英飞凌TLE9104SH汽车动力传动系统

智能四通道动力传动系统开关

1 概述

特性

- 可配置过流保护
- 过温保护
- 开路负载检测
- 对 GND 短路检测
- 静电（ESD）防护
- 16 位 SPI（用于诊断和控制）
- 焊接：自动光学检测功能 (AOI)
- 绿色产品（完全无铅）
- 符合 AEC-Q100/101

潜在应用

TLE9104SH 最适合汽车动力传动系统应用。可用作喷油器、电磁阀、继电器等感性及阻性执行器的驱动 IC。

产品验证

适合汽车应用。产品依据AEC-Q100/101进行验证。

描述

采用智能功率技术 (SPT) 的四路低边开关，具有四个开漏 DMOS 输出级。TLE9104SH 受嵌入式保护功能的保护，专为汽车动力传动系统应用而设计。输出级可以直接由 PWM 应用（例如汽油多端口喷射）的并行输入或 SPI 控制。

Type	Package	Marking
TLE9104SH	PG-DSO-20-88	TLE9104SH

本数据手册的原文使用英文撰写。为方便起见，英飞凌提供了译文；由于翻译过程中可能使用了自动化工具，英飞凌不保证译文的准确性。 为确认准确性，请务必访问 infineon.com 参考最新的英文版本（控制文档）。

Table 1 Product summary

Parameter	Symbol	Value, Unit
Signal supply voltage	V_{IO}	3.0…5.5 V
Analog supply voltage	V_{DD}	4.5…5.5 V
Output clamping voltage	$V_{DS(AZ)}$	50…60 V
Typical On-state resistance CH 1-4 at T_j = 25°C	$R_{DS(ON)}$	150 mΩ
Typical On-state resistance CH 1-4 at T_j = 150°C	$R_{DS(ON)}$	300 mΩ
Nominal load current CH 1-4 (continuous)	I_D	3A
Short circuit to battery detection threshold CH 1-4	I_{SCB}	5A

目录

2 框图

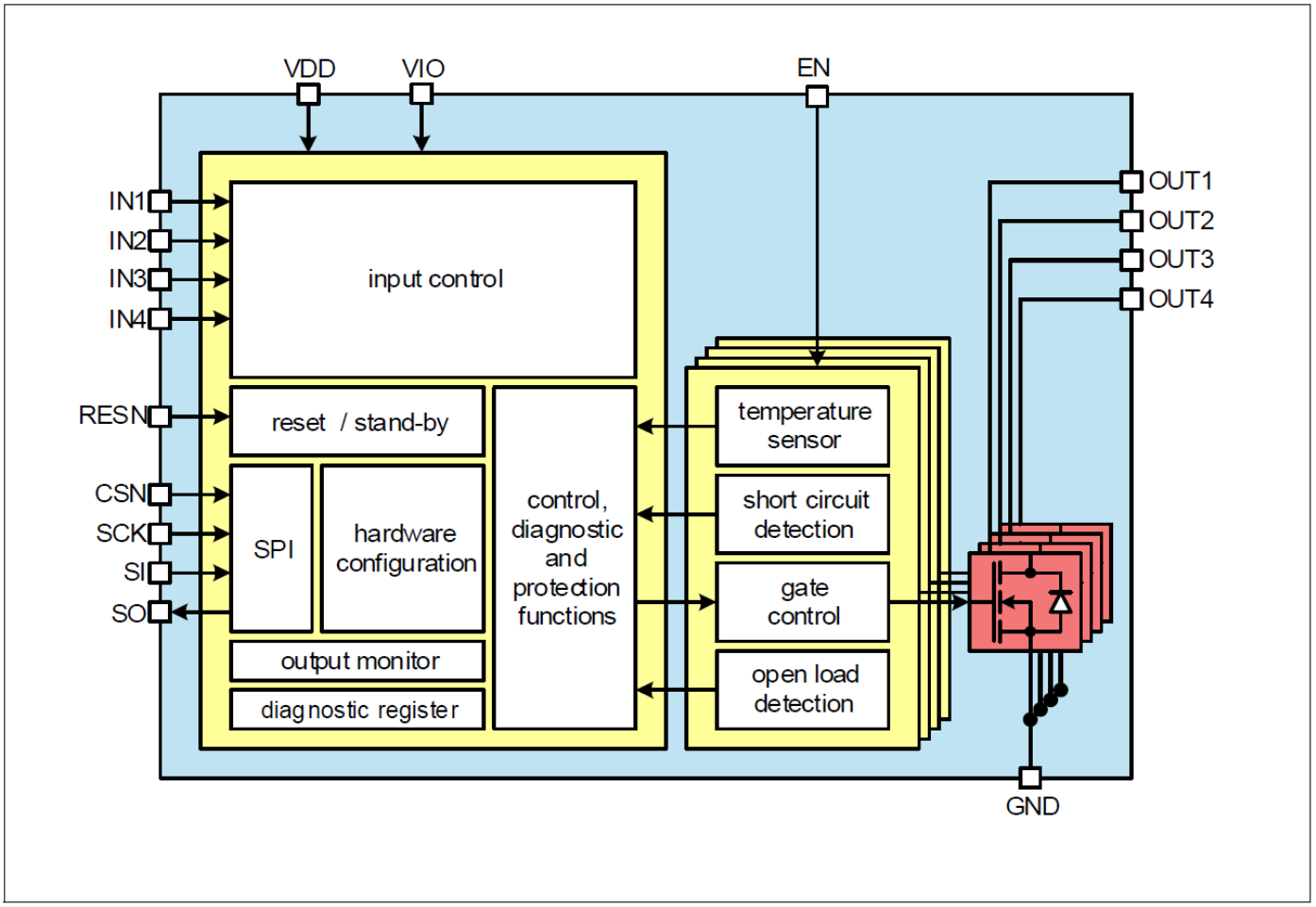


Figure 2-1 Block diagram

3 引脚配置

3.1 引脚分配

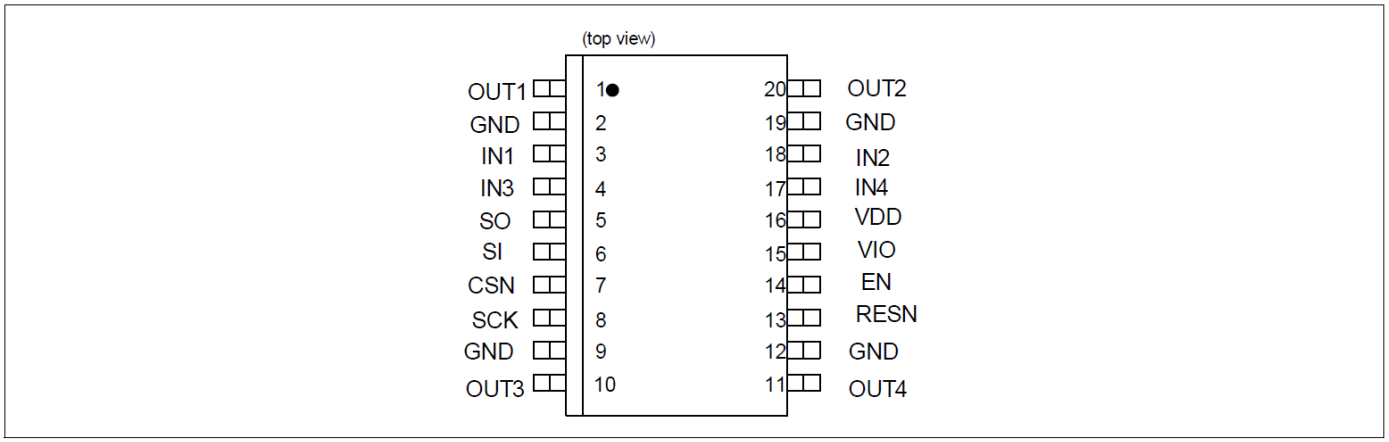


Figure 3-1 Pin configuration (top view)

3.2 引脚定义和功能

Table 3-1 Pin configuration

#	Pin Name	Function
1	OUT1	Power Output 1
2	GND	Ground
3	IN1	Input 1
4	IN3	Input 3
5	SO	Serial Data Output
6	SI	Serial Data Input
7	CSN	Serial Chip Select (active low)
8	SCK	Serial Clock
9	GND	Ground
10	OUT3	Power Output 3
11	OUT4	Power Output 4
12	GND	Ground
13	RESN	Reset (active low)
14	EN	Output Enable
15	VIO	Signal Supply Voltage
16	VDD	Analog Supply Voltage
17	IN4	Input 4
18	IN2	Input 2
19	GND	Ground
20	OUT2	Power Output 2

Pin configuration

注：

1. *TLE9104SH的散热焊盘内部未连接到地。强烈建议将散热焊盘外部连接至GND 引脚。*
2. *引脚2 和19 是输出1 和2 的接地引脚，引脚9 和12 是输出3 和4 的接地引脚。强烈建议将所有GND 引脚进行外部连接。*

4 产品基本特性

4.1 绝对最大额定值

Table 4-1 Absolute maximum ratings

T_j = -40°C 至 +150°C，所有电压相对于地，正电流流入引脚（除非另有规定）。

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Signal supply voltage	V_{IO}	-0.3	–	5.5	V	–	P_4.1.1
Analog supply voltage	V_{DD}	-0.3	–	5.5	V	–	P_4.1.2
Continuous drain source voltage (OUT1 to OUT4)	V_{DS}	-0.3	–	50	V	–	P_4.1.3
Input voltage, all inputs and data outputs, sense lines	V_{IN}	-0.3	–	V_{IO} + 0.3	V	–	P_4.1.4
Output current per channel[1)]	I_D	0	–	5.6	A	Output ON	P_4.1.5
Maximum voltage for short circuit protection (single event)[2)]	$V_{SC, single}$	–	–	30	V	–	P_4.1.6
Electro**s**tatic **D**ischarge voltage - HBM (human body model)[3)]	V_{ESD1}	-2000	–	2000	V	–	P_4.1.7
Electro**s**tatic **D**ischarge voltage - CDM (charge device model)[4)]	V_{ESD2}	-500	–	500	V	–	P_4.1.8

1) 只要不超过最大结温，就输出电流额定值。应用中的最大输出电流必须 根据安装条件使用 R_{thJA} 进行计算。

2) 短路设计符合 AEC-Q100-012 标准，具有抗短路能力。

3) 符合 ANSI/ESDA/JEDEC JS-001。

4) 符合JESD22-C101。

注：

1. *超过此处所列的电气压力可能会对器件造成永久性损坏。长时间暴露在绝对最大额定值条件下可能会影响器件的可靠性。*
2. *集成的保护功能旨在防止IC在数据手册所述故障条件下被毁坏。超出了正常工作范围为故障情况。保护功能不是为了连续重复的操作而设计的。*

4.2 工作条件

Table 4-2 Operating conditions

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Maximum output clamping energy, linearly decreasing current [1) 2)]	E_{AR}	14	–	–	mJ	$I_{D(0)}$ = 1.4 A, $T_{J(0)}$ = 110°C, Cycles: 1 billion	P_4.2.6
Maximum output clamping energy, linearly decreasing current[3)]	E_{AS}	35	–	–	mJ	T_J = 85°C, Cycles: 10	P_4.2.13
Maximum output clamping energy, linearly decreasing current	E_{AS}	25	–	–	mJ	T_J = 145°C, Cycles: 10	P_4.2.14
Maximum output clamping energy in parallel mode	$E_{AR,p}$	1.7 × E_{AR}	–	–	mJ	OUT1&2 or OUT3&4, $I_{D(0),P}$ = 1.8 × $I_{D(0)}$	P_4.2.2
热阻抗							
Junction to case	R_{thJC}	–	1	1.25	K/W	PV = 3 W, homogenously distributed between all output stages	P_4.2.3
温度范围							
Operating temperature range	T_j	-40	–	150	°C	–	P_4.2.4
Storage temperature range	T_{stg}	-55	–	150	°C	–	P_4.2.5

1) 脉冲形状表示电感关断：$I_D(t) = I_D(0) \times (1 - t / t_{pulse})$; $0 < t < t_{pulse}$

2) 给出的热量值基于注释列中指定的累积情景。

3) 给出的热量值基于注释列中指定的累积情景。

注： 在工作范围内，IC按照电路说明中的描述运行。电气特性是在相关电气特性表中注明的条件下指定的。

5 模块的电气和功能描述

5.1 电源

TLE9104SH由模拟电源线V_{DD}和信号电源V_{IO}供电。建议在引脚V_{DD}至 GND 和V_{IO}至 GND之间使用一个电容器。电源启动后，RESN 引脚应保持低电平，直到复位持续时间结束。这会将所有SPI寄存器重置为其默认值。为了使输出级有效，EN 引脚必须保持高电平，并且 OUT_EN 寄存器必须置位。

Table 5-1 Electrical characteristics: power supply

V_{DD} = 4.5 V 至 5.5 V, V_{IO} = 3 V 至 5.5 V, T_j = -40°C 至 +150°C, （除非另有说明）所有电压均相对于地，正电流流入引脚

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Signal supply voltage	V_{IO}	3	–	5.5	V	–	P_5.1.1
Analog supply voltage	V_{DD}	4.5	–	5.5	V	–	P_5.1.2
Supply current	$I_{DD(on)}$	–	–	10	mA	–	P_5.1.3
Input low voltage of pin RESN	$V_{RESN(L)}$	-0.3	–	1	V	–	P_5.1.4
Input high voltage of pin RESN	$V_{RESN(H)}$	2	–	V_{IO} + 0.3	V	–	P_5.1.5
Hysteresis voltage of pin RESN	$V_{RESN(Hys)}$	100	300	500	mV	–	P_5.1.6
Input pull-up current through pin RESN	I_{RESN}	-100	-65	-30	µA	V_{RESET} = 0 V	P_5.1.7
Reset duration time[1)]	$t_{RESN(L)}$	10	–	–	µs	–	P_5.1.8
Input low voltage of pin EN	$V_{EN(L)}$	-0.3	–	1	V	–	P_5.1.9
Input high voltage of pin EN	$V_{EN(H)}$	2	–	V_{IO} + 0.3	V	–	P_5.1.10
Hysteresis voltage of pin EN	$V_{EN(Hys)}$	100	300	500	mV	–	P_5.1.11
Input pull-down current through pin EN	I_{EN}	30	65	100	µA	V_{EN} = 2 V	P_5.1.12

1) 为了正确启动，在电源V_{DD}达到其最终电压后，RESN 引脚应保持低电平直到复位持续时间结束。

5.2 并行输入

每个输入信号控制其相关通道的输出级。例如，IN1 控制 OUT1，IN2 控制 OUT2 等。输入信号为低电平有效。因此，向 INx 施加小于$V_{IN(L)}$的电压将打开 OUTx。可以将 OUT1-2 和 OUT3-4 串联。为此，必须在 CFG 寄存器中选择正确的配置。在这种情况下，IN1 控制 OUT1-2，IN3 控制 OUT3-4。

Table 5-2 Electrical characteristics: parallel inputs

V_{DD} = 4.5 V 至 5.5 V， V_{IO} = 3 V 至 5.5 V， T_j = -40°C 至 +150°C，（除非另有说明）
所有电压均相对于地，正电流流入引脚（除非引脚 SO）

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Input low voltage of pin INx	$V_{IN(L)}$	-0.3	–	1	V	–	P_5.2.1
Input high voltage of pin INx	$V_{IN(H)}$	2	–	V_{IO} + 0.3	V	–	P_5.2.2
Input voltage hysteresis	$V_{IN(Hys)}$	100	300	500	mV	–	P_5.2.3
Input pull-up current through pin INx	$I_{IN(L)}$	-100	-65	-30	µA	V_{IN} = 0 V	P_5.2.4

5.3 功率级

Table 5-3 Electrical characteristics: power outputs

V_{DD} = 4.5 V 至 5.5 V， V_{IO} = 3 V 至 5.5 V， T_j = -40°C 至 +150°C，（除非另有说明）
所有电压均相对于地，正电流流入引脚（除非引脚 SO）

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
ON resistance	$R_{DS(ON)}$	–	150		mΩ	T_J = 25°C,	P_5.3.1
ON resistance	$R_{DS(ON)}$	–	300	350	mΩ	T_J = 150°C,	P_5.3.2
ON resistance in parallel mode	$R_{DS(ON)}$	–	75	–	mΩ	T_J = 25°C, outputs 1&2 or 3&4 in parallel	P_5.3.3
ON resistance in parallel mode	$R_{DS(ON)}$	–	150	175	mΩ	T_J = 150°C, outputs 1&2 or 3&4 in parallel	P_5.3.4
Output clamping voltage	$V_{DS(AZ)}$	50	–	60	V	output OFF	P_5.3.5
Output leakage current	$I_{D(lkg)}$	–	–	10	µA	RESN=0	P_5.3.6
Output off-state current	I_{OUTx_OFF}	–	–	30	µA	RESN=1, OUTx_DIAG_EN =0, V_{OUTx} = 35 V	P_5.3.6
Turn-on time	t_{ON}	–	15	–	µs	from 50% of INx to 20% of Vbat	P_5.3.7

Table 5-3 Electrical characteristics: power outputs (cont'd)

V_{DD} = 4.5 V 至 5.5 V， V_{IO} = 3 V 至 5.5 V， T_j = -40°C 至 +150°C，（除非另有说明）
所有电压均相对于地，正电流流入引脚（除非引脚 SO）

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Turn-off time	t_{OFF}	–	15	–	µs	from 50% of INx to 80% of Vbat	P_5.3.8
Overtemperature shutdown threshold	$T_{j(OT)}$	165	–	200	°C	–	P_5.3.9

5.4 保护功能

TLE9104SH 提供嵌入式保护功能。集成的保护功能旨在防止IC在数据表所述故障条件下被毁坏。超出了正常工作范围为故障情况。保护功能不是为了连续重复的操作而设计的。TLE9104SH 实现了以下保护功能：

- 过温保护（OT）
- 对电池短路（SCB）保护。
- 过流保护（OC）

注：　集成的保护功能旨在防止IC在数据手册所述故障条件下被毁坏。超出了正常工作范围为故障情况。保护功能不是为了连续重复的操作而设计的。

5.4.1 过温保护

每个通道的专用温度传感器可检测其通道温度是否超过过热关断阈值。如果通道温度超过过热关断阈值，则过热通道会立即关闭以防止损坏。清除过热错误后，可以再次打开通道；但是，如果感测到的温度仍然高于过热关断阈值，则通道将在滤波时间t_{OT}后关闭。

5.4.2 对电池的保护

TLE9104SH在对电池短路的情况下受到保护。如果输出通道的电流超过I_{SCB} ，则相应通道立即关闭。故障条件消除且错误清除后，通道可再次打开。

5.4.3 过流保护

通过可配置的过流保护进行TLE9104SH保护。如果输出通道的电流超过I_{OC}，则在刺激时间 $t_{d(OC)}$后关闭相应通道。故障条件消除且错误清除后，通道可再次打开。电流极限阈值I_{OC}及其辅助时间$t_{d(OC)}$均可通过SPI配置。仅当寄存器中的输出位 OUT_EN 在SPI寄存器中为低电平时，才能配置滤波时间$t_{d(OC)}$和电流极限阈值 I_{OC}。

5.5 诊断功能

TLE9104SH 的所有输出级均实现了以下诊断功能：
- 如果输出级已打开，则可以检测到电池短路检测 (SCB)。
- 如果输出级已打开，则可以检测到过温检测 (OT)。
- 如果输出级已打开，则可以检测到基于时间的过流检测 (OCF)。
- 如果输出级已打开，则可以检测到基于温度的过流检测 (OCT)。
- 如果输出级已关闭，则可以检测到短路至 GND 检测 (SCG)。
- 如果输出级已关闭，则可以检测到负载开路检测（OL）。

TLE9104SH 的诊断信息可通过 SPI 接口访问。OL 和 SCG 诊断使用两个阈值 ($V_{OUTn-SCG}$和$V_{OUTn-OL}$) 进行识别。还可以关闭内部诊断下拉和上拉电流源。在这种情况下，OL 和 SCG 的诊断将被停用。

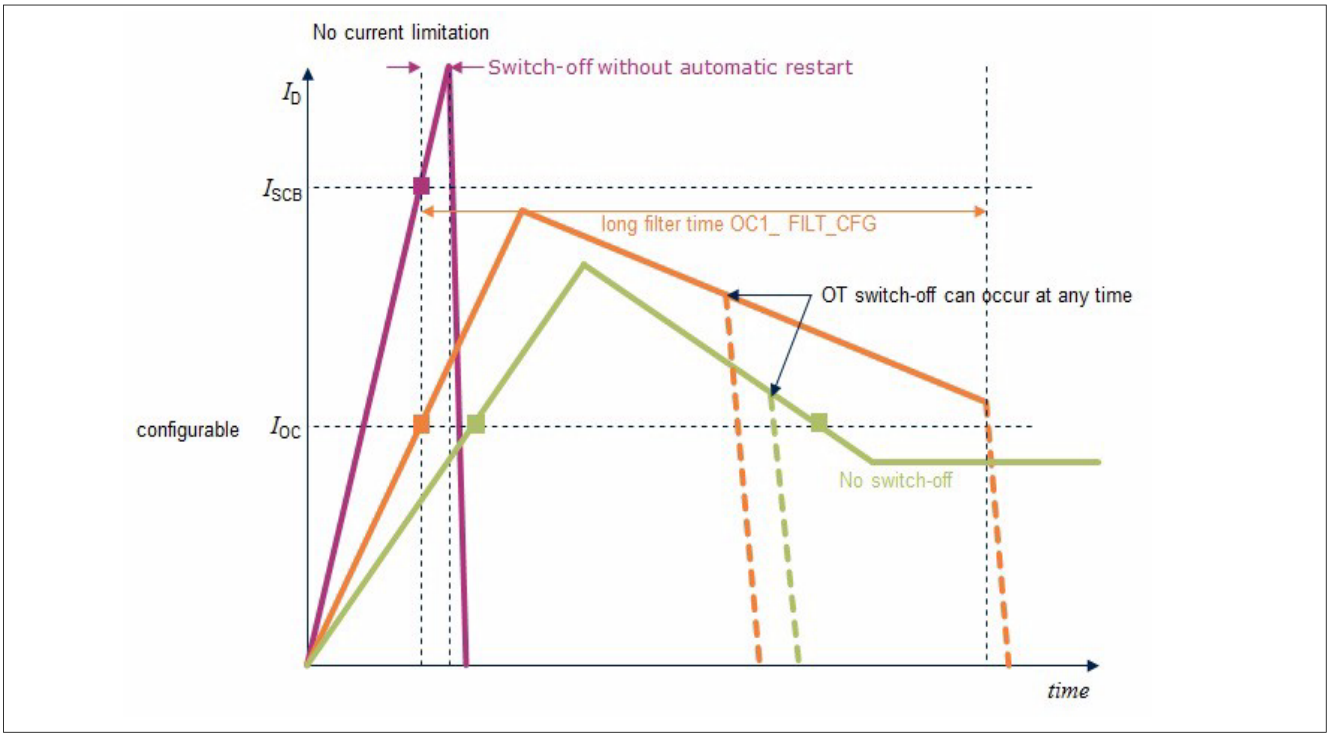


Figure 5-1 Overcurrent and short circuit to battery protection

直到集成的滤波时间 $t_{d(fault)}$ 到期后， 故障条件 SCG 和 OL 才会被存储 。 除了滤波时间，还可以配置额外的消隐时间$t_{b(fault)}$。 *消隐时间* $t_{b(fault)}$ 只能在SPI寄存器中的输出使能位 OUT_EN 为低电平时进行配置。

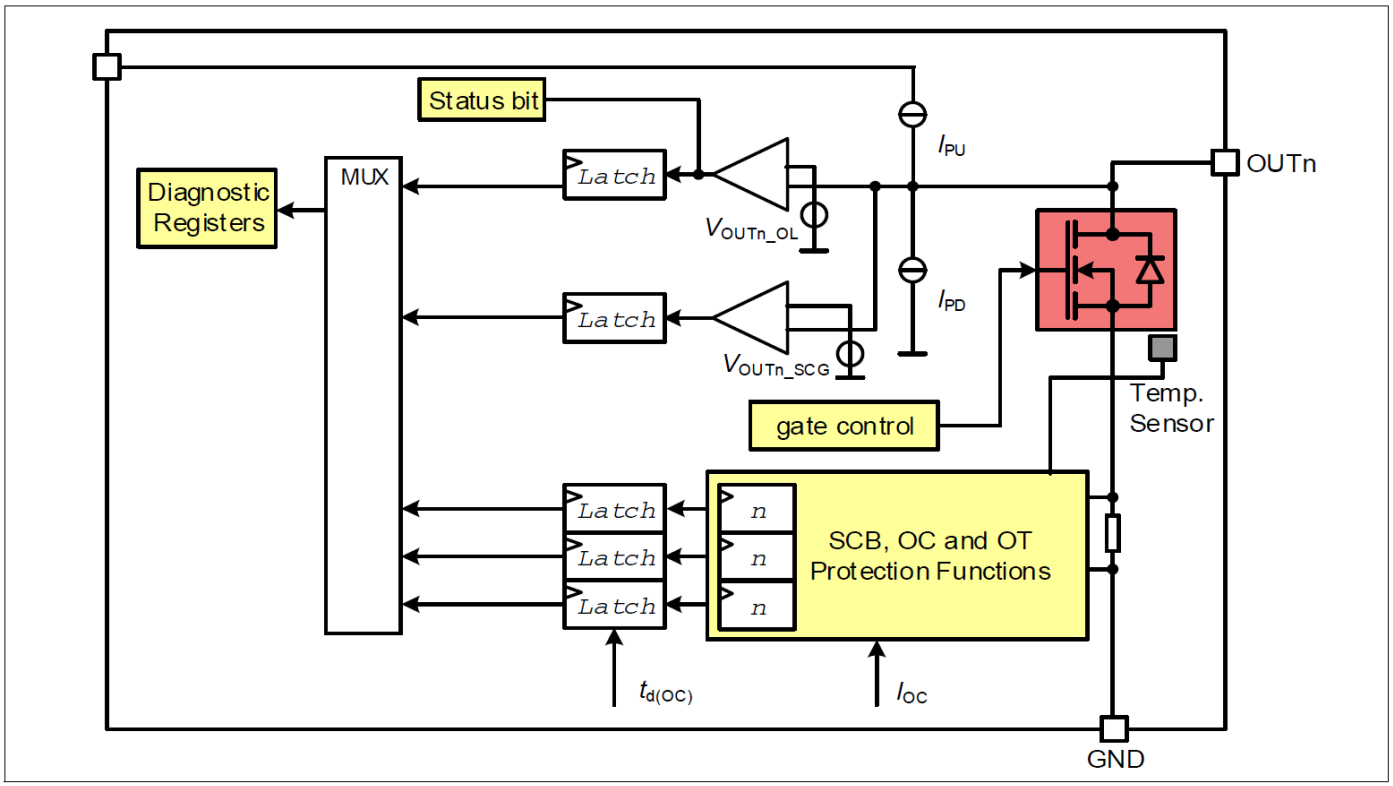


Figure 5-2 Diagnostic functions (overview only)

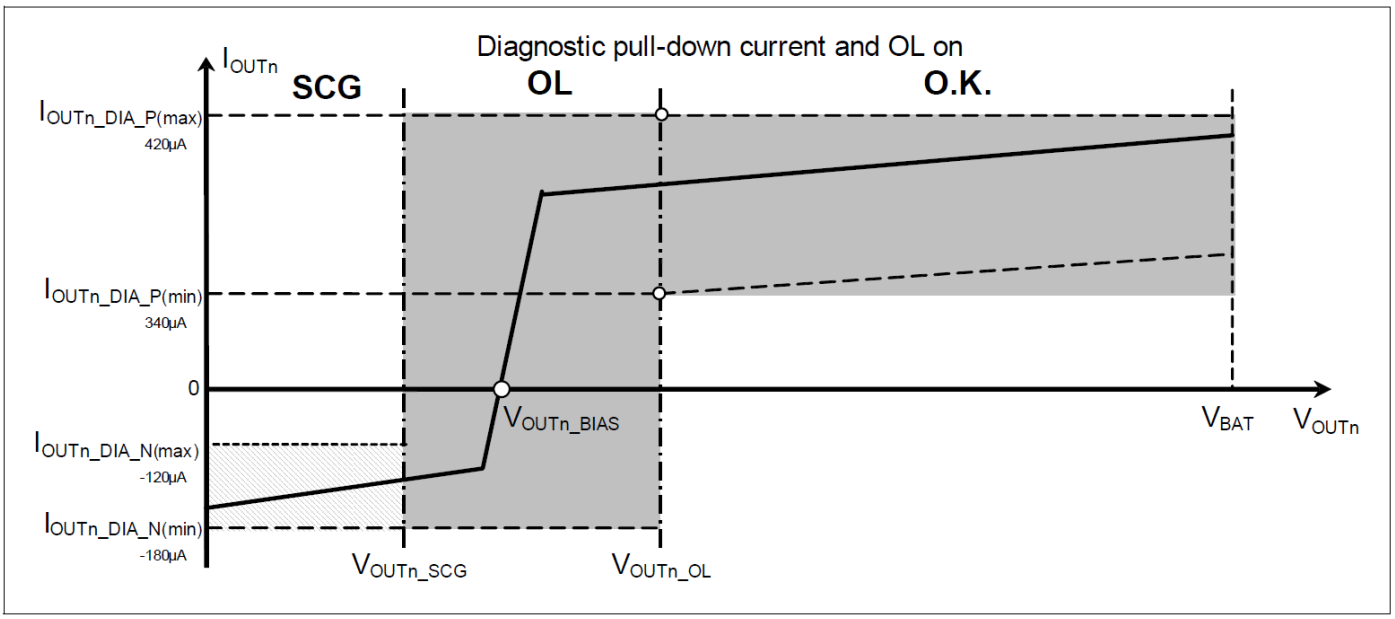


Figure 5-3 SCG and OL diagnostic function (overview only)

Table 5-4 Electrical characteristics: diagnostic functions

V_{DD} = 4.5 V 至 5.5 V， V_{IO} = 3 V 至 5.5 V， T_j = -40°C 至 +150°C，（除非另有说明）
所有电压均相对于地，正电流流入引脚（除非引脚 SO）

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Open load detection voltage	$V_{OUTn-OL}$	0.6 V_{DD} - 0.2	–	0.6 V_{DD} + 0.2	V	–	P_5.5.1
Diagnostic pull-down current	I_{PD}	300	380	450	µA	V_{OUTn} = 0.6 V_{DD}	P_5.5.2
Diagnostic pull-up current	I_{PU}	-180	-150	-120	µA	V_{OUTn} = 0.4 V_{DD}	P_5.5.3
Short circuit to ground detection voltage	$V_{OUTn-SCG}$	0.4 V_{DD} - 0.2	–	0.4 V_{DD} + 0.2	V	–	P_5.5.4
Short circuit to battery detection current	I_{SCB}	4.5	5	5.6	A	–	P_5.5.5
Short circuit to battery detection current in parallel mode	I_{SCB}	9	10	11	A	Outputs 1&2 or outputs 3&4 connected in parallel	P_5.5.6
Fault filtering time[1)]	$t_{d(fault)}$	0.015	0.02	0.025	ms		P_5.5.7
Fault blanking time[2)]	$t_{b(fault)}$	0.16	0.2	0.24	ms	configurable via SPI	P_5.5.8
Fault blanking time	$t_{b(fault)}$	0.4	0.5	0.60	ms	default value	P_5.5.9
Fault blanking time	$t_{b(fault)}$	0.8	1	1.2	ms	configurable via SPI	P_5.5.10
Fault blanking time	$t_{b(fault)}$	1.6	2	2.4	ms	configurable via SPI	P_5.5.11
Overcurrent filtering time	$t_{d(OC)}$	0.04	0.06	0.08	ms	default value	P_5.5.12
Overcurrent filtering time	$t_{d(OC)}$	0.1	0.12	0.14	ms	configurable via SPI	P_5.5.13
Overcurrent filtering time	$t_{d(OC)}$	0.4	0.5	0.6	ms	configurable via SPI	P_5.5.14

Table 5-4 Electrical characteristics: diagnostic functions (cont'd)

V_{DD} = 4.5 V 至 5.5 V， V_{IO} = 3 V 至 5.5 V， T_j = -40°C 至 +150°C，（除非另有说明）
所有电压均相对于地，正电流流入引脚（除非引脚 SO）

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Overcurrent filtering time	$t_{d(OC)}$	0.8	1	1.2	ms	configurable via SPI	P_5.5.15
Overcurrent filtering time	$t_{d(OC)}$	4	5	6	ms	configurable via SPI	P_5.5.16
Overcurrent filtering time	$t_{d(OC)}$	8	10	12	ms	configurable via SPI	P_5.5.17
Overcurrent filtering time	$t_{d(OC)}$	16	20	24	ms	configurable via SPI	P_5.5.18
Overcurrent filtering time	$t_{d(OC)}$	24	30	36	ms	configurable via SPI	P_5.5.19
Overcurrent threshold	I_{OC}	0.75	1	1.25	A	configurable via SPI	P_5.5.20
Overcurrent threshold	I_{OC}	1.75	2	2.25	A	default value	P_5.5.21
Overcurrent threshold	I_{OC}	2.5	3	3.5	A	configurable via SPI	P_5.5.22
Overcurrent threshold	I_{OC}	3.5	4	4.5	A	configurable via SPI	P_5.5.23
Overcurrent threshold in parallel mode	I_{OC}	1.35	2	2.5	A	configurable via SPI, outputs 1&2 or outputs 3&4 connected in parallel	P_5.5.24
Overcurrent threshold in parallel mode	I_{OC}	3.15	4	4.5	A	default value, outputs 1&2 or outputs 3&4 connected in parallel	P_5.5.25
Overcurrent threshold in parallel mode	I_{OC}	4.5	6	7	A	configurable via SPI, outputs 1&2 or outputs 3&4 connected in parallel	P_5.5.26
Overcurrent threshold in parallel mode	I_{OC}	6.3	8	9	A	configurable via SPI, outputs 1&2 or outputs 3&4 connected in parallel	P_5.5.27
Overtemperature filter time	t_{OT}	2	3	4	µs	–	P_5.5.28
Short circuit to battery filter time	t_{SCB}	1.2	–	2	µs	–	P_5.5.28

1) $t_{d(fault)}$是负载开路和接地短路诊断功能的故障滤波时间。
2) $t_{d(fault)}$是负载开路和接地短路诊断功能的消隐时间。

5.5.1 输出级状态

每个通道的开路负载比较器的输出可通过 OUTx_STAT 位直接获得。该状态位可用于检测故障条件，其中通道由 INx 或SPI打开，但功率级保持关闭状态。通过 INx 或 SPI 开启和状态位改变之间的延迟取决于输出电压变化率，因此也取决于负载本身。

5.6 通讯看门狗

TLE9104SH利用看门狗原理来监测SPI通讯。如果没有通讯或者持续通讯故障，所有输出都将被禁用。如果SPI帧出现故障，CWD 定时器不会重新触发，并且在滤波时间之后，寄存器 CWD-TO 将被置位，并且可以在SPI恢复正常运行后立即读取。看门狗默认是使能的；但是，可以通过SPI指令禁用它。

一旦器件完成启动并且所有块都从复位状态释放，看门狗就开始工作。如果满足这些条件，则启动看门狗计时器t_{CWD}。每个正确的SPI通讯都会重新启动t_{CWD}计时器。如果在超时时间内没有收到有效的通讯，t_{CWD}定时器将失效并且所有输出被关闭。为了重新使能，需要通过SPI清除故障并使能输出。通过清除错误，输出不会自动使能。

看门狗计时器t_{CWD}可通过SPI *配置。仅当*$_{SPI}$寄存器中的使能位 OUT_EN 为低时，才能配置看门狗计时器 t CWD 。

以下SPI通讯问题被看门狗检测为故障：

- 暂无通讯
- 错误指令
- 帧不等于 16 个时钟

Table 5-5 Communication watchdog timeout configuration

V_{DD} = 4.5 V 至 5.5 V， V_{IO} = 3 V 至 5.5 V， T_j = -40°C 至 +150°C，（除非另有说明）
所有电压均相对于地，正电流流入引脚（除非引脚 SO）

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
Communication watchdog timeout	t_{CWD0}	20	25	30	ms	configurable via SPI	P_5.6.1
Communication watchdog timeout	t_{CWD1}	40	50	60	ms	default value	P_5.6.2
Communication watchdog timeout	t_{CWD2}	60	75	90	ms	configurable via SPI	P_5.6.3

6 16 位 SPI 接口

诊断和控制接口基于串行外设接口（SPI）。

SPI是全双工同步串行从机接口，使用四条线：SO，SI，SCK，CSN。数据通过SI和 SO 线路以 SCK 给出的数据传输速率进行传输。CSN 的下降沿指示数据存取的开始。数据在 SCK 的下降沿从 SI 线采样，在 SCK 的上升沿从 SO 线移出。每个访问应由 CSN 的上升沿终止。模 16 计数器确保仅当传输了 16 位的倍数时才获取数据。

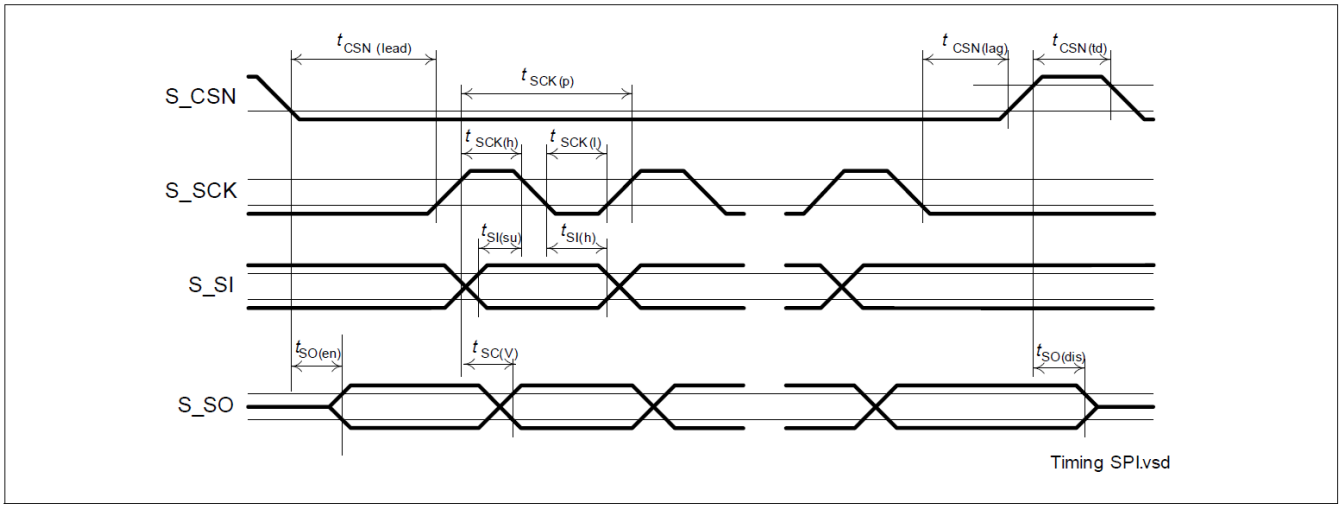


Figure 6-1 SPI timing

6.1 电气特性 16 位SPI接口

Table 6-1 Electrical characteristics: 16 bit SPI interface

V_{DD} = 4.5 V 至 5.5 V, V_{IO} = 3 V 至 5.5 V，T_j = -40°C 至 +150°C，所有电压相对于地，正电流流入引脚（除非另有说明）

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
输入特性（CSN、SCK、SI）							
L level of pin CSN, SCK, SI	V_{IO_CSNL} V_{IO_SCKL} V_{IO_SIL}	-0.3	–	1	V	–	P_6.1.1
H level of pin CSN, SCK, SI	V_{IO_CSNH} V_{IO_SCK} H V_{IO_SIH}	2	–	V_{IO} + 0.3	V	–	P_6.1.2
Hysteresis input pins	V_{IO_CSNHy} V_{IO_SCKHy} V_{IO_SIHy}	100	300	500	mV	–	P_6.1.3
输出特性（SO）							
L level output voltage	V_{IO_SOL}	0	–	1	V	I_{IO_SO} = -2 mA	P_6.1.4
H level output voltage	V_{IO_SOH}	V_{IO} - 0.5	–	V_{IO} + 0.3	–	–	P_6.1.5
Output tristate leakage current	I_{IO_SOoff}	-10	–	10	µA	–	P_6.1.6

Table 6-1 Electrical characteristics: 16 bit SPI interface

V_{DD} = 4.5 V 至 5.5 V, V_{IO} = 3 V 至 5.5 V, T_j = -40°C 至 +150°C，所有电压相对于地，正电流流入引脚（除非另有说明）

Parameter	Symbol	Values			Unit	Note or Test Condition	Number
		Min.	Typ.	Max.			
输入电容时序							
For CSN, SCK, SI and SO	C_{in}	–	6	8	pF	–	P_6.1.13
Serial clock frequency[1)]	f_{SCK}	0	–	8	MHz	C_L = 25 pF	P_6.1.7
Serial clock period	$t_{SCK(P)}$	125	–	–	ns	–	P_6.1.8
Serial clock high time	$t_{SCK(h)}$	50	–	–	ns	–	P_6.1.9
Serial clock low time	$t_{SCK(l)}$	50	–	–	ns	–	P_6.1.10
Enable lead time (falling CSN to rising SCK)	$t_{CSN(lead)}$	250	–	–	ns	–	P_6.1.11
Enable lag time (falling SCK to rising CSN)	$t_{CSN(lag)}$	250	–	–	ns	–	P_6.1.12
Data setup time (required time SI to falling SCK)	$t_{SI(su)}$	20	–	–	ns	–	P_6.1.14
Data hold time (falling SCK to SI)	$t_{SI(h)}$	20	–	–	ns		P_6.1.15
Output enable time (falling CSN to SO valid)	$t_{SO(en)}$	–	–	200	ns	C_L = 25 pF	P_6.1.16
Output disable time (rising CSN to SO tri-state)	$t_{SO(dis)}$	–	–	200	ns	C_L = 25 pF	P_6.1.17
Output data valid time with capacitive load	$t_{SO(v)}$	–	–	100	ns	C_L = 25 pF	P_6.1.18
Transfer delay time (rising CSN to falling CSN)	$t_{CSN(td)}$	1	–	100	µs	C_L = 25 pF	P_6.1.19

1) 应用中的最大SPI时钟频率可能会较小，具体取决于 SO 引脚上的负载以及对微控制器SPI外设的时间要求。

6.2 SPI 寄存器

一般SPI帧长度固定为16位。每个帧的位0到7用作数据帧，位8到10用于地址，位14是校验位，位15用于指定读或写指令。奇偶校验位定义为：

$$b_{14} = (1 + b_{15} + \sum_{i=0}^{13} b_i) \bmod 2 \tag{6.1}$$

MOSI

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R/W	**Parity**	**0**	**0**	**Address**				**Data**							

MISO

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R/W	**Parity**	**Fault Communi-cation**	**Fault Global**	**Address**				**Data**							

在 MOSI 和 MISO 中，读取用“0”定义，写入用“1”定义。每个MISO SPI帧将位 12 和 13 中的重要系统故障报告为全局或通讯故障，如下所示：

- 当 Global_Status 寄存器中的一般故障位被置位时，全局故障被触发（不锁存）。
- 当存在下列故障之一时，通讯故障被触发（不锁定）：
  - 通讯错误(与Global_Status寄存器中的COM_ERR相同)
  - 通讯看门狗超时
  - 奇偶校验错误

此外，全局状态寄存器存储以下故障：

- 如果至少存在下列故障之一，则为一般故障：
  - 过流
  - 过温
  - 过流时过热
  - 短路到电池
  - 开路
  - 对地短路
- 通讯错误：
  - 暂无通讯
  - 错误指令
  - 不等于 16 位的帧
- 奇偶校验错误
- 通讯看门狗

除故障外，全局寄存器还恢复使能锁存信号（EN_Latch）和复位锁存功率（POR_Latch），如下所示：

- EN_Latch：此位的复位值为“0”。设置 OUT_EN 位后，该位变为“1”。这一位表明自上次清零之后，输出是否已启用（通过SPI ）至少一次。
- POR_Latch：该位的复位值为“1”。它可以通过 SPI 更改为“0”。任何上电复位都会将这一位设置回 1。这可用于检查自从上次清零以来是否发生过了上电复位。

Table 6-2 Register Address Space

Module	Base Address	End Address	Note
apb	0_H	$1F_H$	–

Table 6-3 Register Overview

Register Short Name	Register Long Name	Offset Address	Page Number
CTRL	Output control register	00_H	22
CFG	Configuration register	01_H	24
OFF_DIAG_CFG	Off-state diagnostic configuration register	02_H	25
ON_DIAG_CFG	On-state diagnostic configuration register	03_H	26
DIAG_OUT_1_2_ON	On-state diagnostic result register OUT1 & OUT2	04_H	27
DIAG_OUT_3_4_ON	On-state diagnostic result register OUT3 & OUT4	05_H	28
DIAG_OFF	Off-state diagnostic result register	06_H	29
GLOBAL_STATUS	Global device status register	07_H	30
ICVID	IC Version ID	08_H	31

寄存器按字寻址。

Table 6-4 Register Overview

Bit type short name	Bit type description	Note
r	read	–
rw	read/write	–
rwc	read and clear on write	clear on write 0

注：所有配置仅可在 OUT_EN 位被清除时被更改。

6.2.1 寄存器

Output control register

CTRL	Offset	Reset Value
Output control register	**00_H**	**00_H**

7	6	5	4	3	2	1	0
OUT4_ON_S	OUT4_ON_C	OUT3_ON_S	OUT3_ON_C	OU 2_ON_S	OUT2_ON_C	OUT1_ON_S	OUT1_ON_C
rw	rw	rw	rw	rw	rw	rw	rw

Field	Bits	Type	Description
OUT4_ON_S	7	rw	**OUT4 SPI control bit (used if CFG.OUT4_DD = 0)** 1_D **SET**, Output 4 set 0_D **NO_ACTION**, Output 4 no action Reset: 0_B
OUT4_ON_C	6	rw	**OUT4 SPI control bit (used if CFG.OUT4_DD = 0)** 1_D **CLEAR**, Output 4 clear 0_D **NO_ACTION**, Output 4 no action Reset: 0_B
OUT3_ON_S	5	rw	**OUT3 SPI control bit (used if CFG.OUT3_DD = 0)** 1_D **SET**, Output 3 set 0_D **NO_ACTION**, Output 3 no action Reset: 0_B
OUT3_ON_C	4	rw	**OUT3 SPI control bit (used if CFG.OUT3_DD = 0)** 1_D **CLEAR**, Output 3 clear 0_D **NO_ACTION**, Output 3 no action Reset: 0_B
OUT2_ON_S	3	rw	**OUT2 SPI control bit (used if CFG.OUT2_DD = 0)** 1_D **SET**, Output 2 set 0_D **NO_ACTION**, Output 2 no action Reset: 0_B
OUT2_ON_C	2	rw	**OUT2 SPI control bit (used if CFG.OUT2_DD = 0)** 1_D **CLEAR**, Output 2 clear 0_D **NO_ACTION**, Output 2 no action Reset: 0_B
OUT1_ON_S	1	rw	**OUT1 SPI control bit (used if CFG.OUT1_DD = 0)** 1_D **SET**, Output 1 set 0_D **NO_ACTION**, Output 1 no action Reset: 0_B

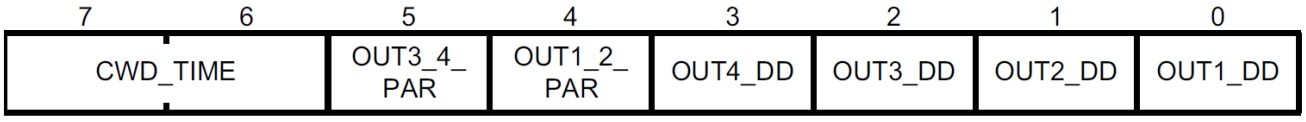
16 bit SPI interface

Field	Bits	Type	Description
OUT1_ON_C	0	rw	**OUT1 SPI control bit (used if CFG.OUT1_DD = 0)** 1_D **CLEAR**, Output 1 clear 0_D **NO_ACTION**, Output 1 no action Reset: 0_B

16 bit SPI interface

Configuration register

CFG	Offset	Reset Value
Configuration register	**01_H**	**$8F_H$**

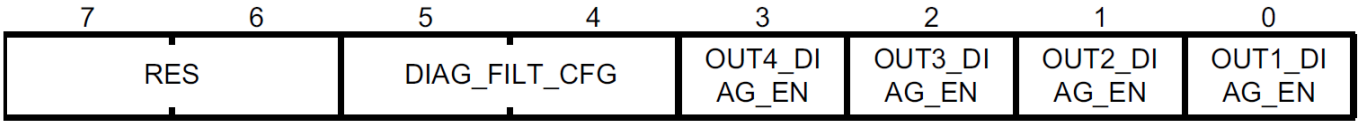


Field	Bits	Type	Description
CWD_TIME	7:6	rw	**Communication watchdog timeout configuration** 3_D **LONG**, 75 ms 2_D **MEDIUM**, 50 ms (default) 1_D **SHORT**, 25 ms 0_D **DISABLED**, Communication watchdog disabled Reset: 10_B
OUT3_4_PAR	5	rw	**OUT3-4 parallel mode** 1_D **ENABLED**, OUT3-4 parallel mode (controlled by IN3 or CTRL.OUT3_ON) 0_D **DISABLED**, OUT3, OUT4 controlled separately (default) Reset: 0_B
OUT1_2_PAR	4	rw	**OUT1-2 parallel mode** 1_D **ENABLED**, OUT1-2 parallel mode (controlled by IN1 or CTRL.OUT1_ON) 0_D **DISABLED**, OUT1, OUT2 controlled separately (default) Reset: 0_B
OUT4_DD	3	rw	**OUT4 direct drive mode** 1_D **ENABLED**, OUT4 controlled by IN4 (default) 0_D **DISABLED**, OUT4 controlled by SPI (CTRL.OUT4_ON) Reset: 1_B
OUT3_DD	2	rw	**OUT3 direct drive mode** 1_D **ENABLED**, OUT3 controlled by IN3 (default) 0_D **DISABLED**, OUT3 controlled by SPI (CTRL.OUT3_ON) Reset: 1_B
OUT2_DD	1	rw	**OUT2 direct drive mode** 1_D **ENABLED**, OUT2 controlled by IN2 (default) 0_D **DISABLED**, OUT2 controlled by SPI (CTRL.OUT2_ON) Reset: 1_B
OUT1_DD	0	rw	**OUT1 direct drive mode** 1_D **ENABLED**, OUT1 controlled by IN1 (default) 0_D **DISABLED**, OUT1 controlled by SPI (CTRL.OUT1_ON) Reset: 1_B

16 bit SPI interface

Off-state diagnostic configuration register

OFF_DIAG_CFG	Offset	Reset Value
Off-state diagnostic configuration register	02_H	$1F_H$

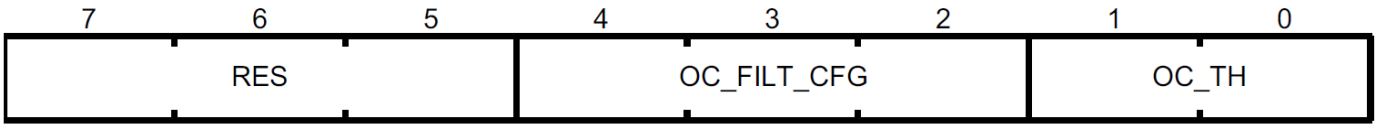


Field	Bits	Type	Description
DIAG_FILT_CFG	5:4	rw	**Diagnostic filter time configuration** 3_D **2000_us**, 2000 us 2_D **1000_us**, 1000 us 1_D **500_us**, 500 us (default) 0_D **200_us**, 200 us Reset: 01_B
OUT4_DIAG_EN	3	rw	**Enable diagnostic current OUT4** 1_D **ON**, Diagnostic current ON (default) 0_D **OFF**, Diagnostic current OFF Reset: 1_B
OUT3_DIAG_EN	2	rw	**Enable diagnostic current OUT3** 1_D **ON**, Diagnostic current ON (default) 0_D **OFF**, Diagnostic current OFF Reset: 1_B
OUT2_DIAG_EN	1	rw	**Enable diagnostic current OUT2** 1_D **ON**, Diagnostic current ON (default) 0_D **OFF**, Diagnostic current OFF Reset: 1_B
OUT1_DIAG_EN	0	rw	**Enable diagnostic current OUT1** 1_D **ON**, Diagnostic current ON (default) 0_D **OFF**, Diagnostic current OFF Reset: 1_B

16 bit SPI interface

On-state diagnostic configuration register

ON_DIAG_CFG	Offset	Reset Value
On-state diagnostic configuration register	**03_H**	**01_H**

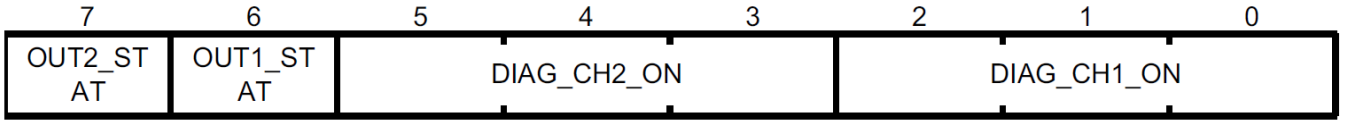


Field	Bits	Type	Description
OC_FILT_CFG	4:2	rw	**Overcurrent shut-down delay time (for all channels)** 7_D **30_ms**, 30 ms 6_D**20_ms**, 20 ms 5_D**10_ms**, 10 ms 4_D**5_ms**, 5 ms 3_D **1_ms**, 1 ms 2_D **500_us**, 500 us 1_D **120_us**, 120 us 0_D **60_us**, 60 us (default) Reset: 000_B
OC_TH	1:0	rw	**Overcurrent shut-down threshold (for all channels) (d_oc_th)** 3_D **4000_mA**, 4 A 2_D **3000_mA**, 3 1_D **2000_mA**, 2 A (default) 0_D **1000_mA**, 1 A Reset: 01_B

16 bit SPI interface

On-state diagnostic result register OUT1 & OUT2

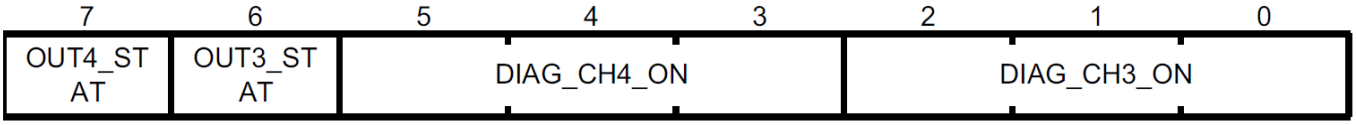
DIAG_OUT_1_2_ON	Offset	Reset
On-state diagnostic result register OUT1 &OUT2	04_H	00_H



Field	Bits	Type	Description
OUT2_STAT	7	r	**Channel 2 output status** 1_D **ON**, Channel is ON 0_D **OFF**, Channel is OFF Reset: 0_B
OUT1_STAT	6	r	**Channel 1 output status** 1_D **ON**, Channel is ON 0_D **OFF**, Channel is OFF Reset: 0_B
DIAG_CH2_ON	5:3	rwc	**On-state diagnostic result register - Channel 2** 7_D **UNUSED**, unused combination 6_D **UNUSED**, unused combination 5_D **OT**, Overtemperature 4_D **OC_TIME**, Overcurrent timeout 3_D **OC_OT**, Overtemperature during overcurrent 2_D **SCB**, Short to battery 1_D **NO_FAIL**, no failure detected 0_D **UNKNOWN**, no diagnosis done Reset: 000_B
DIAG_CH1_ON	2:0	rwc	**On-state diagnostic result register - Channel 1** 7_D **UNUSED**, unused combination 6_D **UNUSED**, unused combination 5_D **OT**, Overtemperature 4_D **OC_TIME**, Overcurrent timeout 3_D **OC_OT**, Overtemperature during overcurrent 2_D **SCB**, Short to battery 1_D **NO_FAIL**, no failure detected 0_D **UNKNOWN**, no diagnosis done Reset: 000_B

On-state diagnostic result register OUT3 &

DIAG_OUT_3_4_ON	Offset	Reset
On-state diagnostic result register OUT3 & OUT4	05_H	00_H

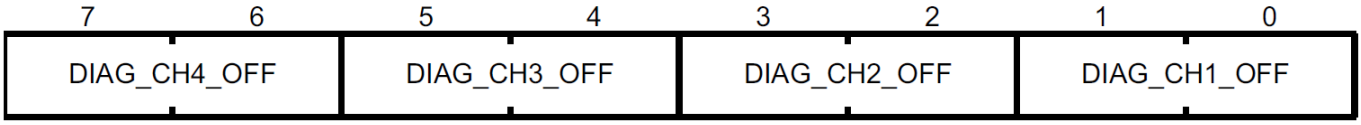


Field	Bits	Type	Description
OUT4_STAT	7	r	**Channel 4 output status** 1_D **ON**, Channel is ON 0_D **OFF**, Channel is OFF Reset: 0_B
OUT3_STAT	6	r	**Channel 3 output status** 1_D **ON**, Channel is ON 0_D **OFF**, Channel is OFF Reset: 0_B
DIAG_CH4_ON	5:3	rwc	**On-state diagnostic result register - Channel 4** 7_D **UNUSED**, unused combination 6_D **UNUSED**, unused combination 5_D **OT**, Overtemperature 4_D **OC_TIME**, Overcurrent timeout 3_D **OC_OT**, Overtemperature during overcurrent 2_D **SCB**, Short to battery 1_D **NO_FAIL**, no failure detected 0_D **UNKNOWN**, no diagnosis done Reset: 000_B
DIAG_CH3_ON	2:0	rwc	**On-state diagnostic result register - Channel 3** 7_D **UNUSED**, unused combination 6_D **UNUSED**, unused combination 5_D **OT**, Overtemperature 4_D **OC_TIME**, Overcurrent timeout 3_D **OC_OT**, Overtemperature during overcurrent 2_D **SCB**, Short to battery 1_D **NO_FAIL**, no failure detected 0_D **UNKNOWN**, no diagnosis done Reset: 000_B

16 bit SPI interface

Off-state diagnostic result

DIAG_OFF	Offset	Reset Value
Off-state diagnostic result	06_H	



Field	Bits	Type	Description
DIAG_CH4_OFF	7:6	rwc	**OFF-state diagnostic result register Channel 4** 3_D **SCG**, Short to ground 2_D **OL**, Open load 1_D **NO_FAIL**, no failure detected 0_D **UNKNOWN**, no diagnosis done Reset: 00_B
DIAG_CH3_OFF	5:4	rwc	**Off-state diagnostic result register Channel 3** 3_D **SCG**, Short to ground 2_D **OL**, Open load 1_D **NO_FAIL**, no failure detected 0_D **UNKNOWN**, no diagnosis done Reset: 00_B
DIAG_CH2_OFF	3:2	rwc	**Off-state diagnostic result register Channel 2** 3_D **SCG**, Short to ground 2_D **OL**, Open load 1_D **NO_FAIL**, no failure detected 0_D **UNKNOWN**, no diagnosis done Reset: 00_B
DIAG_CH1_OFF	1:0	rwc	**Off-state diagnostic result register Channel 1** 3_D **SCG**, Short to ground 2_D **OL**, Open load 1_D **NO_FAIL**, no failure detected 0_D **UNKNOWN**, no diagnosis done Reset: 00_B

16 bit SPI interface

Global device status register

GLOBAL_STATUS	Offset	Reset Value
Global device status register	07_H	

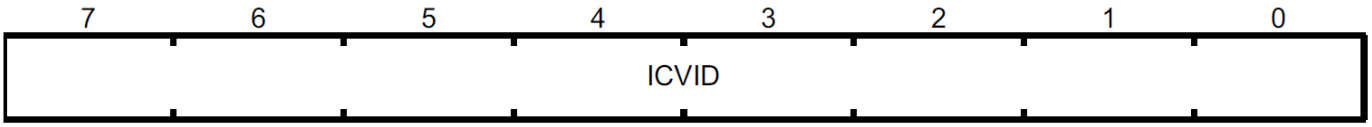
7	6	5	4	3	2	1	0
OUT_EN	SPARE	GEN_FAULT	COM_ERR	PAR_ERR	CWD_TO	EN_LATCH	POR_LATCH
	rw						

Field	Bits	Type	Description
OUT_EN	7	rw	**OUTx enable bit** 1_D **ENABLED**, Output switching enabled 0_D **DISABLED**, Outputs disabled (default) Reset: 0_B
SPARE	6	rw	**Spare register for future use** 1_D **GLOBAL_STATUS_SPARE_EN**, 0_D **GLOBAL_STATUS_SPARE_DIS**, (default) Reset: 0_B
GEN_FAULT	5	rwc	**General fault flag** 1_D **ERR**, At least one fault was detected 0_D **NO_ERR**, No fault was detected Reset: 0_B
COM_ERR	4	rwc	**Communication Error Flag** 1_D **ERR**, At least one communication failure was detected 0_D **NO_ERR**, No communication failure was detected Reset: 0_B
PAR_ERR	3	rwc	**Parity Error Flag** 1_D **ERR**, At least one parity error was detected 0_D **NO_ERR**, No parity error was detected Reset: 0_B
CWD_TO	2	rwc	**Communication watchdog timeout** 1_D **ERR**, Communication watchdog timeout occurred 0_D **NO_ERR**, No communication watchdog timeout (default) Reset: 0_B
EN_LATCH	1	rwc	**EN Latch** 1_D **EN**, Device was enabled since last read-out 0_D **NO_EN**, Device was not enabled since last cleared Reset: 0_B
POR_LATCH	0	rwc	**Power-on reset latch** 1_D **POR**, Device was reset since last cleared 0_D **NO_POR**, Device was not reset since last cleared Reset: 1_B

16 bit SPI interface

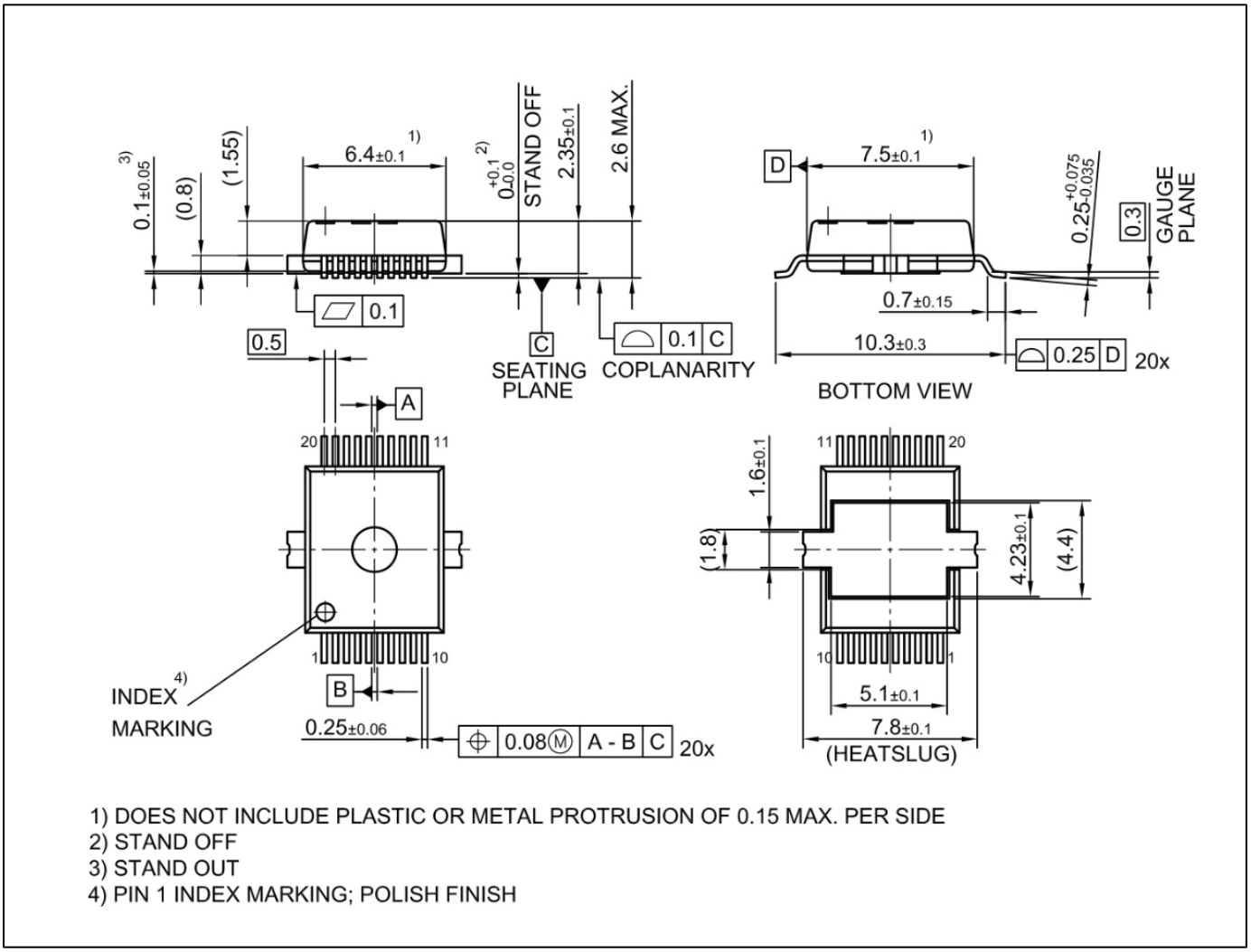
IC Version ID

ICVID	Offset	Reset Value
IC Version ID	08_H	



Field	Bits	Type	Description
ICVID	7:0	r	**IC Version ID** 177_D **ICVID**, Reset: $B1_H$

7 封装外形



1) DOES NOT INCLUDE PLASTIC OR METAL PROTRUSION OF 0.15 MAX. PER SIDE
2) STAND OFF
3) STAND OUT
4) PIN 1 INDEX MARKING; POLISH FINISH

Figure 7-1 PG-DSO-20-88 (Plastic Dual Small Outline Package) Green Product - Package dimensions are preliminary and may be updated

绿色产品：符合 RoHS 标准

为了满足全球客户对环保产品的需求，并遵守政府法规，该器件以绿色产品的形式提供。绿色产品符合RoHS标准（即，引线采用无铅涂层，并且符合IPC/JEDEC J-STD-020标准，适用于无铅焊接）。

浮动散热焊盘

TLE9104SH的散热焊盘内部未连接到地。强烈建议将散热焊盘外部连接至 GND 引脚。

有关备选封装的更多信息，请访问我们的网站：
http://www.infineon.com/packages.

8 应用信息

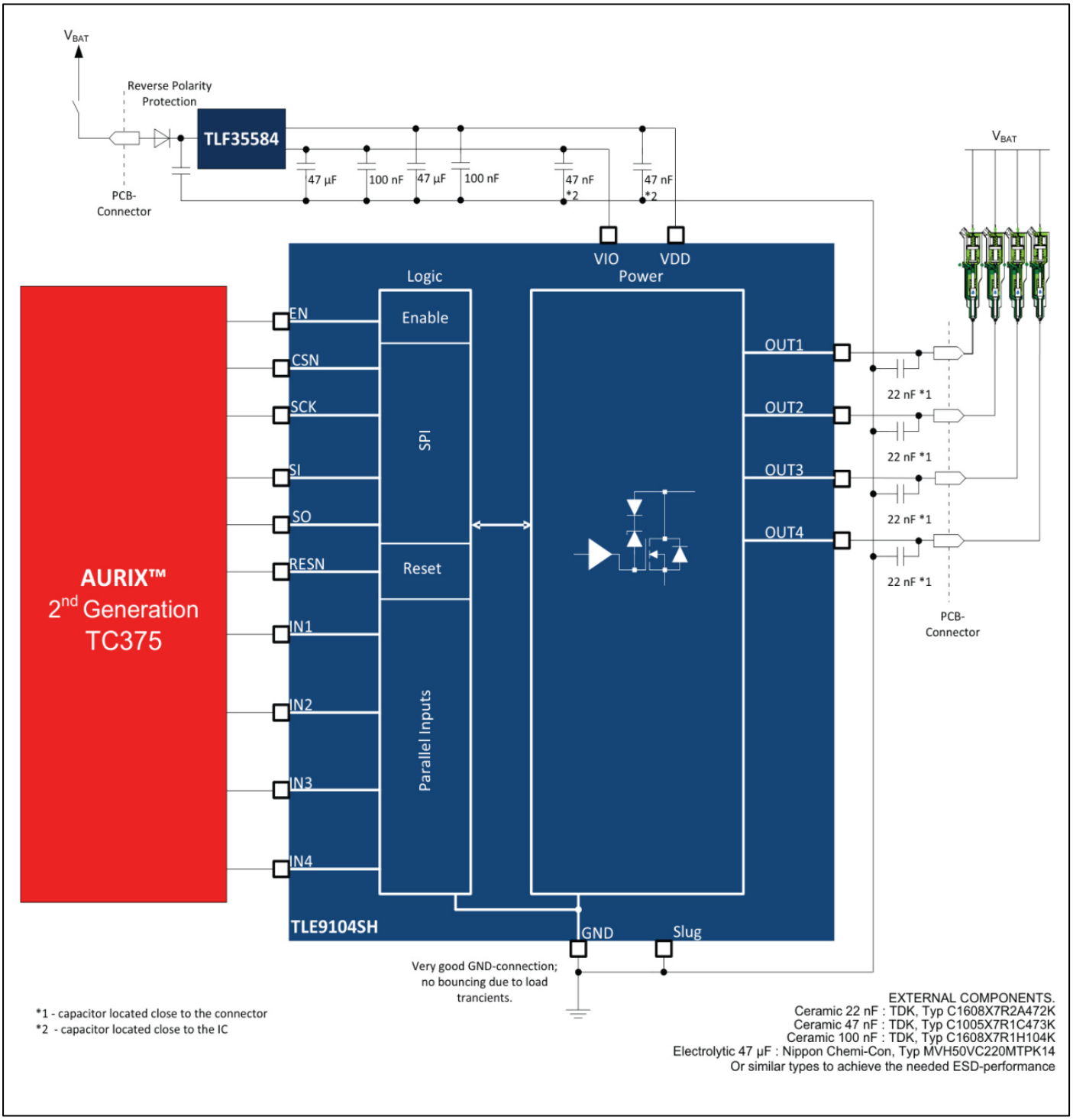


Figure 8-1 Multi port injection application diagram

9 修订记录

Table 9-1 Revision history

Version	Date	Changes
Rev. 1.31	2020-09-30	Update of Output current per channel max. rating to 5.6 A (P_4.1.5)
Rev. 1.3	2020-06-05	Max. value of Short circuit to battery detection current modified
Rev. 1.2	2018-10-26	Changed H level output voltage of SO Pin symbol and minimum value changed
Rev. 1.1	2018-02-15	OC filter times updates in SPI table
Rev. 1.0	2018-02-01	First datasheet release

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