AND9538/D

Forward / Reverse Motor Driver IPM Application Note using the STK681-310N-E

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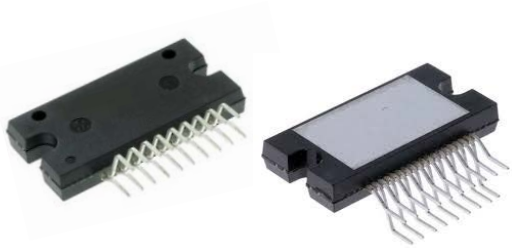
APPLICATION NOTE

Overview

The STK681-310N-E is an Intelligent Power Module (IPM) for use in PWM current control Forward/Reverse DC motor driver with brush.

Function

- Allows forward, reverse, and brake operations in accordance with the external input PWM signal.
- 4.2 A peak startup output current and 8 A peak brake output current.
- Built-in current detection resistor (0.1 Ω) and supports constant-current control.
- Obviate the need to design for the dead time in order to turn off the upper- and lower drive devices when switching between the forward and reverse operation mode.



Specifications

bsolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	unit
Maximum supply voltage 1	$V_{CC}1$ max	$V_{CC}2$ = 0 V	52	V
Maximum supply voltage 2	$V_{CC}2$ max	No signal	–0.3 to +7.0	V
Input voltage	V_{IN} max	Logic input pins	–0.3 to +7.0	V
Output current 1	I_O max	V_{DD} = 5.0 V, DC current	4.2	A
Brake current	I_OB max	V_{DD} = 5.0 V, square wave current, operating time 60 ms (single pulse, low side brake)	8	A
Allowable power dissipation	PdPK max	No heat sink	3.1	W
Operating substrate temperature	Tc	Metal surface temperature of the package	105	°C
Junction temperature	Tj max		150	°C
Storage temperature	Tstg		–40 to +125	°C

Notes
*1 : Refer to the graph for each conduction-period tolerance range for the output current and brake current.
*2 : PWM pin (14 pin) is active Hi.
*3 : Io1, Io2, Io3 connect Vref2 pin to GND and a current value when over-heating current control does not work

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

ORDERING INFORMATION

See detailed ordering and shipping information on page 16 of this data sheet.

Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Uint
Supply voltage 1	$V_{CC}1$	With signals applied	10 to 42	V
Supply voltage 2	$V_{CC}2$	With signals applied	5.0 ±5%	V
Input voltage	Vin	10,11,12,13,14,15,17 pin	0 to $V_{CC}2$	V
Output current 1 *1,3	Io1	$V_{CC}2$ = 5.0 V, DC current, Tc ≤ 70°C	4.2	A
Output current 2 *1,3	Io2	$V_{CC}2$ = 5.0 V, DC current, Tc = 90°C	3.2	A
Output current 3 *1,3	Io3	$V_{CC}2$ = 5.0 V, DC current, Tc = 105°C	2.5	A
Braking current *1	IoB	$V_{CC}2$ = 5.0 V, square wave current waveform, operating time : 3.6 ms, Tc = 105°C	8	A

Note
*1 : Refer to the graph for each conduction-period tolerance range for the output current and brake current.
*2 : PWM pin (14 pin) is active Hi.
*3 : Io1, Io2, Io3 connect Vref2 pin to GND and a current value when over-heating current control does not work
*4 : A fixed-voltage power supply must be used.

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

Electrical Characteristics at Ta = 25°C, $V_{CC}1$ = 24 V, V_{CC} 2 = 5 V

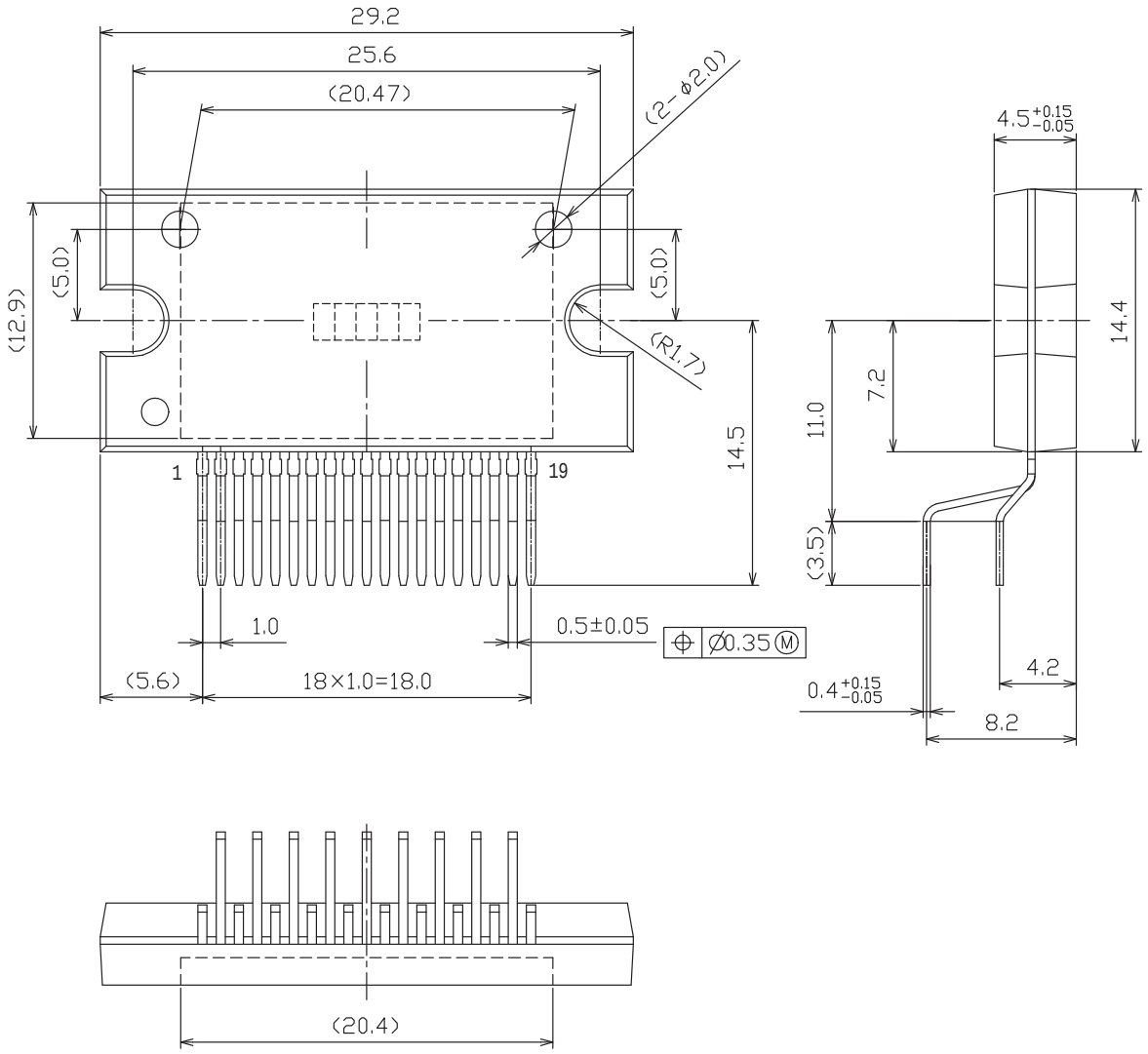
Parameter	Symbol	Conditions	min	typ	max	unit
Vcc2 Supply current	Icco	During forward or reverse operation		1.7	4	mA
Diode forward voltage	Vdf	If = 1 A (RL = 23 Ω)		1.0	1.6	V
Output saturation voltage 1	Vsat1	RL = 23 Ω, TR1, TR2		0.8	1.1	V
Output saturation voltage 2	Vsat2	RL = 23 Ω, F1, F2 + current detection resistor		0.19	0.26	V
Output leakage current	IOL	When TR1, TR2, F1, and F2 are operating in the off state			50	μA
High-level input voltage 1	VIH1	The IN1 and IN2 pins	4.5			V
High-level input voltage 2	VIH2	The INH pin	2.5			V
Low-level input voltage	VIL	The IN1, IN2, and INH pins			0.6	V
Input current 1	IIH1	The IN1 and IN2 pins	0.1	0.2	0.4	mA
Input current 2	IIH2	The INH pin, VIH = 5 V	0.3	0.6	1.2	mA
Current setting voltage	Vref1	Between the Vref1 and S.P pins		0.42		V

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

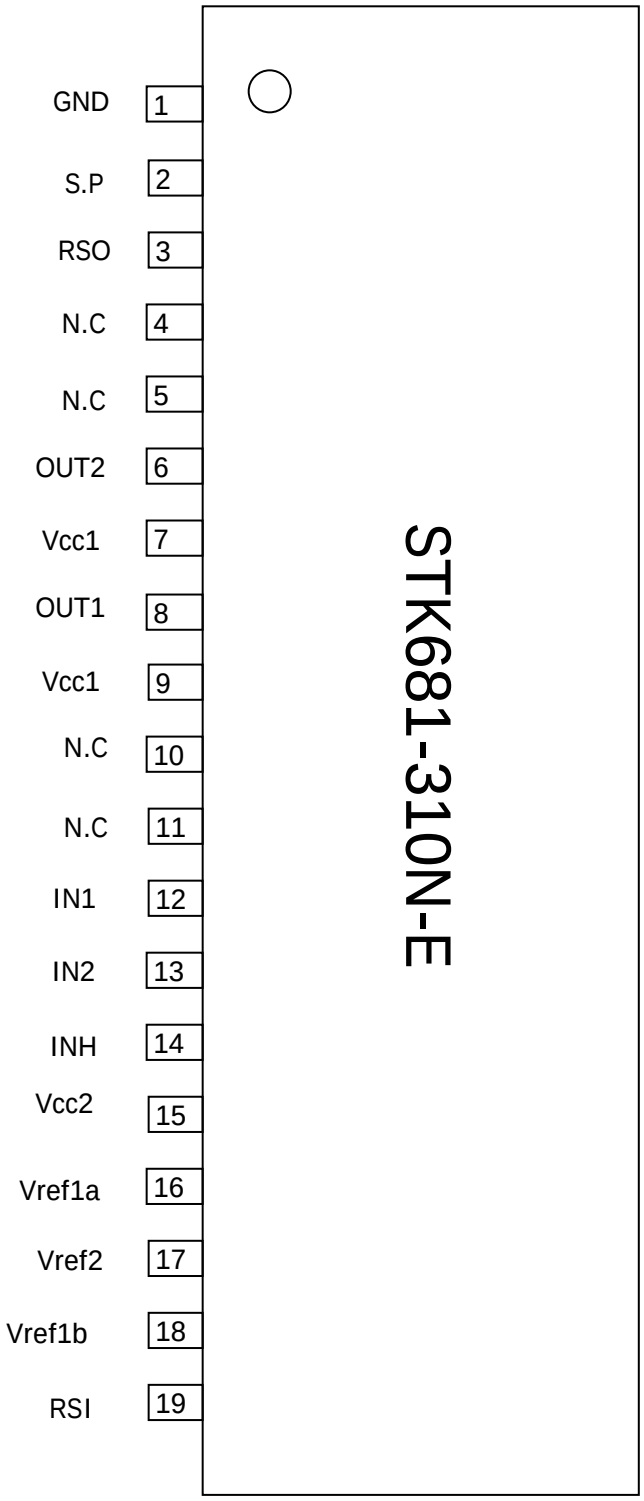
Package Dimensions

unit : mm

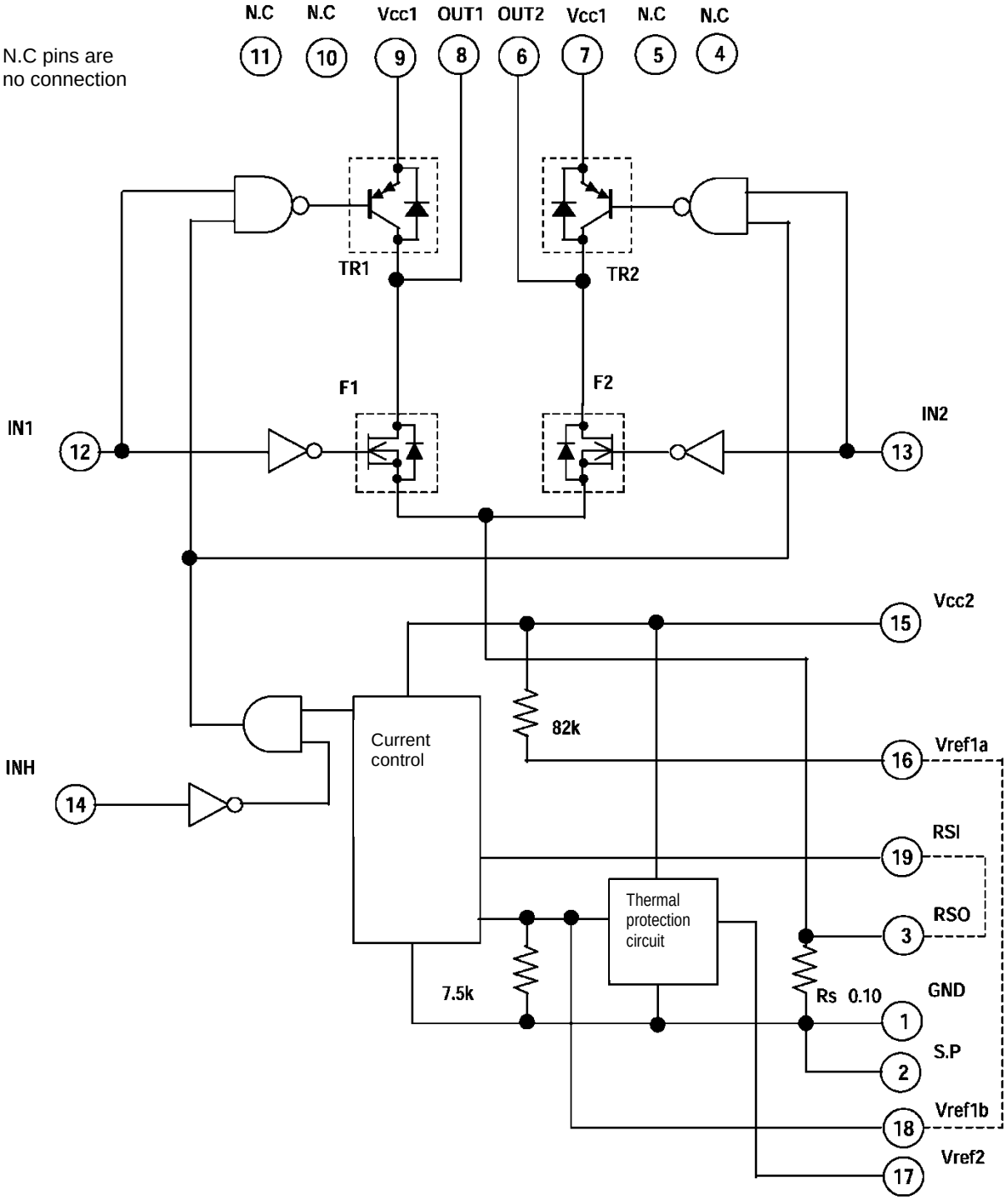
SIP19 29.2x14.4
CASE 127CF
ISSUE O



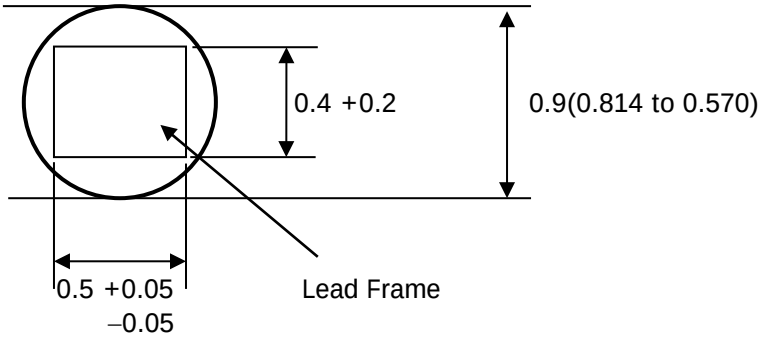
Pin Assignment



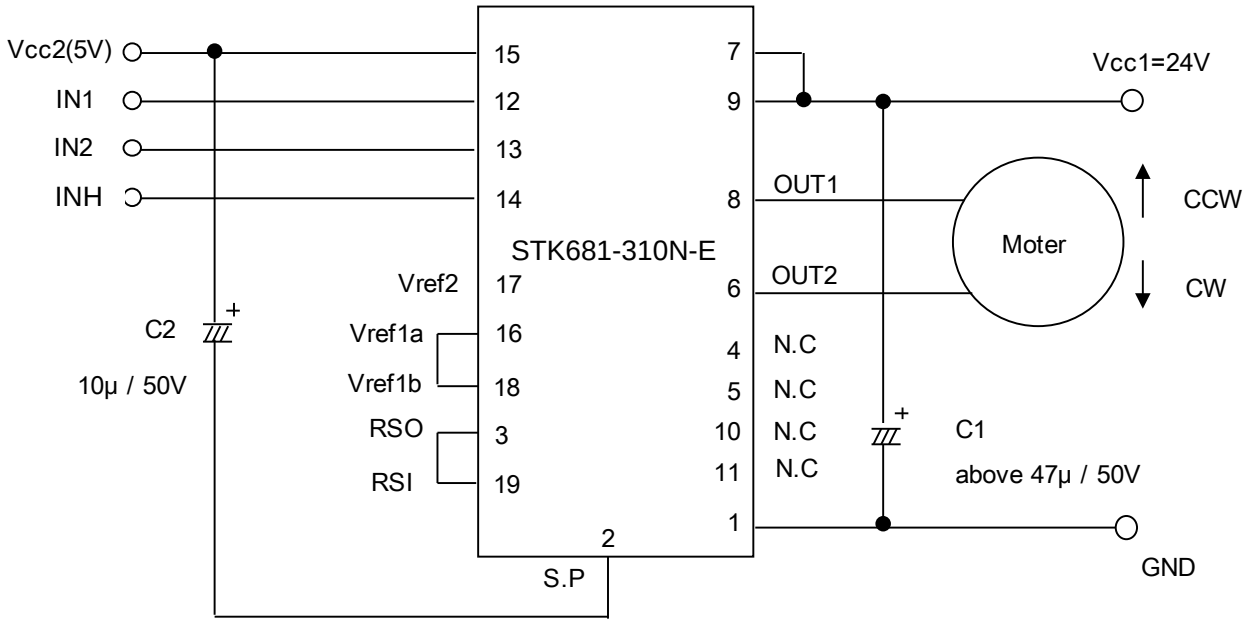
Block Diagram



Recommend hole size for Lead Frame on PCB ; 0.9 mm (max)



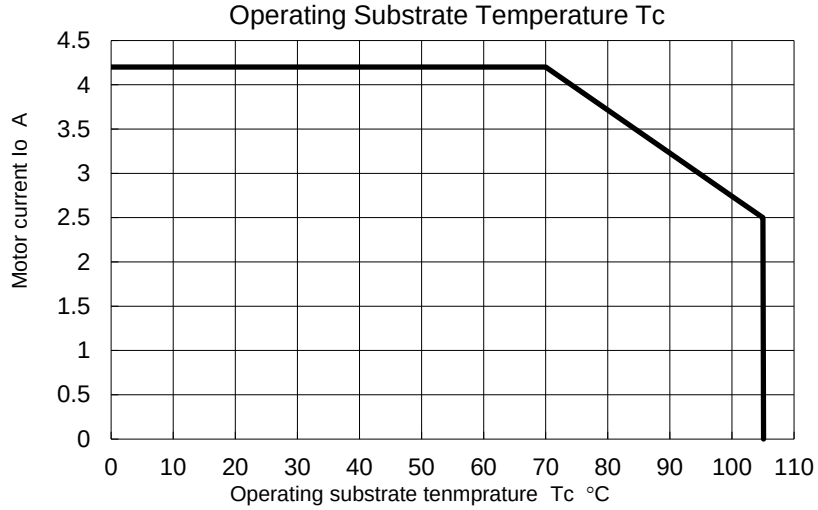
Application Circuit Example



Note

A fixed-voltage power supply must be used.

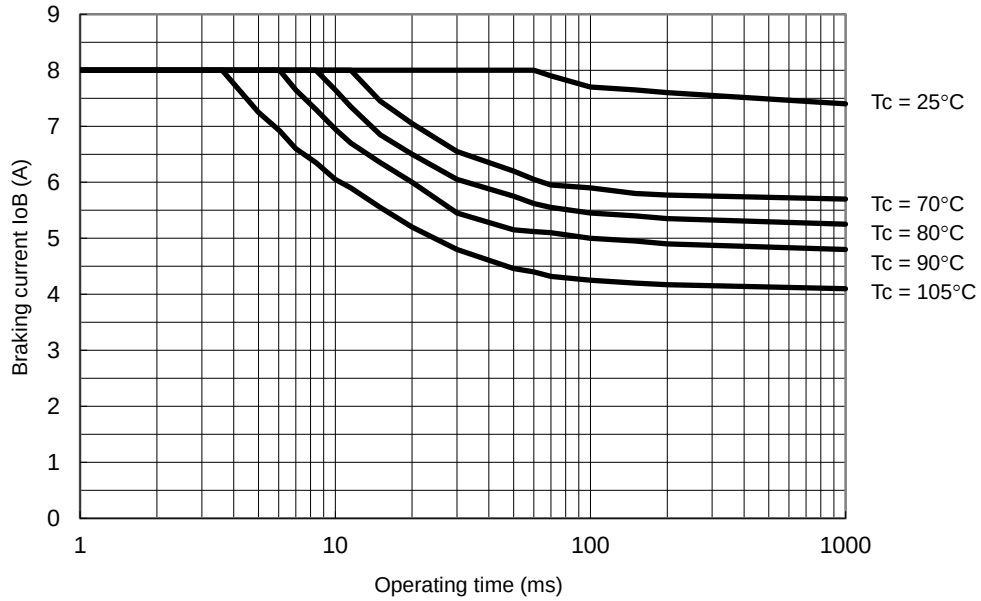
STK681-310N-E Motor Current Derating Curve for the Operating Substrate Temperature Tc



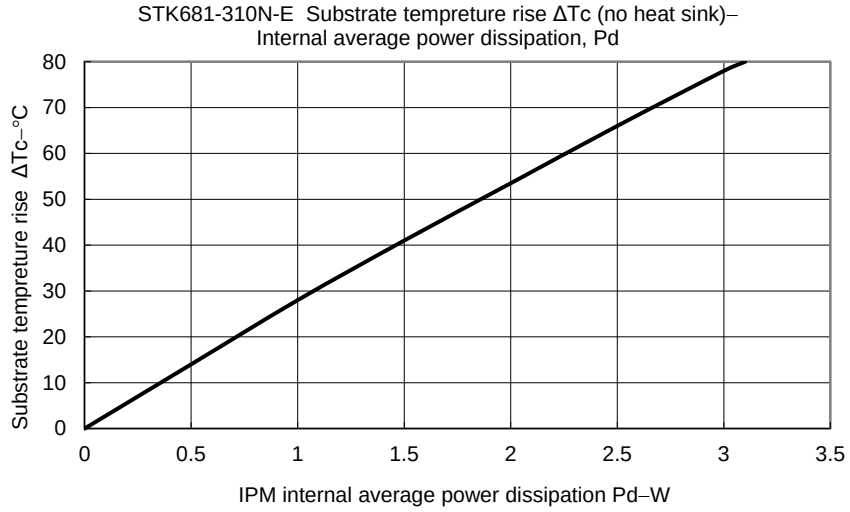
Notes

- Motor current Io shown above is the range for chopping operation when Vcc1 is under 28 V
- Substrate temperatures in the figure above are values measured when the motor is operating.
  The temperature Tc varies with the ambient temperature Ta, the motor drive current, and whether the motor current is continuous or the state of its intermittent operation. Therefore Tc must be verified in an actual end product system.

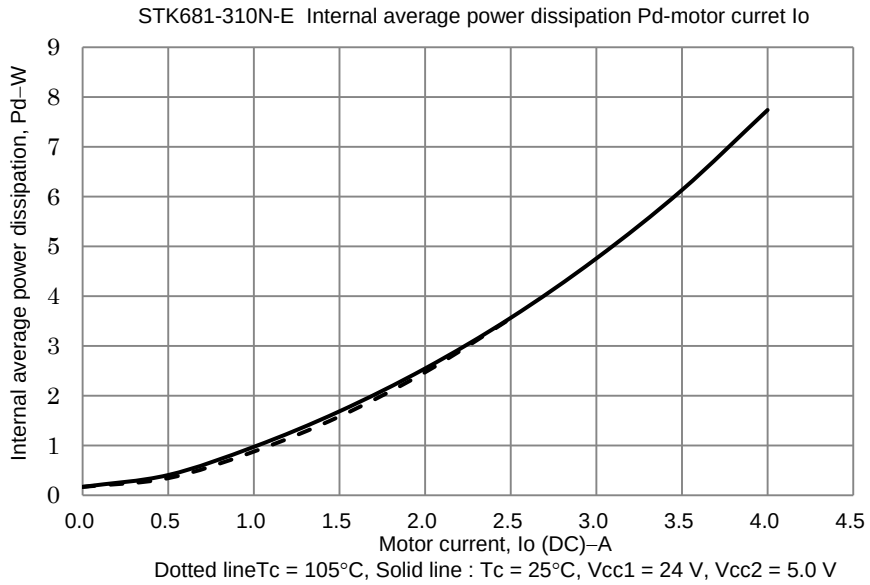
Allowable STK681-310N-E braking current ranges



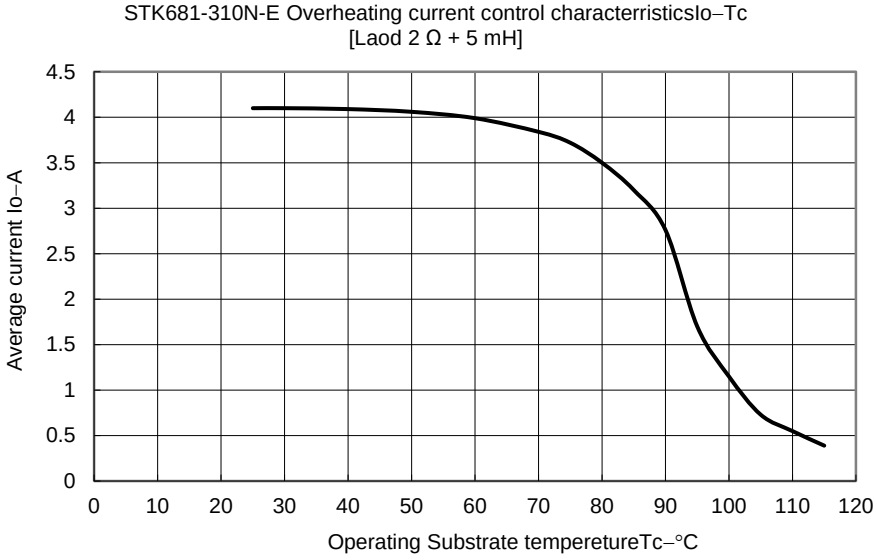
1. Substrate temperature rise, ΔTc(no heat sink) – Internal average power dissipation, PD



2. Internal average power dissipation, Pd,in the DC current-motor current,Io,characterristics



3. Overheating current control characterristics

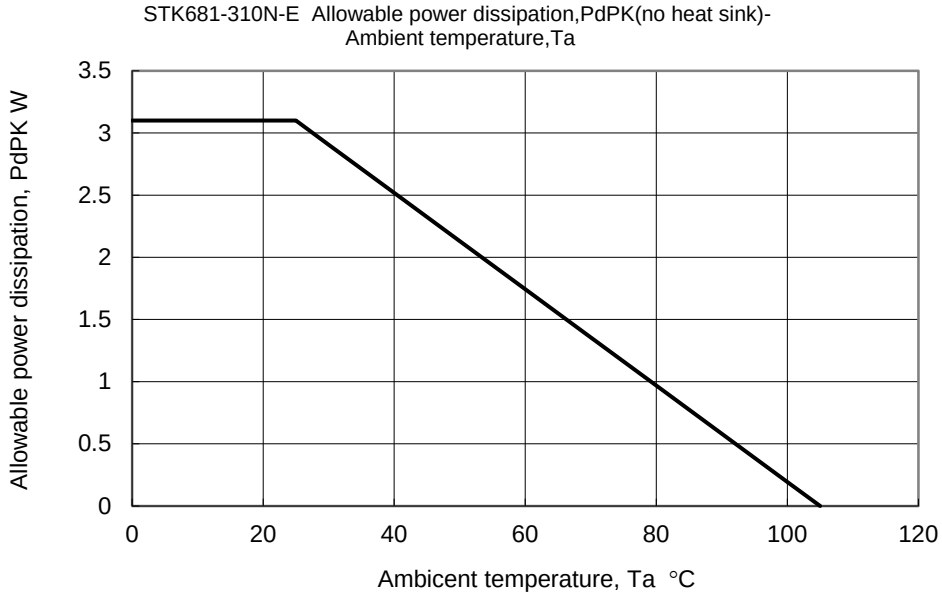


The over temperature current suppression function protects the driver from destruction when an abnormal motor locked (physically constrained) state occurs.

4. Package power loss PdPK derating curve for the ambient temperature Ta.

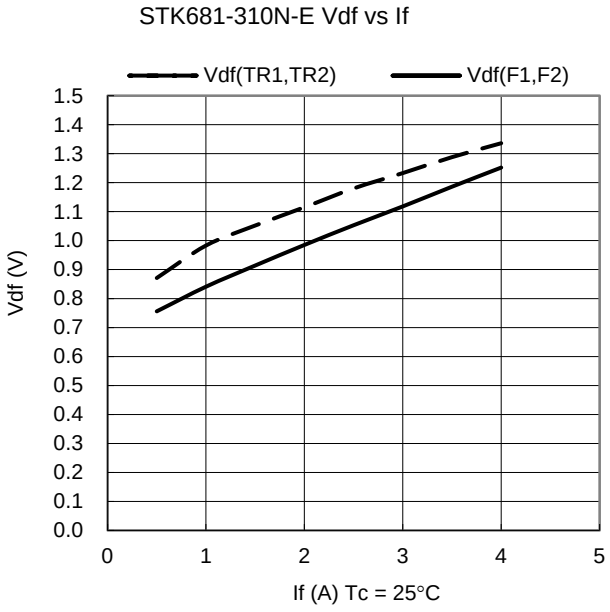
Package power loss, PdPK, refers to theaverage internal power loss, PdAV, allowable without a heat sink. The figure below represents the allowable power loss, PdPK, vs. fluctuations in the ambient temperatire, Ta. Power loss of up to 3.1 W is allowable at Ta = 25°C, and of up to 1.75 W at Ta = 60°C.

* Thermal resistance θc-a of the package is the 25.8°C /W.

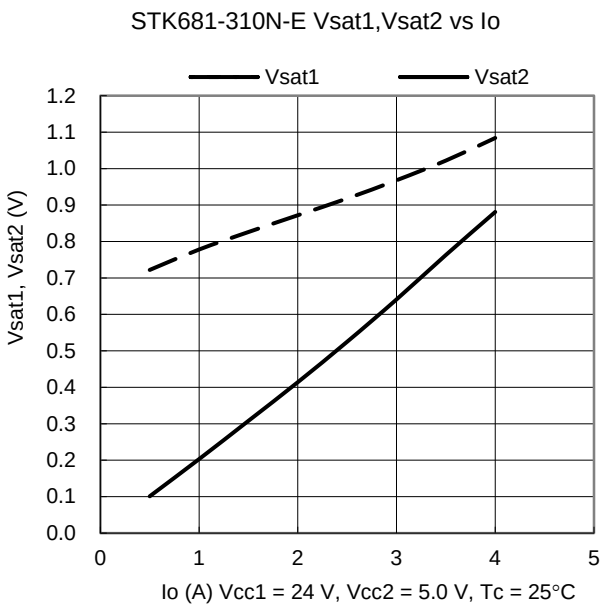


5. Electrical characteristics

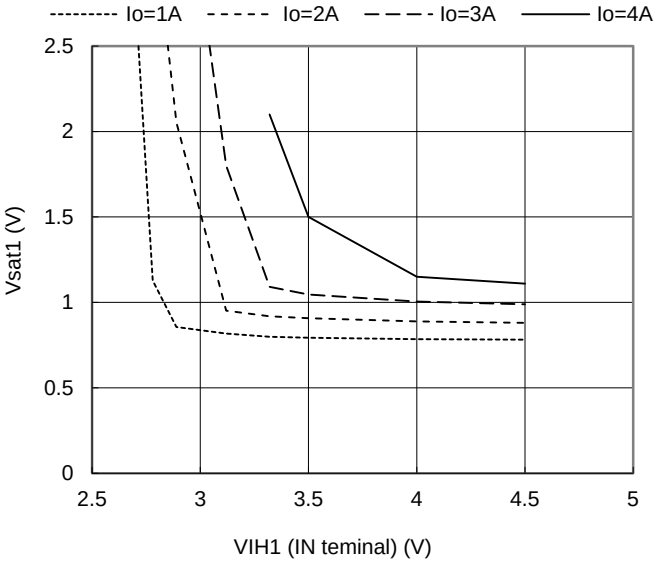
<Vdf vs If>



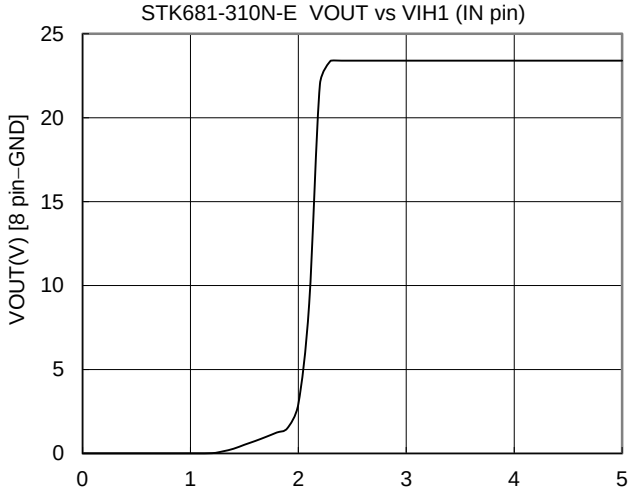
<Vsat1・Vsat2 vs Io>



STK681-310N-E Vsat1 vs VIH1

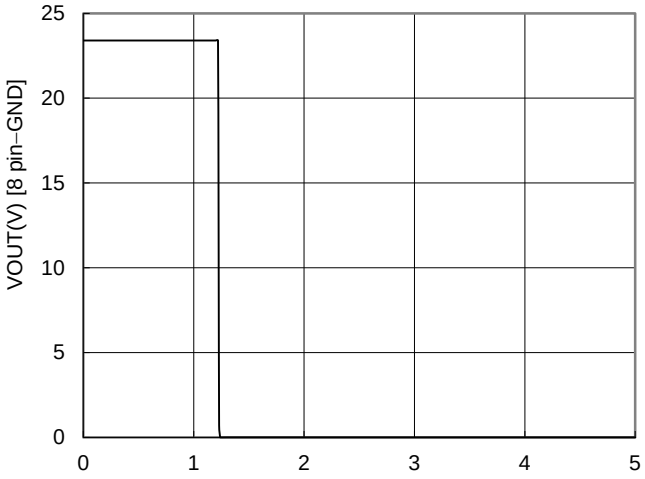


STK681-310N-E VOUT vs VIH1 (IN pin)



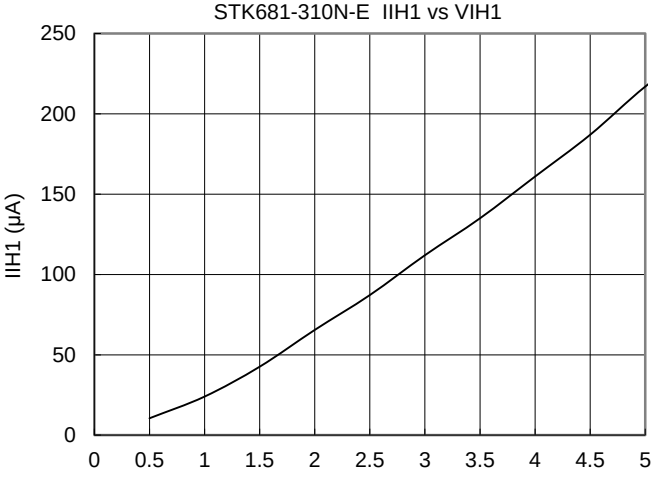
VIH1 (INH Pin IN) (V) [12 pin−GND]
Vcc1 = 24 V, Vcc2 = 5.0 V, Tc = 25°C,
OUT1−OUT2 = 1 kΩ, 14 pin = Low

STK681-310N-E VOUT vs VIH2 (INH pin)



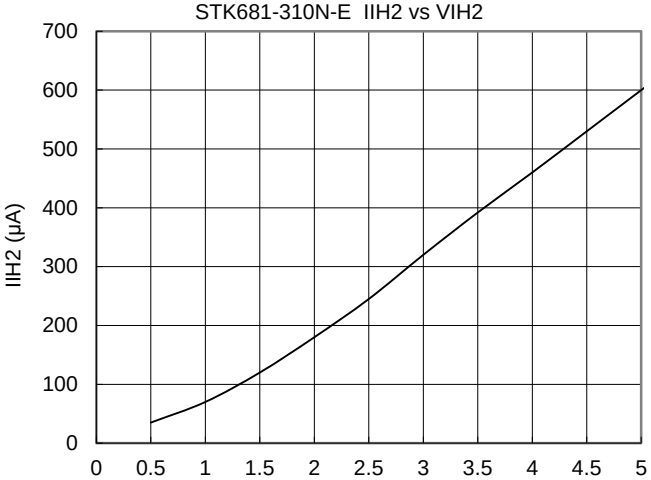
VIH2 (INH Pin INH) (V) [14 pin−GND]
Vcc1 = 24 V, Vcc2 = 5.0 V, Tc = 25°C,
OUT1−OUT2 = 1 kΩ,12 pin = High

STK681-310N-E IIH1 vs VIH1



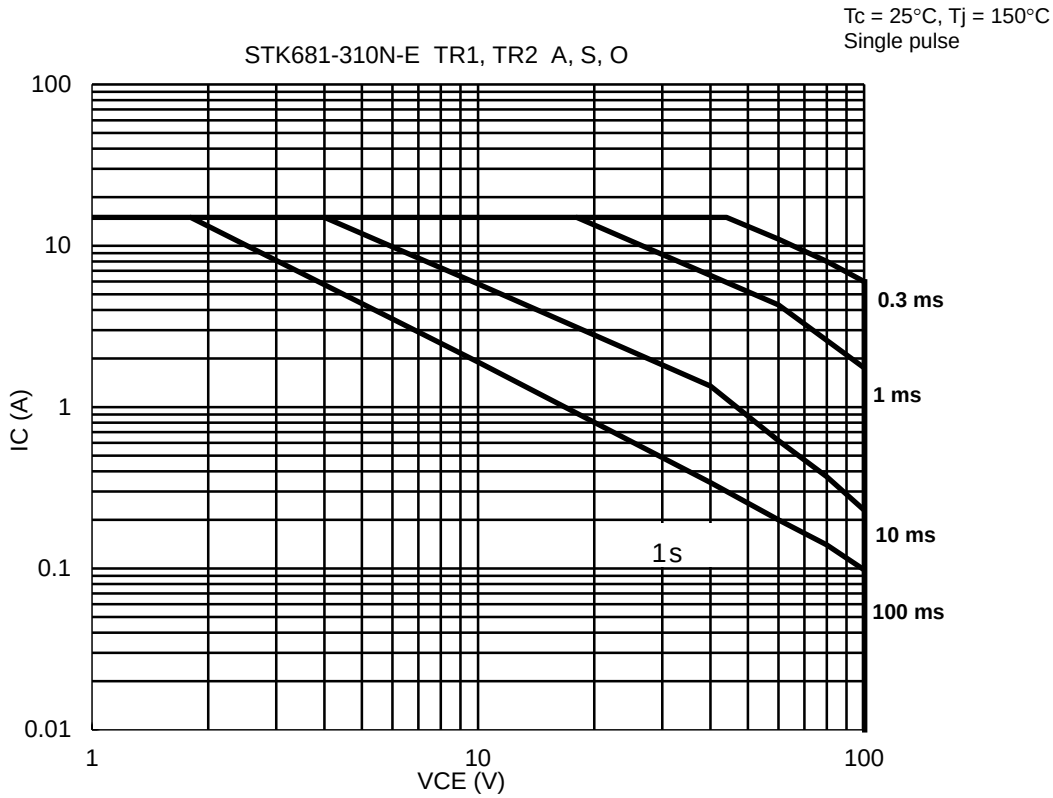
VIH1 (V) [12, 13 pin−GND]
Vcc1 = 24 V, Vcc2 = 5.0 V, Tc = 25°C

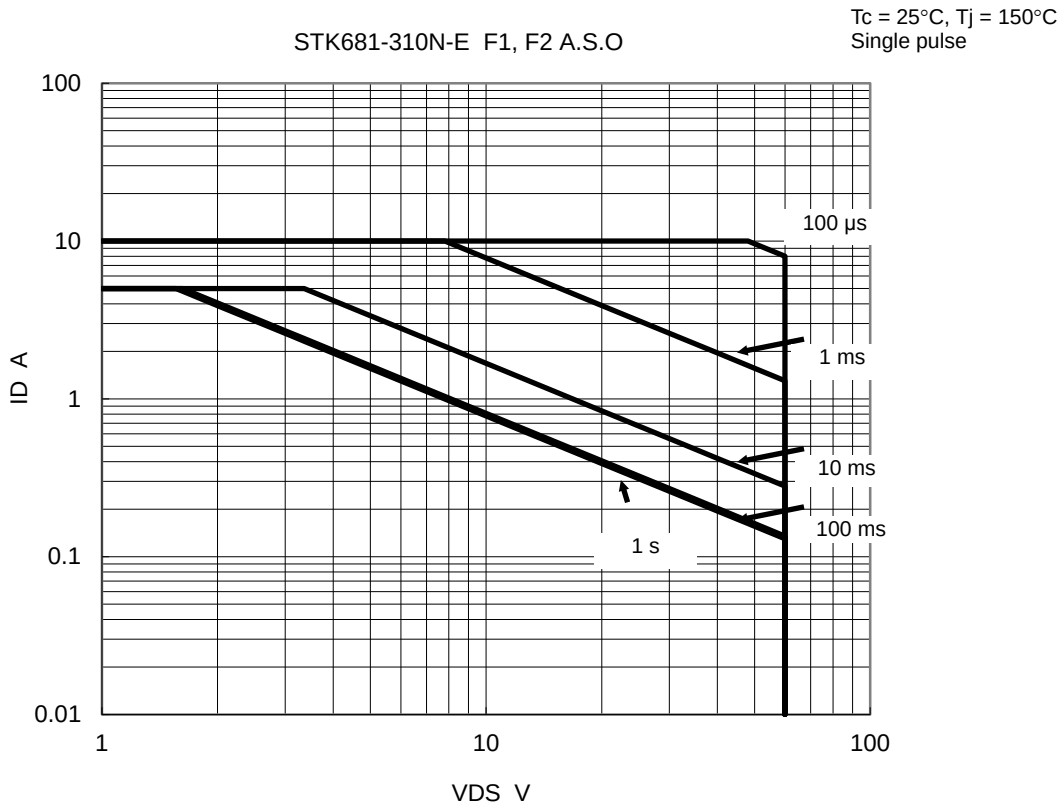
STK681-310N-E IIH2 vs VIH2



VIH2 (V) [14 pin−GND]
Vcc1 = 24 V, Vcc2 = 5.0 V, Tc=25°C

6. A.S.O (F1, F2, F3, F4)





Motor Drive Conditions (H : High-level input ; L : Low-Level Input)

	IN1	IN2	INH	Function
Stop 1 (Standby)	H	H	L or H	The state where the motor is not turning
Stop 2 (Power supply to the motor is off due to an input during motor operation)	H	H	H	Power supply to the motor was turned off due to a stop signal being applied during motor operation.
	H	L	H	
	L	H	H	
Forward (CW)	H	L	L	An input signal that turns off the high and low side drive elements during forward/reverse switching is not required.
Reverse (CCW)	L	H	L	
Brake	L	L	L or H	The ground side MOSFET is in the on state.

* The state IN1 = IN2 = high, PWM = L is illegal during motor operation.
* INH pin (14 pin) is active Low.

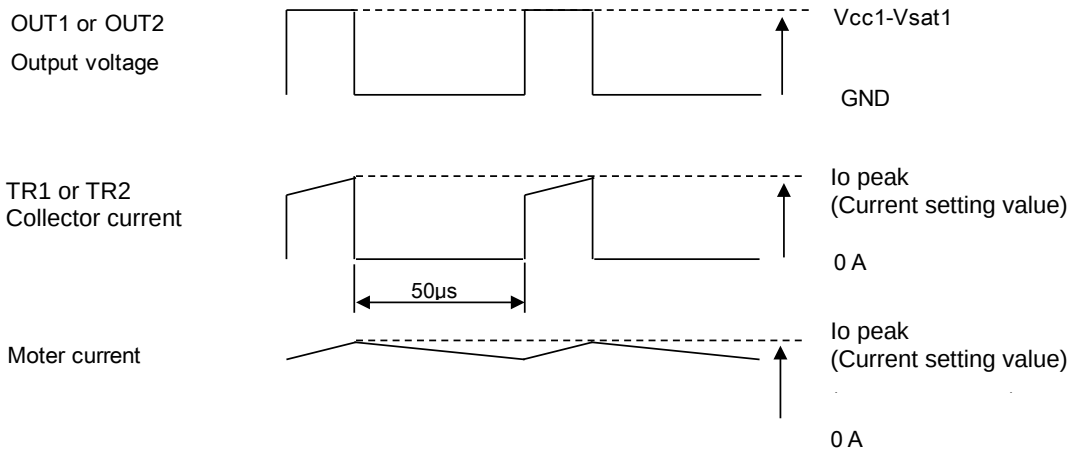
Notes

(1) The value of the power supply bypass capacitor C1 must be set so that the capacitor ripple current, which changes with the motor current, remains within the allowable range.

(2) While the Vref2 pin is normally handled by being left open, note that the thermal protection circuit will no longer operate if this pin is connected to ground or the P.S pin.

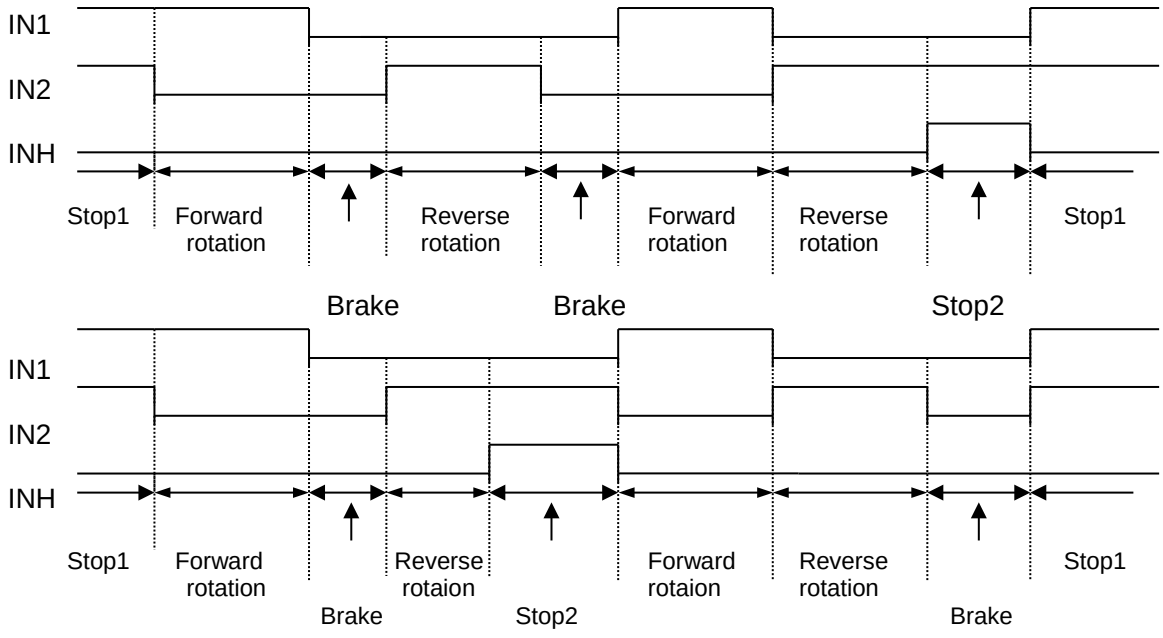
(3) Current is controlled by a constant-current chopping operation by transistors TR1 and TR2. The timing for the OUT1 or OUT2 output voltage and the TR1 orTR2 drain current is shown below.

(4) Do not connect or wire any of the NC (unused) pins that appear in either the block diagram or the application circuit examples to the circuit pattern on the PCB.



(5) Since the response time of the ground side drive element during forward/reverse direction switching is a few tens of microseconds, this product is not appropriate for H bridge applications. This device should only be used as a DC motor driver.

(6) Timing Charts



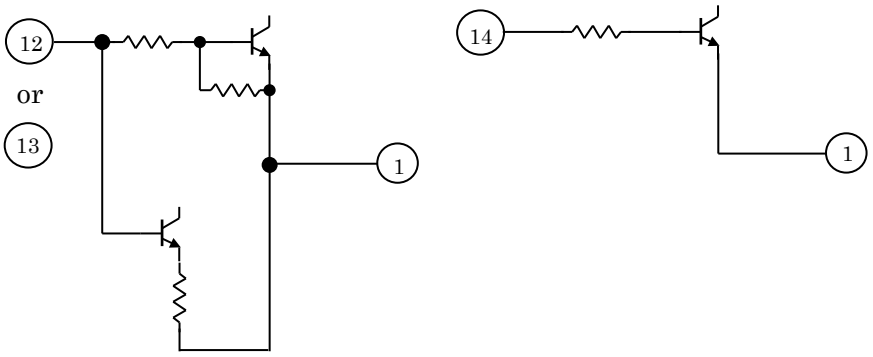
(7) Smoke emission warning: This hybrid IC may emit smoke if it is used under conditions that exceed its specifications.

I/O Functions of Each Pin

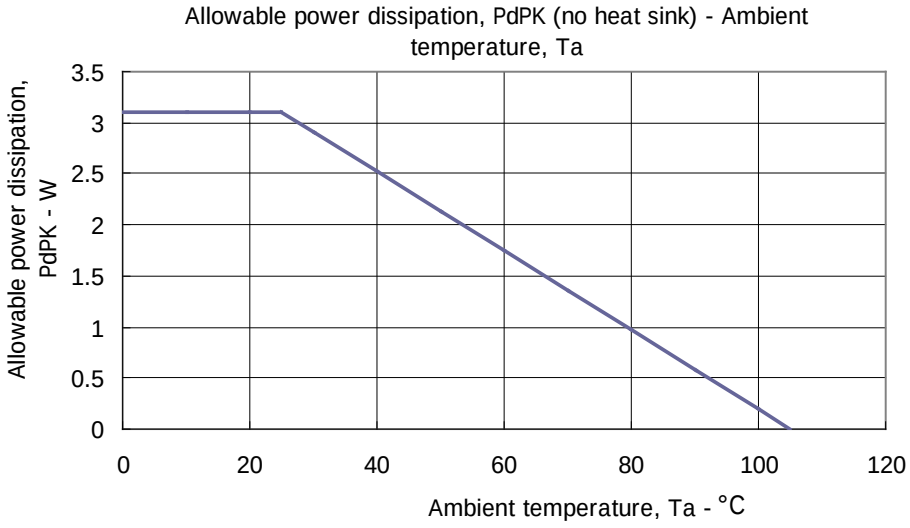
Pin name	Pin No	Functions
IN1	12	Input that controls the on/off state of F1 and F3. When high: TR1: on, F1: off, when low: TR1: off, F1: on.
IN2	13	Input that controls the on/off state of F2 and F4. When high: TR2: on, F2: off, when low: TR2: off, F2: on.
INH	14	Pin for turning TR1 and TR2 OFF ; at high level TR1 and TR2 : OFF This pin is usualy low or open
OUT1	8	Motor connection that outputs a source or sink current depending on the states of IN1 and IN2.
OUT2	6	Motor connection that outputs a source or sink current depending on the states of IN1 and IN2.
Vref1a Vref1b	16 18	This pin is used for current setting for constant-current operation performed with the Vrefa and Vrefb pins connected. A voltage of 0.42 V at Tc = 25°C results for Vref1. 0.42 V is set by connecting 82 kΩ and 7.5 kΩ in series. Current detection resistance is Rs = 0.10 Ω. set using IO peak = Vref1 ÷ Rs It is to be noted, there is a CR time constant delay in RSI input. Io peak load conditions (load specs and power supply specifications) will vary (increase). Please check with the actual machine.
Vref2	17	This pin should normally be left open. Connecting this pin to ground or the S.P pin disables the thermal protection circuit.
S.P	2	The Vref1 voltage can be reduced by connecting a resistor between Vref1 and the S.P pin.
RSO	3	This pin can be used to monitor the voltage across the current detection resistor Rs and is connected to the RSI pin.
RSI	19	Input for the circuit that compares with Vref1. This pin is used connected to the RSO pin.

Configuration of I/O Pin

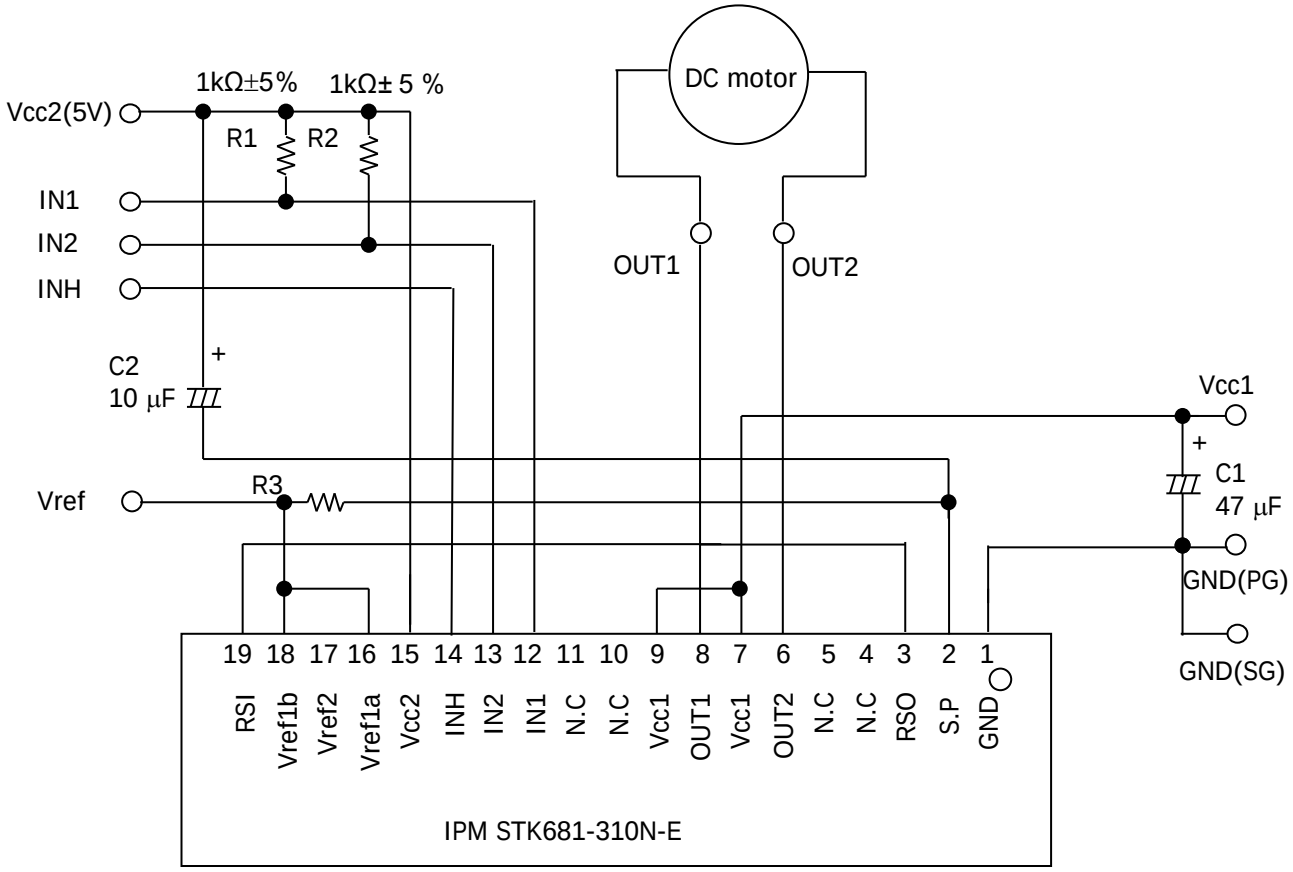
<IN1,IN2> <INH>



Allowable power dissipation (Reference value)



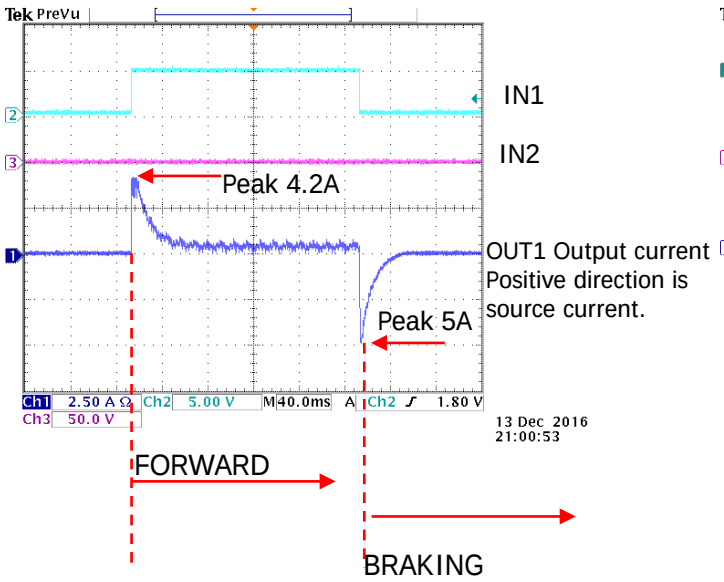
TEST Circuit



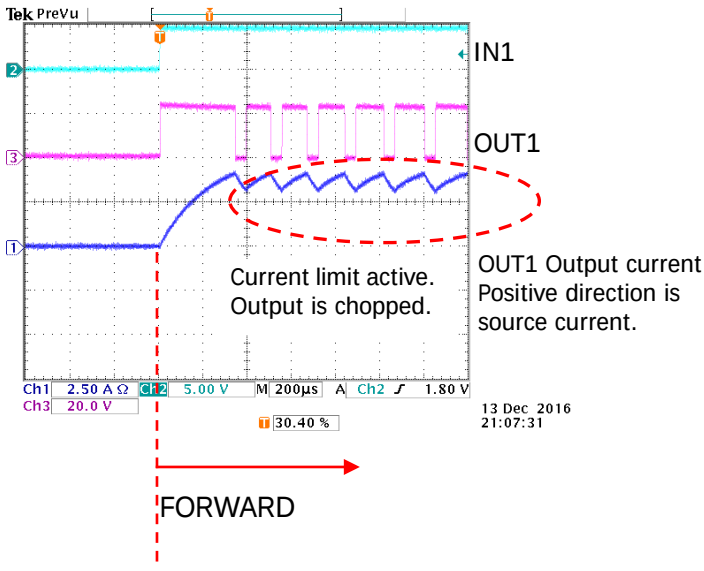
Notes : R3 are used to Vref for current setting.

Waveform example

STK681-310N-E (Current limit 4.2 A setting)
IN1 and IN2 ; 5 V/div, Output current ; 2.5 A/div



STK681-310N-E (Current limit 4.2 A setting)
IN1 5 V/div, OUT1 20 V/div, Output current ; 2.5 A/div



ORDERING INFORMATION

Device	Package	Shipping (Qty / Packing)
STK681-310N-E	SIP19 29.2x14.4 (Pb-Free)	15 / Tube