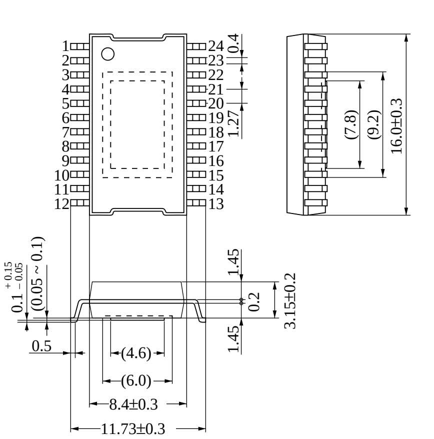
AN8294S

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.

Unit : mm



24-pin SOP Package (HSOP024-P-0450A)

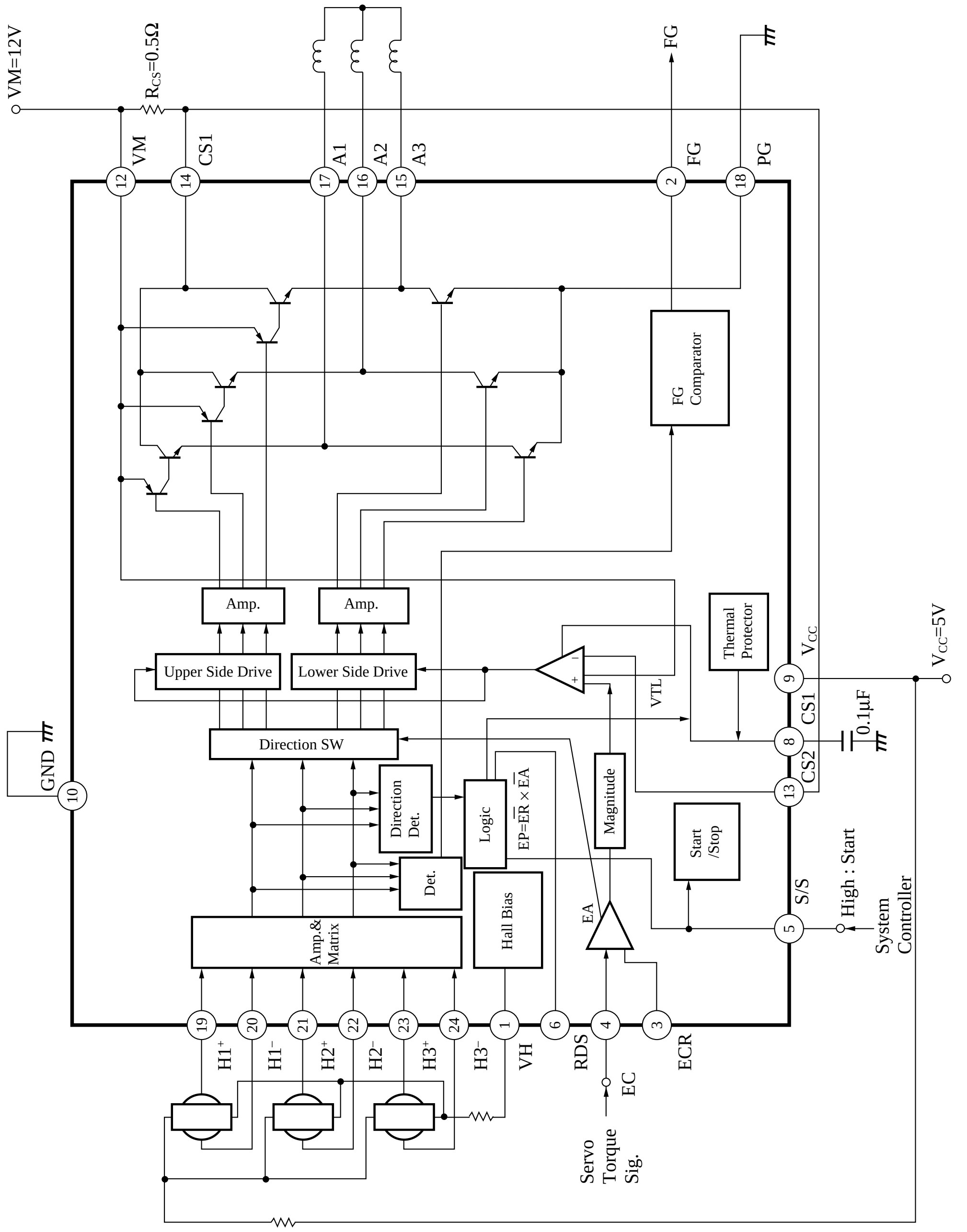
■ Features

- 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_2	Current detection terminal 2
2	FG	FG signal output terminal	14	CS_1	Current detection terminal 1
3	ECR	Torque command reference input terminal	15	A_3	Drive output 3
4	EC	Torque command input terminal	16	A_2	Drive output 2
5	SS	Start/Stop control terminal	17	A_1	Drive output 1
6	RDS	Reverse rotation detection signal output terminal	18	PG	Power GND terminal
7	NC	NC	19	H_1^+	Hall element 1 positive input terminal
8	PCI	Current feedback system phase compensation terminal	20	H_1^-	Hall element 1 negative input terminal
9	V_{CC}	Power supply terminal	21	H_2^+	Hall element 2 positive input terminal
10	SG	Signal GND terminal	22	H_2^-	Hall element 2 negative input terminal
11	NC	NC	23	H_3^+	Hall element 3 positive input terminal
12	V_M	Motor power supply terminal	24	H_3^-	Hall element 3 negative input terminal

■ Block Diagram



■ Absolute Maximum Rating (Ta=25˚C)

Parameter	Symbol	Rating	Unit
Supply voltage	V_{CC}	7	V
	V_M	14.4	
Supply current	I_{CC}	30	mA
Output current Note 1)	$I_{O(n)}$	±1200	mA
Hall bias current	I_{HB}	50	mA
Control signal input voltage Note 2)	V_n	0 to V_{CC}	V
Power dissipation	P_D	909 (Ta=70˚C, Single unit)	mW
Operating ambient temperature	T_{opr}	–20 to + 70	˚C
Storage temperature	T_{stg}	–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_{CC}	4.25V to 5.5V
	V_M	4.5V to 14V

■ Electrical Characteristics (Ta=25±2˚C)

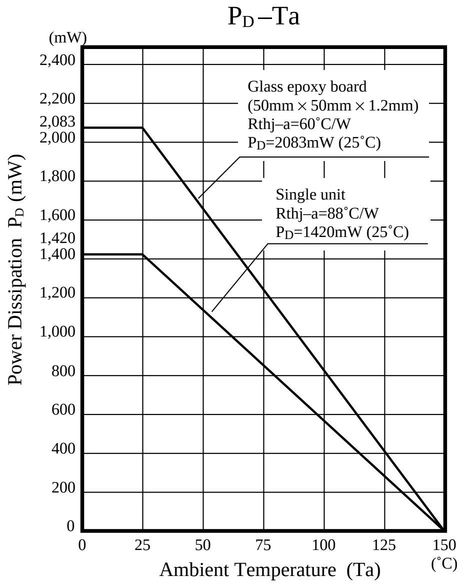
Parameter	Symbol	Condition	min	typ	max	Unit
Total						
Circuit current 1	I_{CC1}	V_{CC}=5V, Power Save	—	0	0.1	mA
Circuit current 2	I_{CC2}	V_{CC}=5V, I_O=0mA	—	7	14	mA
Start/Stop						
Start voltage	V_{start}	Voltage which turns on the circuit when V_{CC}=5V, L→H	3.5	—	—	V
Stop voltage	V_{stop}	Voltage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

■ Electrical Characteristics (Ta=25±2˚C)

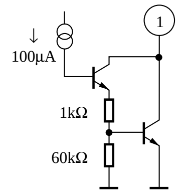
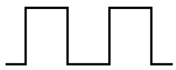
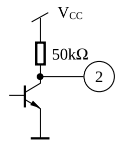
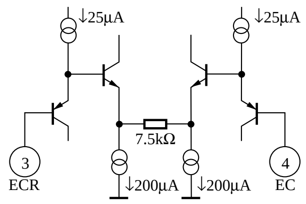
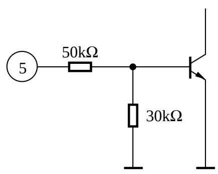
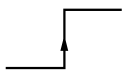
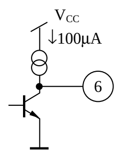
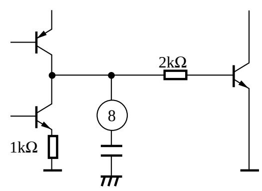
Parameter	Symbol	Condition	min	typ	max	Unit
FG						
FG output high level	FG_H	V_{CC}=5V, I_{FG}=–0.01mA	3.0	—	V_{CC}	V
FG output low level	FG_L	V_{CC}=5V, I_{FG}=0.01mA	—	—	0.5	V
Common-mode input voltage range	V_{FGR}	Input D-range of $H2^+$, $H2^-$	1.5	—	3.0	V
FG hysteresis width	HFG	V_{CC}=5V	5	10	20	mV
RDS						
RDS output high level	RDS_H	V_{CC}=5V	4	—	V_{CC}	V
RDS output low level	RDS_L	V_{CC}=5V	0	—	1	V
Thermal Protection						
Thermal protection operation Note)	$T_{SD\ ON}$	V_{CC}=5V, D_{EC}=100mV	—	170	—	˚C
Thermal protection hysteresis width Note)	DT_{SD}	V_{CC}=5V, D_{EC}=100mV	—	45	—	˚C

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

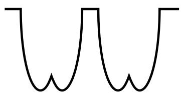
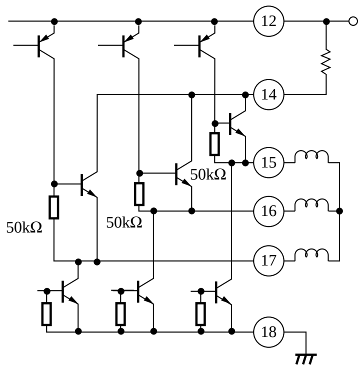
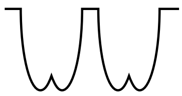
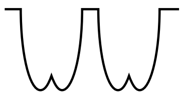
■ Package Power Dissipation



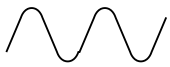
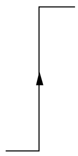
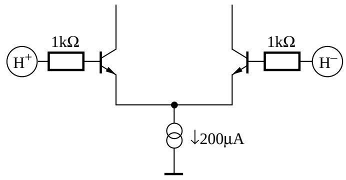
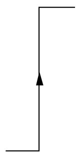
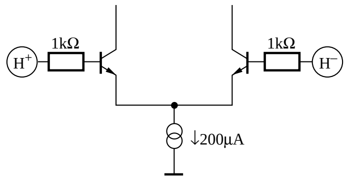
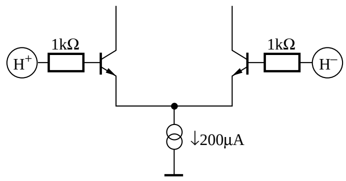
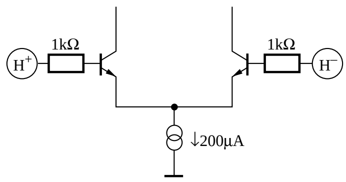
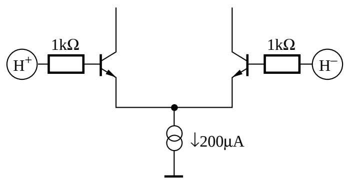
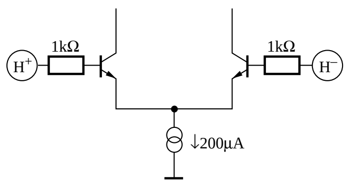
■ Pin Descriptions

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. High : ON 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. $H_3 \rightarrow H_2 \rightarrow H_1$ for Low $H_1 \rightarrow H_2 \rightarrow H_3$ 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_{CC} : 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.)

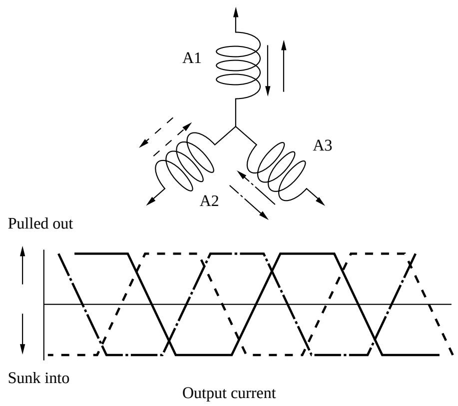
Pin No.	Pin name	Standard waveform	Description	Equivalent circuit
11	NC	———	———	———
12	V_M : Motor power supply	———	Power supply terminal for supplying the power supply for motor drive	
13	CS2 : current detection 2	———	Terminal connecting the resistance to the V_M to detect the motor current amount. Normally, it is shorted with CS1.	
14	CS1 : Current detection 1	———	Common collector terminal for upper side power Tr of A1, A2 and A3	
15	A3 : 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 : Drive output 2		Same as the above	
17	A1 : Drive output 1		Same as the above	

■ Pin Descriptions (cont.)

Pin No.	Pin name	Standard waveform	Description	Equivalent circuit
18	PG : Power ground		Common emitter for lower side power Tr of A1, A2 and A3	—
19	H_1^+ : 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. ∗Signal deviated by 180˚ from that for H_1^- is applied.	
20	H_1^- : Hall element input		Same as the above ∗Signal deviated by 180˚ from that for H_1^+ is appllied.	
21	H_2^+ : Hall element input	—	Same as for H_1^+ ∗Signal deviated by 180˚ from that for H_2^- is applied.	
22	H_2^- : Hall element input	—	Same as the above ∗Signal deviated by 180˚ from that for H_2^+ is applied.	
23	H_3^+ : Hall element input	—	Same as the above ∗Signal deviated by 180˚ from that for H_3^- is applied.	
24	H_3^- : Hall element input	—	Same as the above ∗Signal deviated by 180˚ from that for H_3^+ is applied.	

■ Function Description

1) Three-phase full-wave soft switch system, snubber-less



The AN8294S employs highly effective three-phase full-wave drive system, by which current is pulled out or sunk from/into each phase, A1, A2 and A3.

Current switching for each phase is done with the trapezoid-wave-shaped linear switching current. The AN8294S applies the snubber-less drive system, which does not require the external capacitor at coil ends.

2) Start/Stop terminal provided and power saved in stop mode

The circuit operation starts by “H” signal. In stop mode, the entire circuit is turned off and the bias circuit current is not flown either. Thus consumption power becomes very small.

3) TSD (Thermal Shunt Down)

The TSD detects the junction temperature, and when it exceeds the detection temperature (170 ˚C, typ.), it turns off the motor current. Under this condition, the consumption power is low, almost the same as when the start/stop terminal is set to the stop condition.

The TSD has hysteresis, and is automatically reset when the temperature decreases. The hysteresis width is set to 45˚C (typ.).

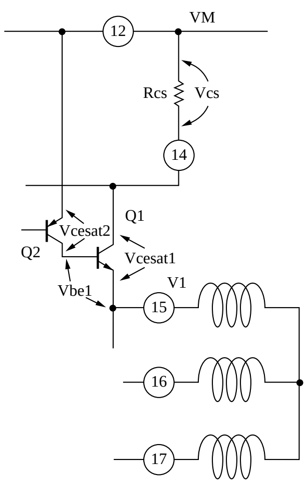
4) Current limitation

The current limitation is achieved through detection of the voltage fall of the resistor (detection resistor) which is connected between Pins12, 13 and 14. The detection voltage is set to 0.35V (typ.). When 0.5 Ω is connected between Pins12, 13 and 14, the limitation current is :

$$\frac{0.35\text{V}}{0.5\Omega} = 0.70\text{A}$$

The fall of voltage between Pins12, 13 and 14 doesn't affect the rise of saturation voltage.

In addition, Pins13 and 14 separate the drive system and sensor system. Pin14 CS1 is connected to the collector of upper side power Tr and functions as power supply which drive the coil. Pin13 CS2 functions as input for drive amp. of current feedback system. Pins13 and 14 should be shorted for use.



The V15 voltage of upper transistor block is given as follows :

$V15 = VM - Vbe1 - Vcesat2$ or $V15 = VM - V_{cesat1} - V_{cs}$

Therefore, $V_{be1} + V_{cesat2} = V_{cesat1} + V_{cs}$

$V_{cesat1} - V_{cesat2} = V_{be1} - V_{cs}$

If the voltage drop V_{cs} does not exceed V_{be} (the voltage between base and emitter of Q1), assuming that Q1 and Q2 have the same saturation voltage, the saturation voltage of upper side transistor block is not affected.

The above calculation can be also applied to the other phases.

The current limitation voltage is set to 0.35V. This voltage is lower than the voltage between base and emitter, and therefore the voltage fall due to detection resistance does not have a certain relationship with the saturation voltage, which affects the motor current. Thus, the AN8294S has the superior current detection system.

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

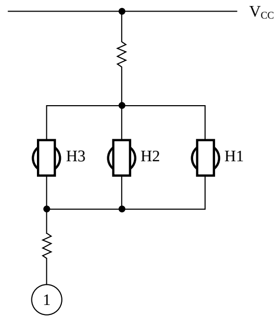
The direction of torque applied to the motor can be changed by changing the sequence of current flowing in each output phase through voltage setting with EC/ECR. Voltage difference between EC and ECR is proportional to the motor torque (motor current) (V characteristics).

6) Hall Bias Built-in

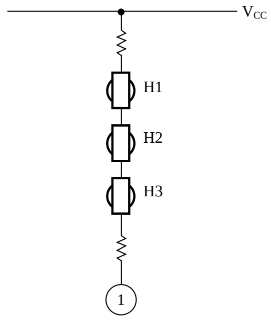
The AN8294S incorporates the power supply for Hall element, a position sensor.

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.

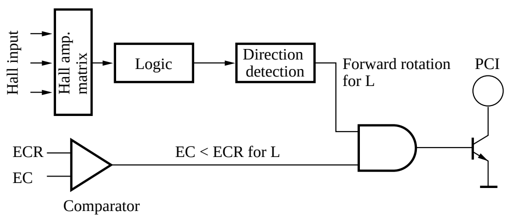


Parallel connection



Series connection

7) Reverse rotation prevention function

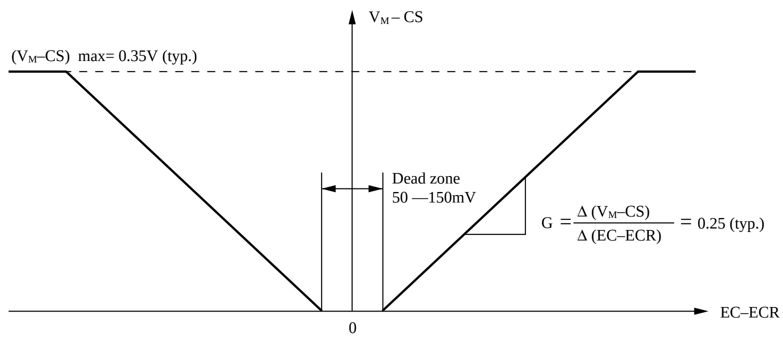


With Hall input, it detects the motor rotation direction.

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 Rcs = 0.5Ω,

· Transmission gain Acs from EC terminal voltage to output current is :

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

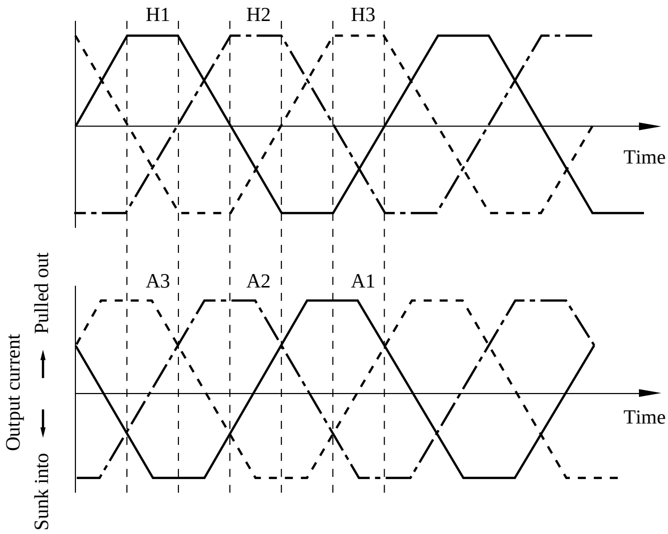
· Output maximum current I_{TL} is :

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

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

9) Phase relationship between Hall input and output currents.

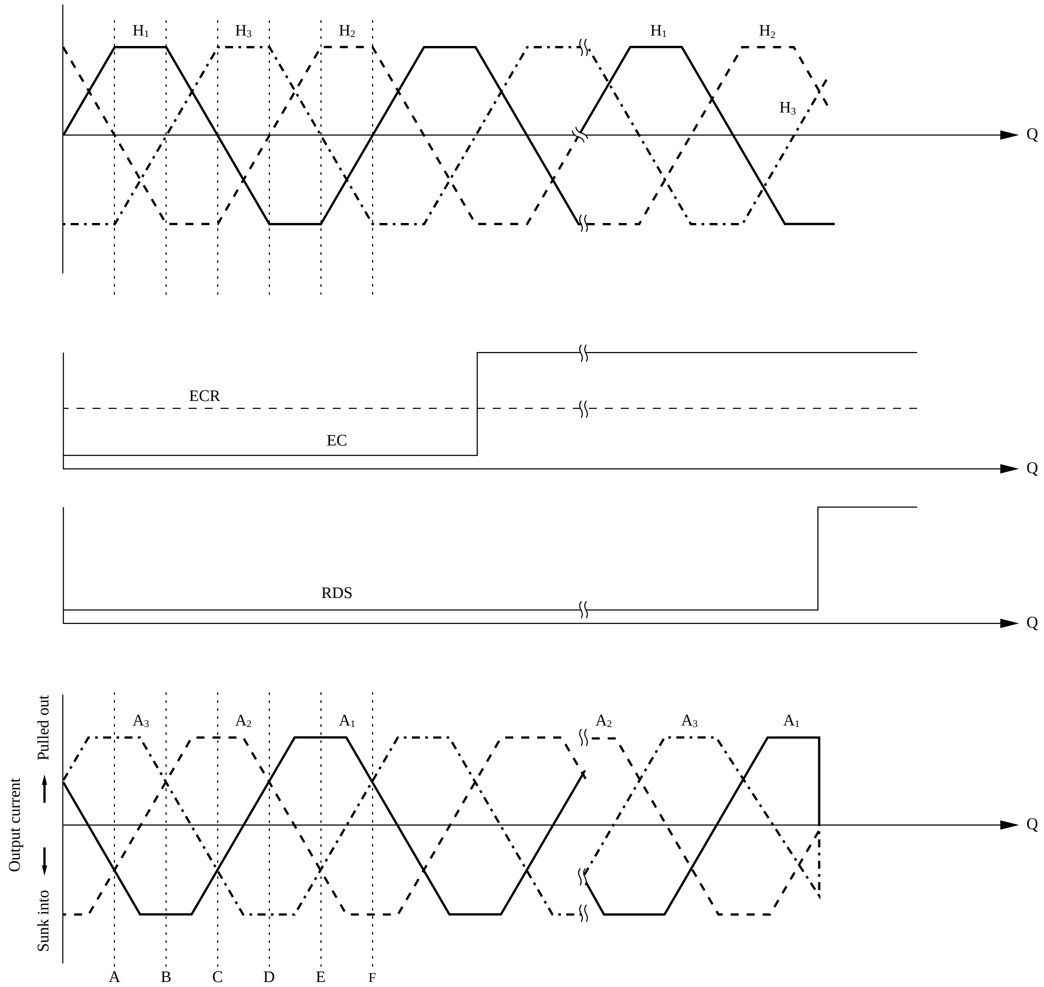
The phase relationship between Hall input and output currents when EC < ECR is shown in the following figure :



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 (Hn^{+}–Hn^{-}) 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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