

# TLE 8088 EM

Engine management IC for Small Engines

## Data Sheet

Rev 1.0, 2012-10-01

## Table of Contents

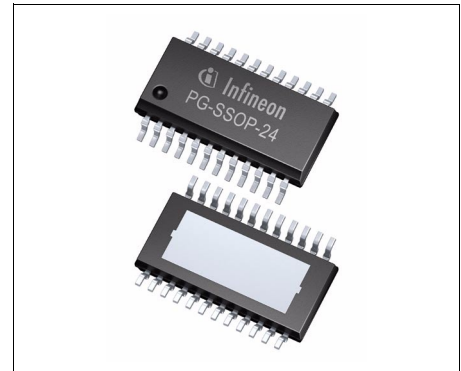
|           |  |           |
|-----------|--|-----------|
| <b>1</b>  | <b>Overview</b> .....                        | <b>3</b>  |
| <b>2</b>  | <b>Block Diagram</b> .....                   | <b>4</b>  |
| <b>3</b>  | <b>Pin Configuration</b> .....               | <b>5</b>  |
| 3.1       | Pin Assignment .....                         | 5         |
| 3.2       | Pin Definitions and Functions .....          | 5         |
| <b>4</b>  | <b>General Product Characteristics</b> ..... | <b>7</b>  |
| 4.1       | Absolute Maximum Ratings .....               | 7         |
| 4.2       | Functional Range .....                       | 8         |
| 4.3       | Thermal Resistance .....                     | 8         |
| <b>5</b>  | <b>Voltage Regulator</b> .....               | <b>9</b>  |
| 5.1       | Voltage Regulator .....                      | 9         |
| 5.2       | Power On Reset and Reset Output .....        | 9         |
| 5.3       | Watchdog Operation .....                     | 10        |
| <b>6</b>  | <b>Power Drivers</b> .....                   | <b>14</b> |
| 6.1       | Low-Side Drivers .....                       | 14        |
| 6.2       | Electrical Characteristics .....             | 15        |
| <b>7</b>  | <b>K-Line</b> .....                          | <b>18</b> |
| 7.1       | K-Line .....                                 | 18        |
| <b>8</b>  | <b>Application Information</b> .....         | <b>21</b> |
| 8.1       | Further Application Information .....        | 21        |
| <b>9</b>  | <b>Package Outlines</b> .....                | <b>22</b> |
| <b>10</b> | <b>Revision History</b> .....                | <b>23</b> |



## 1 Overview

### Features

- Supply 5 V ( $\pm 2\%$ ), 250mA
  - Over-temperature and Over-current Protection
- Watchdog and Reset Function
- K-Line Transceiver
- 1 low side driver for inductive loads with maximum operation current of 2.6A including over-temperature, over-current protection and open load/short to GND in off diagnosis
- 1 low side driver for resistive loads with maximum operation current of 3A including over-temperature and over-current protection
- Small Package PG-SSOP-24 Exposed Pad
- Temperature Range:  $-40^{\circ}\text{C}$  to  $150^{\circ}\text{C}$
- Green Product (RoHS compliant)
- AEC Qualified



**PG-SSOP-24**

### Description

TLE8088EM is an engine management IC based on Infineon Smart Power Technology (SPT). It is protected by embedded protection functions and integrates a Power Supply, K-line and power stages to drive different loads in an Engine Management System. It is designed to provide a compact and cost optimized solution for Engine Management and Powertrain Systems. It is specially suitable for one cylinder motorcycle engine management system.

| Type      | Package    | Marking   |
|-----------|------------|-----------|
| TLE8088EM | PG-SSOP-24 | TLE8088EM |

## 2 Block Diagram

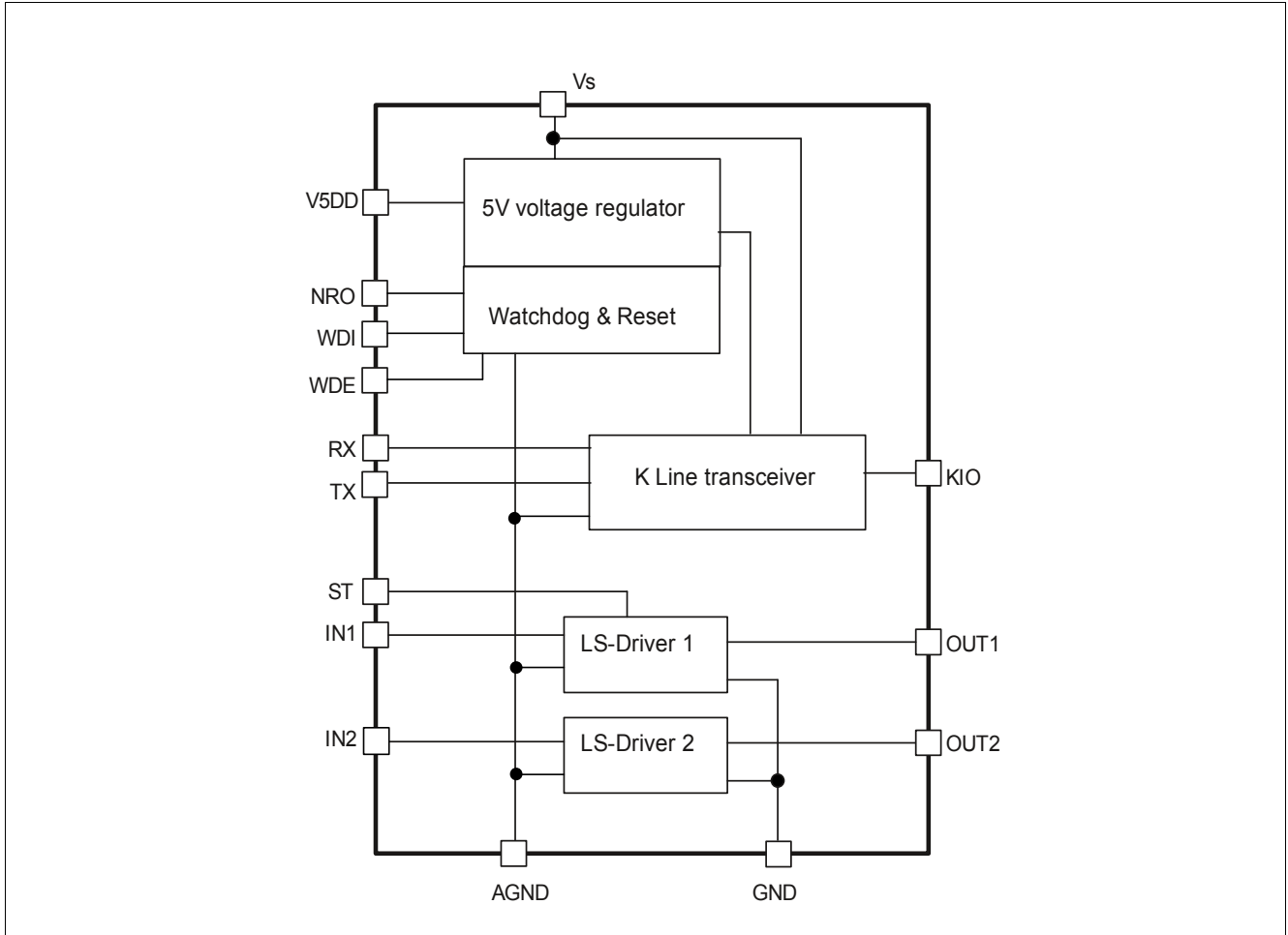


Figure 1 Block Diagram

### 3 Pin Configuration

#### 3.1 Pin Assignment

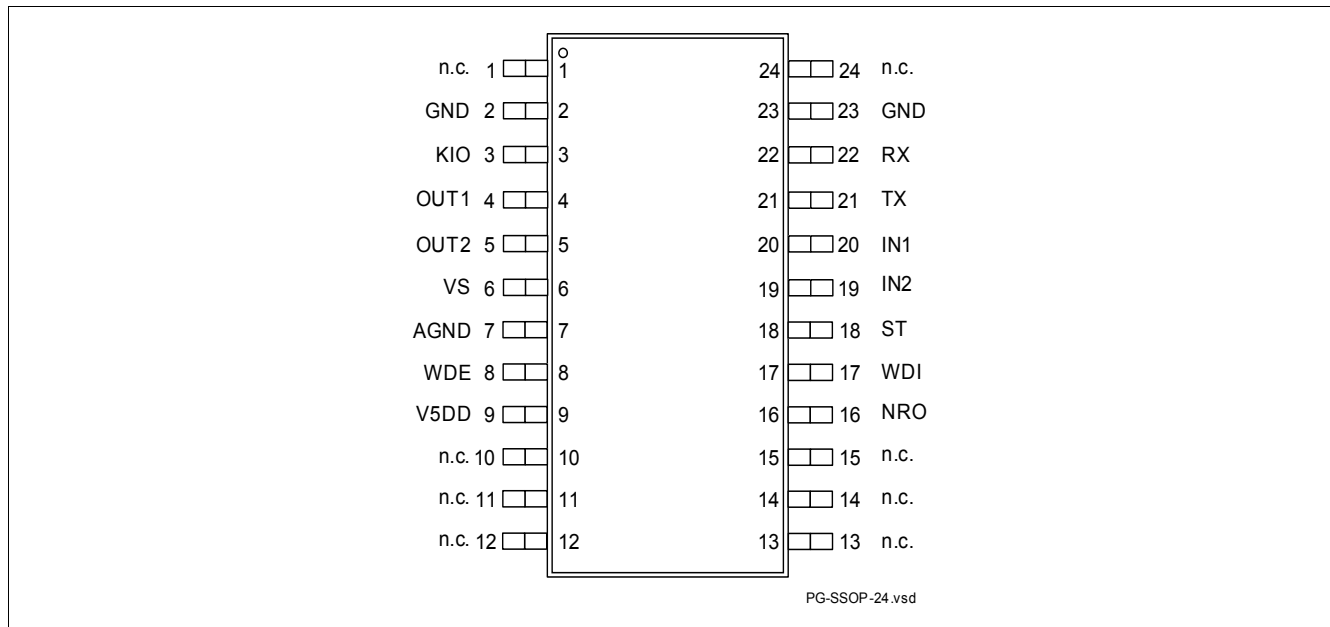


Figure 2 Pin Configuration

#### 3.2 Pin Definitions and Functions

| Pin | Symbol | Function  |
|-----|--------|---|
| 1   | n.c.   | Not connected   |
| 2   | GND    | Power Ground  |
| 3   | KIO    | K-Line bus connection   |
| 4   | OUT1   | Output channel 1  |
| 5   | OUT2   | Output channel 2  |
| 6   | VS     | Battery voltage: 100nF ceramic capacitor directly connected at the IC to ground |
| 7   | AGND   | Analog ground: should be connected to the system logic ground                   |
| 8   | WDE    | Watchdog enable: active high, internal pull up                                  |
| 9   | V5DD   | 5V supply output: connected to external blocking capacitor.                     |
| 10  | n.c.   | Not connected   |
| 11  | n.c.   | Not connected   |
| 12  | n.c.   | Not connected   |
| 13  | n.c.   | Not connected   |
| 14  | n.c.   | Not connected   |
| 15  | n.c.   | Not connected   |
| 16  | NRO    | Reset output: open drain, active low  |
| 17  | WDI    | Watchdog input: trigger input for watchdog pulses                               |
| 18  | ST     | Status signal: output diagnostic signal   |
| 19  | IN2    | Control Input Channel 2: internal pull down                                     |

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**Pin Configuration**

| <b>Pin</b> | <b>Symbol</b> | <b>Function</b>  |
|------------|---------------|--|
| 20         | IN1           | Control Input Channel 1: internal pull down                        |
| 21         | TX            | Logic level input for data to be transmitted on the K-Line bus KIO |
| 22         | RX            | Logic output of data received from the K-Line bus KIO.             |
| 23         | GND           | Power Ground   |
| 24         | n.c.          | Not connected  |
|            | Exposed pad   | should be connected to GND and to the ground plane of the ECU      |

## 4 General Product Characteristics

### 4.1 Absolute Maximum Ratings

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

$T_j = -40\text{ °C}$  to  $+150\text{ °C}$ ; All voltages with respect to ground.

Positive current flowing into pin (unless otherwise specified)

| Pos.                      | Parameter   | Symbol          | Limit Values |      | Unit | Conditions  |
|---------------------------|---|-----------------|--------------|------|------|---|
|                           |   |                 | Min.         | Max. |      |   |
| <b>Voltages</b>           |   |                 |              |      |      |   |
| 4.1.1                     | Continuous Voltage on pin Vs                                  | $V_S$           | -0.3         | 40   | V    |   |
| 4.1.2                     | Continuous Voltage on pin OUT1                                | $V_{OUT1}$      | -0.3         | 30   | V    | IN1=0V  |
| 4.1.3                     | Continuous Voltage on pin OUT2, KIO                           | $V_{OUT2, KIO}$ | -0.3         | 35   | V    | IN2=0V<br>TX=V5DD                                 |
| 4.1.4                     | IN1, IN2, V5DD, RxD, TxD, ST, NRO, WDI, WDE                   | $V_x$           | -0.3         | 5.5  | V    | <sup>2)</sup>                                     |
| <b>Temperatures</b>       |   |                 |              |      |      |   |
| 4.1.5                     | Junction Temperature  | $T_j$           | -40          | 150  | °C   | –   |
| 4.1.6                     | Storage Temperature   | $T_{stg}$       | -55          | 150  | °C   | –   |
| <b>ESD Susceptibility</b> |   |                 |              |      |      |   |
| 4.1.7                     | ESD Resistivity to GND, Vs, K-LINE, OUT1,2                    | $V_{ESD}$       | -4           | 4    | kV   | HBM <sup>3)</sup>                                 |
| 4.1.8                     | ESD Resistivity to GND, other pins                            | $V_{ESD}$       | -2           | 2    | kV   | HBM <sup>3)</sup>                                 |
| 4.1.9                     | Electro Static Discharge Voltage "Charged Device Model - CDM" | $V_{ESD}$       | -500         | 500  | V    | All Pins CDM <sup>4)</sup>                        |
| 4.1.10                    | Electro Static Discharge Voltage "Charged Device Model - CDM" | $V_{ESD}$       | -750         | 750  | V    | Pin 1, 12, 13, 24 (corner pins) CDM <sup>4)</sup> |

1) Not subject to production test, specified by design

2) For outputs no short circuit is allowed

3) ESD susceptibility, HBM according to EIA/JESD 22-A114B (1.5KOhm, 100pF)

4) ESD susceptibility, Charged Device Model "CDM" EIA/JESD22-C101-C

*Note: Stresses above the ones listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

*Note: Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as "outside" normal operating range. Protection functions are not designed for continuous repetitive operation.*

## 4.2 Functional Range

| Pos.  | Parameter            | Symbol | Limit Values |      | Unit | Conditions |
|-------|----------------------|--------|--------------|------|------|------------|
|       |                      |        | Min.         | Max. |      |            |
| 4.2.1 | Supply Voltage       | $V_S$  | 6            | 18   | V    | –          |
| 4.2.2 | Junction Temperature | $T_j$  | -40          | 150  | °C   | –          |

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.

## 4.3 Thermal Resistance

| Pos.  | Parameter           | Symbol     | Limit Values |      |      | Unit | Conditions                            |
|-------|---------------------|------------|--------------|------|------|------|---------------------------------------|
|       |                     |            | Min.         | Typ. | Max. |      |                                       |
| 4.3.1 | Junction to Case    | $R_{thJC}$ | –            | 6.3  | 9    | K/W  | Measured to exposed pad <sup>1)</sup> |
| 4.3.2 | Junction to Ambient | $R_{thJA}$ | –            | 29   | –    | K/W  | <sup>1)</sup> <sup>2)</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 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.



## 5 Voltage Regulator

### 5.1 Voltage Regulator

The TLE8088EM integrates a voltage regulator for load currents up to 250mA. The voltage applied to pin **VS** is regulated at pin **V5DD** to 5.0 V with a precision of  $\pm 2\%$ . The sophisticated design allows to achieve stable operation even with ceramic output capacitors down to 470nF. The voltage regulator features under-voltage reset, power on reset and watchdog. It is protected against over-current, short circuit and over temperature conditions. The low-side switch function and the K-line transceiver are independent of the reset and watchdog signals.

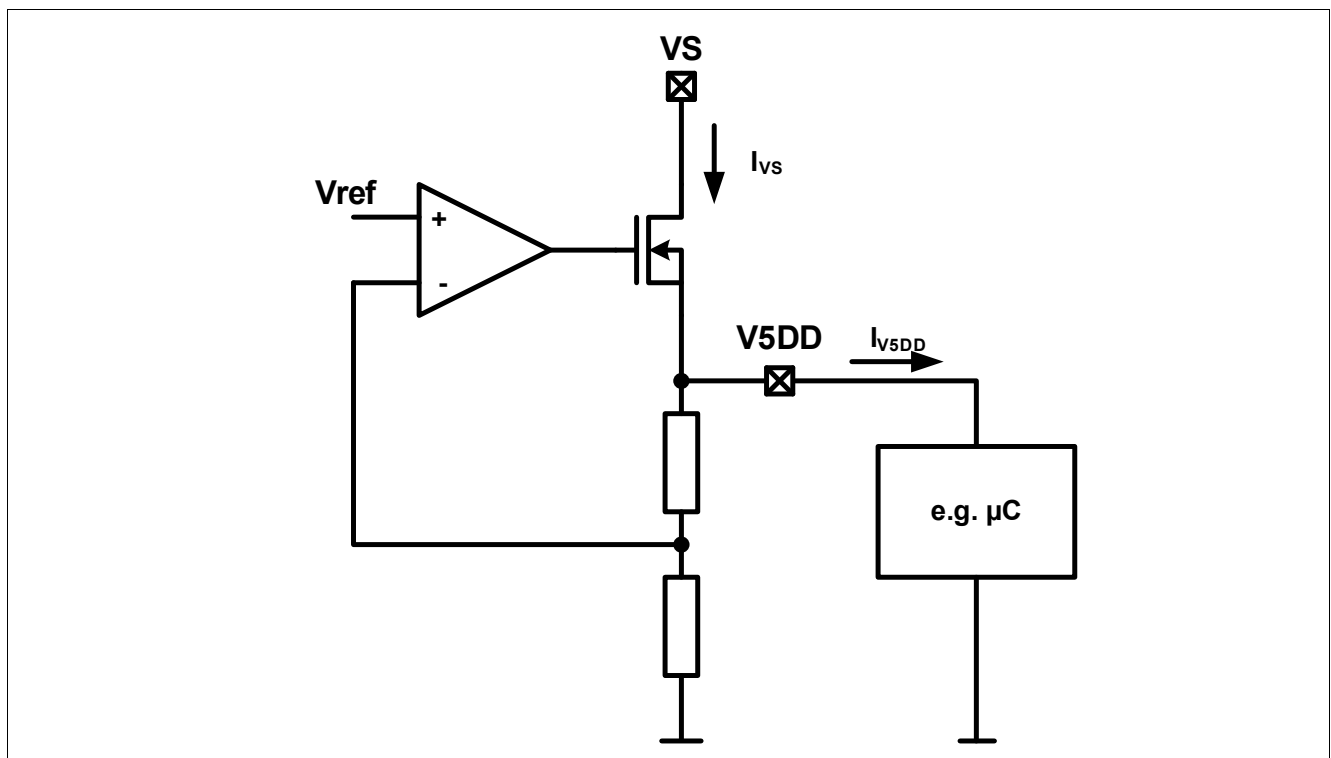


Figure 3 5V Supply

### 5.2 Power On Reset and Reset Output

Reset output is an open drain output. When the level of  $V_{V5DD}$  reaches the reset threshold  $V_{RT}$ , the signal at NRO remains low for the power-on reset delay time  $T_{RD}$ . The reset function and timing is illustrated in Figure 4. The reset reaction time  $t_{RR}$  avoids wrong triggering caused by short “glitches” on the V5DD-line. In case of V5DD power down ( $V_{V5DD} < V_{RT}$  for  $t > t_{RR}$ ) a logic low signal is generated at the pin NRO to reset an external micro controller. The level of the reset threshold for increasing  $V_{V5DD}$  is for the hysteresis ( $V_{RH}$ ) higher than the level for decreasing  $V_{V5DD}$ .

The reset and watchdog signals are for external use and do not affect the state of the channels and K-line transceiver. The correct functionality of the devices is ensured by an independent voltage monitoring circuitry.

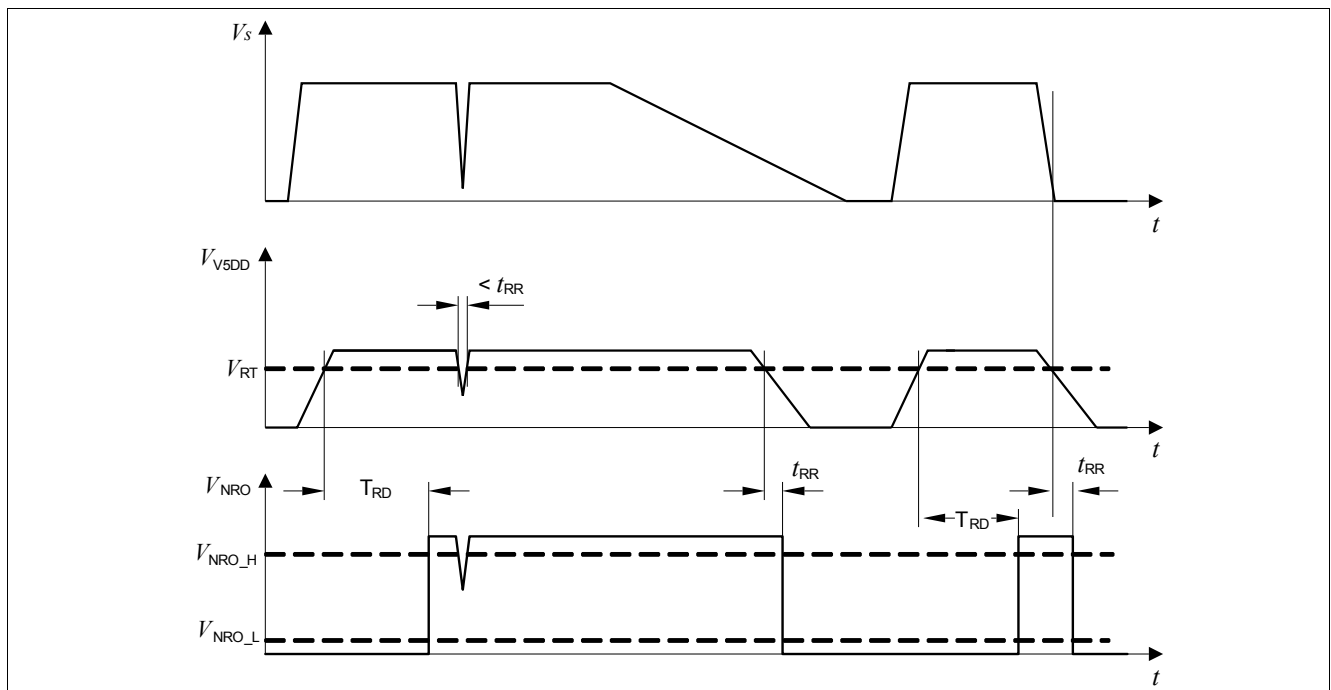


Figure 4 Reset Function and Timing Diagram

### 5.3 Watchdog Operation

After power on, the reset output signal at the NRO pin is kept LOW for the power-on reset delay time  $T_{RD}$  of typ. 15ms. With the LOW to HIGH transition of the signal at NRO the micro controller reset is released.

The TLE8088EM integrates a watchdog function. If WDE is connected to low, the watchdog function is disabled. If the WDE is connected to 5V or left open, the watchdog function is enabled. A pull up current source is integrated in the WDE pin.

After the activation of the watchdog function, the timing of the signal on WDI from the micro-controller must correspond the WD-Period  $T_{WD,p}$  specified in the electrical characteristics. A Re-Trigger of the WD-Period is done with a HIGH-to-LOW transition at the WDI-pin within the time  $T_{WD,p}$ .

A HIGH to LOW transition of the watchdog trigger signal on pin WDI is taken as a trigger. To avoid wrong triggering due to parasitic glitches two HIGH samples followed by two LOW samples (sample period  $t_{sam}$  typ. 64 $\mu$ s ) are decoded as a valid trigger, see Figure 6. A reset is generated (NRO goes LOW) for the time  $T_{WR}$  if there is no trigger pulse during the Watchdog Period as shown in Figure 5.

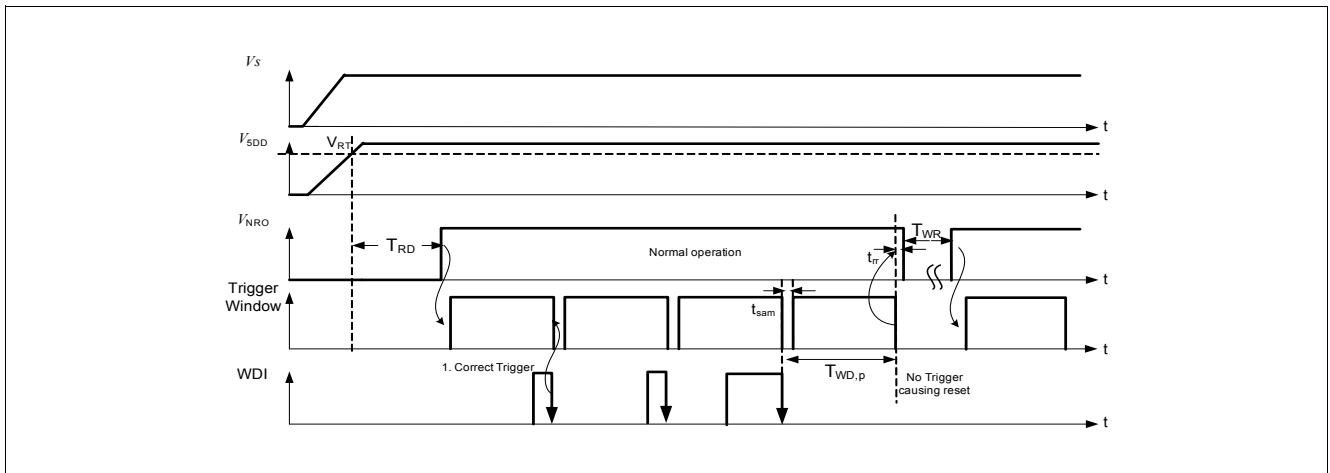


Figure 5 Watchdog Timing Diagram

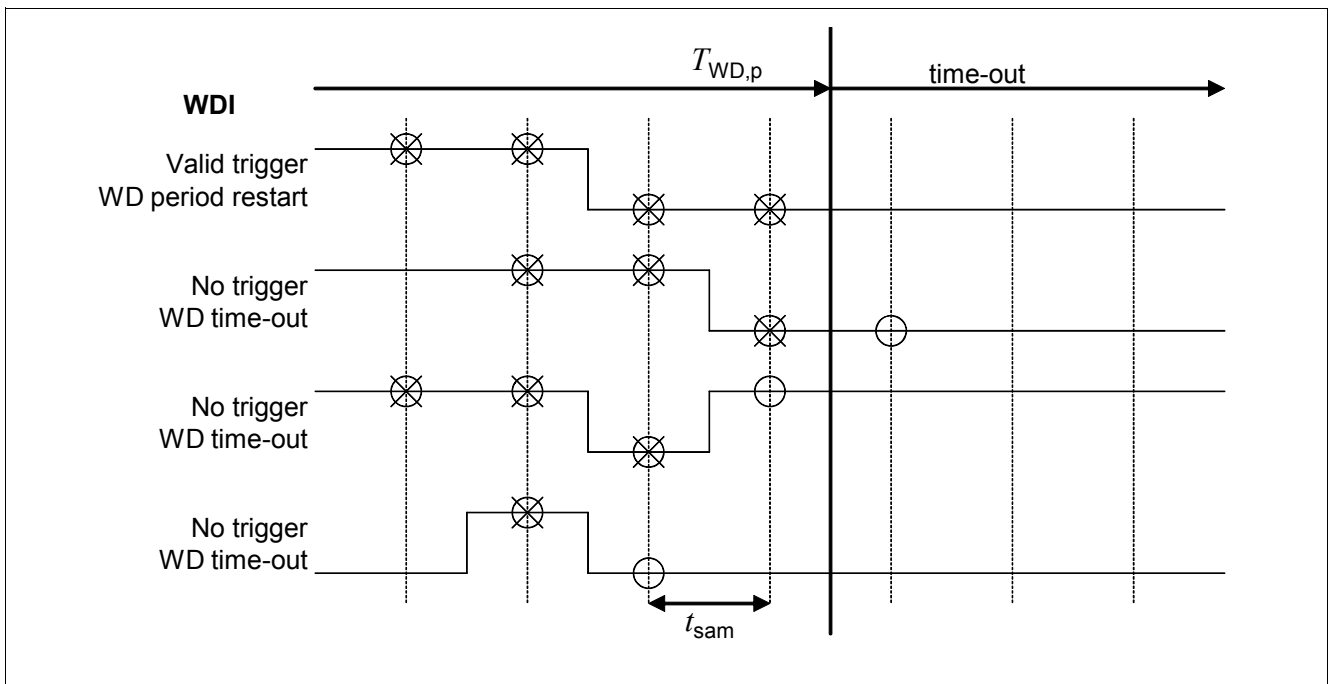


Figure 6 Watchdog valid trigger

**Electrical Characteristics: Voltage Regulator**

$V_S = 13.5\text{ V}$ ,  $T_j = -40\text{ °C}$  to  $+150\text{ °C}$ , 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 V5DD</b>         |                              |                      |              |      |      |               |   |
| 5.3.1                      | Output Voltage               | $V_{V5DD}$           | 4.90         | 5.00 | 5.10 | V             | $0\text{mA} < I_{V5DD} < 150\text{mA}$<br>$6\text{V} < V_S < 18\text{V}$  |
| 5.3.2                      | Output Voltage               | $V_{V5DD}$           | 4.90         | 5.00 | 5.10 | V             | $0\text{mA} < I_{V5DD} < 250\text{mA}$<br>$6\text{V} < V_S < 18\text{V}$ <sup>1)</sup>                          |
| 5.3.3                      | Output Current Limitation    | $I_{V5DD}$           | 250          | –    | 650  | mA            | $V_{V5DD} = 0\text{V}$ ,<br>$6\text{V} < V_S < 18\text{V}$  |
| 5.3.4                      | Load Regulation              | $\Delta V_{V5DD,Lo}$ | –            | –    | 20   | mV            | $1\text{mA} < I_{V5DD} < 150\text{mA}$  |
| 5.3.4a                     | Load Regulation              | $\Delta V_{V5DD,Lo}$ | –            | –    | 50   | mV            | $1\text{mA} < I_{V5DD} < 250\text{mA}$<br><sup>1)</sup>   |
| 5.3.5                      | Line Regulation              | $\Delta V_{V5DD,Li}$ | –            | –    | 10   | mV            | $I_{V5DD} = 1\text{mA}$ ;<br>$10\text{V} < V_S < 18\text{V}$  |
| 5.3.6                      | Power Supply Rejection Ratio | $PSRR$               | –            | 60   | –    | dB            | $f_r = 100\text{Hz}$ ;<br>$V_r = 0.5\text{Vpp}$ <sup>1)</sup>   |
| 5.3.7                      | Output Capacitor             | $C_Q$                | 470          | –    | –    | nF            | <sup>1)</sup>   |
|                            |                              | $ESR(C_Q)$           | –            | –    | 10   | $\Omega$      |   |
| 5.3.8                      | Low Drop Voltage             | $V_{V5DD}$           | 4.80         | –    | –    | V             | $I_{V5DD} = 1\text{mA}$<br>$V_S = 5\text{V}$  |
| 5.3.9                      |                              |                      | 4.40         | –    | –    | V             | $I_{V5DD} = 150\text{mA}$<br>$V_S = 5\text{V}$ ;<br>after device ramp-up<br>( $V_S > 9\text{V}$ )               |
| 5.3.9a                     |                              |                      | 4.15         | –    | –    | V             | $I_{V5DD} = 250\text{mA}$<br>$V_S = 5\text{V}$ ;<br>after device ramp-up<br>( $V_S > 9\text{V}$ ) <sup>1)</sup> |
| <b>Current Consumption</b> |                              |                      |              |      |      |               |   |
| 5.3.10                     | Quiescent Current            | $I_q$                | –            | –    | 4    | mA            | $I_{V5DD} = 0\text{A}$ ; CH1,CH2<br>off, K-Line off   |
| <b>WDE</b>                 |                              |                      |              |      |      |               |   |
| 5.3.11                     | Low Level Input Voltage      | $V_{IN,L}$           | –            | –    | 1.00 | V             | –   |
| 5.3.12                     | High Level Input Voltage     | $V_{IN,H}$           | 2.00         | –    | –    | V             | –   |
| 5.3.13                     | Hysteresis WDE               | $V_{IN,HYS}$         | 50           | –    | 250  | mV            | <sup>1)</sup>   |
| 5.3.14                     | Input Pull Up Current        | $I_{IN\_PU\_L}$      | -20          | -50  | -100 | $\mu\text{A}$ | $V_{IN} = 0\text{V}$  |
|                            |                              | $I_{IN\_PU\_H}$      | -2.40        | –    | –    | $\mu\text{A}$ | $V_{IN} = 4.4\text{V}$  |
| <b>Watchdog Input WDI</b>  |                              |                      |              |      |      |               |   |
| 5.3.15                     | Low Level Input Voltage      | $V_{IN,L}$           | –            | –    | 1.00 | V             |   |
| 5.3.16                     | High Level Input Voltage     | $V_{IN,H}$           | 2.00         | –    | –    | V             |   |
| 5.3.17                     | Input Voltage Hysteresis     | $V_{IN,HYS}$         | 50           | –    | 250  | mV            | <sup>1)</sup>   |

**Electrical Characteristics: Voltage Regulator (cont'd)**

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

| Pos.   | Parameter               | Symbol          | Limit Values |      |      | Unit          | Conditions           |
|--------|-------------------------|-----------------|--------------|------|------|---------------|----------------------|
|        |                         |                 | Min.         | Typ. | Max. |               |                      |
| 5.3.18 | Input Pull Down Current | $I_{IN\_PD\_H}$ | 20           | 50   | 100  | $\mu\text{A}$ | $V_{IN}=5\text{V}$   |
|        |                         | $I_{IN\_PD\_L}$ | 2.40         | –    | –    | $\mu\text{A}$ | $V_{IN}=0.6\text{V}$ |
| 5.3.19 | Watchdog Sampling Time  | $t_{sam}$       | 40           | 64   | 130  | $\mu\text{s}$ |                      |
| 5.3.20 | Watchdog Period         | $T_{WD,p}$      | 50           | 60   | 70   | ms            |                      |
| 5.3.21 | Watchdog Reset Time     | $T_{WR}$        | 120          | 240  | 360  | $\mu\text{s}$ |                      |

**Reset Output NRO**

|        |  |              |      |      |      |               |                       |
|--------|--|--------------|------|------|------|---------------|-----------------------|
| 5.3.22 | Output Voltage Reset Switching Threshold | $V_{RT}$     | 4.00 | 4.25 | 4.50 | V             | $V_{V5DD}$ decreasing |
| 5.3.23 | Reset Hysteresis                         | $V_{RH}$     | 10   | –    | 150  | mV            |                       |
| 5.3.24 | Low Level Output Voltage                 | $V_{NRO,L}$  | –    | –    | 1.10 | V             | $I_{NRO}=1\text{mA}$  |
| 5.3.25 | Leakage Current                          | $I_{NRO,LK}$ | –    | –    | 1    | $\mu\text{A}$ | $V_{RT} = 5\text{V}$  |
| 5.3.26 | Power-on Reset Delay Time                | $T_{RD}$     | 10   | 15   | 20   | ms            |                       |
| 5.3.27 | Reset Reaction Time                      | $t_{RR}$     | 1    | 4    | 8    | $\mu\text{s}$ | –                     |

**Over Temperature Protection**

|        |                             |           |     |    |     |                    |    |
|--------|-----------------------------|-----------|-----|----|-----|--------------------|----|
| 5.3.28 | Over-temperature            | $T_{OT}$  | 150 | –  | 200 | $^{\circ}\text{C}$ | 1) |
| 5.3.29 | Over-temperature Hysteresis | $T_{OTH}$ | –   | 20 | –   | $^{\circ}\text{C}$ | 1) |

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

## 6 Power Drivers

### 6.1 Low-Side Drivers

The power stages are built by N-channel power MOSFET transistors. The channels are universal multi channel switches but mostly suitable to be used in Engine Management Systems. Within an Engine Management System, the best fit of the channels to the typical loads is:

- Channel 1 for injector, valves or similar sized solenoids with a maximum operation current requirement of 2.6A
- Channel 2 for malfunction indication lamps or other resistive loads with a maximum current requirement of 3A

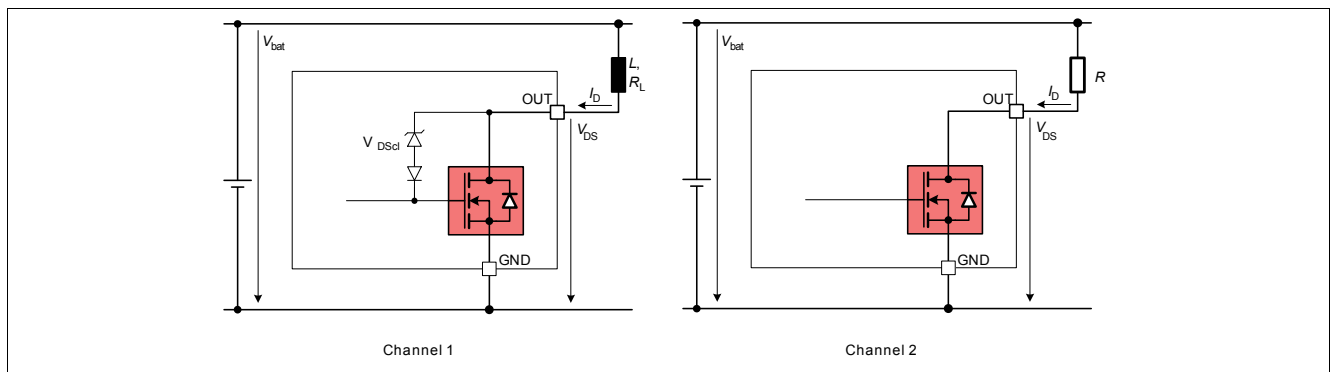


Figure 7 Low-side Switches

Channel 1 has open load detection in off state. If an open load condition persists for a time longer than the filter time  $t_d$ , an open load will be detected and the ST pin set to low. On the rising edge of the IN1 signal the ST pin will be released after the time  $t_{ST,clear}$ , see Figure 9.

In over-current situation channel 1 will be switched off and kept latched. Additionally the ST signal will be set to low after the settling time  $t_{ST,set,OC}$ . On the falling edge of the IN1 signal the ST pin will be released after the time  $t_{ST,clear}$ , see Figure 10. Therefore channel 1 can be switched on again by toggling the IN1 pin.

During an over-temperature event the ST signal is set to low and will turn back to high if the failure condition is disappeared (see Table 1).

Table 1 Truth Table for Diagnostics of CH1

| Open Load | Over Current | Over Temperature | ST | Status  |
|-----------|--------------|------------------|----|---|
| 0         | 0            | 0                | 1  | Normal operation  |
| 1         | x            | x                | 0  | Failure detected  |
| x         | 1            | x                | 0  | Failure detected and latched<br>Channel 1 is switched off |
| x         | x            | 1                | 0  | Failure detected and channel 1 is<br>switched off         |

| Failure Situation           | ST                   |
|-----------------------------|----------------------|
| 0 = Situation doesn't exist | 1 = Normal operation |
| 1 = Situation exists        | 0 = Failure detected |
| X = 0 or 1                  |                      |

In over-current situation the channel 2 will be switched off, and after typ. 4ms the channel will be switched on again. Channel 2 is also over-temperature protected. In over-temperature situation channel 2 will be switched off and will restart if the junction temperature falls by thermal shutdown hysteresis  $T_{OTH}$ .

## 6.2 Electrical Characteristics

### Electrical Characteristics

$V_S = 13.5\text{ V}$ ,  $T_j = -40\text{ °C}$  to  $+150\text{ °C}$ : All voltages with respect to ground.

Positive current flowing into pin (unless otherwise specified).

| Pos. | Parameter | Symbol | Limit Values |      |      | Unit | Conditions |
|------|-----------|--------|--------------|------|------|------|------------|
|      |           |        | Min.         | Typ. | Max. |      |            |

### Output Channel Resistance

|       |                         |            |   |      |      |          |   |
|-------|-------------------------|------------|---|------|------|----------|---|
| 6.2.1 | On State Resistance CH1 | $R_{DSon}$ | – | 0.60 | 0.70 | $\Omega$ | $I_{Dnom}=1.3\text{A}$ ; $T_j=150\text{°C}$ |
| 6.2.2 | On State Resistance CH2 | $R_{DSon}$ | – | 1.10 | 1.20 | $\Omega$ | $I_{Dnom}=0.3\text{A}$ ; $T_j=150\text{°C}$ |

### Input Characteristics

|       |   |                 |      |    |      |               |                      |
|-------|---|-----------------|------|----|------|---------------|----------------------|
| 6.2.3 | Parallel Input Pin Low level IN1,IN2                | $V_{IN,L}$      | –    | –  | 1.00 | V             | –                    |
| 6.2.4 | Parallel Input Pin High level IN1,IN2               | $V_{IN,H}$      | 2.00 | –  | –    | V             | –                    |
| 6.2.5 | Parallel Input Pin Hysteresis IN1,IN2               | $V_{IN,HYS}$    | 50   | –  | 250  | mV            | <sup>1)</sup>        |
| 6.2.6 | Parallel Input Pin Input Pull Down Current IN1, IN2 | $I_{IN\_PD\_H}$ | 20   | 50 | 100  | $\mu\text{A}$ | $V_{IN}=5\text{V}$   |
|       |   | $I_{IN\_PD\_L}$ | 2.40 | –  | –    | $\mu\text{A}$ | $V_{IN}=0.6\text{V}$ |

### Clamping Voltage

|       |                             |            |    |    |    |   |                         |
|-------|-----------------------------|------------|----|----|----|---|-------------------------|
| 6.2.7 | Output Clamping Voltage CH1 | $V_{DScl}$ | 30 | 35 | 40 | V | $I_{OUT1}=0.02\text{A}$ |
|-------|-----------------------------|------------|----|----|----|---|-------------------------|

### Leakage Currents

|       |   |            |   |   |   |               |  |
|-------|---|------------|---|---|---|---------------|--|
| 6.2.8 | Output Leakage Current in Off Mode, CH1 | $I_{Doff}$ | – | – | 3 | $\mu\text{A}$ | $V_{DS}=13.5\text{V}$ ; $T_j=150\text{°C}$<br><sup>1) 2)</sup> |
| 6.2.9 | Output Leakage Current in Off Mode, CH2 | $I_{Doff}$ | – | – | 3 | $\mu\text{A}$ | $V_{DS}=13.5\text{V}$ ; $T_j=150\text{°C}$<br><sup>1)</sup>    |

### Timing

|        |                         |            |   |      |     |               |   |
|--------|-------------------------|------------|---|------|-----|---------------|---|
| 6.2.10 | Turn-on Delay Time CH1  | $t_{dON}$  | – | 0.25 | 1   | $\mu\text{s}$ | $V_S = 13.5\text{V}$ ,<br>$I_{DS1} = 1.3\text{A}$ , resistive load <sup>1) 3)</sup> |
| 6.2.11 | Turn-on Delay Time CH2  | $t_{dON}$  | – | 0.15 | 1.2 | $\mu\text{s}$ | $V_S = 13.5\text{V}$ ,<br>$I_{DS2} = 0.3\text{A}$ , resistive load <sup>1)</sup>    |
| 6.2.12 | Turn-off Delay Time CH1 | $t_{dOFF}$ | – | 0.65 | 1.5 | $\mu\text{s}$ | $V_S = 13.5\text{V}$ ,<br>$I_{DS1} = 1.3\text{A}$ , resistive load <sup>1)</sup>    |
| 6.2.13 | Turn-off Delay Time CH2 | $t_{dOFF}$ | – | 0.35 | 1.5 | $\mu\text{s}$ | $V_S = 13.5\text{V}$ ,<br>$I_{DS2} = 0.3\text{A}$ , resistive load <sup>1)</sup>    |
| 6.2.14 | Turn-on Time CH1        | $t_{sON}$  | – | 0.45 | 1.2 | $\mu\text{s}$ | $V_S = 13.5\text{V}$ ,<br>$I_{DS1} = 1.3\text{A}$ , resistive load <sup>1)</sup>    |

**Electrical Characteristics (cont'd)**

$V_S = 13.5\text{ V}$ ,  $T_j = -40\text{ °C}$  to  $+150\text{ °C}$ : All voltages with respect to ground.  
Positive current flowing into pin (unless otherwise specified).

| Pos.   | Parameter         | Symbol     | Limit Values |      |      | Unit          | Conditions   |
|--------|-------------------|------------|--------------|------|------|---------------|--|
|        |                   |            | Min.         | Typ. | Max. |               |  |
| 6.2.15 | Turn-on Time CH2  | $t_{sON}$  | –            | 0.20 | 1    | $\mu\text{s}$ | $V_S = 13.5\text{V}$ ,<br>$I_{DS2} = 0.3\text{A}$ , resistive load <sup>1)</sup> |
| 6.2.16 | Turn-off Time CH1 | $t_{sOFF}$ | –            | 0.40 | 1.2  | $\mu\text{s}$ | $V_S = 13.5\text{V}$ ,<br>$I_{DS1} = 1.3\text{A}$ , resistive load <sup>1)</sup> |
| 6.2.17 | Turn-off Time CH2 | $t_{sOFF}$ | –            | 0.20 | 1    | $\mu\text{s}$ | $V_S = 13.5\text{V}$ ,<br>$I_{DS2} = 0.3\text{A}$ , resistive load <sup>1)</sup> |

**Over Current Protection**

|        |   |              |     |   |     |               |                                |
|--------|---|--------------|-----|---|-----|---------------|--------------------------------|
| 6.2.18 | Output Current Switch Off Threshold CH1 | $I_{DS\_OC}$ | 2.6 | – | 5   | A             | $6\text{V} < V_S < 18\text{V}$ |
| 6.2.19 | Output Current Switch off Threshold CH2 | $I_{DS\_OC}$ | 3.0 | – | 6.5 | A             | $6\text{V} < V_S < 18\text{V}$ |
| 6.2.20 | Off Time of CH2 in Current Switch Off   | $t_{off}$    | 3   | – | 8   | ms            | –                              |
| 6.2.21 | Current Switch off Filter Time CH1, CH2 | $t_{CL\_f}$  | 0.5 | – | 3   | $\mu\text{s}$ | –                              |

**Open Load Diagnosis for CH 1 in OFF state**

|        |  |            |      |      |      |               |                          |
|--------|--|------------|------|------|------|---------------|--------------------------|
| 6.2.22 | Open Load Detection Threshold Voltage for CH 1 | $V_{DSol}$ | 2.00 | 2.80 | 3.20 | V             | –                        |
| 6.2.23 | Output pull-down Diagnosis Current             | $I_{Dpd}$  | 50   | 100  | 150  | $\mu\text{A}$ | $V_{DS} = 13.5\text{ V}$ |
| 6.2.24 | Open Load Diagnosis Delay Time                 | $t_d$      | 100  | –    | 200  | $\mu\text{s}$ | –                        |

**Status Signal**

|        |   |                 |                 |   |     |               |                             |
|--------|---|-----------------|-----------------|---|-----|---------------|-----------------------------|
| 6.2.25 | Low level output voltage                | $V_{OUT\_L}$    | –               | – | 0.4 | V             | $I_{NRO} = 100\mu\text{A}$  |
| 6.2.26 | High level output voltage               | $V_{OUT\_H}$    | $V_{5DD} - 0.4$ | – | –   | V             | $I_{NRO} = -100\mu\text{A}$ |
| 6.2.27 | Status settling time after Over Current | $t_{ST,set,OC}$ | –               | – | 20  | $\mu\text{s}$ | <sup>1)</sup>               |
| 6.2.28 | Status Clear Time                       | $t_{ST,clear}$  | –               | – | 20  | $\mu\text{s}$ | <sup>1)</sup>               |

**Over Temperature Protection**

|        |                             |           |     |    |     |                    |               |
|--------|-----------------------------|-----------|-----|----|-----|--------------------|---------------|
| 6.2.29 | Over temperature            | $T_{OT}$  | 150 | –  | 200 | $^{\circ}\text{C}$ | <sup>1)</sup> |
| 6.2.30 | Over temperature hysteresis | $T_{OTH}$ | –   | 20 | –   | $^{\circ}\text{C}$ | <sup>1)</sup> |

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

2) in OFF mode open load diagnosis pull down current active

3) Definition see [Figure 8](#)



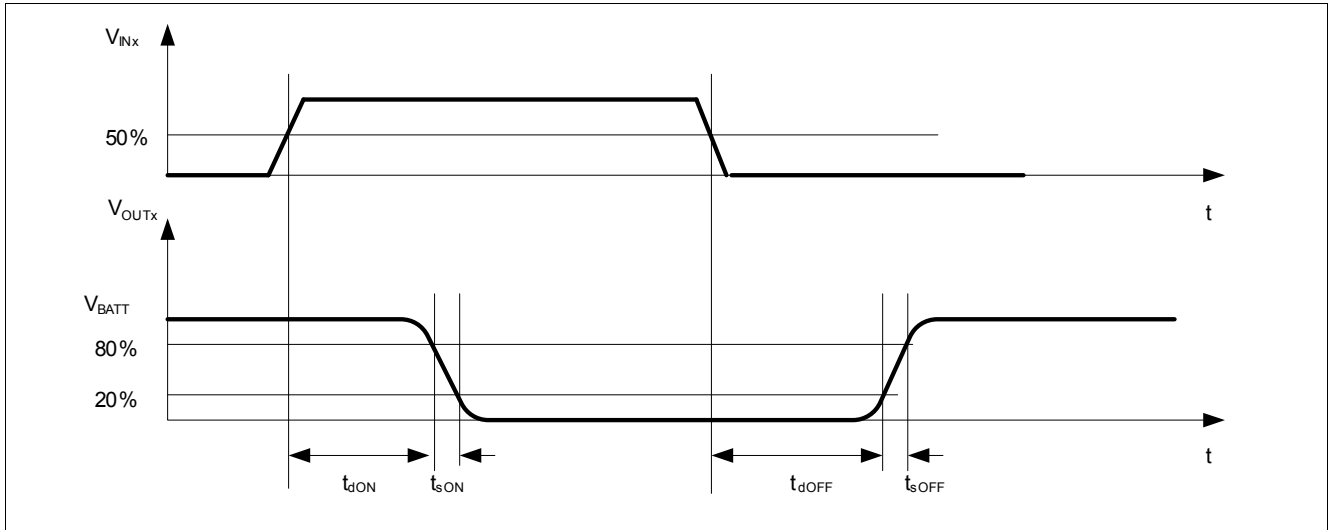


Figure 8 Timing

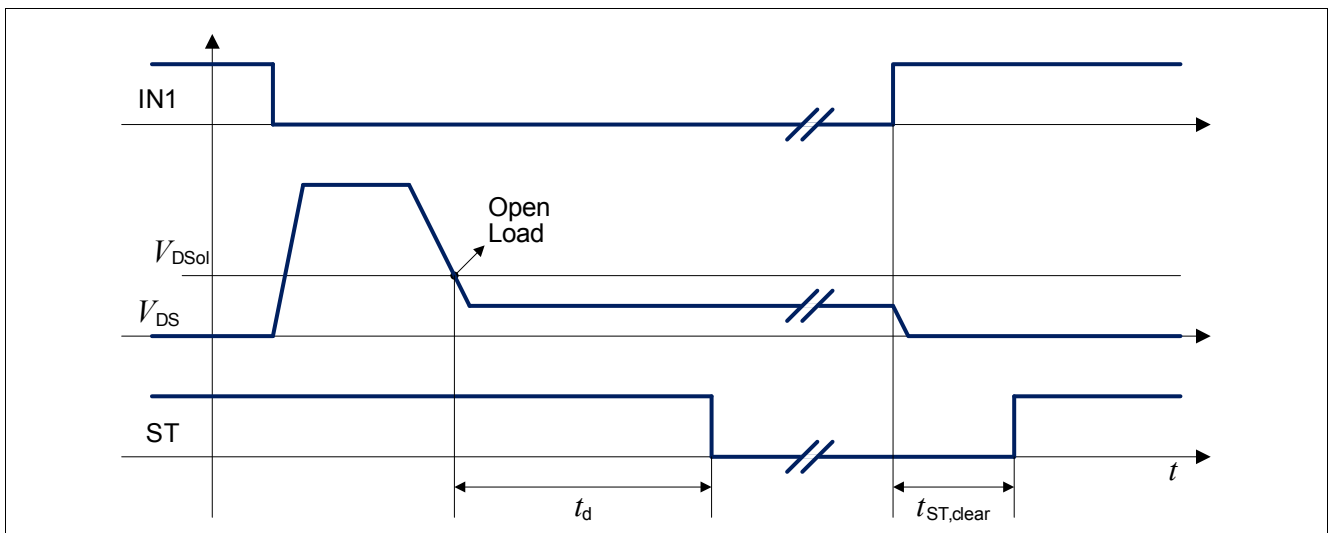


Figure 9 Open Load Detection

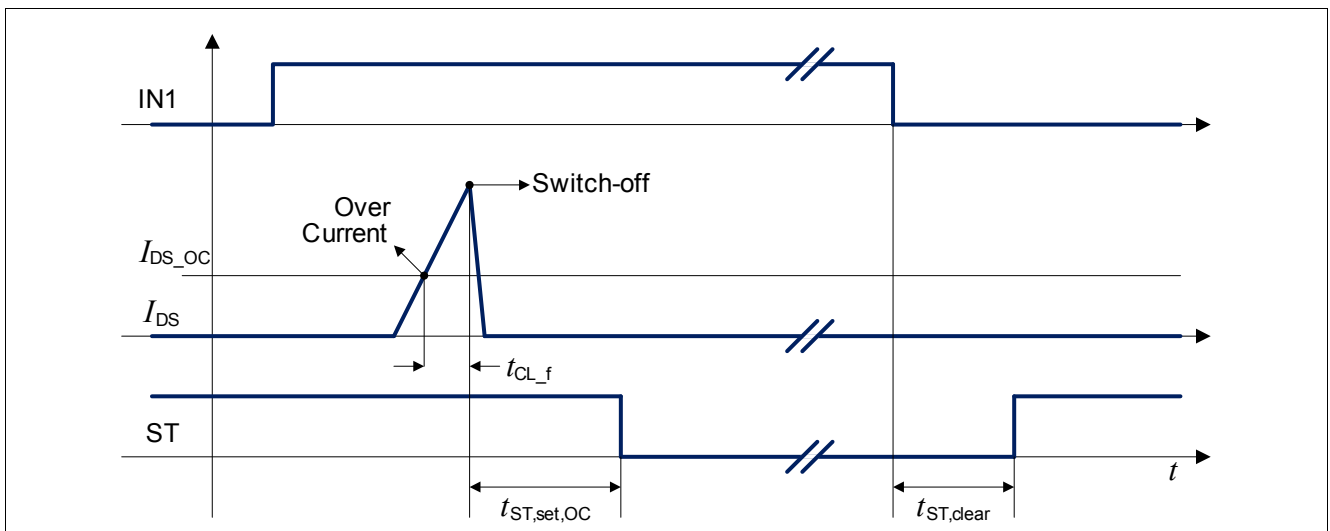


Figure 10 Over Current Detection

## 7 K-Line

### 7.1 K-Line

The K-Line module is a serial link bus interface device designed to provide bi-directional half-duplex communication interfacing. It is designed to interface between the vehicles via the special ISO K-line and meets the ISO norm 9141 specification. The device's K line bus driver's output is protected against bus shorts.

K-Line module transforms 5.0V micro-controller logic signals to battery level logic signals and vice versa. The over current limitation limits the current to a specified limit. In case of over-temperature on OUT1 the low-side switch and the output stage KIO will be switched off and can only be re-activated if the temperature has decreased below the minimum hysteresis value.

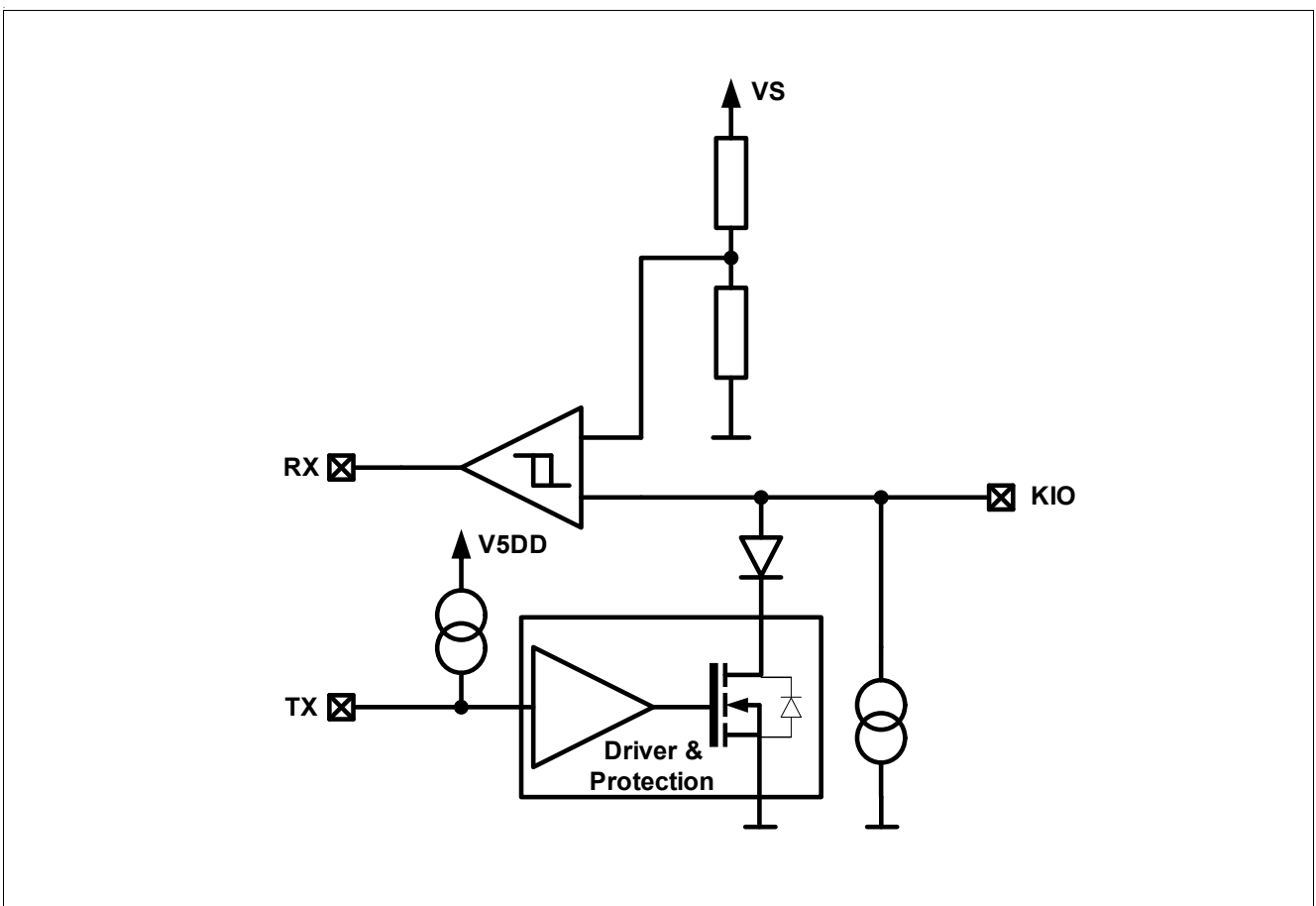


Figure 11 K-Line

**Electrical Characteristics: K-Line**
**Table 2 Electrical Characteristics: K-Line**

$V_S = 13.5\text{ V}$ ,  $T_j = -40\text{ °C}$  to  $+150\text{ °C}$ : 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 RX</b> |                           |              |               |      |      |               |                          |
| 7.1.1            | Low Level Output Voltage  | $V_{RX,L}$   | –             | –    | 0.4  | V             | $I_{RX}=100\mu\text{A}$  |
| 7.1.2            | High Level Output Voltage | $V_{RX,H}$   | $V_{5DD}-0.4$ | –    | –    | V             | $I_{RX}=-100\mu\text{A}$ |
| <b>Input TX</b>  |                           |              |               |      |      |               |                          |
| 7.1.3            | Input Pin Low level       | $V_{TX,L}$   |               | –    | 1.00 | V             | –                        |
| 7.1.4            | Input Pin High level      | $V_{TX,H}$   | 3.20          | –    |      | V             | –                        |
| 7.1.5            | Input Pin Hysteresis      | $V_{TX,HYS}$ | 280           | 500  | 700  | mV            | 1)                       |
| 7.1.6            | Input Pin Pull Up Current | $I_{IN,PU}$  | -70           | –    | -150 | $\mu\text{A}$ | $V_{TX}=0$               |

**KIO input / Output**

|       |                          |                |    |   |     |               |                                |
|-------|--------------------------|----------------|----|---|-----|---------------|--------------------------------|
| 7.1.7 | Low Level Output Voltage | $V_{KIO,L}$    | –  | – | 1.4 | V             | TX=low,<br>$R_{KIO}=480\Omega$ |
| 7.1.8 | Current Limitation       | $I_{KIO(lim)}$ | 40 | – | 140 | mA            |                                |
| 7.1.9 | Output Pull-Down current | $I_{KIO,PD}$   | 5  | – | 15  | $\mu\text{A}$ | TX=high                        |

**KIO Input Comparator**

|        |                            |              |            |   |             |   |   |
|--------|----------------------------|--------------|------------|---|-------------|---|---|
| 7.1.10 | Input Low Voltage          | $V_{IN,L}$   | –          | – | $0.4*V_S$   | V | – |
| 7.1.11 | Input High Voltage         | $V_{IN,H}$   | $0.6*V_S$  | – | –           | V | – |
| 7.1.12 | Input Threshold Hysteresis | $V_{IN,Hys}$ | $0.02*V_S$ | – | $0.175*V_S$ | V | – |

**Transfer characteristics KIO->RX and TX->KIO**

$CRX=25\text{pF}$ ;  $RKIO=540\Omega$ ;  $CKIO\leq 1.3\text{nF}$ ;  $V_S=13.5\text{V}$

|        |                                |            |      |   |     |               |                                   |
|--------|--------------------------------|------------|------|---|-----|---------------|-----------------------------------|
| 7.1.13 | Transmission Frequency KIO->RX | $f_{RKIO}$ | –    | – | 500 | kHz           | $C_{KIO}=0\text{pF}$              |
| 7.1.14 | Transmission Frequency TX->KIO | $f_{TKIO}$ | –    | – | 100 | kHz           | –                                 |
| 7.1.15 | Off Delay / Rise Time KIO->RX  | $t_{drR}$  | 0.05 | – | 0.5 | $\mu\text{s}$ | $C_{RX,load}=1.6\text{pF}$ 2)     |
| 7.1.16 | Off Delay / Rise time TX->KIO  | $t_{drT}$  | 0.05 | – | 0.5 | $\mu\text{s}$ | $C_{KIO,load}=1.6\text{pF}$ 1) 2) |
| 7.1.17 | On Delay / Fall time KIO->RX   | $t_{dfR}$  | 0.05 | – | 0.5 | $\mu\text{s}$ | $C_{RX,load}=1.6\text{pF}$ 2)     |
| 7.1.18 | On Delay / Fall time TX->KIO   | $t_{dfT}$  | 0.05 | – | 0.5 | $\mu\text{s}$ | $C_{KIO,load}=1.6\text{pF}$ 2)    |

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

2) For definition see [Figure 12](#)

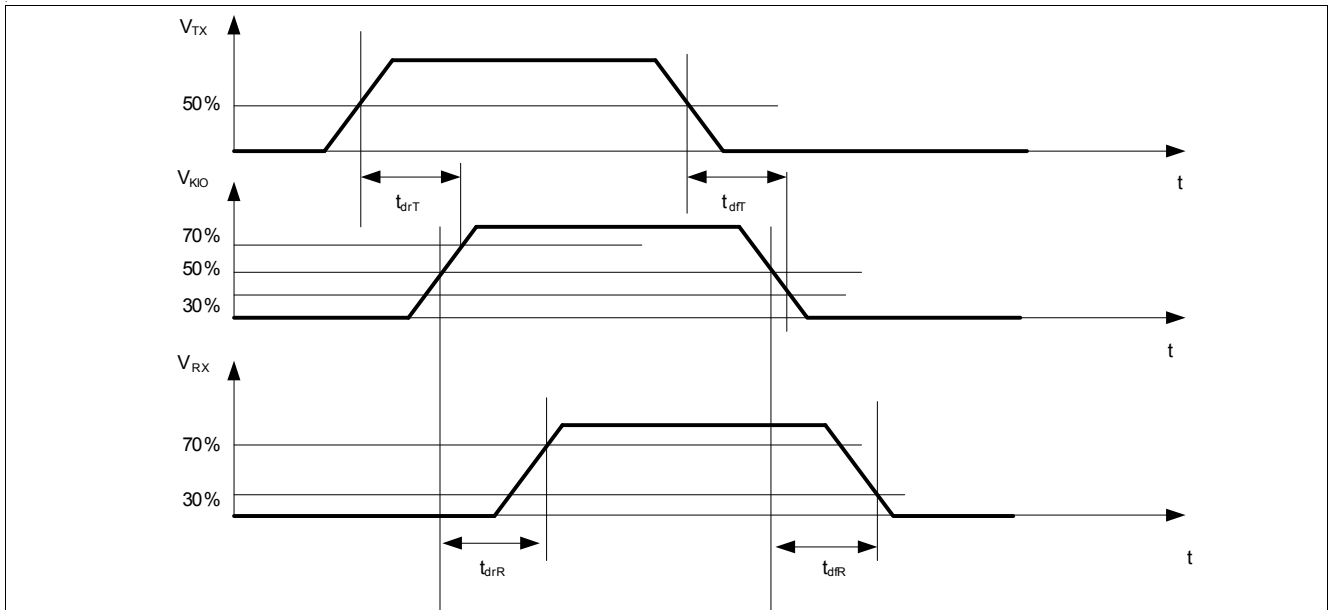


Figure 12 Transfer characteristics

## 8 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.

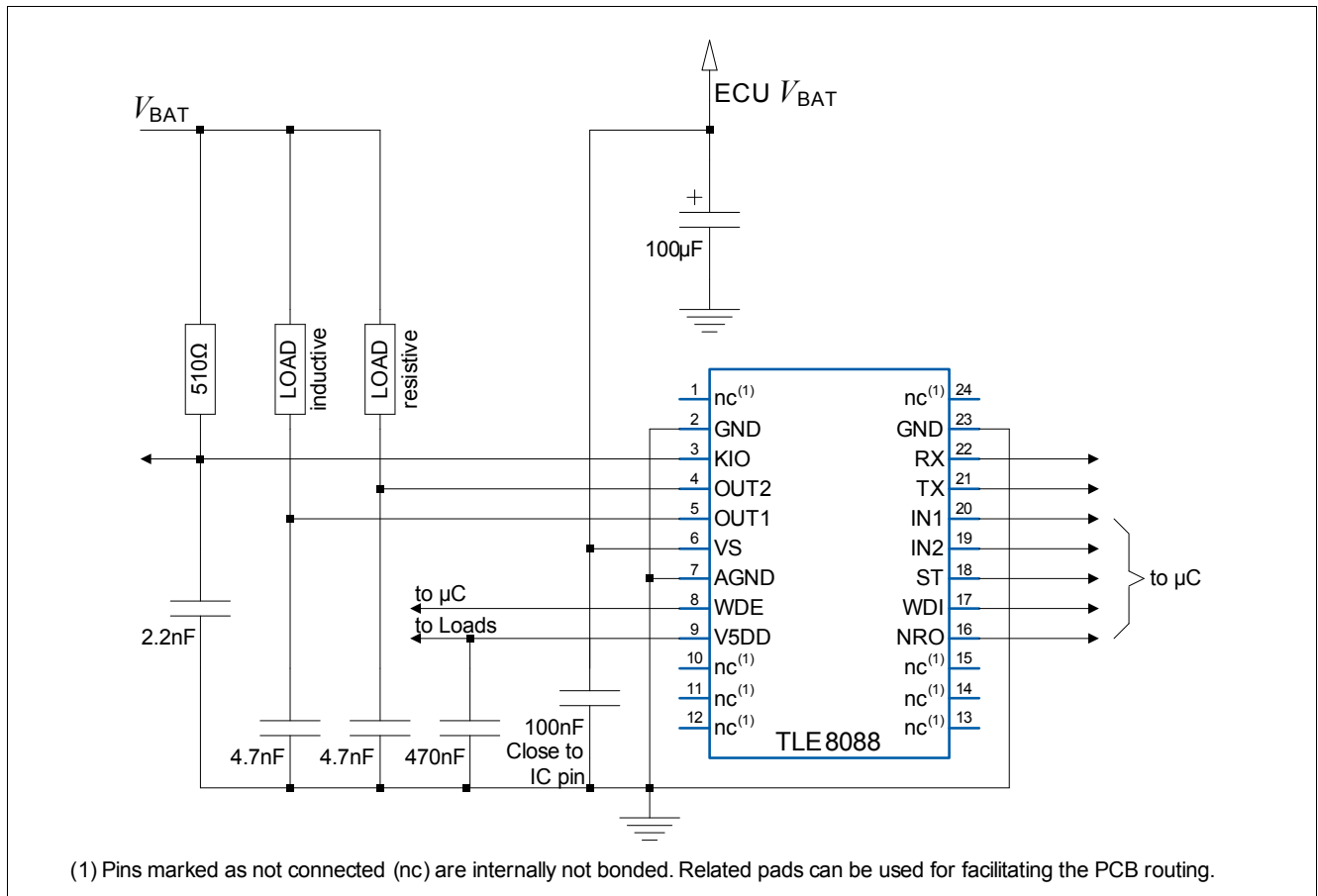


Figure 13 Application Diagram

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

### 8.1 Further Application Information

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

## 9 Package Outlines

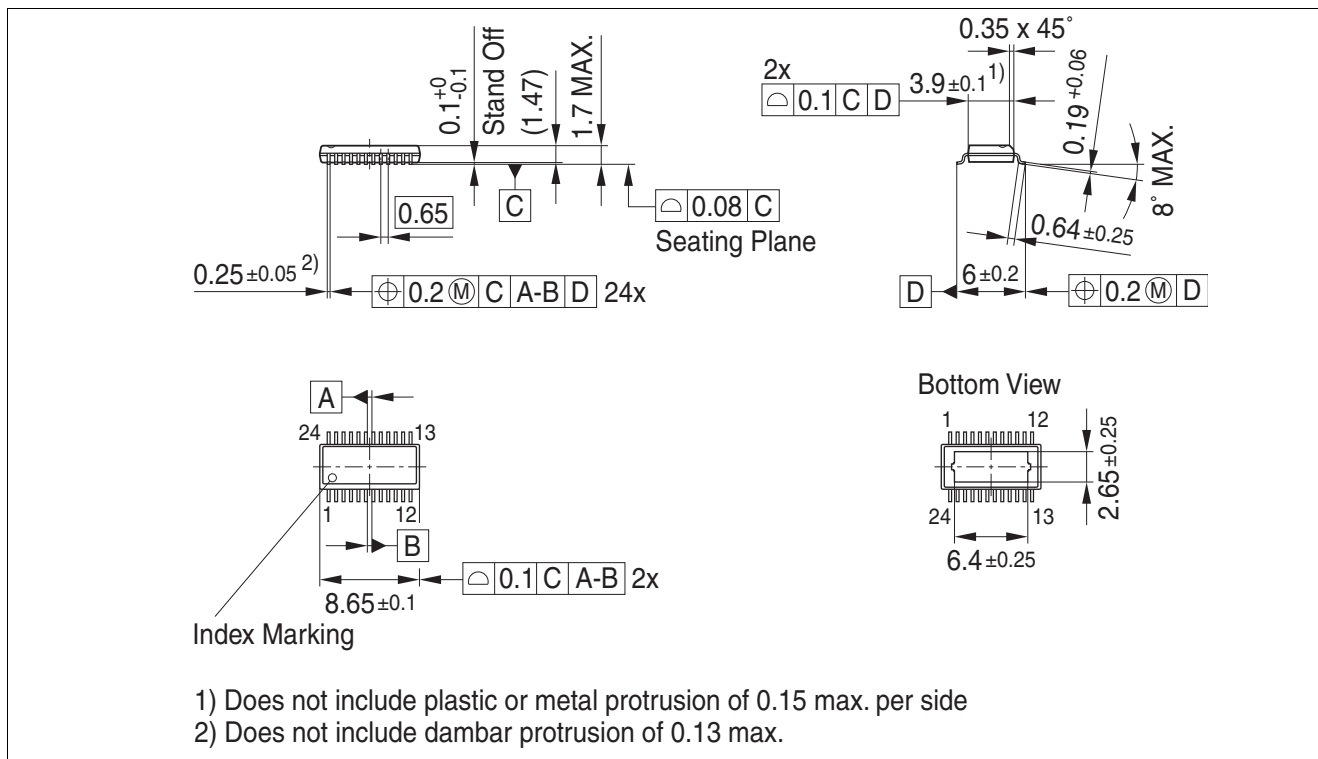


Figure 14 PG-SSOP-24

### Green Product (RoHS compliant)

To meet the world-wide customer requirements for environmentally friendly products and to be compliant with government regulations, the device is available as a green product. Green products are RoHS-Compliant (i.e. Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

## 10 Revision History

| Revision | Date       | Changes            |
|----------|------------|--------------------|
| 1.0      | 2012-10-01 | Data Sheet Release |
|          |            |                    |
|          |            |                    |

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