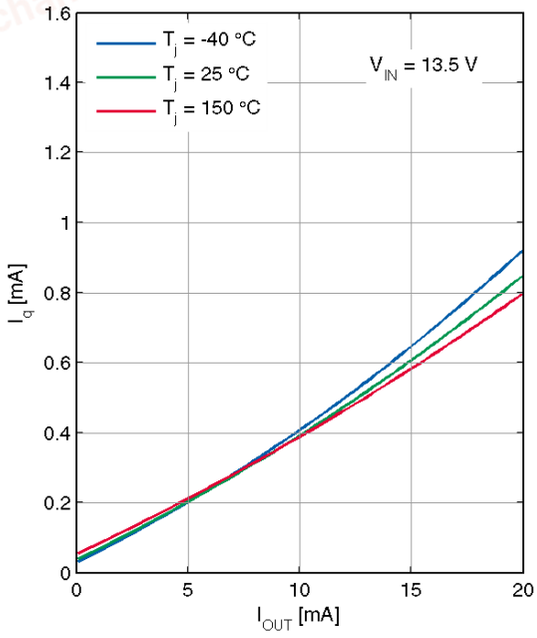
| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Current consumption<br>stand-by mode<br>$I_{q,off} = I_{IN}$ | $I_{q,off}$ | – | 3 | 4.5 | µA | $V_{EN/ADJ}$ ≤ 0.4 V;<br>$T_j$ ≤ 125 °C |
| Current consumption<br>$I_q = I_{IN} - I_{OUT}$ | $I_q$ | – | 40 | 75 | µA | $I_{OUT}$ ≤ 0.1 mA;<br>$V_{EN/ADJ}$ = 5 V;<br>$T_j$ ≤ 125°C |
| Current consumption<br>$I_q = I_{IN} - I_{OUT}$ | $I_q$ | – | 1 | 1.5 | mA | $I_{OUT}$ ≤ 20 mA;<br>$V_{EN/ADJ}$ = 5 V |

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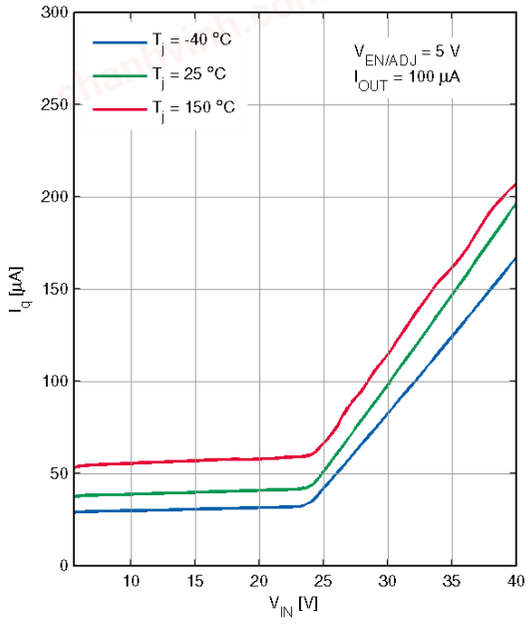


## 4.4 Typical performance characteristics current consumption

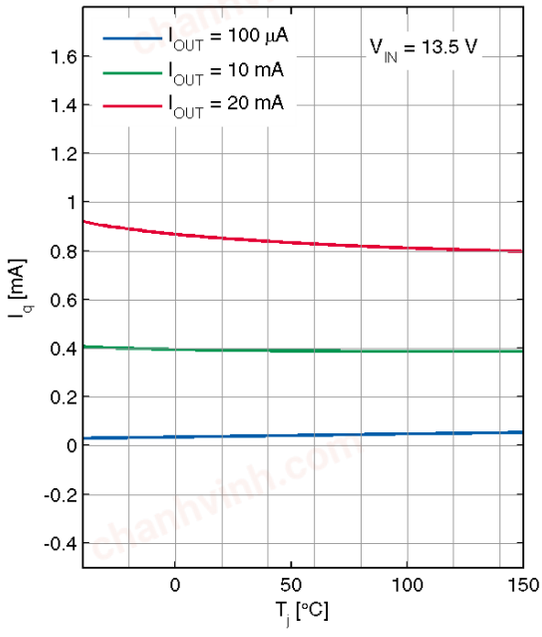
Current consumption $I_q$ versus output current $I_{OUT}$



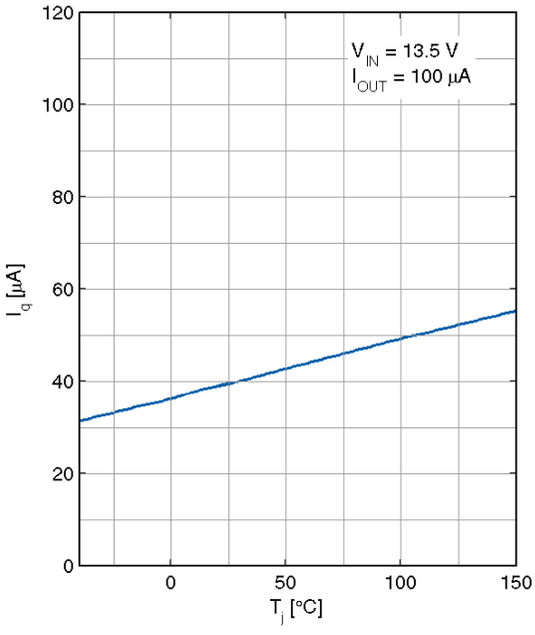

Current consumption $I_q$ versus input voltage $V_{IN}$




Current consumption $I_q$ versus junction temperature $T_j$



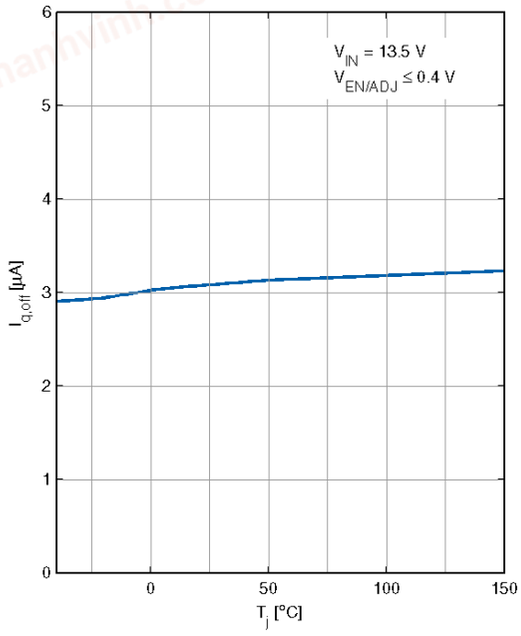

Current consumption $I_q$ versus junction temperature $T_j$ ($I_{OUT}$ low)



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Current consumption in OFF mode $I_{q,off}$ versus junction temperature $T_j$



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## 4.5 Enable/Adjust input

In order to reduce the quiescent current to a minimum, the TLS102B0MB can be switched to stand-by mode by setting the corresponding enable/adjust input “EN/ADJ” to “low”.

If the pin EN/ADJ is left open, an internal pull-down resistors keeps the voltage at the pin low and therefore ensures that the regulator is switched off.

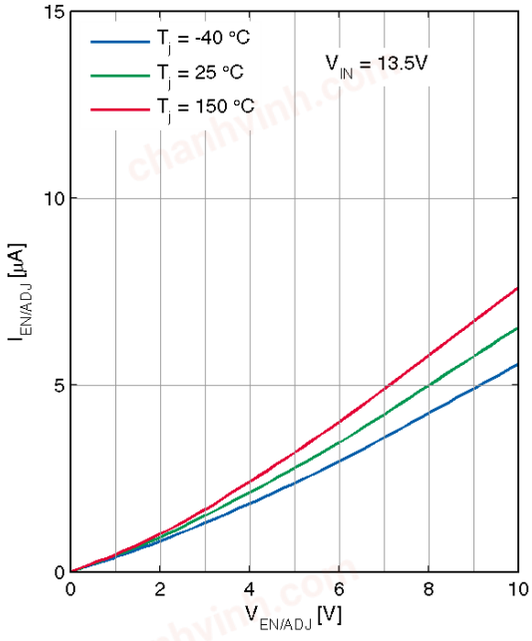
**Table 8 Electrical characteristics Enable input**

$V_{IN}$ = 13.5 V, 2.0 V ≤ $V_{EN/ADJ}$ ≤ 20 V, $T_j$ = -40°C to 150°C, all voltages with respect to ground, positive current flowing into pin (unless otherwise specified).

| Parameter | Symbol | Values | | | Unit | Note or condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| Enable/Adjust off voltage range | $V_{EN/ADJ,off}$ | – | – | 0.8 | V | $V_{OUT}$ = 0 V |
| Enable/Adjust on voltage range | $V_{EN/ADJ,on}$ | 2 | – | – | V | $V_{OUT}$ settled |
| Enable/Adjust input current | $I_{EN/ADJ}$ | – | 3 | 5 | µA | $V_{EN/ADJ}$ = 5 V |

## 4.6 Typical performance characteristics Enable/Adjust input

Enable/Adjust input current $I_{EN/ADJ}$ versus
input voltage $V_{EN/ADJ}$



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# 5 Application information

*Note: The following information is given as an example 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

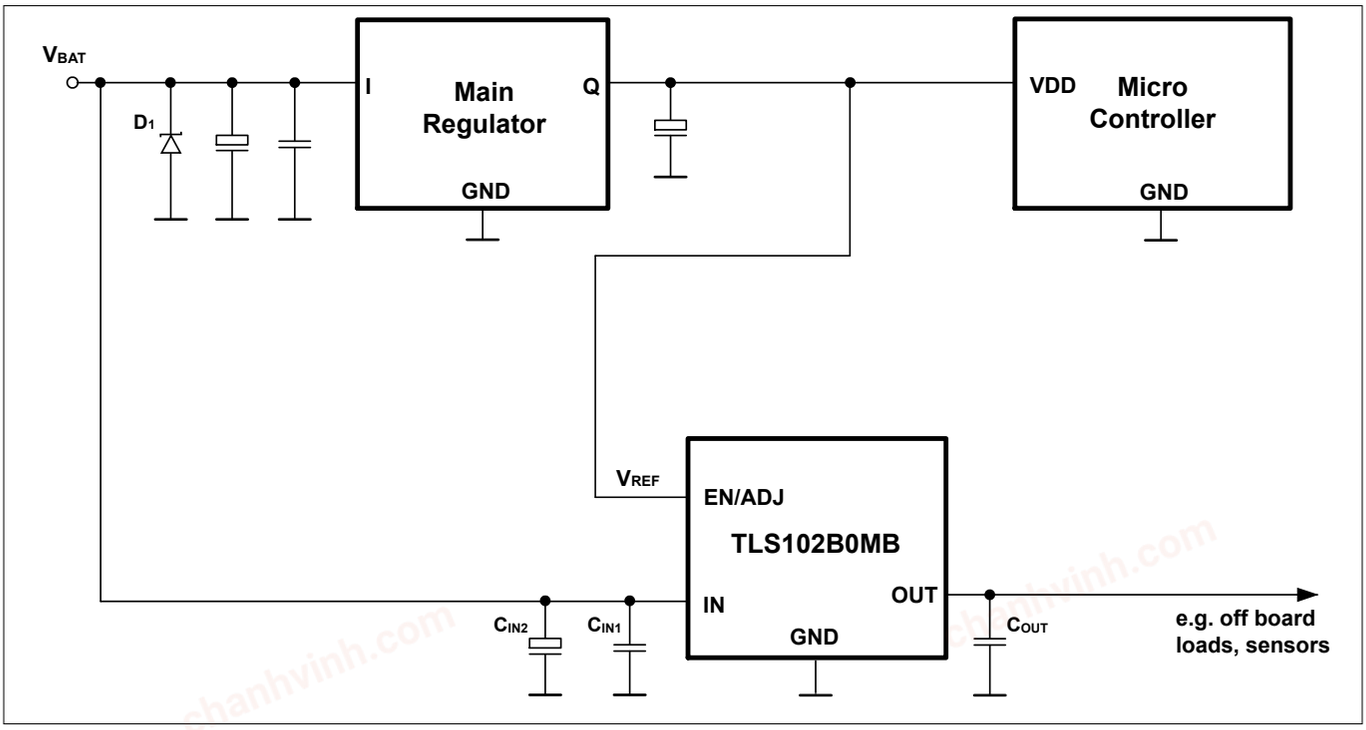



**Figure 3 Application circuit**

*Note: This figure is a very simplified example of an application circuit. The function must be verified in the real application.*

## 5.2 Selection of external components

### 5.2.1 Input pin

***Figure 3*** shows a typical input circuitry for a voltage tracking regulator. The following external components at the input are recommended in case of possible external disturbance.

**Ceramic capacitor**

A ceramic capacitor $C_{IN1}$ (100 nF to 470 nF) at the input filters high frequency disturbance imposed by the line, such as ISO pulses 3a/b. Place $C_{IN1}$ as close as possible to the input pin of the voltage tracking regulator on the PCB.

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#### Aluminum electrolytic capacitor

An aluminum electrolytic capacitor $C_{IN2}$ (10 µF to 470 µF) at the input smoothens high energy pulses, such as ISO pulse 2a. Place $C_{IN2}$ close to the input pin of the voltage tracking regulator on the PCB.

#### Overvoltage suppression diode

A suitably sized diode $D_1$ suppresses high voltage beyond the maximum ratings of the circuit components and protects the devices from damage due to overvoltage.

### 5.2.2 Output pin

An output capacitor $C_{OUT}$ is mandatory for the stability of the voltage tracking regulator. The values for $C_{OUT}$ and $ESR_{C_{OUT}}$ must comply with the specifications in ***Table 3*** described under ***Output capacitor's capacitance required for stability*** and ***Output capacitor's ESR required for stability***. The graph of ***Output capacitor Equivalent Series Resistance $ESR_{C_{OUT}}$ versus output current $I_{OUT}$*** shows the stable operating range of the TLS102B0MB.

For the automotive environment, ceramic capacitors with X5R or X7R dielectrics are recommended.

Place $C_{OUT}$ on the same side of the PCB as the regulator itself and as close as possible to both the tracker output pin and the GND pin.

To deal with rapid transients of input voltage or load current, $C_{OUT}$ must be dimensioned appropriately for the application. The output stability must be verified in the actual application.

### 5.2.3 Enable/Adjust pin

***Figure 3*** shows the typical input circuitry for a voltage tracking regulator. Typically the Enable/Adjust Pin is connected to a fixed voltage reference which is tracked by the regulator. In the example of the application diagram EN/ADJ is connected to the supply voltage of a microcontroller. Alternatively, the voltage reference can also be adjusted by a voltage divider.

## 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 by:

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_q$$

**Equation 1**

with

- $P_D$: continuous power dissipation
- $V_{IN}$: input voltage
- $V_{OUT}$: output voltage
- $I_{OUT}$: output current
- $I_q$: quiescent current

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

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## Application information

$$R_{thJA,\,max} = \frac{T_{j,\,max} - T_a}{P_D}$$

**Equation 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 specification in ***Table 4***.

### Example

Application conditions:

- $V_{IN}$ = 13.5 V
- $V_{OUT} = V_{ADJ}$ = 5 V
- $I_{OUT}$ = 20 mA
- $T_a$ = 125°C

Calculation of $R_{thJA,max}$:

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_q = (13.5\,V - 5\,V) \times 20\,mA + 13.5\,V \times 0.9\,mA = 0.182\,W$$

**Equation 3**

$$R_{thJA,\,max} = \frac{T_{j,max} - T_a}{P_D} = \frac{150°C - 125°C}{0.182\,W} = 137.36\,K/W$$

**Equation 4**

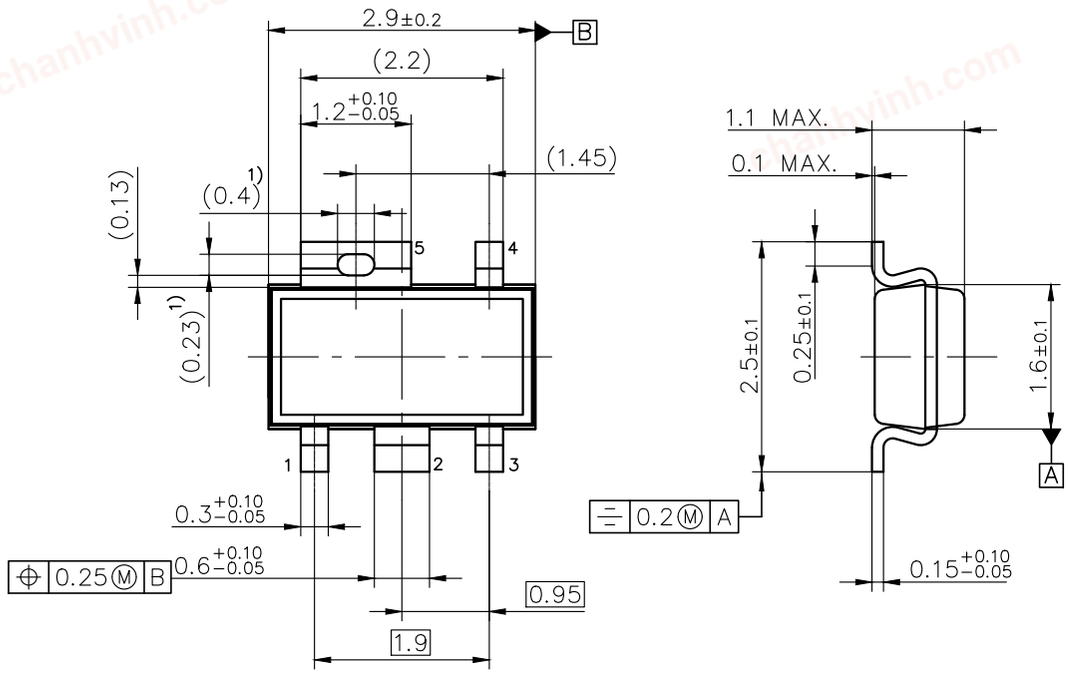
As a result, the PCB design must ensure a thermal resistance $R_{thJA,max}$ lower than 137.36 K/W.

According to ***Table 4***, at least 300 mm$^2$ heatsink area is required on the FR4 1s0p PCB, or the FR4 2s2p board can be used.

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# 6 Package information




NOTE: MOLD FLASH, PROTRUSIONS OR GATE BURRS OF 0.2 MM MAXIMUM PER SIDE ARE NOT INCLUDED
1) CONTOUR OF SLOT DEPENDS ON PROFILE OF GULL–WING LEAD FORM

ALL DIMENSIONS ARE IN UNITS MM
THE DRAWING IS IN COMPLIANCE WITH ISO 128 & PROJECTION METHOD 1

**Figure 4 PG-SCT595-5[1)]**

### 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).

### Information on alternative packages

Please visit ***www.infineon.com/packages***

1 Dimensions in mm

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# Revision history

| Revision | Date | Changes |
|---|---|---|
| 1.1 | 2018-07-31 | Data Sheet updated:<br>• Package outline drawing:<br>- algebraic sign "+" → "-" for some tolerance values<br>- add pin 1 to pin 3 distance<br>• Editorial changes |
| 1.0 | 2018-01-22 | Data Sheet - Initial Version |

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**Edition 2018-07-31**

**Published by**

**Infineon Technologies AG**

**81726 Munich, Germany**

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**Document reference**
**IFX-Z8F56638467**

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