

# 3Phase spindle motor driver for CD-RW

## BD6670FM

BD6670FM is a 3-phase spindle motor driver adopting 180° PWM direct driving system. Noise occurred from the motor driver when the disc is driver can be reduced. Low power consumption and low heat operation are achieved by using DMOS FET in output and driving directly.

### ●Applications

CD-RW

### ●Features

- 1) 180 degree Direct-PWM driving system.
- 2) Built in power save circuit.
- 3) Built in current limit circuit.
- 4) Built in FG-output.
- 5) Built in 3phase synthesized FG-output.
- 6) Built in hall bias circuit.
- 7) Built in reverse protection circuit.
- 8) Built in short brake circuit.
- 9) Low consumption by MOS-FET.
- 10) Built in capacitor for oscillator.
- 11) Built in gain switch and current limit switch.

### ●Absolute maximum ratings (Ta=25°C)

Parameter	Symbol	Limits	Unit
Power supply voltage	V <sub>CC</sub>	7	V
Supply voltage for motor	V <sub>M</sub>	15	V
V <sub>G</sub> pin voltage	V <sub>G</sub>	20	V
Output current	I <sub>OMAX</sub>	2500 * <sup>1</sup>	mA
Power dissipation	P <sub>d</sub>	2200 * <sup>2</sup>	mW
Junction temperature	T <sub>JMAX</sub>	150	°C
Operating temperature range	T <sub>opr</sub>	-20~+75	°C
Storage temperature range	T <sub>stg</sub>	-55~+150	°C

\*1 However, do not exceed P<sub>d</sub>, ASO and T<sub>J</sub>=150°C.

The current is guaranteed 3.0A in case of the current is turn on / off in a duty-ratio of less than 1/10 with a maximum on-time of 5msec.

\*2 70mm×70mm×1.6mm glass epoxy board.

Debating in done at 17.6mW / °C for operating above Ta=25°C.

### ●Recommended operating conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Power supply voltage	V <sub>CC</sub>	4.5	–	5.5	V
Supply voltage for motor	V <sub>M</sub>	4.0	–	13.2	V
V <sub>G</sub> pin voltage	V <sub>G</sub>	8.5	–	19	V

Motor driver ICs

●Block diagram

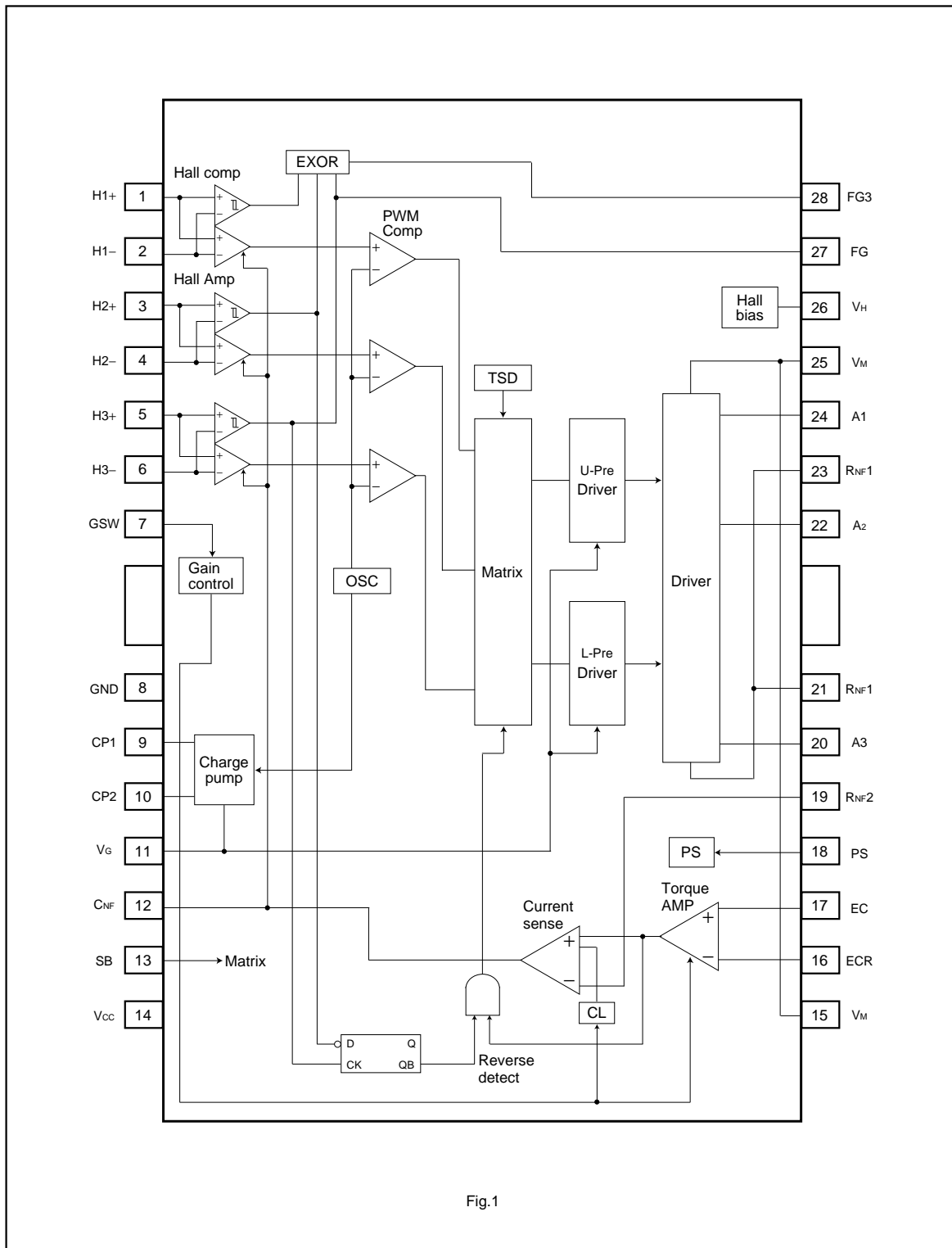


Fig.1

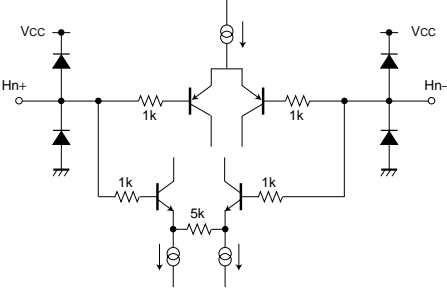
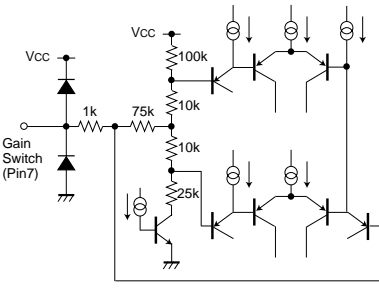
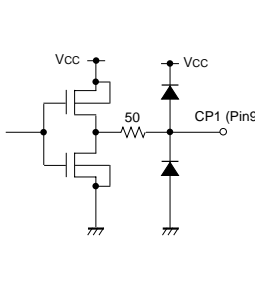
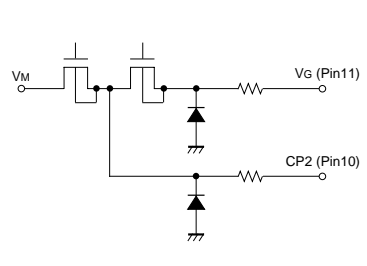
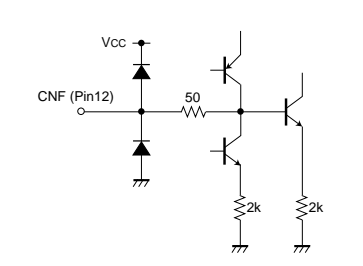
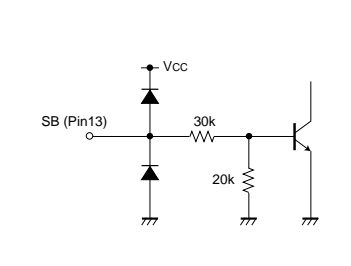
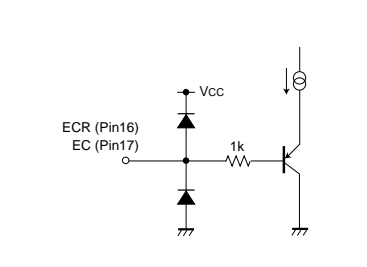
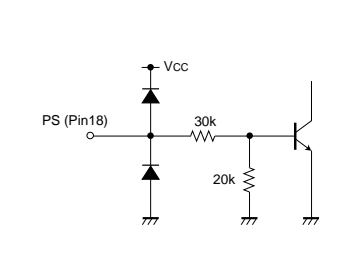
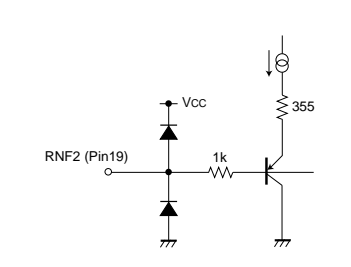
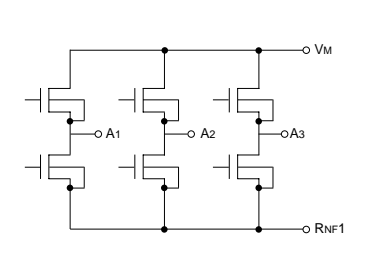
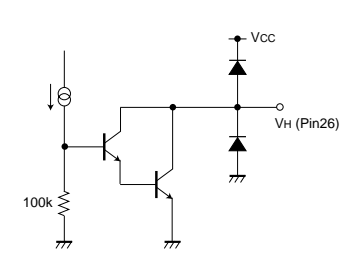
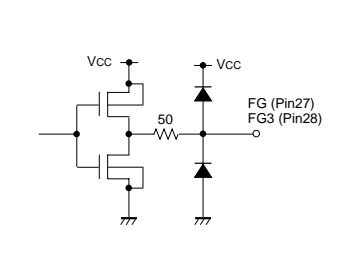
## Motor driver ICs

## ●Pin descriptions

Pin No.	Pin name	Function
1	H1 <sup>+</sup>	Hall input AMP 1 positive input
2	H1 <sup>-</sup>	Hall input AMP 1 negative input
3	H2 <sup>+</sup>	Hall input AMP 2 positive input
4	H2 <sup>-</sup>	Hall input AMP 2 negative input
5	H3 <sup>+</sup>	Hall input AMP 3 positive input
6	H3 <sup>-</sup>	Hall input AMP 3 negative input
7	GSW	Gain switch pin
8	GND	GND
9	CP1	Capacitor pin 1 for charge pump
10	CP2	Capacitor pin 2 for charge pump
11	V <sub>G</sub>	Capacitor connection pin for charge pump
12	CNF	Capacitor connection pin for phase compensation
13	SB	Short brake pin
14	V <sub>CC</sub>	Power supply for signal division
15	V <sub>M</sub>	Power supply for driver
16	ECR	Torque control standard voltage input terminal
17	EC	Torque control voltage input terminal
18	PS	Power save pin
19	RNF2	Resistor connection pin for current sense
20	A <sub>3</sub>	Output 3 for motor
21	RNF1	Resistor connection pin for current sense
22	A <sub>2</sub>	Output 2 for motor
23	RNF1	Resistor connection pin for current sense
24	A <sub>1</sub>	Output 1 for motor
25	V <sub>M</sub>	Power supply for driver
26	V <sub>H</sub>	Hall bias pin
27	FG	FG output pin
28	FG3	FG3 output pin

Motor driver ICs

●Input output circuits

<p>Hall input H1+ : Pin1, H1- : Pin2, H2+ : Pin3, H2- : Pin4, H3+ : Pin5, H3- : Pin6</p>	<p>Gain switch Pin7</p>	<p>CP1 output Pin9</p>
		
<p>CP2 / Vg output CP2 : Pin10, Vg : Pin11</p>	<p>CNF Pin12</p>	<p>Short brake Pin13</p>
		
<p>Torque amplifier ECR : Pin16, EC : Pin17</p>	<p>Power save Pin18</p>	<p>RNF2 Pin19</p>
		
<p>Output pins A1 : Pin24, A2 : Pin22, A3 : Pin20</p>	<p>Hall bias Pin26</p>	<p>FG / FG3 output FG : Pin27, FG3 : Pin28</p>
		

## Motor driver ICs

## ●Electrical characteristics (unless otherwise noted, Ta=25°C, VCC=5V, VM=12V)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions	Test Circuit
<Total>							
Circuit current 1	I <sub>CC1</sub>	–	1	10	μA	Stand by mode	Fig.2
Circuit current 2	I <sub>CC2</sub>	7	12	17	mA		Fig.2
<Power save>							
ON voltage range	V <sub>PSON</sub>	–	–	1.0	V	Stand by mode	Fig.2
OFF voltage range	V <sub>PSOFF</sub>	2.5	–	–	V		Fig.2
<Hall bias>							
Hall bias voltage	V <sub>HB</sub>	0.7	1.0	1.3	V	I <sub>HB</sub> =10mA	Fig.2
<Hall AMP>							
In-phase input voltage range	V <sub>HAR</sub>	1.4	–	3.6	V		Fig.3
Minimum input level	V <sub>INH</sub>	80	–	–	mV <sub>PP</sub>	Oneside input level	Fig.3
Hall hysteresis level (+)	V <sub>HYS+</sub>	5	20	40	mV		Fig.3
Hall hysteresis level (–)	V <sub>HYS–</sub>	–40	–20	–5	mV		Fig.3
<Gain switch>							
Low voltage range	V <sub>GSWL</sub>	–	–	0.6	V		Fig.4
High voltage range	V <sub>GSWH</sub>	2.0	–	–	V		Fig.4
Open voltage range	V <sub>GSWOP</sub>	–	1.3	–	V		Fig.4
<Torque control>							
Input voltage range	E <sub>c</sub> , E <sub>CR</sub>	0	–	5	V	Linear range : 0.5V~3.0V	Fig.6
Offset voltage (+)	E <sub>cofs+</sub>	5	50	100	mV		Fig.6
Offset voltage (–)	E <sub>cofs–</sub>	–100	–50	5	mV		Fig.6
Input current	E <sub>CIN</sub>	–11	–2.5	0	μA	E <sub>c</sub> =E <sub>CR</sub> =1.65V	Fig.6
Input / Output gain L	G <sub>ECL</sub>	0.28	0.35	0.42	A/V	G <sub>SL</sub> =L, R <sub>NF</sub> =0.5Ω	Fig.7
Input / Output gain M	G <sub>E<sub>CM</sub></sub>	0.56	0.70	0.84	A/V	G <sub>SL</sub> =M, R <sub>NF</sub> =0.5Ω	Fig.7
Input / Output gain H	G <sub>E<sub>CH</sub></sub>	1.12	1.40	1.68	A/V	G <sub>SL</sub> =H, R <sub>NF</sub> =0.5Ω	Fig.7
<Output>							
Output ON-resistance	R <sub>ON</sub>	–	1.0	1.35	Ω	I <sub>O</sub> =±600mA (Upper+Lower)	Fig.8
Torque limit current L	I <sub>TLL</sub>	340	400	460	mA	G <sub>SW</sub> =L, R <sub>NF</sub> =0.5Ω	Fig.4
Torque limit current M	I <sub>TLM</sub>	680	800	920	mA	G <sub>SW</sub> =M, R <sub>NF</sub> =0.5Ω	Fig.4
Torque limit current H	I <sub>TLH</sub>	1020	1200	1380	mA	G <sub>SW</sub> =H, R <sub>NF</sub> =0.5Ω	Fig.4
<FG / FG3 output>							
High voltage	V <sub>FGH</sub>	4.6	–	–	V	I <sub>FG</sub> =–100μA	Fig.5
Low voltage	V <sub>FG<sub>L</sub></sub>	–	–	0.4	V	I <sub>FG</sub> =+100μA	Fig.5
<Charge pump voltage>							
Charge pump output voltage	V <sub>PUMP</sub>	12.5	17	19	V	V <sub>CC</sub> =5V, V <sub>M</sub> =12V, CP1=CP2=0.1μF	Fig.9
<CP1 output>							
Upper saturation voltage	V <sub>CP1H</sub>	0.25	0.45	0.65	V	I <sub>CP1</sub> =–4mA	Fig.10
Lower saturation voltage	V <sub>CP1L</sub>	0.2	0.4	0.6	V	I <sub>CP1</sub> =+4mA	Fig.10
<CP2 output>							
Upper saturation voltage	V <sub>CP2H</sub>	0.4	0.6	0.8	V	I <sub>CP2</sub> =–4mA	Fig.11
Lower saturation voltage	V <sub>CP2L</sub>	0.15	0.35	0.55	V	I <sub>CP2</sub> =+4mA	Fig.11

Motor driver ICs

● Measuring circuit

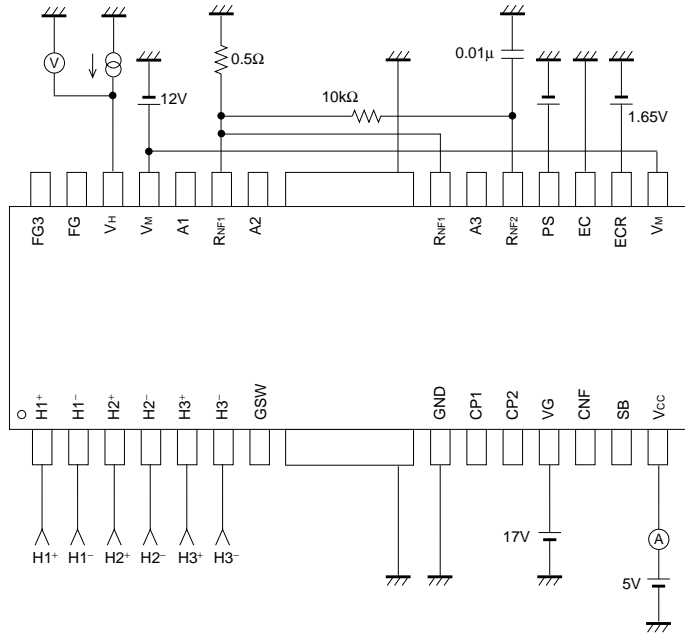


Fig.2

I<sub>cc1</sub> : Value of A  
V<sub>PS</sub>=Low

I<sub>cc2</sub> : Value of A  
V<sub>PS</sub>=High

V<sub>PSON</sub> : Range of V<sub>PS</sub> that output pins become Input-output table

V<sub>PSOFF</sub> : Range of V<sub>PS</sub> that output become open

V<sub>HB</sub> : Value of A  
V<sub>PS</sub>=5V  
I<sub>VH</sub>=10mA

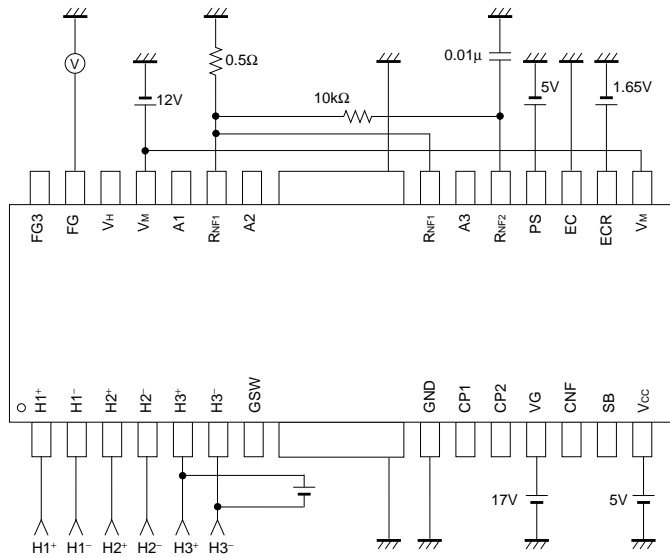


Fig.3

V<sub>HAR</sub> : Hall in-phase input voltage range that output pins become Input-output table

V<sub>INH</sub> : Hall minimum input level that output pins become Input-output table

V<sub>HYS+/-</sub> : Voltage difference H3+ from H3- at the point that FG voltage changes

Motor driver ICs

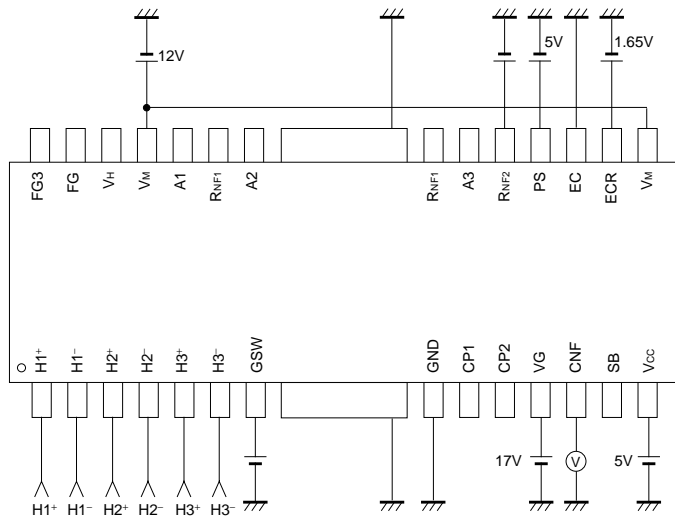


Fig.4

$I_{TL}$  : Defining  $V_{RNF2}$  as the voltage that CNF becomes low,  
 $I_{TL} = V_{RNF2} / 0.5$   
 $V_{GSW} = \text{Low}$

$I_{TLM}$  : Defining  $V_{RNF2}$  as the voltage that CNF becomes low,  
 $I_{TLM} = V_{RNF2} / 0.5$   
 $V_{GSW} = \text{Open}$

$I_{TLH}$  : Defining  $V_{RNF2}$  as the voltage that CNF becomes low,  
 $I_{TLH} = V_{RNF2} / 0.5$   
 $V_{GSW} = \text{High}$

$V_{GSWL}$  : Range of  $V_{GSW}$  that  $I_{TL} < I_{TLM}$

$V_{GSWH}$  : Range of  $V_{GSW}$  that  $I_{TLH} > I_{TLM}$

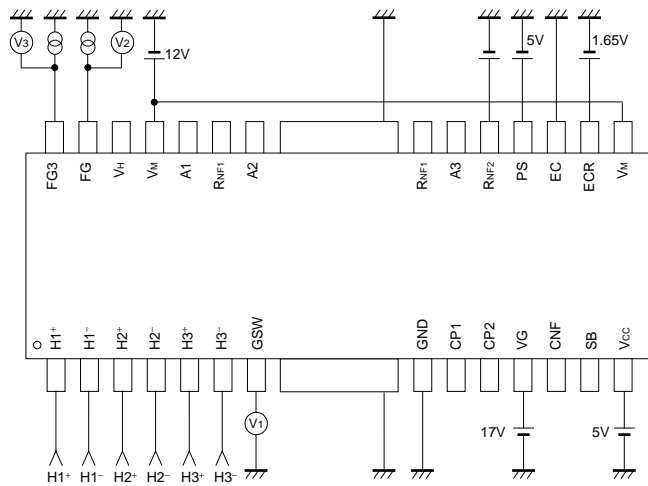


Fig.5

$V_{GSWOP}$  : Value of  $V$

$V_{FGH}$  :  $I_{FG} (I_{FG3}) = \text{Value of } V2(V3) \text{ at } I_{FG} (I_{FG3}) = -100\mu\text{A}$

- H1+=L, H2+=M, H3+=H
- H1-=M, H2-=M, H3-=M (for FG)
- H1+=L, H2+=H, H3+=H
- H1-=M, H2-=M, H3-=M (for FG3)

$V_{FGL}$  :  $I_{FG} (I_{FG3}) = \text{Value of } V2(V3) \text{ at } I_{FG} (I_{FG3}) = 100\mu\text{A}$

- H1+=M, H2+=H, H3+=L
- H1-=M, H2-=M, H3-=M (for FG)
- H1+=L, H2+=H, H3+=L
- H1-=M, H2-=M, H3-=M (for FG3)

Motor driver ICs

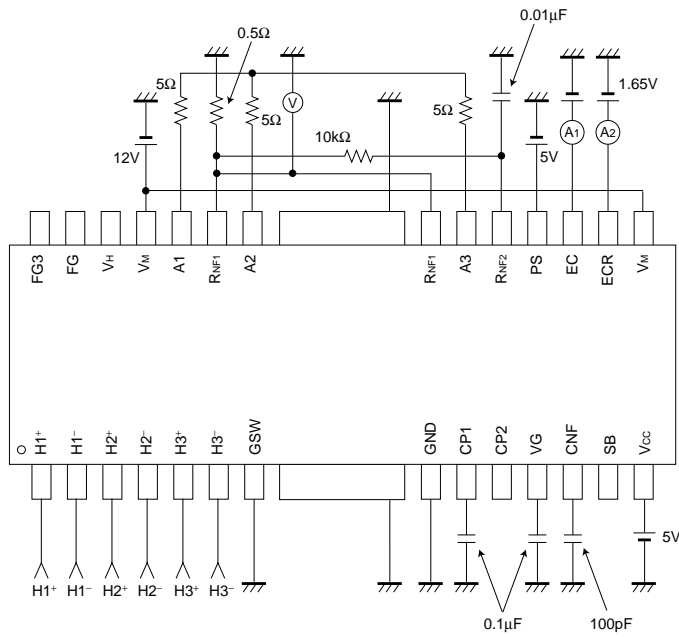


Fig.6

Ec / Ecr : Torque control operating range

Ecofs+ / - : EC voltage range that Vm current is 0A monitor VRNF1

ECIN : Value of A1 and A2 at EC=ECR=1.65V

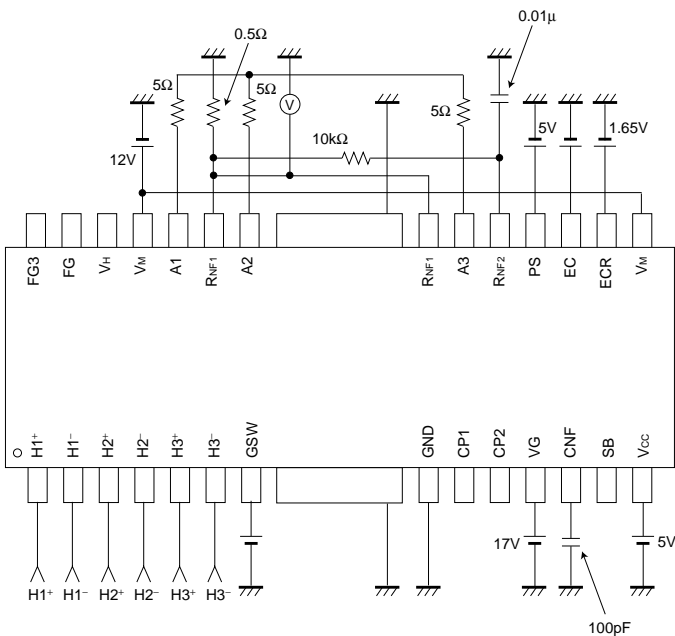


Fig.7

GECL : Defining V1 as value of V at EC=1.2V and V2 as value of V at EC=1.5V on condition that GSW=0V,  

$$GECL = \{(V1 - V2) / (1.5 - 1.2)\} / 0.5$$

GECM : Defining V1 as value of V at EC=1.2V and V2 as value of V at EC=1.5V on condition that GSW=open,  

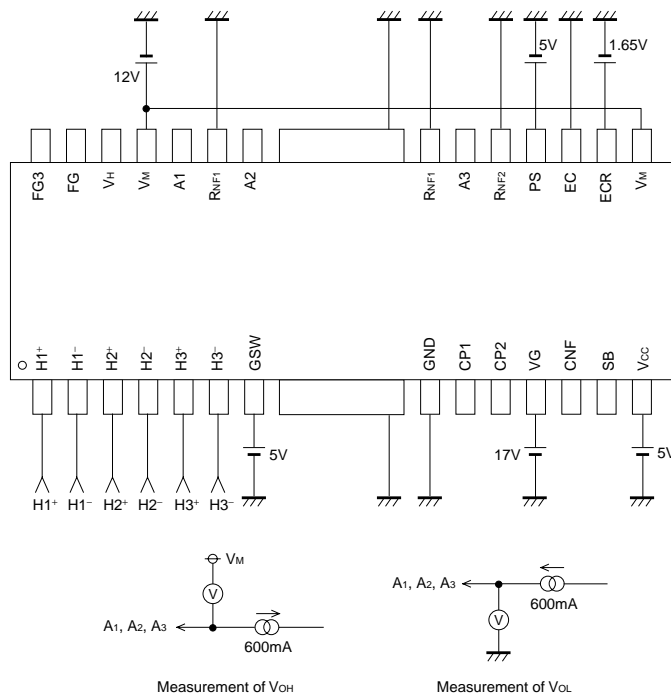
$$GECL = \{(V1 - V2) / (1.5 - 1.2)\} / 0.5$$

GECH : Defining V1 as value of V at EC=1.2V and V2 as value of V at EC=1.5V on condition that GSW=5V,  

$$GECL = \{(V1 - V2) / (1.5 - 1.2)\} / 0.5$$



Motor driver ICs

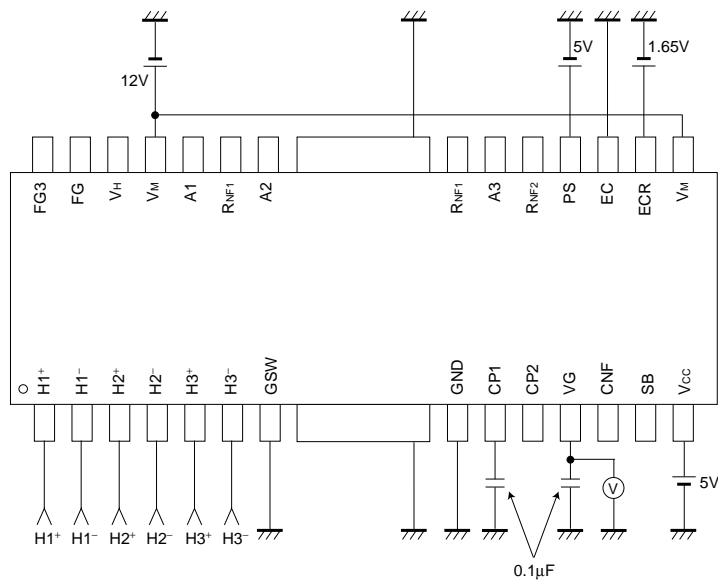


$V_{OH}$  : Value of V on condition that output pin is H and  $I_O = -600\text{mA}$

$V_{OL}$  : Value of V on condition that output pin is L and  $I_O = 600\text{mA}$

$R_{ON} : R_{ON} = (V_{OH} + V_{OL}) / 0.6$

Fig.8



$V_{PUMP}$  : Value of V

Fig.9

Motor driver ICs

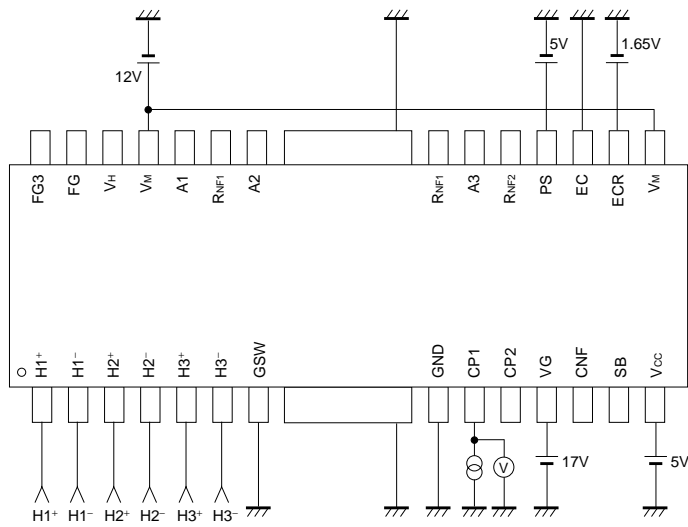


Fig.10

$V_{CP1H}$  : Value of V on condition that CP1 is H and  $I_{CP1}=-4mA$

$V_{CP1L}$  : Value of V on condition that CP1 is L and  $I_{CP1}=4mA$

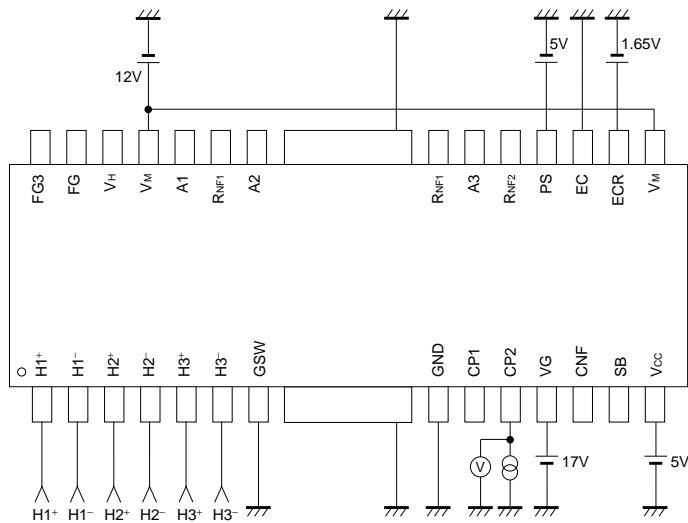


Fig.11

$V_{CP2H}$  : Value of V on condition that CP2 is H and  $I_{CP2}=-4mA$

$V_{CP2L}$  : Value of V on condition that CP2 is L and  $I_{CP2}=4mA$

## Motor driver ICs

## ●Circuit operation

## 1. Application

## (1) Input-output table

Pin No.	Input condition						Output condition					
							$E_C < E_{CR}$			$E_C > E_{CR}$		
	1 H <sub>1+</sub>	2 H <sub>1-</sub>	3 H <sub>2+</sub>	4 H <sub>2-</sub>	5 H <sub>3+</sub>	6 H <sub>3-</sub>	24 A <sub>1</sub>	22 A <sub>2</sub>	20 A <sub>3</sub>	24 A <sub>1</sub>	22 A <sub>2</sub>	20 A <sub>3</sub>
Condition 1	L	M	H	M	M	M	H	L	L	L	H	H
Condition 2	H	M	L	M	M	M	L	H	H	H	L	L
Condition 3	M	M	L	M	H	M	L	H	L	H	L	H
Condition 4	M	M	H	M	L	M	H	L	H	L	H	L
Condition 5	H	M	M	M	L	M	L	L	H	H	H	L
Condition 6	L	M	M	M	H	M	H	H	L	L	L	H

## (2) Hall input

Hall element can be used with both series and parallel connection. Determining R1 and R2, make sure to leave an adequate margin for temperature and dispersion in order to satisfy in-phase input voltage range and minimum input level.

A motor doesn't reach the regular number of rotation, if hall input decrease under high temperature.

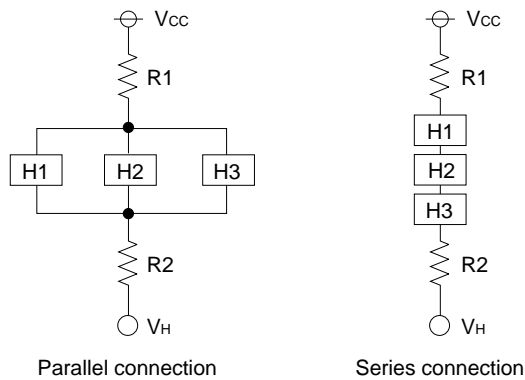


Fig.12

## Motor driver ICs

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### (3) Torque voltage

By the voltage difference between EC and ECR, the current driving motor changes as shown in Fig.13 below.

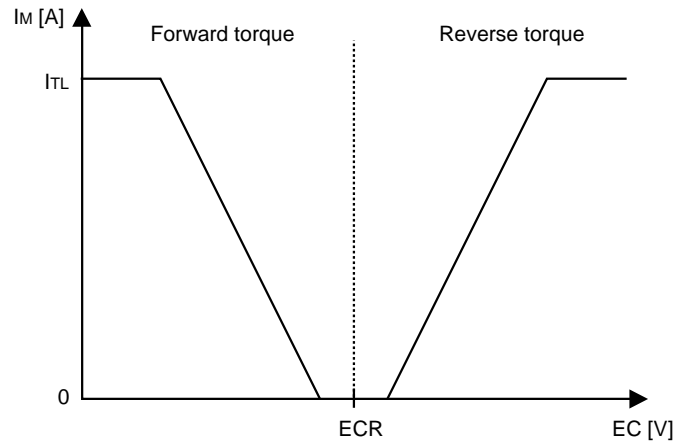


Fig.13

The gain of the current driving motor for the voltage of  $EC$  can be changed by the resistance of  $RNF$  and the voltage of  $GSW$ .

$$GECL=0.175 / RNF \text{ [A / V]} \text{ (GSW=L)}$$

$$GECM=0.35 / RNF \text{ [A / V]} \text{ (GSW=M)}$$

$$GECH=0.70 / RNF \text{ [A / V]} \text{ (GSW=H)}$$

### (4) Current limit

The maximum value of the current driving motor can be changed by the resistance of  $RNF$  and the voltage of  $GSW$ .

$$ITLL=0.2 / RNF \text{ [A]} \text{ (GSW=L)}$$

$$ITLM=0.4 / RNF \text{ [A]} \text{ (GSW=M)}$$

$$ITLH=0.6 / RNF \text{ [A]} \text{ (GSW=H)}$$

Motor driver ICs

(5) Short brake

The short brake is switched by SB pin and its operation is shown in table below.

SB	EC < ECR	EC > ECR
L	Rotating forward	Reverse brake
H	Short brake	Short brake

Output upper (3phase) FET turn off and lower (3phase) FET turn on in short brake mode, as shown Fig.14.

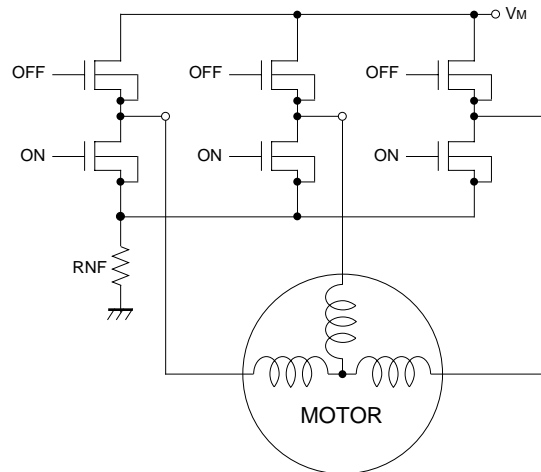


Fig.14

(6) Reverse detection

Reverse detection is constructed as shown in Fig.15. Output is opened when EC>ECR and the motor is rotating reverse.

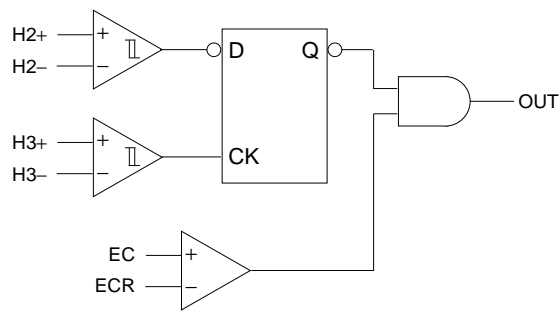
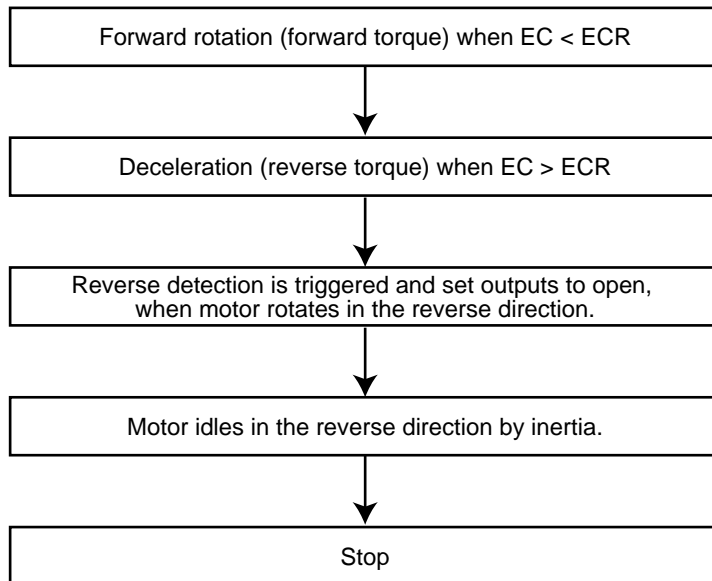


Fig.15

Motor rotation at reverse detection

## Motor driver ICs

## (6) Timing chart

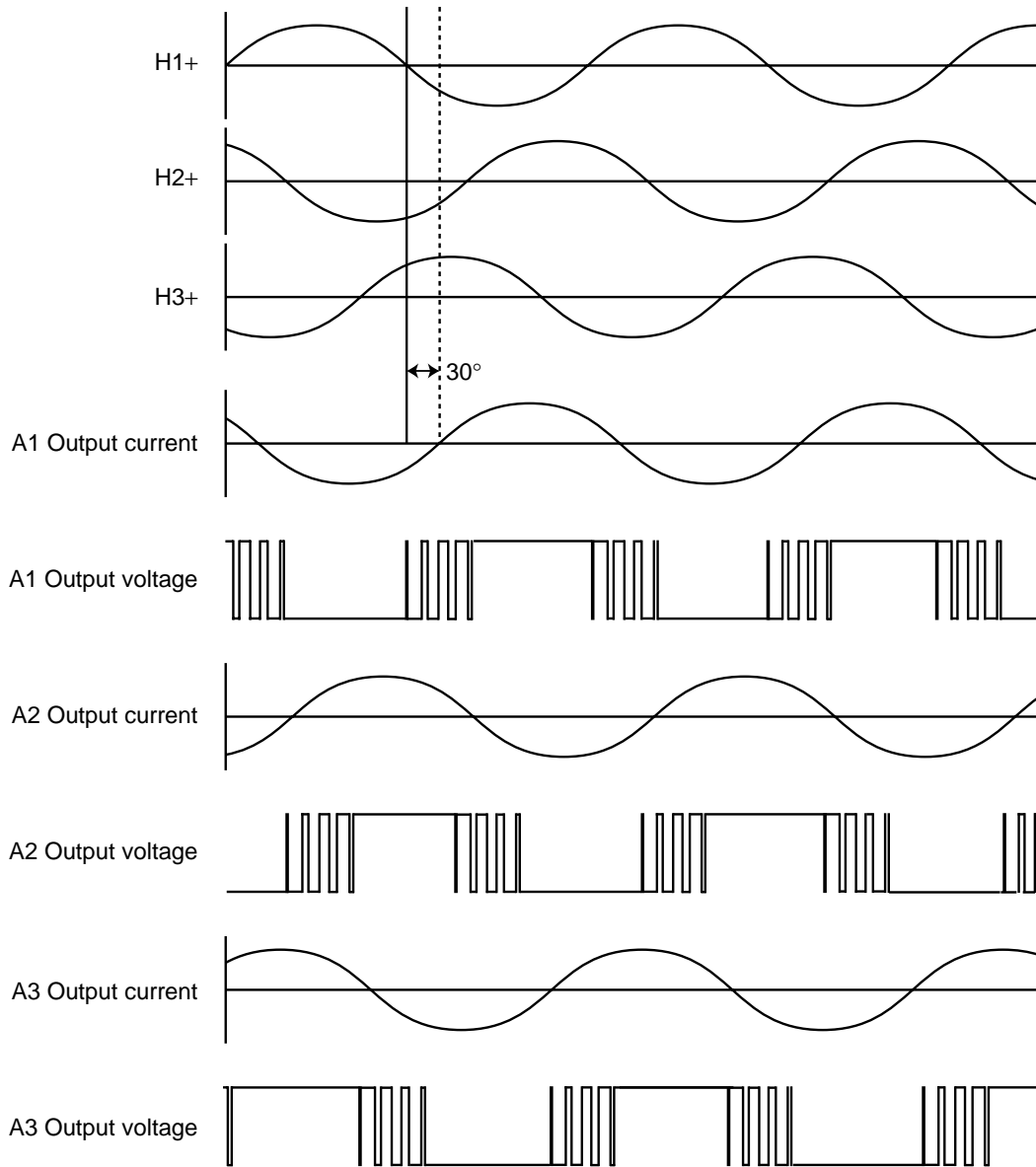


Fig.16

Motor driver ICs

●Application example

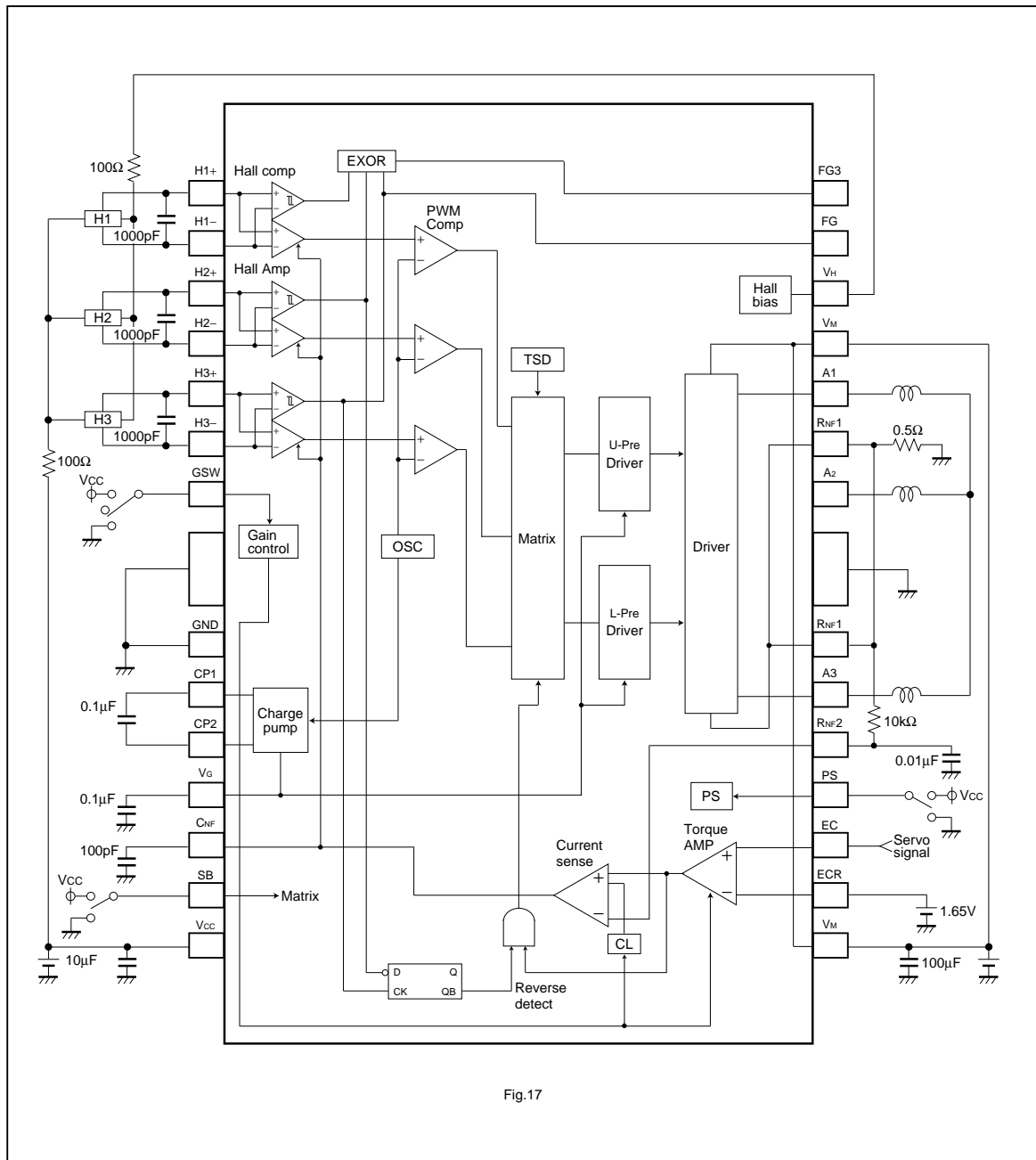


Fig.17

●Operation notes

1. Absolute maximum ratings

Absolute maximum ratings are those values which, if exceeded, may cause the life of a device to become significantly shortened. Moreover, the exact failure mode cannot be defined, such as a short or an open. Physical countermeasures, such as fuse, need to be considered when using a device beyond its maximum ratings.

2. GND potential

The GND terminal should be the location of the lowest voltage on the chip. All other terminals should never go under this GND level, even in transition.



Motor driver ICs

3. Thermal design

The thermal design should allow enough margin for actual power dissipation.

4. Mounting failures

Mounting failures, such as misdirection or mismounts, may destroy the device.

5. Electromagnetic fields

A strong electromagnetic field may cause malfunctions.

6. Coil current flowing into VM

A coil current flows from motor into VM when torque control input changes from EC<ECR into EC>ECR, and VM voltage rises if VM voltage source doesn't have an ability of current drain. A protect circuit turns on and a current (40mA (typ.)) flows from VM to GND when VM voltage reaches to 15V (Typ.).

Make sure that surrounding circuits work correctly and aren't destroyed, when VM voltage rises.

Physical countermeasures, such as a diode for voltage clamp, need to be considered under these conditions.

7. CNF pin

An appropriate capacitor (100pF (typ.)) at CNF pin make motor current smooth. Make sure the motor current doesn't oscillate, even in transition.

●Electrical characteristics curve

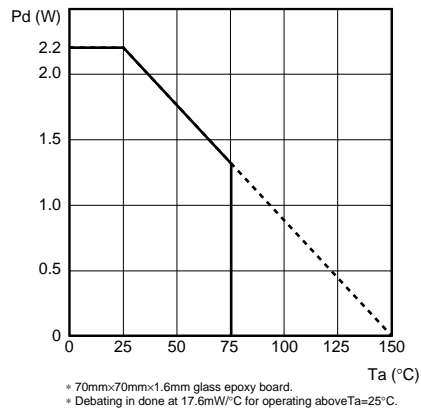


Fig.16 Power dissipation curve

●External dimensions (Units : mm)

