

# AN8294S

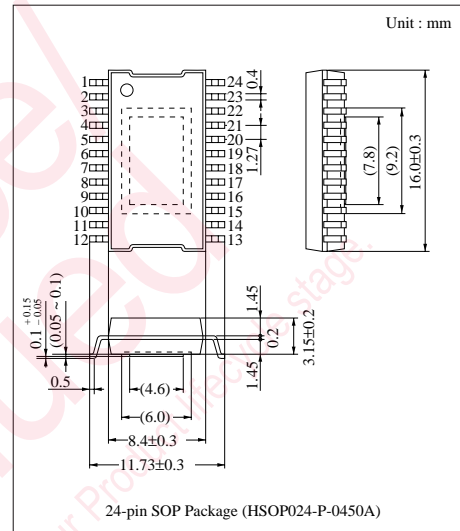
## Optical Disc Brush-less Spindle Motor Drive IC

### ■ Overview

The AN8294S is an IC for driving the Optical Disc spindle motor. It employs three-phase full-wave soft switch driving system, and its current drive do not require the electrolytic capacitor between motor windings (snubber-less). It is suitable for 4 to 12 times speed CD-ROM spindle motor drive.

### ■ Features

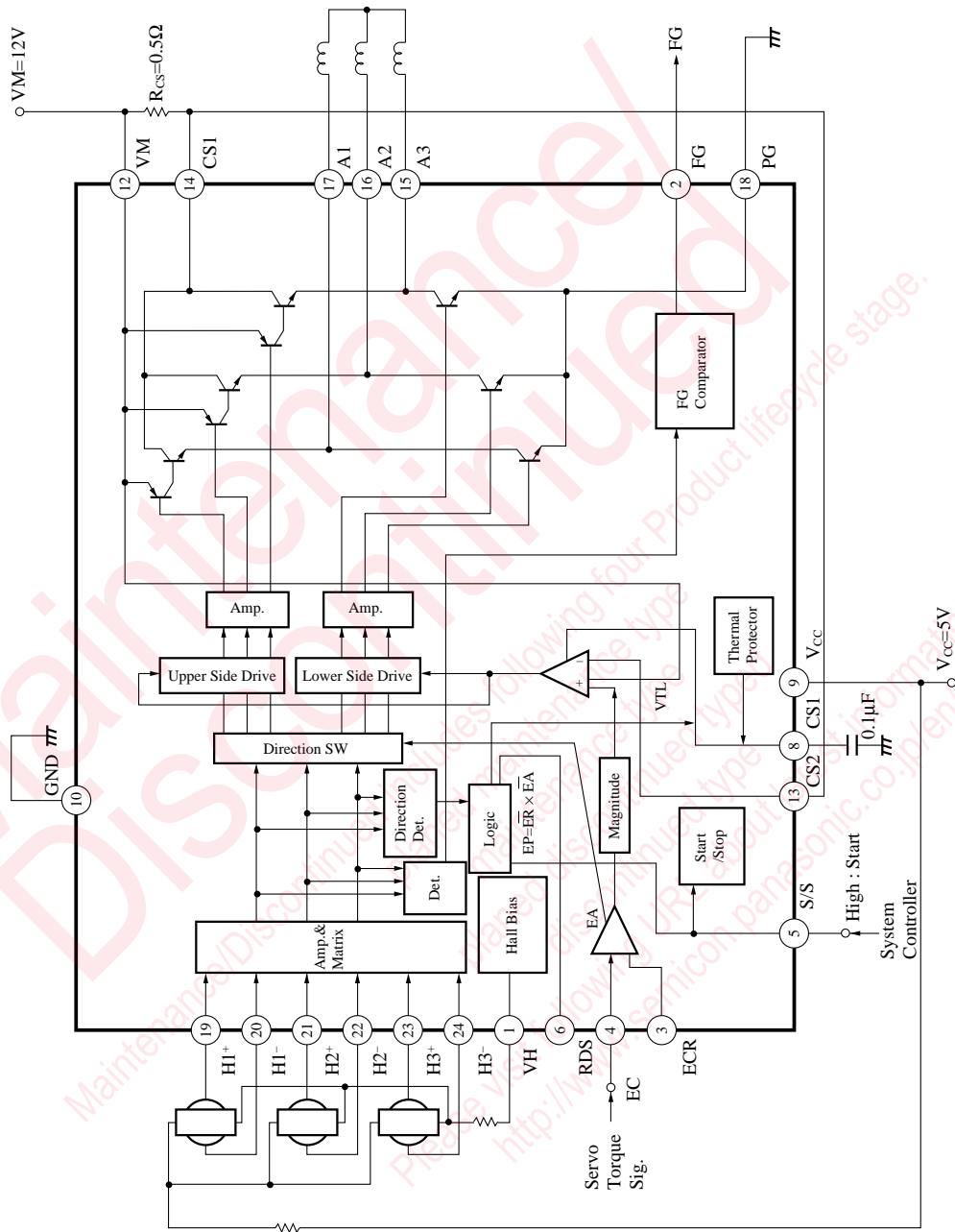
- Three-phase full-wave soft switch system used and snubber-less
- Copper block with good heat radiation built-in.
- Start/Stop terminal provided and power saved in stop mode
- The thermal shunt down detecting the junction temperature and turning off the motor current under high temperature
- FG output and rotation direction detection output terminal provided
- Current limitation function built-in, and voltage fall of detection resistance does not affect the saturation voltage
- Reverse rotation brake realized by voltage setting with EC/ECR
- Hall bias built-in
- Reverse rotation function built-in



### ■ Pin Name

| Pin No. | Symbol          | Pin name  | Pin No. | Symbol                      | Pin name                               |
|---------|-----------------|---|---------|-----------------------------|--|
| 1       | VH              | Hall bias terminal                                  | 13      | CS <sub>2</sub>             | Current detection terminal 2           |
| 2       | FG              | FG signal output terminal                           | 14      | CS <sub>1</sub>             | Current detection terminal 1           |
| 3       | ECR             | Torque command reference input terminal             | 15      | A <sub>3</sub>              | Drive output 3                         |
| 4       | EC              | Torque command input terminal                       | 16      | A <sub>2</sub>              | Drive output 2                         |
| 5       | SS              | Start/Stop control terminal                         | 17      | A <sub>1</sub>              | Drive output 1                         |
| 6       | RDS             | Reverse rotation detection signal output terminal   | 18      | PG                          | Power GND terminal                     |
| 7       | NC              | NC  | 19      | H <sub>1</sub> <sup>+</sup> | Hall element 1 positive input terminal |
| 8       | PCI             | Current feedback system phase compensation terminal | 20      | H <sub>1</sub> <sup>-</sup> | Hall element 1 negative input terminal |
| 9       | V <sub>CC</sub> | Power supply terminal                               | 21      | H <sub>2</sub> <sup>+</sup> | Hall element 2 positive input terminal |
| 10      | SG              | Signal GND terminal                                 | 22      | H <sub>2</sub> <sup>-</sup> | Hall element 2 negative input terminal |
| 11      | NC              | NC  | 23      | H <sub>3</sub> <sup>+</sup> | Hall element 3 positive input terminal |
| 12      | V <sub>M</sub>  | Motor power supply terminal                         | 24      | H <sub>3</sub> <sup>-</sup> | Hall element 3 negative input terminal |

■ Block Diagram



## ■ Absolute Maximum Rating (Ta=25°C)

| Parameter                                       | Symbol            | Rating                     | Unit |
|---|-------------------|----------------------------|------|
| Supply voltage                                  | V <sub>CC</sub>   | 7                          | V    |
|   | V <sub>M</sub>    | 14.4                       |      |
| Supply current                                  | I <sub>CC</sub>   | 30                         | mA   |
| Output current <sup>Note 1)</sup>               | I <sub>O(n)</sub> | ±1200                      | mA   |
| Hall bias current                               | I <sub>HB</sub>   | 50                         | mA   |
| Control signal input voltage <sup>Note 2)</sup> | V <sub>n</sub>    | 0 to V <sub>CC</sub>       | V    |
| Power dissipation                               | P <sub>D</sub>    | 909 (Ta=70°C, Single unit) | mW   |
| Operating ambient temperature                   | T <sub>opr</sub>  | -20 to +70                 | °C   |
| Storage temperature                             | T <sub>stg</sub>  | -55 to 150                 | °C   |

Note 1) Pin No.=14, 15, 16, 17, 18

Note 2) Pin No.=3, 4, 5, 19, 20, 21, 22, 23, 24

## ■ Recommended Operating Range (Ta=25°C)

| Parameter                | Symbol          | Range         |
|--------------------------|-----------------|---------------|
| Operating supply voltage | V <sub>CC</sub> | 4.25V to 5.5V |
|                          | V <sub>M</sub>  | 4.5V to 14V   |

## ■ Electrical Characteristics (Ta=25±2°C)

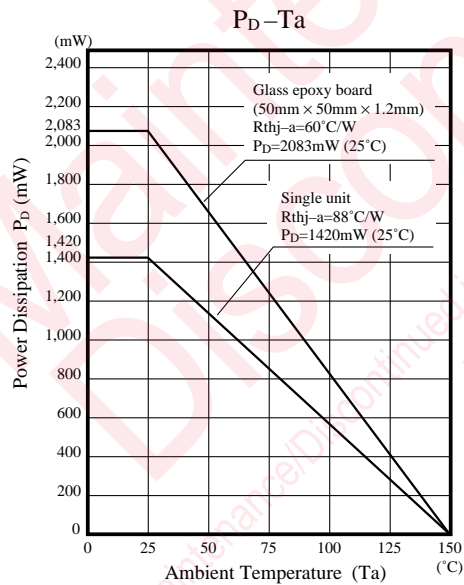
| Parameter                       | Symbol             | Condition   | min  | typ | max  | Unit              |
|---------------------------------|--------------------|---|------|-----|------|-------------------|
| Total                           |                    |   |      |     |      |                   |
| Circuit current 1               | I <sub>CC1</sub>   | V <sub>CC</sub> =5V, Power Save                                   | —    | 0   | 0.1  | mA                |
| Circuit current 2               | I <sub>CC2</sub>   | V <sub>CC</sub> =5V, I <sub>O</sub> =0mA                          | —    | 7   | 14   | mA                |
| Start/Stop                      |                    |   |      |     |      |                   |
| Start voltage                   | V <sub>start</sub> | Voltage which turns on the circuit when V <sub>CC</sub> =5V, L→H  | 3.5  | —   | —    | V                 |
| Stop voltage                    | V <sub>stop</sub>  | Voltage which turns off the circuit when V <sub>CC</sub> =5V, H→L | —    | —   | 1.0  | V                 |
| Hall Bias                       |                    |   |      |     |      |                   |
| Hall bias voltage               | V <sub>HB</sub>    | V <sub>CC</sub> =5V, I <sub>HB</sub> =20mA                        | 0.9  | 1.2 | 1.6  | V                 |
| Hall Amp.                       |                    |   |      |     |      |                   |
| Input bias current              | I <sub>BH</sub>    | V <sub>CC</sub> =5V   | —    | 1   | 5    | μA                |
| Common-mode input voltage range | V <sub>HBR</sub>   | V <sub>CC</sub> =5V   | 1.5  | —   | 4.0  | V                 |
| Minimum input level             | V <sub>INH</sub>   | V <sub>CC</sub> =5V   | 60   | —   | —    | mV <sub>P-P</sub> |
| Torque Command                  |                    |   |      |     |      |                   |
| Common-mode input voltage range | E <sub>C</sub>     | V <sub>CC</sub> =5V   | 1    | —   | 3.9  | V                 |
| Offset voltage                  | E <sub>C OF</sub>  | V <sub>CC</sub> =5V   | -150 | —   | 150  | mV                |
| Dead zone                       | E <sub>C DZ</sub>  | V <sub>CC</sub> =5V   | 50   | —   | 150  | mV                |
| Input current                   | E <sub>C IN</sub>  | V <sub>CC</sub> =5V, EC=ECR=2.5V                                  | -5   | -1  | —    | μA                |
| Input/Output gain               | A <sub>CS</sub>    | V <sub>CC</sub> =5V, RCS=0.5Ω                                     | 0.4  | 0.5 | 0.6  | A/V               |
| Output                          |                    |   |      |     |      |                   |
| Output saturation voltage H     | V <sub>OH</sub>    | V <sub>CC</sub> =5V, I <sub>O</sub> =-300mA                       | —    | 0.9 | 1.4  | V                 |
| Output saturation voltage L     | V <sub>OL</sub>    | V <sub>CC</sub> =5V, I <sub>O</sub> =300mA                        | —    | 0.2 | 0.45 | V                 |
| Torque limit current            | I <sub>TL</sub>    | V <sub>CC</sub> =5V, RCS=0.5Ω                                     | 560  | 700 | 840  | mA                |
| Idle voltage                    | V <sub>idle</sub>  | V <sub>CC</sub> =5V, EC=ECR                                       | 0    | —   | 7    | mV                |

## ■ Electrical Characteristics (Ta=25±2°C)

| Parameter  | Symbol             | Condition  | min | typ | max             | Unit |
|--|--------------------|--|-----|-----|-----------------|------|
| FG   |                    |  |     |     |                 |      |
| FG output high level                                 | FG <sub>H</sub>    | V <sub>CC</sub> =5V, I <sub>FG</sub> =-0.01mA      | 3.0 | —   | V <sub>CC</sub> | V    |
| FG output low level                                  | FG <sub>L</sub>    | V <sub>CC</sub> =5V, I <sub>FG</sub> =0.01mA       | —   | —   | 0.5             | V    |
| Common-mode input voltage range                      | V <sub>FGR</sub>   | Input D-range of H2 <sup>+</sup> , H2 <sup>-</sup> | 1.5 | —   | 3.0             | V    |
| FG hysteresis width                                  | HFG                | V <sub>CC</sub> =5V                                | 5   | 10  | 20              | mV   |
| RDS  |                    |  |     |     |                 |      |
| RDS output high level                                | RDS <sub>H</sub>   | V <sub>CC</sub> =5V                                | 4   | —   | V <sub>CC</sub> | V    |
| RDS output low level                                 | RDS <sub>L</sub>   | V <sub>CC</sub> =5V                                | 0   | —   | 1               | V    |
| Thermal Protection                                   |                    |  |     |     |                 |      |
| Thermal protection operation <sup>Note)</sup>        | T <sub>SD ON</sub> | V <sub>CC</sub> =5V, D <sub>EC</sub> =100mV        | —   | 170 | —               | °C   |
| Thermal protection hysteresis width <sup>Note)</sup> | DT <sub>SD</sub>   | V <sub>CC</sub> =5V, D <sub>EC</sub> =100mV        | —   | 45  | —               | °C   |

Note) These are design reference values, but not guaranteed ones.

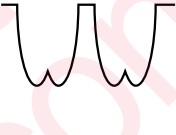
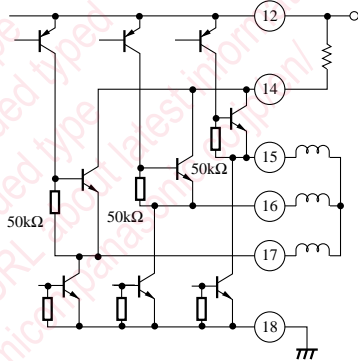
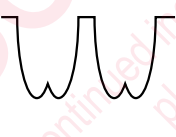
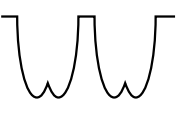
## ■ Package Power Dissipation






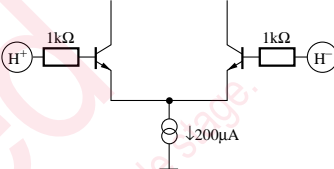

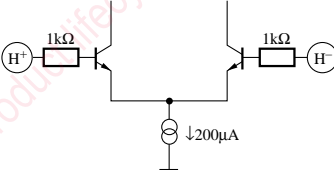

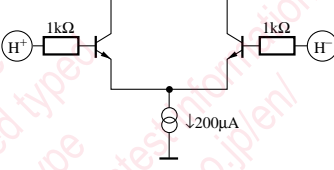

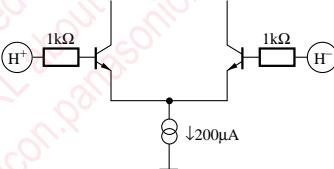

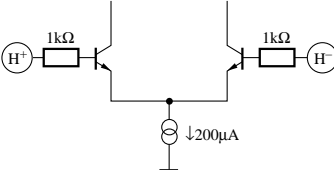

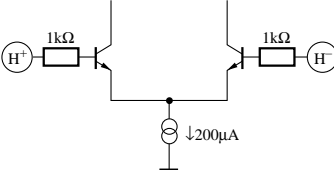
## ■ Pin Descriptions

| Pin No. | Pin name   | Standard waveform | Description   | Equivalent circuit (Note)  |
|---------|--|-------------------|---|--|
| 1       | VH : Hall bias                                   |                   | Terminal supplying the current to the Hall element  |  |
| 2       | FG : FG signal output                            |                   | Terminal for comparison outputting "High" or "Low" according to signals of H2+, H2-.  |  |
| 3       | ECR : Torque command reference input             |                   |   |  |
| 4       | EC : Torque command input                        |                   | Terminal inputting the command about what amount of current is flown into the motor   |  |
| 5       | S/S : Start/Stop control                         |                   | Terminal turning on or off the IC.<br>High : ON<br>Low or Open : OFF  |  |
| 6       | RDS : Reverse rotation detection signal output   |                   | Terminal outputting the "High" or "Low" which indicates normal or reverse rotation according to the Hall element signal.<br>H <sub>3</sub> →H <sub>2</sub> →H <sub>1</sub> for Low<br>H <sub>1</sub> →H <sub>2</sub> →H <sub>3</sub> for High |  |
| 7       | NC   |                   |   |  |
| 8       | PCI : Current feedback system phase compensation |                   | Terminal attaching the capacitor to compensate the phase for the current feedback loop  |  |
| 9       | V <sub>cc</sub> : Supply voltage                 |                   | Power supply terminal for IC  | Note : The value shown above for such as bias current or resistance is not a guaranteed value, but a design reference one. |
| 10      | SG : Signal ground                               |                   |   |  |

## ■ Pin Descriptions (cont.)

| Pin No. | Pin name                               | Standard waveform   | Description  | Equivalent circuit   |
|---------|--|---|--|--|
| 11      | NC                                     | ————  | ————   |  |
| 12      | V <sub>M</sub> :<br>Motor power supply | ————  | Power supply terminal for supplying the power supply for motor drive   |  |
| 13      | CS2 :<br>current detection 2           | ————  | Terminal connecting the resistance to the V <sub>M</sub> to detect the motor current amount.<br>Normally, it is shorted with CS1.  | ————   |
| 14      | CS1 :<br>Current detection 1           | ————  | Common collector terminal for upper side power Tr of A1, A2 and A3   |  |
| 15      | A3 :<br>Drive output 3                 |  | One of three output terminals which directly drive the motor by flowing the current in or out with two power Tr. For A1, A2 and A3, the waveform is deviated respectively by 120°. |  |
| 16      | A2 :<br>Drive output 2                 |  | Same as the above  |  |
| 17      | A1 :<br>Drive output 1                 |  | Same as the above  |  |

## ■ Pin Descriptions (cont.)

| Pin No. | Pin name  | Standard waveform   | Description  | Equivalent circuit  |
|---------|---|---|--|---|
| 18      | PG :<br>Power ground                                |    | Common emitter for lower side power Tr of A1, A2 and A3  |    |
| 19      | H <sub>1</sub> <sup>+</sup> :<br>Hall element input |    | Two signals are developed from three Hall element respectively, and in total 6 signals are developed. Each signal is received by one of 6 terminals including this terminal.<br>*Signal deviated by 180° from that for H <sub>1</sub> <sup>-</sup> is applied. |    |
| 20      | H <sub>1</sub> <sup>-</sup> :<br>Hall element input |    | Same as the above<br>*Signal deviated by 180° from that for H <sub>1</sub> <sup>+</sup> is applied.  |   |
| 21      | H <sub>2</sub> <sup>+</sup> :<br>Hall element input |  | Same as for H <sub>1</sub> <sup>+</sup><br>*Signal deviated by 180° from that for H <sub>2</sub> <sup>-</sup> is applied.  |  |
| 22      | H <sub>2</sub> <sup>-</sup> :<br>Hall element input |  | Same as the above<br>*Signal deviated by 180° from that for H <sub>2</sub> <sup>+</sup> is applied.  |  |
| 23      | H <sub>3</sub> <sup>+</sup> :<br>Hall element input |  | Same as the above<br>*Signal deviated by 180° from that for H <sub>3</sub> <sup>-</sup> is applied.  |  |
| 24      | H <sub>3</sub> <sup>-</sup> :<br>Hall element input |  | Same as the above<br>*Signal deviated by 180° from that for H <sub>3</sub> <sup>+</sup> is applied.  |  |



5) Reverse rotation brake is available by EC/ECR voltage setting.

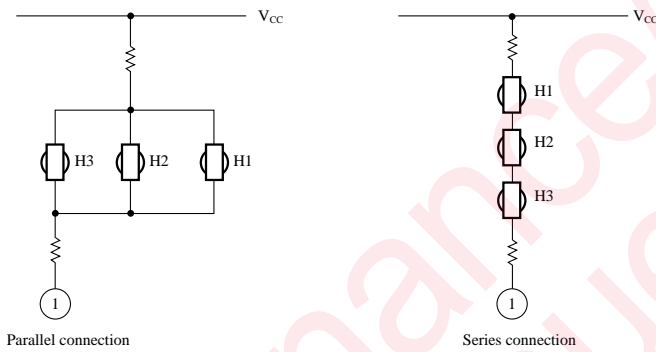
The direction of torque applied to the motor can be changed by changing the sequence of current flowing in each output phase through voltage setting with EC/ECR. Voltage difference between EC and ECR is proportional to the motor torque (motor current) (V characteristics).

6) Hall Bias Built-in

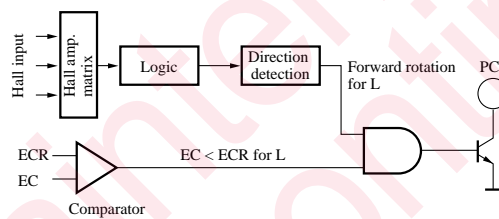
The AN8294S incorporates the power supply for Hall element, a position sensor.

Hall bias voltage is 1.2V, typ. ( $V_{CC}=5V$ , Hall current is 20mA). It is almost stable, even when the supply voltage is changed.

In addition, Hall element may be connected either in series or in parallel.



7) Reverse rotation prevention function

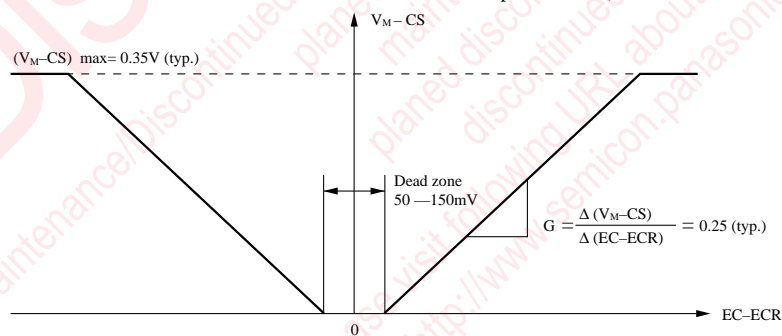


With Hall input, it detects the motor rotation direction.

When the reverse rotation of motor is detected and the reverse rotation command,  $EC > ECR$ , is also developed at the same time, it cuts the motor current to stop the motor.

8) Torque Command and Output Current

The voltage difference between EC terminal and ECR terminal controls the output current. (Refer to the following figure.)



The  $G$  shown in the above figure and  $(V_M - CS)_{max}$  are almost stable, independent of current detection resistance (resistance between  $V_M$  and  $CS$  terminals),  $R_{CS}$ . For example, if  $R_{CS} = 0.5\Omega$ ,

· Transmission gain  $A_{CS}$  from EC terminal voltage to output current is :

$$A_{CS} = \frac{G}{R_{CS}} = \frac{0.25}{0.5\Omega} = 0.50 \text{ (A/V) (typ.)}$$

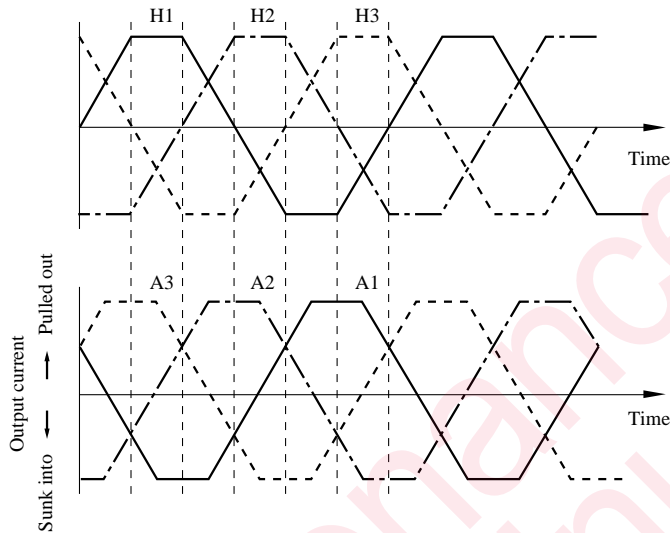
· Output maximum current  $I_{TL}$  is :

$$I_{TL} = \frac{0.35V}{0.5\Omega} = 0.70A \text{ (typ.)}$$

The  $R_{CS}$  should be set at the value of approximately 0.5 to 2.0 $\Omega$ .

9) Phase relationship between Hall input and output currents.

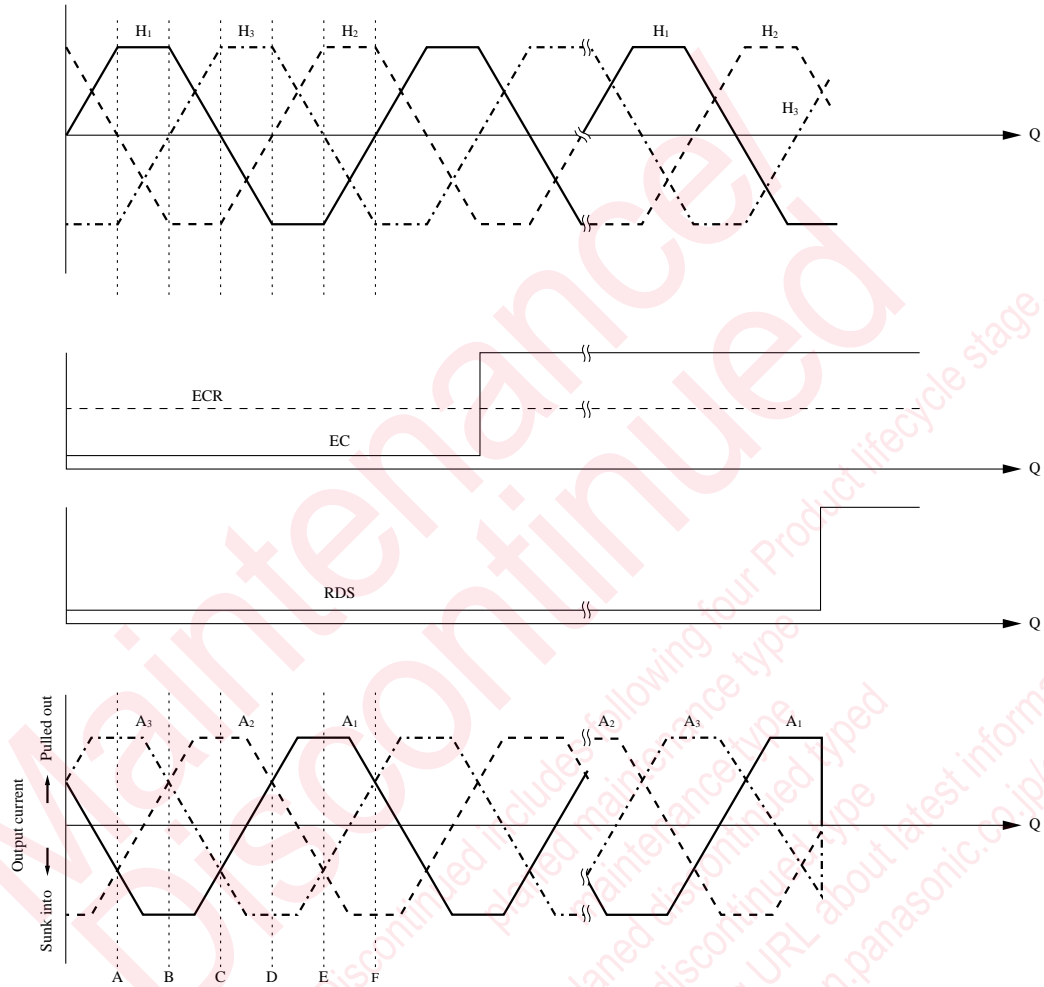
The phase relationship between Hall input and output currents when  $EC < ECR$  is shown in the following figure :



When  $EC > ECR$ , the pulling-out and sinking-into of the output current is just reversed from those shown in the above figure, and the motor rotation direction is reversed.

For Hall input, DC level should be set at 1.5 to 4.0V and the amplitude of each phase ( $H_n^+ - H_n^-$ ) should be set at  $60mV_{P-P}$  or more.

## Phase Conditions of Hall Input and Output Current



| Phase of Hall Element |         |         |         |
|-----------------------|---------|---------|---------|
|                       | $H_1^+$ | $H_2^+$ | $H_3^+$ |
| A                     | H       | M       | L       |
| B                     | H       | L       | M       |
| C                     | M       | L       | H       |
| D                     | L       | M       | H       |
| E                     | L       | H       | M       |
| F                     | M       | H       | L       |

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