

KA3011BD

3-Phase BLDC Motor Driver

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

Description

The KA3011BD is a monolithic IC, suitable for a 3-phase spindle motor driver of a CD-media system.



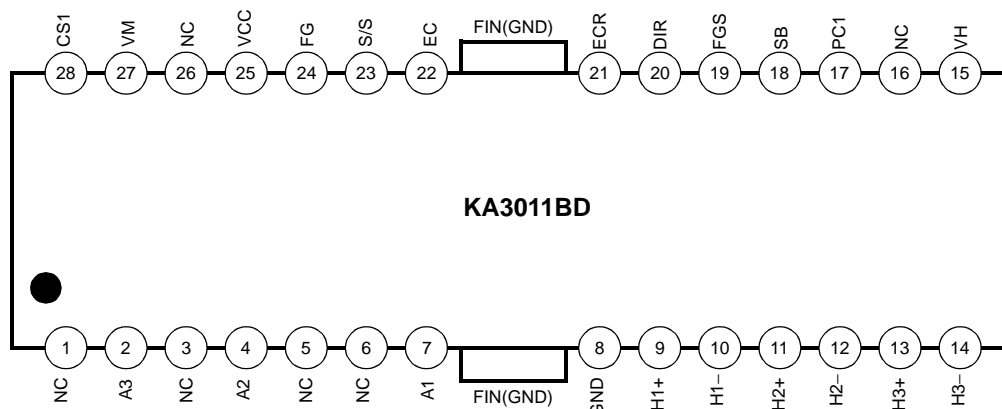
Typical Applications

- Compact disk ROM (CD-ROM) spindle motor
- Compact disk RW (CD-RW) spindle motor
- Digital video disk ROM (DVD-ROM) spindle motor
- Digital video disk RAM (DVD-RAM) spindle motor
- Digital video disk Player (DVDP) spindle motor
- Other compact disk media spindle motor
- Other 3-phase BLDC motor

Ordering Information

| Device | Package | Operating Temp. |
|------------|--------------|-----------------|
| KA3011BD | 28-SSOPH-375 | -25°C ~ +75°C |
| KA3011BDTF | 28-SSOPH-375 | -25°C ~ +75°C |

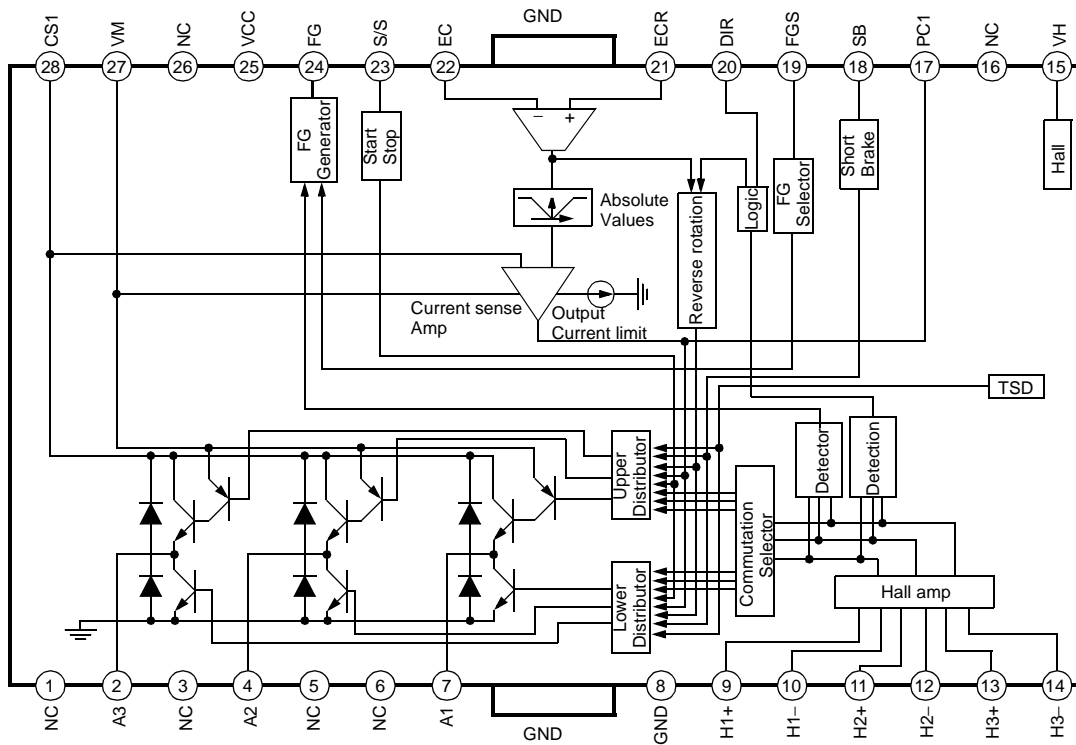
Pin Assignments



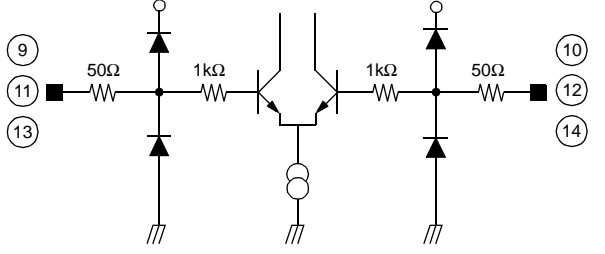
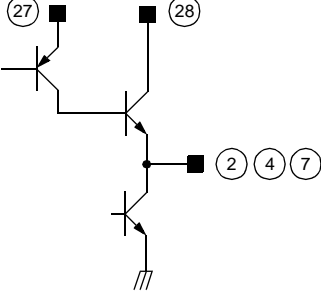
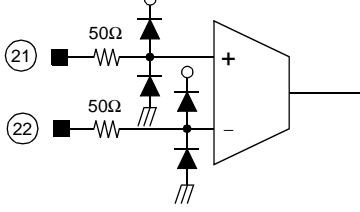
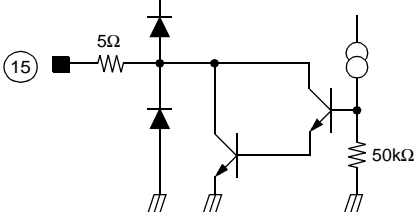
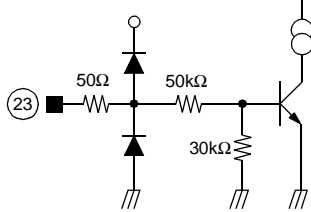
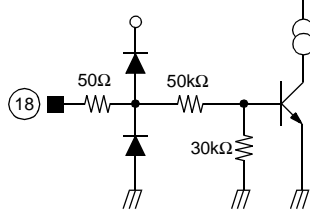
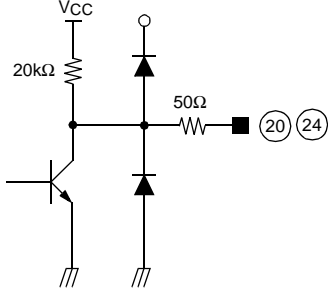
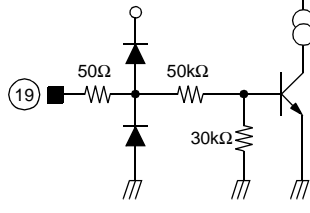
Pin Definitions

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

Internal Block Diagram



Equivalent Circuits

| Hall input | Driver output |
|--|--|
|  <p>Circuit diagram for Hall input. It features a differential pair of transistors. Each base is connected to a diode (anode to input, cathode to ground). The emitters are tied together and connected to ground. The collectors are connected to a common load. Resistors of 50Ω and 1kΩ are used for biasing and signal conditioning. Terminals 9, 11, 13, 10, 12, and 14 are indicated.</p> |  <p>Circuit diagram for Driver output. It is a push-pull stage using two transistors. The top transistor's emitter is connected to the bottom transistor's collector, which is connected to ground. The output is taken from the common emitter/collector node. Terminals 27, 28, 2, 4, and 7 are indicated.</p> |
| Torque control input | Hall bias input |
|  <p>Circuit diagram for Torque control input. It uses an operational amplifier configured as a differential input stage. The non-inverting input (+) and inverting input (-) are each connected to a diode (anode to input, cathode to ground). Resistors of 50Ω are used for biasing. Terminals 21 and 22 are indicated.</p> |  <p>Circuit diagram for Hall bias input. It features a transistor circuit with a diode (anode to input, cathode to ground). The transistor's emitter is connected to ground, and its collector is connected to a load. A 50kΩ resistor is used for biasing. Terminal 15 is indicated.</p> |
| Current detector | Start / Stop |
|  <p>Circuit diagram for Current detector. It uses a transistor with a diode (anode to input, cathode to ground). The transistor's emitter is connected to ground, and its collector is connected to a load. Resistors of 50Ω, 50kΩ, and 30kΩ are used for biasing. Terminal 23 is indicated.</p> |  <p>Circuit diagram for Start / Stop. It uses a transistor with a diode (anode to input, cathode to ground). The transistor's emitter is connected to ground, and its collector is connected to a load. Resistors of 50Ω, 50kΩ, and 30kΩ are used for biasing. Terminal 18 is indicated.</p> |
| Dir or FG output | FGS input |
|  <p>Circuit diagram for Dir or FG output. It features a transistor with a diode (anode to input, cathode to ground). The transistor's emitter is connected to ground, and its collector is connected to a load. Resistors of 20kΩ and 50Ω are used for biasing. Terminals 20 and 24 are indicated.</p> |  <p>Circuit diagram for FGS input. It uses a transistor with a diode (anode to input, cathode to ground). The transistor's emitter is connected to ground, and its collector is connected to a load. Resistors of 50Ω, 50kΩ, and 30kΩ are used for biasing. Terminal 19 is indicated.</p> |

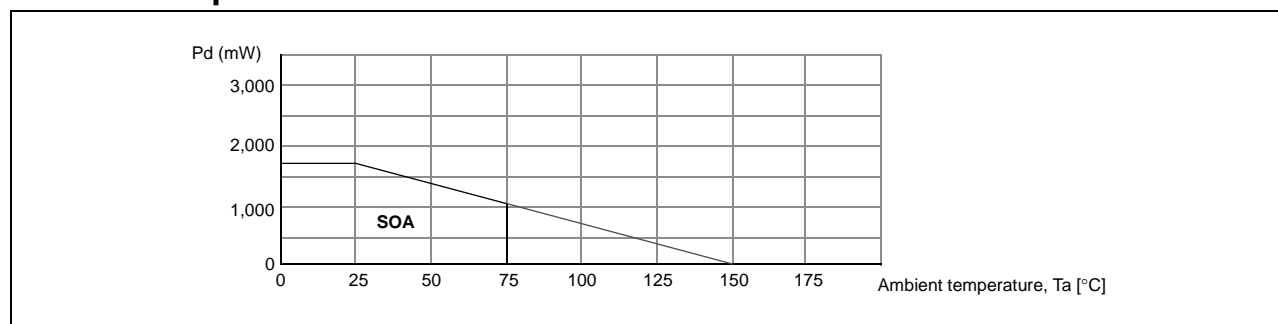
Absolute Maximum Rating (Ta=25°C)

| Parameter | 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 | T _{STG} | -55 ~ +150 | °C |

NOTE:

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

Power Dissipation Curve



Recommended Operating Conditions (Ta=25°C)

| Parameter | Symbol | Min. | Typ. | Max | Units |
|----------------------|-----------------|------|------|-----|-------|
| Supply voltage | V _{CC} | 4.5 | 5 | 5.5 | V |
| Motor supply voltage | V _M | 3.0 | 12 | 15 | V |

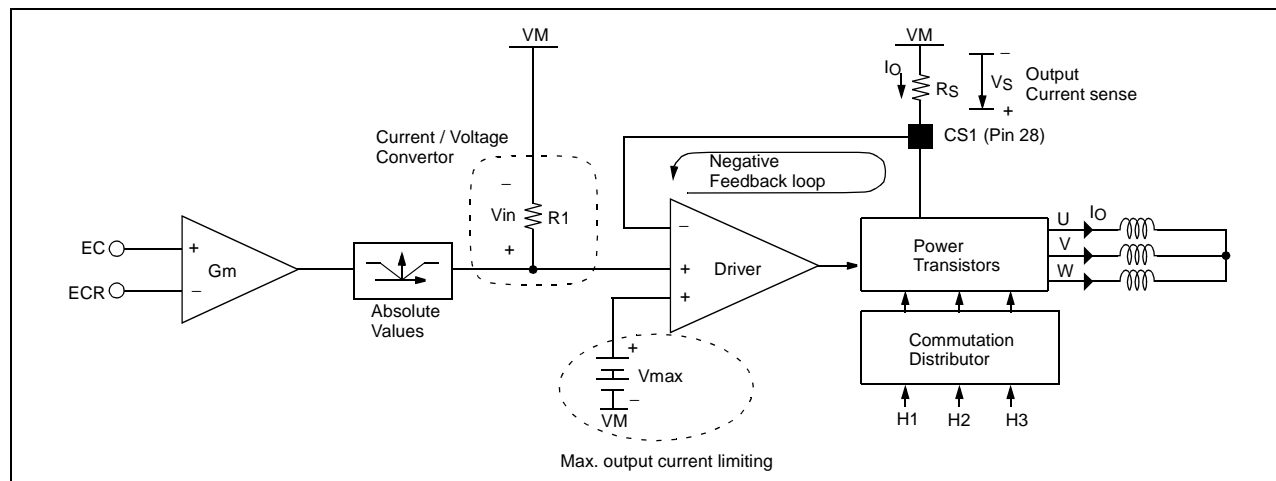
Electrical Characteristics

(Unless otherwise specified, $T_a=25^{\circ}\text{C}$, $V_{CC}=5\text{V}$, $V_M=12\text{V}$)

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Units |
|-------------------------------|-------------|---|------|------|----------|---------------|
| 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} | $I_{HB}=20\text{mA}$ | 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 | | | | | | |
| ECR input voltage range | E_{CR} | – | 0.2 | - | 4.0 | V |
| EC input voltage range | E_C | – | 0.2 | - | 4.0 | V |
| Offset voltage (-) | E_{Coff-} | $E_C=2.5\text{V}$ | -80 | -50 | -20 | mV |
| Offset voltage (+) | E_{Coff+} | $E_C=2.5\text{V}$ | 20 | 50 | 80 | mV |
| EC input current | E_{Cin} | $E_C=2.5\text{V}$ | -5 | 0.5 | 5 | μA |
| ECR input current | E_{CRin} | $E_{CR}=2.5\text{V}$ | -5 | 0.5 | 5 | μA |
| In/output gain | G_{EC} | $E_{CR}=2.5\text{V}$, $R_{CS}=0.5\Omega$ | 0.41 | 0.51 | 0.61 | A / V |
| FG | | | | | | |
| FG output voltage (H) | V_{FGH} | $I_{FG}=-10\mu\text{A}$ | 3.0 | - | V_{CC} | V |
| FG output voltage (L) | V_{FGL} | $I_{FG}=10\mu\text{A}$ | - | - | 0.5 | V |
| Input voltage range | | – | - | 50 | - | % |
| OUTPUT BLOCK | | | | | | |
| Saturation voltage (upper TR) | V_{Oh} | $I_o=-300\text{mA}$ | - | 0.9 | 1.6 | V |
| Saturation voltage (lower TR) | V_{Ol} | $I_o=300\text{mA}$ | - | 0.2 | 0.6 | V |
| Torque limit current | I_{TL} | $R_{CS}=0.5\Omega$ | 560 | 700 | 840 | mA |
| DIRECTION DETECTOR | | | | | | |
| Dir output voltage (H) | V_{DIRh} | $I_{FG}=-10\mu\text{A}$ | 3.0 | - | V_{CC} | V |
| Dir output voltage (L) | V_{DIRl} | $I_{FG}=10\mu\text{A}$ | - | - | 0.5 | V |
| FG SELECTION | | | | | | |
| 3X frequency selection | V_{FG3X} | $FGS > 2.5\text{V}$ | 2.5 | - | V_{CC} | V |
| 1X frequency selection | V_{FG1X} | $FGS < 1.0\text{V}$ | - | - | 1.0 | V |
| SHORT BRAKE | | | | | | |
| On voltage range | V_{SBon} | - | 2.5 | - | V_{CC} | V |
| Off voltage range | V_{SBoff} | - | 0 | - | 1.0 | V |

Electrical Characteristics (Continued)

Calculation of Gain & Torque Limit Current



0.255 from GM times R1 is a fixed value within IC.

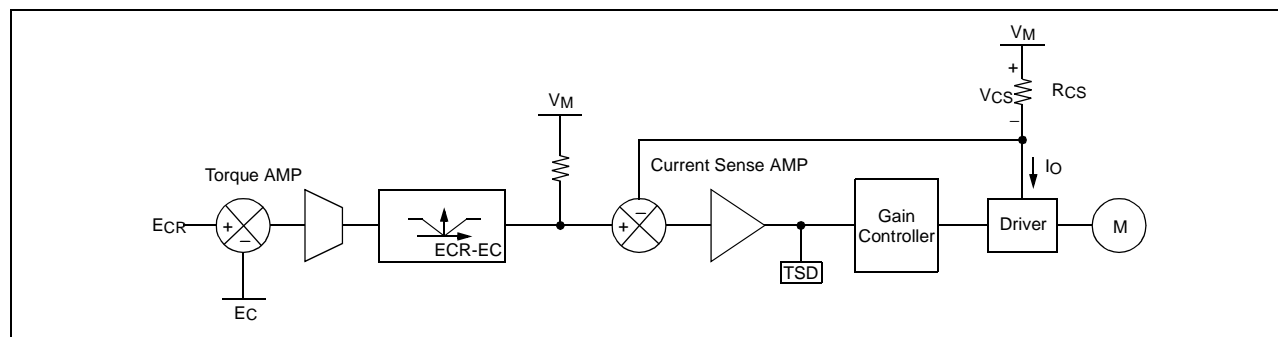
$$\text{Gain} = \frac{0.255}{R_S}$$

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

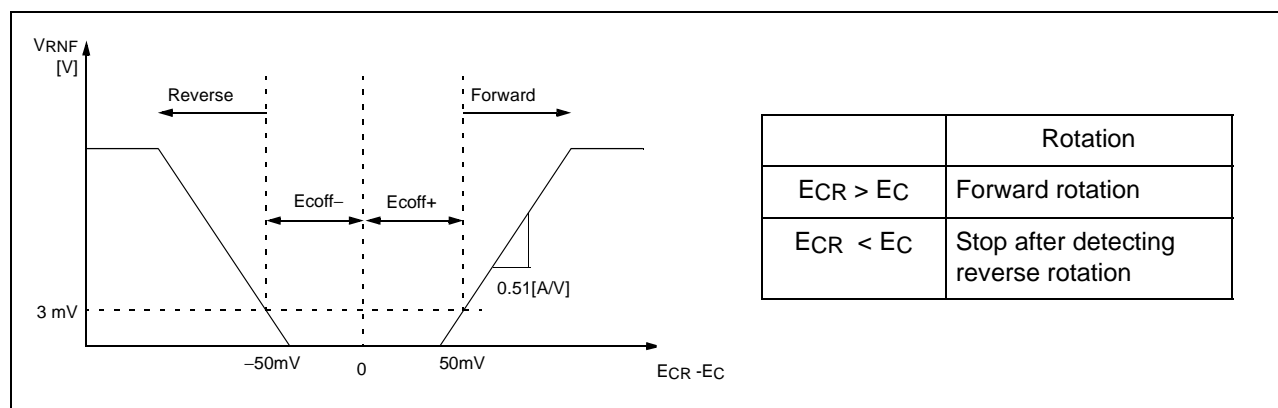
$$|I_t|[\text{mA}] = \frac{V_{\text{max}}}{R_S} = \frac{350[\text{mV}]}{R_S}$$

Application Information

1. TORQUE & OUTPUT CURRENT CONTROL

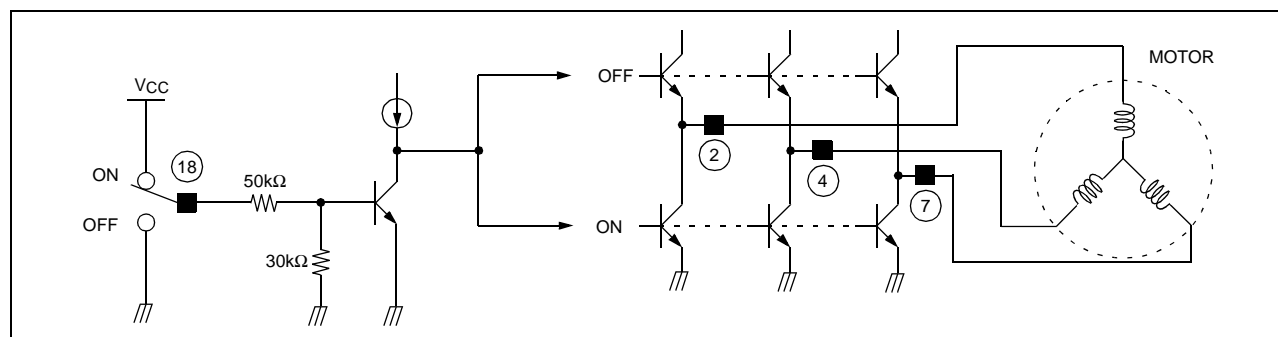


- By amplifying the voltage difference between EC and ECR from servo IC, the torque sense amp produces the input (V_{AMP}) for the current sense amp.
- The output current (I_O) is converted into the voltage (V_{CS}) through the sense resistor (R_{CS}) and compared with the V_{AMP} . By the negative feedback 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, EC and ECR 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.



The input range of ECR , EC is $0.2V \sim 4V$.

2. SHORT BRAKE



| | |
|----------|-------------|
| Pin # 18 | Short brake |
|----------|-------------|

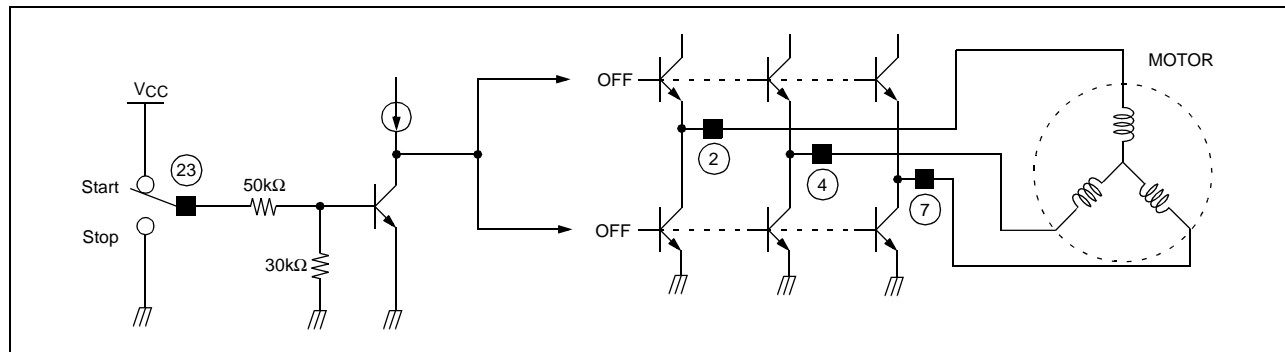
| | |
|------|-----|
| High | On |
| Low | Off |

When the pick-up mechanism 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 more heat at the Drive IC.

To remove this shortcoming and to enhance the braking efficiency, the short brake function is added to KA3011BD. When the short brake function is active, all upper power TRs turn off and all lower power TRs turn on, and the Motor slows down. But FG and DIR functions continue to operate normally.

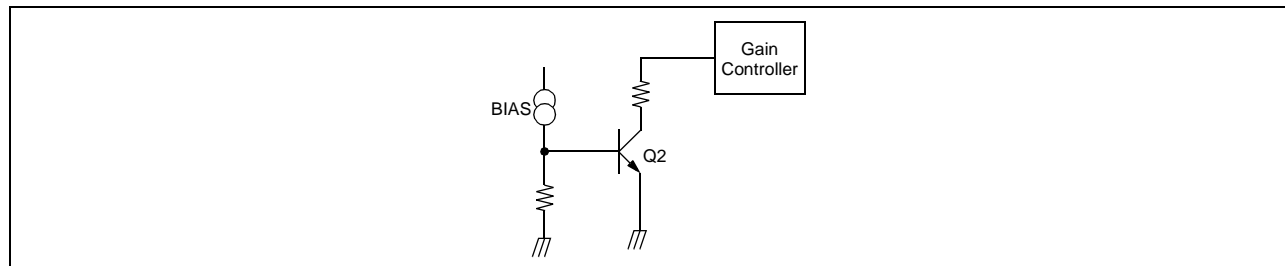
3. POWER SAVE



| Pin # 23 | Start/Stop |
|----------|------------|
| High | Operate |
| Low | Stop |

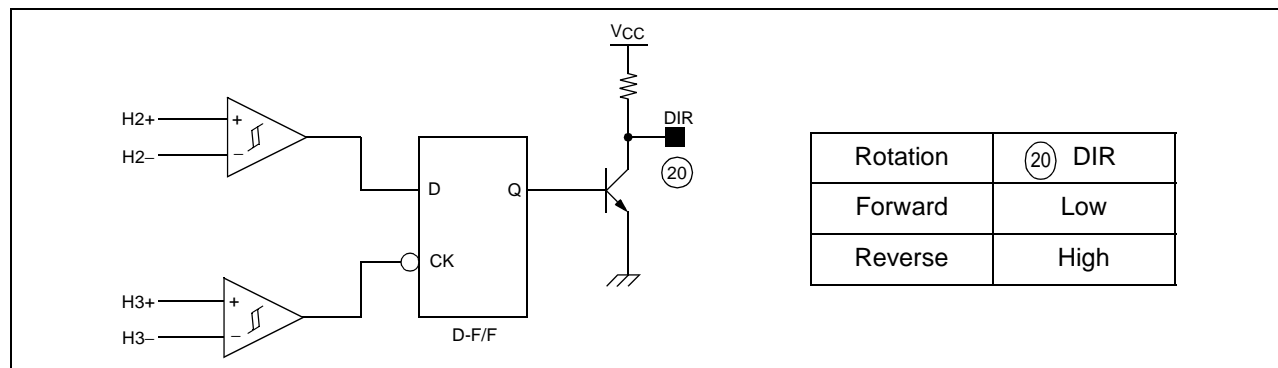
When power save function is active, all power TRs turn off but FG and DIR functions continue to operate normally.

4. TSD (THERMAL SHUTDOWN)

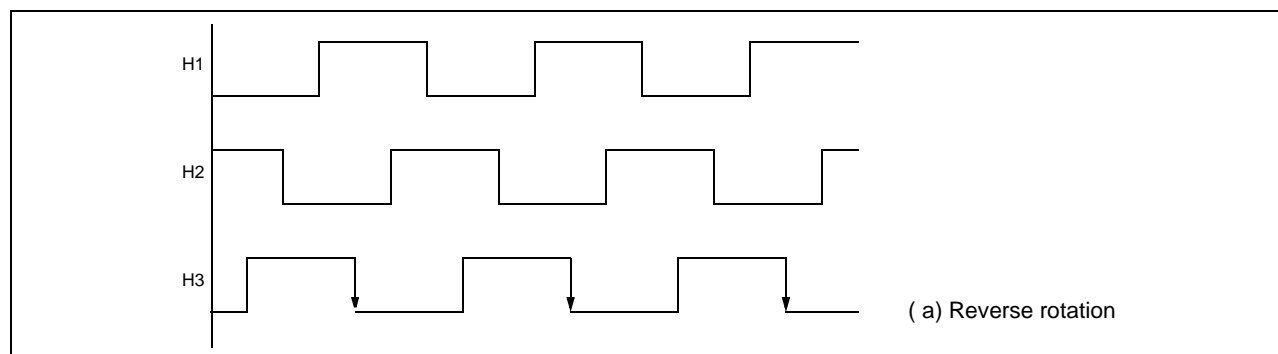


When the chip temperature rises above 175°C, the Q2 turns on and the output driver shuts down. When the chip temperature falls off to about 150°C, then the Q2 turns off and the driver operates normally. TSD has the temperature hysteresis of about 25°C.

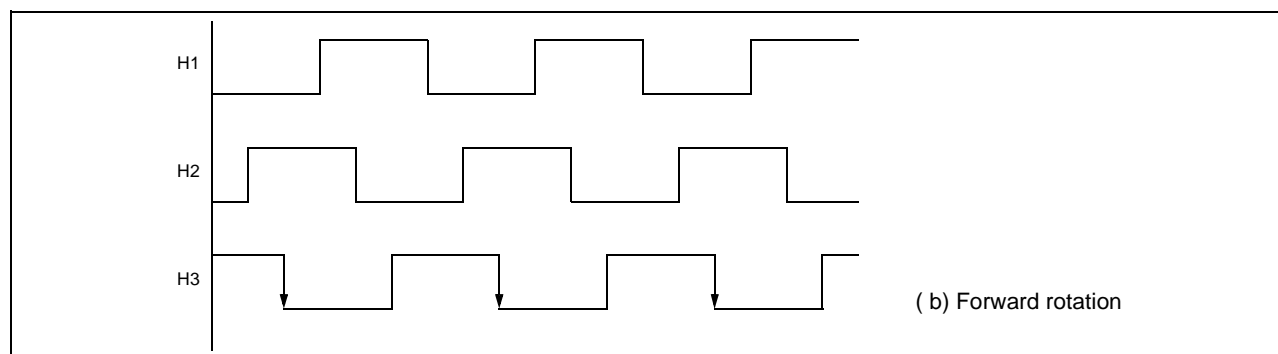
5. ROTATIONAL DIRECTION DETECTION



- The forward and the reverse rotations of the CD are detected by the D-F/F and the truth table is shown above.
- The rotational direction of the CD can be explained by the output waveform of the hall sensors. 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). The phases order are in H1→H2→H3 with a 120° phase difference.

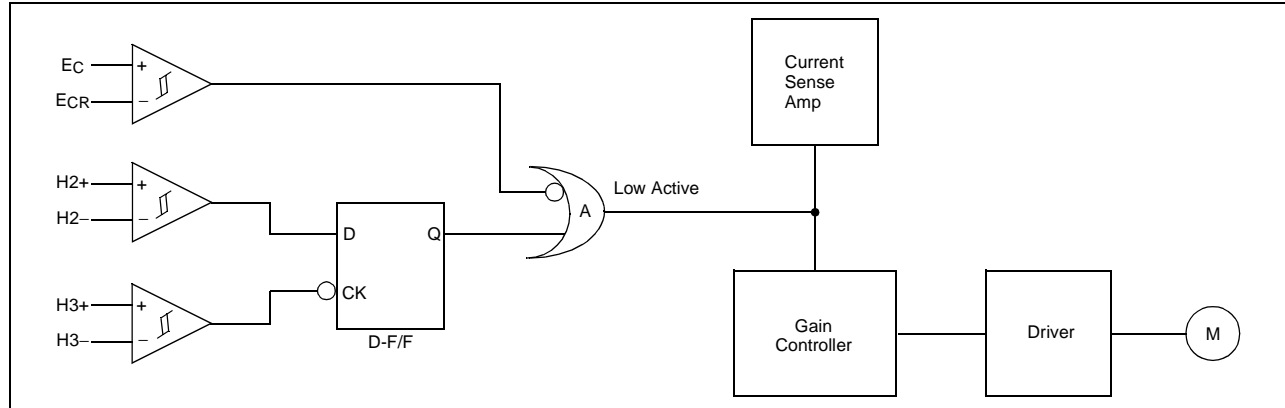


On the other hand, if the spindle rotates in forward rotation, the phase relationship is H3→H2→H1 as shown in Fig.(b).



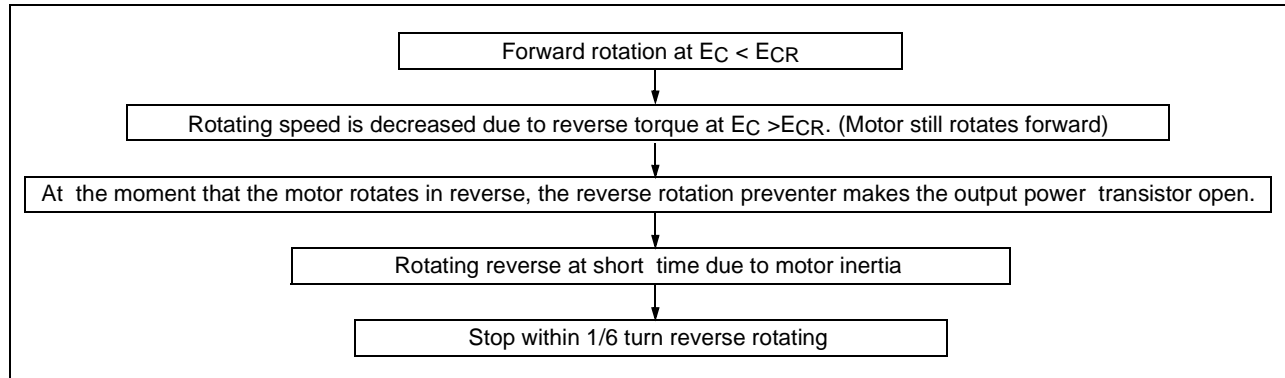
The output of the rotational direction detector is low, when the spindle rotates forward, and high in the reverse rotation.

6. REVERSE ROTATION PREVENTION

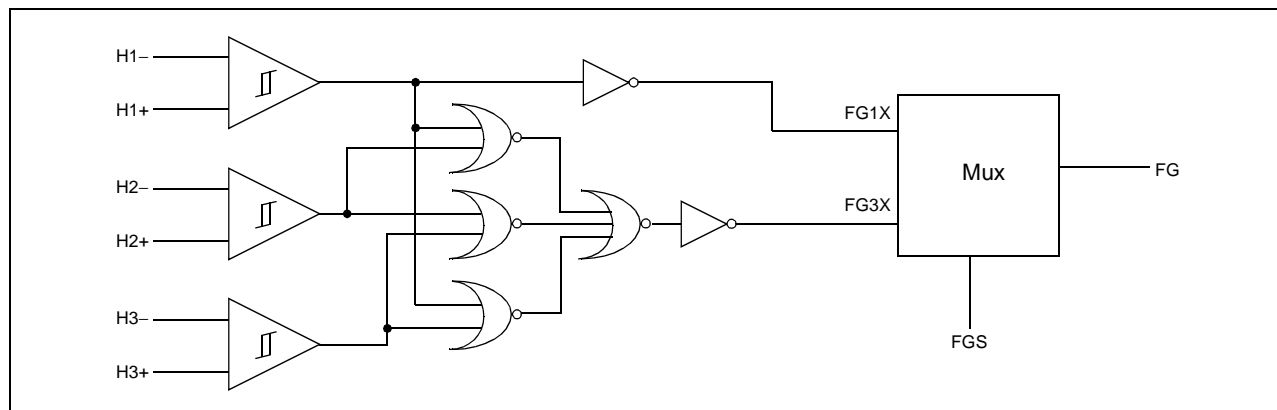


- When the output of the OR Gate, A is LOW, it steers all the output current of the current sense Amp to the Gain Controller zero. The output current of the Driver becomes zero and the motor stops.
- As in the state of the forward rotation, the D-F/F output, Q is HIGH and the motor rotates normally. At this state, if the control input is changed such that $EC > ECR$, then the motor rotates slowly by the reverse commutation in the Driver. When the motor rotates in reverse direction, the D-F/F output becomes Low and the OR Gate output, 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 | |
|----------|----|-----|-----------|----------------------------|----------------|
| | | | | $EC < ECR$ | $EC > ECR$ |
| Forward | H | H→L | H | Forward | - |
| Reverse | L | H→L | L | - | Brake and stop |

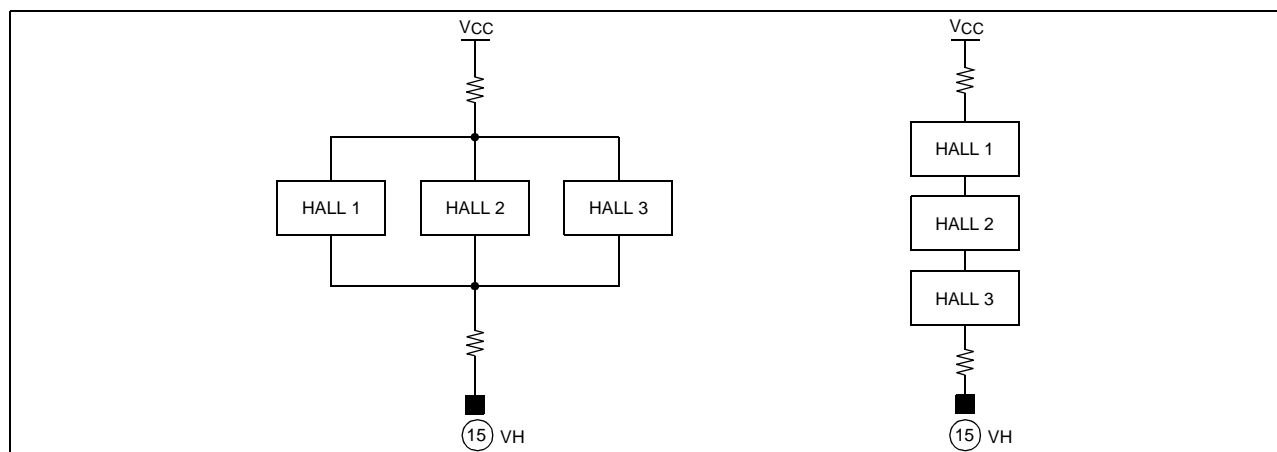


7. FG OUTPUT

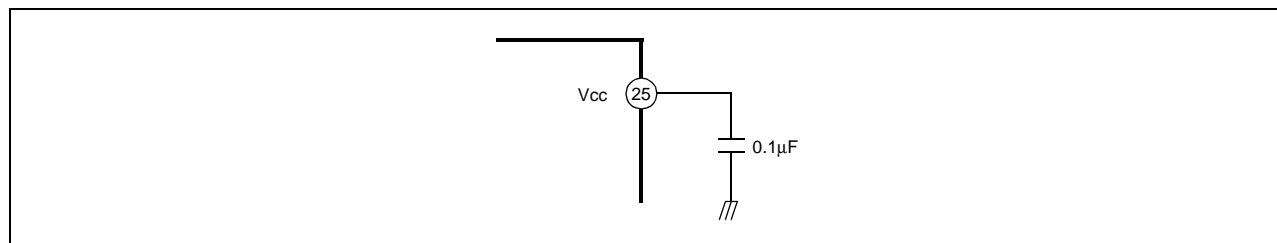


| FGS | FG |
|-------------|--------------------------|
| GND or Open | FG1X (1X hall frequency) |
| VCC | FG3X (3X hall frequency) |

8. HALL SENSOR CONNECTION

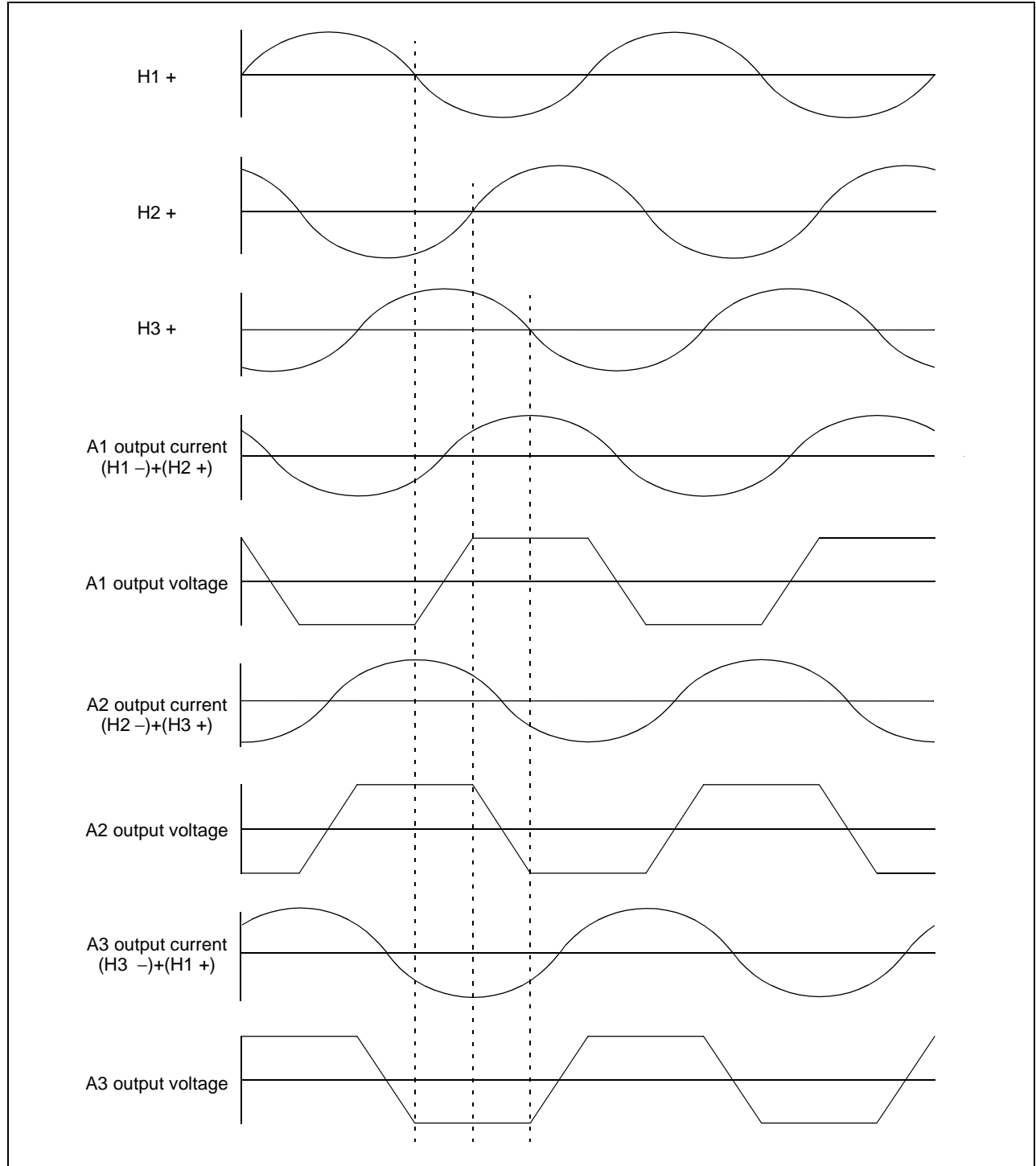


9. Connect a by-pass capacitor, 0.1mF between the supply voltage source.

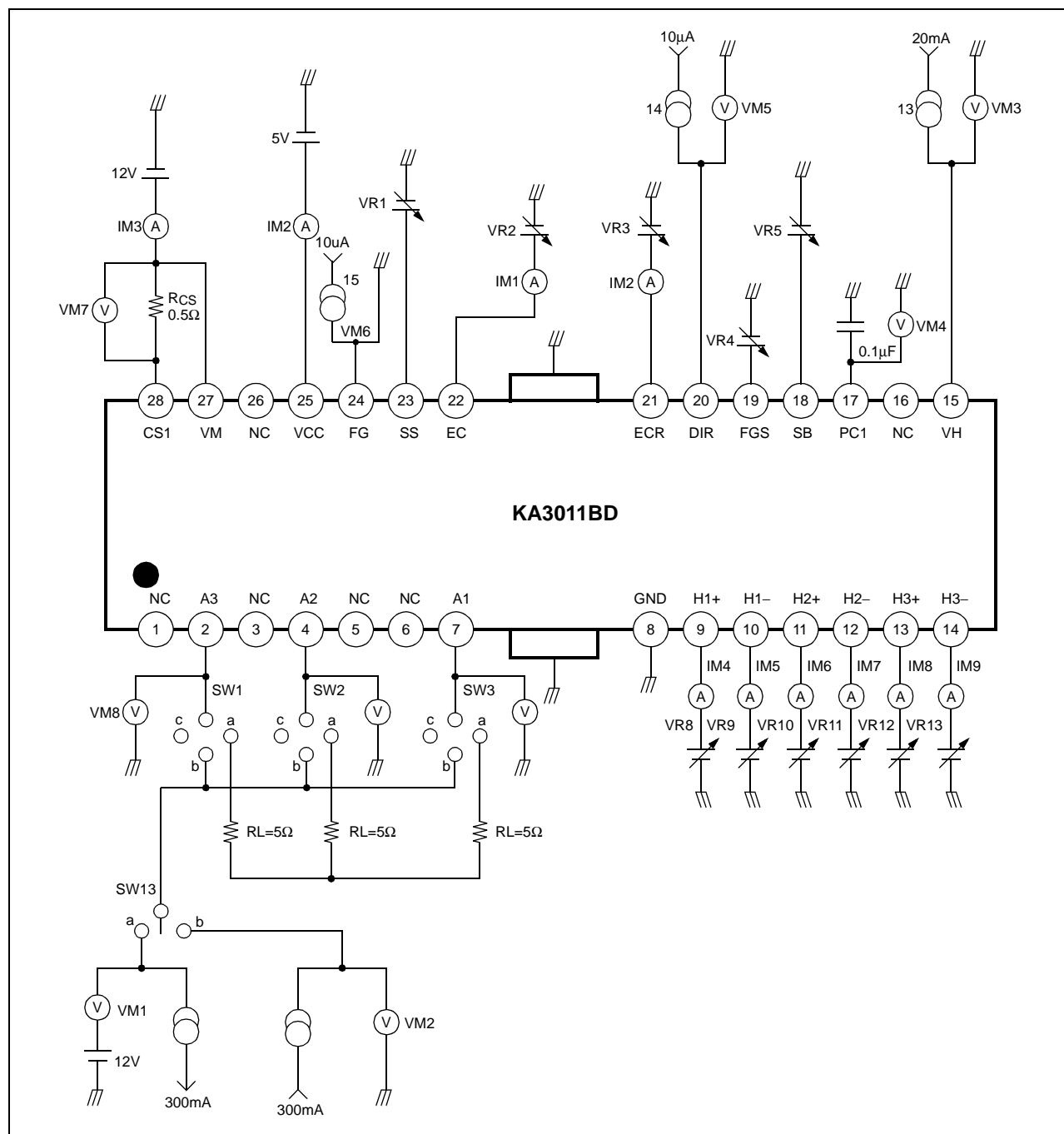


10. The heat radiation fin is connected to the internal GND of the package.
Connect that fin to the external GND.

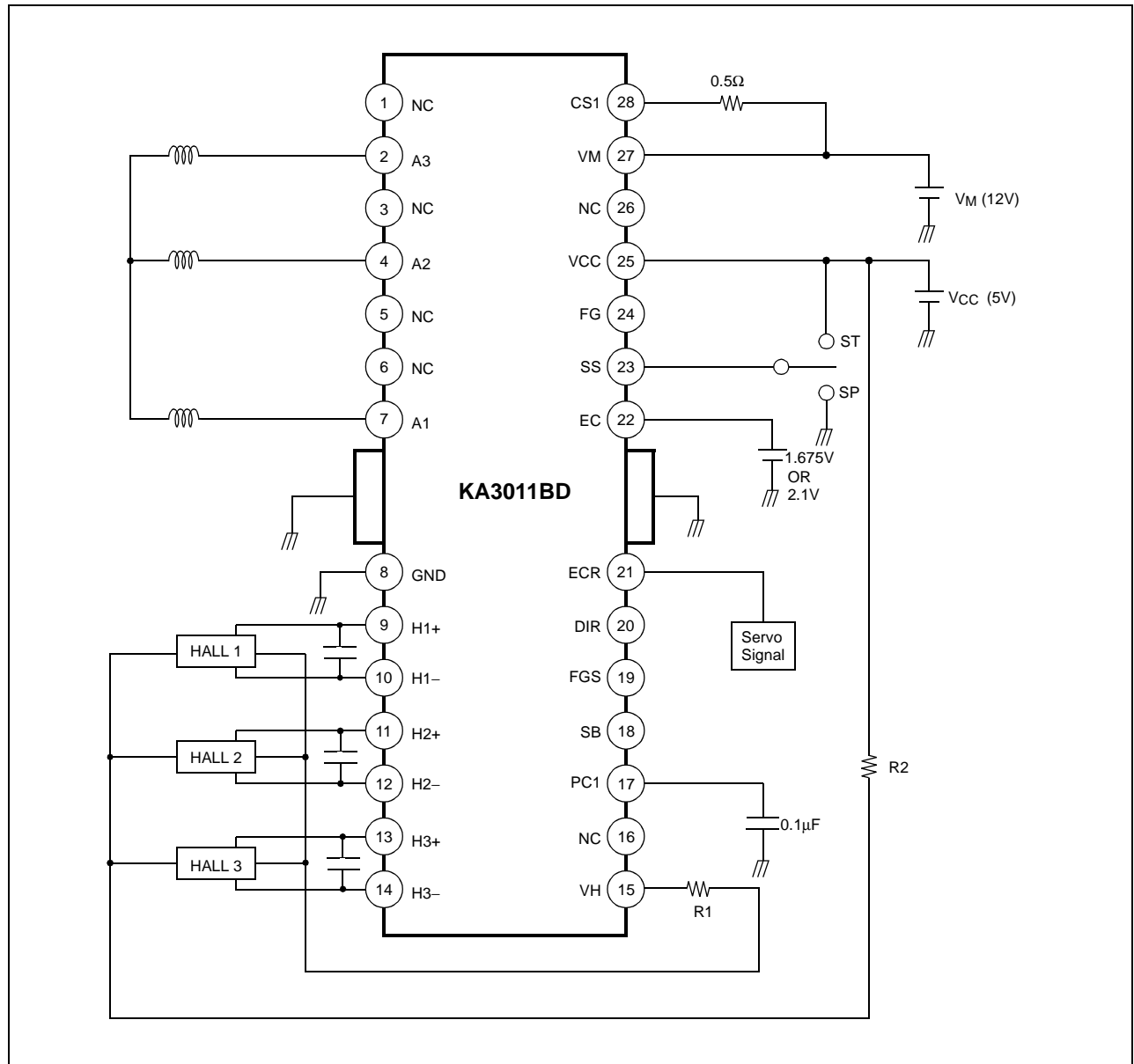
11. INPUT-OUTPUT TIMING CHART



Test Circuits



Typical Application Circuits



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