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STK681-360-E

Thick Film Hybrid IC

Forward/Reverse Motor Driver Application Note

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Overview

The STK681-360-E is a hybrid IC 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.
- 5.8A peak startup output current and 8A peak brake output current.
- Built-in current detection resistor (0.05Ω : resistor tolerance $\pm2\%$) 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	Vcc1 max	Vcc2=0V	52	V
Maximum supply voltage 2	Vcc2 max	No signal	-0.3 to +7.0	V
Input voltage	V_{IN} max	Logic input pins	-0.3 to +7.0	V
Output current1	I_O max	V_{DD}=5.0V, DC current	5.8	A
Brake current	I_OB max	V_{DD}=5.0V, square wave current, operating time 60ms (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 (14pin) is active Low.

*3 Io1, Io2, Io3 connect Vref2 pin to GND and a current value when over-heating current control does not work

STK681-360-E Application Note

Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	unit
Maximum supply voltage 1	Vcc1 max	Vcc2=0V	52	V
Maximum supply voltage 2	Vcc2 max	No signal	-0.3 to +7.0	V
Input voltage	V_{IN} max	Logic input pins	-0.3 to +7.0	V
Output current1	I_O max	V_{DD}=5.0V, DC current	5.8	A
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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

*4: A fixed-voltage power supply must be used.

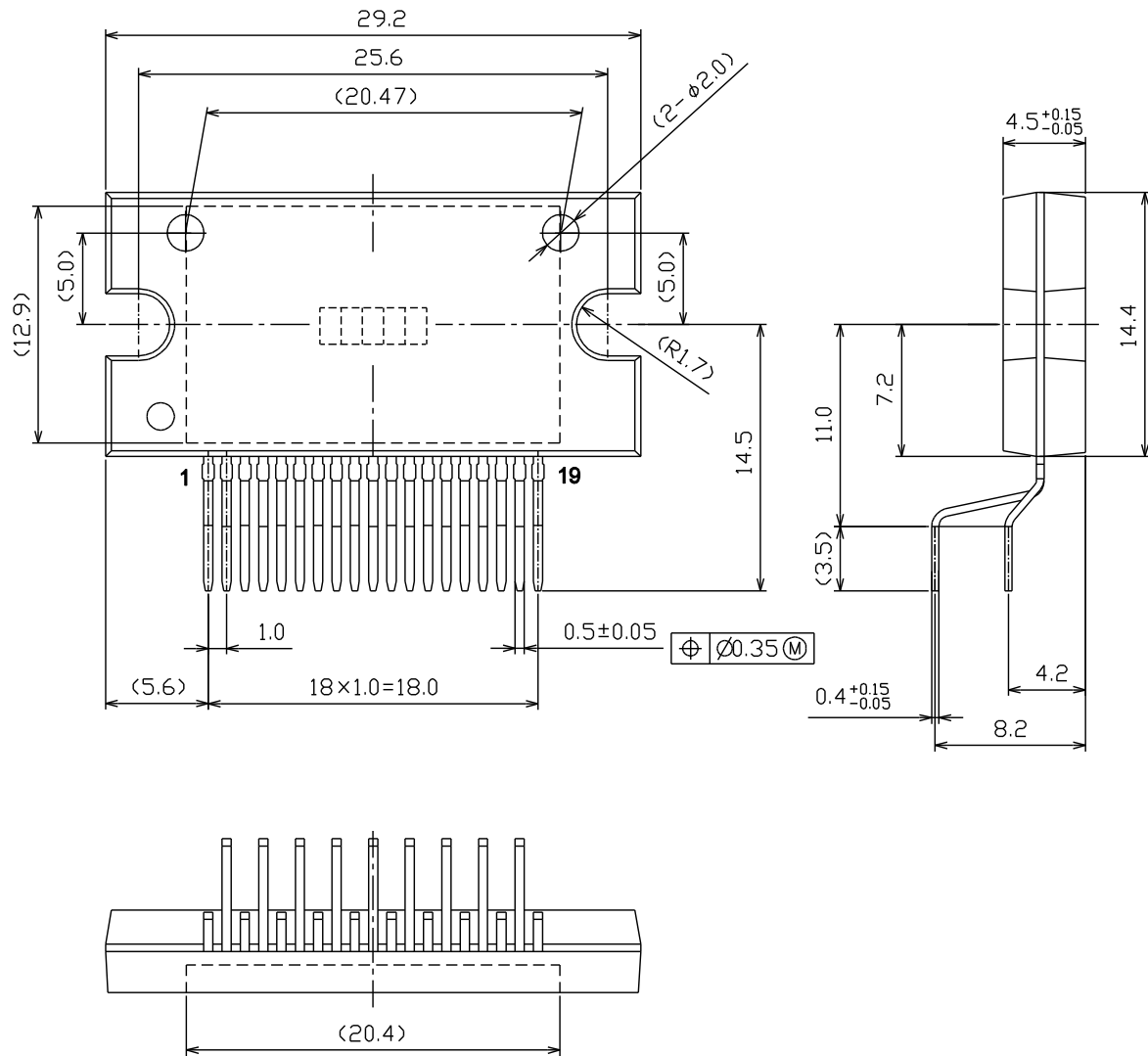## Electrical Characteristics at Ta = 25°C, V_{CC} = 5V

Parameter	Symbol	Conditions	min	typ	max	unit
V_{CC2} supply current	I_{CCO}	Forward or reverse operation		2.6	3.5	mA
FET diode forward voltage	Vdf	If=1A (R_L=23Ω)		0.8	1.4	V
Output saturation voltage 1	Vsat1	R_L=23Ω, F1, F2		0.09	0.15	V
Output saturation voltage 2	Vsat2	R_L=23Ω, F3, F4+ current detection resistor		0.11	0.17	V
Output leak current	I_{OL}	F1, F2, F3, and F4 OFF operation			50	μA
Input high voltage 1	V_{IH1}	IN1, IN2 pin	4.5			V
Input high voltage 2	V_{IH2}	PWM pin	4.5			V
Input low voltage	V_{IL}	IN1 ,IN2 and PWM pins			0.6	V
Input current	I_{IH1}	IN1, IN2 pins, V_{IH1}=5V	0.1	0.2	0.4	mA
Current setting voltage	Vref1	Between Vref1 and S.P pins		0.29		V
PWM Input current	IILP	PWM pin, VIL=GND	0.1	0.6	0.65	mA
PWM pin turn-on delay time	ton-*	Output current 1A		0.8		μs
PWM pin turn-on delay time	toff-*	Output current 1A		3.5		μs

Package Dimensions

unit : mm (typ)

SIP19 29.2x14.4
CASE 127CF
ISSUE O

Pin Assignment
STK681-360-E

Pin	Name
1	GND
2	S.P
3	RSO
4	N.C
5	N.C
6	OUT2
7	Vcc1
8	OUT1
9	Vcc1
10	N.C
11	N.C
12	IN1
13	IN2
14	PWM
15	Vcc2
16	Vref1a
17	Vref2
18	Vref1b
19	RSI
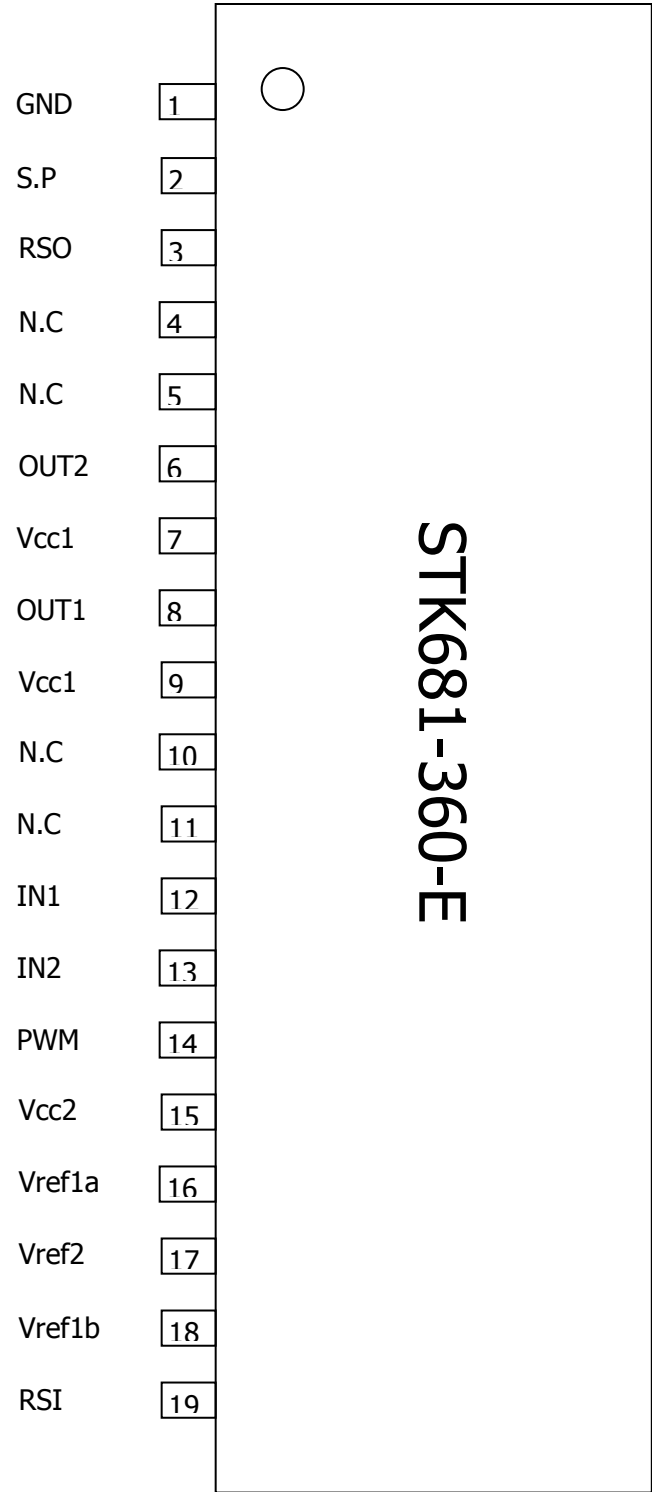
STK681-360-E

Block Diagram
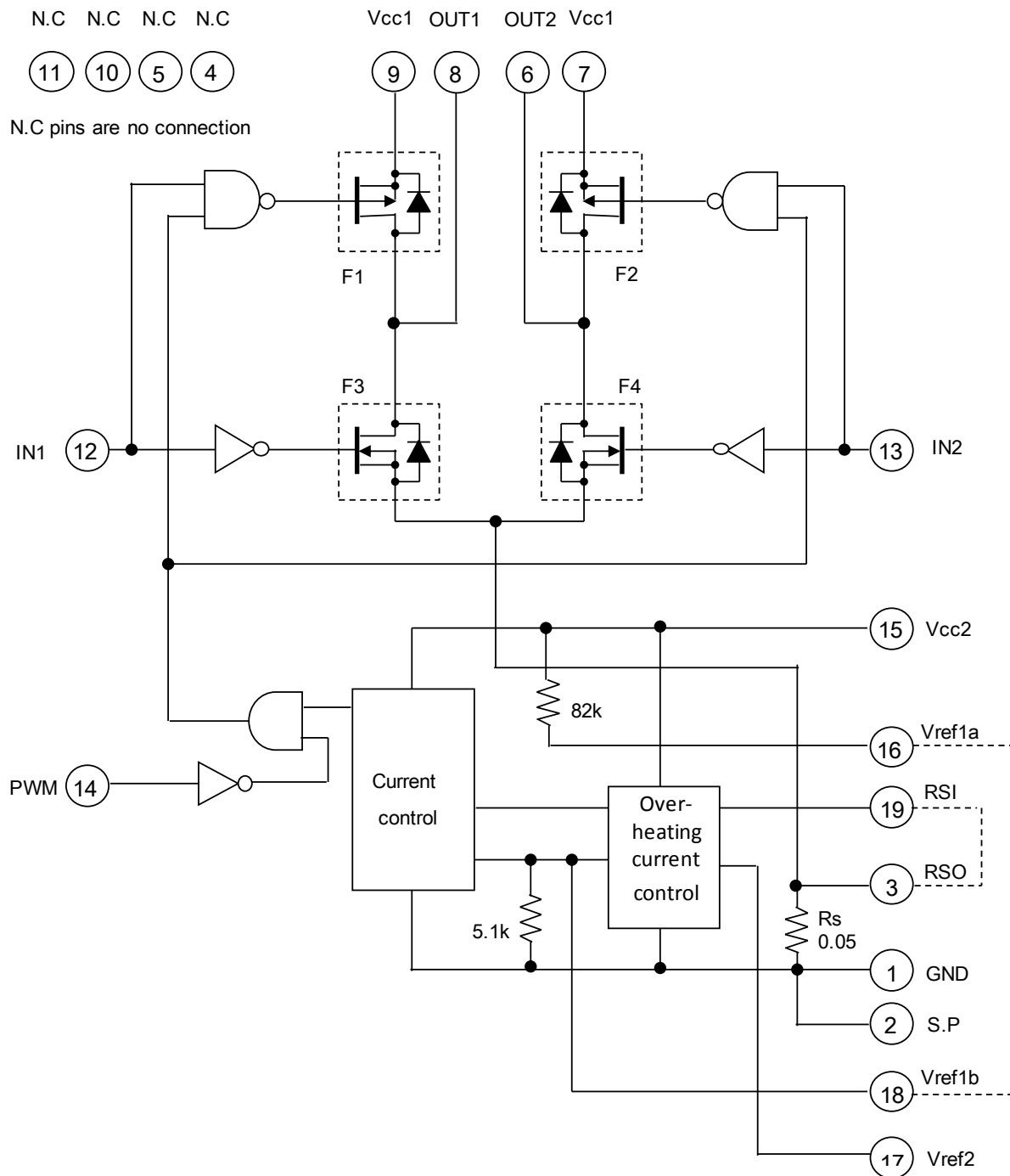
Recommend hole size for Lead Frame on PCB; 0.9 mm(max)
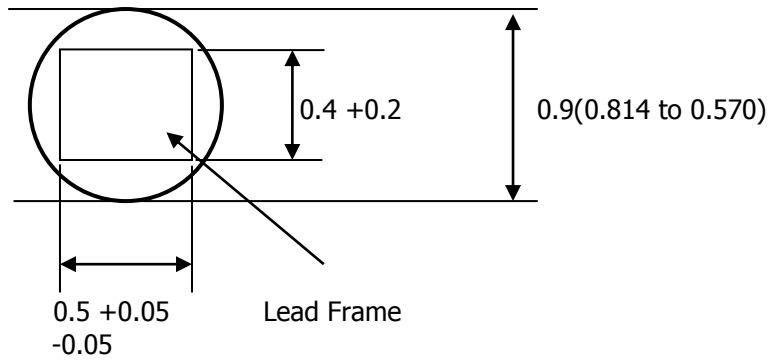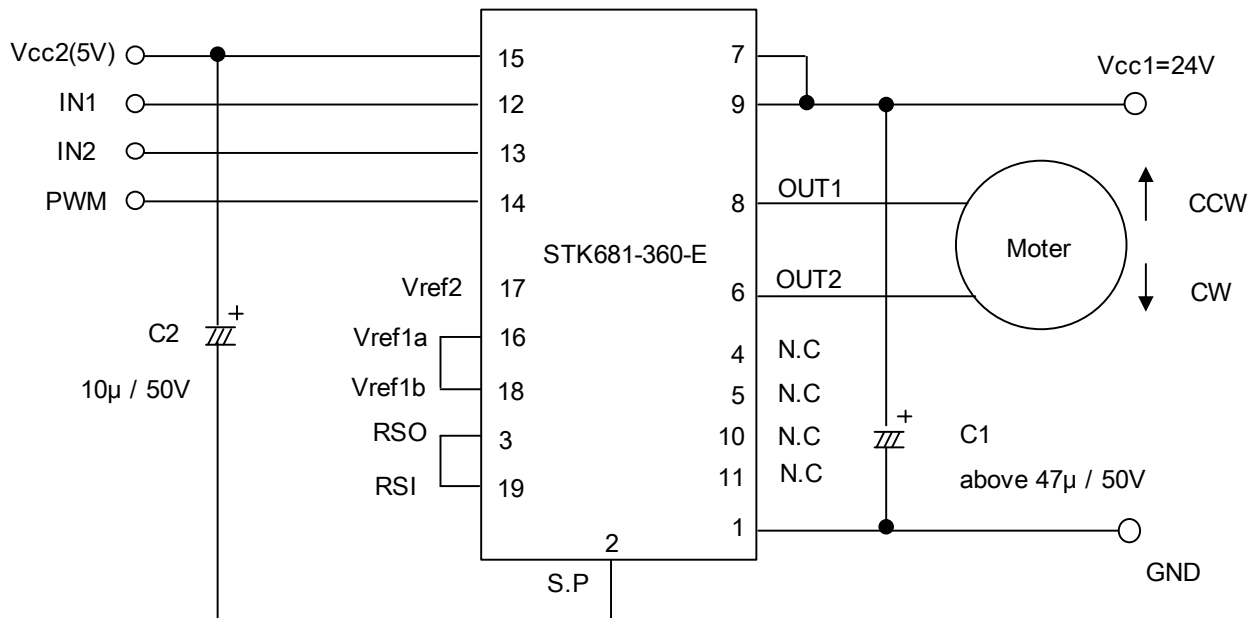
0.4 +0.2

0.9(0.814 to 0.570)

0.5 +0.05
-0.05

Lead Frame

Application Circuit Example

Vcc2(5V)

IN1

IN2

PWM

15

12

13

14

7

9

OUT1 8

OUT2 6

STK681-360-E

Vref2 17

Vref1a 16

Vref1b 18

RSO 3

RSI 19

C2

10μ / 50V

S.P 2

4 N.C

5 N.C

10 N.C

11 N.C

1

Vcc1=24V

Moter

CCW

CW

C1

above 47μ / 50V

GND

Notes

A fixed-voltage power supply must be used.

STK681 -360 -E motor current derating curve

for the operating substrate temperature Tc

Operating substrate tempareture

Tc °C

Notes

- The motor current Io shown above is the range for DC and chopping operation.
  The DC operating current range is within both the allowable Vcc1 operating range and the derating curve shown in the figure.
- The operating 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.
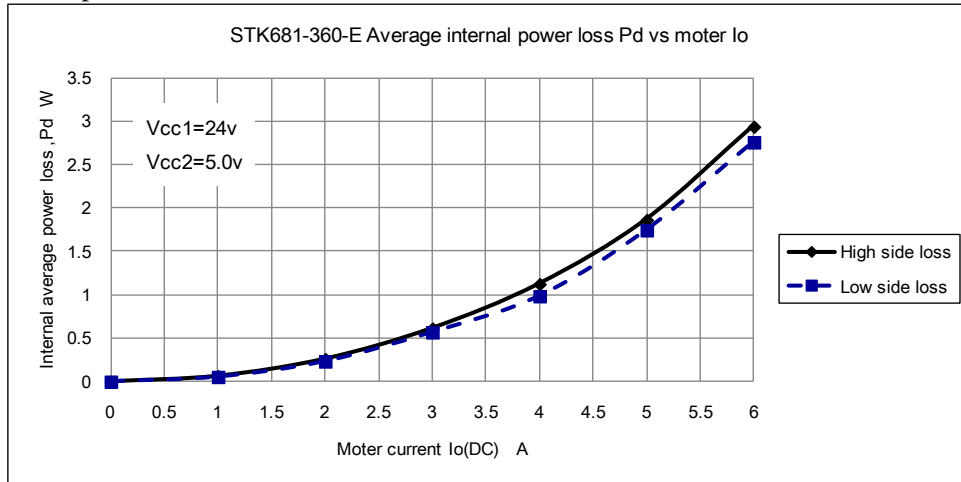- The Tc temperature should be checked in the center of the metal surface of the product package.

Allowable STK681-360-E braking current ranges (High side:F1,F2=ON)

Allowable STK681-360-E braking current ranges (Low side:F3,F4=ON)
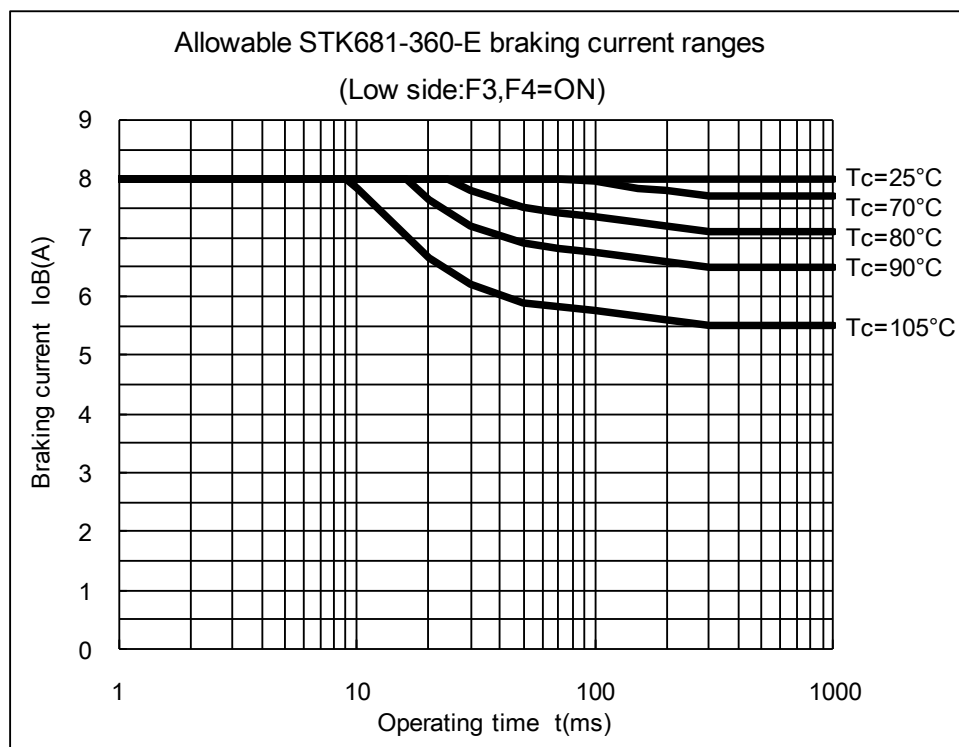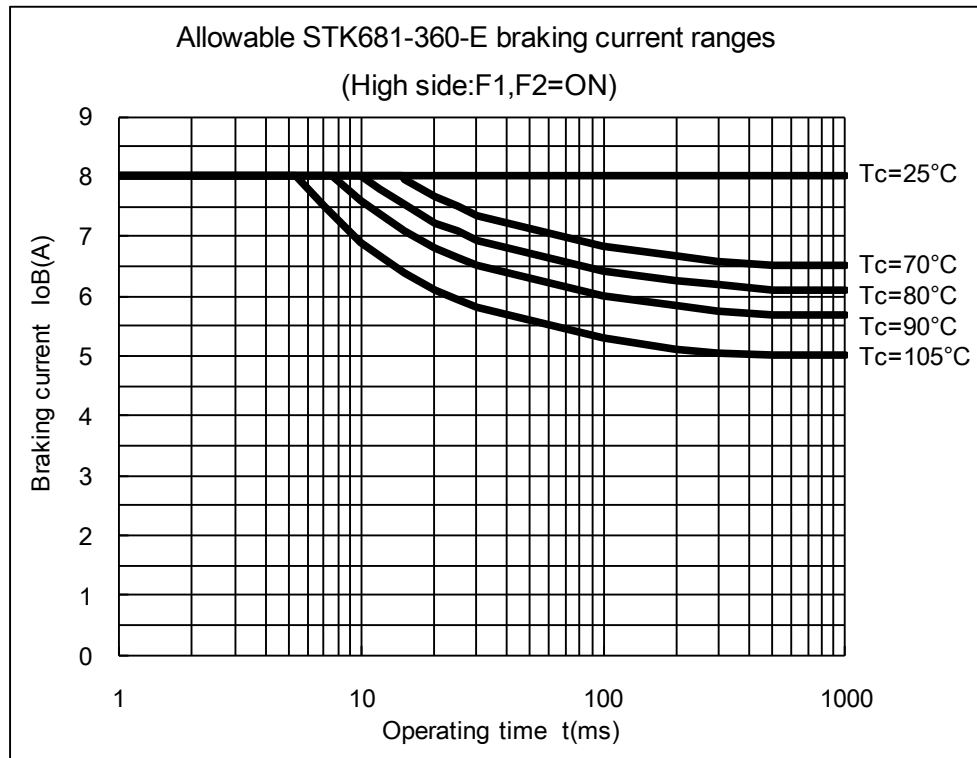
1.Substrate temperature rise□ΔTc-Internal average power loss PdAV characteristics(no heat sink)

Substrate temperature rise, ΔTc (no heat sink) - Internal average power dissipation, PdAV

Substrate temperature rise rise, ΔTc - °C

Hybrid IC internal average power loss, PdAV - W
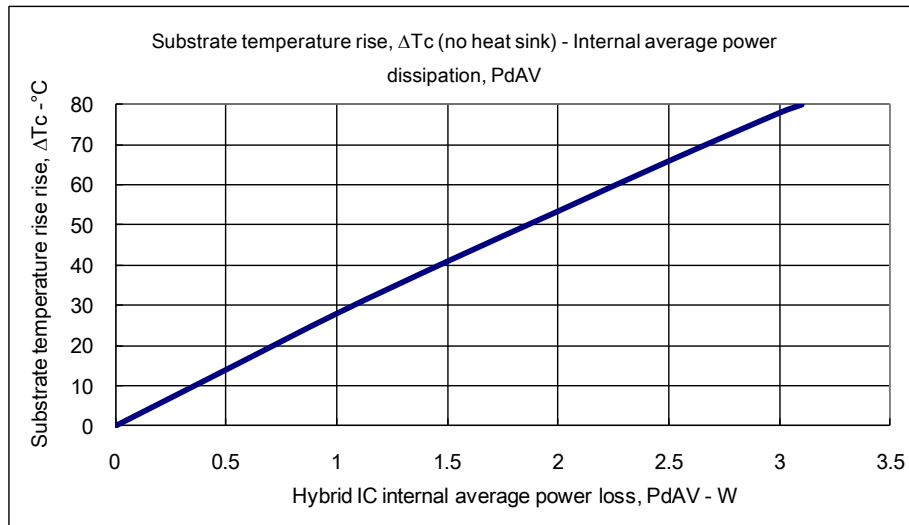
2. Average internal power loss (Pd) at DC - motor current (Io) characteristics.

STK681-360-E Average internal power loss Pd vs moter Io

Internal average power loss , Pd W

Vcc1=24v
Vcc2=5.0v

Moter current Io(DC)   A

High side loss
Low side loss

3. Over temperature current suppression characteristics.

STK681-360-E Over temperature current suppression characteristics
Io vs Tc < Load:2Ω + 5mH>

Average current Io A

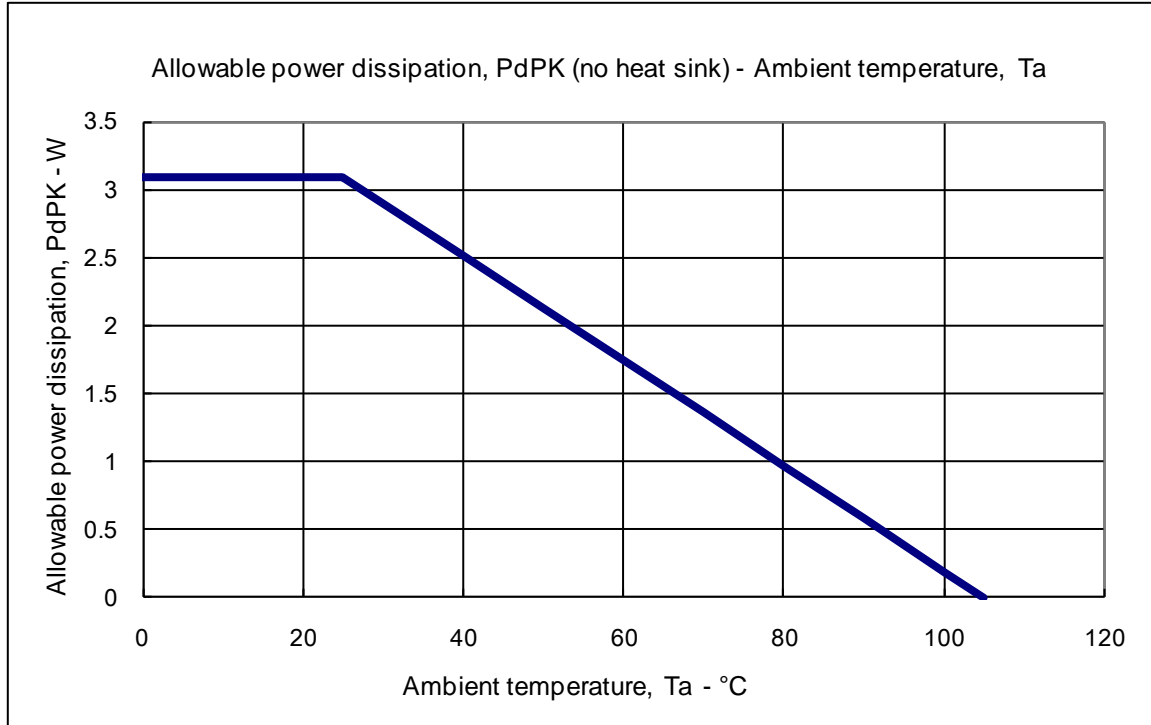Operating substrate temperture Tc °C
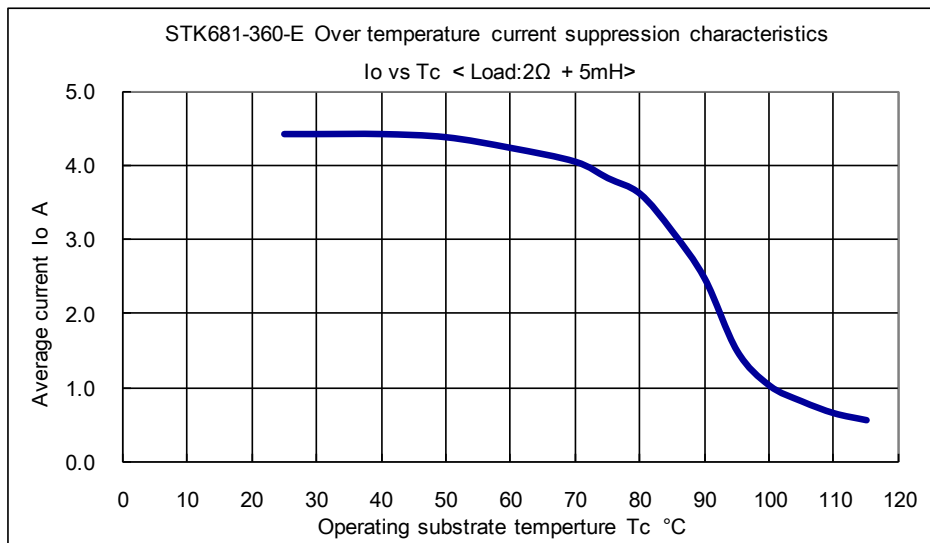
The over temperature current suppression function protects the driver from destruction when
an abnormal motor locked (physically constrained) state occurs.

4. Package power loss PdPK derating curve for the ambient temperature Ta.
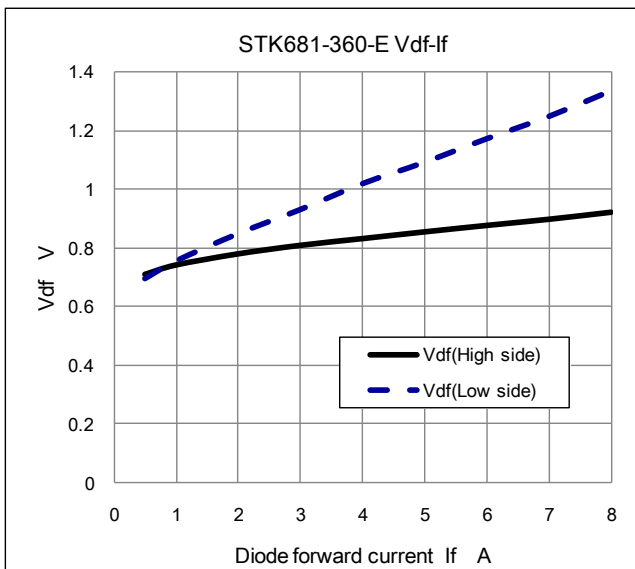
   Package power loss, PdPK, refers to the average internal power loss, PdAV, allowable without a heat sink.
   The figure below represents the allowable power loss, PdPK, vs. fluctuations in the ambient temperature, Ta.
   Power loss of up to 3.1W is allowable at Ta=25°C, and of up to 1.75W at Ta=60°C.
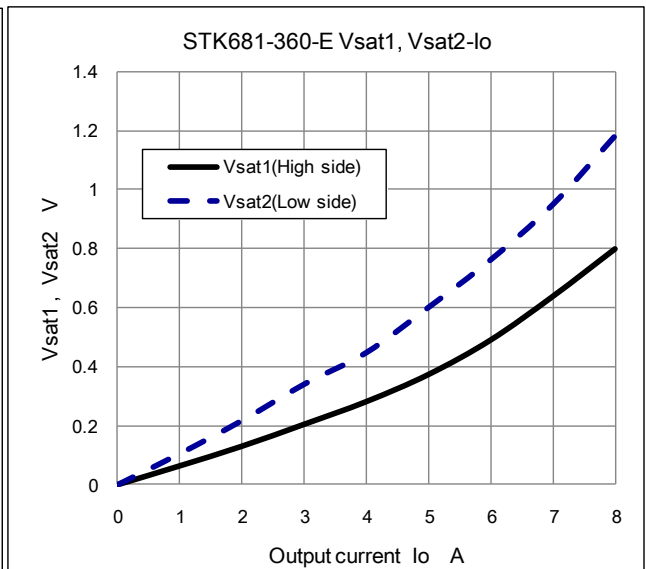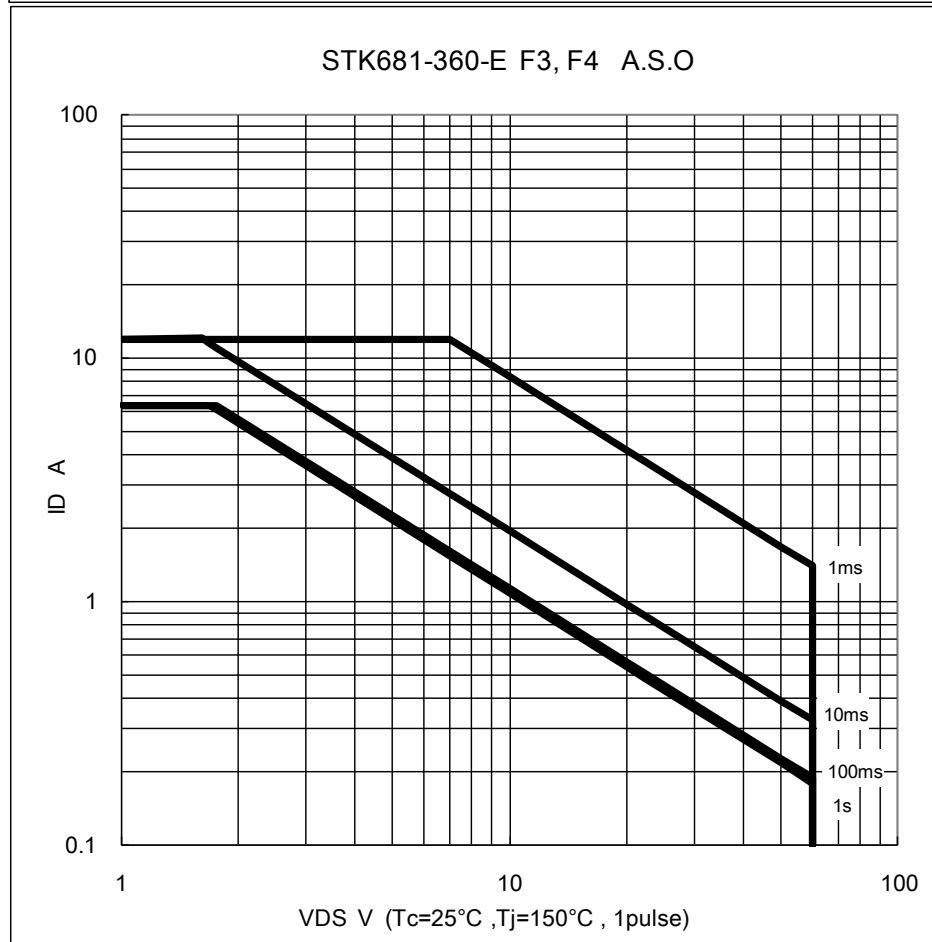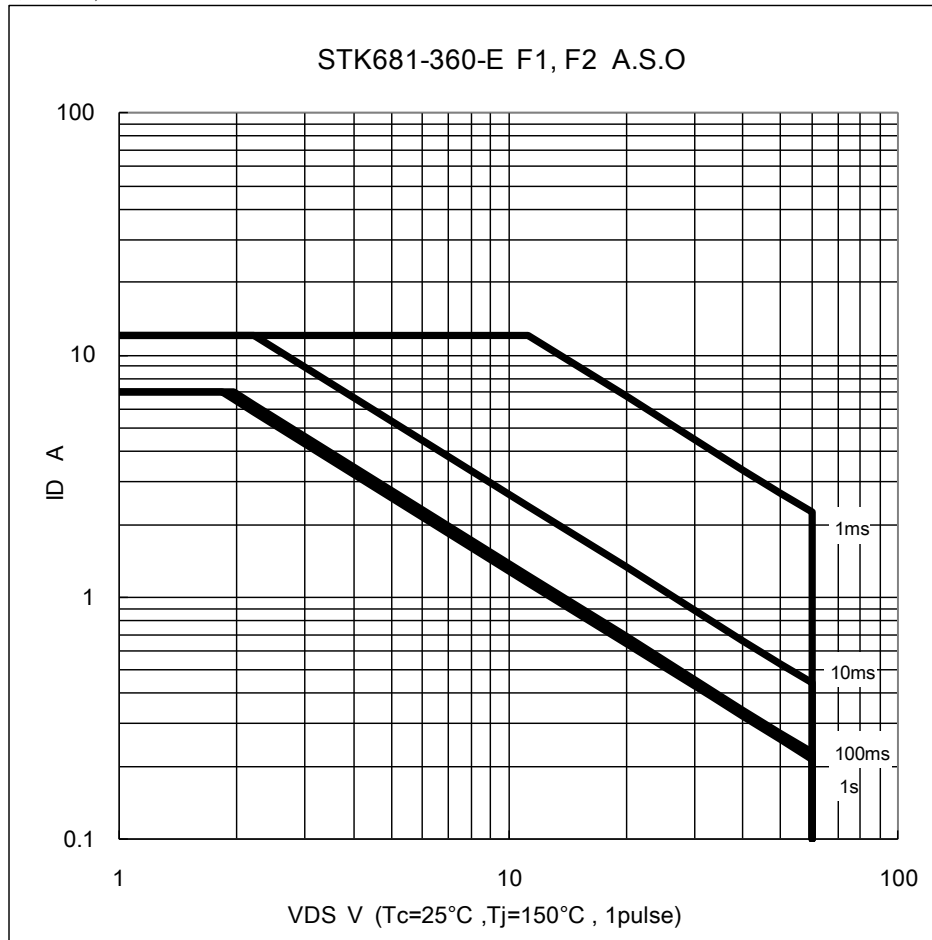   * The package thermal resistance θc-a is 25.8°C/W.

Allowable power dissipation, PdPK (no heat sink) - Ambient temperature, Ta

5. Electrical characteristics

<Vdf vs If>

STK681-360-E Vdf-If

<Vsat1 / Vsat2 vs Io>

STK681-360-E Vsat1, Vsat2-Io

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

STK681-360-E F1, F2 A.S.O

ID A

VDS V (Tc=25℃ ,Tj=150℃ , 1pulse)

1ms
10ms
100ms
1s

STK681-360-E F3, F4 A.S.O

ID A

VDS V (Tc=25℃ ,Tj=150℃ , 1pulse)

1ms
10ms
100ms
1s

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

	IN1	IN2	PWM	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.
* PWM pin (14pin) 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 F1 and F2. The timing for the OUT1 or OUT2 output voltage and the F1 or F2 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.
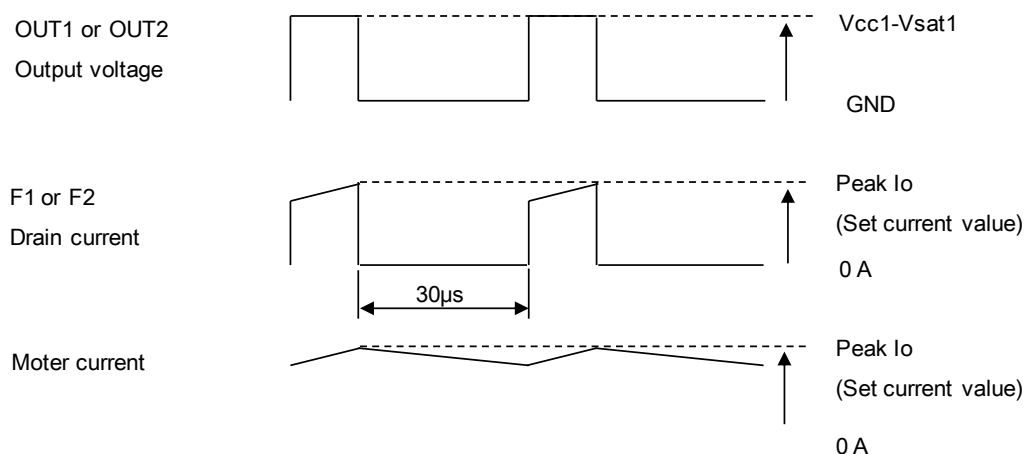
(5) Since the response time of the ground side drive element during forward/reverse direction switching is a few tens of microseconds, this product is not appropriate for H bridge applications. This device should only be used as a DC motor driver.

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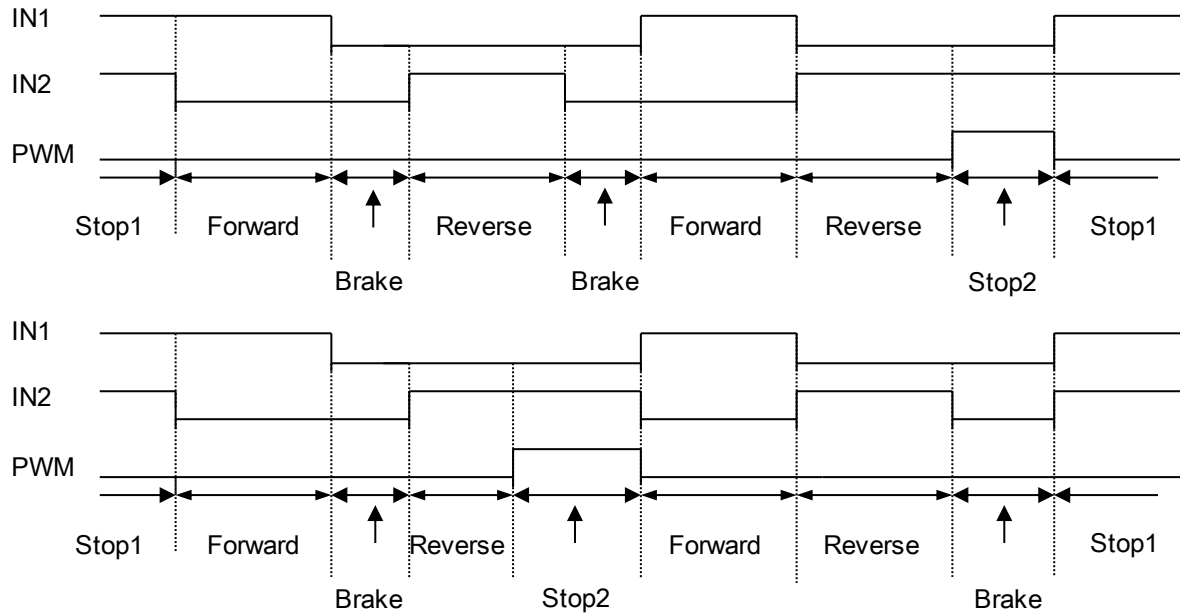
(7)Smoke emission warning: This hybrid IC may emit smoke if it is used under conditions that exceed its specifications.

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: F1: on, F3: off, when low: F1: off, F3: on.
IN2	13	Input that controls the on/off state of F2 and F4. When high: F2: on, F4: off, when low: F2: off, F4: on.
PWM	14	Input that forces F1 and F2 to the off state: when high F1 and F2 will be off. When high F1 and F2 will be off, When low F1 and F2 will be on,
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	The current setting voltage (Vref1) is used by connecting Vrefa to Vrefb The peak Io level is determined by Io(peak) = Vref1 ÷ Rs.
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>   <PWM>
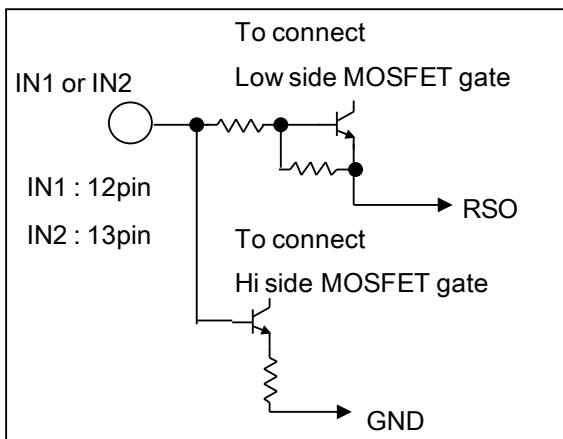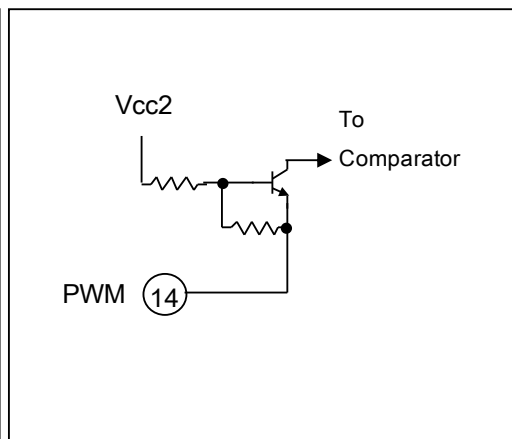
Substrate Specifications (Substrate recommended for operation of STK681-360-E)
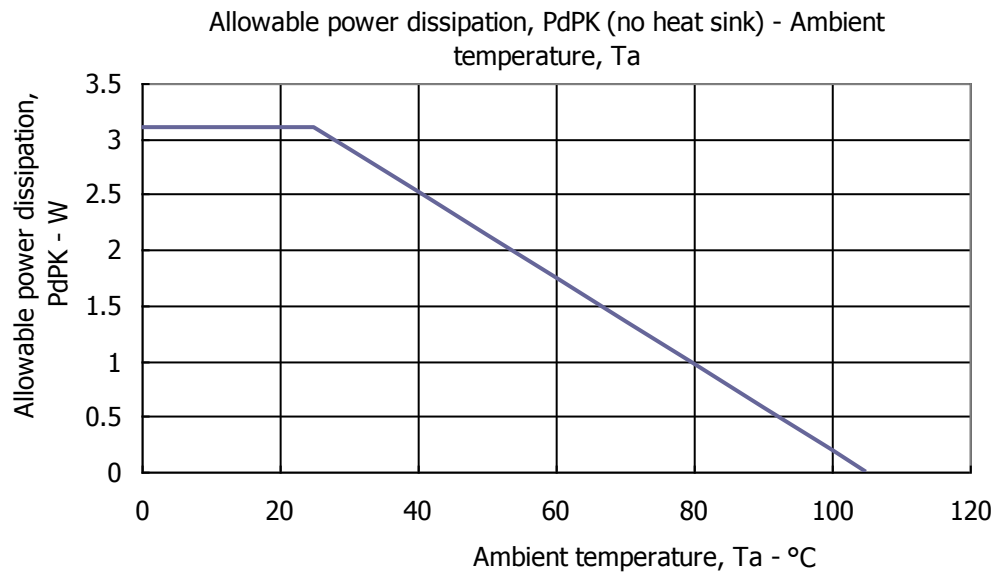Size : 100mm × 65mm × 1.6mm 1-layer board
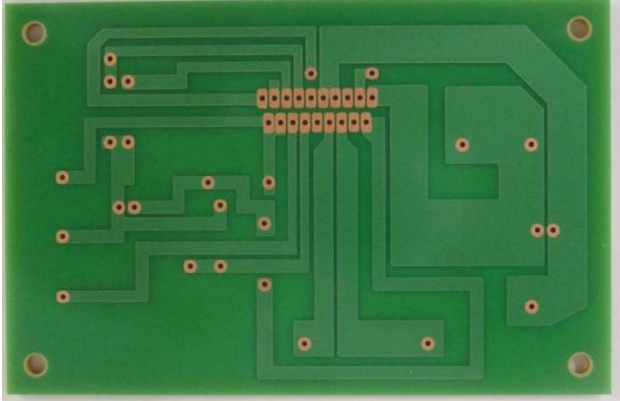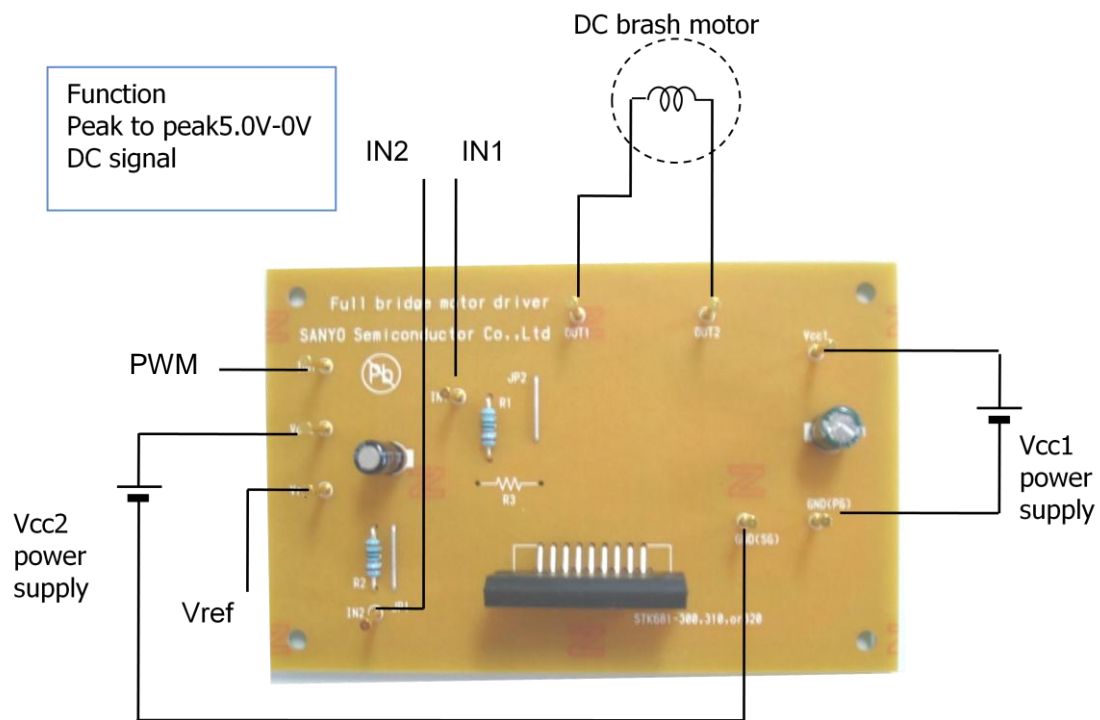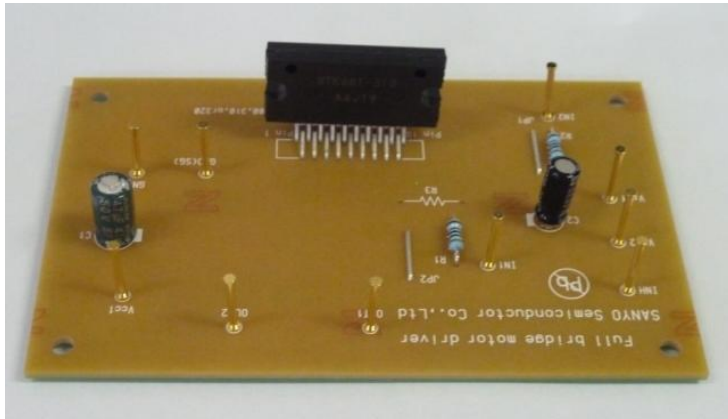
Material : Phenol

Copper side (35μ)

Allowable power dissipation(Reference value)

Allowable power dissipation, PdPK (no heat sink) - Ambient temperature, Ta

Evaluation board
STK681-360-E (100.0mm x 65.0mm x 1.6mm, phenol 1-layer board)

Bill of Materials for STK681-360-E Evaluation Board

Designator	Quantity	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free
C1	1	Vcc1 Bypass Capacitor	47μF /50V	±20%		SUN ERECTRONICS	50ME47CA	YES	YES
C2	1	Vcc2 Bypass Capacitor	10μF /50V	±20%		SUN ERECTRONICS	50ME10CA	YES	YES
R1	1	Pull-up Resistor	1.0 kΩ	±5%		AKAHANE ERECTRONICS	RN14S102JK	YES	YES
R2	1	Pull-up Resistor	1.0 kΩ	±5%		AKAHANE ERECTRONICS	RN14S102JK	YES	YES
R3	1	Resistor to Set Vref		±1%		AKAHANE ERECTRONICS	RN14S****FK	YES	YES
HIC	1	Hybrid IC				SANYO semiconductor	STK681-360-E	NO	YES
JP1, 2, 3	3	Jumper for				Mac-Eight	JR-4	YES	YES
TP1 to TP10	10	Test Point				Mac-Eight	ST-1-3	YES	YES

Notes: R3 are used to Vref for current setting. Therefore their value do not mention on this table.
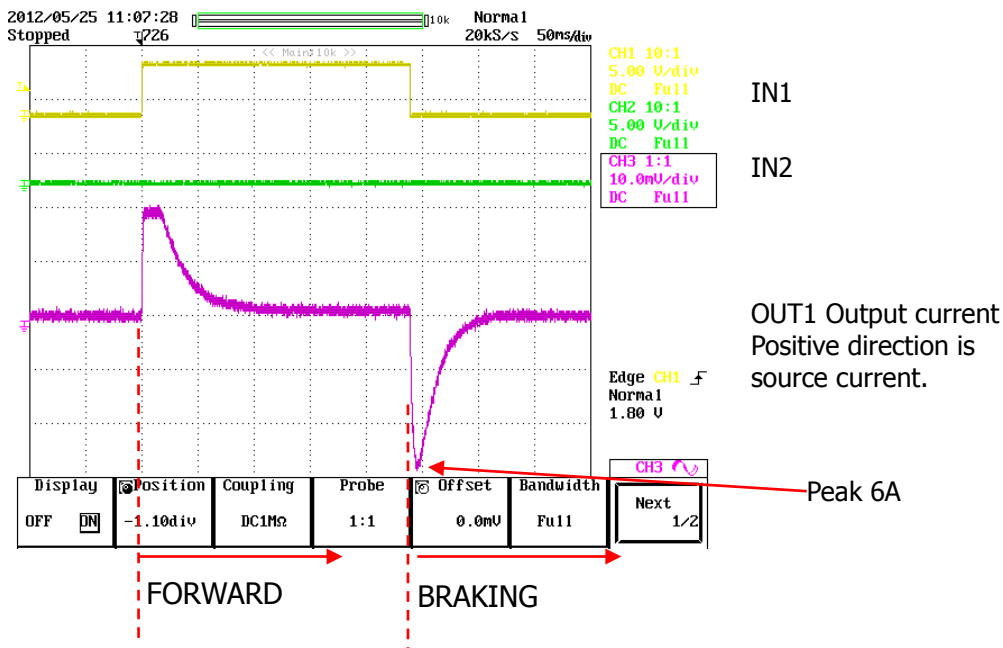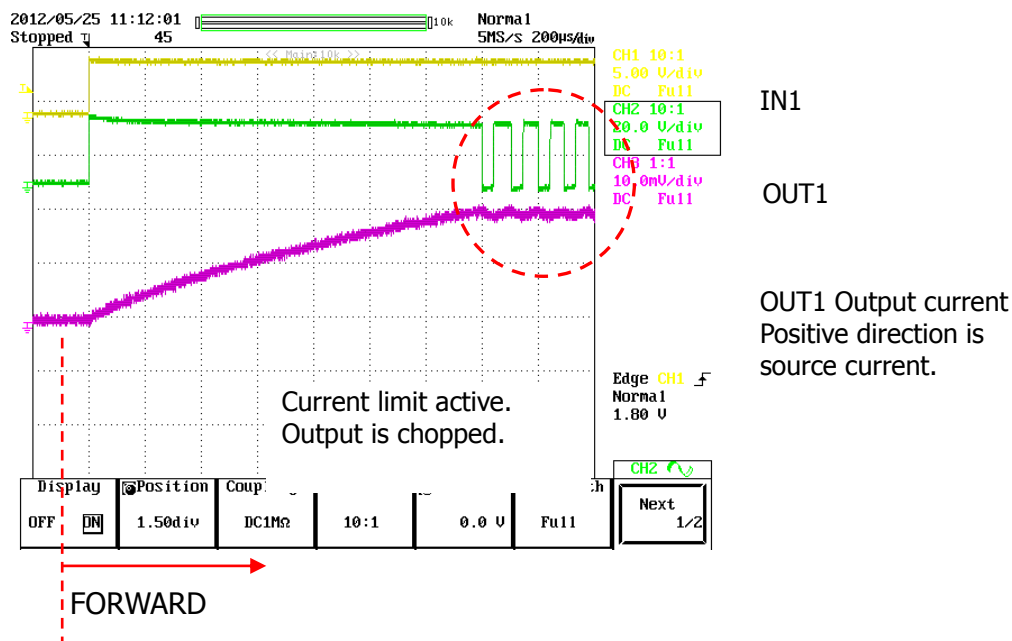
Evaluation Circuit
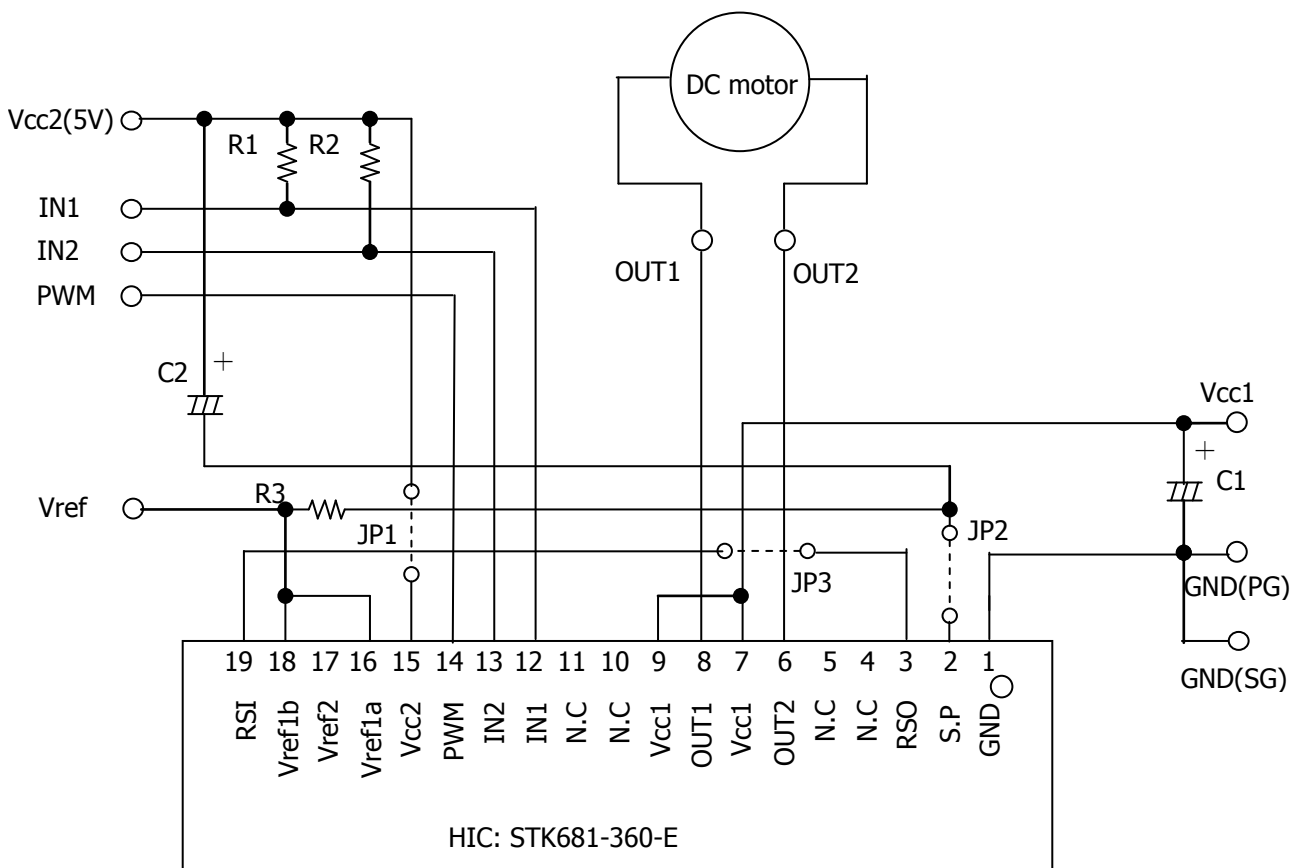
Waveform example

STK681-360-E(Current limit 4.2A setting)
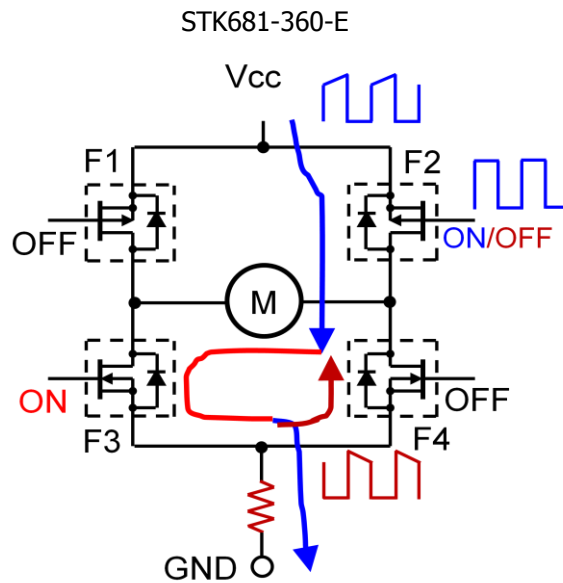IN1 and IN2; 5V/div, Output current; 2A/div

IN1

IN2

OUT1 Output current
Positive direction is
source current.

Peak 6A

FORWARD BRAKING

STK681-360-E(Current limit 2A setting)
IN1 5V/div, OUT1 20V/div, Output current; 2A/div

IN1

OUT1

OUT1 Output current
Positive direction is
source current.

Current limit active.
Output is chopped.

FORWARD

Current control is slow decay.

STK681-360-E control Bipolar Transistor or MOSFET at High side by constant-current PWM control system. Current control enters Slow decay mode.

STK681-360-E

STK681-360-E(Current limit 4.2A setting)
IN1 and IN2; 5V/div, Output current; 2A/div

IN1

IN2

OUT1 Output current
Positive direction is
source current.
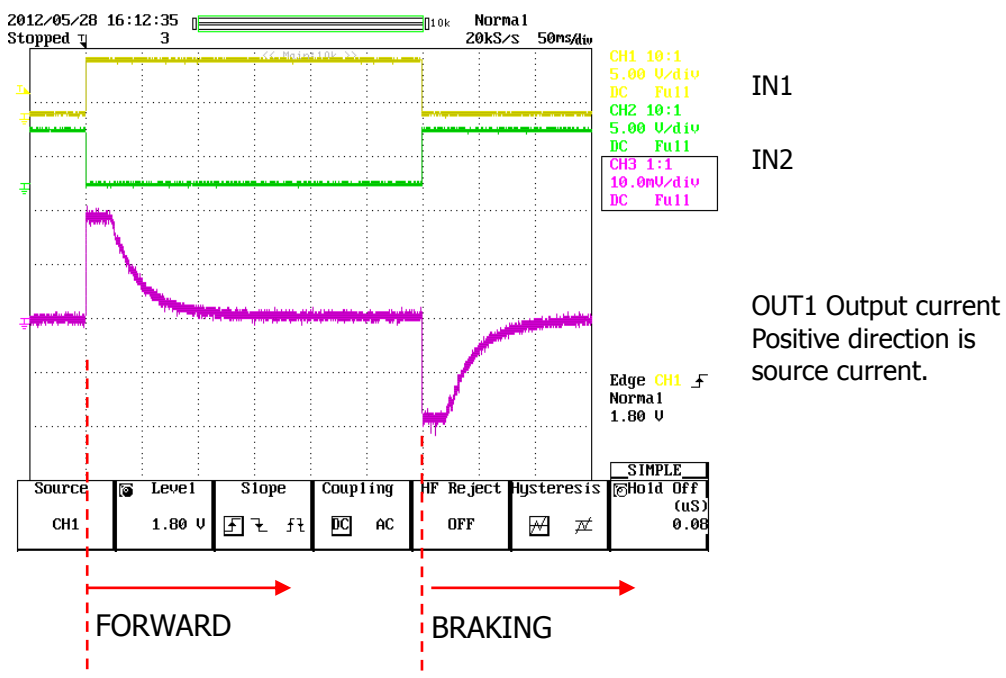
Evaluation Board Manual

[Supply Voltage]   Vcc1 (10 to 30V) : Power Supply for DC motor
                      Vcc2 (5V)   : Power Supply for internal logic IC

[Operation Guide]
   1. Motor Connection:
        Connect the motor to OUT1 and OUT2.

   2. Initial Condition Setting:
        Set to signal condition IN1=H, IN2=H, and PWM=L.

   3. Power Supply:
        At first, supply DC voltage to Vcc2(5.0V).
        Next, supply DC voltage to Vcc1.

   4. Set to Forward or Reverse signal condition with PWM=Low.
        Turn "High" INH signal.
        Output current flows between OUT1 and OUT2.

   5. Motor Operation

[Setting the current limit using the Vref pin]

Notes in design

(1) Allowable operating range

    Operation of this product assumes use within the allowable operating range. If a supply voltage or an input voltage outside the allowable operating range is applied, an overvoltage may damage the internal control IC or the MOSFET.

    If a voltage application mode that exceeds the allowable operating range is anticipated, connect a fuse or take other measures to cut off power supply to the product.

(2)Input pins

    If the input pins are connected directly to the PC board connectors, electrostatic discharge or other overvoltage outside the specified range may be applied from the connectors and may damage the product. Current generated by this overvoltage can be suppressed to effectively prevent damage by inserting 100Ω to 1kΩ resistors in lines connected to the input pins. Take measures such as inserting resistors in lines connected to the input pins.

(3) Input Signal Lines

    1) Do not use an IC socket to mount the driver, and instead solder the driver directly to the PC board to minimize fluctuations in the GND potential due to the influence of the resistance component and inductance component of the GND pattern wiring.

    2) To reduce noise due to electromagnetic induction to small signal lines, do not design small signal lines (sensor signals, 5V power supply signal lines) that run parallel near the motor output lines OUT1 and OUT2.

    3) Pins 4, 5, 10 and 11 of this product are N.C pins. Do not connect any wiring to these pins.

ORDERING INFORMATION

Device	Package	Shipping (Qty / Packing)
STK681-360-E	SIP-19 (Pb-Free)	15 / Tube