

# KA3017

## Spindle + 4CH Motor Driver

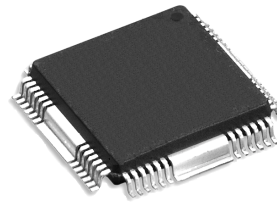
### Features

- Built-in power save circuit
- Built-in current limit circuit
- Built-in thermal shutdown circuit (TSD)
- Built-in hall bias
- Built-in FG signal output circuit
- Built-in rotational direction detecting circuit
- Built-in protection circuit for reverse rotation
- Built-in short brake circuit
- Built-in normal OP-AMP
- Built-in 4-CH balanced transformerless (BTL) driver
- Built-in BTL MUTE circuit (CH1-2, CH3 and CH4)
- Corresponds to 3.3V DSP

### Description

The KA3017 is a monolithic integrated circuit suitable for a 4-ch motor driver which drives the tracking actuator, focus actuator, sled motor, loading motor and 3-phase BLDC spindle motor of the MDP/CAR-MD/CAR-NAVIGATION system.

48-QFPH-1414



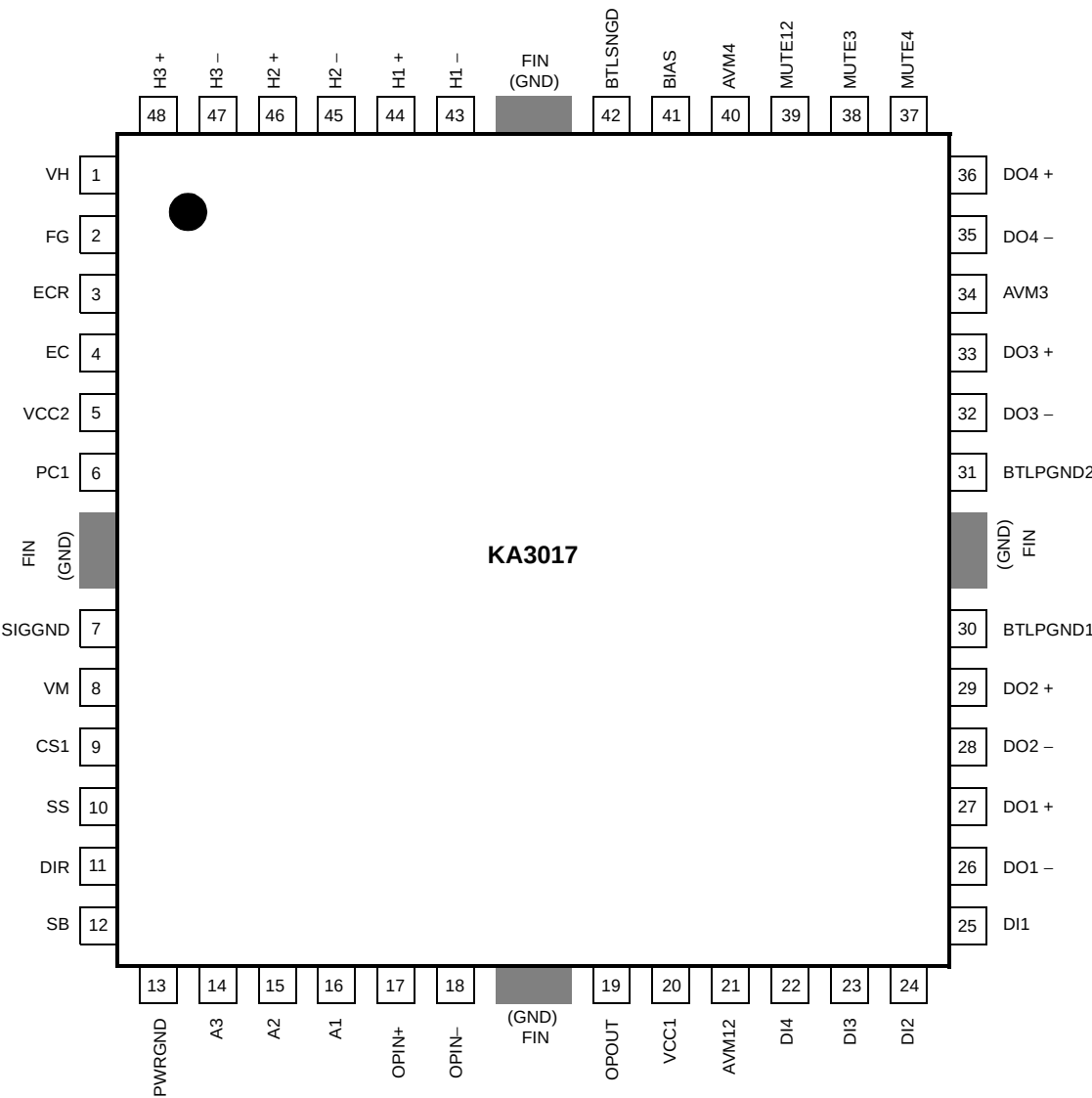
### Target Application

- Mini disk player
- Digital video disk player
- Car mini disk player
- Car navigation system

### Ordering Information

| Device | Package      | Operating Temp. |
|--------|--------------|-----------------|
| KA3014 | 48-QFPH-1414 | -35°C ~ +85°C   |

Pin Assignments



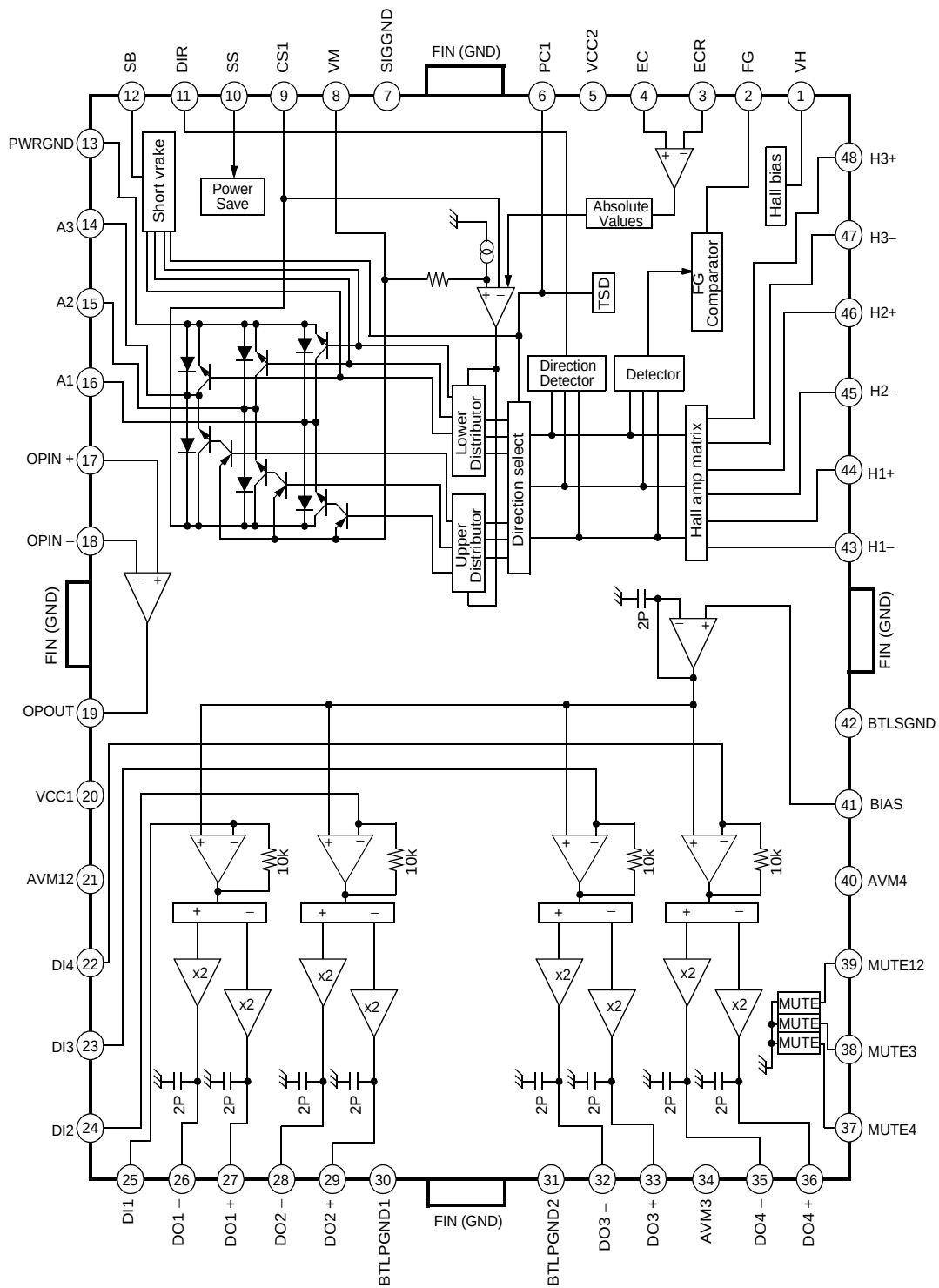
## Pin Definitions

| Pin Number | Pin Name | I/O | Pin Function Description            |
|------------|----------|-----|-------------------------------------|
| 1          | VH       | I   | HALL BIAS                           |
| 2          | FG       | O   | FG SIGNAL OUTPUT                    |
| 3          | ECR      | I   | TORQUE CONTROL REFERENCE            |
| 4          | EC       | I   | TORQUE CONTROL SIGNAL               |
| 5          | VCC2     | –   | SUPPLY VOLTAGE                      |
| 6          | PC1      | –   | PHASE COMPENSATION CAPACITOR        |
| 7          | SIGGND   | –   | SIGNAL GROUND                       |
| 8          | VM       | –   | MOTOR SUPPLY VOLTAGE                |
| 9          | CS1      | I   | CURRENT SENSOR                      |
| 10         | S/S      | I   | START/STOP                          |
| 11         | DIR      | O   | 3-PHASE ROTATIONAL DIRECTION OUTPUT |
| 12         | SB       | I   | SHORT BRAKE                         |
| 13         | PWRGND   | –   | POWER GROUND                        |
| 14         | A3       | O   | 3-PHASE OUTPUT 3                    |
| 15         | A2       | O   | 3-PHASE OUTPUT 2                    |
| 16         | A1       | O   | 3-PHASE OUTPUT 1                    |
| 17         | OPIN+    | I   | OP AMP INPUT (+)                    |
| 18         | OPIN-    | I   | OP AMP INPUT (-)                    |
| 19         | OPOUT    | O   | OP AMP OUTPUT                       |
| 20         | VCC1     | –   | SUPPLY VOLTAGE                      |
| 21         | AVM12    | –   | BTL CH-1, 2 MOTOR SUPPLY VOLTAGE    |
| 22         | DI4      | I   | BTL DRIVE INPUT 4                   |
| 23         | DI3      | I   | BTL DRIVE INPUT 3                   |
| 24         | DI2      | I   | BTL DRIVE INPUT 2                   |
| 25         | DI1      | I   | BTL DRIVE INPUT 1                   |
| 26         | DO1-     | O   | BTL DRIVE 1 OUTPUT (-)              |
| 27         | DO1+     | O   | BTL DRIVE 1 OUTPUT (+)              |
| 28         | DO2-     | O   | BTL DRIVE 2 OUTPUT (-)              |
| 29         | DO2+     | O   | BTL DRIVE 2 OUTPUT (+)              |
| 30         | BTLPGND1 | –   | BTL POWER GROUND 1                  |
| 31         | BTLPGND2 | –   | BTL POWER GROUND 2                  |
| 32         | DO3-     | O   | BTL DRIVE 3 OUTPUT (-)              |
| 33         | DO3+     | O   | BTL DRIVE 3 OUTPUT (+)              |

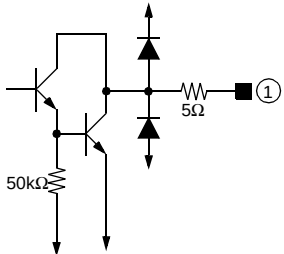
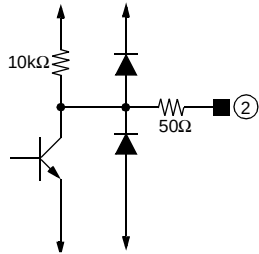
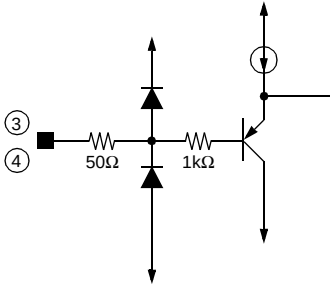
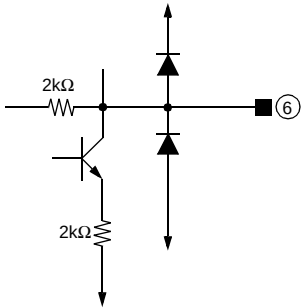
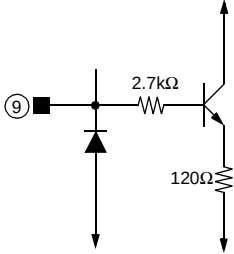
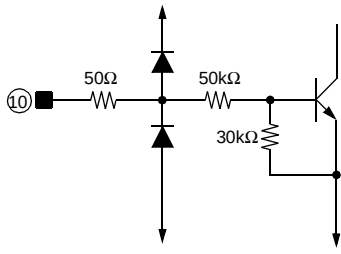
**Pin Definitions (Continued)**

| Pin Number | Pin Name | I/O | Pin Function Description      |
|------------|----------|-----|-------------------------------|
| 34         | AVM3     | –   | BTL CH3 MOTOR SUPPLY VOLTAGE  |
| 35         | DO4-     | O   | BTL DRIVE 4 OUTPUT (-)        |
| 36         | DO4+     | O   | BTL DRIVE 4 OUTPUT (+)        |
| 37         | MUTE4    | I   | BTL DRIVE MUTE CH 4           |
| 38         | MUTE3    | I   | BTL DRIVE MUTE CH 3           |
| 39         | MUTE12   | I   | BTL DRIVE MUTE CH 1, 2        |
| 40         | AVM4     | –   | BTL CH 4 MOTOR SUPPLY VOLTAGE |
| 41         | BIAS     | –   | BTL BIAS VOLTAGE              |
| 42         | BTLSGND  | –   | BTL DRIVE SIGNAL GROUND       |
| 43         | H1-      | I   | HALL1(-) INPUT                |
| 44         | H1+      | I   | HALL1(+) INPUT                |
| 45         | H2-      | I   | HALL2(-) INPUT                |
| 46         | H2+      | I   | HALL2(+) INPUT                |
| 47         | H3-      | I   | HALL3(-) INPUT                |
| 48         | H3+      | I   | HALL3(+) INPUT                |

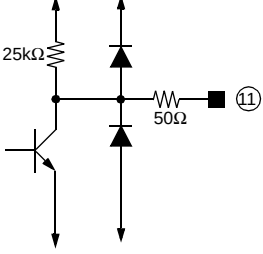
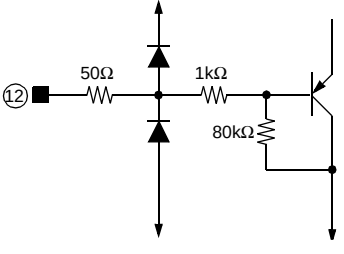
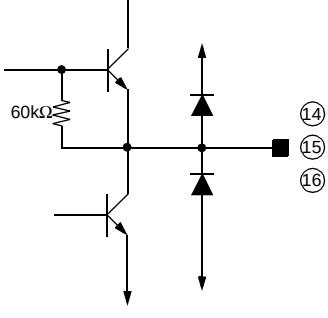
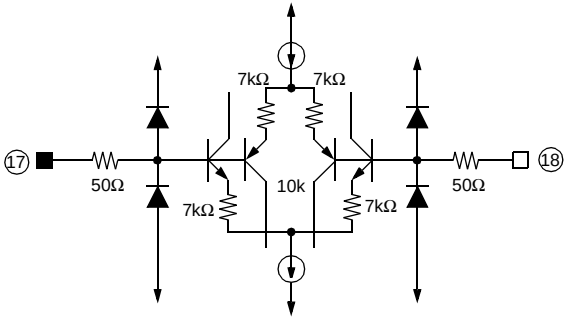
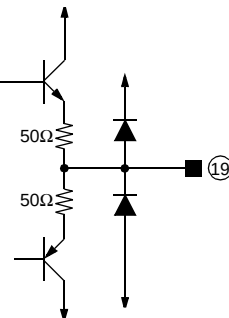
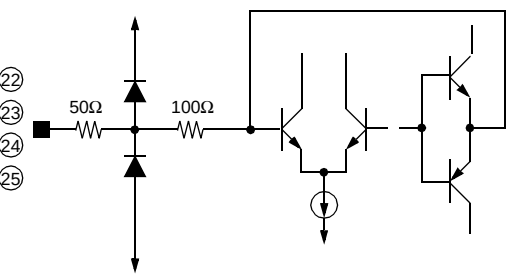
# Internal Block Diagram



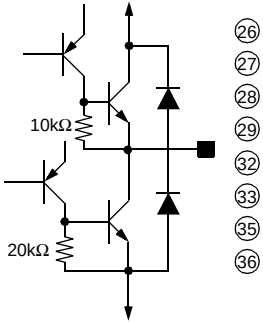
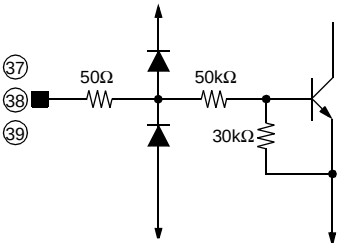
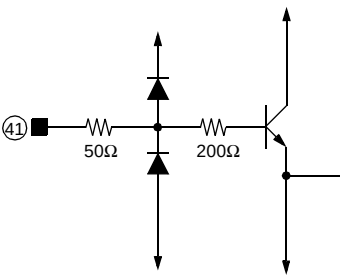
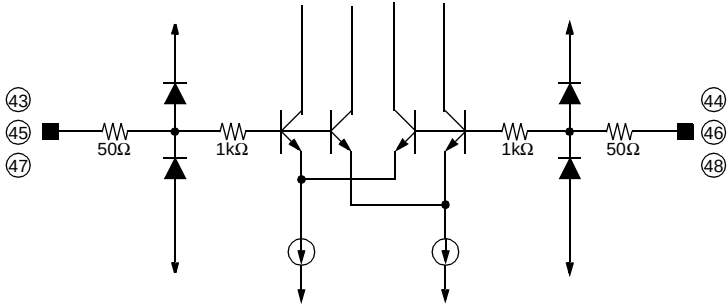
Equivalent Circuits

| HALL BIAS                                                                           | FG SIGNAL OUTPUT                                                                     |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|    |    |
| TORQUE CONTROL REFERENCE & SIGNAL                                                   | PHASE COMPENSATION CAPACITOR                                                         |
|   |   |
| CURRENT DETECTOR                                                                    | START/STOP                                                                           |
|  |  |

# Equivalent Circuits (Continued)

| 3-PHASE ROTATIONAL DIRECTION OUTPUT                                                 | SHORT BRAKE                                                                          |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|    |    |
| 3-PHASE OUTPUT                                                                      | OP AMP INPUT                                                                         |
|   |   |
| OP AMP OUPUT                                                                        | BTL DRIVE INPUT                                                                      |
|  |  |

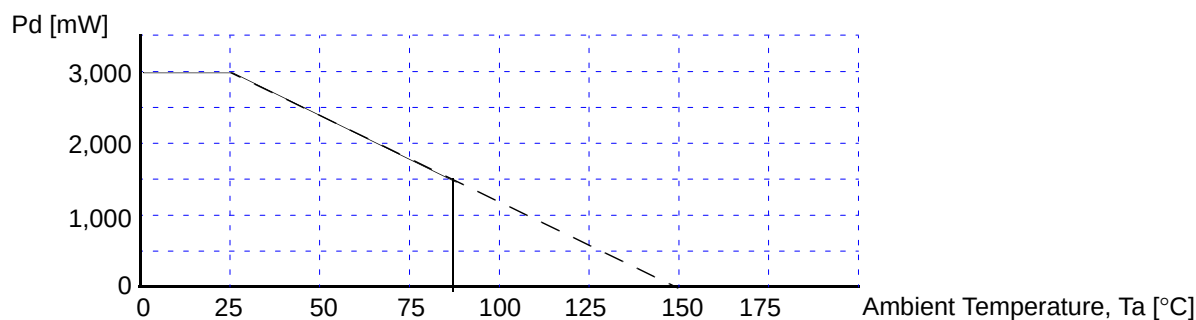
Equivalent Circuits (Continued)

| BTL DRIVE OUTPUT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | BTL DRIVE MUTE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>The BTL Drive Output circuit is a push-pull stage. It features two NPN transistors at the output, with their emitters connected to ground. The bases are driven by a differential signal through a network of resistors and diodes. A 10kΩ resistor is connected to the base of the upper transistor, and a 20kΩ resistor is connected to the base of the lower transistor. Diodes are used for level shifting and protection. Pin numbers 26, 27, 28, 29, 32, 33, 35, and 36 are indicated on the right side of the diagram.</p> |  <p>The BTL Drive Mute circuit is a simple mute switch. It consists of a 50Ω resistor in series with a 50kΩ resistor, which is then connected to the base of an NPN transistor. The emitter of the transistor is grounded, and the collector is connected to the output. A 30kΩ resistor is connected between the base and emitter of the transistor. Pin numbers 37, 38, and 39 are indicated on the left side of the diagram.</p>                                                                                                              |
| BTL BIAS VOLTAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | HALL INPUT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|  <p>The BTL Bias Voltage circuit is a simple biasing network. It consists of a 50Ω resistor in series with a 200Ω resistor, which is then connected to the base of an NPN transistor. The emitter of the transistor is grounded, and the collector is connected to the output. Diodes are used for level shifting and protection. Pin number 41 is indicated on the left side of the diagram.</p>                                                                                                                                    |  <p>The Hall Input circuit is a complex differential input stage. It features two NPN transistors at the input, with their emitters connected to ground. The bases are driven by a differential signal through a network of resistors and diodes. A 50Ω resistor is connected to the base of the upper transistor, and a 1kΩ resistor is connected to the base of the lower transistor. Diodes are used for level shifting and protection. Pin numbers 43, 45, 47, 44, 46, and 48 are indicated on the left and right sides of the diagram.</p> |

## Absolute Maximum Ratings ( Ta=25°C)

| Parameter                             | Symbol   | Value               | Unit |
|---------------------------------------|----------|---------------------|------|
| Supply Voltage (BTL SIGNAL)           | VCC1max  | 15                  | V    |
| Supply Voltage (SPINDLE SIGNAL)       | VCC2max  | 7                   | V    |
| Supply Voltage (MOTOR)                | VMmax    | 15                  | V    |
| Supply Voltage (BTL MOTOR)            | VMBTLmax | 15                  | V    |
| Power Dissipation                     | Pd       | 3.0 <sup>note</sup> | W    |
| Operating Temperature Range           | Topr     | -35 ~ +85           | °C   |
| Storage Temperature Range             | Tstg     | -55 ~ +150          | °C   |
| Maximum Output Current (SPINDLE part) | IOMAXS   | 1.3                 | A    |
| Maximum Output Current (BTL part)     | IOMAXB   | 1                   | A    |

NOTE: 1. When mounted on 70mm × 70 mm × 1.6mm PCB (Phenolic resin material)  
 2. Power dissipation is reduced 24 mW/°C for using above Ta=25°C  
 3. Do not exceed Pd and SOA (Safe Operating Area).



## Recommended Operating Conditions ( Ta=25°C)

| Parameter                                 | Symbol | Min. | Typ. | Max. | Unit |
|-------------------------------------------|--------|------|------|------|------|
| Operating Supply Voltage (BTL SIGNAL)     | VCC1   | 4.5  | —    | 13.2 | V    |
| Operating Supply Voltage (SPINDLE SIGNAL) | VCC2   | 4.5  | —    | 5.5  | V    |
| Operating Supply Voltage ( SPINDLE MOTOR) | VM     | 4.5  | —    | 13.2 | V    |
| Operating Supply Voltage (BTL MOTOR)      | VMBTL  | 4.5  | —    | 13.2 | V    |

**Electrical Characteristics** (Ta=25°C, VCC2=5V, VM=12V)

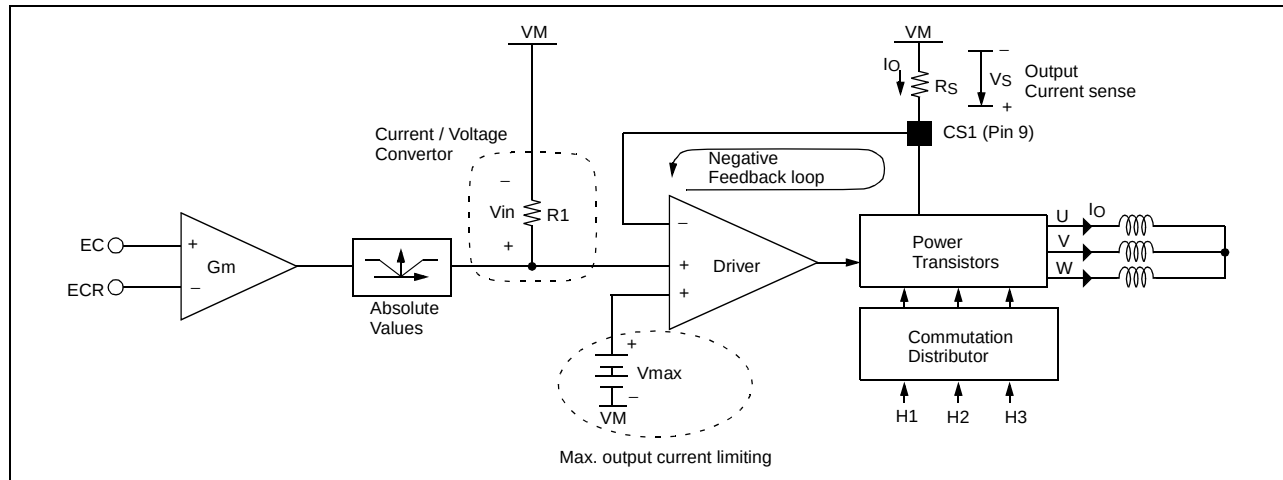
| Parameter                     | Symbol | Condition              | Min. | Typ. | Max. | Units |
|-------------------------------|--------|------------------------|------|------|------|-------|
| Circuit Current 1             | ICC 1  | Power Save=0V          | –    | 0    | 0.1  | mA    |
| Circuit Current 2             | ICC2   | Power Save=5V          | –    | 8.0  | –    | mA    |
| <b>START/STOP</b>             |        |                        |      |      |      |       |
| On Voltage Range              | VPSON  | L-H Circuit On         | 2.5  | –    | –    | V     |
| Off Voltage Range             | VPSOFF | H-L Circuit Off        | –    | –    | 0.5  | V     |
| <b>HALL BIAS</b>              |        |                        |      |      |      |       |
| Hall Bias Voltage             | VHB    | IHB=20mA               | –    | 1.2  | 1.8  | V     |
| <b>HALL AMP</b>               |        |                        |      |      |      |       |
| Hall Bias Current             | IHA    | -                      | –    | 1    | 5    | uA    |
| In-phase in Voltage Range     | VHAR   | -                      | 1.5  | –    | 4.0  | V     |
| Minimum in Level              | VINH   | -                      | 60   | –    | –    | mVpp  |
| <b>TORQUE CONTROL</b>         |        |                        |      |      |      |       |
| In Voltage Range              | EC     |                        | 0.5  | –    | 3.3  | V     |
| Offset Voltage (-)            | ECOFF- | ECR=2.5V               | -80  | -50  | -20  | mV    |
| Offset Voltage (+)            | ECOFF+ | ECR=2.5V               | 20   | 50   | 80   | mV    |
| In Current                    | ECIN   | EC=ECR=2.5V            | -5   | -1   | –    | uA    |
| In/output Gain                | GEC    | ECR=2.5V, RCS=0.5Ω     | 0.41 | 0.51 | 0.61 | A / V |
| <b>FG</b>                     |        |                        |      |      |      |       |
| FG Output Voltage (H)         | VFGH   | IFG= -10uA             | 3.0  | –    | VCC  | V     |
| FG Output Voltage (L)         | VFHL   | IFG=10uA               | –    | –    | 0.5  | V     |
| Input Voltage Range           | VFGR   | Hn+, Hn- input D-range | 1.5  | –    | 4.0  | V     |
| <b>OUTPUT BLOCK</b>           |        |                        |      |      |      |       |
| Saturation Voltage (upper TR) | VOH    | IO= -300mA             | –    | 0.9  | 1.6  | V     |
| Saturation Voltage (lower TR) | VOL    | IO=300mA               | –    | 0.2  | 0.6  | V     |
| Torque Limit Current          | ITL    | RCS=0.5Ω               | 560  | 700  | 840  | mA    |
| <b>DIRECTION DETECTOR</b>     |        |                        |      |      |      |       |
| Dir Output Voltage (H)        | VDIRH  | IFG=-10uA              | 3.0  | –    | VCC  | V     |
| Dir Output Voltage (L)        | VDIRL  | IFG=10uA               | –    | –    | 0.5  | V     |
| <b>SHORT BRAKE</b>            |        |                        |      |      |      |       |
| On Voltage Range              | VSBON  | -                      | 2.5  | –    | VCC  | V     |
| Off Voltage Range             | VSOFF  | -                      | 0    | –    | 0.5  | V     |

## Electrical Characteristics (continued)

BTL Drive Part (Ta=25°C, VCC1=12V, VMBTL=12V, RL=24Ω)

| Parameter                        | Symbol  | Condition                 | Min. | Typ. | Max. | Units |
|----------------------------------|---------|---------------------------|------|------|------|-------|
| Quiescent Circuit Current        | ICC     | -                         | –    | 9    | 12   | mA    |
| Output Offset Voltage            | VOO     | -                         | -30  | –    | 30   | mV    |
| Maximum Output Amplitude Voltage | VOM     | -                         | 9.5  | 10.5 | –    | V     |
| Voltage Gain                     | GVC     | VIN=0.1Vrms, 1kHz         | 10.5 | 12.0 | 13.5 | dB    |
| Ripple Rejection Ratio           | RR      | VIN=0.1Vrms, 120kHz       | –    | 60   | –    | dB    |
| Slew Rate                        | SR      | 120Hz, 2Vpp               | –    | 1.0  | –    | V/us  |
| CH Mute Off Voltage              | VMOFFCH | pin37, 38, 39 = Variation | –    | –    | 0.5  | V     |
| CH Mute On Voltage               | VMONCH  | pin37, 38, 39 = Variation | 2.5  | –    | –    | V     |
| <b>NORMAL OP- AMP</b>            |         |                           |      |      |      |       |
| Input Offset Voltage             | VOF     | -                         | -10  | –    | +10  | mV    |
| Input Bias Current               | IB1     | -                         | –    | –    | 300  | nA    |
| High Level Output Voltage        | VOH1    | -                         | 6    | 6.8  | –    | V     |
| Low Level Output Voltage         | VOL1    | -                         | –    | 1    | 1.8  | V     |
| Output Sink Current              | ISINK   | -                         | 10   | 20   | –    | mA    |
| Output Source Current            | ISOU1   | -                         | 10   | 20   | –    | mA    |
| Open Loop Voltage Gain           | GVO1    | f=1kHz, VIN=-75dB         | –    | 75   | –    | dB    |
| Ripple Rejection Ratio           | RR1     | f=120Hz, VIN=-20dB        | –    | 65   | –    | dB    |
| Slew Rate                        | SR1     | f=120Hz, 2Vp-p            | –    | 1    | –    | V/us  |
| Common Mode Rejection Ratio      | CMRR1   | f=1kHz, VIN=-20dB         | –    | 80   | –    | dB    |

## Calculation of Gain & Torque Limit Current



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

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

$V_{max}$  (see above block diagram) is set to 350mV.

$$I_{tl}[\text{mA}] = \frac{V_{max}}{R_S} = \frac{350[\text{mV}]}{R_S}$$

## Application Information

### 1. MUTE FUNCTION

#### 1) Mute Control Voltage Condition

When using the mute function, the applied control voltage condition is as follows.

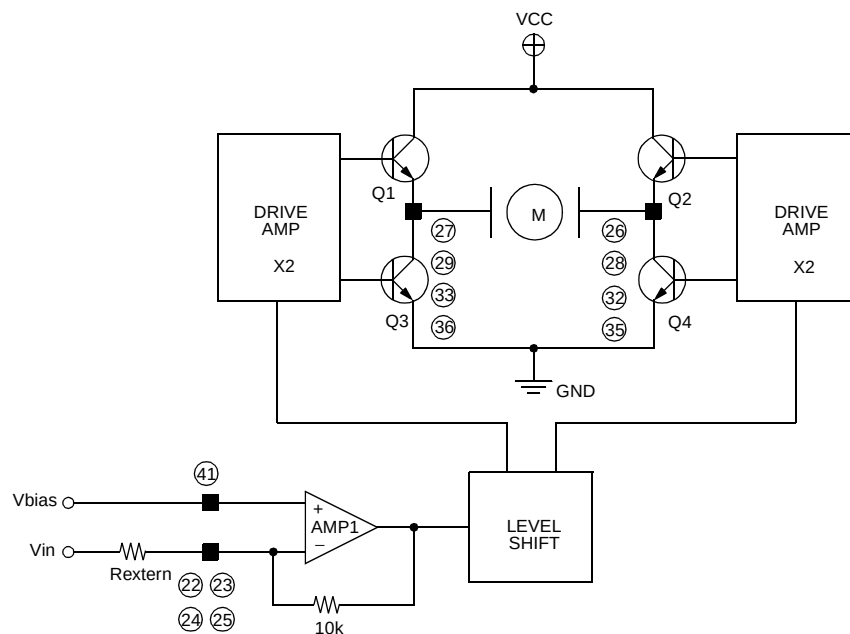
|                  |                      |                         |
|------------------|----------------------|-------------------------|
| MUTE ON Voltage  | 2.5[V] above         | Mute function operation |
| MUTE OFF Voltage | OPEN or 0.5[V] below | Normal operation        |

#### 2) Individual channel Mute Function

These pins are used for individual channel mute operation.

- When the mute pins (pin 37, 38 and 39) are OPEN or the voltages at the mute pins are below 0.5[V], the mute circuit is disabled and BTL output circuits operate normally.
- When the mute pins (pin 37, 38 and 39) are above 2.5[V], the mute circuits are activated so that the BTL output circuit will be muted.
- If the junction temperature rises above 175°C, then the thermal shutdown (TSD) circuit is activated and all the output circuits (4-CH BTL Drivers and 3-phase BLDC Driver) are muted.

### 2. 4-CH BALANCED TRANSFORMERLESS (BTL) DRIVER

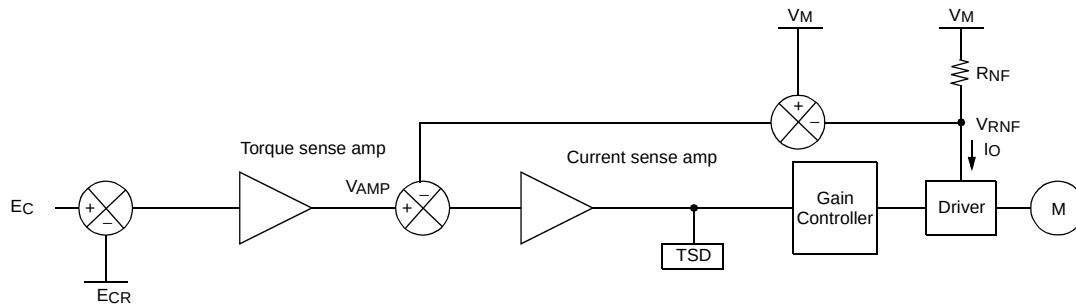


- The voltage, Vbias, is the reference voltage given by the external bias voltage of pin 41.
- The input signals, Vin, through the pins (pin 22, 23, 24 and 25) are amplified 10K/Rextern times and then fed to the level shift.
- The level shift produces the current due to the difference between the input signal (Vin) and the arbitrary reference voltage (Vbias). The current produced as +  $\Delta I$  and -  $\Delta I$  are fed into the drive buffers.
- The drive buffer operates the power TR of the output stage according to the state of the input signal (Vin).
- The output stage is the BTL driver, and the motor (or actuator) rotates in forward direction, when TR Q1 and TR Q4 are on. On the other hand, if TR Q2 and TR Q3 are on, the motor (or actuator) rotates in reverse direction.
- When the input signal Vin, through the pin (pin 22, 23, 24 and 25) is below the Vbias, then the motor (actuator) moves in forward direction.

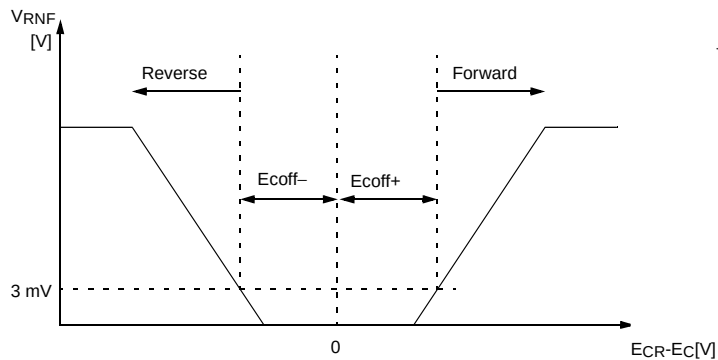
- When the input signal  $V_{in}$ , through the pin (pin 22, 23, 24 and 25) is above the  $V_{bias}$ , then the motor (actuator) moves in reverse direction.
- To change the gain, modify the external resistor's value ( $R_{extern}$ )

### 3. TORQUE & OUTPUT CURRENT CONTROL

Torque & Output Current Control



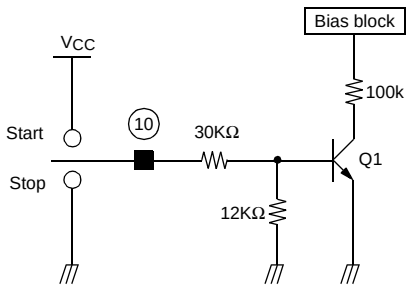
- By amplifying the voltage difference between  $E_C$  and  $E_{CR}$  from the Servo IC, the torque sense AMP produces the input voltage ( $V_{AMP}$ ) for the current sense AMP.
- The current sense AMP produces the input for the Gain controller to allow the output current ( $I_O$ ) of the driver to be controlled by the input voltage ( $V_{AMP}$ ), where the output current ( $I_O$ ) is detected by the sense resistor ( $R_{NF}$ ) and is converted into  $V_{RNF}$ .
- In the end, the signals of the Servo IC control the velocity of the motor by controlling the output current ( $I_O$ ) of the driver.
- When the junction temperature rises up to  $175^{\circ}\text{C}$ , the output drive circuit shuts down.
- The range of the torque control input voltage is as shown below.



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

The input range ( $E_C$ ) of the Torque Sense AMP is  $0.5\text{V} \sim 3.3\text{V}$

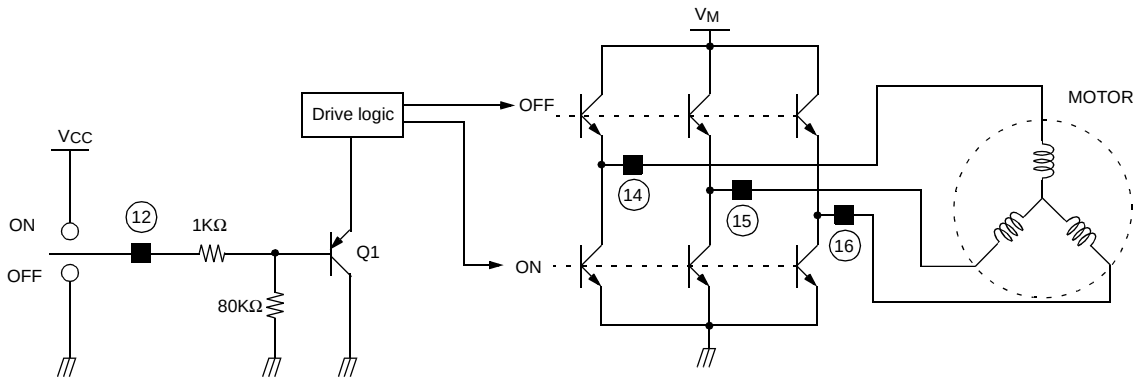
#### 4. POWER SAVE FUNCTION



- The power save circuit is activated by operating TR Q1.
- When the SS (Start/Stop) pin 10 is high (VCC), the TR Q1 is turned on and the bias circuit is enabled. On the other hand, when the SS (Start/Stop) pin 10 is Open or Low (GND), the TR Q1 is turned off and the bias circuit is disabled.
- The power save operation controlled by SS (pin 10) input conditions is as follows;

| Pin#10   | KA3017 |
|----------|--------|
| HIGH     | START  |
| OPEN/LOW | STOP   |

#### 5. SHORT BRAKE FUNCTION



When the pick-up mechanism moves from the inner to the outer spindle of the MD(Mini Disk), the brake function of the reverse voltage is commonly employed to rate the rotational velocity of the spindle motor. However, if the spindle motor rotates rapidly, the brake function of the reverse voltage may produce too much heat at the drive IC.

To remove these shortcomings and to enhance efficiency, the short brake function is added to KA3017. When the short brake function is active, all upper Power transistors are turned off and the lower Power transistors turned on, so as to reduce the rotational velocity of the motor. The short brake operation controlled by SB (pin 12), and the input conditions are as follows.

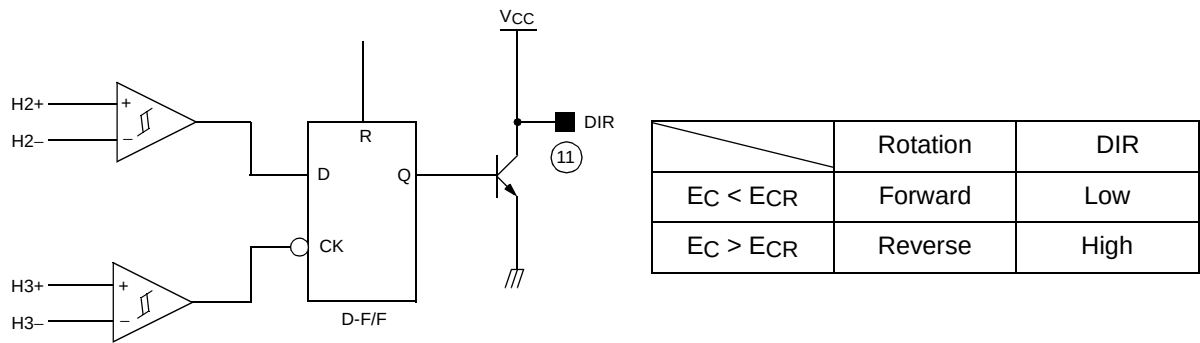
| Pin#12 | SHORT BRAKE |
|--------|-------------|
|--------|-------------|

|      |     |
|------|-----|
| HIGH | ON  |
| LOW  | OFF |

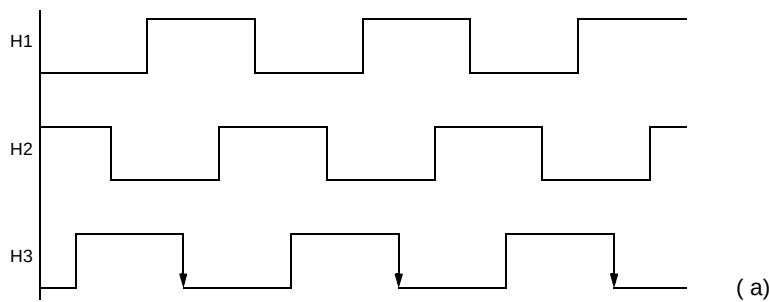
6. THERMAL SHUTDOWN (TSD) FUNCTION

When the junction temperature rises up to 175°C, the output drive circuit shuts down, when the junction temperature falls off to 160°C, the output drive circuit operates normally. It has the temperature hysteresis of about 15°C.

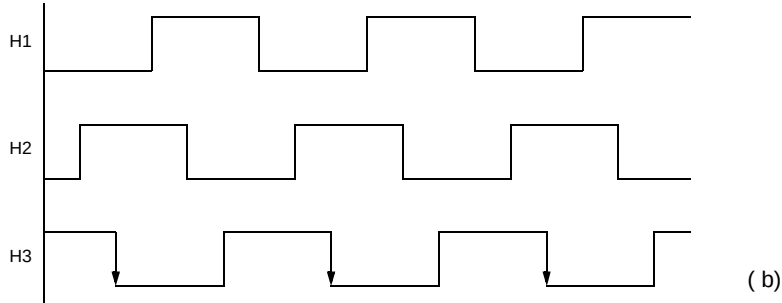
7. ROTATING DIRECTION DETECTING FUNCTION



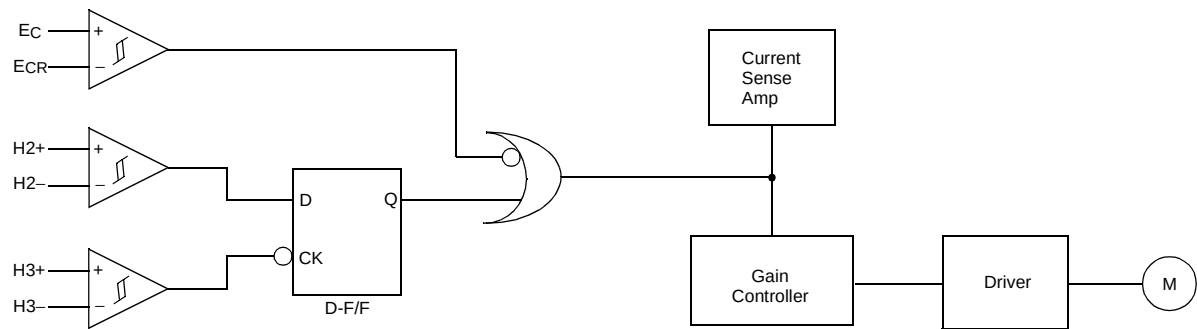
- The forward and reverse rotations of the MD are detected by the circuit, as shown in the above Table.
- The rotational direction of the MD can be learned by the output waveforms of the hall sensor and/or the driver. Hall sensors are turned on in the order,  $H1 \rightarrow H2 \rightarrow H3$  for the reverse rotation. The output waveforms of the hall sensors are as shown below.



Inversely, if the hall sensors turn on in the order,  $H3 \rightarrow H2 \rightarrow H1$ , then this shows forward rotation. The output waveforms of the hall sensors are as shown below.



### 8. REVERSE ROTATION PREVENTING FUNCTION

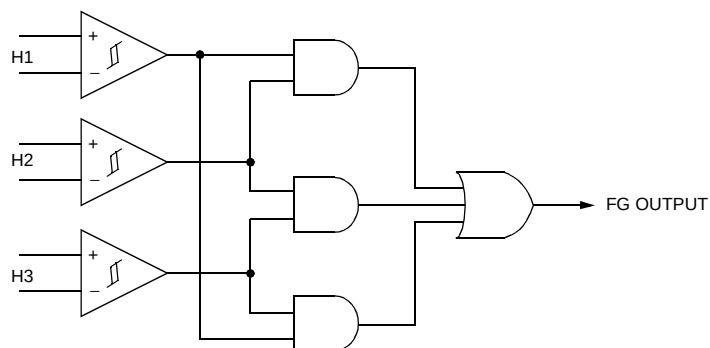


- The forward and reverse rotation of the motor are detected, as shown in the table below. Consequently at reverse rotation, the D-F/F output Q becomes Low and cuts off the output current sense Amp, resulting in the stoppage of the Gain controller function.
- When the MD is rotating in forward direction,  $EC > ECR$  is sometimes controlled to retard and/or stop the MD. As the controlling time of  $EC > ECR$  gets longer, MD slows down, stops, and then rotates in the reverse direction. To prevent the MD from rotating in the reverse direction, a reverse rotation resistant function is required. Its operational principles are discussed below.

| Rotation | H2 | H3                | D-F/F | Reverse Rotation Preventer |                |
|----------|----|-------------------|-------|----------------------------|----------------|
|          |    |                   |       | $EC < ECR$                 | $EC > ECR$     |
| Forward  | H  | $H \rightarrow L$ | H     | Forward                    | Brake and Stop |
| Reverse  | L  | $H \rightarrow L$ | L     | —                          | Stop           |

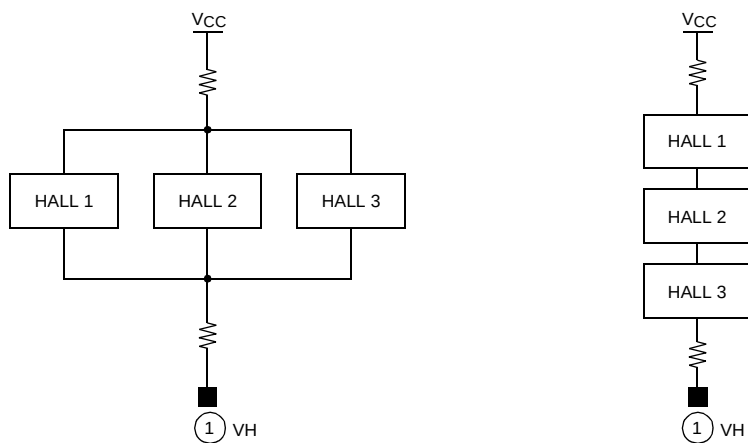
## 9. FG OUTPUT FUNCTION

The FG output detects the number of rotations of the MD. This is generated from combination zero-crossing of the hsl sensor output waveforms. The FG output circuit is as shown below.



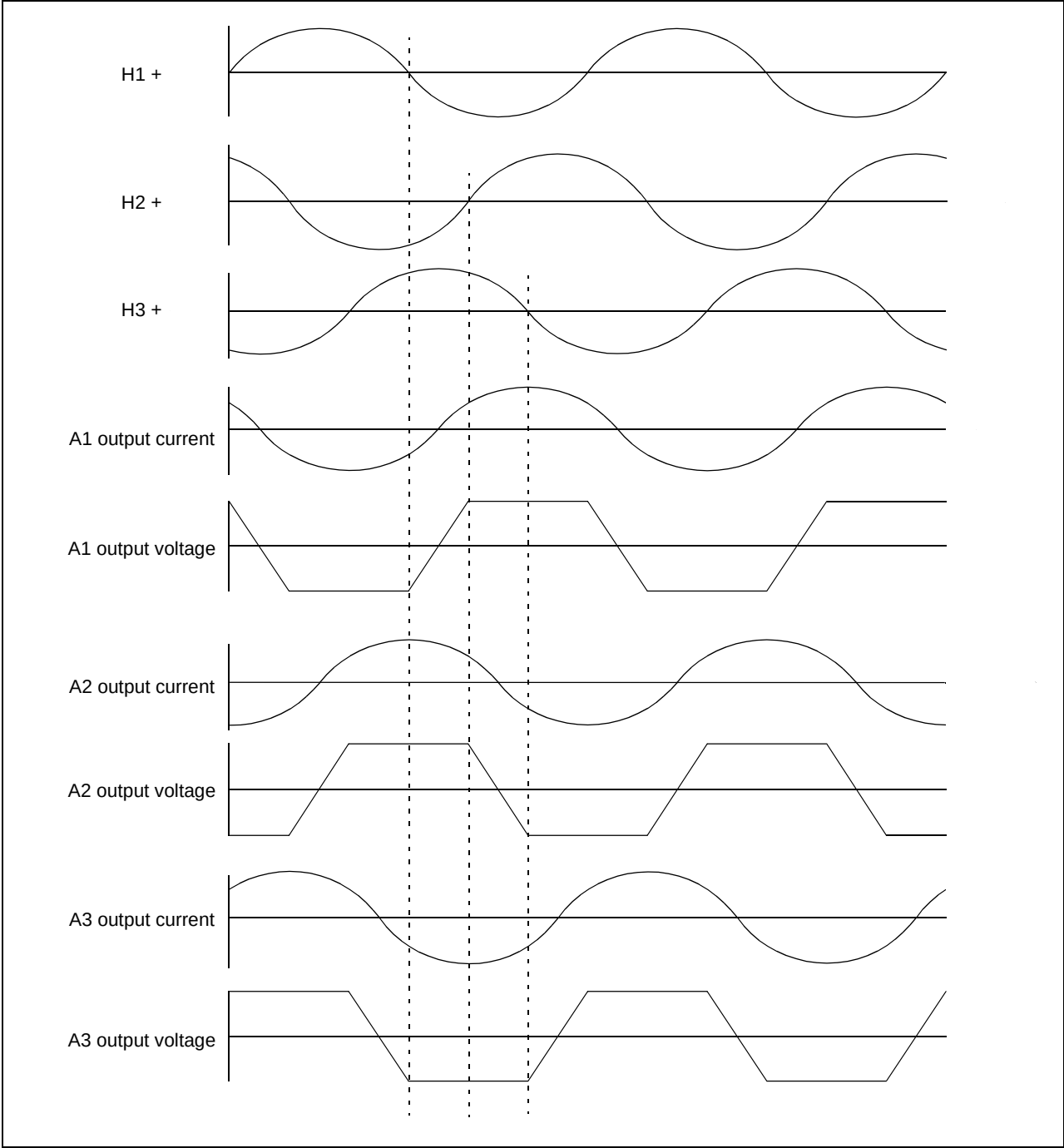
## 10. HALL SENSOR CONNECTION

External Hall sensors are used in series or in parallel connection as shown below.



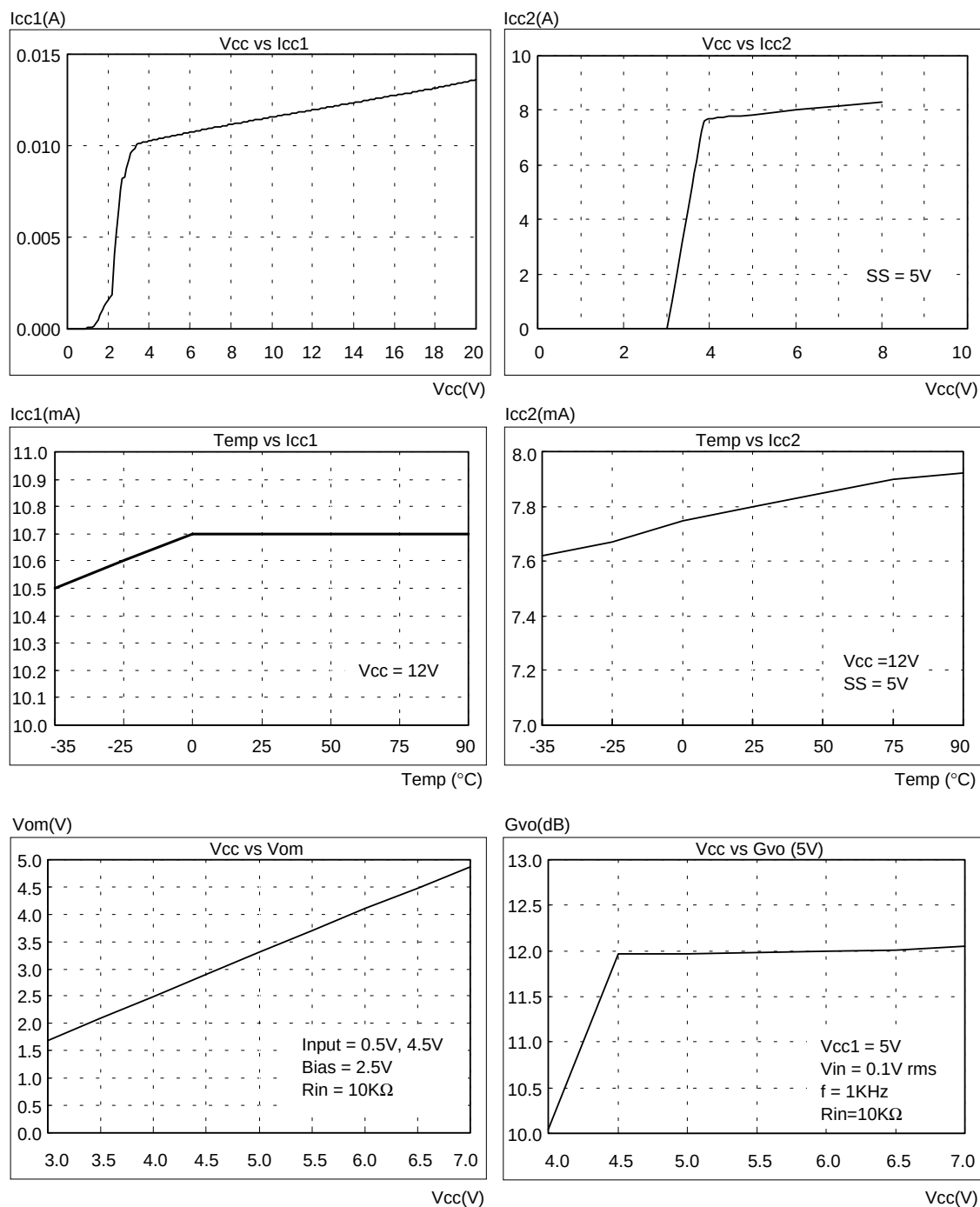
# 11. HALL INPUT OUTPUT TIMMING CHART

The 3-phase hall signal is amplified in the hall amplifiers and sent to the matrix section, where the signal is further amplified. After the signal is converted to a current in the amplitude control circuit, the current is supplied to the output driver, which then provides a motor drive current. The phases of the hall input signal, output voltage, and output current are shown below.



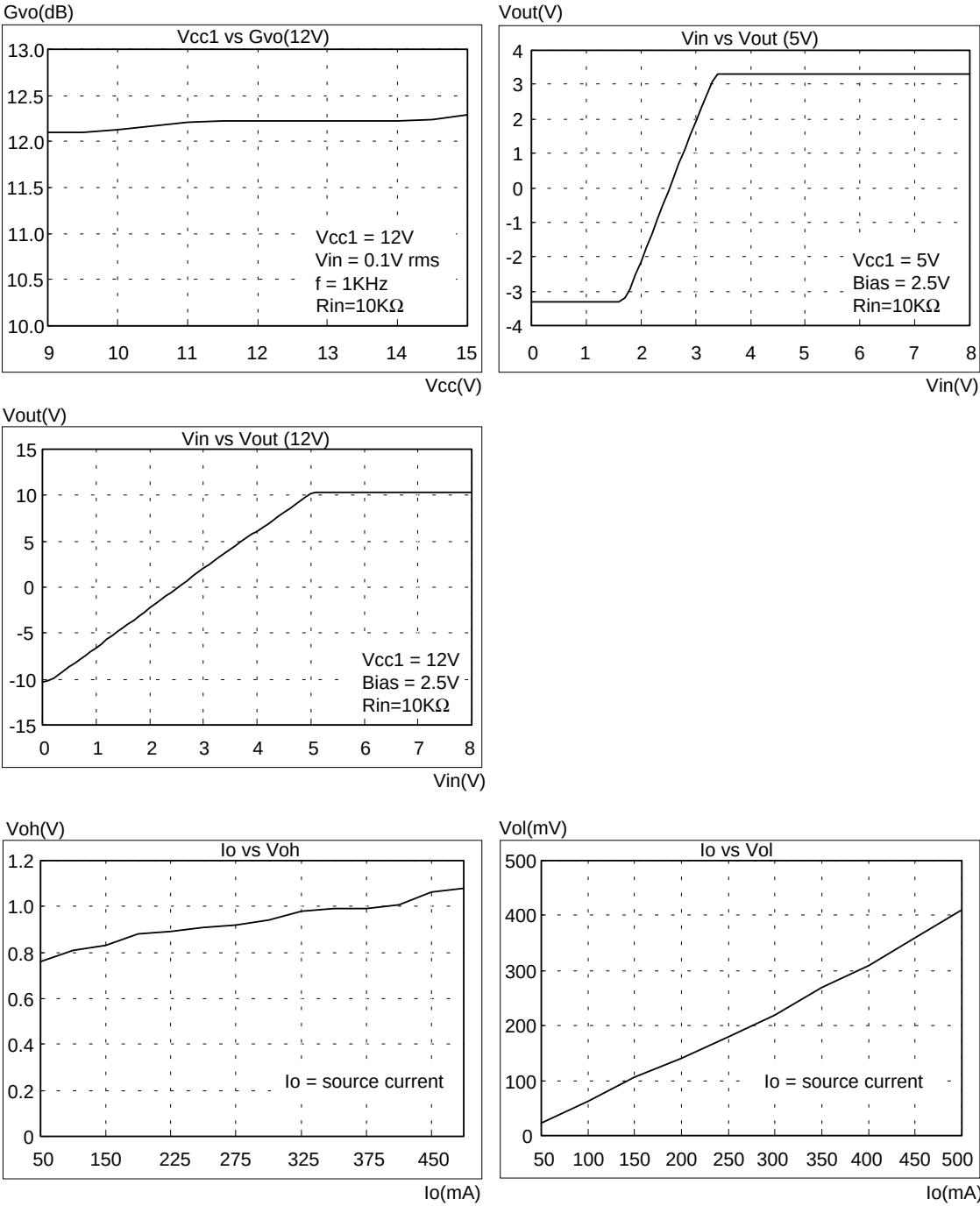
## Typical Performance Characteristics

### Total Circuit



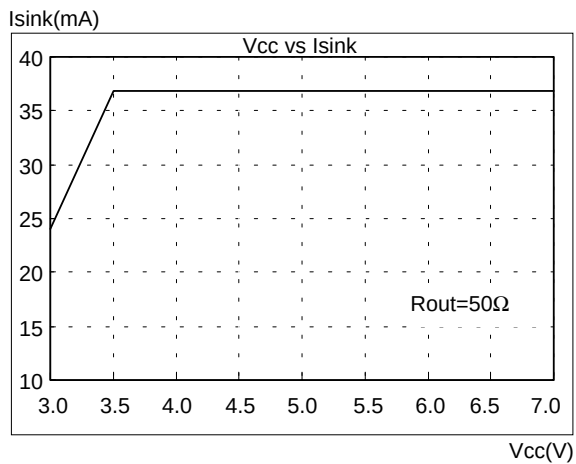
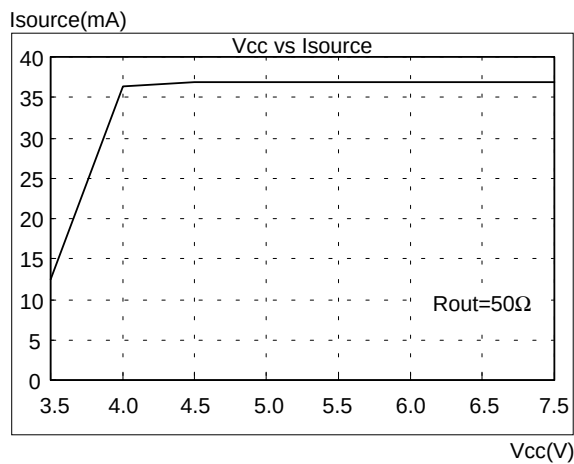
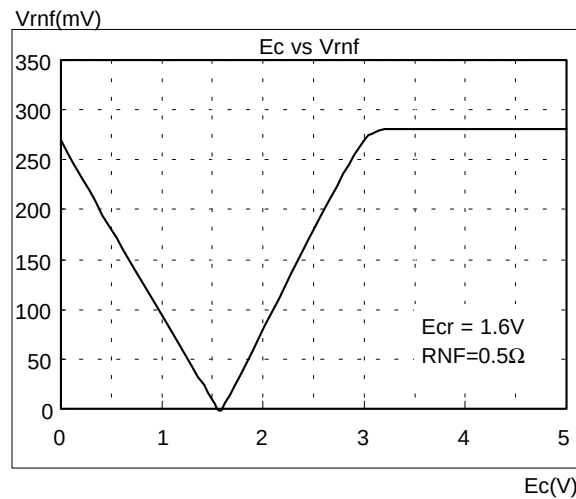
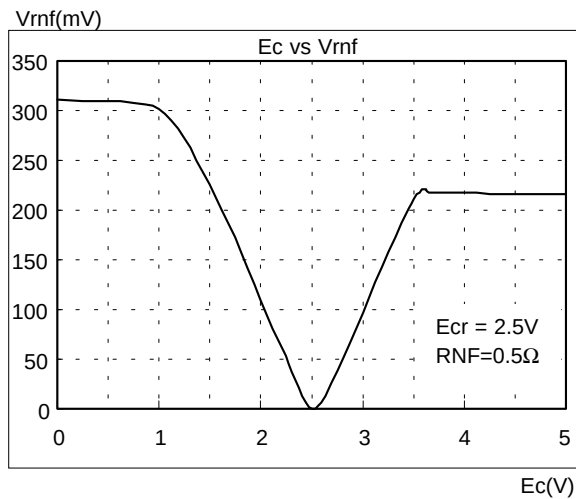
# Typical Performance Characteristics (Continued)

## Spindle Drive Part



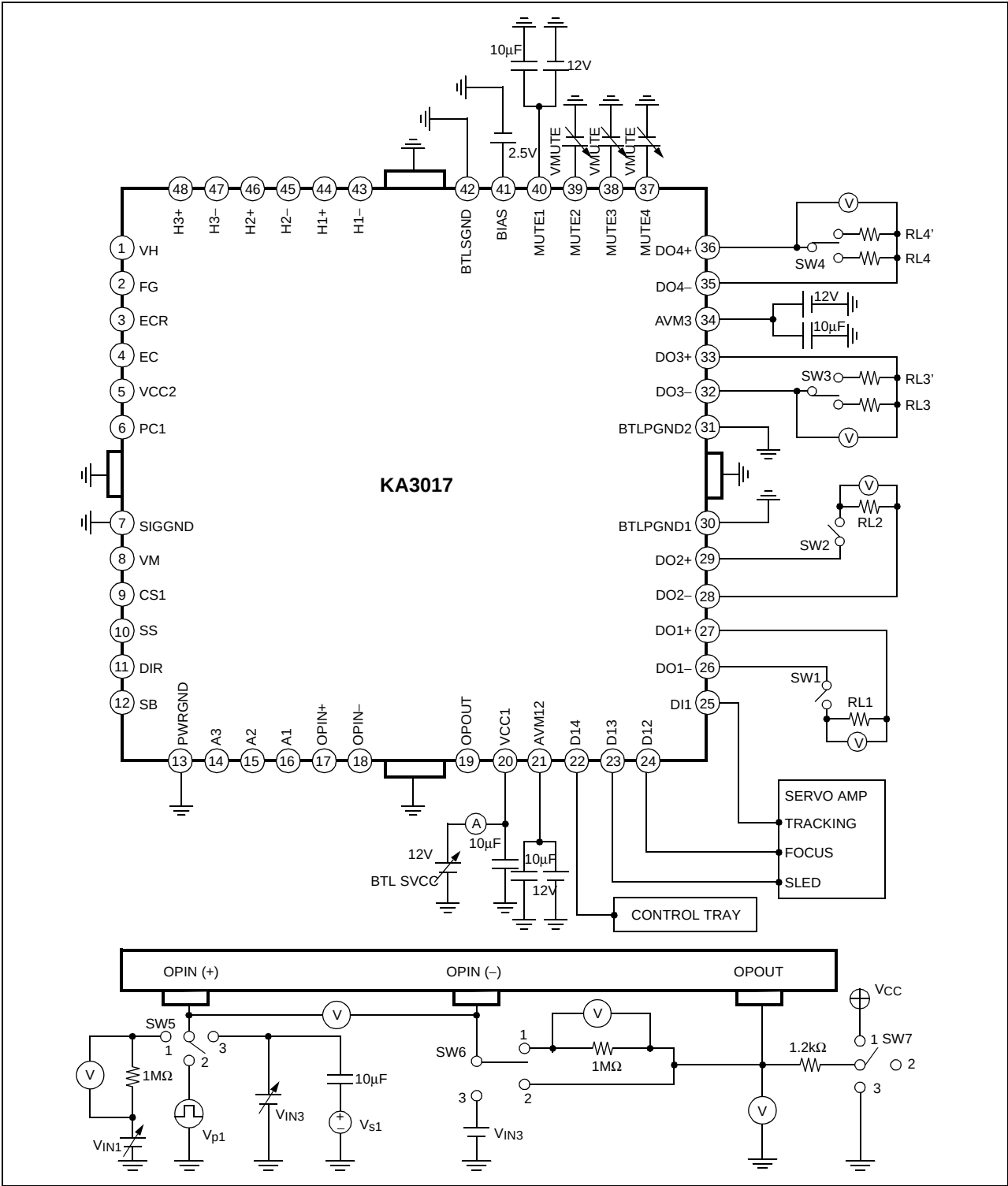
Typical Performance Characteristics (Continued)

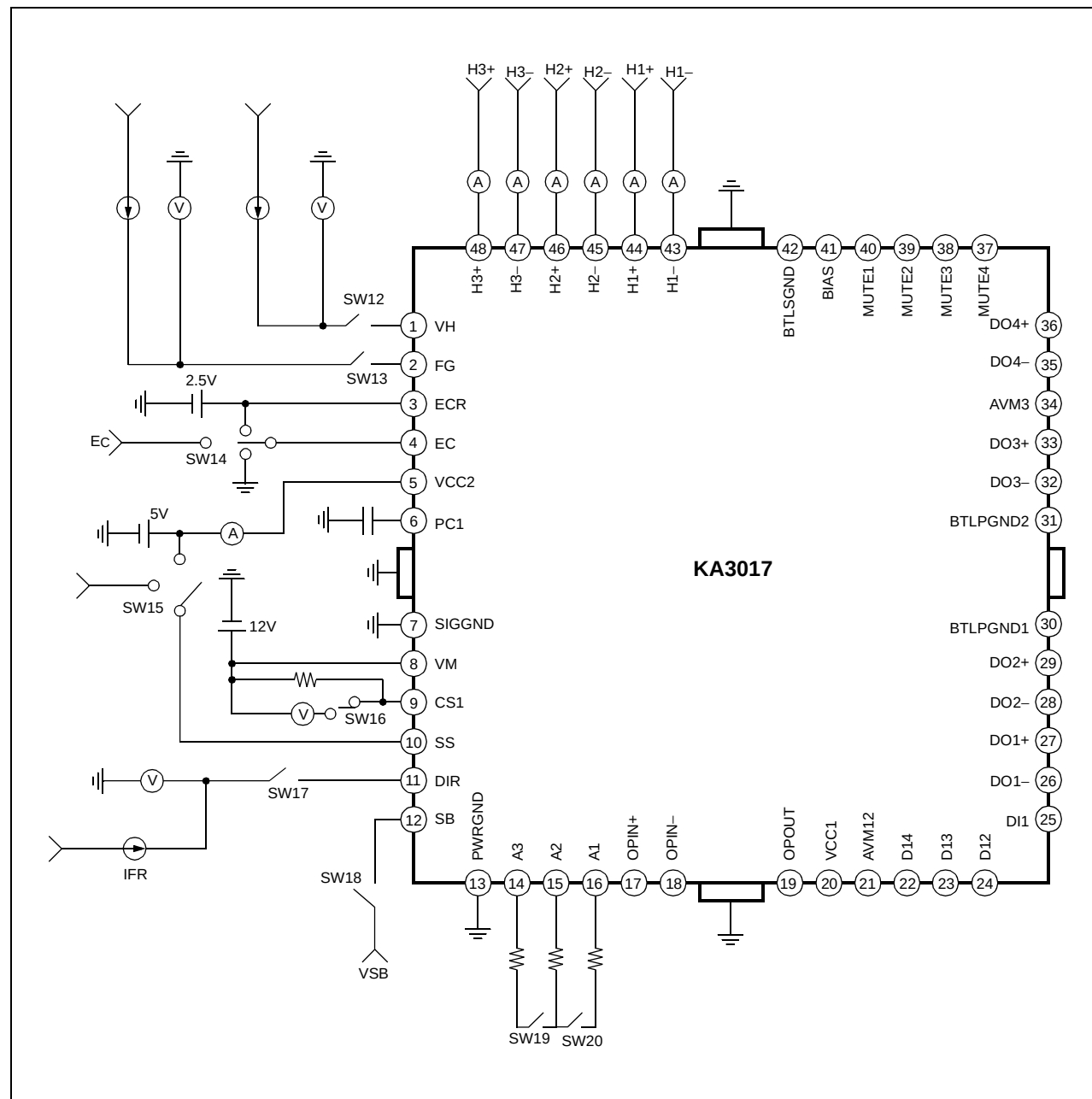
OP AMP Part



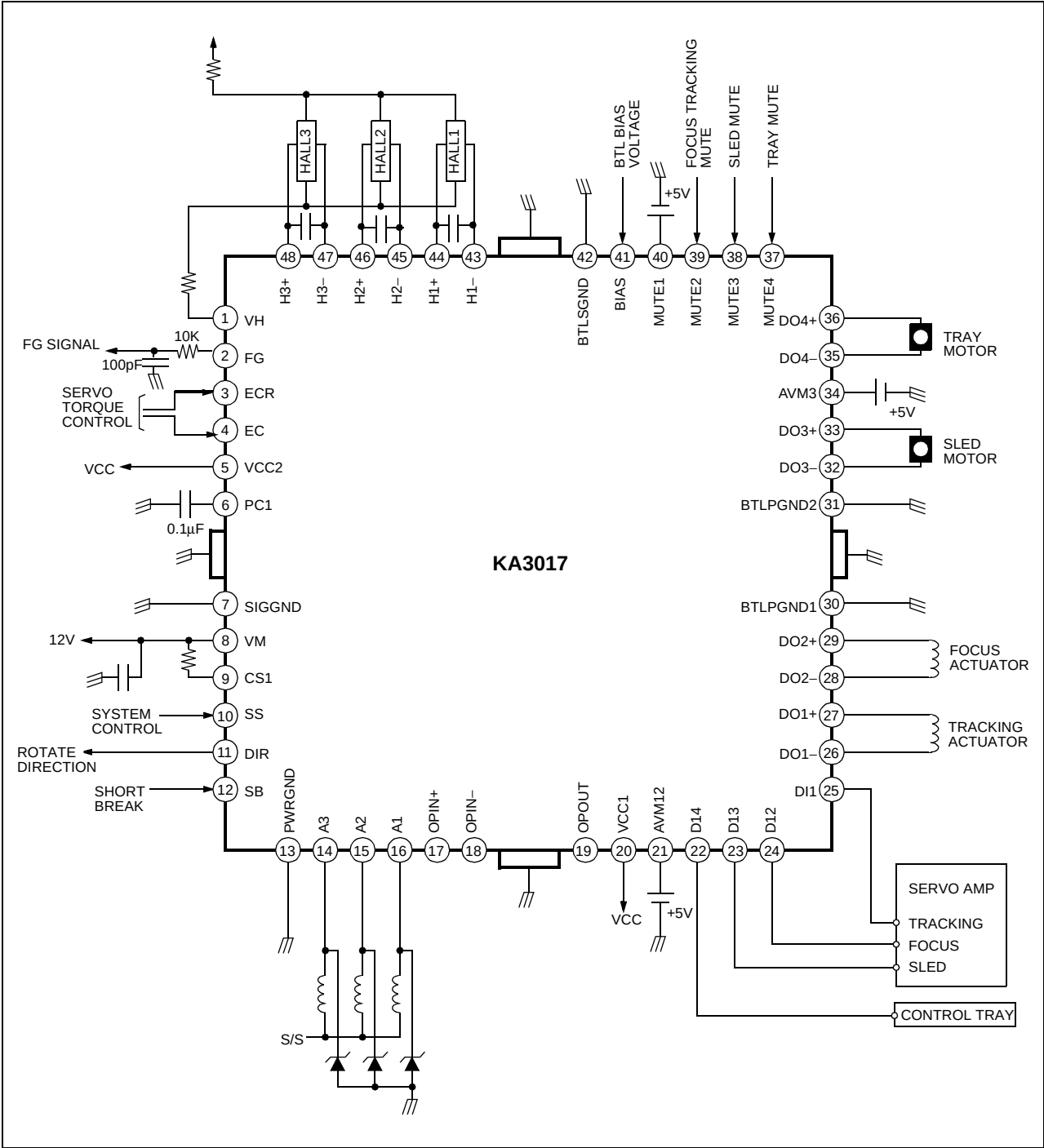
# Test Circuits 1

## BTL Drive Part





# Application Circuits



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