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_{CC}	7	V
Supply voltage for motor	V_M	15	V
V_G pin voltage	V_G	20	V
Output current	I_{OMAX}	2500 ∗1	mA
Power dissipation	Pd	2200 ∗2	mW
Junction temperature	T_{JMAX}	150	°C
Operating temperature range	Topr	−20~+75	°C
Storage temperature range	Tstg	−55~+150	°C

∗1 However, do not exceed Pd, ASO and Tj=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_{CC}	4.5	–	5.5	V
Supply voltage for motor	V_M	4.0	–	13.2	V
V_G pin voltage	V_G	8.5	–	19	V

●**Block diagram**

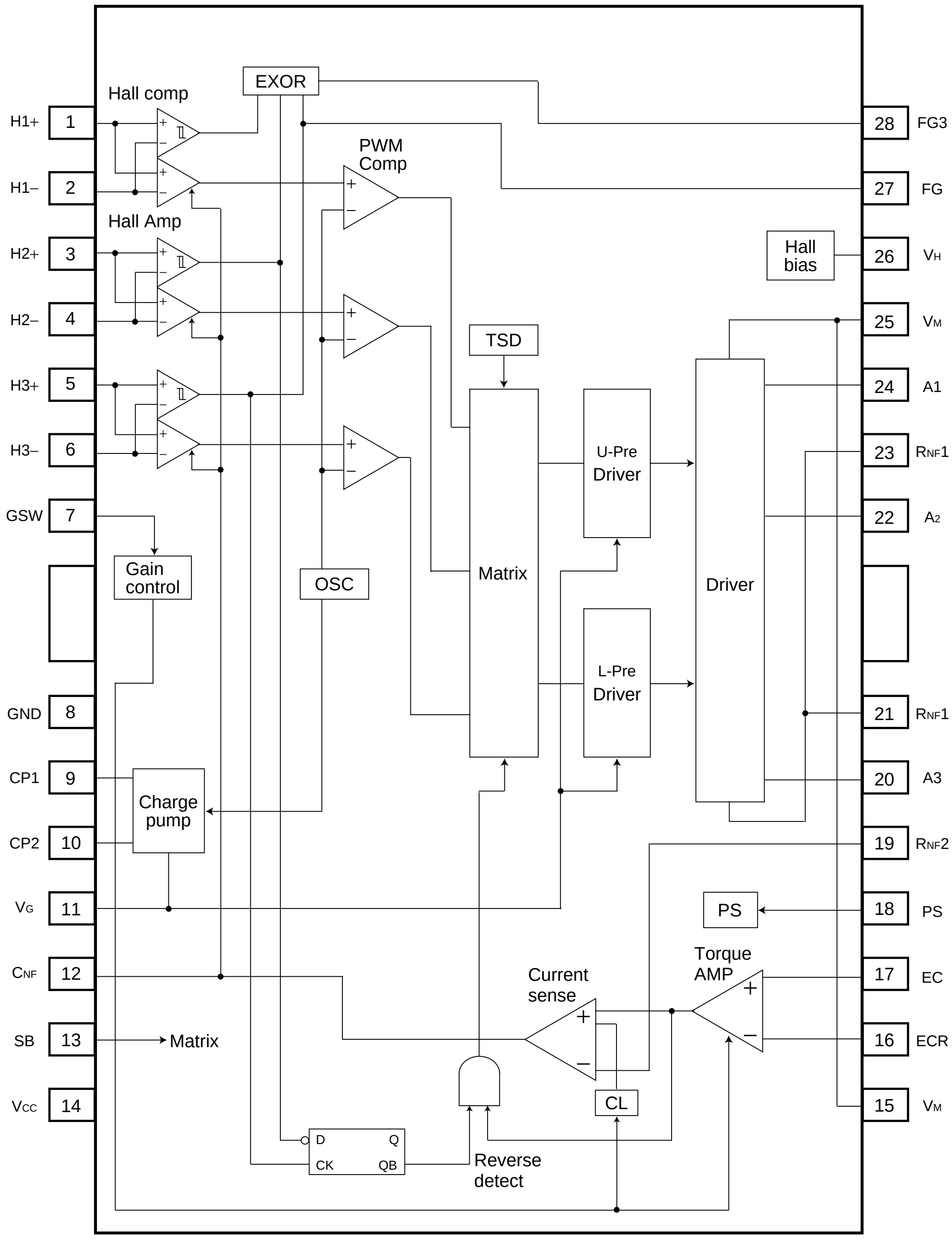


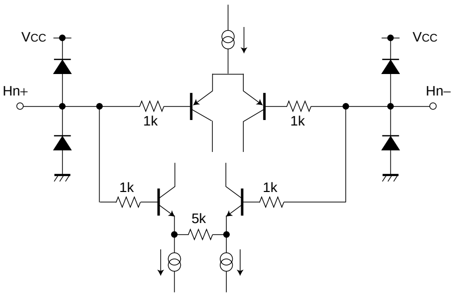
Fig.1

●**Pin descriptions**

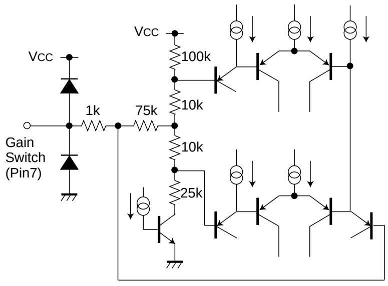
Pin No.	Pin name	Function
1	H_1^+	Hall input AMP 1 positive input
2	H_1^-	Hall input AMP 1 negative input
3	H_2^+	Hall input AMP 2 positive input
4	H_2^-	Hall input AMP 2 negative input
5	H_3^+	Hall input AMP 3 positive input
6	H_3^-	Hall input AMP 3 negative input
7	GSW	Gain switch pin
8	GND	GND
9	CP1	Capacitor pin 1 for charge pump
10	CP2	Capacitor pin 2 for charge pump
11	V_G	Capacitor connection pin for charge pump
12	CNF	Capacitor connection pin for phase compensation
13	SB	Short brake pin
14	V_{CC}	Power supply for signal division
15	V_M	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	R_{NF2}	Resistor connection pin for current sense
20	A_3	Output 3 for motor
21	R_{NF1}	Resistor connection pin for current sense
22	A_2	Output 2 for motor
23	R_{NF1}	Resistor connection pin for current sense
24	A_1	Output 1 for motor
25	V_M	Power supply for driver
26	V_H	Hall bias pin
27	FG	FG output pin
28	FG3	FG3 output pin

●Input output circuits

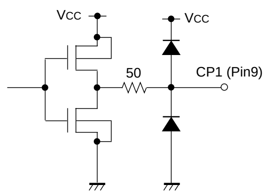
Hall input
H1+ : Pin1, H1− : Pin2, H2+ : Pin3,
H2− : Pin4, H3+ : Pin5, H3− : Pin6



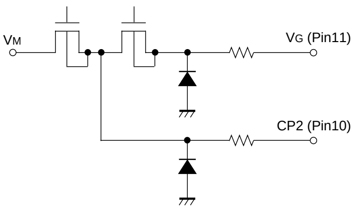
Gain switch
Pin7



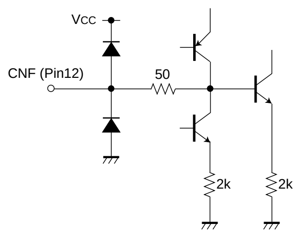
CP1 output
Pin9



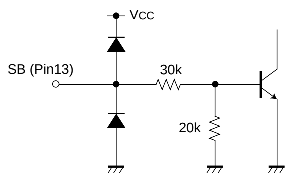
CP2 / VG output
CP2 : Pin10, VG : Pin11



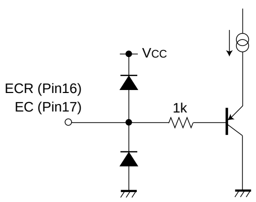
CNF
Pin12



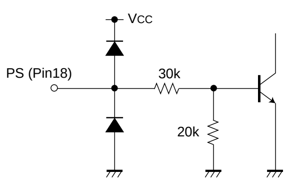
Short brake
Pin13



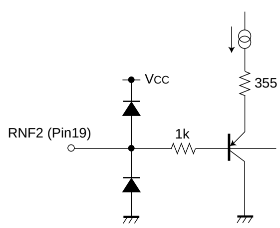
Torque amplifier
ECR : Pin16, EC : Pin17



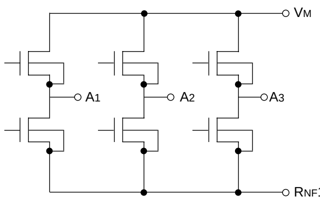
Power save
Pin18



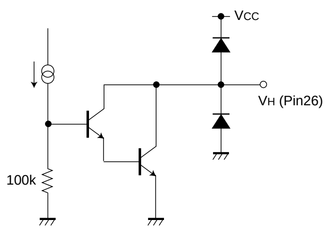
RNF2
Pin19



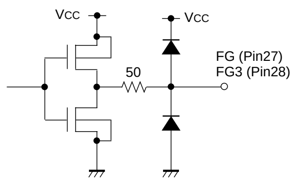
Output pins
A1 : Pin24, A2 : Pin22, A3 : Pin20



Hall bias
Pin26



FG / FG3 output
FG : Pin27, FG3 : Pin28



●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	$I_{CC}1$	–	1	10	µA	Stand by mode	Fig.2
Circuit current 2	$I_{CC}2$	7	12	17	mA		Fig.2
<Power save>							
ON voltage range	V_{PSON}	–	–	1.0	V	Stand by mode	Fig.2
OFF voltage range	V_{PSOFF}	2.5	–	–	V		Fig.2
<Hall bias>							
Hall bias voltage	V_{HB}	0.7	1.0	1.3	V	I_{HB}=10mA	Fig.2
<Hall AMP>							
In-phase input voltage range	V_{HAR}	1.4	–	3.6	V		Fig.3
Minimum input level	V_{INH}	80	–	–	mV_{PP}	Oneside input level	Fig.3
Hall hysteresis level (+)	V_{HYS^+}	5	20	40	mV		Fig.3
Hall hysteresis level (–)	V_{HYS^-}	–40	–20	–5	mV		Fig.3
<Gain switch>							
Low voltage range	V_{GSWL}	–	–	0.6	V		Fig.4
High voltage range	V_{GSWH}	2.0	–	–	V		Fig.4
Open voltage range	V_{GSWOP}	–	1.3	–	V		Fig.4
<Torque control>							
Input voltage range	E_C, E_{CR}	0	–	5	V	Linear range : 0.5V~3.0V	Fig.6
Offset voltage (+)	$Ecofs^+$	5	50	100	mV		Fig.6
Offset voltage (–)	$Ecofs^-$	–100	–50	5	mV		Fig.6
Input current	E_{CIN}	–11	–2.5	0	µA	E_C=E_{CR}=1.65V	Fig.6
Input / Output gain L	G_{ECL}	0.28	0.35	0.42	A/V	GSL=L, R_{NF}=0.5Ω	Fig.7
Input / Output gain M	G_{ECM}	0.56	0.70	0.84	A/V	GSL=M, R_{NF}=0.5Ω	Fig.7
Input / Output gain H	G_{ECH}	1.12	1.40	1.68	A/V	GSL=H, R_{NF}=0.5Ω	Fig.7
<Output>							
Output ON-resistance	R_{ON}	–	1.0	1.35	Ω	I_O=±600mA (Upper+Lower)	Fig.8
Torque limit current L	I_{TLL}	340	400	460	mA	GSW=L, R_{NF}=0.5Ω	Fig.4
Torque limit current M	I_{TLM}	680	800	920	mA	GSW=M, R_{NF}=0.5Ω	Fig.4
Torque limit current H	I_{TLH}	1020	1200	1380	mA	GSW=H, R_{NF}=0.5Ω	Fig.4
<FG / FG3 output>							
High voltage	V_{FGH}	4.6	–	–	V	I_{FG}=–100µA	Fig.5
Low voltage	V_{FGL}	–	–	0.4	V	I_{FG}=+100µA	Fig.5
<Charge pump voltage>							
Charge pump output voltage	V_{PUMP}	12.5	17	19	V	V_{CC}=5V, V_M=12V, CP1=CP2=0.1µF	Fig.9
<CP1 output>							
Upper saturation voltage	V_{CP1H}	0.25	0.45	0.65	V	I_{CP1}=–4mA	Fig.10
Lower saturation voltage	V_{CP1L}	0.2	0.4	0.6	V	I_{CP1}=+4mA	Fig.10
<CP2 output>							
Upper saturation voltage	V_{CP2H}	0.4	0.6	0.8	V	I_{CP2}=–4mA	Fig.11
Lower saturation voltage	V_{CP2L}	0.15	0.35	0.55	V	I_{CP2}=+4mA	Fig.11

● **Measuring circuit**

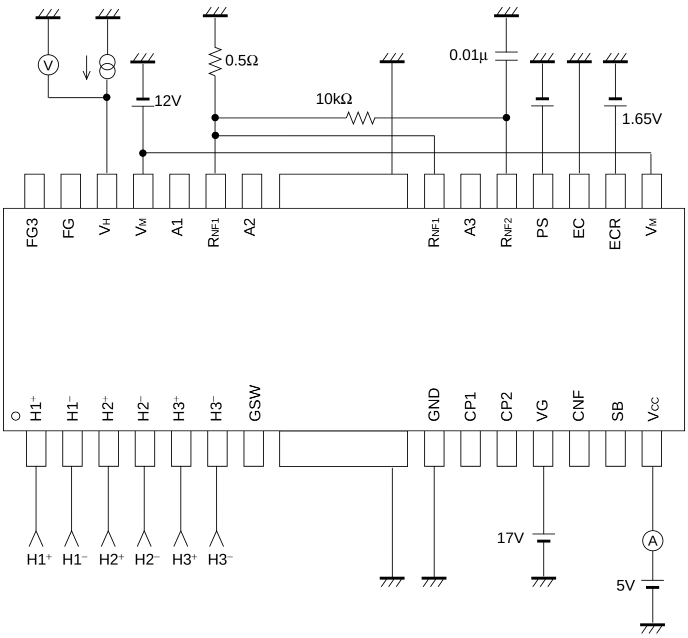


Fig.2

$I_{CC}1$: Value of A
V_{PS}=Low

$I_{CC}2$: Value of A
V_{PS}=High

V_{PSON} : Range of V_{PS} that output pins become Input-output table

V_{PSOFF} : Range of V_{PS} that output become open

V_{HB} : Value of A
V_{PS}=5V
I_{VH}=10mA

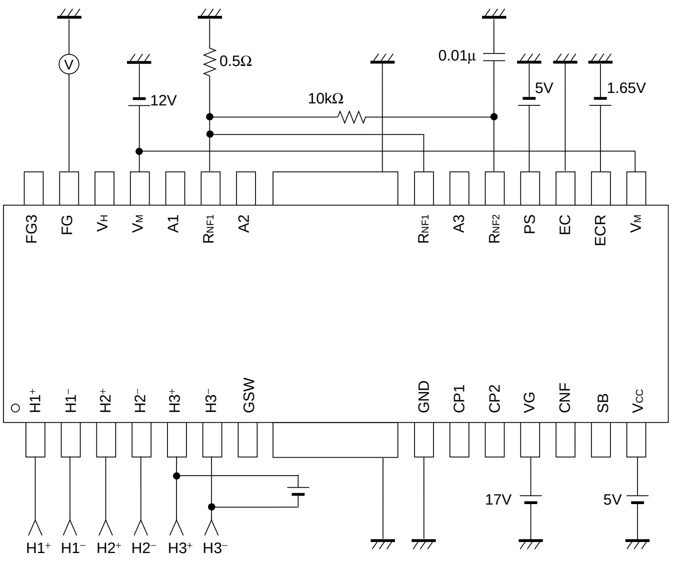


Fig.3

V_{HAR} : Hall in-phase input voltage range that output pins become Input-output table

V_{INH} : Hall minimum input level that output pins become Input-output table

V_{HYS}+/− : Voltage difference H3+ from H3− at the point that FG voltage changes

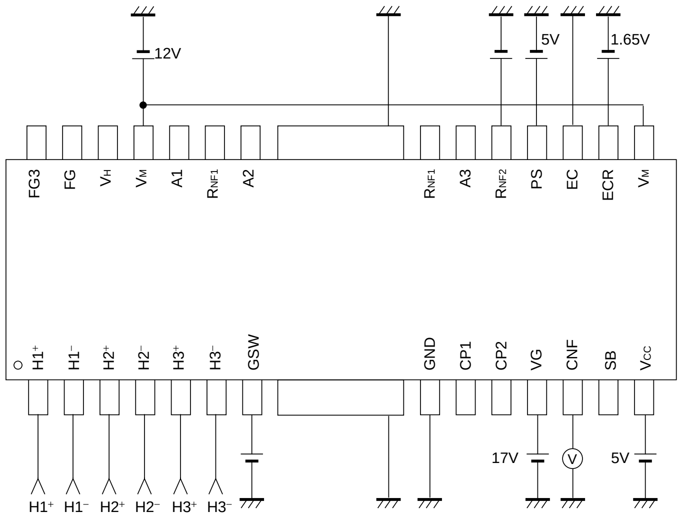


Fig.4

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

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

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

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

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

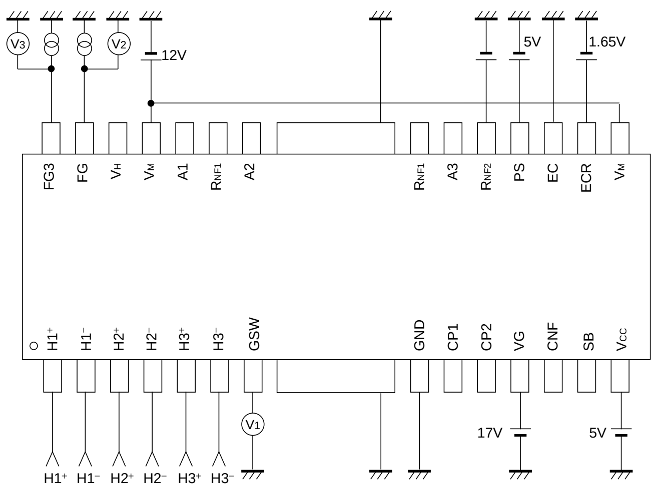


Fig.5

V_{GSWOP} : Value of V

V_{FGH} : I_{FG} (I_{FG3}) = Value of V2(V3) at I_{FG} (I_{FG3}) = −100µA
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}) = Value of V2(V3) at I_{FG} (I_{FG3}) = 100µA
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)

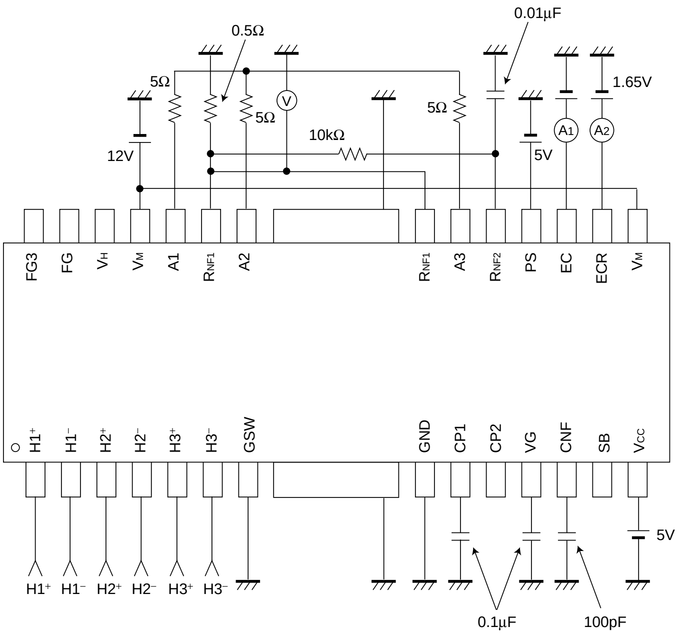


Fig.6

E_C / E_{CR} : Torque control operating range

E_{COFS}+ / – : EC voltage range that V_M current is 0A monitor V_{RNF1}

E_{CIN} : Value of A1 and A2 at EC=ECR=1.65V

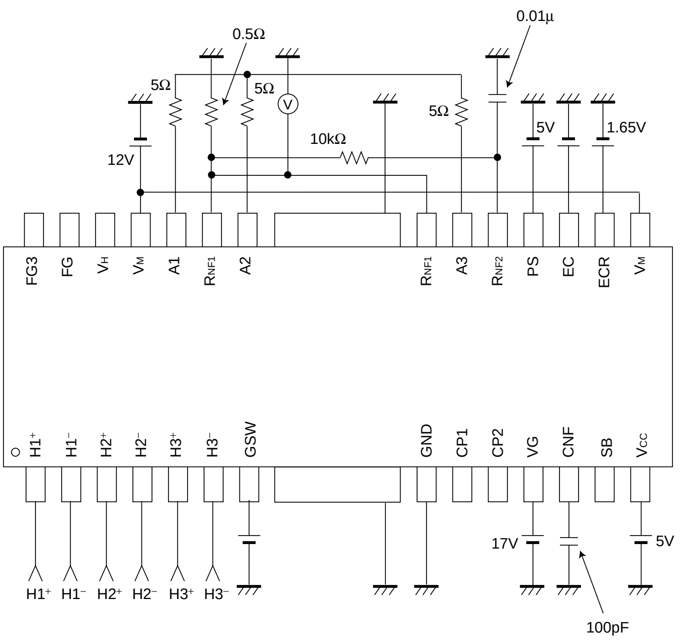
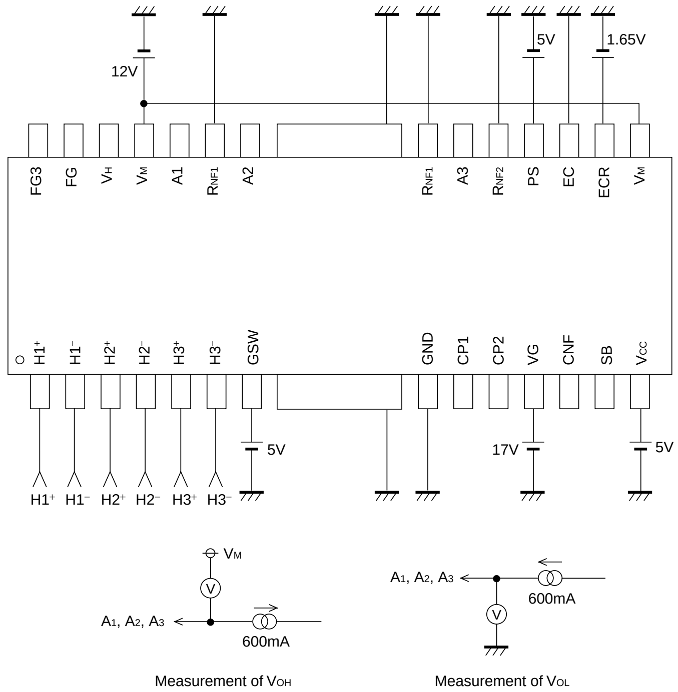


Fig.7

G_{ECL} : 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,
G_{ECL}={(V1–V2) / (1.5–1.2)} / 0.5

G_{ECM} : 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,
G_{ECL}={(V1–V2) / (1.5–1.2)} / 0.5

G_{ECH} : 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,
G_{ECL}={(V1–V2) / (1.5–1.2)} / 0.5

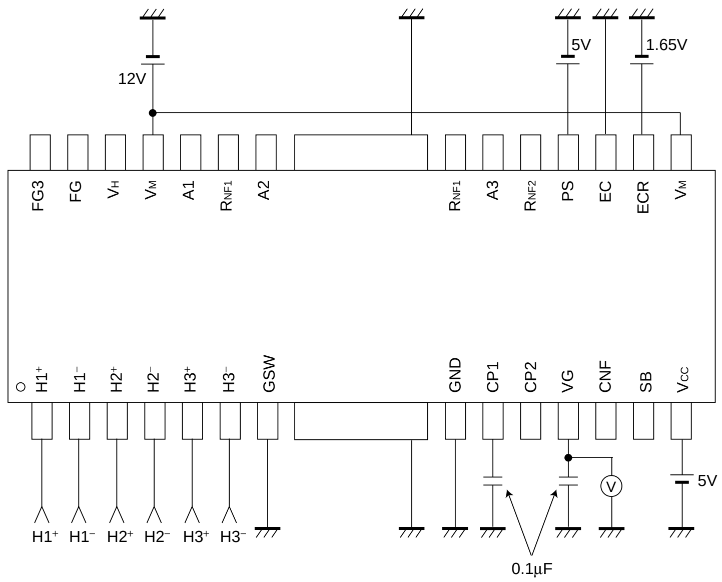


V_{OH} : Value of V on condition that output pin is H and I_O=−600mA

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

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

Fig.8



V_{PUMP} : Value of V

Fig.9

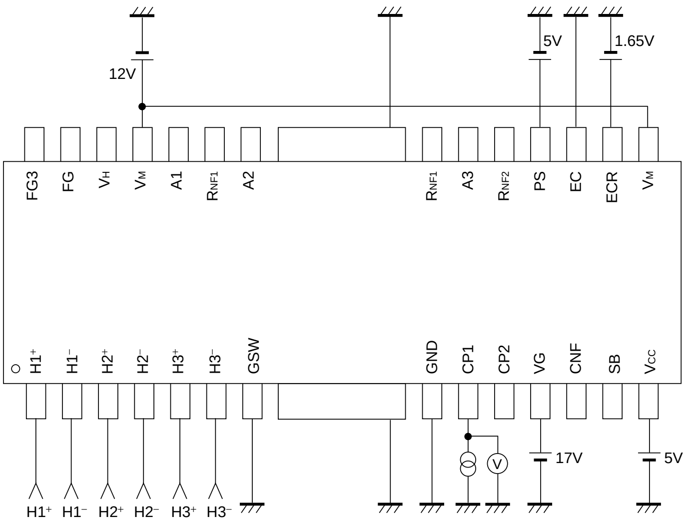


Fig.10

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

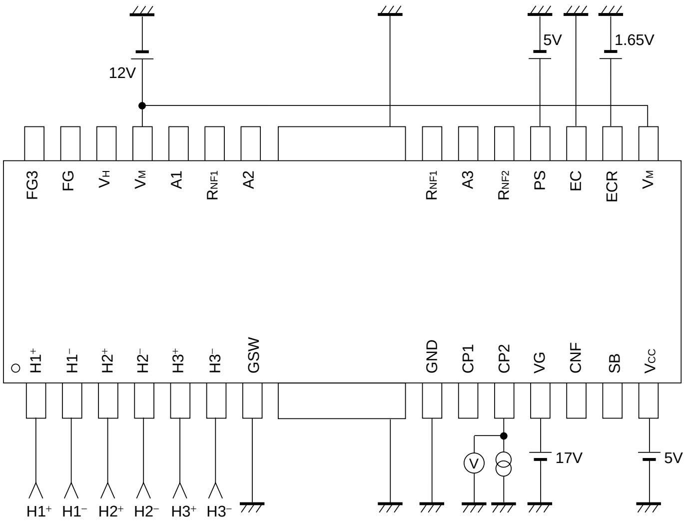


Fig.11

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

●Circuit operation

1. Application

(1) Input-output table

	Input condition						Output condition					
							$E_C < E_{CR}$			$E_C > E_{CR}$		
Pin No.	1	2	3	4	5	6	24	22	20	24	22	20
	H_1^+	H_1^-	H_2^+	H_2^-	H_3^+	H_3^-	A_1	A_2	A_3	A_1	A_2	A_3
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 dispertion 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.

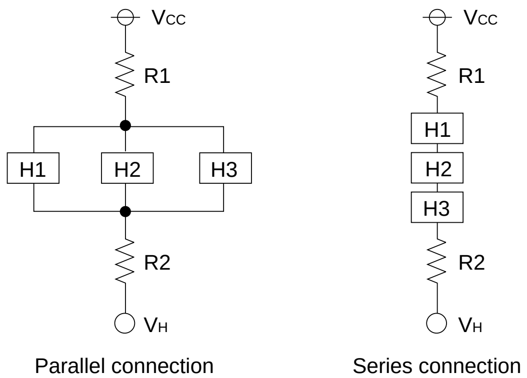


Fig.12

(3) Torque voltage

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

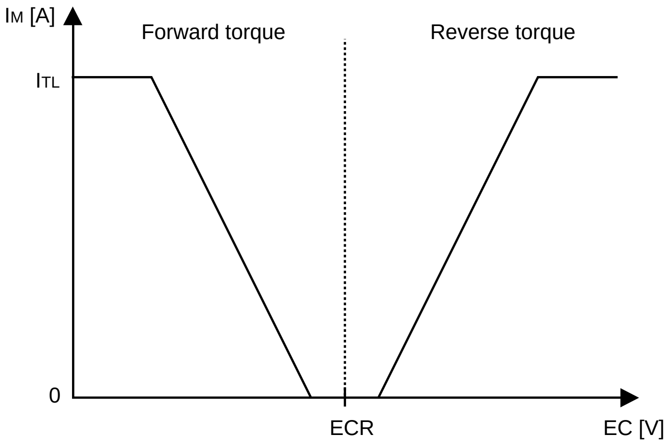


Fig.13

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.

G_{ECL}=0.175 / RNF [A / V] (GSW=L)
G_{ECM}=0.35 / RNF [A / V] (GSW=M)
G_{ECH}=0.70 / RNF [A / V] (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.

I_{TLL}=0.2 / RNF [A] (GSW=L)
I_{TLM}=0.4 / RNF [A] (GSW=M)
I_{TLH}=0.6 / RNF [A] (GSW=H)

(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.

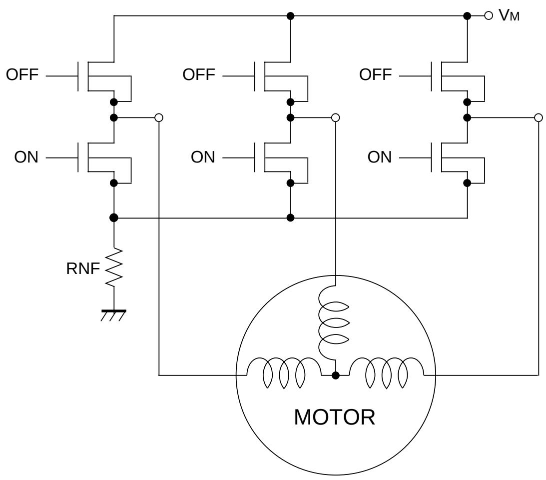


Fig.14

(6) Reverse detection

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

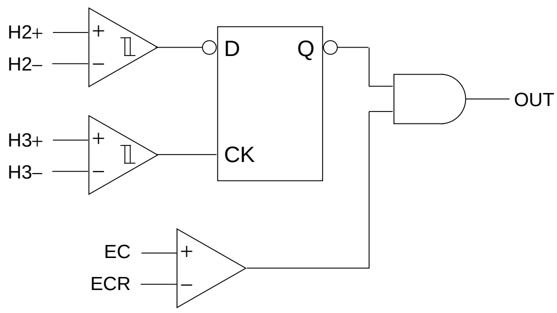
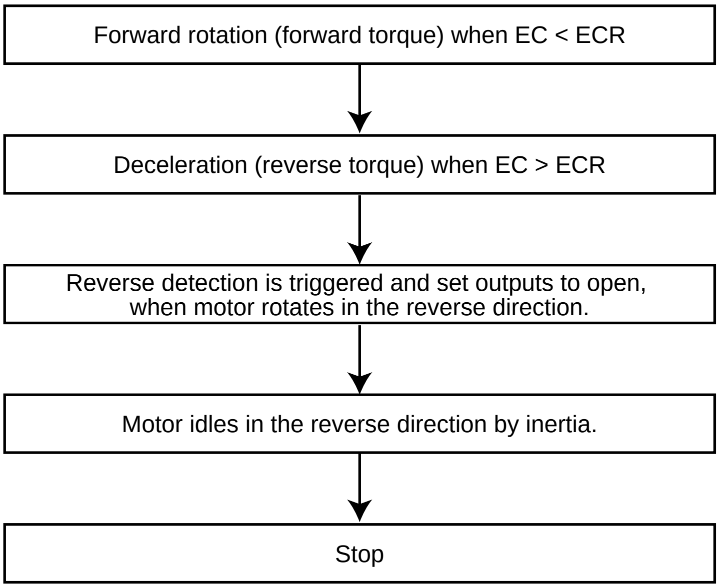


Fig.15

Motor rotation at reverse detection



(7) Timing chart

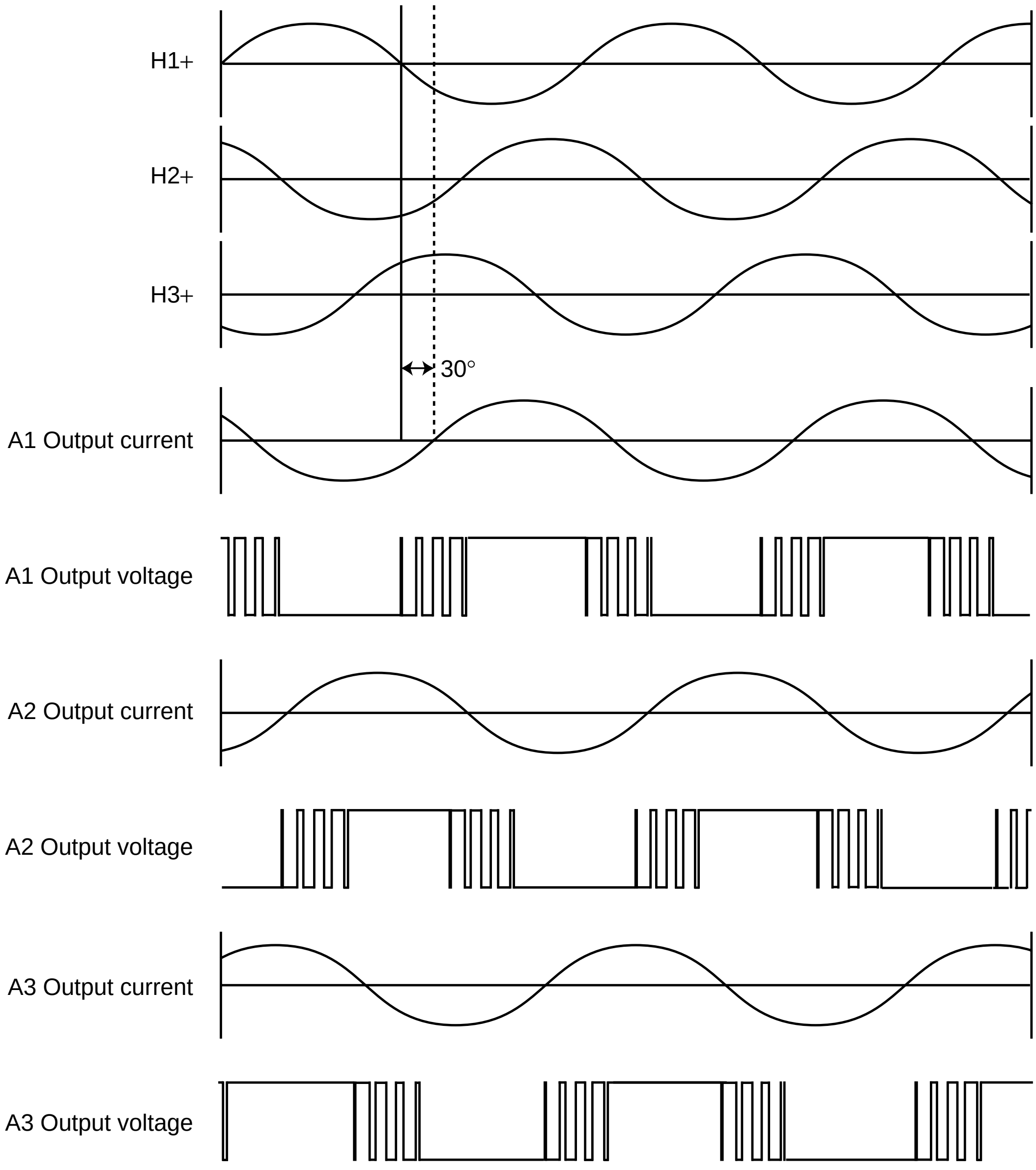


Fig.16

●Application example

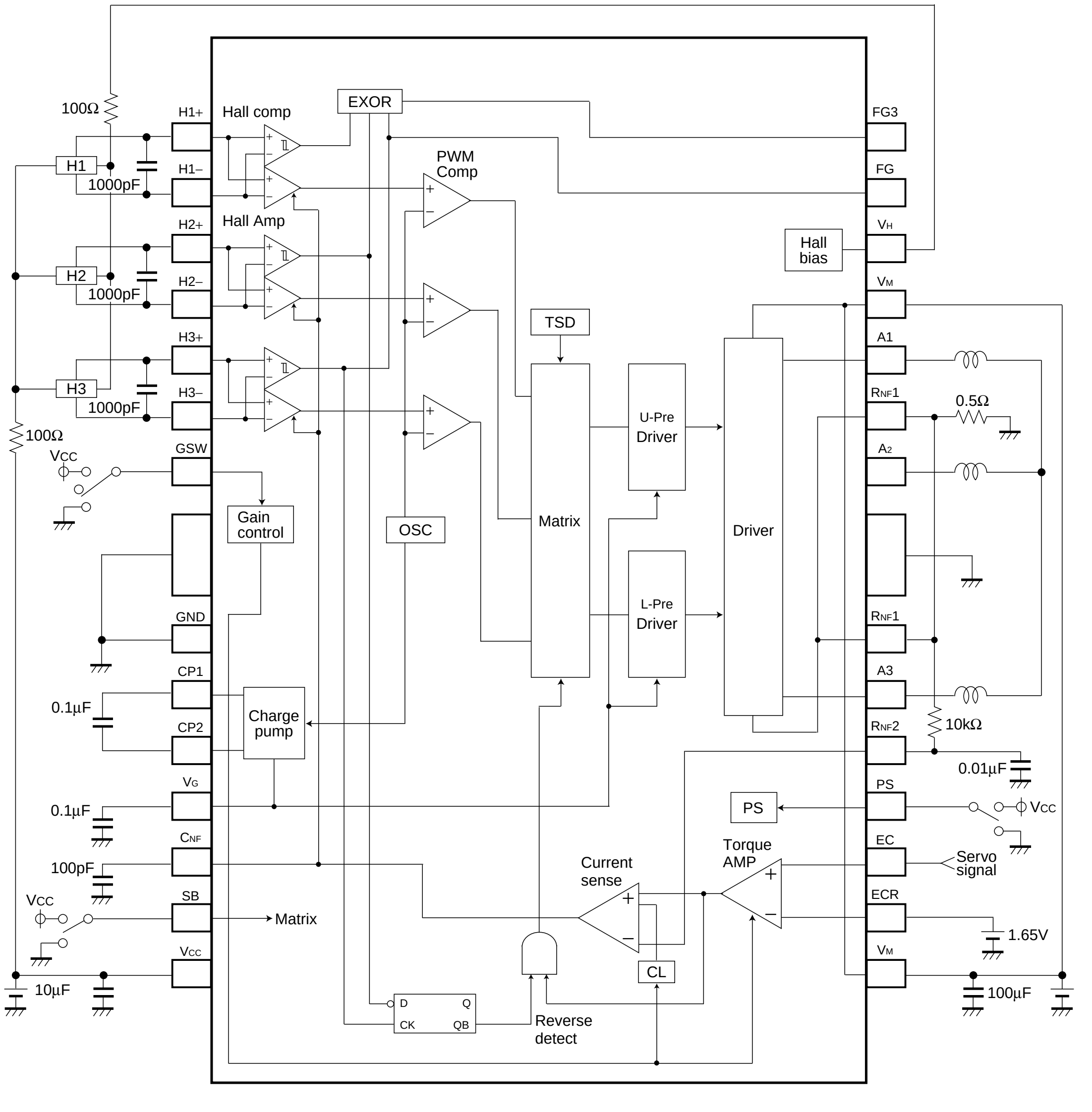


Fig.17

●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 shorted. 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.

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

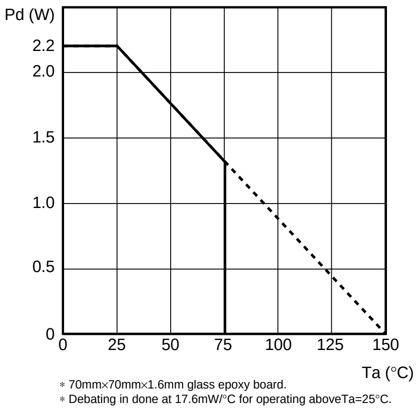


Fig.18 Power dissipation curve

●External dimensions (Units : mm)