iT8500E

Datasheet Rev. 0.6

Digital Single-Phase BLDC Motor Driver

Description

The iT8500E is a single-phase, brushless DC motor driver. It is composed of Hall sensor, MOSFET, gate driver and control logic which can provide minimal components of total BOM to save the total cost and space.

The iT8500E provides various parameters to tune motor efficiently and quickly, ex. Poles, Lead Angle, Target Speed and PWM Duty …etc. All the parameters shall be set via inergy's software tool "INGUI".

The iT8500E is equipped TSD, OCP, OVP, UVP, and Rotor Locked Protections.

Power & Input

- Wide voltage range: 3.2~18 V
- Continuous current output : up to 0.6A
- Supports VSP (0~3.3 V) and PWM (100~100 KHz) input
- Embedded high-sensitivity Hall Sensor : +/-15G (support external Hall Sensor)
- Programmable FG/RD diagnostics outputs

Advanced Control

- Soft Start & Kick Start mechanisms
- Open Loop / Close Loop control
- ZCD for Anti-BEMF improvement
- Quick start with acceleration / deceleration slope selectable
- Programmable lead / lag angle setting

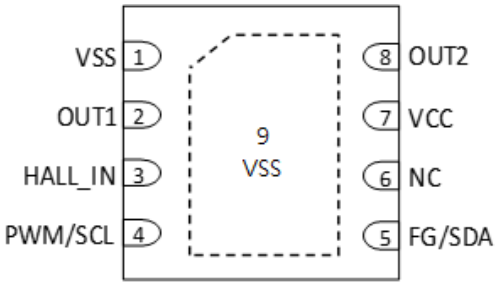
Protections

- Multi-fault protection : OCP, SCP, OVP, UVP, TSD
- Programmable current limitation
- Programmable rotor locked detection and recovery time

Intelligent GUI

- Visual development environment : inergy GUI tool for rapid parameter tuning
- 4-points flexible speed curve setting
- 16-point editable driving waveform

1. Pin Assignments



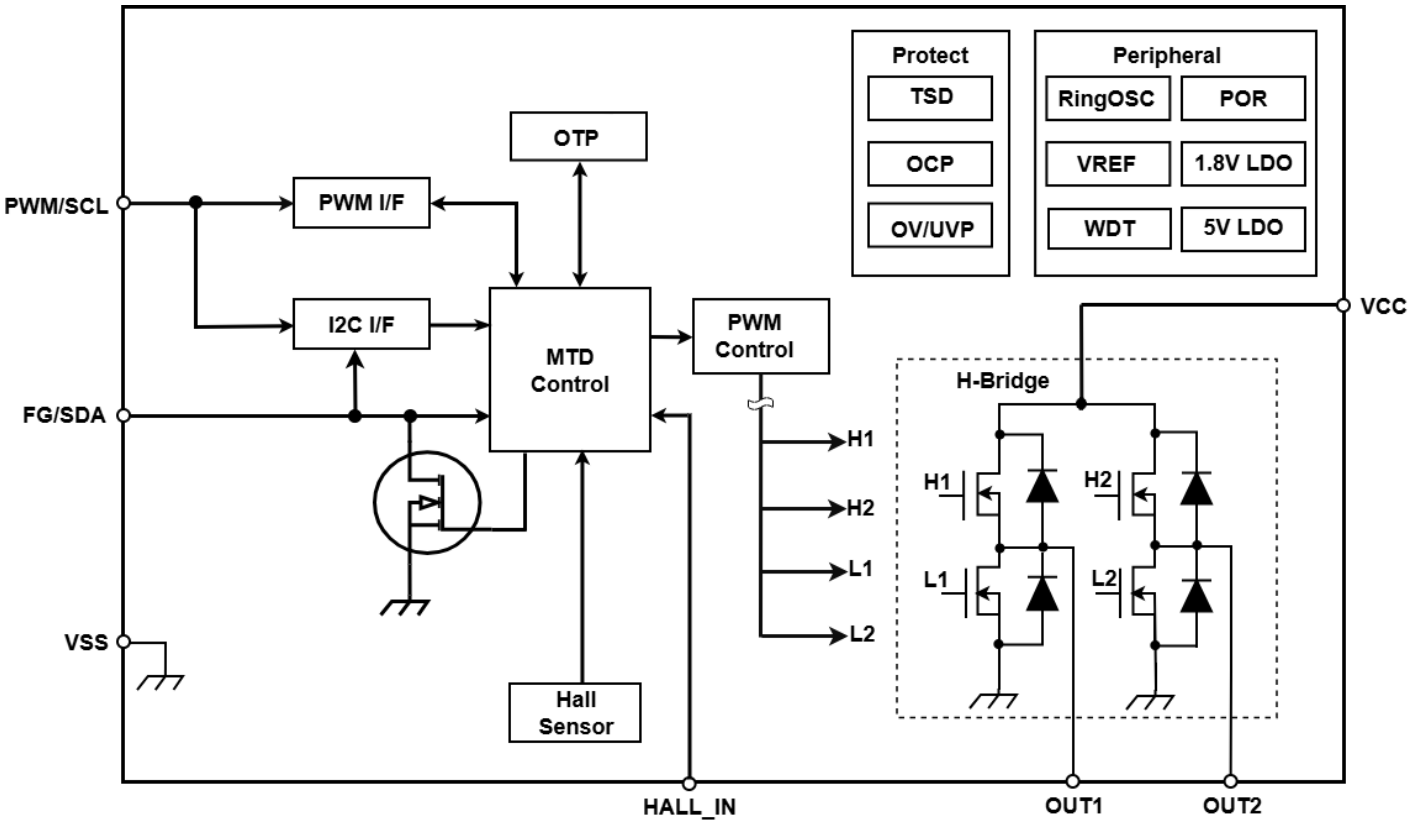
2. Marking Information

Ordering Code	Marking
iT8500E	iNERGY 8500XXX □□-YYYY ● X: Date code Y: Checksum □□: Internal code

3. Pin Definitions

Pin No.	Symbol	Description
1	VSS	Ground pin
2	OUT1	Driving motor output
3	HALL_IN	External hall IC signal input
4	PWM/SCL	Direct PWM input/ SCL
5	FG/SDA	Speed signal output / SDA
6	NC	No connection
7	VCC	Power supply pin
8	OUT2	Driving motor output
9	VSS	Ground pin (Exposed PAD)

4. Block Diagram



5. Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are absolute voltages referenced to VSS (GND), all currents are defined positive into any lead. The thermal resistance and power dissipation ratings are measured under board mounted and still air conditions.

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Supply Voltage	-0.3	22	V
I_{Opeak}	Output Peak Current	-	1.2	A
I_O	Output Current(Continuous)	-	0.6	A
P_D	Package power dissipation @ $T_A \leq +25$ ℃	-	2.5	W
V_{PWM}	PWM/SCL signal input voltage	-0.3	6	V
V_{FG}	FG/Alarm/RD signal output voltage	-0.3	18	V
I_{FG}	FG/Alarm/RD signal sink current	-	10	mA
V_{HALL_IN}	HALL_IN signal input voltage	-0.3	6	V
R_{thJA}	Thermal resistance, junction to ambient	-	50	℃ / W
T_J	Junction temperature	-	150	℃
T_S	Storage temperature	-55	150	
T_L	Lead temperature (soldering 10 seconds)	-	260	

6. Recommended Operating Conditions

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Operating supply voltage	3.5	18	V
V_{PWM}	PWM input voltage	-0.3	5.5	V
V_{FG}	FG output voltage	-0.3	16	V
V_{HALL_IN}	HALL_IN input voltage	-0.3	5.5	V
D_{PWM}	Duty of PWM input	0	100	%
F_{PWMIN}	Frequency of PWM input	100	100K	Hz
T_A	Ambient temperature (*1)	- 40	85	℃

*Note：Please do not exceed Tj limitation

7. Electrical Characteristics

V_{CC}=12V, T_A = 25 ºC, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max	Unit
I_{cc}	Circuit Current	Vcc=12V		6		mA
IDDQ	Power saving mode current	Vcc=12V		85		uA
TH_{PG}	Vcc power good threshold		-15%	2.25	+15%	V
HYS_{PG}	Vcc power good hysteresis			0.1		V
TH_{PreOVP}	Vcc PreOVP threshold	GUI setting 19.5V		19.5		V
		GUI setting 21.5V		21.5		V
HYS_{PreOVP}	Vcc Pre-over voltage hysteresis			1		V
TH_{OVP}	Vcc OVP threshold	GUI setting 24V		24		V
HYS_{ovp}	Vcc OVP hysteresis			1		V
TH_{uv}	Vcc under voltage threshold			8		V
HYS_{uv}	Vcc under voltage hysteresis			1		V
V_{PWMH}	PWM input high voltage		2.0		5.5	V
V_{PWML}	PWM input low voltage		-0.3		1.4	
F_{PWM}	PWM input frequency		0.1		100	kHz
R_{PWM_UP}	PWM input internal pull-up resistance			20		kΩ
R_{PWM_DOWN}	PWM input internal pull-down resistance			400		kΩ
R_{on}	High side + Low side resistance	I_O=0.5A / Vcc=12V		0.9		Ω
R_{FG}	Internal resistance of FG	IFG=10mA		20		Ω
V_{FGL}	FG low level voltage	I=10mA			0.3	V
I_{oc}	Over current threshold				1.2	A
I_{lim}	Output current limit range	0.2A / step	0.2		1.2	A
F_{PWM}	PWM output frequency	GUI setting 25KHz	-5%	25	+5%	kHz
		GUI setting 50KHz	-5%	50	+5%	
LA	Lead Angle	GUI setting	-90		+90	°
T_{locd}	Lockout detect time	GUI setting Bypass/0.25/0.5sec	-5%	setting	+5%	sec
T_{lodr}	Lock recovery time	GUI setting 0/1.5/3/6sec	-5%	setting	+5%	sec
B_{OP}	Operate magnetic field			15		Gauss
B_{RP}	Release magnetic field			-15		Gauss
B_{HYS}	magnetic field hysteresis	$\lvert B_{OP} - B_{RP} \rvert$		30		Gauss

7. Electrical Characteristics(cont.)

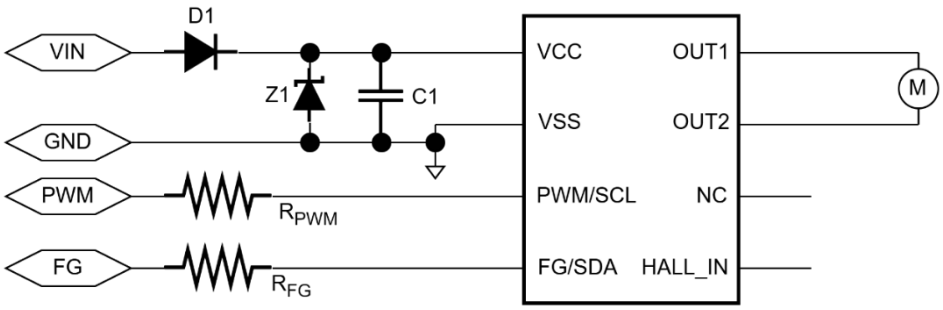
V_{CC}=12V, T_A = 25 ºC, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max	Unit
GUI setting TSD 1 : Thermal shutdown (Error) =150℃ + Thermal alarm 100℃						
TH_{tsd}	Thermal shutdown threshold	GUI setting 150 ℃	140	150	160	℃
HYS_{tsd}	Thermal shutdown hysteresis			50		℃
TH_{tam}	Thermal alarm threshold	GUI setting 100 ℃	90	100	110	℃
HYS_{tam}	Thermal alarm hysteresis			25		℃
GUI setting TSD 2 : Thermal shutdown (Error) =175℃ + Thermal alarm 125℃						
HYS_{tsd}	Thermal shutdown hysteresis	GUI setting 175 ℃	165	175	185	℃
HYS_{tsd}	Thermal shutdown hysteresis			50		℃
TH_{tam}	Thermal alarm threshold	GUI setting 125 ℃	115	125	135	℃
HYS_{tam}	Thermal alarm hysteresis			25		℃

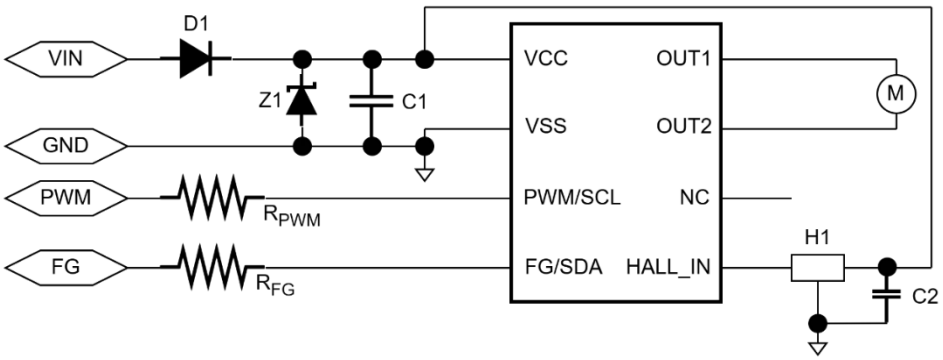
*Note：TSD shutdown or alarm protection can be set to be turned on or off by the user.

8. Application Circuit

<Use internal Hall sensor>



<Use external Hall sensor>



Note：

1. C1 must be placed to VCC / VSS pins as close as possible, suggest at least **2.2uF/25V**.
2. Z1 is essential for protection at hot plug or some strictly operating conditions. **16~18V TVS** is preferred.
3. R_{PWM} = **1K~1.2KΩ** and R_{FG} = **47~100Ω** for the system ESD/EFT improvement.
4. D1 suggest to use **Schottky diode** with **2A/20~40V** spec.

9. Application Information

General Description

The iT8500E is a single-phase brushless DC (BLDC) motor driver with integrated power MOSFETs and a Hall-effect sensor.

It provides comprehensive protection features, including over-voltage, under-voltage, over-current, over-temperature.

VCC Power Good

The VCC Power Good signal is asserted when VCC exceeds 2.5 V. The Power Good signal is deasserted when VCC falls below 2.3 V.

Under-Voltage Lockout (UVLO)

If VCC falls below the under-voltage lockout (UVLO) threshold voltage at any time, all internal circuitry is disabled and the internal logic is reset. Normal operation resumes automatically when VCC rises above the UVLO threshold.

Speed Control

Speed control can be achieved through a PWM input signal and can be configured to use either PWM duty cycle control or VSP analog voltage control.

The device is controlled through a pulse-width modulation (PWM) input interface that is compatible with industry-standard devices. The IC detects the duty cycle of the PWM input signal and linearly controls the H-bridge output duty cycle. As the input duty cycle increases, the fan speed increases proportionally.

The PWM input supports a wide frequency range from 100 Hz to 100 kHz, while the output switching frequency remains constant.

Speed Acceleration Slope (ACC)

The rotor acceleration time (ACC) is programmable to 2.66 s, 5.33 s, 7.98 s, or 10.64 s.

Speed Deceleration Slope (DEC)

The rotor deceleration time (DEC) is programmable to 2.66 s, 5.33 s, 7.98 s, or 10.64 s.

Rotor Speed Indication (FG)

The device outputs the Hall sensor detection signal to the FG pin as a speed indication signal.

The FG output frequency can be configured to 0.5×, 1.0×, or 2.0× the frequency of the internal Hall sensor signal.

The FG pin is an open-drain output and requires an external pull-up resistor in the application circuit.

The FG/RD output waveform is illustrated in Figure 1.

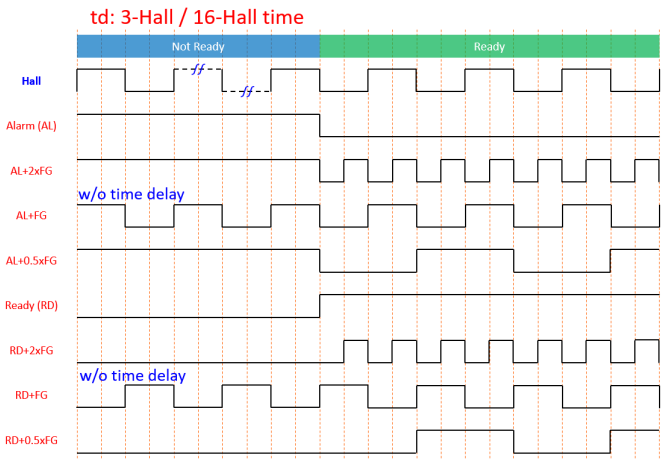


Fig.1

PWM Output Drive

The IC controls the switching of the H-bridge MOSFETs to minimize speed variation and improve system efficiency.

When the rotor's south magnetic pole (S) approaches the Hall sensor, the internal Hall sensor output goes high. When the rotor's north magnetic pole (N) approaches, the Hall sensor output goes low. Based on the Hall sensor signal, the IC performs soft-on and soft-off switching transitions to maintain smooth current flow and reduce fan vibration.

Rotor Lock Protection

The iT8500E monitors the internal Hall sensor signal and outputs a rotor-lock indication through the FG pin.

If no Hall signal edge transition is detected within the programmable detection period of 0.25 s or 0.5 s, the low-side MOSFETs of the H-bridge are turned on.

After a programmable lock-retry interval of 0 s, 1.5 s, 3 s, or 6 s, the IC automatically attempts to restart the motor.

The FG pin resumes output only after 3 or 16 Hall signal edges have been detected following recovery from the rotor-lock condition. A delay is introduced in the FG/RD output when the frequency multiplier is set to 0.5× or 2.0×, while the 1.0× setting provides real-time output.

Over-Current Protection (OCP)

The iT8500E protects against internal overload and short-circuit conditions by monitoring the current flowing through each MOSFET.

If the current through any MOSFET exceeds the over-current protection (OCP) threshold of 1.65 A or twice the configured current-limit setting (programmable) for longer than the 2 µs blanking time, the corresponding MOSFET is turned off immediately. After the programmable lock-retry interval expires, the H-bridge is automatically re-enabled.

The above parameters are configurable through the GUI.

Overload Current Limit

During normal operation, the current flowing through the high-side MOSFET (HS-FET) of the H-bridge is continuously monitored.

If the HS-FET current exceeds the threshold configured by the SUCL register bits for longer than the approximately 3 µs blanking time, the HS-FET is turned off immediately. The HS-FET resumes normal switching operation in the next PWM switching cycle.

The current-limit threshold is programmable from 0.10 A to 1.65 A in 0.05 A increments. If no configuration is applied, the default current-limit threshold is 0.80 A.

The above parameters are configurable through the GUI.

Over-Voltage Protection (OVP)

If VCC exceeds the over-voltage protection (OVP) threshold of 24 V, all four H-bridge MOSFETs are turned off. The IC remains in the protection state until VCC falls below 23 V, at which point normal operation resumes automatically. The OVP timing diagram is shown in Figure 2.

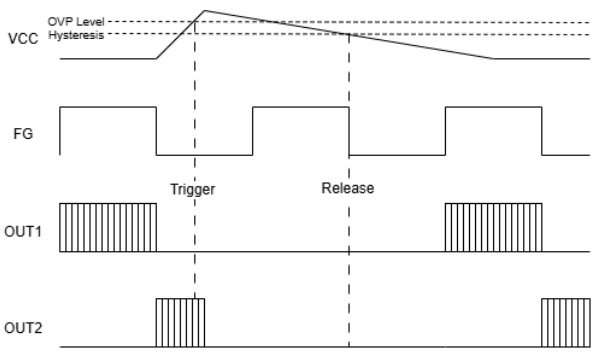


Fig.2

Thermal Shutdown Detection (TSD)

Thermal monitoring is integrated into the iT8500E. Two TSD operating modes are available: Error Mode and Alarm Mode.

TSD Alarm Mode

If the internal junction temperature exceeds the Alarm threshold of 100°C or 125°C (programmable), the output duty cycle of the switching half-bridge is limited to 50% of the target duty cycle. Once the junction temperature falls below the Alarm recovery temperature of 75°C or 100°C, normal operation resumes automatically.

TSD Error Mode

If the internal junction temperature exceeds the Error threshold of 150°C or 175°C (programmable), the MOSFETs of the switching half-bridge are turned off. Once the junction temperature falls below the Error recovery temperature of 125°C or 150°C, normal operation resumes automatically.

Power Saving Mode

After VCC exceeds the UVLO rising threshold, if the PWM pin remains low for more than 10 ms, the IC automatically enters Power Saving Mode to reduce power consumption.

The IC exits Standby Mode when a valid PWM input signal is present for at least 10 ms, or after a power-on reset caused by cycling the supply voltage.

The standby-mode timing diagram is shown in Figure 3.

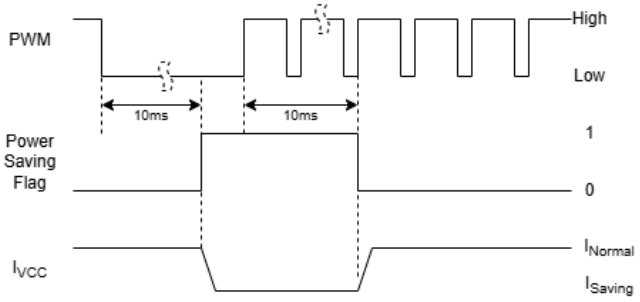
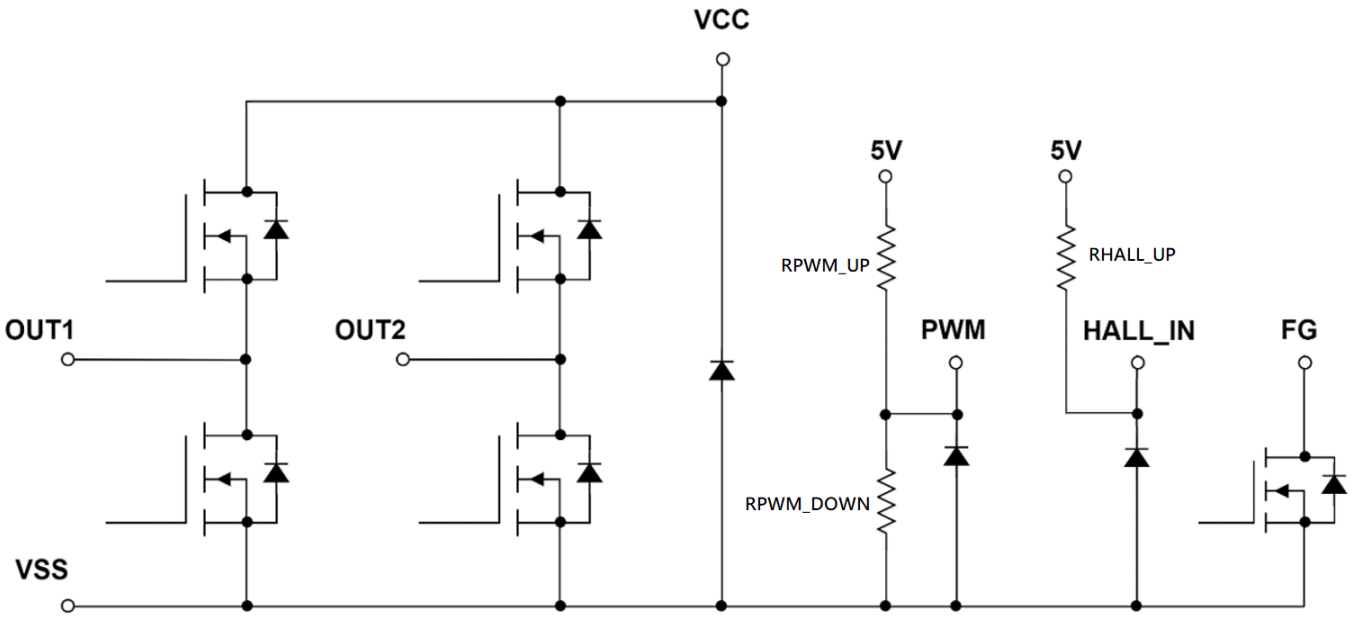


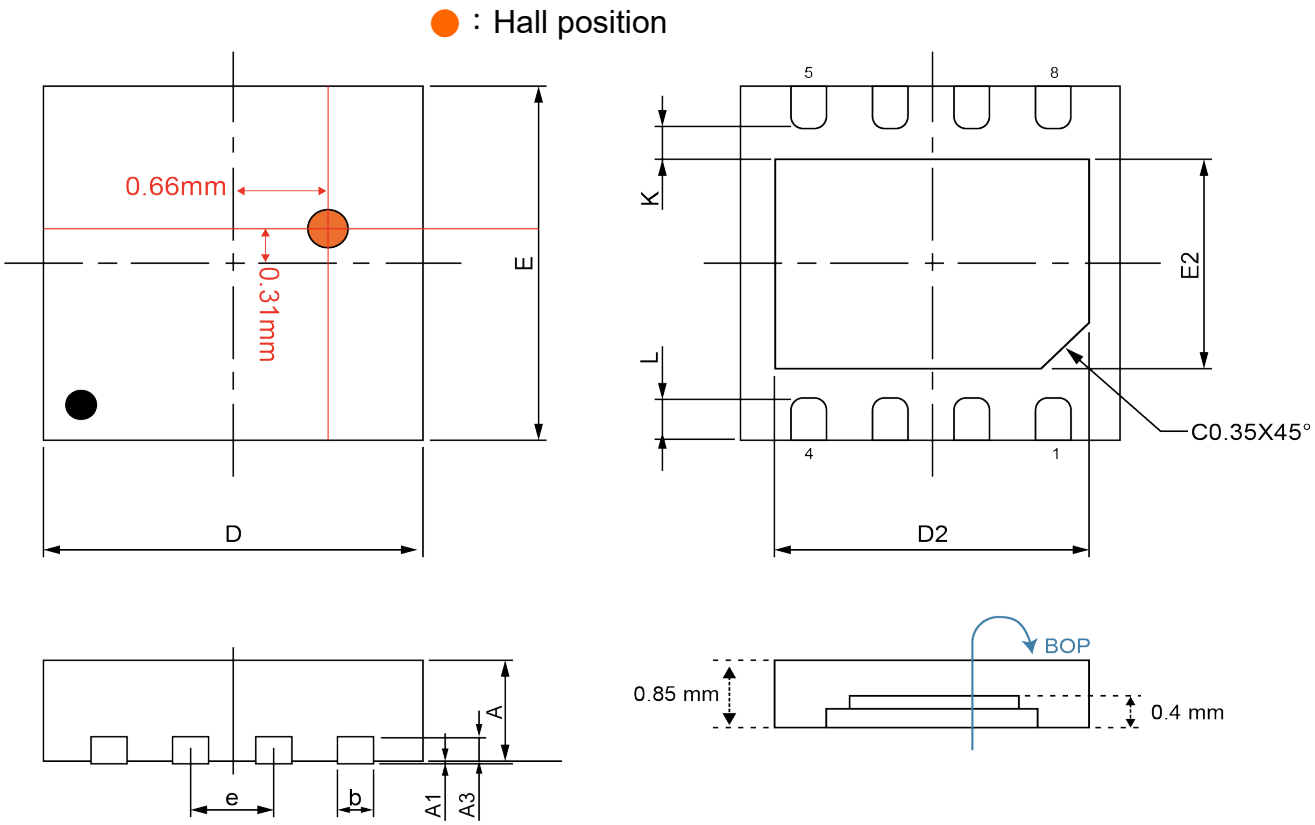
Fig.3

10. I/O Equivalent Circuit

ESD Protection



11. Package Information



SYMBOL	Dimension in mm		
	MIN.	NOM.	MAX.
A	0.70	0.85	0.90
A1	0.00	0.02	0.05
A3		0.203 REF	
D	2.90	3.00	3.10
E	2.90	3.00	3.10
e	0.55	0.65	0.75
K	0.20	0.30	0.40
D2	1.95	2.50	2.55
E2	1.50	1.80	1.85
L	0.30	0.40	0.50
b	0.25	0.30	0.40

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