SPINDLE MOTOR DRIVER

The KA3016D is a monolithic integrated circuit, suitable for a 3-phase spindle motor drive of a CD system.

28-SSOPH-375

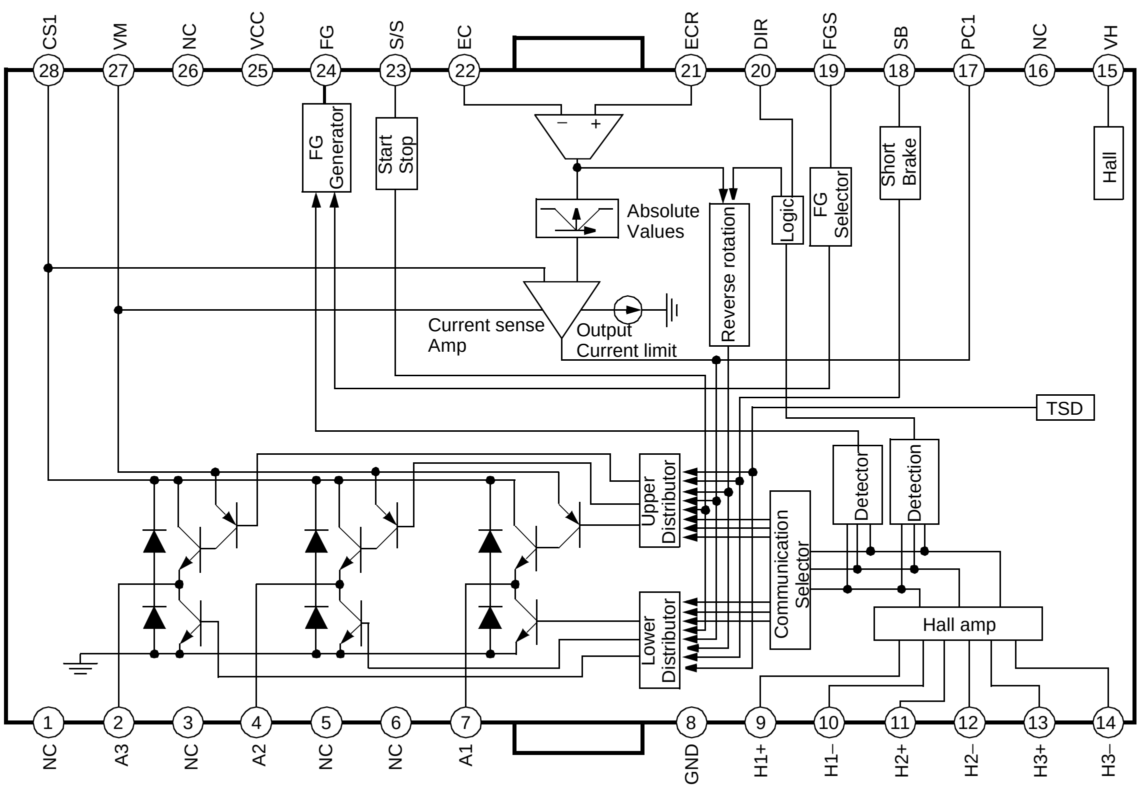
FEATURES

- 3-phase, full-wave, linear BLDC motor driver
- Power save at stop mode
- Built-in current limiter
- Built-in TSD (Thermal shutdown) circuit
- Built-in 3X or 1X hall FG output
- Built-in hall bias circuit
- Built-in rotational direction detector
- Built-in reverse rotation preventer
- Built-in short braker
- Corresponds to 3.3V or 5V DSP

ORDERING INFORMATION

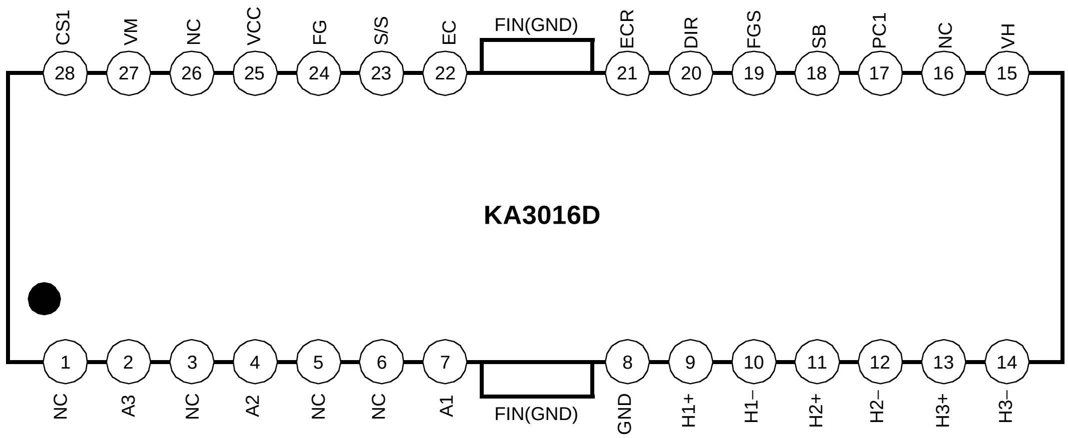
Device	Package	Operating Temperature
KA3016D	28-SSOPH-375	–25°C ~ +75°C

BLOCK DIAGRAM



FAIRCHILD SEMICONDUCTOR TM

PIN CONFIGURATION

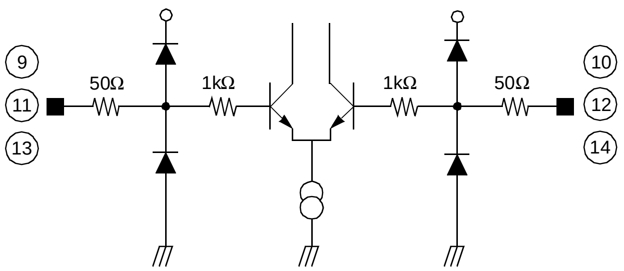


PIN DESCRIPTIONS

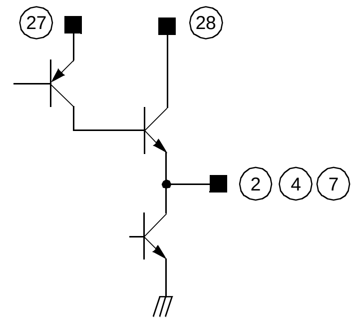
Pin No.	Symbol	I/O	Description	Pin No.	Symbol	I/O	Description
1	NC	–	No connection	15	VH	I	Hall bias
2	A3	O	Output (A3)	16	NC	–	No connection
3	NC	–	No connection	17	PC1	–	Phase compensation capacitor
4	A2	O	Output (A2)	18	SB	I	Short brake
5	NC	–	No connection	19	FGS	I	Frequency generation selection
6	NC	–	No connection	20	DIR	O	Rotational direction output
7	A1	O	Output (A1)	21	ECR	I	Output current control reference
8	GND	–	Ground	22	EC	I	Output current control voltage
9	H1+	I	Hall signal (H1+)	23	S/S	I	Power save (Start/Stop switch)
10	H1–	I	Hall signal (H1–)	24	FG	O	Frequency generation waveform (3X or 1X hall frequency)
11	H2+	I	Hall signal (H2+)	25	VCC	–	Supply voltage (Signal)
12	H2–	I	Hall signal (H2–)	26	NC	–	No connection
13	H3+	I	Hall signal (H3+)	27	VM	–	Supply voltage (Motor)
14	H3–	I	Hall signal (H3–)	28	CS1	–	Output current detection

EQUIVALENT CIRCUITS

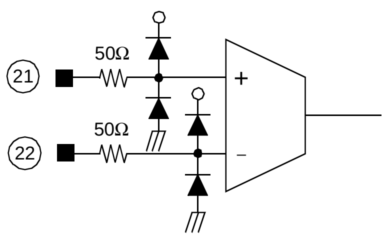
Hall input



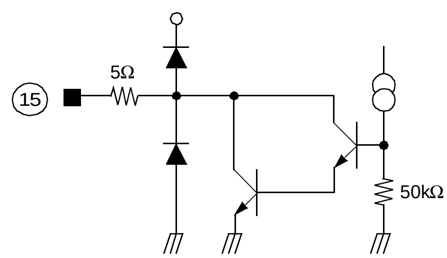
Driver output



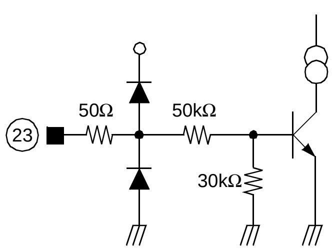
Torque control input



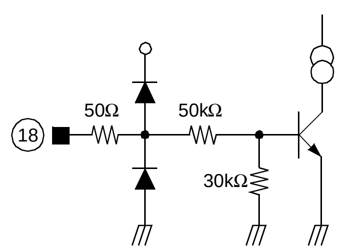
Hall bias input



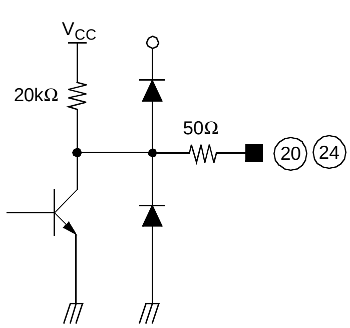
Current detector



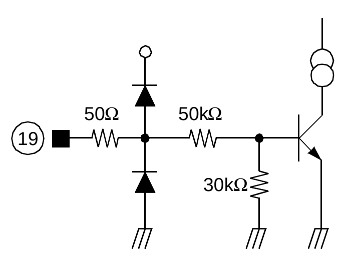
Start / Stop



Dir or FG output



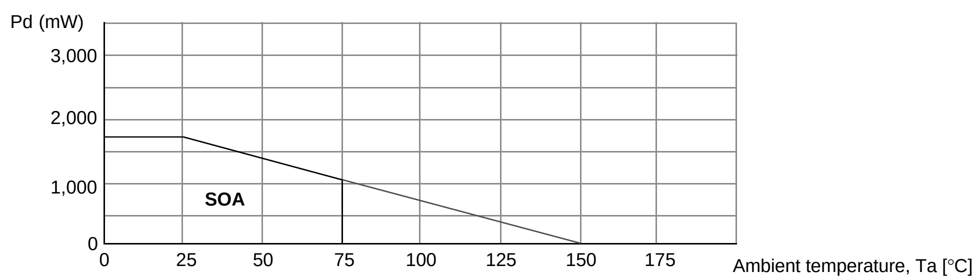
FGS input



ABSOLUTE MAXIMUM RATING (Ta=25°C)

Characteristics	Symbol	Value	Unit
Maximum supply voltage (Signal)	V_{CCMAX}	7	V
Maximum supply voltage (Motor)	V_{MMAX}	18	V
Power dissipation	P_D	1.7[note]	W
Maximum output current	I_{OMAX}	1.3	A
Operating temperature range	T_{OPR}	–25 ~ +75	°C
Storage temperature range	TSTG	–55 ~ +150	°C

NOTE:
1. When mounted on 76.2mm × 114mm × 1.57mm PCB (Phenolic resin material)
2. Power dissipation is reduced 13.6 mV / °C for using above Ta=25°C
3. Do not exceed Pd and SOA (Safe operating area).



RECOMMENDED OPERATING CONDITIONS

Characteristics	Symbol	Min.	Typ.	Max.	Unit
Supply voltage	V_{CC}	4.5	5	5.5	V
Motor supply voltage	V_M	3.0	12	15	V

ELECTRICAL CHARATERISTICS

(Unless otherwise specified, Ta=25°C, V_{CC}=5V, V_M=12V)

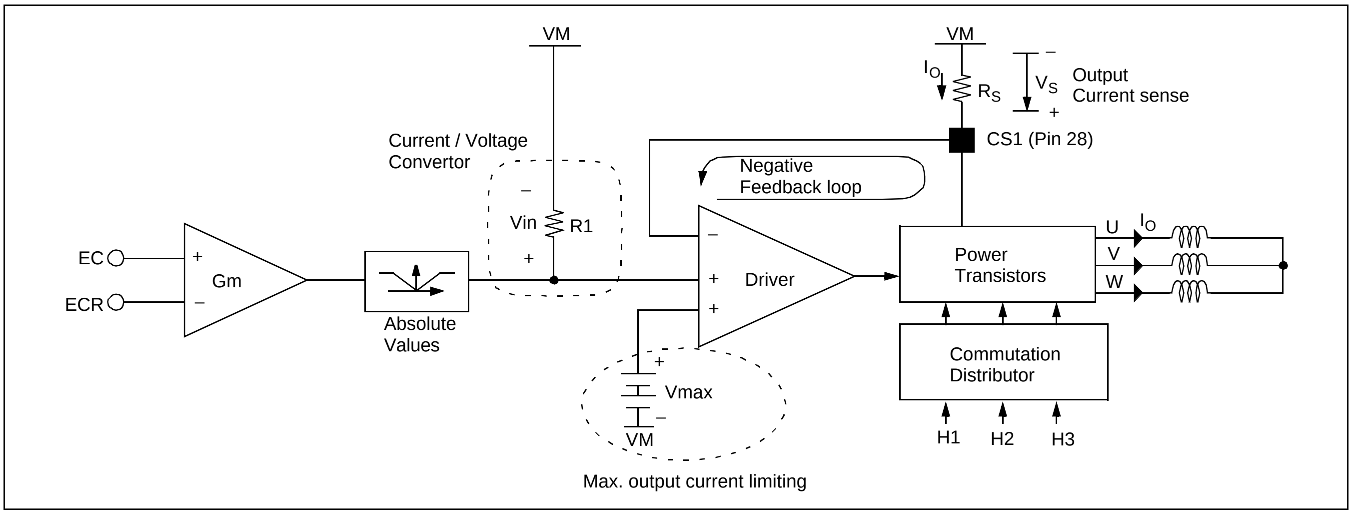
Characteristics	Symbol	Test conditions	Min.	Typ.	Max.	Unit
Quiescent circuit current	I_{CC}	–	2	5	8	mA
START / STOP						
On voltage range	V_{SSON}	Output drive on	2.5	–	V_{CC}	V
Off voltage range	V_{SSOFF}	Output driver off	0.0	–	1.0	V
HALL BIAS						
Hall bias voltage	V_{HB}	I_{HB}=20mA	0.4	1.0	1.8	V
HALL AMP						
Hall bias current	I_{HA}	–	–	0.5	2	µA
Common mode input range	V_{HAR}	–	1.5	–	4.0	V
Minimum input level	V_{INH}	–	100	–	–	mVpp
TORQUE CONTROL						
E_{CR} input voltage range	E_{CR}	–	0.2	–	4.0	V
E_C input voltage range	E_C	–	0.2	–	4.0	V
Offset voltage (–)	E_{COFF-}	E_C=2.5V	–80	–50	–20	mV
Offset voltage (+)	E_{COFF+}	E_C=2.5V	20	50	80	mV
E_C input current	E_{CIN}	E_C=2.5V	–5	0.5	5	µA
E_{CR} input current	E_{CRIN}	E_{CR}=2.5V	–5	0.5	5	µA
In/output gain	G_{EC}	E_{CR}=2.5V, R_{CS}=0.5Ω	0.41	0.51	0.61	A / V
FG						
FG output voltage (H)	V_{FGH}	I_{FG}= –10µA	3.0	–	V_{CC}	V
FG output voltage (L)	V_{FGI}	I_{FG}=10µA	–	–	0.5	V
Input voltage range		–	–	50	–	%
OUTPUT BLOCK						
Saturation voltage (upper TR)	V_{OH}	I_O= –300mA	–	0.9	1.6	V
Saturation voltage (lower TR)	V_{OL}	I_O=300mA	–	0.2	0.6	V
Torque limit current	I_{TL}	R_{CS}=0.5Ω	560	700	840	mA
DIRECTION DETECTOR						
Dir output voltage (H)	V_{DIRH}	I_{FG}=–10µA	3.0	–	V_{CC}	V
Dir output voltage (L)	V_{DIRL}	I_{FG}=10µA	–	–	0.5	V

ELECTRICAL CHARATERISTICS (Continued)

(Unless otherwise specified, Ta=25°C, V_{CC}=5V, V_M=12V)

Characteristics	Symbol	Test conditions	Min.	Typ.	Max.	Unit
FG SELECTION						
3X frequency selection	V_{FG3X}	FGS > 2.5V	2.5	–	V_{CC}	V
1X frequency selection	V_{FG1X}	FGS < 1.0	–	–	1.0	V
SHORT BRAKE						
On voltage range	V_{SBON}	–	2.5	–	V_{CC}	V
Off voltage range	V_{SBOFF}	–	0	–	1.0	V

CALCUALTION OF GAIN & TORQUE LIMIT CURRENT



0.255 which is made from GM times R1 is fixed value within IC.

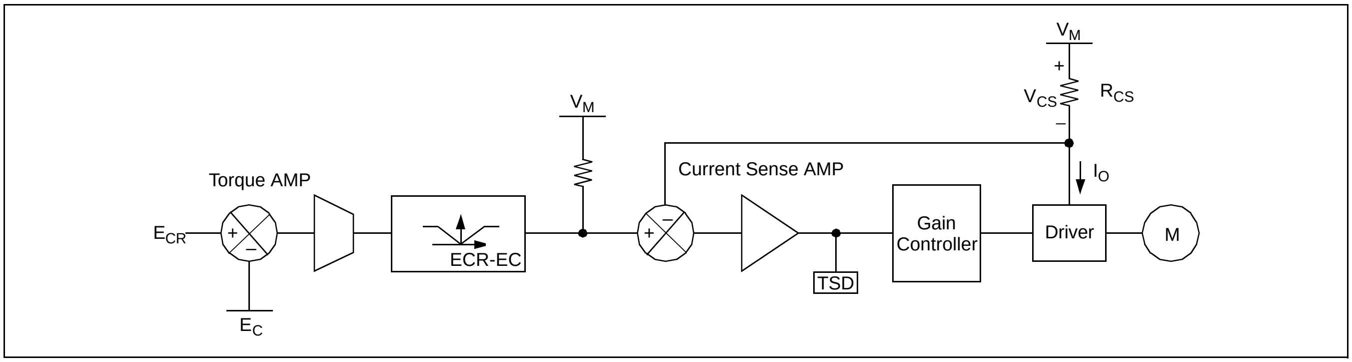
$$Gain = \frac{0.255}{R_S}$$

Vmax (see above block diagram) is setted to 350mV.

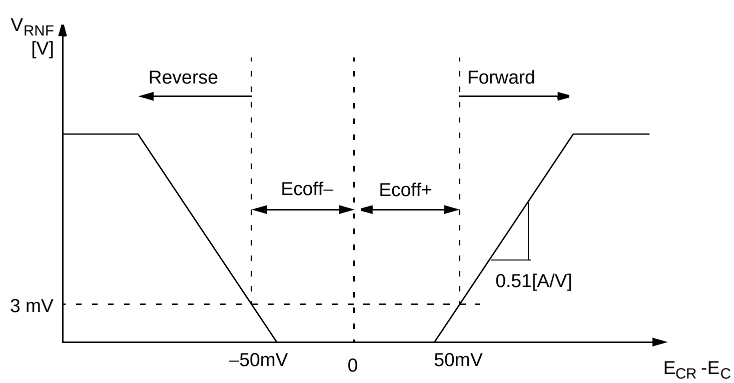
$$Itl[mA] = \frac{Vmax}{R_S} = \frac{350[mV]}{R_S}$$

APPLICATION INFORMATION

1. TORQUE CONTROL & OUTPUT CURRENT CONTROL



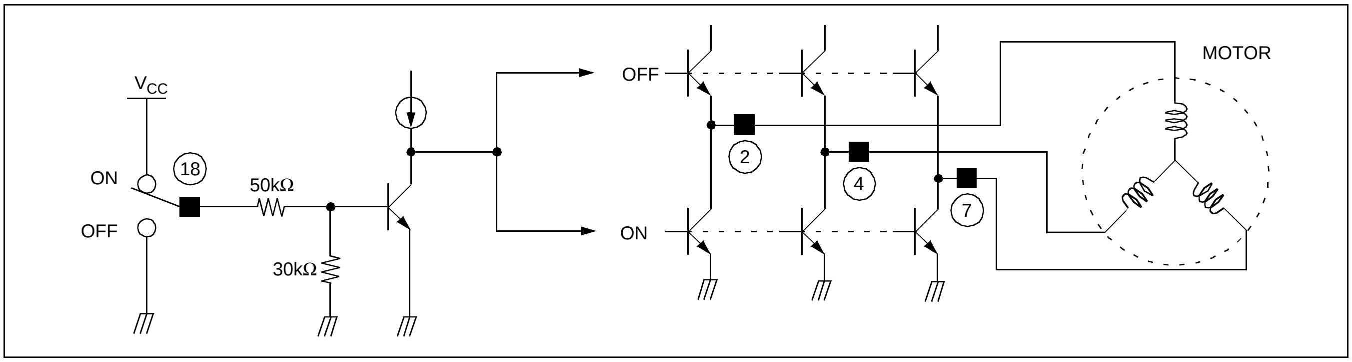
- By amplifying the voltage difference between E_C and ecr from servo IC, the torque sense amp produces the input (V_{AMP}) for the current sense amp.
- The output current (I_O) is converted into the voltage (V_{CS}) through the sense resistor (R_{CS}) and compared with the V_{AMP}. By the negative feedback loop, the sensed output voltage, V_{CS} is equal to the input V_{AMP}. Therefore, the output current (I_O) is linearly controlled by the input V_{AMP}.
- As a result, the signals, E_C and E_{CR} can control the velocity of the Motor by controlling the output current (I_O) of the Driver.
- The range of the torque voltage is as shown below.



	Rotation
$E_{CR} > E_C$	Forward rotation
$E_{CR} < E_C$	Stop after detecting reverse rotation

The input range of E_{CR}, E_C is 0.2V ~ 4V.

2. SHORT BRAKE

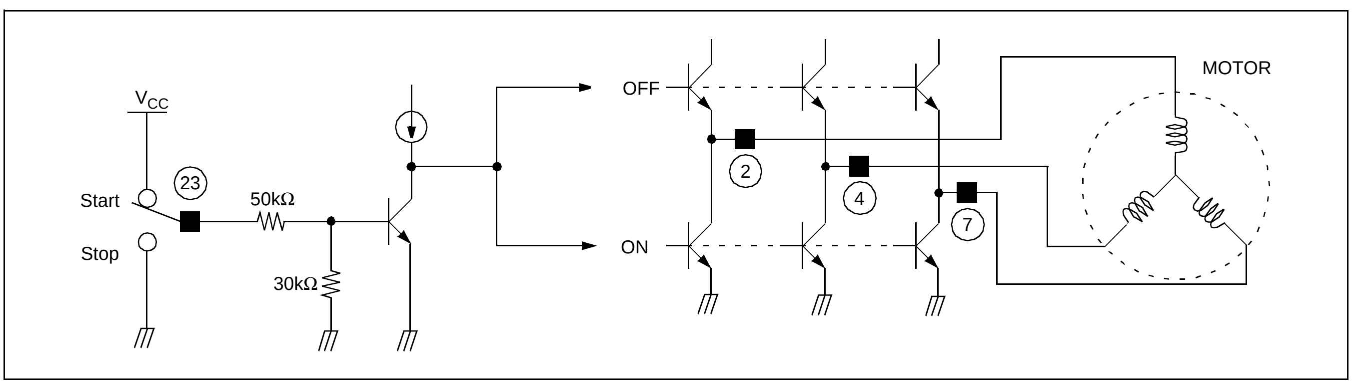


Pin # 18	Short brake
High	On
Low	Off

When the pick-up part moves from the inner to the outer spindle of the CD, the brake function of the reverse voltage is commonly employed to decrease the rotating velocity of the spindle motor.
However, if the spindle motor rotates rapidly, the brake function of the reverse voltage may produce much heat at the Drive IC.

To remove this shortcoming and to enhance the braking efficiency, the short brake function is added to KA3016D. When the short brake function is active, all upper power TRs turn off and all lower power TRs turn on, so as to make the rotating velocity of the Motor slow down. But FG and DIR functions continue to operate normally.

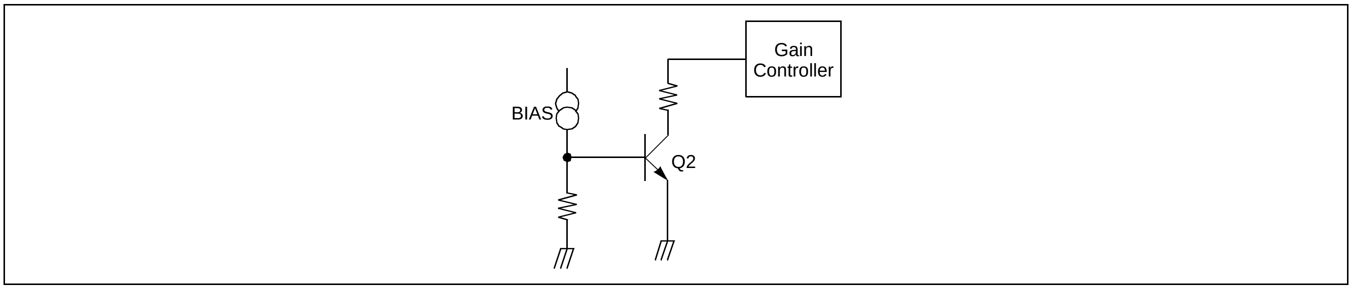
3. POWER SAVE



Pin # 23	Start/Stop
High	Operate
Low	Stop

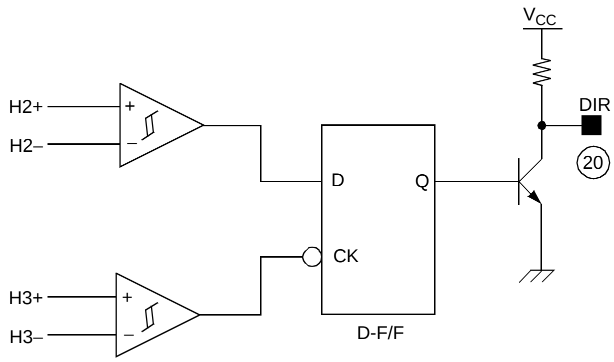
When power save function active, all power TRs turn off but FG and DIR functions continue to operate normally.

4. TSD (THERMAL SHUTDOWN)



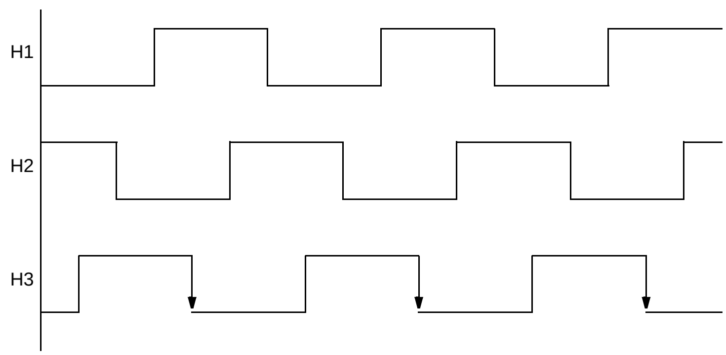
When the chip temperature rises up to about 175°C, the Q2 turns on so that the output driver will be shutdown. When the chip temperature falls off to about 150°C, then the Q2 turns off so that the driver is to operate normally. Thus, TSD has the temperature hysteresis of about 25°C.

5. ROTATIONAL DIRETION DETECTION



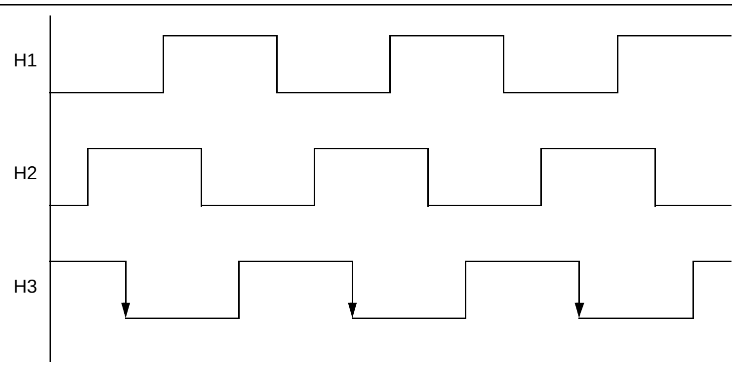
Rotation	(20) DIR
Forward	Low
Reverse	High

- The forward and the reverse rotations of the CD are simply detected by using the D-F/F and the truth table is shown in the above table.
- The rotational direction of the CD can be explained by the output waveforms of the hall sensors. Let the three outputs of hall sensors be H1, H2 and H3 respectively.
  When the spindle rotates in reverse direction, the hall sensor output waveforms are shown in Fig.(a). Thus the phases orderd in H1→H2→H3 with a 120°C phase difference.



(a) Reverse rotation

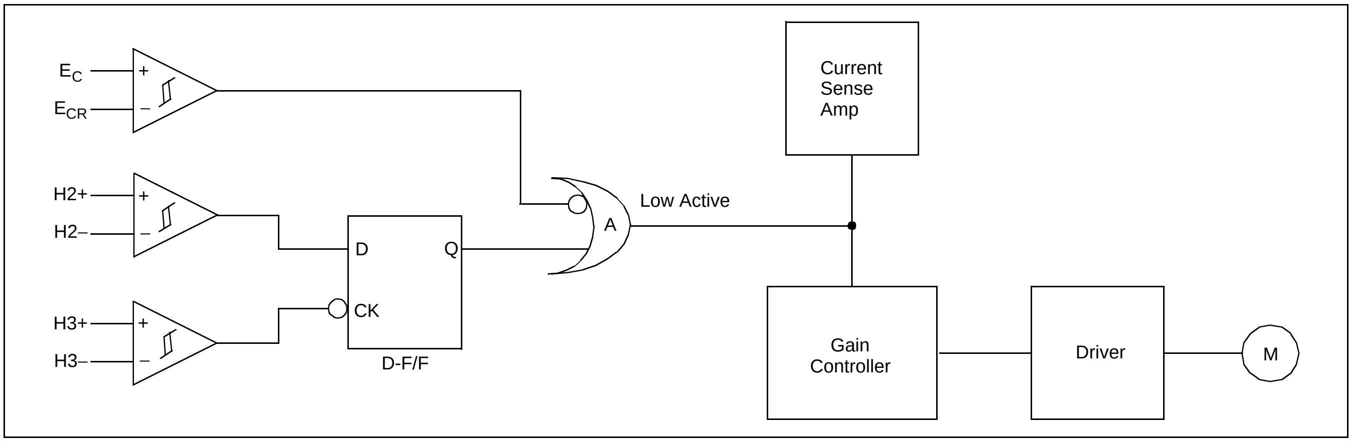
On the other hand, if the spindle rotates in forwand rotation, the phase relationship is H3→H2→H1 as shown in fig.(b).



(b) Forward rotaion

Therefore, the output of the rotational direction detector is low, when the spindle rotates forward, while high as in the case of the reverse rotation.

6. REVERSE ROTATION PREVENTION



- When the output of the OR Gate, A is low, it steers all the output current of the current sense amp makes the current delivered to the gain controller zero. Thus the output current of the driver becomes zero and the motor is stopped.
- As in the state of the forward rotation, the D-F/F output, Q is high and the motor rotates normally. At this state if the control input is changed such that $E_C > E_{CR}$, then the motor rotates slowly more and more by the reverse commutation in the driver. At the moment that the motor rotates in reverse direction, the D-F/F output becomes low and the OR gate output, thus, becomes low. This prevents the motor from rotating in reverse direction. The operation principle is shown in the table and the flow chart..

Rotation	H2	H3	D-F/F (Q)	Reverse rotation preventer	
				$E_C > E_{CR}$	$E_C > E_{CR}$
Forward	H	H→L	H	Forward	–
Reverse	L	H→L	L	–	Brake and stop

Forward rotation at $E_C < E_{CR}$

↓

Rotating speed is decreased due to reverse torque at $E_C > E_{CR}$. (Motor still rotates forward)

↓

At the moment that the motor rotates in reverse, the reverse rotation preventer makes the output power transistor open.

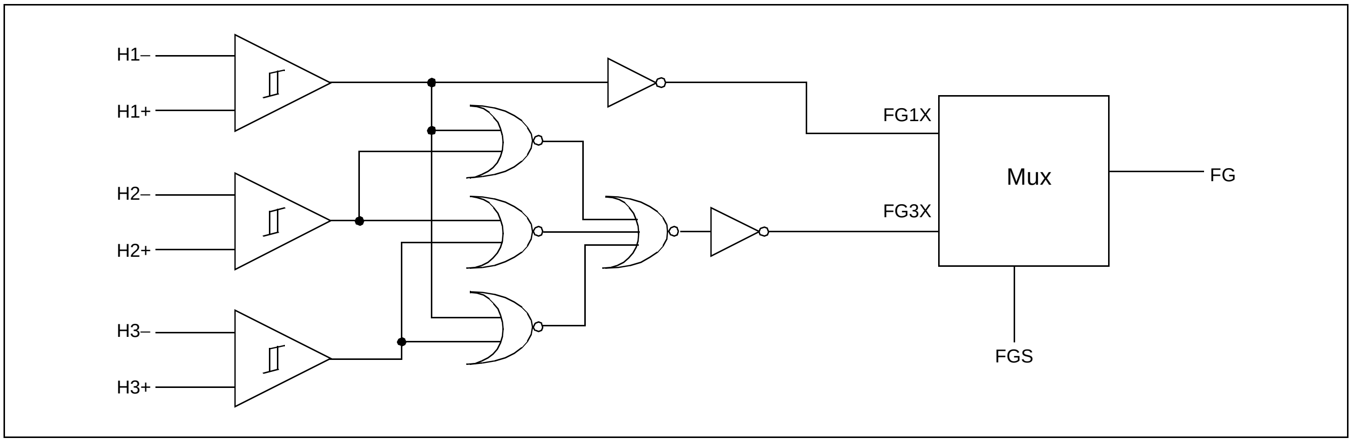
↓

Rotating reverse at short time due to motor inertia

↓

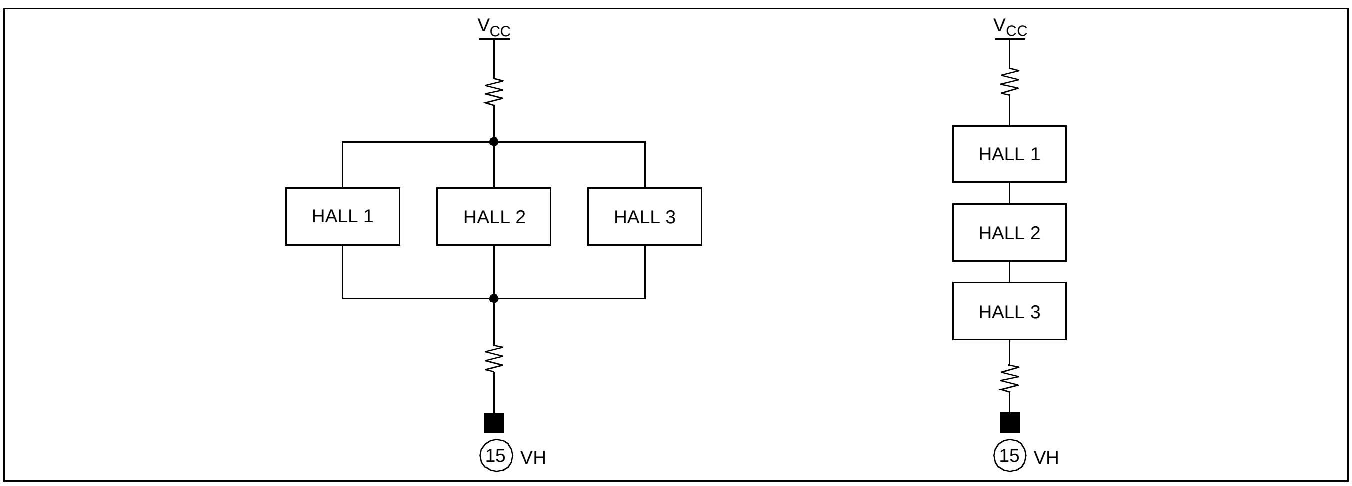
Stop within 1/6 turn reverse rotating

7. FG OUTPUT

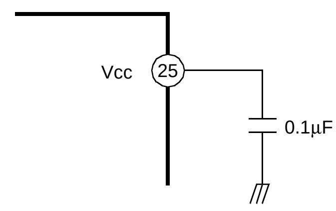


FGS	FG
GND or Open	FG1X (1X hall frequency)
V_{CC}	FG3X (3X hall frequency)

8. HALL SENSOR CONNECTION

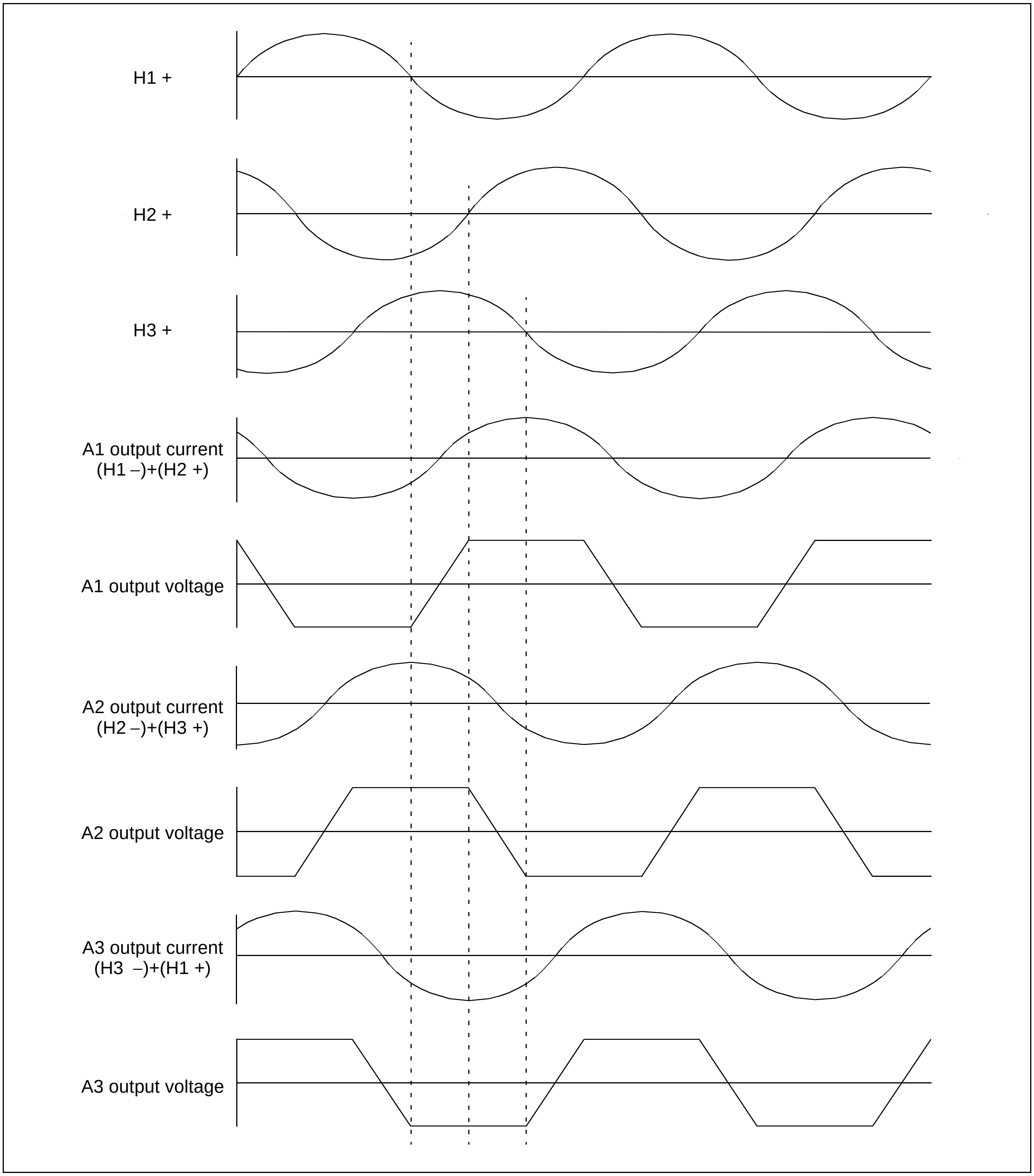


9. **Connect a by-pass capacitor, 0.1µF between the supply voltage source.**

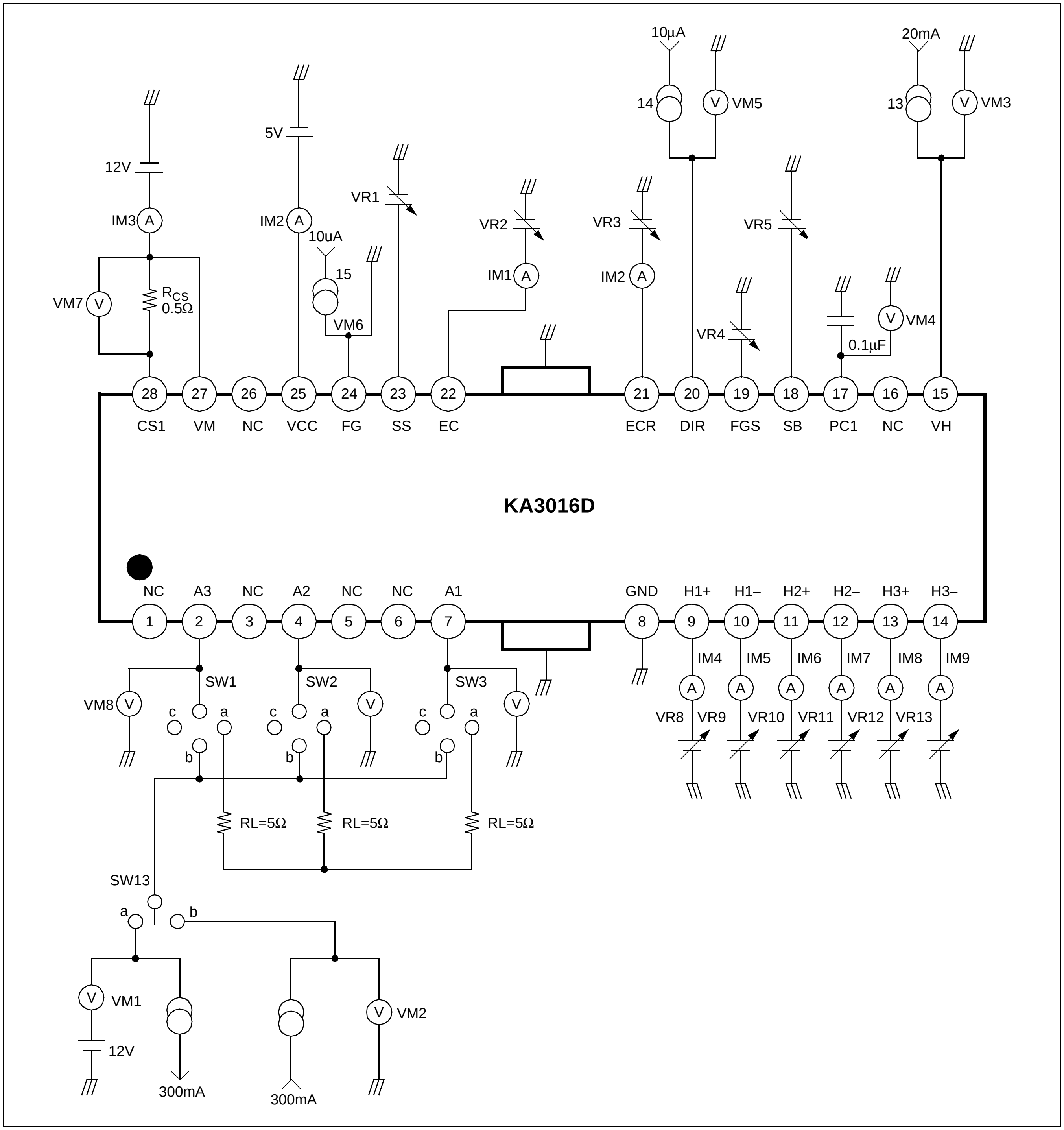


10. **The heat radiation fin is connected to the internal GND of the package. Connect that fin to the external GND.**

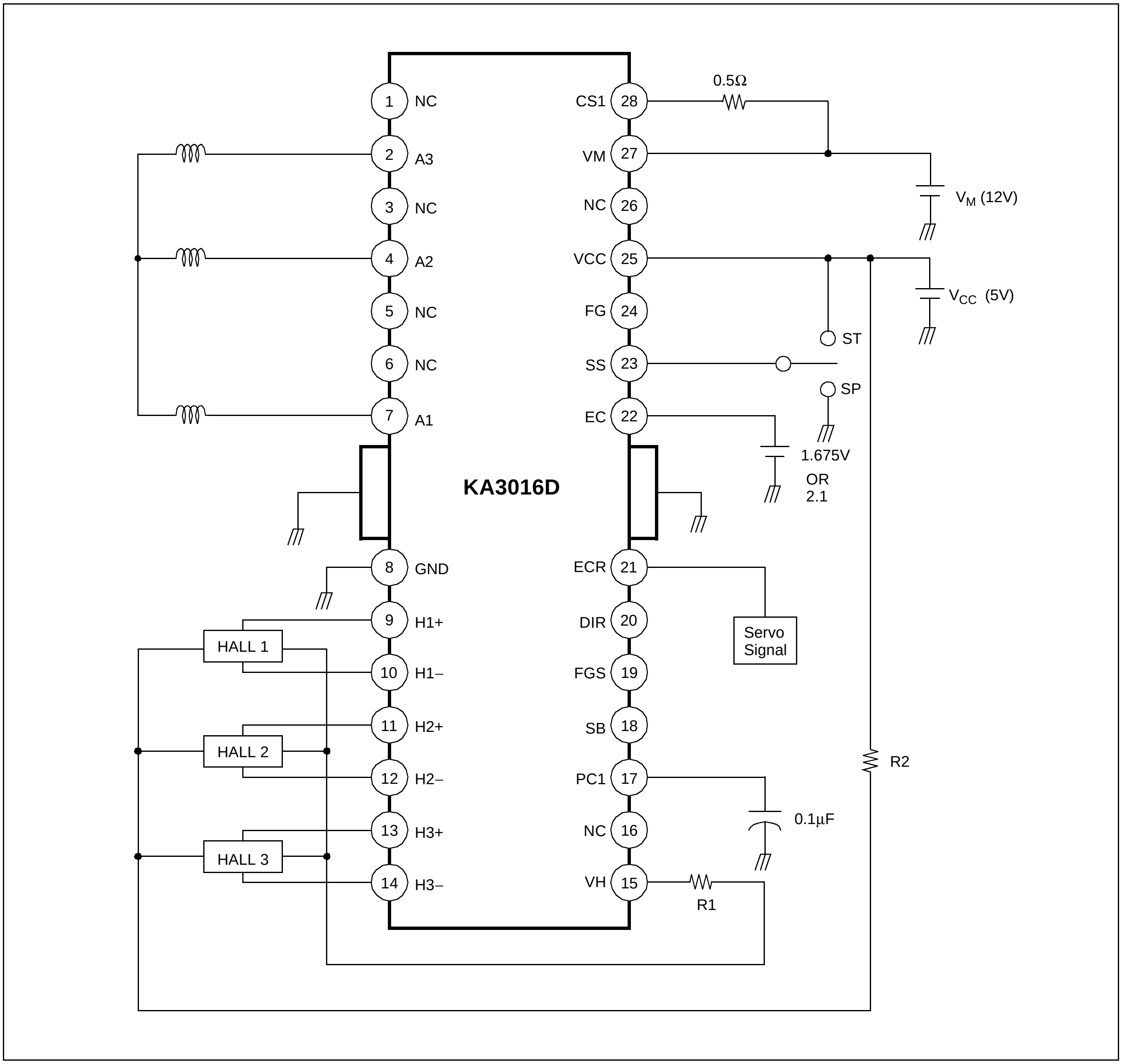
11. INPUT-OUTPUT TIMING CHART



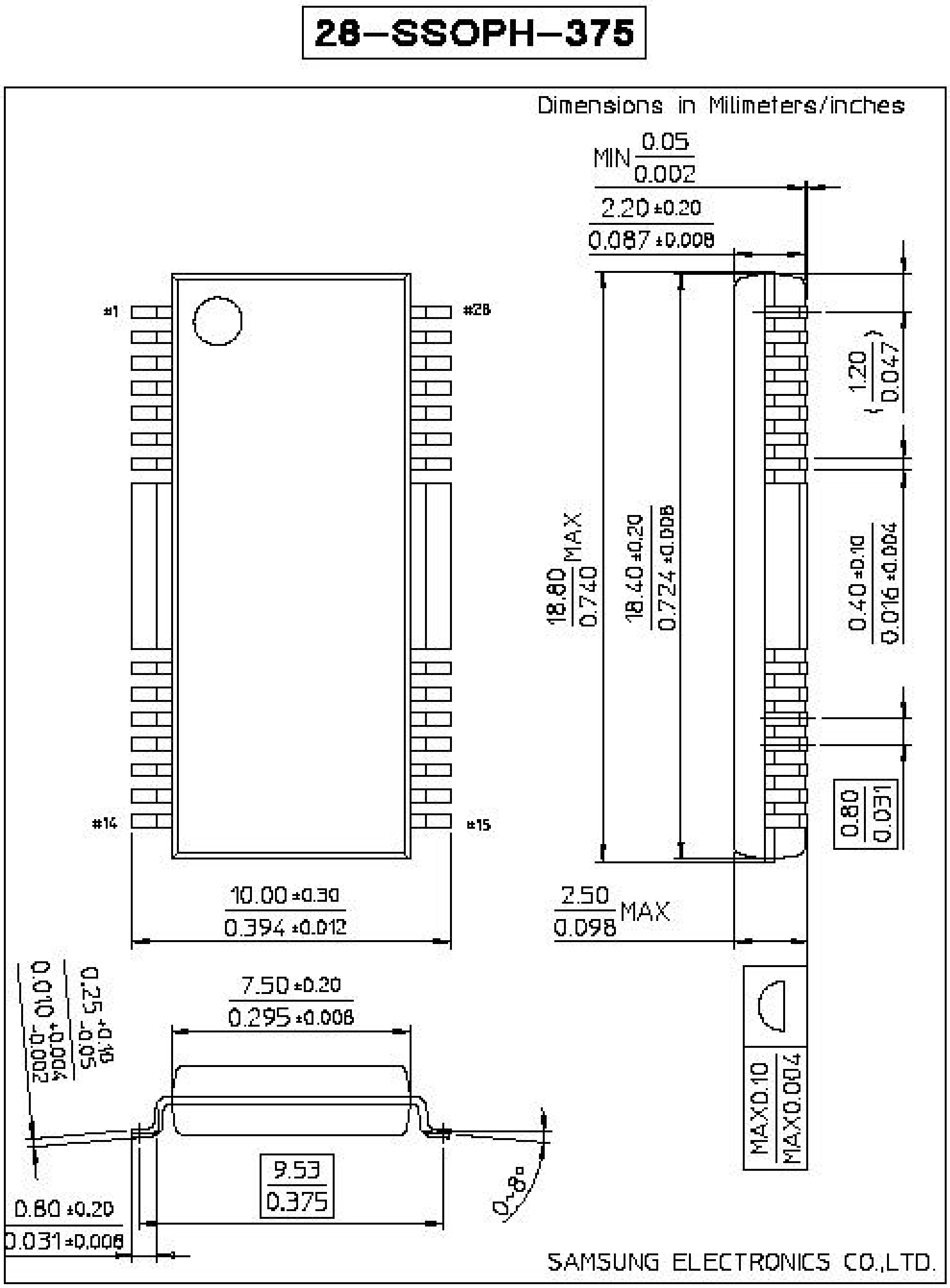
TEST CIRCUITS



TYPICAL APPLICATION



PACKAGE DIMENSION



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PRODUCT STATUS DEFINITIONS

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Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
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