特点 / Features

- Vcc端最高耐压40V
- 正常工作电压范围4V至28V
- 负载过流保护
- 输出短路保护
- 待机功耗<0.5μA
- 单通道140mΩ高侧开关
- 内置过温关断功能
- 输出开路检测
- 内置VCC钳位功能
- VCC欠压保护
- 高精度输出电流监控
- 内部温度输出监控
- VCC电压输出监控
- 符合RoHS且无卤素

应用领域 / Application

◆所有类型的汽车电阻，电感和容性负载
◆专用于汽车信号灯

概述 / General Description

- WS7140是一款高集成度140mΩ的High-side单通道驱动开关芯片。用于搭配3V或者5V CMOS控制信号驱动12V车用负载，并提供先进的保护和告警功能。
- 集成保护功能，如负载电流限制、功率限制、过载主动管理和超温关机可配置闩锁。
- 管脚Fault用于故障或者闩锁之后重新使能芯片。
- 一个专用的多功能多路模拟输出引脚提供复杂的诊断功能包括高精度比例负载电流检测，电源电压反馈和芯片温度感知，除了检测过载 对地短路，对VCC短路和off状态开负载短路。
- 电流传感器使能，在待机模式下或者有来自外围的电路共享了类似的信息时，关闭内部传感器使能。

1.电路内部框图 / Block diagram and pin description

图1：内部电路框图

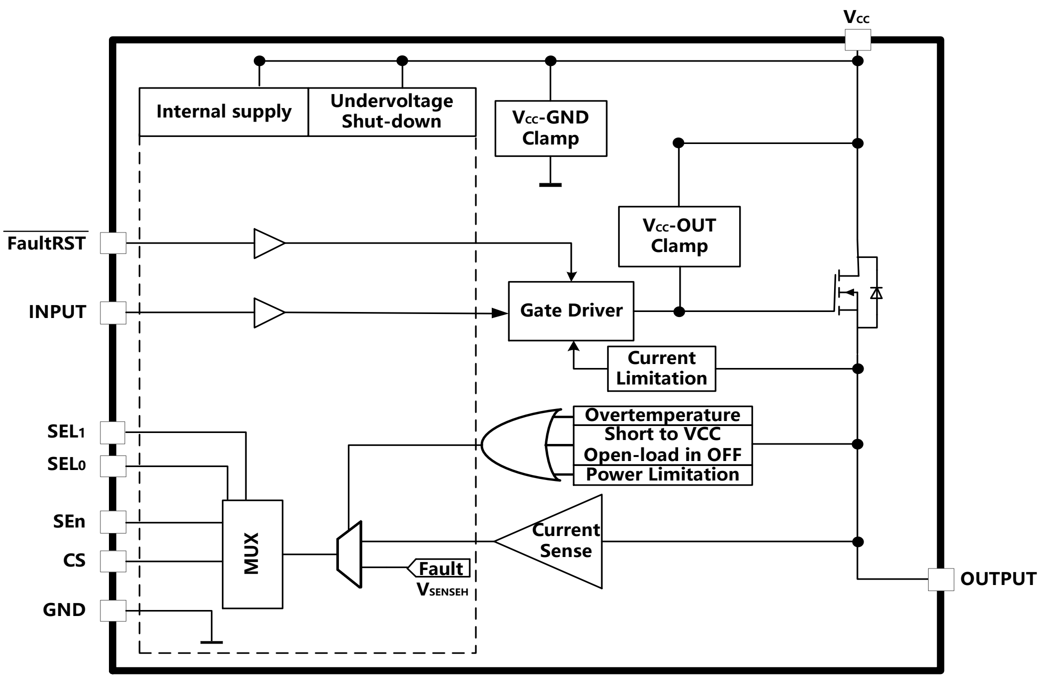
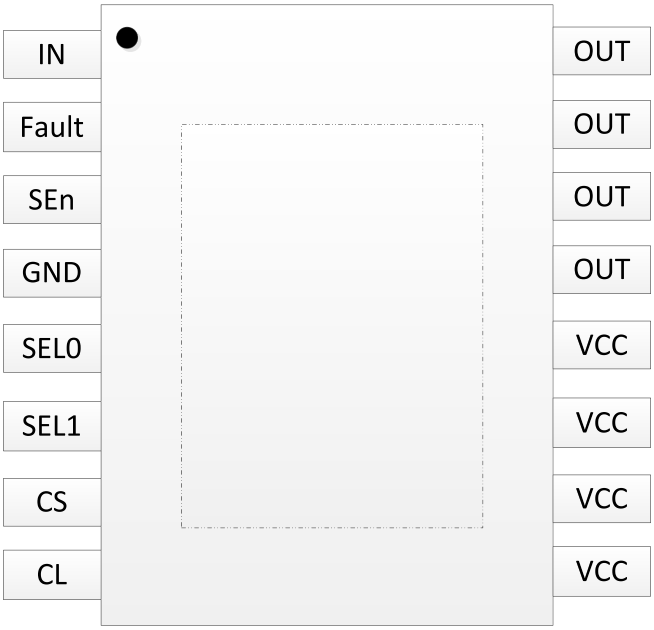


图2：管脚与位号定义



HTSSOP-16

表1：引脚功能

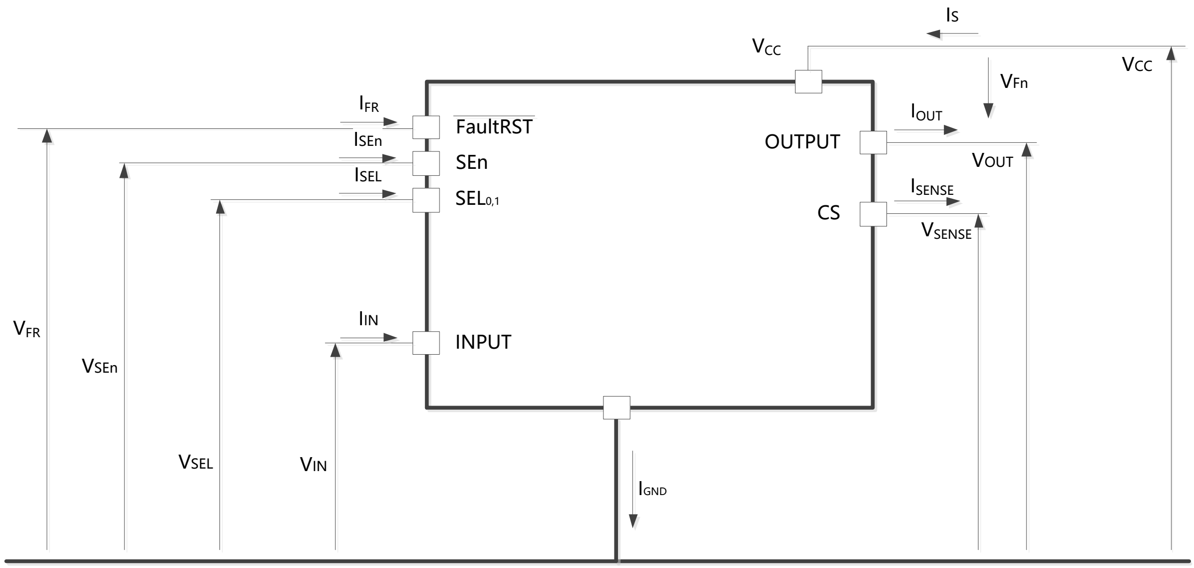
引脚名称 Pin Name	引脚描述 Pin Description
VCC	供电端,连接电池正极。
OUT	功率输出端。
GND	芯片地，必须外接反向电池保护的二极管电阻网络。
IN	电压控制的输入引脚，控制输出的开关状态。
CS	模拟电流检测输出管脚，输出一个和负载电流成比例的电流，电源电压VCC或者芯片温度。
SEn	高电平有效，它是CS诊断功能的使能。
SEL$_{0,1}$	高电平有效，控制选择器输出。
Fault	低电平有效，如果一直保持低电平，输出则为自启动模式。

表2：未使用或者未连接引脚的处理方式

管脚 Connection/pin	CS	N.C.	Output	IN	SEn,SELx, $\overline{\text{FaultyRST}}$
浮空	不允许	X[(1)]	X	X	X
接地	串1K电阻	X	不允许	串25K电阻	串25K电阻

2.电路应用规范 /Electrical specification

图3:外部电流和电压



注：VFn=VOUT-V_{CC} during reverse battery condition

2.1极限参数（注2）(表3)/ Absolute Maximum Ratings

符号 Symbol	参数/Parameter	参数范围 Value	单位 Unit
V_{CC}	DC supply voltage	40	V
$-V_{CC}$	Reverse DC supply voltage	0.3	V
$-I_{GND}$	DC reverse ground pin current	50	mA
I_{OUT}	OUTPUT DC output current	Internally limited	A
$-I_{OUT}$	Reverse DC output current	2	
V_{IN}, V_{SEn}, V_{SEL}, V_{SEL}	IN , SEn , $SEL_{0,1}$, Fault，DC IN voltage	-0.3 to6.6	V
I_{SENSE}	CS pin DC output current	20	mA
	CS pin DC output current in reverse	-20	
E_{MAX}	Maximum switching energy (single pulse)(T_{DEMAG} = 0.4 ms; T_{jstart} = 150℃)	40	mJ
V_{ESD}	JEDEC standard (Electrostatic discharge)	JEDEC 22A-114F	
	IN,CS, SEn,$SEL_{0,1}$，Fault	3000	V
	V_{CC} ,OUTPUT	4000	
V_{ESD}	Charge device model (CDM-AEC-Q100-011)/设备ESD模型	1000	V
T_j	Junction operating temperature/结工作温度	-40 to 150	℃
T_{stg}	Storage temperature/存储温度	-55 to 150	

注2：最大极限值是指超出该工作范围，芯片有可能损坏。推荐工作范围是指在该范围内，器件功能正常，但并不完全保证满足个别性能指标。电气参数定义了器件在工作范围内并且在保证特定性能指标的测试条件下的电参数规范。对于未给定上下限值的参数，该规范不予保证其精度，但其典型值合理反映了器件性能。

2.2电气特性参数（注3） / Electrical Characteristics

POWER Section						
Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Operating supply voltage	V_{CC}		4.5	13	28	V
Under voltage shutdown	V_{USD}				4.5	
Under voltage shutdown reset	$V_{USDReset}$				5	
Unde rvoltage shutdown hysteresis	$V_{USDhyst}$			0.3		
On-state resistance	R_{ON}	I_{OUT} = 1 A; T_j = 25℃		140		mΩ
		I_{OUT} = 1 A; T_j = 150℃			280	
		I_{OUT} = 1 A; V_{CC} = 5 V; T_j = 25℃			210	
VCC Clamp voltage	V_{clamp}	I_S = 20 mA; 25℃ < T_j< 150℃	40	45	51	V
		I_S = 20 mA; T_j = -40℃	38			
Supply current inStandby at VCC = 13 V	I_{STBY}	V_{CC} = 13 V; V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0 V; $V_{SEL0,1}$ = 0 V; T_j = 25℃			0.65	μA
		V_{CC} = 13 V; V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0 V; $V_{SEL0,1}$ = 0 V; T_j = 85℃ (6)			1.0	μA
		V_{CC} = 13 V; V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0 V; VSEL0,1 = 0 V; T_j = 125℃			3.0	μA
Standby mode blanking time	t_{D_STBY}	V_{CC} = 13 V V_{IN} = V_{OUT} = V_{FR} = $V_{SEL0,1}$ = 0 V; V_{SEn} = 5 V to 0 V	60	300	550	μs
Supply current	$I_{S(ON)}$	V_{CC} = 13 V; V_{SEn} = V_{FR} = $V_{SEL0,1}$ = 0 V; V_{IN} = 5 V; I_{OUT} = 0 A		3	5	mA
Control stage current consumption in ON state.	$I_{GND(ON)}$	V_{CC} = 13 V; V_{SEn} = 5 V; V_{FR} = $V_{SEL0,1}$ = 0 V; V_{IN} = 5 V;I_{OUT} = 1 A			6	mA
Off-state output current at VCC = 13 V	$I_{L(off)}$	V_{IN} = V_{OUT} = 0 V; V_{CC} = 13 V; T_j = 25℃	0	0.05	0.5	μA
		V_{IN} = V_{OUT} = 0 V; V_{CC} = 13 V; T_j = 125℃	0		3	
Output - VCC diode voltage at Tj = 150℃	V_F	I_{OUT} = -0.2A; T_j = 150℃			0.9	V

Switching/V_{CC} = 13 V; -40℃ < T_j< 150℃, unless otherwise specified						
Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Turn-on delay time at T_j = 25℃	$t_{d(on)}$	RL=13Ω	10	35	120	μs
Turn-off delay time at T_j = 25℃	$t_{d(off)}$		20	60	100	μs
Turn-on voltage slope at T_j = 25℃	$(dV_{OUT}/dt)on$	RL=13Ω	0.1	0.3	0.7	V/μs
Turn-off voltage slope at T_j = 25℃	$(dV_{OUT}/dt)off$		0.1	0.4	0.7	

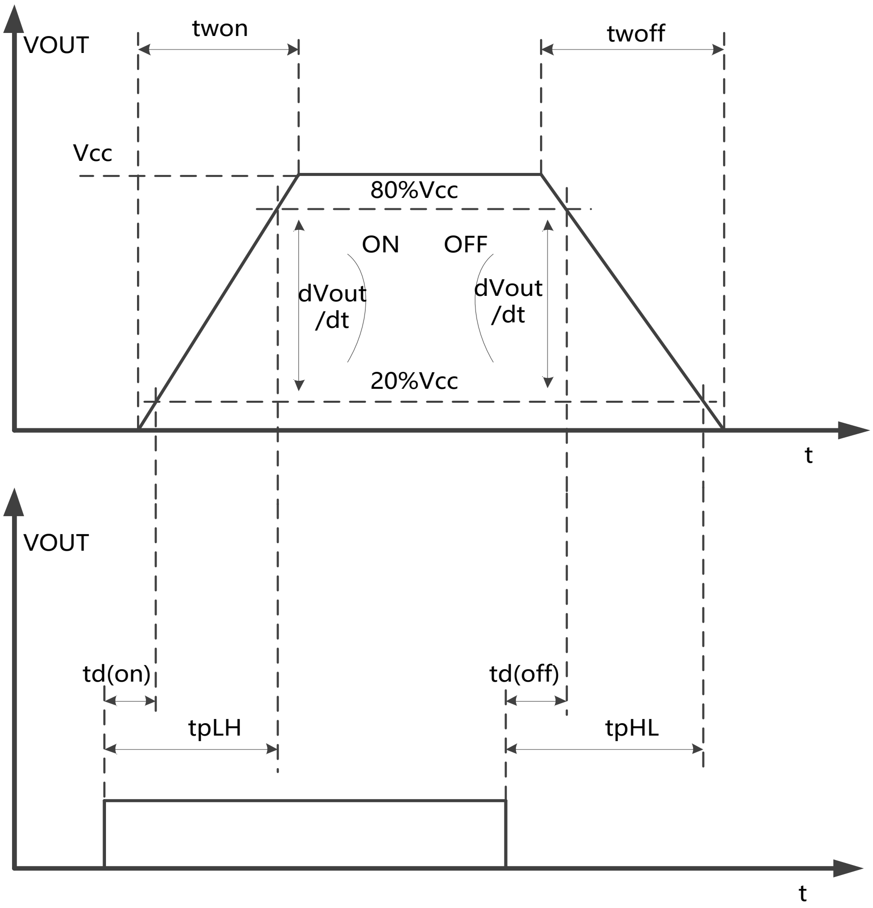
Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Differential Pulse skew(t_{PHL} - t_{PLH})	t_{SKEW}	RL=13Ω	-20	25	80	μs
LOGIC INPUT (IN，Fault , SEL0,1, SEn)						
Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
IN low level voltage	V_{IL}				0.9	V
Low level IN current	I_{IL}	V_{INL}=0.9V	0.5			μA
IN high level voltage	V_{IH}		2.1		6.6	V
High level IN current	I_{IH}	V_{INH}=2.2V			12	μA
IN hysteresis voltage	$V_{I(hyst)}$		0.1			V
Protections(7 V < V_{CC}< 28 V; -40℃ < T_j < 150℃)						
Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
DC short circuit current	I_{LIMH}	V_{CC}=13V	8	12	16	A
		4 V < V_{CC}< 18 V (6)			20	A
Short circuit current during thermal cycling	I_{LIML}	V_{CC}=13V；T_R< T_j< T_{TSD}		5		A
Shutdown temperature	T_{TSD}		150	175	200	℃
Thermal hysteresis	T_{HYST}			20		℃
Dynamic temperature	ΔT_{J_SD}	T_j = -40℃; V_{CC} = 13 V		60		℃
Fault reset time for output unlatch	t_{LATCH_RST}	V_{Fault} = 5 V to 0 V; V_{SEn} = 5 V• V_{IN} = 5 V; V_{SEL0}= V_{SEL1}= 0 V	3	10	20	μs
Turn-off output voltage clamp	V_{DEMAG}	I_{OUT}= 1 A; L = 6 mH; T_j = -40℃	V_{CC}-34			V
		I_{OUT}= 1 A; L = 6 mH; T_j = 25℃ to 150℃	V_{CC}-35	V_{CC}-39	V_{CC}-44	V
CurrentSense/7 V < V_{CC}< 18 V; -40℃ < Tj < 150℃						
Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Current sense clamp voltage	V_{SENSE_CL}	V_{SEn} = 0 V; I_{SENSE} = 1 mA		-15		V
		V_{SEn} = 0 V; I_{SENSE} = -1 mA		7		V
Chip temperature analog feedback						
CS output voltage proportional to chip temperature	V_{SENSE_TC}	V_{SEn} = 5 V; V_{SEL0} = 0 V; V_{SEL1} = 5 V; V_{IN} = 0 V; R_{SENSE} = 1 kΩ; Tj = -40℃	2.325	2.42	2.495	V
		V_{SEn} = 5 V; V_{SEL0} = 0 V; V_{SEL1} = 5 V; V_{IN} = 0 V; R_{SENSE} = 1 kΩ; Tj = 25℃	1.785	2.07	2.155	V
		V_{SEn} = 5 V; V_{SEL0} = 0 V; V_{SEL1} = 5 V; V_{IN} = 0 V; R_{SENSE} = 1 kΩ; Tj = 150℃	1.275	1.35	1.425	V
Temperature coefficient	dV_{SENSE_TC} /dT	Tj = -40°C to 150°C		-5.60		mV/K
VCC supply voltage analog feedback						

CS output voltage proportional to VCC supply voltage	V_{SENSE_VCC}	VCC =13 V; V_{SEn} = 5 V; V_{SEL0}= V_{SEL1}= 5 V; V_{IN} = 0 V; R_{SENSE} = 1 kΩ	3.52	2.6	2.68	V
CurrentSense characteristics						
IOUT/ISENSE	K_0	I_{OUT} = 0.025 A; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	-30%	600	+30%	
Current sense ratio drift	dK_0/K_0 [6] [11]	I_{OUT} = 0.025 A; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	-20		+20	%
IOUT/ISENSE	K_1	I_{OUT} = 0.15 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	-15%	500	+15%	
Current sense ratio drift	dK_1/K_1 [6] [11]	I_{OUT} = 0.15 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	-10		+10	%
IOUT/ISENSE	K_2	I_{OUT} = 0.7 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	-10%	500	10%	
Current sense ratio drift	dK_2/K_2 [6] [11]	I_{OUT} = 0.7 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	-5		+5	%
I_{OUT}/I_{SENSE}	K_3	I_{OUT} = 2 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	-10%	500	+10%	
Current sense ratio drift	dK_3/K_3 [6] [11]	I_{OUT} = 2 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	-5		+5	%
CS current for OL detection	I_{SENSE0}	Current sense disabled: V_{SEn} = 0 V;	0		0.5	μA
		Current sense disabled: -1 V < V_{SENSE}< 5 V[6]	-0.5		0.5	
		Current sense enabled: V_{SEn} = 5 V ,V_{IN} = 5 V; V_{SEL0} = 0 V; V_{SEL1} = 0 V;I_{OUT}= 0	0		2	
		Current sense enabled: V_{SEn} = 5 V ,V_{IN} = 0 V; V_{SEL0} = 0 V; V_{SEL1} = 0 V;I_{OUT}= 0	0		2	
Output Voltage for Current sense shutdown	V_{OUT_MSD}[6]	V_{SEn} = 5 V; R_{SENSE} = 2.7 kΩ, V_{IN} = 5 V; V_{SEL0} = V_{SEL1}= 0 V; I_{OUT} = 1 A		5		V
CS saturation voltage	V_{SENSE_SAT}[6]	V_{CC} =7V; R_{SENSE} = 2.7 kΩ; V_{SEn} =5V;V_{IN}=5V; V_{SEL0}= V_{SEL1}= 0 V; I_{OUT0} = 2 A;T_j =150 ℃	5			V
CS saturation current	I_{SENSE_SAT}[6]	V_{CC} = 7 V; V_{SENSE} = 4 V; V_{IN} = 5 V;V_{SEn}= 5 V; V_{SEL0}= V_{SEL1}= 0 V; T_j = 150 ℃	4			mA
Output saturation current	I_{OUT_SAT}[6]	V_{CC}=7V;V_{SENSE}=4V;V_{IN}=5V, V_{SEn} = 5 V; V_{SEL0}= V_{SEL1}= 0 V; T_j = 150 ℃	2.2			A
OFF-state diagnostic						
OFF-state open-load voltage	V_{OL}	V_{SEn}=5V; V_{IN}=0V; V_{SEL0}= V_{SEL1}=	2	3	4	V

detection threshold		0 V				
OFF-state output sink current	$I_{L\ (off2)}$ (12)	V_{IN} = 0 V; V_{OUT} = V_{OL}; T_j = -40℃ to 150℃	-260	-120	-30	μA
OFF-state diagnostic delay time from falling edge of IN	t_{DSTKON}	V_{SEn}=5V; V_{IN}= 5V to 0 V; V_{SEL0}= V_{SEL1}= 0V;V_{OUT} = 4 V; I_{OUT} = 0 A	100	350	700	μs
Settling time for valid OFFstate open-load diagnostic indication from rising edge of SEn	$t_{D\_OL\_V}$	V_{IN}=0V;V_{FAULT}=0V;V_{SEL0}=V_{SEL1}= 0 V，V_{OUT}= 4V; V_{SEn} = 0 V to 5 V			150	μs
OFF-state diagnostic delay time from rising edge of V_{OUT};	t_{D_VOL}	V_{SEn}=5V; V_{IN}=0V; V_{SEL0}= V_{SEL1}= 0 V; V_{OUT}= 0 V to 4 V		5	30	μs
Fault diagnostic feedback						
Current sense output voltage in fault condition;	V_{SENSEH}	V_{CC} = 13 V; R_{SENSE} = 1 kΩ V_{IN} = 0 V; V_{SEn} = 5 V; V_{SEL0}= V_{SEL1}= 0 V; I_{OUT}= 0 A; V_{OUT} = 4 V	5	6.0	6.6	V
Current sense output current in fault condition	I_{SENSEH}	V_{CC} = 13 V; V_{SENSE} = 5 V	7	20	30	mA
Current sense timings						
Current sense settling time from rising edge of SEn	$t_{DSENSE1H}$	V_{IN} = 5 V; V_{SEn} = 0 V to 5 V; R_{SENSE} = 1 kΩ; R_L = 13 Ω			60	μs
Current sense disable delay time from falling edge of SEn	$t_{DSENSE1L}$	V_{SEn} = 5 V to 0 V; R_{SENSE} = 1 kΩ;R_L = 13Ω		5	20	μs
Current sense settling time from rising edge of IN	$t_{DSENSE2H}$	V_{IN} = 0 V to 5 V; V_{SEn} = 5 V; R_{SENSE} = 1 kΩ; R_L = 13Ω		60	150	μs
Current sense settling time from rising edge of IOUT(dynamic response to a step change of IOUT)	$\Delta t_{DSENSE2H}$	V_{IN} = 5 V; V_{SEn} = 5 V; R_{SENSE} = 1 kΩ; I_{SENSE} = 90 % of $I_{SENSEMAX}$; R_L = 13Ω			100	μs
Current sense turn-off delay time from falling edge of IN	$t_{DSENSE2L}$	V_{IN} =5 V to 0V; V_{SEn}= 5V; R_{SENSE} = 1 kΩ; R_L = 13Ω		100	250	μs
V_{SENSE_TC} settling time from rising edge of SEn	$t_{DSENSE3H}$	V_{SEn}=0V to 5V; V_{SEL0}=0 V;V_{SEL1} = 5 V; R_{SENSE}=1 kΩ			60	μs
V_{SENSE_TC} disable delay time from falling edge of SEn	$t_{DSENSE3L}$	V_{SEn}=5V to 0V; V_{SEL0}=0 V;V_{SEL1} = 5 V; R_{SENSE}=1 kΩ			20	μs
V_{SENSE_VCC} settling time from rising edge of SEn	$t_{DSENSE4H}$	V_{SEn}=0V to 5V; V_{SEL0}=5 V;V_{SEL1} = 5 V; R_{SENSE}=1 kΩ			60	μs
V_{SENSE_VCC} disable delay time from falling edge of SEn	$t_{DSENSE4L}$	V_{SEn}=0V to 5V; V_{SEL0}=5 V;V_{SEL1} = 5 V; R_{SENSE}=1 kΩ			20	μs

注3：除特殊测试说明外，电气参数均在T_A= +25℃条件下测试。规格书的最小、最大规范范围由测试保证，典型值由设计、测试或统计分析保证。

开关时间和脉冲斜率/Switching times and Pulse skew



电流检测模块的时序关系

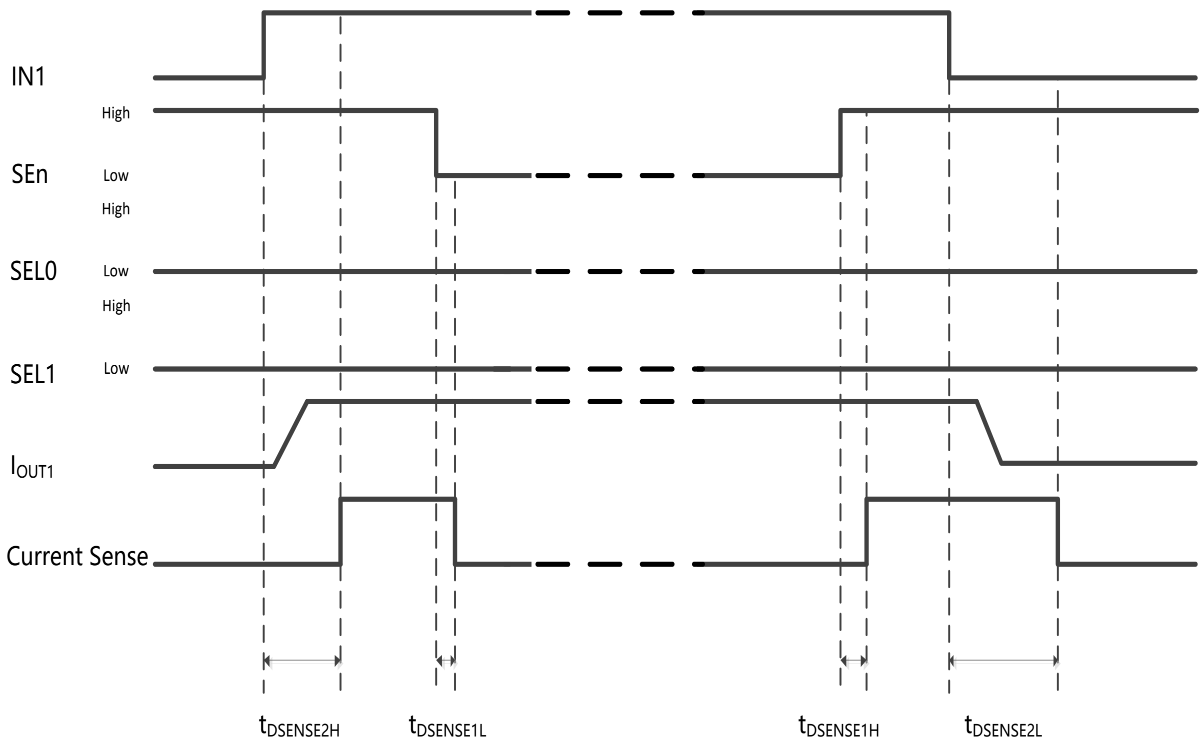
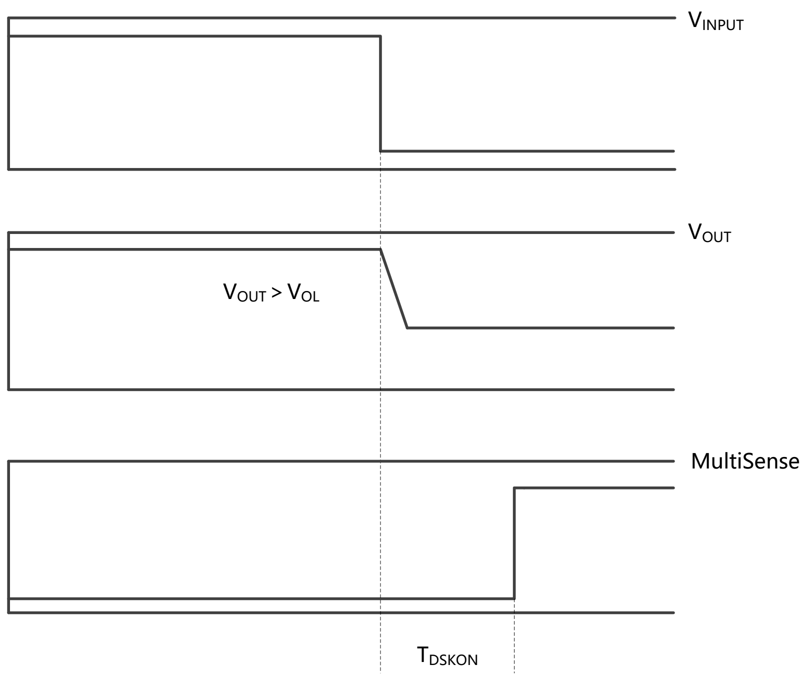

IN1
High
SEn
Low
High
SEL0
Low
High
SEL1
Low
IOUT1
Current Sense
tDSENSE2H
tDSENSE1L
tDSENSE1H
tDSENSE2L

图8：TDSKON


VINPUT
VOUT
VOUT > VOL
MultiSense
TDSKON

Truth table

Mode	Conditions	IN	FR	SEnx	SELx	OUT	Current sense	Comments
Standby	All logic INs low	L	L	L	L	L	Hi-Z	Low quiescent current consumption
Normal	Nominal load connected; Tj < 150 ° C	L	X	见下表		L	见下表	
		H	L			H	见下表	Outputs configured for auto-restart
		H	H			H	见下表	Outputs configured for latch-off(1)
Overload	Overload or short to GND causing: Tj > TTSD or ΔTj > ΔTj _SD	L	X	见下表		L	见下表	
		H	L			H	见下表	Output cycles with temperature hysteresis
		H	H			L	见下表	Output latches-off
Undervoltage	$V_{CC} < V_{USD}$	X	X	X		L	Hi-Z	Re-start when VCC > VUSD + VUSDhyst (rising)
OFF-state diagnostics	Short to V_{CC}	L	X	见下表		H	见下表	
	Open-Load	L	X			H	见下表	External pull-up
Negative output voltage	Inductive loads turn-off	L	X	见下表		<0	见下表	

Current sense output

SEn	SEL_1	SEL_0	MUX Channel	Current sense output			
				Normal	Overload	OFF-state	Negative output
L	X	X		Hi-Z			
H	L	L	Channel0 diagnostic	$I_{SENSE} = 1/K * I_{OUT0}$	$V_{SENSE} = V_{SENSEH}$	$V_{SENSE} = V_{SENSEH}$	Hi-Z
H	L	H	Channel1 diagnostic	$I_{SENSE} = 1/K * I_{OUT1}$	$V_{SENSE} = V_{SENSEH}$	$V_{SENSE} = V_{SENSEH}$	Hi-Z
H	H	L	TCHIP Sense	VSENSE = VSENSE_TC			
H	H	H	VCC Sense	VSENSE = VSENSE_VCC			

3.保护功能 / Protections

3.1 Power limitation

The basic working principle of this protection consists of an indirect measurement of the junction temperature swing △Tj through the direct measurement of the spatial temperature gradient on the device surface in order to automatically shut off the output MOSFET as soon as △Tj exceeds the safety level of △Tj_SD. According to the voltage level on the Fault pin, the output MOSFET switches on and cycles with a thermal hysteresis according to the maximum instantaneous power which can be handled (Fault = Low) or remains off(Fault = High). The protection prevents fast thermal transient effects and, consequently, reduces thermo-mechanical fatigue.

3.2 Thermal shutdown

In case the junction temperature of the device exceeds the maximum allowed threshold (typically 175℃), it automatically switches off and the diagnostic indication is triggered. According to the voltage level on the Fault pin, the device switches on again as soon as its junction temperature drops to TR (Fault = Low) or remains off (Fault = High).

3.3 Current limitation

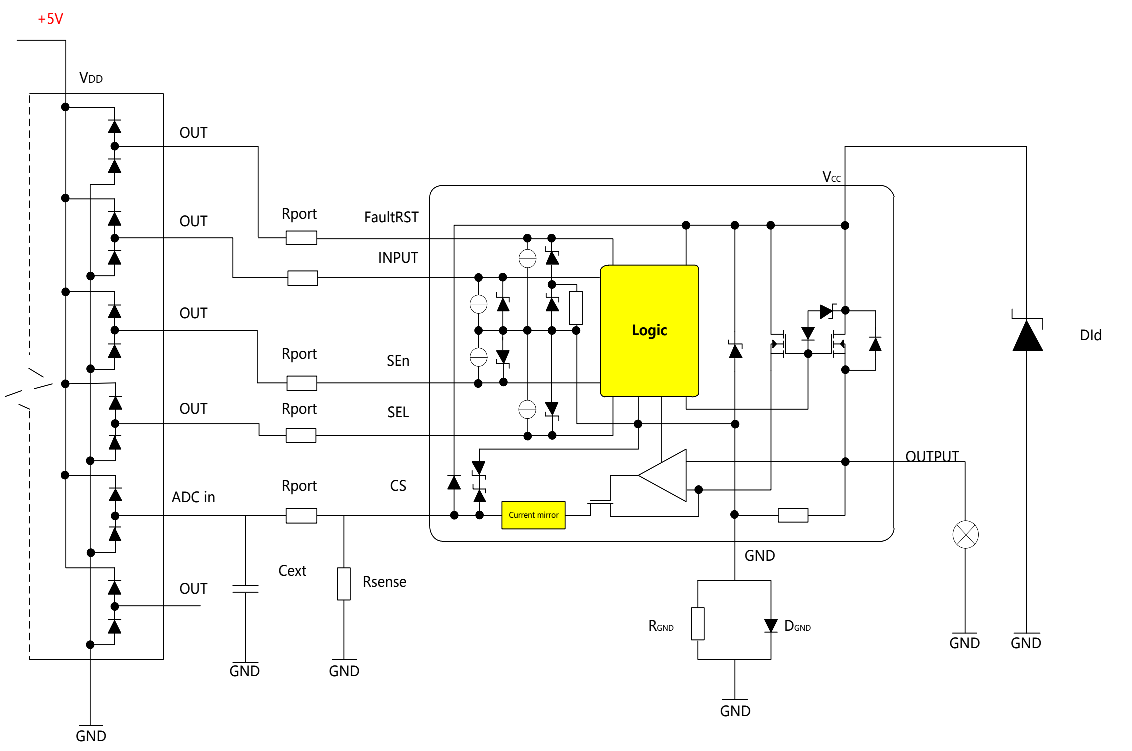
The device is equipped with an output current limiter in order to protect the silicon as well as the other components of the system (e.g. bonding wires, wiring harness, connectors, loads, etc.) from excessive current flow. Consequently, in case of short circuit, overload or during load power-up, the output current is clamped to a safety level, ILIMH, by operating the output power MOSFET in the active region.

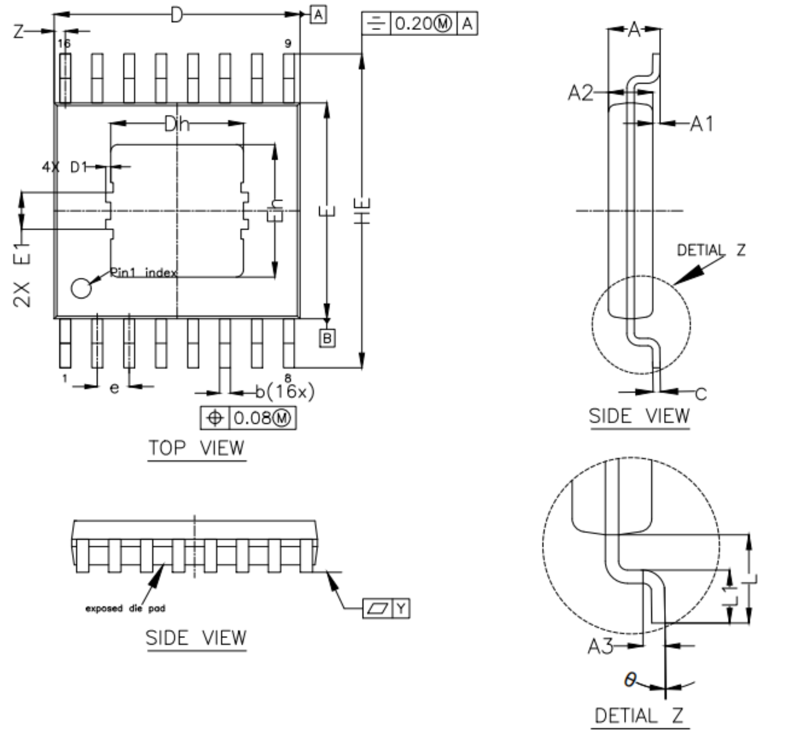
3.4 Negative voltage clamp

In case the device drives inductive load, the output voltage reaches a negative value during turn off. A negative voltage clamp structure limits the maximum negative voltage to a certain value, VDEMAG, allowing the inductor energy to be dissipated without damaging the device.

4. Application information

Application diagram





* CONTROLLING DIMENSION : MM

SYMBOL	MILLIMETER		
	MIN.	NOM.	MAX.
A	---	---	1.10
A1	0.05	---	0.15
A2	0.85	---	0.95
b	0.19	0.22	0.30
c	0.09	0.15	0.20
D	4.90	5.00	5.10
E	4.30	4.40	4.50
HE	6.20	6.40	6.60
Dh	2.40	2.70	3.00
Eh	2.40	2.70	3.00
D1	---	---	0.15
E1	---	---	0.95
e	0.65 bsc		
L	1.00 bsc		
L1	0.50	0.625	0.75
Y	0.100 TYP.		
A3	---	0.25	---
Z	0.225 bsc		
θ	0°	4°	8°

NOTES

1.0 COPLANARITY APPLIES TO LEADS, CORNER LEADS AND DIE ATTACH PAD.