FAN8725 (KA3025)

Spindle Motor and 5-Channel Motor Driver

Features

Common

- Built-in thermal shutdown circuit (TSD)
- Built-in power save circuit
- 3 Independent voltage source
- Corresponds to 3.3V or 5V DSP

Spindle

- 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

BTL (5-channel)

- Built-in 5-CH balanced transformerless (BTL) driver
- Built-in Level shift circuit
- Independent voltage sources
- VM2 = CH1,CH2 / VM3 = CH3, CH4 ,CH5

Description

The FAN8725 is a monolithic IC suitable for a 3-phase BLDC spindle motor driver and 5-ch motor drivers which drives the focus actuator, tracking actuator, loading motor, stepping motor driver of the CD-media systems.
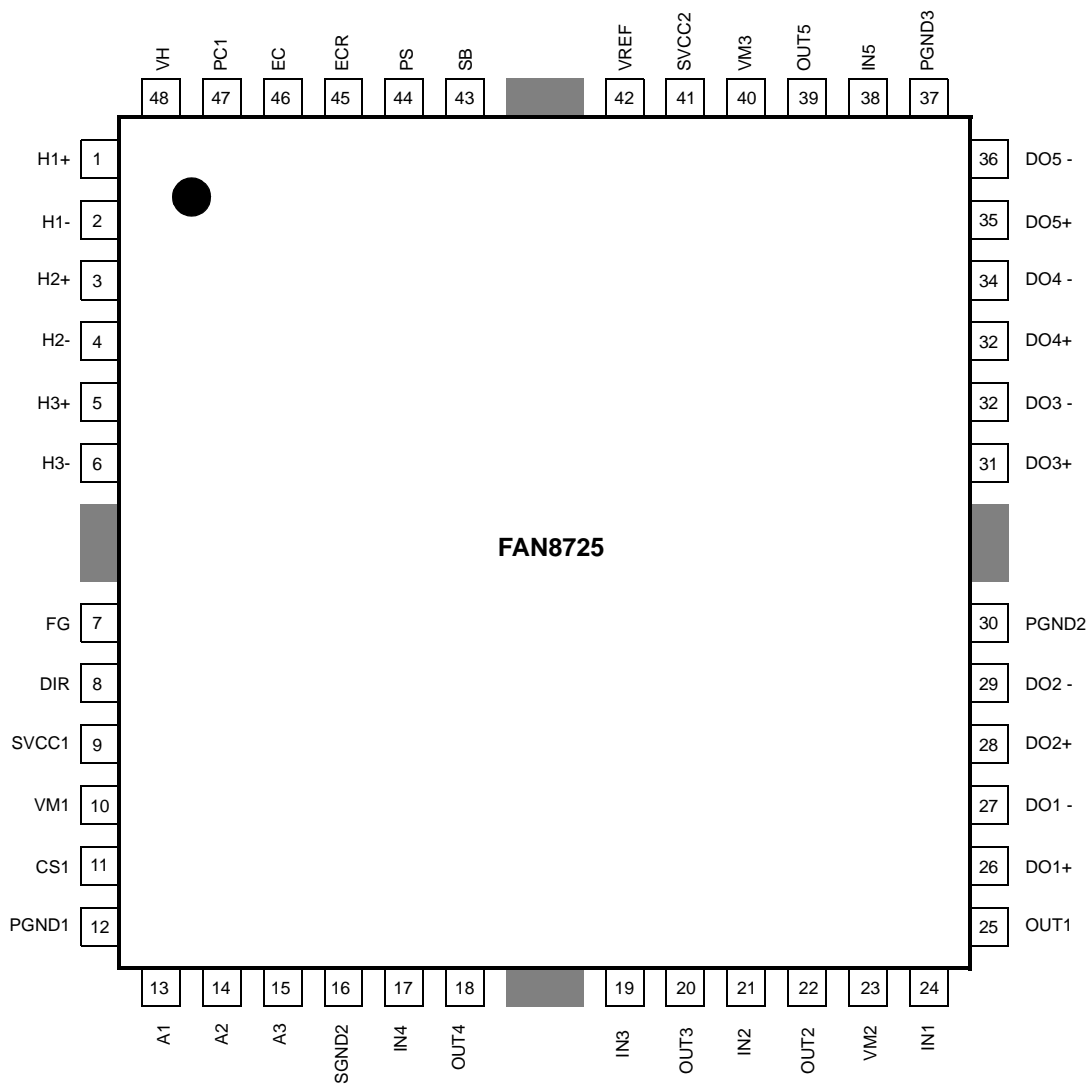
48-QFPH-1414
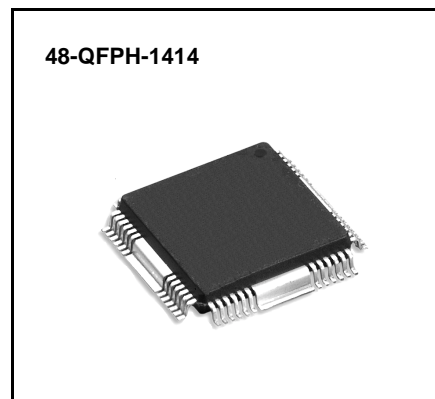
Typical Applications

- Compact disk ROM (CD-ROM)
- Compact disk RW (CD-RW)
- Digital video disk ROM (DVD-ROM)
- Digital video disk RAM (DVD-RAM)
- Digital video disk Player (DVDP)
- Other compact disk media

Ordering Information

Device	Package	Operating Temp.
FAN8725	48-QFPH-1414	−35°C ~ +85°C

Rev. 1.0.1
March. 2000.

Pin Assignments

	Pin
H1+	1
H1-	2
H2+	3
H2-	4
H3+	5
H3-	6
FG	7
DIR	8
SVCC1	9
VM1	10
CS1	11
PGND1	12

Top pins (left to right): 48 VH, 47 PC1, 46 EC, 45 ECR, 44 PS, 43 SB, 42 VREF, 41 SVCC2, 40 VM3, 39 OUT5, 38 IN5, 37 PGND3

Right pins (top to bottom): 36 DO5 -, 35 DO5+, 34 DO4 -, 32 DO4+, 32 DO3 -, 31 DO3+, 30 PGND2, 29 DO2 -, 28 DO2+, 27 DO1 -, 26 DO1+, 25 OUT1

Bottom pins (left to right): 13 A1, 14 A2, 15 A3, 16 SGND2, 17 IN4, 18 OUT4, 19 IN3, 20 OUT3, 21 IN2, 22 OUT2, 23 VM2, 24 IN1

FAN8725

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Pin Definitions

Pin Number	Pin Name	I/O	Pin Function Description
1	H1-	I	Hall 1(-) input
2	H1+	I	Hall 1(+) input
3	H2+	I	Hall 2(-) input
4	H2-	I	Hall 2(+) input
5	H3+	I	Hall 3(-) input
6	H3-	I	Hall 3(+) input
7	FG	O	Frequency Generator output
8	DIR	O	Rotation direction output
9	SVCC1	-	Spindle Signal supply voltage
10	VM1	-	Spindle power supply
11	CS1	I	Spindle current sense
12	PGND1	-	Spindle power ground
13	A1	O	3-phase output1
14	A2	O	3-phase output2
15	A3	O	3-phase output3
16	SGND2	-	CH signal ground
17	IN4	I	OP-Amp CH 4 input(-)
18	OUT4	O	OP-Amp CH 4 output
19	IN3	I	OP-Amp CH 3 input(-)
20	OUT3	O	OP-Amp CH 3 output
21	IN2	I	OP-Amp CH 2 input(-)
22	OUT2	O	OP-Amp CH 2 output
23	VM2	-	CH1/CH2 power supply
24	IN1	I	OP-Amp CH 1 input(-)
25	OUT1	O	OP-Amp CH 1 output
26	DO1+	O	Channel 1 output (+)
27	DO1 -	O	Channel 1 output (−)
28	DO2+	O	Channel 2 output (+)
29	DO2 -	O	Channel 2 output (−)
30	PGND2	-	CH1/CH2 power ground
31	DO3+	O	Channel 3 output (+)
32	DO3 -	O	Channel 3 output (−)
33	DO4+	O	Channel 4 output (+)

Pin Definitions (Continued)

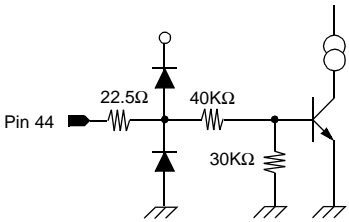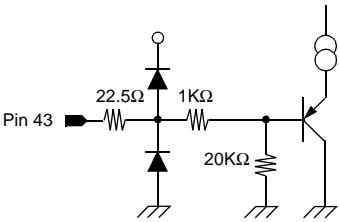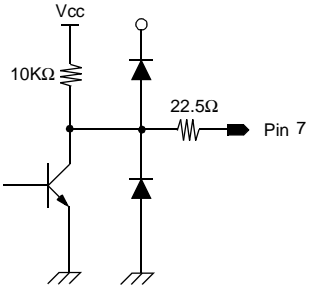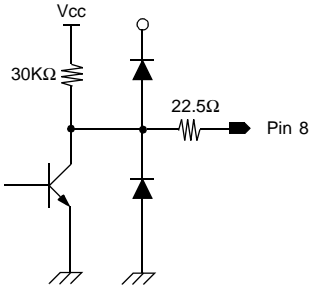| Pin Number	Pin Name	I/O	Pin Function Description
34	DO4 -	O	Channel 4 output (−)
35	DO5+	O	Channel 5 output (+)
36	DO5-	O	Channel 5 output (−)
37	PGND3	-	CH3/CH4/CH5 power ground
38	IN5	I	OP-Amp CH 5 input(-)
39	OUT5	O	OP-Amp CH 5 output
40	VM3	-	CH3/CH4/CH5 power supply
41	SVCC2	-	CH Signal supply voltage
42	VREF	I	BTL reference voltage
43	SB	I	Short brake
44	PS	I	Power save
45	ECR	I	Torque control reference
46	EC	I	Torque control
47	PC1	-	Phase compensation capacitor
48	VH	I	Hall bias
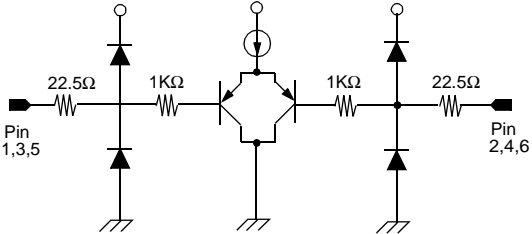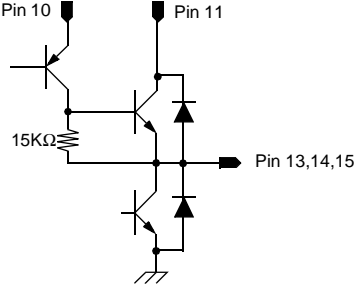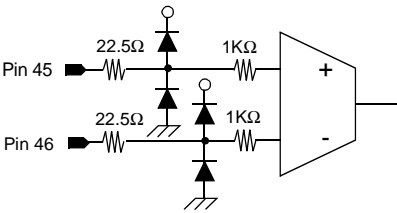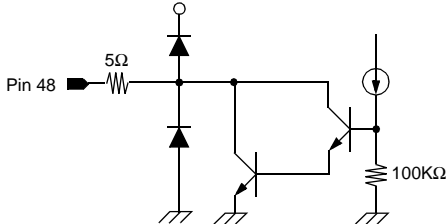
Notes:

BTL drive part symbol(+,- outputs of drives) is determined according to the polarity of input pin.

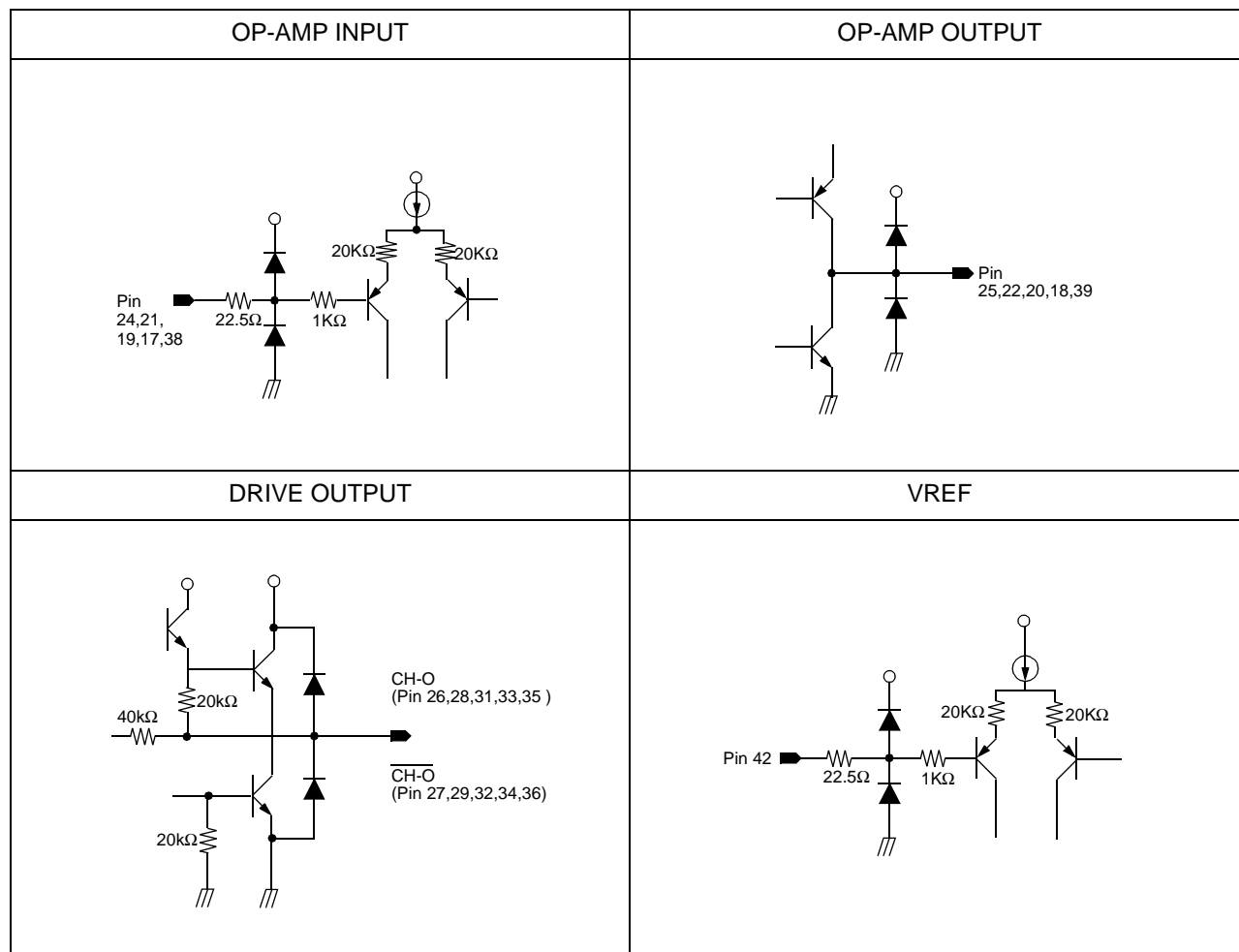(For example, if the voltage of pin 24 is high, the output of pin 26 is high)

Internal Block Diagram
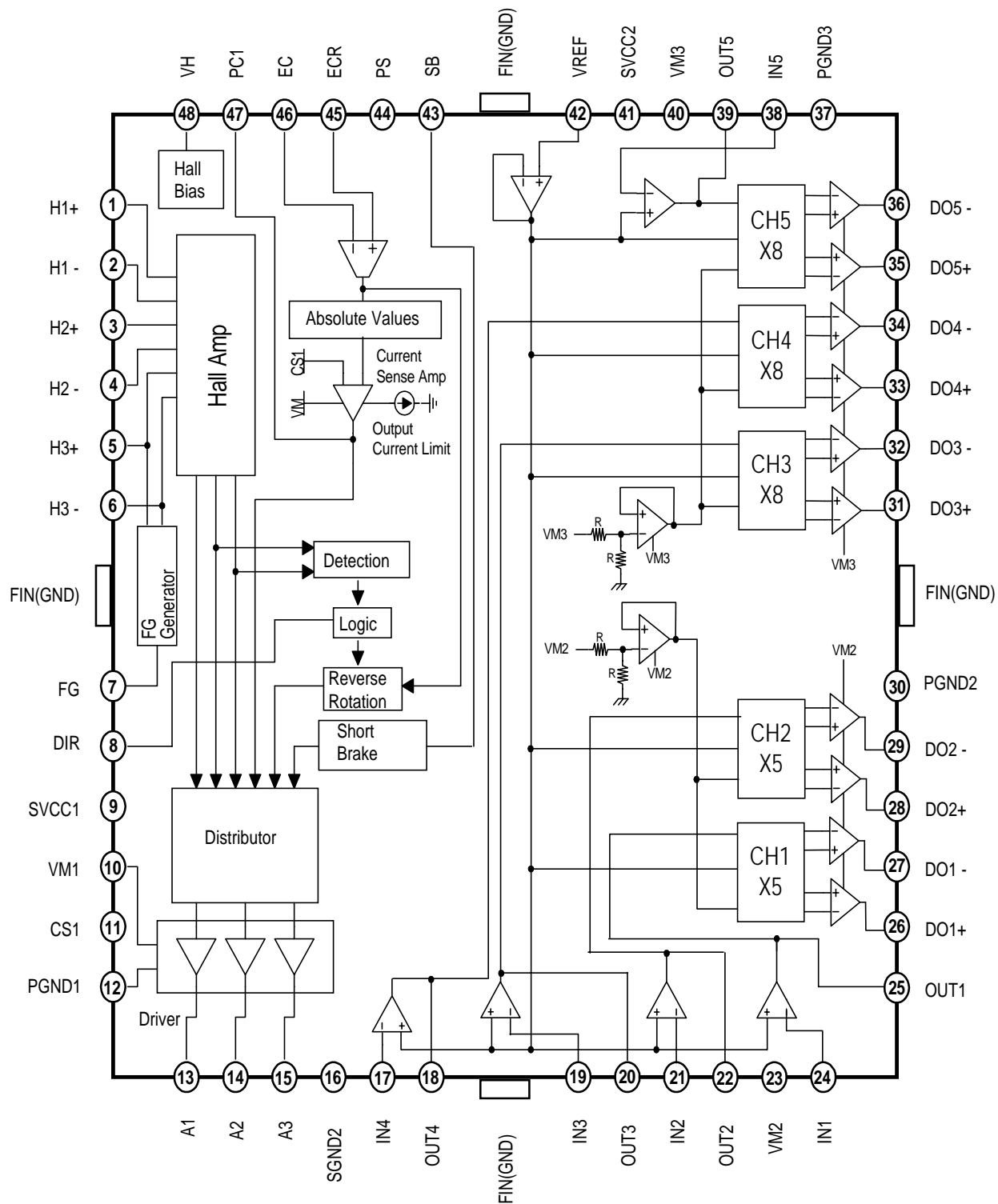
Equivalent Circuits (Spindle Part)

HALL INPUT	DRIVER OUTPUT

TORQUE CONTROL INPUT	HALL BIAS INPUT

POWER SAVE INPUT	SHORT BRAKE INPUT

FG OUTPUT	DIR OUTPUT

Equivalent Circuits (BTL Part)

OP-AMP INPUT	OP-AMP OUTPUT
DRIVE OUTPUT	VREF

Absolute Maximum Ratings (Ta = 25°C)

Parameter	Symbol	Value	Unit
Supply Voltage (Spindle Signal)	SV_{CC1max}	7	V
Supply Voltage (BTL Signal)	SV_{CC2max}	15	V
Supply Voltage (Spindle Motor)	V_{M1max}	15	V
Supply Voltage (BTL CH1/2)	V_{M2max}	15	V
Supply Voltage (BTL CH3/4/5)	V_{M3max}	15	V
Power dissipation	P_D	3.0 note	W
Operating Temperature Range	T_{OPR}	-35 ~ +85	°C
Storage temperature Range	T_{STG}	-55 ~ +150	°C
Maximum Output Current (Spindle)	I_{Omaxa}	1.3	A
Maximum Output Current (BTL)	I_{Omaxb}	0.6	A

NOTE:

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

Power Dissipation Curve
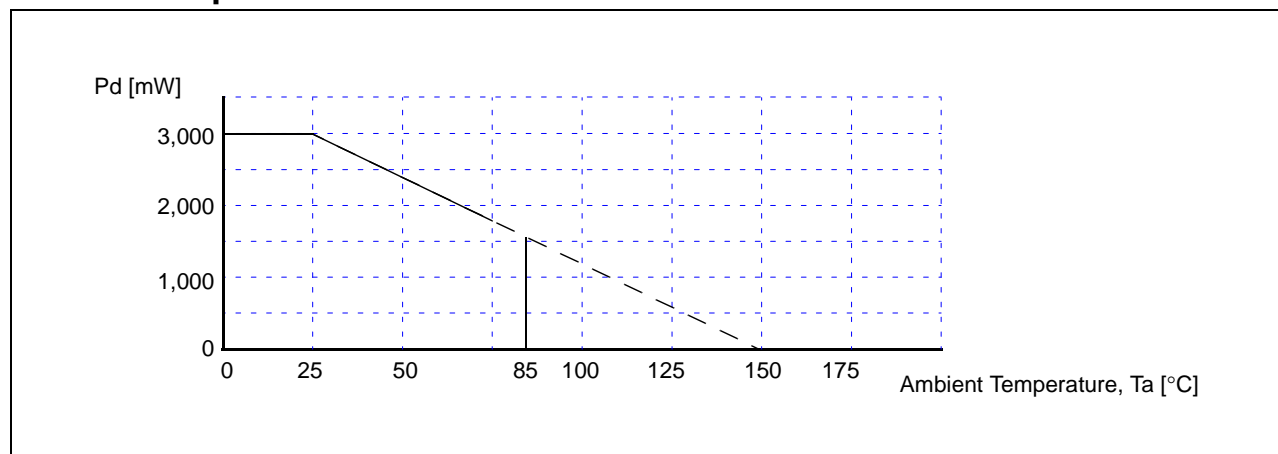
Recommended Operating Conditions (Ta = 25°C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Operating Supply Voltage (Spindle Signal)	SV_{CC1}	4.5	–	5.5	V
Operating Supply Voltage (BTL Signal)	SV_{CC2}	10.8	–	13.2	V
Operating Supply Voltage (Spindle Motor)	V_{M1}	10.8	–	13.2	V
Operating Supply Voltage (BTL CH1/2)	V_{M2}	4.5	–	SV_{CC2}	V
Operating Supply Voltage (BTL CH3/4/5)	V_{M3}	4.5	–	SV_{CC2}	V

Electrical Characteristics (Ta = 25°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
FULL CHIP						
Quiescent Circuit Current 1	I_{CC1}	FULL CHIP (PS=0V)	–	0	0.2	mA
Quiescent Circuit Current 2	I_{CC2}	SPINDLE (PS=5V)	–	5	10	mA
Quiescent Circuit Current 3	I_{CC3}	BTL (PS=5V)	–	20	30	mA
POWER SAVE						
On Voltage Range	V_{PSon}	L-H Circuit On	2.5	–	Vcc	V
Off Voltage Range	V_{PSoff}	H-L Circuit Off	–	–	1.0	V
HALL BIAS						
Hall Bias Voltage	V_{HB}	I_{HB}=20mA	0.4	1.0	1.8	V
HALL AMP						
Hall Bias Current	I_{HA}	-	–	0.5	2	uA
Common Mode Input Range	V_{HAR}	-	1.5	–	4.0	V
Minimum in Level	V_{INH}	-	100	–	–	mVpp
H1 Hysteresis	V_{HYS}	-	5	20	40	mVpp
TORQUE CONTROL						
Ecr In Voltage Range	E_{CR}	-	0.2	–	4.0	V
Ec In Voltage Range	E_C	-	0.2	–	4.0	V
Offset Voltage (-)	E_{Coff-}	E_C =1.9V	-80	-50	-20	mV
Offset Voltage (+)	E_{Coff+}	E_{CR} =1.9V	20	50	80	mV
EC In Current	E_{Cin}	E_C=1.9V	-3	-0.5	–	uA
ECR In Current	E_{CRin}	E_{CR}=1.9V	-3	-0.5	–	uA
In/output Gain	G_{EC}	E_{CR}=2.5V, R_{CS}=0.5Ω	0.56	0.70	0.84	A / V
FG						
FG Output Voltage (H)	V_{FGh}	I_{FG}= -10uA	4.5	4.9	VCC	V
FG Output Voltage (L)	V_{FHl}	I_{FG}=10uA	–	–	0.5	V
Duty(Reference Value)		R_{CS}=0.5Ω		50		%
OUTPUT BLOCK						
Saturation Voltage (upper TR)	V_{Oh}	I_O= -300mA	–	1.0	1.4	V
Saturation Voltage (lower TR)	V_{Ol}	I_O=300mA	–	0.4	0.7	V
Torque Limit Current	I_{TL}	R_{CS}=0.5Ω	560	700	840	mA
DIRECTION DETECTOR						
DIR Output Voltage (H)	V_{DIRh}	I_{FG}=-10uA	4.5	4.7		V
Dir Output Voltage (L)	V_{DIRl}	I_{FG}=10uA	–	–	0.5	V
SHORT BRAKE						
On Voltage Range	V_{SBon}	-	2.5	–	VCC	V
Off Voltage Range	V_{SBoff}	-	0	–	1.0	V

ELECTRICAL CHARACTERISTICS (continued)

BTL Drive Part (Ta=25°C, SV$_{CC2}$=12V, V$_{M2}$=5V, V$_{M3}$=12V, R$_L$=8, 24Ω)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
CH1/CH2						
Output Offset Voltage1,2	V$_{OF1/2}$	-	-95	–	95	mV
Maximum Output Voltage1,2	V$_{OM1/2}$	V$_{M2}$=5V,RL=8Ω	3.6	4.0	–	V
Voltage Gain	G$_{VC1/2}$	V$_{IN}$=0.1Vrms, 1kHz	12.0	14.0	16.0	dB
CH3/CH4/CH5						
Output Offset Voltage3,4,5	V$_{OF3/4/5}$	-	-95	–	95	mV
Maximum Output Voltage3,4,5	V$_{OM3/4/5}$	V$_{M3}$=12V,RL=24Ω	8.4	10.5	–	V
Voltage Gain	G$_{VC3/4/5}$	V$_{IN}$=0.1Vrms, 1kHz	16.0	18.0	20.0	dB
OP-AMP CIRCUIT						
Common Mode Input Range	V$_{ICM}$	-	0	–	11.0	V
Input Bias Current	I$_B$	-	-300	-30		nA
Low Level Output Voltage	V$_{CL}$	-	-	0.2	0.5	V
High Level Output Voltage	V$_{OH}$	-	10.0	11	–	V
Output Driving Source Current	I$_{SOURCE}$	-	1	4.0	–	mA
Output Driving Sink Current	I$_{SINK}$	-	5	10	–	mA

# Application Information

1. TORQUE CONTROL & OUTPUT CURRENT CONTROL
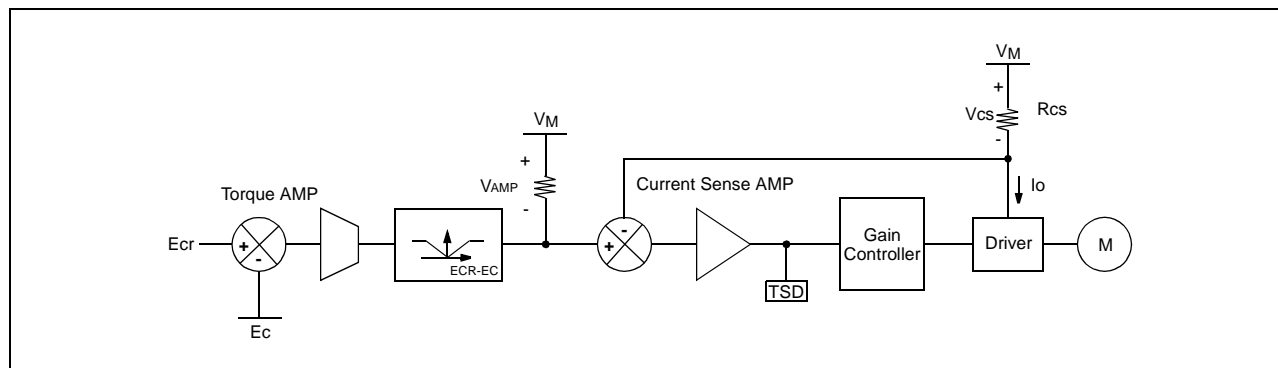
1) By amplifying the voltage difference between Ec and Ecr from Servo IC, the Torque Sense AMP produces the input voltage(V_{AMP}) for the Current Sense AMP.

2) The output current (I_O) is converted into the voltage (V_{CS}) through the sense resistor (R_{CS}) and compared with the V_{AMP}. By the negative feedback loop, the sensed output voltage, V_{CS} is equal to the input V_{AMP}. The output current (I_O) is linearly controlled by the input V_{AMP}.

3) The signals, E_C and E_{CR} can control the velocity of the Motor by controlling the output current (I_O) of the Driver.

4) The range of the torque voltage is as shown below.
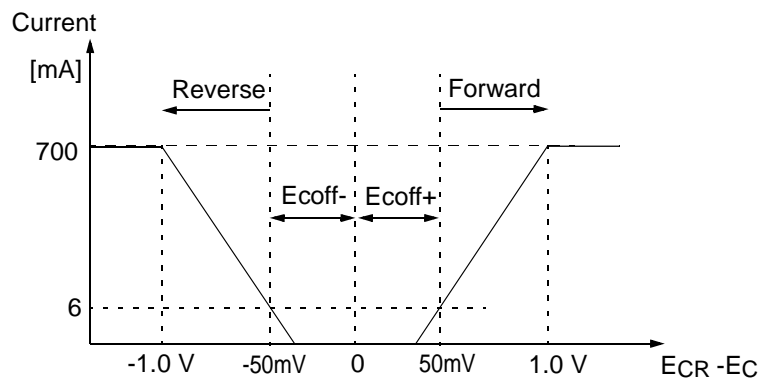
	Rotation
$E_{CR} > E_C$	Forward rotation
$E_{CR} < E_C$	Stop after detecting reverse rotation

The input range of E_{CR}, E_C is 0.2 V ~ 4.0 V (R_{CS} = 0.5[Ω])
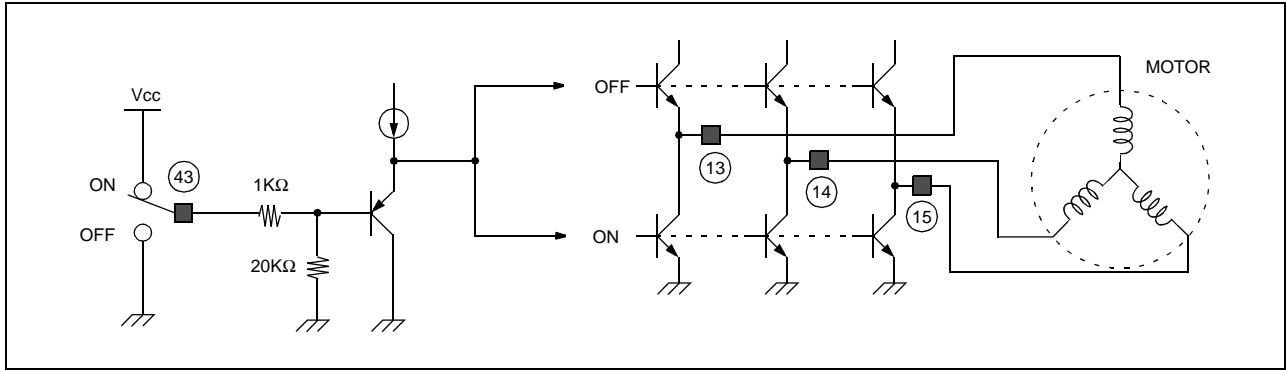
2. SHORT BRAKE

Pin # 43	Short Brake
HIGH	ON
LOW	OFF

When the pick-up mechanism moves from the inner to the outer spindle of the CD, the Brake function of the reverse voltage is commonly employed to decrease the rotating velocity of the Spindle Motor.

However, if the Spindle Motor rotates rapidly, the Brake function of the reverse voltage may produce much heat at the Drive IC.

To enhance the braking efficiency, the Short Brake function is added to FAN8725. When the Short Brake function is activated, all upper Power TRs turn off and all lower Power TRs turn on, so as to make the rotating velocity of the motor slow down. But FG and DIR functions continue to operate normally.

3. POWER SAVE
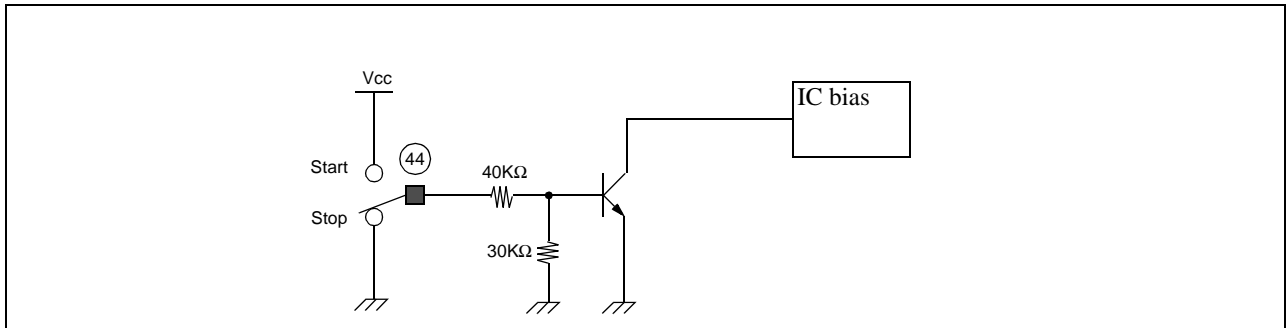
Pin # 44	Power Save
HIGH	Motor Drive Ouput Activated
LOW	Sleep mode

When PowerSave(PS) function is activated, the chip is deactivated.

4. TSD (THERMAL SHUTDOWN)
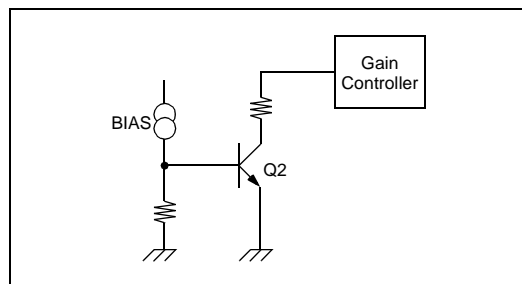
When the chip temperature rises up to about 175C(degree), the Q2 turns on and the output driver shuts down. When the chip temperature falls off to about 150C(degree), then the Q2 turns off and the driver operates normally. TSD has the temperature hysteresis of about 25C(degree).

-- The TSD circuit shuts down all the power drives(spindle and BTL power drives) excluding both CH1 and CH2 power drives(actuator part).
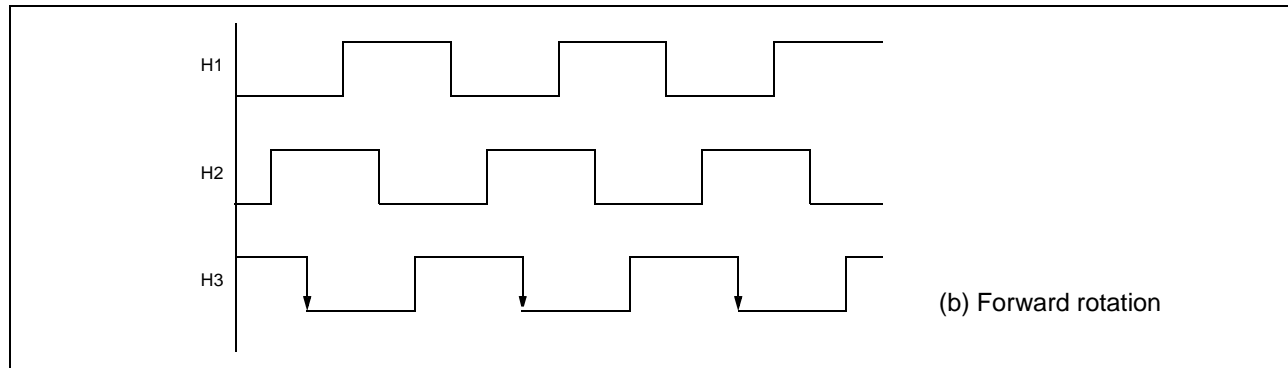
5. ROTATIONAL DIRECTION DETECTION

Rotation	⑧ DIR
Forward	Low
Reverse	High
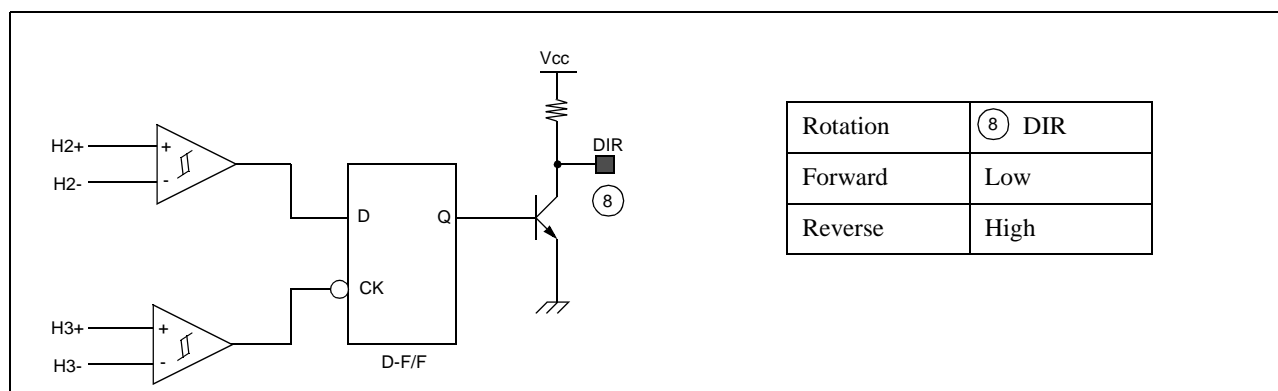
1) The forward and the reverse rotations of the CD are detected by using the D-F/F and the truth table is shown in the above.

2) The rotational direction of the CD can be explained by the output waveform of the Hall sensors. Let the three outputs of Hall sensors be H1, H2 and H3 respectively.
When the spindle rotates in reverse direction, the Hall sensor output waveform are shown in Fig.(a). Thus the phases ordered in H1→H2→H3 with a 120° phase difference.
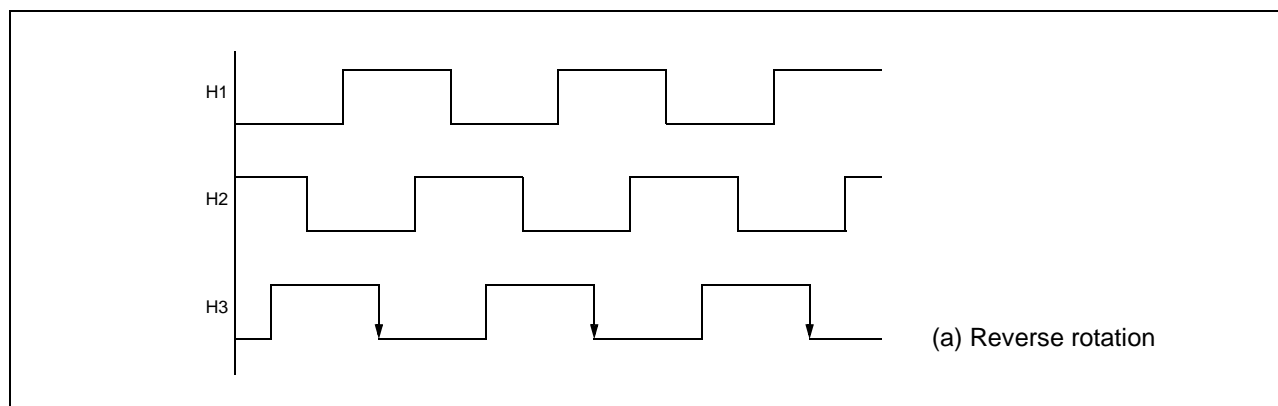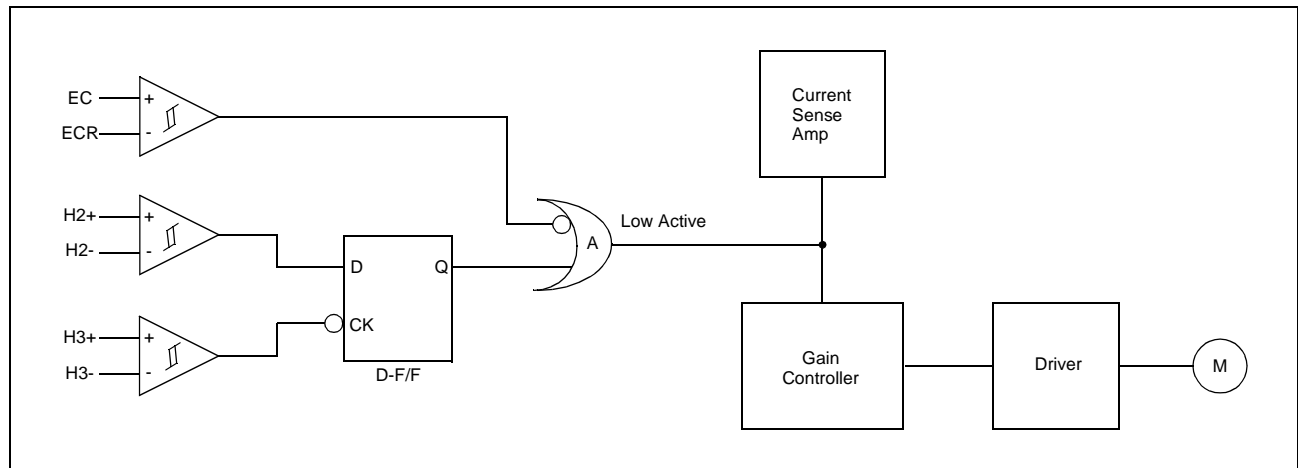

(a) Reverse rotation

On the other hand, if the spindle rotates in forward rotation, the phase relationship is H3->H2->H1 as shown in Fig.(b)
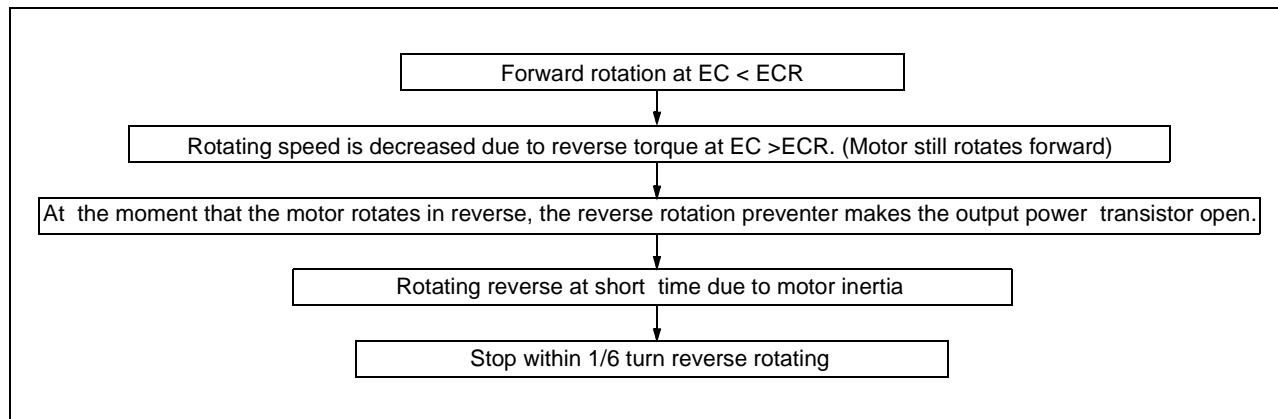

(b) Forward rotation

The direction output ,detector is Low, when the spindle rotates forward, and HIGH in the reverse direction.

6. REVERSE ROTATION PREVENTION

1) When the output of the OR Gate, A is LOW, it steers all the output current of the current sense Amp to the Gain Controller zero. The output current of the Driver becomes zero and the motor stops.

2) As in the state of the forward rotation, the D-F/F output, Q is HIGH and the motor rotates normally. At this state, if the control input is changed such that EC>ECR, then the motor rotates slowly by the reverse commutation in the Driver. When the motor rotates in reverse direction, the D-F/F output becomes Low and the OR Gate output, becomes LOW. This prevents the motor from rotating in reverse direction. The operation principle is shown in the table and the flow chart.

Forward rotation at EC < ECR

Rotating speed is decreased due to reverse torque at EC >ECR. (Motor still rotates forward)

At the moment that the motor rotates in reverse, the reverse rotation preventer makes the output power transistor open.

Rotating reverse at short time due to motor inertia

Stop within 1/6 turn reverse rotating

Rotation	H2	H3	D-F/F (Q)	Reverse Rotation Preventer	
				$EC_R>EC$	$EC>EC_R$
Forward	H	H→L	H	Forward	-
Reverse	L	H→L	L	-	Brake and Stop

7. FG OUTPUT
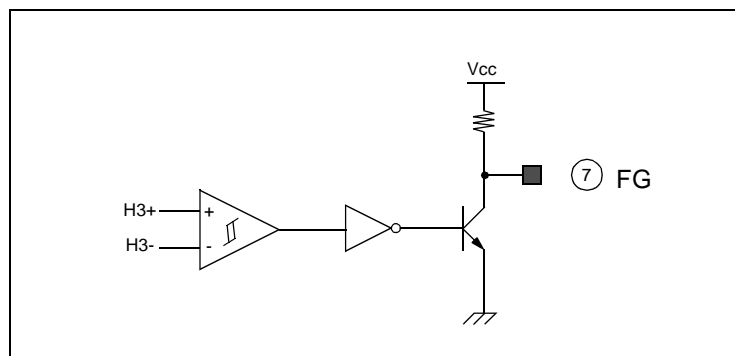
8. HALL SENSOR CONNECTION
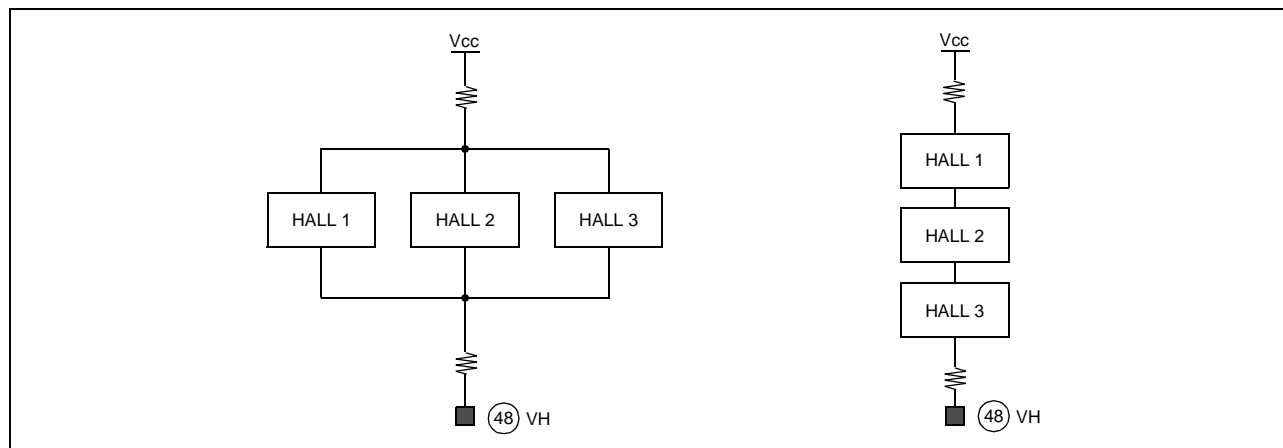
9. CONNECT A BYPASS CAPACITOR, FROM ALL THE SUPPLY VOLTAGE SOURCES TO GROUND.
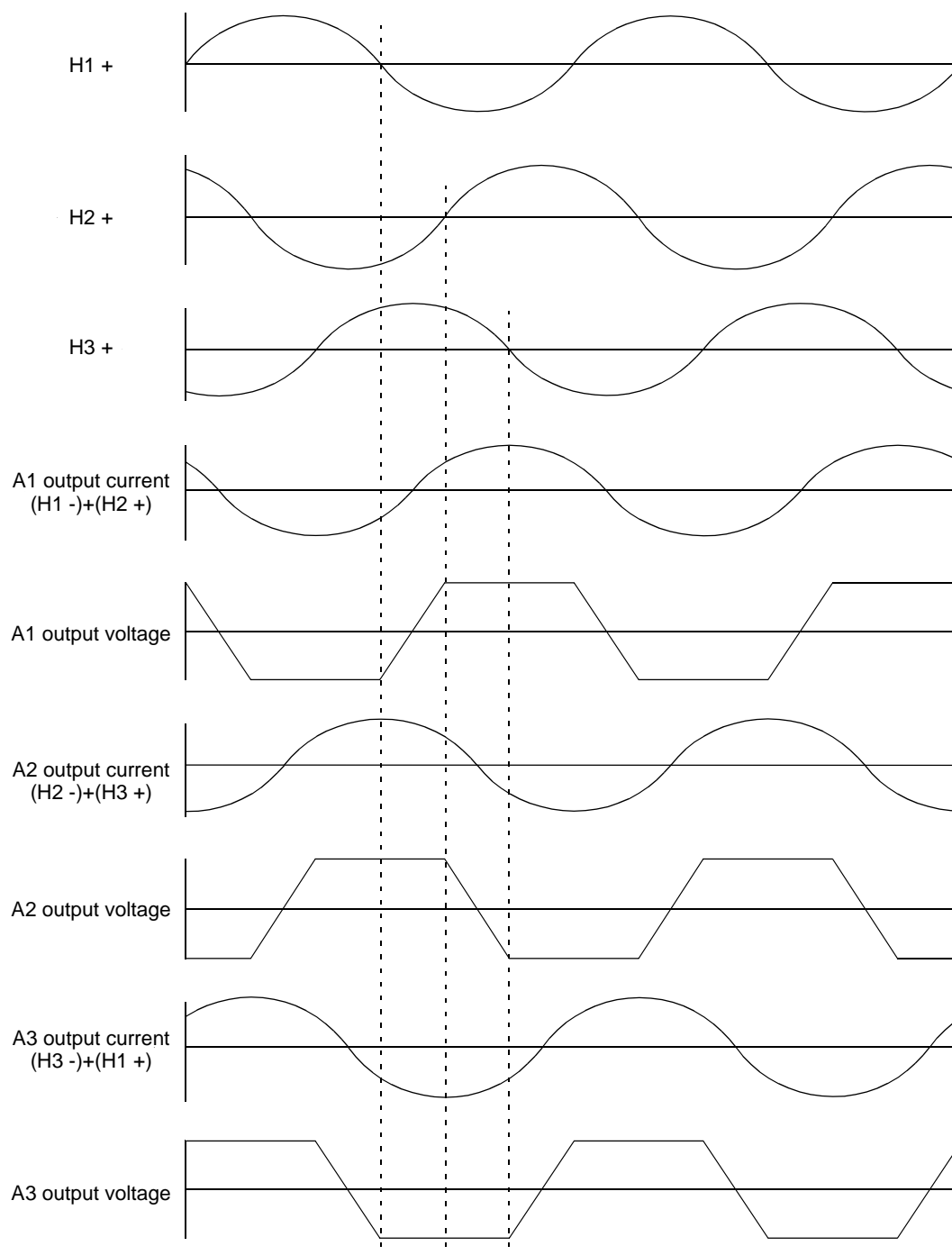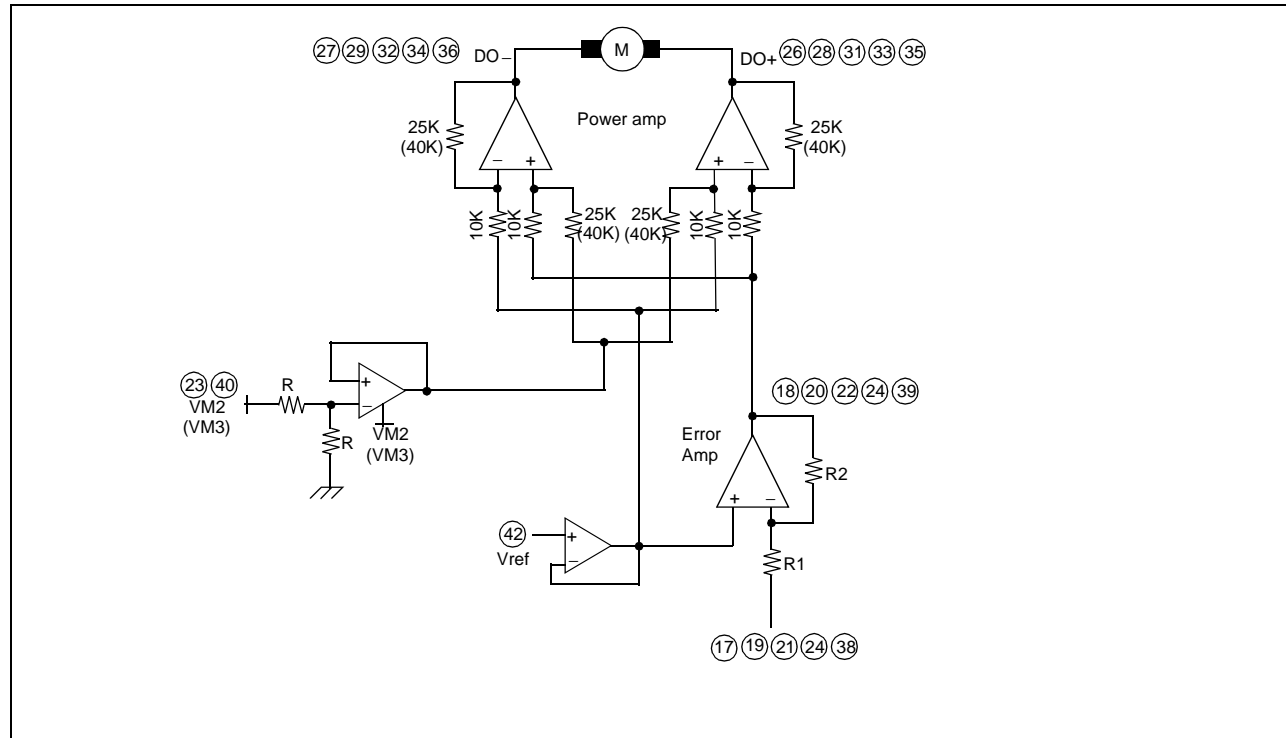
(Typically 0.1uF, or even higher)
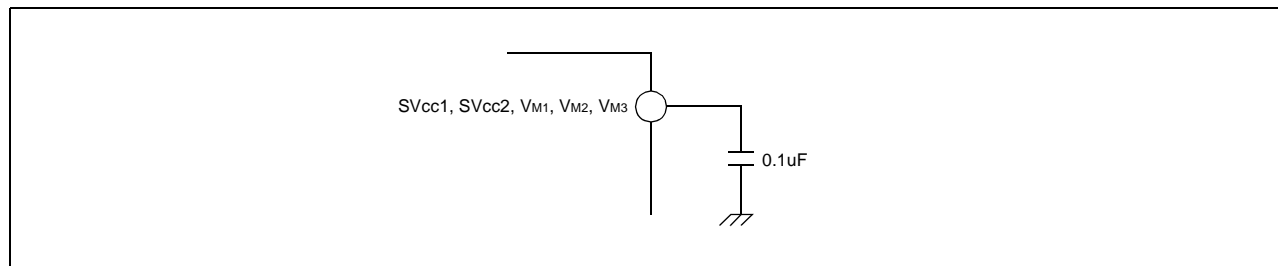
10. THE HEAT RADIATION FIN IS CONNECTED TO THE INTERNAL GND OF THE PACKAGE.

Connect the FIN to the external GND.

11. INPUT-OUTPUT TIMING CHART

H1 +

H2 +

H3 +

A1 output current
(H1 -)+(H2 +)

A1 output voltage

A2 output current
(H2 -)+(H3 +)

A2 output voltage
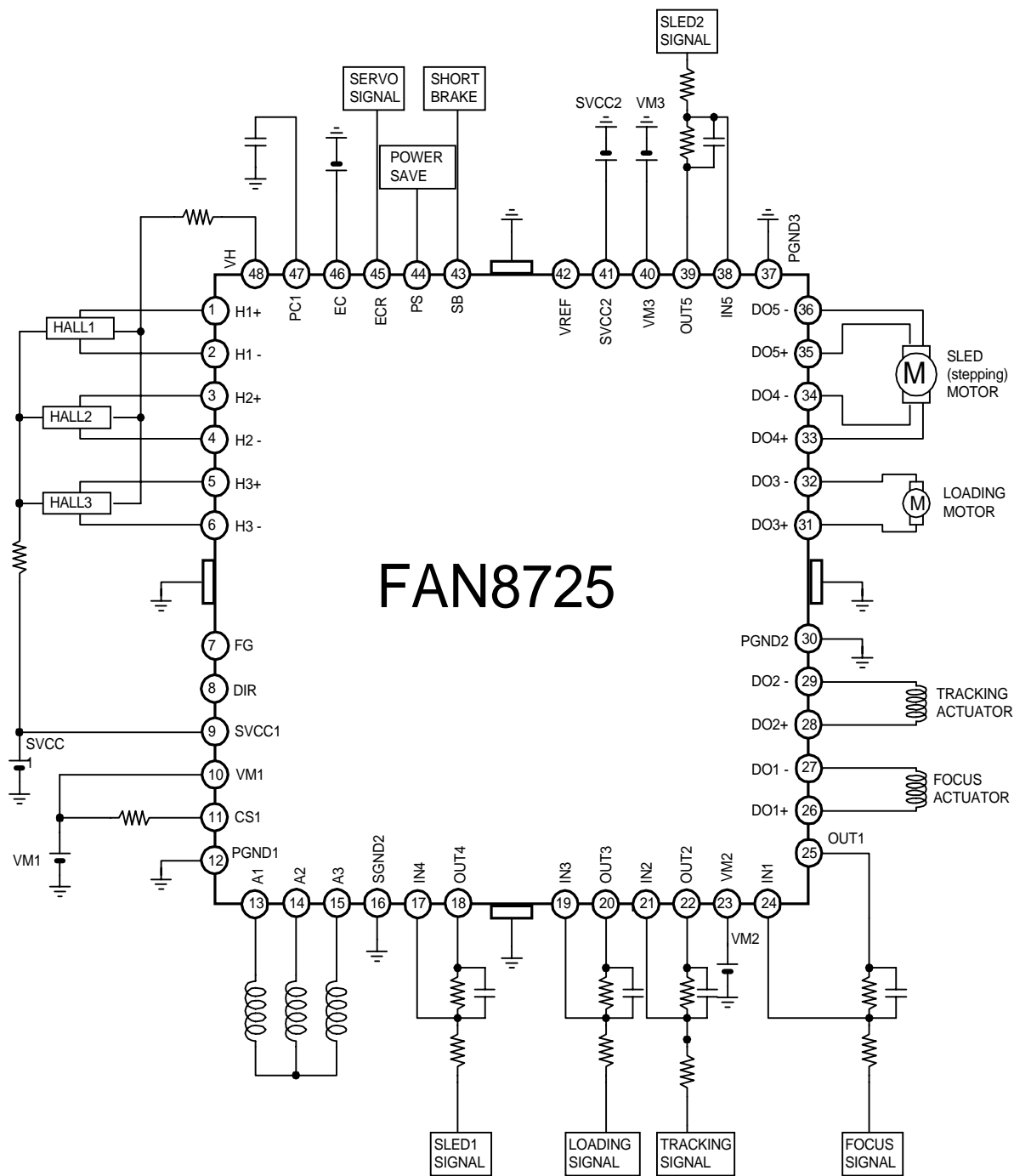
A3 output current
(H3 -)+(H1 +)

A3 output voltage

12. BTL DRIVE PART

- The reference voltage REF is given externally through pin 42.
- The error amp output signal is amplified by R2 / R1 times and then fed to the power amp circuit.
- The power amp circuit produces the differential output voltages and drives the two output power amplifier circuit.
- Since the differential gain of the output amplifiers of CH1/CH2 is equal to $2 \times (25K / 10K)$, the output signal of the error amp is amplified by $(R2 / R1) \times 5$.
- Since the differential gain of the output amplifiers of CH3/CH4/CH5 is equal to $2 \times (40K / 10K)$, the output signal of the error amp is amplified by $(R2 / R1) \times 8$.
- If the total gain is insufficient, the input error amp can be used to increase the gain.
- The CH1/CH2 are generally used as actuator drive circuit so this channels are not affected by TSD circuit.

Typical Application Circuits

FAN8725

SERVO SIGNAL

SHORT BRAKE

POWER SAVE

SLED2 SIGNAL

SVCC2   VM3

PGND3

VH

48 47 46 45 44 43   42 41 40 39 38 37

PC1 EC ECR PS SB   VREF SVCC2 VM3 OUT5 IN5

1   H1+
2   H1 -
3   H2+
4   H2 -
5   H3+
6   H3 -

HALL1
HALL2
HALL3

SVCC

7   FG
8   DIR
9   SVCC1
10 VM1
11 CS1
12 PGND1

VM1

36 DO5 -
35 DO5+   SLED (stepping) MOTOR
34 DO4 -
33 DO4+
32 DO3 -   LOADING MOTOR
31 DO3+
30 PGND2
29 DO2 -   TRACKING ACTUATOR
28 DO2+
27 DO1 -   FOCUS ACTUATOR
26 DO1+
25 OUT1

A1 A2 A3 SGND2 IN4 OUT4   IN3 OUT3 IN2 OUT2 VM2 IN1
13 14 15 16   17   18   19   20   21   22   23   24

VM2

SLED1 SIGNAL

LOADING SIGNAL

TRACKING SIGNAL

FOCUS SIGNAL