

Automotive Fully Integrated H-bridge Motor Driver

■ Features

- AEC-Q100 qualified
 - Device ambient temperature:
 $-40^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$
 - Device junction temperature:
 $-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$
- Operating voltage: 4 to 28 V, 40 V abs. max
- Output current: 12 A
- $R_{DS(on)}$: 100 mΩ typ per half bridge
- 3 V CMOS-compatible inputs
- PWM operation up to 20 kHz
- Very low standby current, 1.5 μA max at 25°C
- Protections:
 - Cross-conduction protection
 - Overvoltage clamp
 - Undervoltage shutdown
 - Current limitation
 - Power limitation
 - Thermal shutdown
 - Output short to ground and short to V_{CC}
 - Loss of ground and loss of V_{CC}
- CS diagnostic functions:
 - Analog motor current feedback
 - OFF-state open load detection
 - Output short to ground detection
 - Output short to VCC detection
 - Thermal shutdown indication
- Flexibility of use as full bridge, dual half bridge and multi-motor driving configuration

■ Package Information

Part Number	Package
DIA57100	SOP16

■ Applications

- Automotive brushed DC motors and solenoids
- Zone control unit (ZCU)
- Hidden door handles
- Side mirror modules
- Electric spoiler adjustment
- Door lock, child lock, tail gate lock
- On board charger

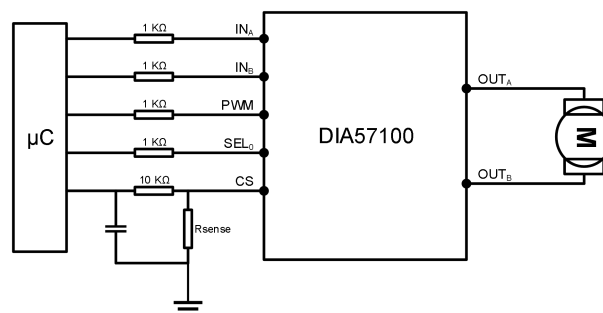
■ Description

The device is a fully integrated H-bridge motor driver intended for a wide range of automotive applications. The design of monolithic die in a power package offers better robustness and higher reliability.

The direction and brake operation of the motor are simply controlled by applying digital signals to the IN_A and IN_B .

The CS pin allows to monitor the motor current by delivering a current proportional to the motor current value, and it also develops a voltage flag for a failure on the relevant output in the ON state as well as the OFF state. The independent PWM pin, up to 20 kHz, allows to control the speed of the motor easily in all possible conditions. In all cases, a low level state on the PWM pin turns off both the LSA and LSB switches.

■ Simplified Schematic



■ Ordering Information

Ordering Part No.	Top Marking	MSL	RoHS	T _A	Package	
DIA57100SO16	DIAEGKV YYWW XZ	3	Green	-40 to 125°C	SOP16	Tape & Reel, 2500

If you encounter any issue in the process of using the device, please contact our customer service at marketing@dioo.com or phone us at (+86)-21-62116882. If you have any improvement suggestions regarding the datasheet, we encourage you to contact our technical writing team at docs@dioo.com. Your feedback is invaluable for us to provide a better user experience.

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1. Pin Assignment and Functions

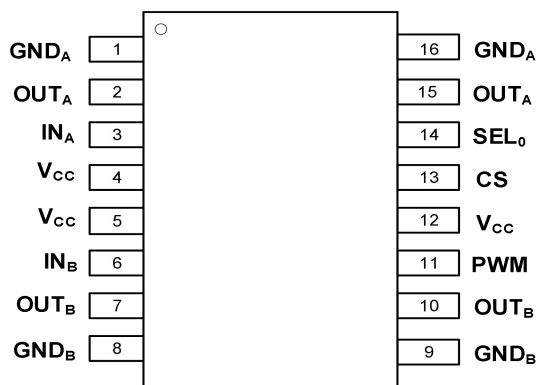


Figure 1. SOP16 (Top view)

Table 1. Pin description

Pin No.	Name	I/O	Description
1, 16	GND _A	GND	Source of low-side switch A.
2, 15	OUT _A	O	Source of high-side switch A / drain of low-side switch A.
3	IN _A	I	Clockwise input.
4, 5, 12	V _{CC}	Power	Power supply voltage.
6	IN _B	I	Counter clockwise input.
7, 10	OUT _B	O	Source of high-side switch B / drain of low-side switch B.
8, 9	GND _B	GND	Source of low-side switch B.
11	PWM	I	Voltage controlled input pin with hysteresis, CMOS compatible. Gates of low-side FETS get modulated by the PWM signal during their on phase allowing speed control of the motor. Active high.
13	CS	O	Multiplexed analog sense output pin. Delivers a current proportional to the motor current.
14	SEL ₀	I	In combination with IN _A , IN _B , the pin addresses the current-sense information that is available to the microcontroller according to the operative truth table. Active high and compatible with 3 V and 5 V CMOS outputs pin.

2. Absolute Maximum Ratings

Exceeding the maximum ratings listed under Absolute Maximum Ratings when designing is likely to damage the device permanently. Do not design to the maximum limits because long-time exposure to them might impact the device's reliability. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Rating	Unit
V_{CC}	Supply voltage	40	V
$-V_{CC}$	Reverse DC supply voltage	0.3	V
I_{max}	Maximum output current (continuous)	Internally limited	A
I_R	Reverse output current	-15	A
V_{CCPK}	Maximum transient supply voltage	40	V
V_{CCJS}	Maximum jump-start voltage for single pulse short-circuit protection	28	V
I_{IN}	Input current (IN_A and IN_B pins)	-1 to 10	mA
I_{SEL0}	SEL_0 pin DC input current	-1 to 10	mA
I_{PWM}	PWM input current	-1 to 10	mA
I_{SENSE}	DC output current on the current sense pin ($V_{GND} = V_{CC}$ and $V_{SENSE} < 0$ V)	10	mA
I_{SENSE}	DC output current in reverse on the current sense pin ($V_{CC} < 0$ V)	-18	mA
T_J	Junction operating temperature	-40 to 150	°C
T_{STG}	Storage temperature	-55 to 150	°C

3. Recommend Operating Conditions

Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Rating	Unit
V_{CC}	Supply voltage	4 to 28	V

4. ESD Ratings

When a statically-charged person or object touches an electrostatic discharge sensitive device, the electrostatic charge might be drained through sensitive circuitry in the device. If the electrostatic discharge possesses sufficient energy, damage might occur to the device due to localized overheating.

Symbol	Model	Condition		Value	Unit
HBM	Human-body model	ANSI/ESDA/JEDEC JS-001	IN _A , IN _B , PWM	±4000	V
			SEL ₀	±4000	
			CS	±4000	
			V _{CC}	±4000	
			Output	±4000	
CDM	Charge-device model	JEDEC/JS-002		±2000	

5. Thermal Considerations

The thermal resistance determines the heat insulation property of a material. The higher the thermal resistance is, the lower the heat loss. Accumulation of heat energy degrades the performance of semiconductor components.

Symbol	Metric	Value	Unit
R _{θJA}	Junction-to-ambient thermal resistance	40	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	7.6	°C/W

6. Electrical Characteristics

6.1. General characteristics

The values are obtained under these conditions unless otherwise specified: $V_{CC} = 7\text{ V}$ up to 28 V ; $-40^{\circ}\text{C} < T_J < 150^{\circ}\text{C}$.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Power section						
V_{CC}	Operating supply voltage		4		28	V
I_S	Supply current	Off-state (standby); $I_{N_A} = I_{N_B} = 0$; $SEL_0 = 0$; PWM = 0; $V_{CC} = 13\text{ V}$; $T_J = 25^{\circ}\text{C}$;			1.5	μA
		Off-state (standby); $I_{N_A} = I_{N_B} = 0$; $SEL_0 = 0$; PWM = 0; $V_{CC} = 13\text{ V}$; $T_J = 85^{\circ}\text{C}$			2	μA
		Off-state (standby) $I_{N_A} = I_{N_B} = 0$; $SEL_0 = 0$; PWM = 0; $V_{CC} = 13\text{ V}$; $T_J = 125^{\circ}\text{C}$			3	μA
		Off-state (no standby) $I_{N_A} = I_{N_B} = 0$; $SEL_0 = 5\text{ V}$; PWM = 0		2	4	mA
		On-state: I_{N_A} or $I_{N_B} = 5\text{ V}$; PWM = 0 or PWM = 5; $SEL_0 = X$		3.5	6	mA
$t_{D_STBY}^{(2)}$	Standby mode blanking time	$V_{CC} = 13\text{ V}$; $I_{N_A} = I_{N_B} = PMW = 0\text{ V}$; V_{SEL0} from 5 V to 0 V	1	2.5	5.5	ms
$R_{ONHS}^{(2)}$	Static high-side resistance	$I_{OUT} = 2.5\text{ A}$; $T_J = 25^{\circ}\text{C}$		60		m Ω
		$I_{OUT} = 2.5\text{ A}$; $T_J = -40$ to 150°C			120	m Ω
$R_{ONLS}^{(2)}$	Static low-side resistance	$I_{OUT} = 2.5\text{ A}$; $T_J = 25^{\circ}\text{C}$		40		m Ω
		$I_{OUT} = 2.5\text{ A}$; $T_J = -40^{\circ}\text{C}$ to 150°C			80	m Ω
$V_f^{(2)}$	Free-wheeling diode forward voltage	$I_{OUT} = -2.5\text{ A}$; $T_J = 150^{\circ}\text{C}$		0.7	0.9	V
$I_{L(off)}$	Off-state output current of one leg	$I_{N_A} = I_{N_B} = 0$; PWM = 0; $V_{CC} = 13\text{ V}$; $T_J = 25^{\circ}\text{C}$	0		0.5	μA
		$I_{N_A} = I_{N_B} = 0$; PWM = 0; $V_{CC} = 13\text{ V}$; $T_J = 125^{\circ}\text{C}$	0		3	μA
$I_{L(off_h)}$	Off-state output current of one leg with other HSD on	$I_{N_A} = 0$; $I_{N_B} = 5\text{ V}$; PWM = 0; $V_{CC} = 13\text{ V}$	20		60	μA
V_{IL}	Input low level voltage				0.9	V
V_{IH}	Input high level voltage		2.1			V
V_{IHYST}	Input hysteresis voltage		0.2			V
V_{ICL}	Input clamp voltage	$I_{IN} = 0.5\text{ mA}$	6		8	V
		$I_{IN} = -1\text{ mA}$		-0.7		V

I _{INL}	Input low level current	V _{IN} = 0.9 V	1			μA
I _{INH}	Input high level current	V _{IN} = 2.1 V			10	μA
SEL ₀ (V _{CC} = 7 V up to 18 V; -40°C < T _J < 150°C)						
V _{SELL}	Input low level voltage				0.9	V
I _{SELL}	Low level input current	V _{SEL} = 0.9 V	1			μA
V _{SELH}	Input high level voltage		2.1			V
I _{SELH}	High level input current	V _{SEL} = 2.1 V			10	μA
V _{SEL(hyst)}	Input hysteresis voltage		0.2			V
V _{SELCL}	Input clamp voltage	I _{SEL} = 0.5 mA	6		8	V
		I _{SEL} = -1 mA		-0.7		V
PWM (V _{CC} = 7 V up to 28 V; -40°C < T _J < 150°C)						
V _{PWM}	Input low level voltage				0.9	V
I _{PWM}	Low level input current	V _{PWM} = 0.9 V	1			μA
V _{PWM}	Input high level voltage		2.1			V
I _{PWMH}	High level input current	V _{PWM} = 2.1 V			10	μA
V _{PWM(hyst)}	Input hysteresis voltage		0.2			V
V _{PMWCL}	Input clamp voltage	I _{PWM} = 0.5 mA	6		8	V
		I _{PWM} = -1 mA		-0.7		V

Note:

- (1) Specifications subject to change without notice.
- (2) Guaranteed by design.

6.2. Switching

The values are obtained under these conditions unless otherwise specified: $V_{CC} = 13\text{ V}$, $R_{LOAD} = 5.2\ \Omega$.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$f^{(1)}$	PWM frequency		0		20	kHz
$t_{d(on)}^{(3)(6)}$	Turn-on delay time	Input rise time $< 1\ \mu\text{s}$		20		μs
$t_{d(off)}^{(3)(6)}$	Turn-off delay time	Input rise time $< 1\ \mu\text{s}$		13		μs
$t_r^{(4)(6)}$	Rise time			0.7	1.5	μs
$t_f^{(4)(6)}$	Fall time			0.2	0.5	μs
$t_{cross}^{(1)(5)}$	Low-side turn-on delay time	Input rise time $< 1\ \mu\text{s}$	40	150	350	μs

Note:

- (1) Parameter guaranteed by design and characterization; not subjected to production test.
- (2) Specifications subject to change without notice.
- (3) See Figure 5.
- (4) See Figure 4.
- (5) See Figure 6.
- (6) Guaranteed by design.

6.3. Protections and diagnostics

The values are obtained under these conditions unless otherwise specified: $V_{CC} = 7\text{ V}$ up to 18 V , $-40^{\circ}\text{C} < T_J < 150^{\circ}\text{C}$.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{USD}	Undervoltage shutdown				4	V
$V_{USDreset}$	Undervoltage shutdown reset				4	V
$V_{USDHyst}$	Undervoltage shutdown hysteresis			0.2		V
$I_{LIM_H}^{(3)}$	High-side current limitation		12	18	24	A
$I_{SD_LS}^{(3)}$	Shutdown low-side current		13	19	25	A
$t_{SD_LS}^{(3)}$	Time to shutdown for the low-side	$V_{INA} = V_{INB} = 0\text{ V}$; PWM = 5 V (See Figure 7)		5		μs
$V_{CL_HSD}^{(3)}$	High-side clamp voltage (V_{CC} to $OUT_A = 0$ or $OUT_B = 0$)	$I_{OUT} = 100\text{ mA}$; $t_{CLAMP} = 1\text{ ms}$	40	46		V
$V_{CL_LSD}^{(3)}$	Low-side clamp voltage ($OUT_A = V_{CC}$ or $OUT_B = V_{CC}$ to GND)	$I_{OUT} = 100\text{ mA}$; $t_{CLAMP} = 1\text{ ms}$	40	46		V
$T_{SD_HS}^{(3)}$	High-side thermal shutdown temperature	$IN_x = 2.1\text{ V}$	160	175	190	$^{\circ}\text{C}$
$T_{R_HS}^{(3)}$	High-side thermal reset temperature		135			$^{\circ}\text{C}$
$T_{HYST_HS}^{(3)}$	High-side thermal hysteresis ($T_{SD_HS} - T_{R_HS}$)			15		$^{\circ}\text{C}$
$T_{TSD_LS}^{(3)}$	Low-side thermal shutdown temperature	$IN_x = 0\text{ V}$	160	175	190	$^{\circ}\text{C}$
$V_{CL}^{(3)}$	Total clamp voltage (V_{CC} to GND)	$I_{OUT} = 100\text{ mA}$; $t_{CLAMP} = 1\text{ ms}$	40	46		V
V_{OL}	OFF-state open-load voltage detection threshold	$IN_A = IN_B = 0$; PWM = 0; $V_{SEL0} = 5\text{ V}$ for CHA; $V_{SEL0} = 0\text{ V}$ and within t_{D_STBY} for CHB	2	3	4	V
$I_{L(off2)}$	OFF-state output sink current	$IN_A = IN_B = 0$; $V_{OUTx} = V_{OL}$; PWM = 0 V; $V_{SEL0} = 5\text{ V}$ for CHA; $V_{SEL0} = 0\text{ V}$ and within t_{D_STBY} for CHB	- 100		- 15	μA
$t_{DSTKON}^{(1)}$	OFF-state diagnostic delay time from falling edge of INPUT ⁽⁴⁾	$IN_A = 5\text{ V}$ to 0 V ; $IN_B = 0\text{ V}$; $V_{SEL0} = 5\text{ V}$; $I_{OUT} = 0\text{ A}$; $V_{OUTA} = 4\text{ V}$; PWM = 0 V	40	150	350	μs
$t_{D_VOL}^{(1)}$	OFF-state diagnostic delay time from rising edge of $V_{OUT}^{(5)}$	$IN_A = IN_B = 0\text{ V}$; PWM = 0 V; $V_{OUTx} = 0\text{ V}$ to 4 V ; $V_{SEL0} = 5\text{ V}$ for CHA; $V_{SEL0} = 0\text{ V}$ and within t_{D_STBY} for CHB		5	30	μs
$t_{Latch_RST_HD}^{(1)}$	Input reset time for high-side fault unlatch ⁽⁶⁾	$V_{INx} = 5\text{ V}$ to 0 V ; HSDx faulting	3	10	20	μs

$t_{\text{Latch_RST_LS}}^{(1)}$	Input reset time for low-side fault unlatch ⁽⁷⁾	$V_{\text{INx}} = 0 \text{ V to } 5 \text{ V; LSDx faulting}$	3	10	20	μs
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Note:

- (1) Parameter guaranteed by design and characterization; not subjected to production test.
- (2) Specifications subject to change without notice.
- (3) Guaranteed by design.
- (4) See figure 3
- (5) See figure 10
- (6) See figure 8
- (7) See figure 9

6.4. Current sense

The values are obtained under these conditions unless otherwise specified: $7 \text{ V} < V_{\text{CC}} < 18 \text{ V}$, $-40^\circ\text{C} < T_{\text{J}} < 150^\circ\text{C}$.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$V_{\text{SENSE_CL}}^{(3)}$	MultiSense clamp voltage	$V_{\text{CC}} = 18 \text{ V; } I_{\text{SENSE}} = -5 \text{ mA}$		11		V
		$V_{\text{CC}} = 18 \text{ V; } I_{\text{SENSE}} = 5 \text{ mA}$	-13		-9	V
K_0	$I_{\text{OUT}}/I_{\text{SENSE}}$	$I_{\text{OUT}} = 0.05 \text{ A; } V_{\text{SENSE}} = 0.5 \text{ V; } T_{\text{J}} = -40^\circ\text{C to } 150^\circ\text{C}$	536			
K_1	$I_{\text{OUT}}/I_{\text{SENSE}}$	$I_{\text{OUT}} = 0.2 \text{ A; } V_{\text{SENSE}} = 0.5 \text{ V; } T_{\text{J}} = -40^\circ\text{C to } 150^\circ\text{C}$	710	1190	1670	
K_2	$I_{\text{OUT}}/I_{\text{SENSE}}$	$I_{\text{OUT}} = 2.5 \text{ A; } V_{\text{SENSE}} = 4 \text{ V; } T_{\text{J}} = -40^\circ\text{C to } 150^\circ\text{C}$	1015	1120	1229	
K_3	$I_{\text{OUT}}/I_{\text{SENSE}}$	$I_{\text{OUT}} = 4 \text{ A; } V_{\text{SENSE}} = 4 \text{ V; } T_{\text{J}} = -40^\circ\text{C to } 150^\circ\text{C}$	1040	1120	1200	
$dK_0/K_0^{(1)(2)}$	Analog sense current drift	$I_{\text{OUT}} = 0.05 \text{ A; } V_{\text{SENSE}} = 0.5 \text{ V; } T_{\text{J}} = -40^\circ\text{C to } 150^\circ\text{C}$	-25		25	%
$dK_1/K_1^{(1)(2)}$	Analog sense current drift	$I_{\text{OUT}} = 0.2 \text{ A; } V_{\text{SENSE}} = 0.5 \text{ V; } T_{\text{J}} = -40^\circ\text{C to } 150^\circ\text{C}$	-21		21	%
$dK_2/K_2^{(1)(2)}$	Analog sense current drift	$I_{\text{OUT}} = 2.5 \text{ A; } V_{\text{SENSE}} = 4 \text{ V; } T_{\text{J}} = -40^\circ\text{C to } 150^\circ\text{C}$	-5		5	%
$dK_3/K_3^{(1)(2)}$	Analog sense current drift	$I_{\text{OUT}} = 4 \text{ A; } V_{\text{SENSE}} = 4 \text{ V; } T_{\text{J}} = -40^\circ\text{C to } 150^\circ\text{C}$	-4		4	%
$V_{\text{SENSE_SAT}}$	Max analog sense output voltage	$V_{\text{CC}} = 7 \text{ V; } R_{\text{SENSE}} = 10 \text{ k}\Omega;$ $V_{\text{SEL0}} = 5 \text{ V; } I_{\text{OUTA}} = 4 \text{ A; } V_{\text{INA}} = 5 \text{ V; } \text{PWM} = 0; T_{\text{J}} = 150^\circ\text{C}$	5			V
I_{SENSE0}	MultiSense leakage current	$I_{\text{OUT}} = 0 \text{ A; } V_{\text{SENSE}} = 0 \text{ V; } I_{\text{Nx}} = 0 \text{ V; } \text{SEL}_0 = 0; T_{\text{J}} = -40^\circ\text{C to } 150^\circ\text{C (standby)}$	0		0.5	μA
		$I_{\text{OUT}} = 0 \text{ A; } V_{\text{SENSE}} = 0 \text{ V; } I_{\text{Nx}} = 0 \text{ V; } \text{SEL}_0 = 5 \text{ V; } T_{\text{J}} = -40^\circ\text{C to } 150^\circ\text{C (no standby)}$	0		0.5	μA

		$I_{N_x} = 5 \text{ V}$; $PWM = 5 \text{ V}$; $T_J = -40^\circ\text{C}$ to 150°C ; $I_{OUT} = 0 \text{ A}$	0		5	μA
V_{SENSEH}	MultiSense output voltage in fault condition	$V_{CC} = 13 \text{ V}$; $R_{SENSE} = 1 \text{ k}\Omega$ – E.g: OUT_A in open-load $I_{N_A} = 0 \text{ V}$; $I_{OUTA} = 0 \text{ A}$; $V_{OUTA} = 4 \text{ V}$; $V_{SEL0} = 5 \text{ V}$	3.6		7	V
I_{SENSEH}	MultiSense output current in fault condition	$9 \text{ V} < V_{CC} < 18 \text{ V}$; $V_{SENSE} = V_{SENSEH}$	8	18	28	mA

Note:

- (1) Analog sense current drift is deviation of factor K for a given device over -40°C to 150°C and $9 \text{ V} < V_{CC} < 18 \text{ V}$, with respect to its value measured at $T_J = 25^\circ\text{C}$, $V_{CC} = 13 \text{ V}$.
- (2) Parameter guaranteed by design and characterization; not subjected to production test.
- (3) Guaranteed by design.
- (4) Specifications subject to change without notice.

6.5. Detailed figures

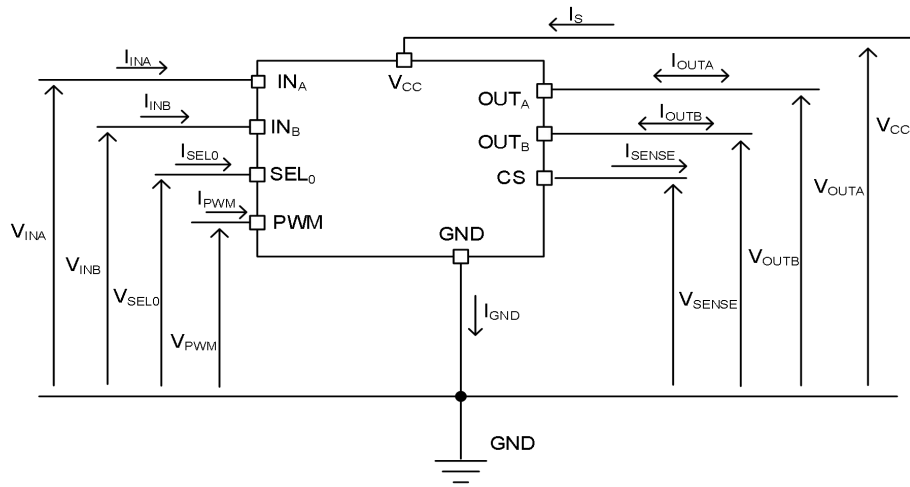


Figure 2. Current and voltage conventions

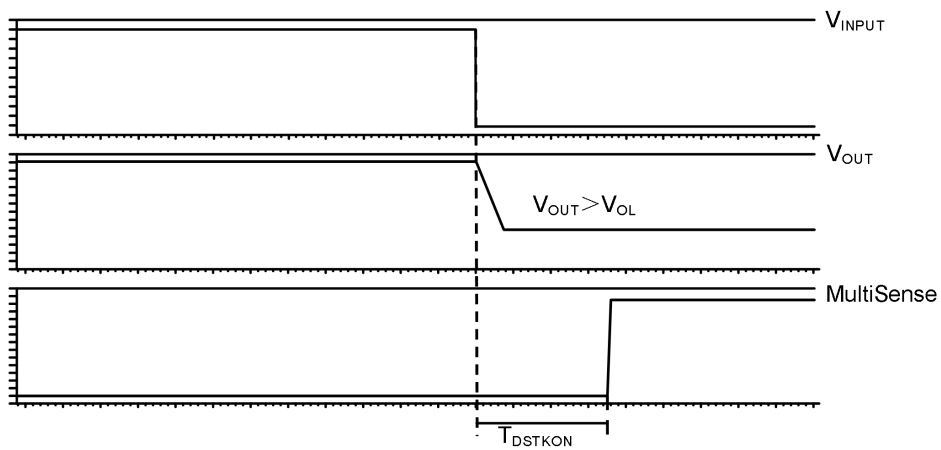


Figure 3. t_{DSTKON}

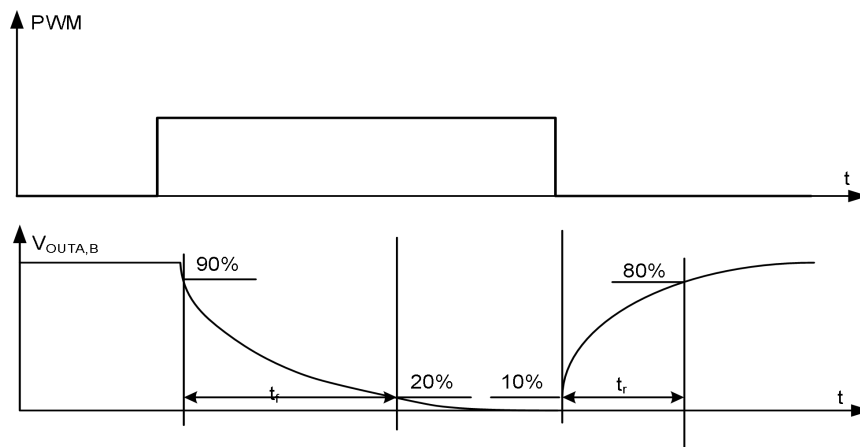


Figure 4. Definition of the low-side switching times

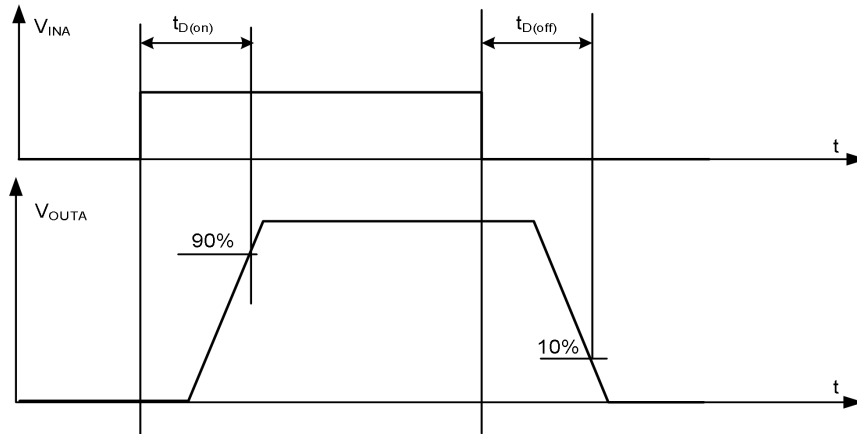


Figure 5. Definition of the high-side switching times

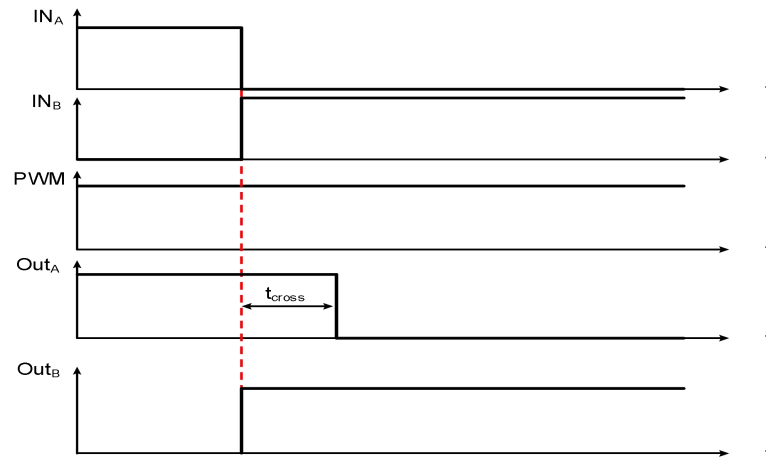


Figure 6. Low-side turn-on delay time

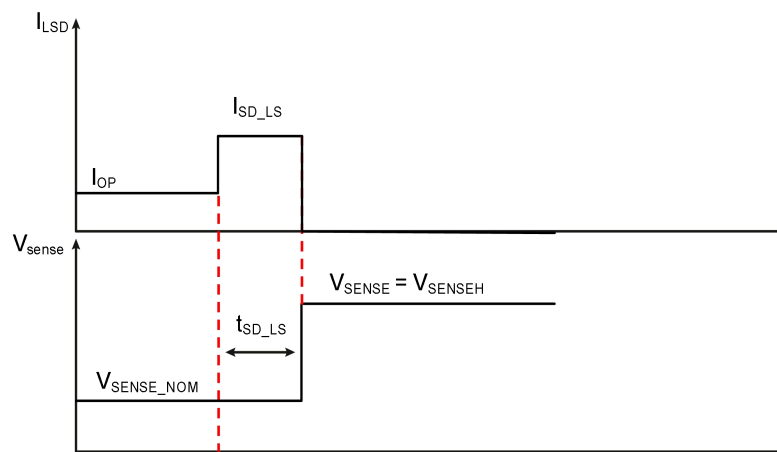


Figure 7. Time to shutdown for the low-side driver

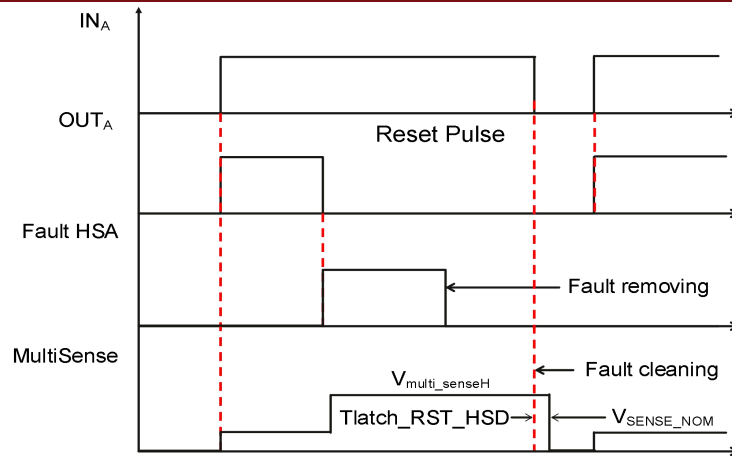


Figure 8. Input reset time for HSD - fault unlatch

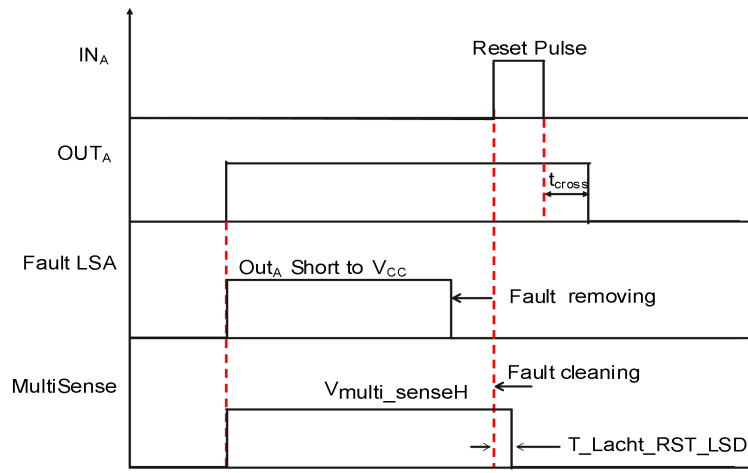


Figure 9. Input reset time for LSD - fault unlatch

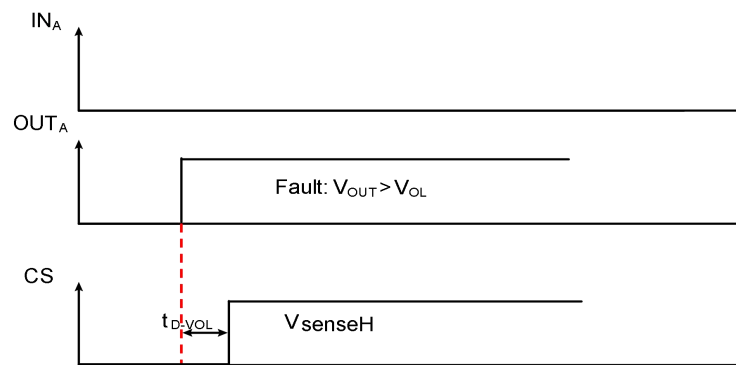


Figure 10. OFF-state diagnostic delay time from rising edge of V_{OUT} (t_{D_VOL})

7. Typical Characteristics

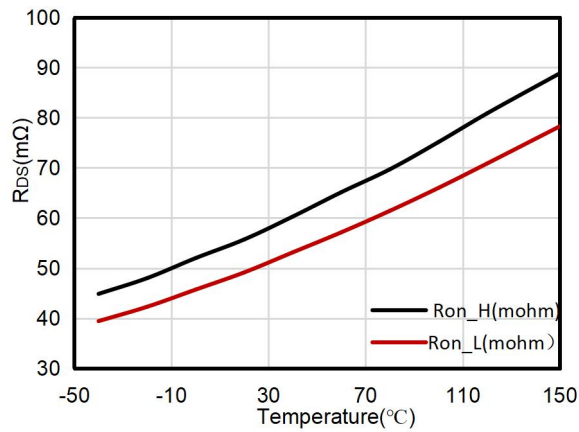


Figure 11. $R_{DS(on)}$ vs. Temperature

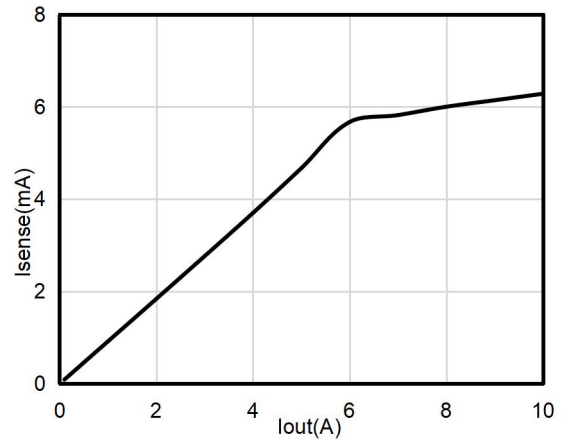
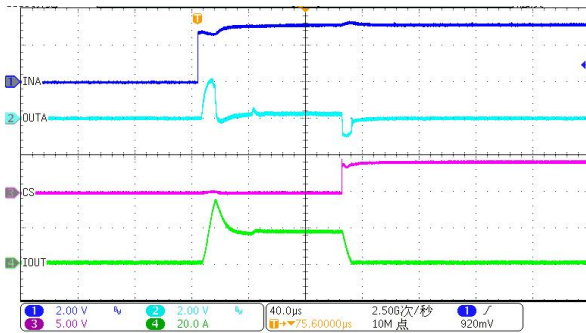
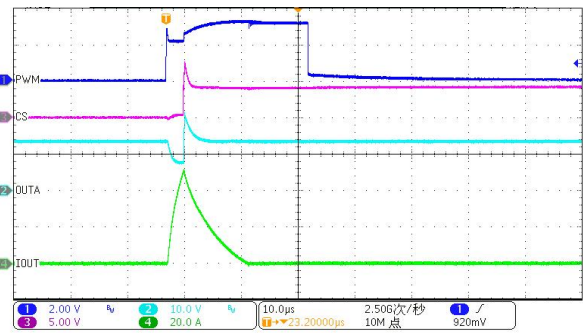


Figure 12. I_{SENSE} vs. I_{OUT}



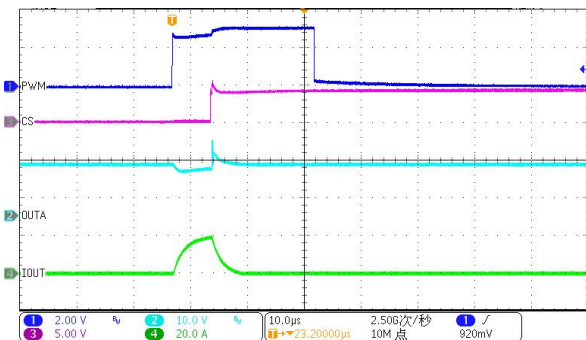
$V_{CC} = 13.5 \text{ V}$, $SEL_0 = 1$

Figure 13. Protection-output short to GND



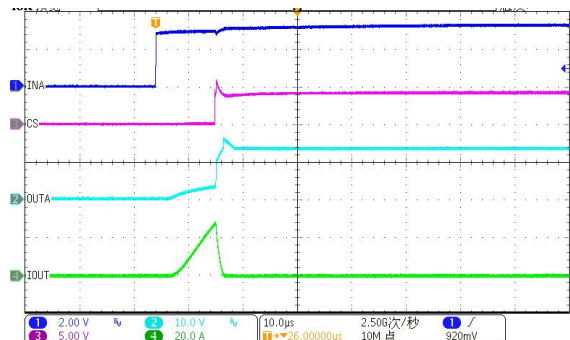
$V_{CC} = 13.5 \text{ V}$, $SEL_0 = 0$, $IN_A = 1$, $IN_B = 0$

Figure 14. Protection-output hard short to V_{CC}



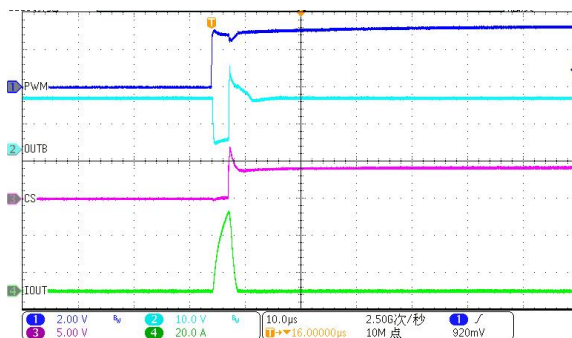
$V_{CC} = 13.5 \text{ V}$, $SEL_0 = 0$, $IN_A = 1$, $IN_B = 0$

Figure 15. Protection-output soft short to V_{CC}



$V_{CC} = 13.5 \text{ V}$, $SEL_0 = 0$, $PWM = 1$

Figure 16. OUT_A short to OUT_B - LSB ON then HSA switched ON



$V_{CC} = 13.5\text{ V}$, $SEL_0 = 0$, $IN_B = 1$

Figure 17. OUT_A short to OUT_B - HSB ON then LSA switched ON

8. Truth Tables

Table 2. Truth table: operative condition

Pin Status					HSDs and LSDs Status			
IN _A	IN _B	SEL0	PWM	Current Sense	HSDA	LSDA	HSDB	LSDB
1	1	1	X	Current monitoring HSDA	On	Off	On	Off
		0		Current monitoring HSDB				
1	0	1	1	Current monitoring HSDA	On	Off	Off	On
			0		On	Off	Off	Off
1	0	0	1	Hi-Z	On	Off	Off	On
			0		On	Off	Off	Off
0	1	1	1	Hi-Z	Off	On	On	Off
			0		Off	Off	On	Off
0	1	0	1	Current monitoring HSDB	Off	On	On	Off
			0		Off	Off	On	Off
0	0	1	1	Hi-Z	Off	On	Off	On
		0						
0	0	1	0	X ⁽¹⁾	Off	Off	Off	Off
		0 ⁽²⁾			Off	Off	Off	Off

Note:

(1) Refer to Table 4.

(2) For IN_A = IN_B = SEL₀ = PWM = 0, the device enters in standby after t_{D_STBY}.

Table 3. Truth table: ON-state fault conditions

Digital Input Pins				Current Sense	Comment
IN _A	IN _B	PWM	SEL0		
0	0	1	0	VsenseH	LSB protection triggered; LSB latched off
0	0	1	1	VsenseH	LSA protection triggered; LSA latched off
0	1	X	0	VsenseH	HSB protection triggered; HSB latched off
0	1	1	1	VsenseH	LSA protection triggered; LSA latched off
1	0	1	0	VsenseH	LSB protection triggered; LSB latched off
1	0	X	1	VsenseH	HSA protection triggered; HSA latched off
1	1	X	0	VsenseH	HSB protection triggered; HSB latched off
1	1	X	1	VsenseH	HSA protection triggered; HSA latched off

Table 4. Truth table: OFF-state

IN _A	IN _B	SEL ₀	PWM	Out _A	Out _B	CS	Description
OFF-state diagnostic							
0	0	1	0	V _{outA} > V _{OL}	X	V _{SENSEH}	Case 1. OUT _A shorted to V _{CC} if no pull-up resistor is applied Case 2. No open-load in full bridge configuration with an external pull-up resistor on OUT _B Case 3. open-load in half bridge configuration with an external pull-up resistor on OUT _A (motor connected between OUT _A and Ground)
				V _{outA} < V _{OL}	X	Hi-Z	Case 1. Open-load in full bridge configuration with an external pull-up resistor on OUT _B Case 2. No open-load in half bridge configuration with an external pull-up resistor on OUT _A (motor connected between OUT _A and Ground)
		0 ⁽¹⁾⁽²⁾		X	V _{outB} > V _{OL}	V _{SENSEH}	Case 1. OUT _B shorted to V _{CC} if no pull-up resistor is applied Case 2. No open-load in full bridge configuration with an external pull-up resistor on OUT _A Case 3. Open-load in half bridge configuration with an external pull-up resistor on OUT _B (motor connected between OUT _B and Ground)
				X	V _{outB} < V _{OL}	Hi-Z	Case 1. Open-load in full bridge configuration with an external pull-up resistor on OUT _A Case 2. No open-load in half bridge configuration with an external pull-up resistor on OUT _B (motor connected between OUT _B and Ground)

Note:

(1) The device enters standby mode after standby mode blanking time.

(2) To power on the device from the standby, toggle IN_A or IN_B from 0 to 1 first and then PWM from 0 to 1 to avoid any over-stress on the device in case of short-to-battery.

9. Waveforms

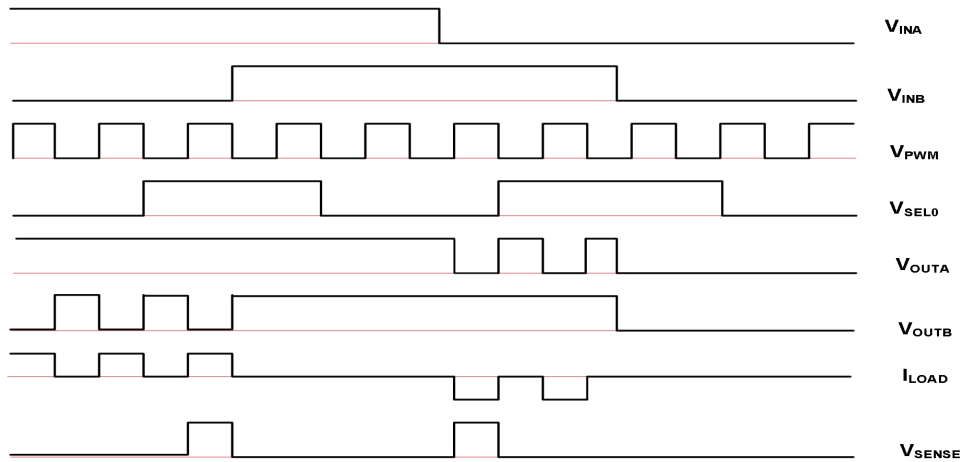


Figure 18. Normal operative conditions

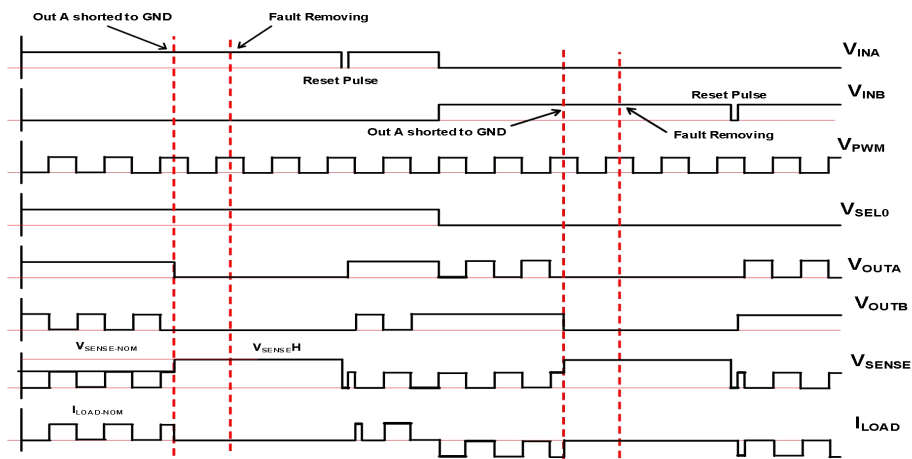


Figure 19. OUT shorted to ground and short clearing

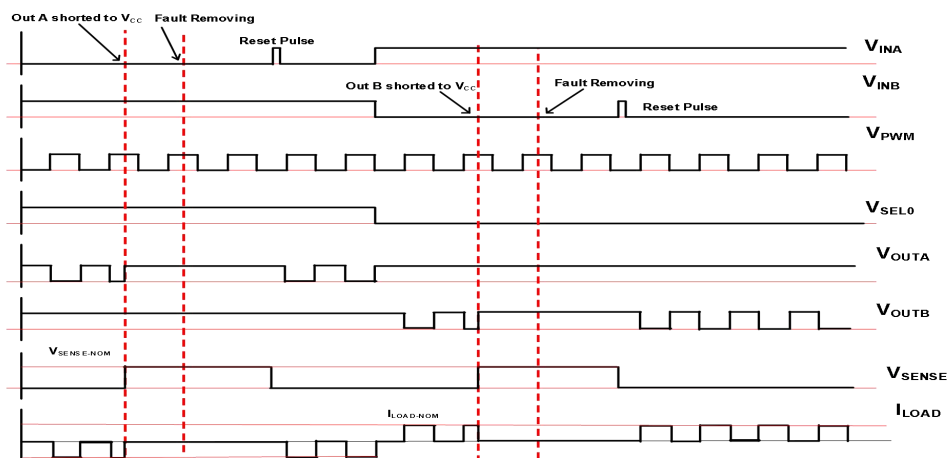
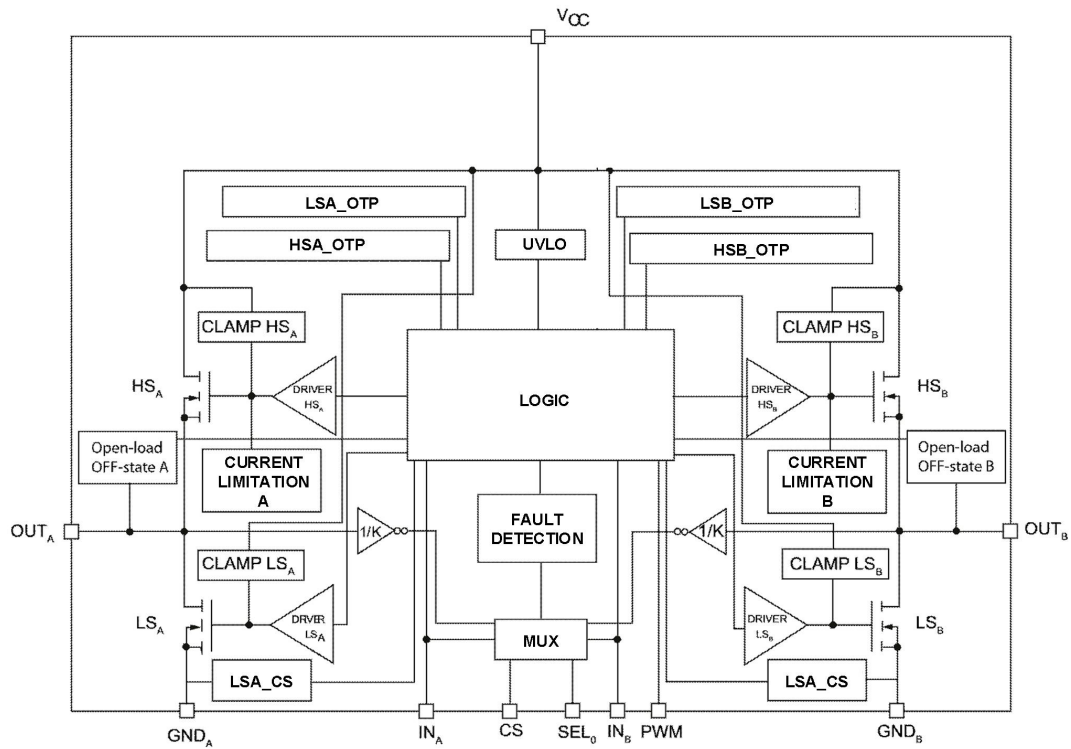


Figure 20. OUT shorted to VCC and short clearing

10. Block Diagram



Name	Description
Logic control	Control the high-side and the low-side switches according to the truth table.
Undervoltage	Shut down the device for battery voltage lower than 4 V.
High-side and low-side clamp voltage	Protect the high-side and the low-side switches from the high voltage on the battery line.
High-side and low-side drivers	Drive the gate of the associated switch to allow a proper R_{on} for the leg of the bridge.
Current limitation	Limit the motor current in case of short-circuit.
High-side and low-side over-temperature protection	Shut down the associated driver to prevent degradation and to protect the die.
Low-side current sense	Detect when low side current exceeds shutdown current and latches off the associated low side.
Fault detection	Declare the abnormal behavior of the switch through MultiSense pin.
Power limitation	Limit the power dissipation of the high-side driver inside safe range in case of short to ground condition.

11. Application Information

Important notice: Validation and testing are the most reliable ways to confirm system functionality. The application information is not part of the specification and is for reference purposes only.

11.1. Reverse battery protection

Three possible solutions to protect the device from reverse battery:

- A Schottky diode D connected to V_{CC} pin
- An N-channel MOSFET connected to the GND pin
- A P-channel MOSFET connected to the V_{CC} pin

When the reverse battery protections is absent, the device sustains less than -15 A because of the tow body diodes of the power MOSFETs. Additionally, in reverse battery condition, the I/Os of the device is pulled down to the V_{CC} line (approximately -1.5 V). To limit the sink current from the microcontroller I/Os, insert a series resistor. The series resistor can be calculated from Equation (1):

$$R = \frac{V_{IOs} - V_{CC}}{I_{Rmax}} \quad (1)$$

where

V_{IOs} is the voltage on the I/Os

V_{CC} is the operating power supply

I_{Rmax} is the maximum target reverse current through microcontroller I/Os

11.2. OFF-state open-load detection

Use an external circuitry to detect an open-load in off-state. Connect the circuitry between the output and V_{Batt} .

Put one network on each leg in case of half bridge operation. Put one network on one of the output in case of full bridge. (See Table 4.)

The external circuitry has an external pull-up resistor R_{pull_up} that connects the output to a positive supply voltage V_{Batt} .

To reduce the overall standby current during the module standby mode, switch off V_{Batt} by using an external pull_up switch.

Dimension R_{pull_up} to ensure that in normal operative conditions V_{OUT} is larger than V_{OLmax} . Select the R_{pull_up} according to Equation (2) and (3).

- When the device is used in half bridge configuration,

$$R_{pull_up} < \frac{V_{BATTmin} - V_{OLmax}}{I_{L(off2)min}} \quad (2)$$

- When the device is used in full bridge configuration,

$$R_{pull_up} < \frac{V_{BATTmin} - V_{OLmax}}{2 \times I_{L(off2)min}} \quad (3)$$

where $I_{L(off2)}$ is minimum when V_{OL} is maximum.

11.4. Device configurations

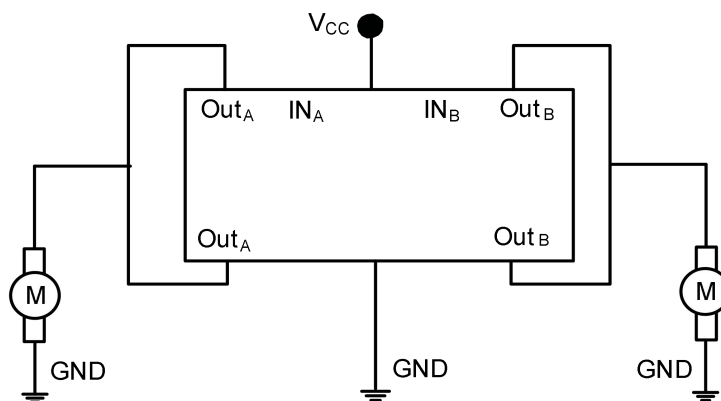


Figure 23. Half-bridge configuration (case A)

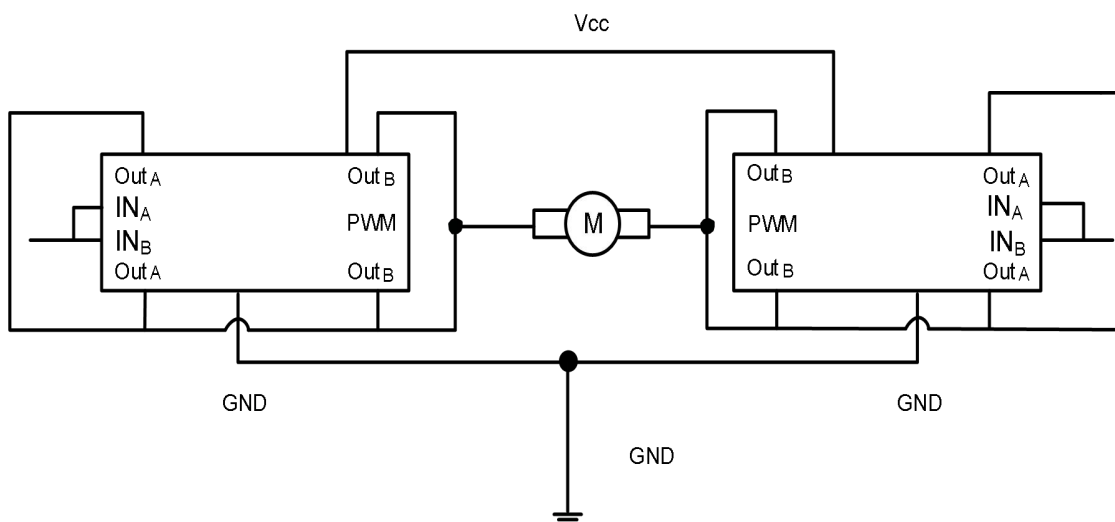
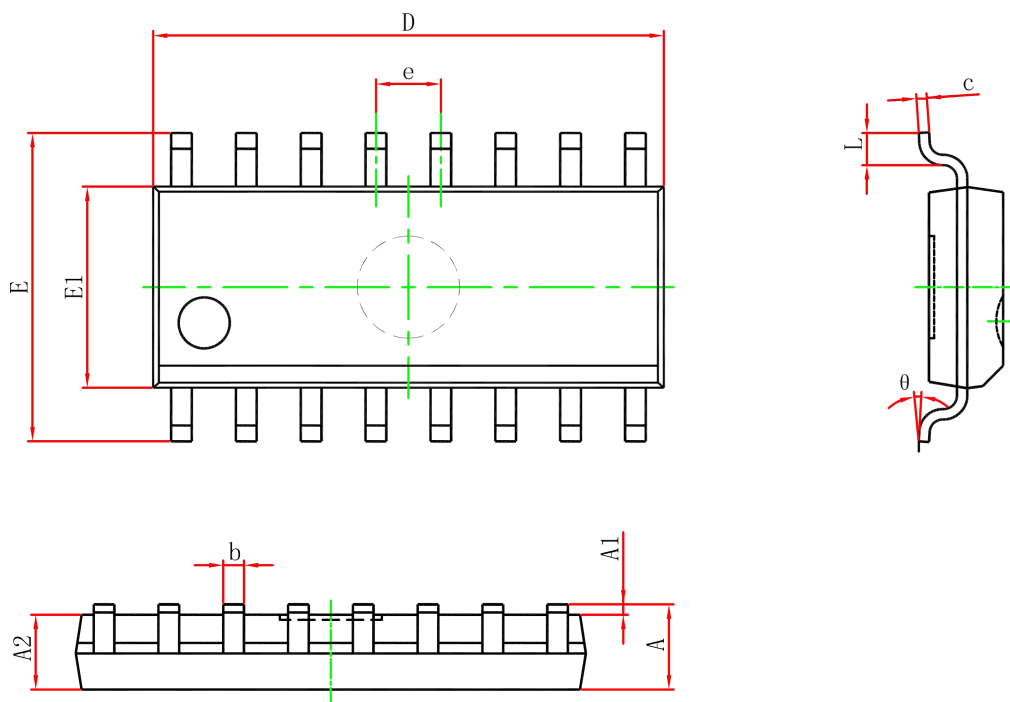


Figure 24. Half-bridge configuration (case B)

12. Physical Dimensions: SOP16



Common Dimensions (Units of measure = Millimeter)		
Symbol	Min	Max
A	-	1.750
A1	0.100	0.250
A2	1.400	1.500
b	0.330	0.510
c	0.170	0.250
D	9.800	10.200
e	1.270 BSC	
E	5.800	6.200
E1	3.800	4.000
L	0.400	1.270
θ	0°	8°

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