

# Two-phase Unipolar DC Brushless Motor Pre-Driver IC

## ■ GENERAL DESCRIPTION

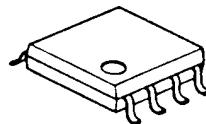
The NJM2644 is a 2-phase DC brushless motor pre-driver IC.

It incorporates Lock Detect and Auto Protection circuit for safety operation. Especially, 1:10 ON/OFF duty ratio while motor is locked reduces heat generation in motor windings.

Moreover, the pin is compatible with 12V LA output two-phase pre-driver NJM2641.

It is suitable for 12V fan motor applications.

## ■ PACKAGE OUTLINE



NJM2644M

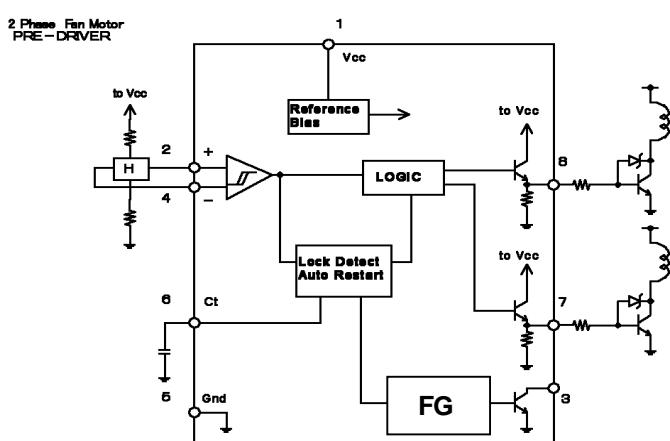


NJM2644RB1

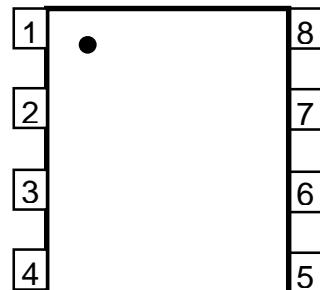
## ■ FEATURES

- Operating Voltage  $V_{DD}=4$  to  $14V$
- Absolute Maximum Voltage  $15V$
- Internal Lock Detect / Auto Protection Release Circuit
- FG Output Terminal
- Package Outline DMP8 / TVSP8

## ■ BLOCK DIAGRAM



## ■ PIN FUNCTION



1: Vcc
2: H1
3: FG
4: H2
5: GND
6: Ct
7: OUT1
8: OUT2

# NJM2644

## ■ ABSOLUTE MAXIMUM RATINGS

(Ta=25°C)

PARAMETER	SYMBOL	RATINGS	UNIT	NOTE
Supply Voltage	V <sub>cc</sub>	15	V	-
Hall Input Voltage Range	V <sub>IH</sub>	-0.3 ~ V <sub>cc</sub>	V	-
Output Current (Peak)	I <sub>OUT</sub>	70	mA	-
Lock Alarm Output Voltage	V <sub>OLA</sub>	15	V	-
Hall Input Differential Voltage	V <sub>IHD</sub>	2	V	-
Lock Alarm Output Current	I <sub>OLA</sub>	10	mA	-
Operating Temperature Range	T <sub>opr</sub>	-40 ~ 85	°C	-
Operating Junction Temperature Range	T <sub>oj</sub>	-40 ~ 150	°C	-
Storage Temperature Range	T <sub>stg</sub>	-55 ~ 150	°C	-
Power Dissipation	P <sub>D</sub>	375(DMP8) / 400(TVSP8)	mW	Device itself

## ■ RECOMMENDED OPERATING CONDITIONS

(Ta=25°C)

PARAMETER	SYMBOL	RATINGS	UNIT (unit)	NOTE
Supply Voltage	V <sub>cc</sub>	4 ~ 14	V	-
Hall Input Voltage Common Mode Voltage	V <sub>ICM</sub>	1.5 ~ V <sub>cc</sub> -2	V	-
Junction Temperature	T <sub>j</sub>	-20 ~ 125	°C	-

## ■ ELECTRICAL CHARACTERISTICS

(V<sub>DD</sub>=12V, Ta=25°C)

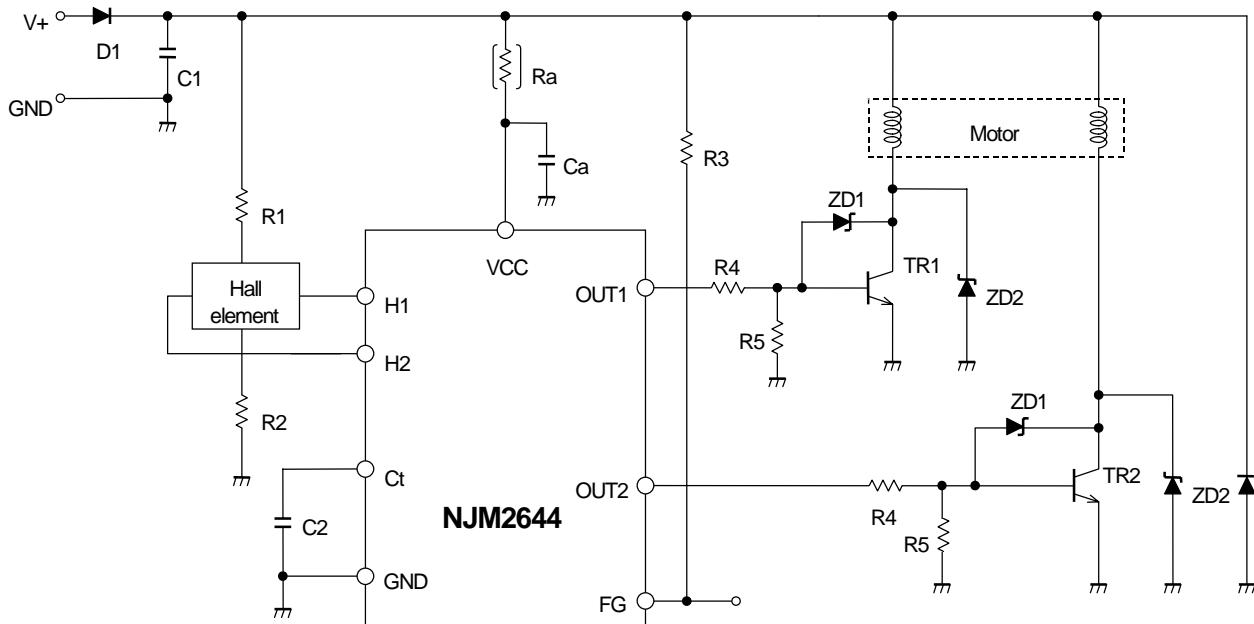
PARAMETER	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Current	I <sub>CC</sub>	V <sub>CC</sub> =12V	-	3.4	4.4	mA
		V <sub>CC</sub> =5V	-	2.8	3.75	
Hall Input Hysteresis Range	V <sub>HYS</sub>	-	8	20	32	mV
Hall Amplifier Input Bias Current	I <sub>B</sub>	-	-	1.0	-	μA
Output Voltage	V <sub>OUT</sub>	I <sub>OUT</sub> =20mA	-	V <sub>CC</sub> -1.5	-	V
Output Leak Current	I <sub>LEAK</sub>	V <sub>CC</sub> =14V	-	1	10	μA
Lock Alarm Output Voltage	V <sub>LA</sub>	Lock Alarm ON, I <sub>LA</sub> =5mA	-	-	0.5	V
Lock Alarm Leak Current	I <sub>LA</sub> leak	V <sub>LA</sub> =14V	-	1	5	μA
Ct Charge Current	I <sub>C</sub>	V <sub>C</sub> =1.5V	-	4.0	5.5	μA
Ct Discharge Current	I <sub>DC</sub>	V <sub>C</sub> =1.5V	-	0.40	0.65	μA
Charge / Discharge Current Ratio	I <sub>C</sub> /I <sub>DC</sub>	-	-	10	-	
Ct H-level Cense Voltage	V <sub>CH</sub>	-	2.5	2.8	3.1	V
Ct L-level Cense Voltage	V <sub>CL</sub>	-	0.6	0.7	0.8	V
Auto Protection Release ON Time	T <sub>ON</sub>	C <sub>T</sub> =0.47μF	-	0.25	-	s
Auto Protection Release OFF Time	T <sub>OFF</sub>	C <sub>T</sub> =0.47μF	-	2.5	-	s

**NJM2644**

## ■ APPLICATION NOTE

The NJM2644 is a two-phase motor unipolar pre-driver IC. It is suitable for fan motor drivers for communication equipment where 12V operation is required.

## [Application Circuit Example]



## [Design Notes]

Above application example is designed for 12V operation with motor current of 300mA. It uses the following components:

## Hall Elements: HW101A (AKE)

TR1,TR2: 2SD2475 (Panasonic)

## 1. Selection of C1 and D1:

C1 is used for a noise reduction purpose. A typical value is 0.1uF.

Optimize the value in actual operating conditions if necessary. D1 is a diode for protection against reverse voltage supply. Silicon rectifier diode (W03C, 10D1 and equivalent) is appropriate.

## 2. Lock Protection Function (Design of C2 value):

Lock Protection Function, consists of Motor Lock Detection and Auto Resume Function, is a safety feature to protect a motor and a driver circuit from fatal destruction in case of motor halt.

Motor Lock Detection detects motor halt due to irregular load conditions and then cuts motor driving current for safety operation. When Lock Detection is activated; FG Output (FG: Pin 3) goes to L.

A value of C2 determines Lock detection time (Ton) and Auto Resume Time (Toff).

Lock detection time (Ton) is given by:

$$T_{ON} = C2 \frac{Vch - Vcl}{I_C} [\text{sec}]$$

Where C2 is 0.47uF:

$$T_{ON} = 0.47 \times 10^{-6} \times \frac{2.8 - 0.7}{4.0 \times 10^{-6}} = 0.25[\text{sec}]$$

Auto Resume Time (Toff) is given by:

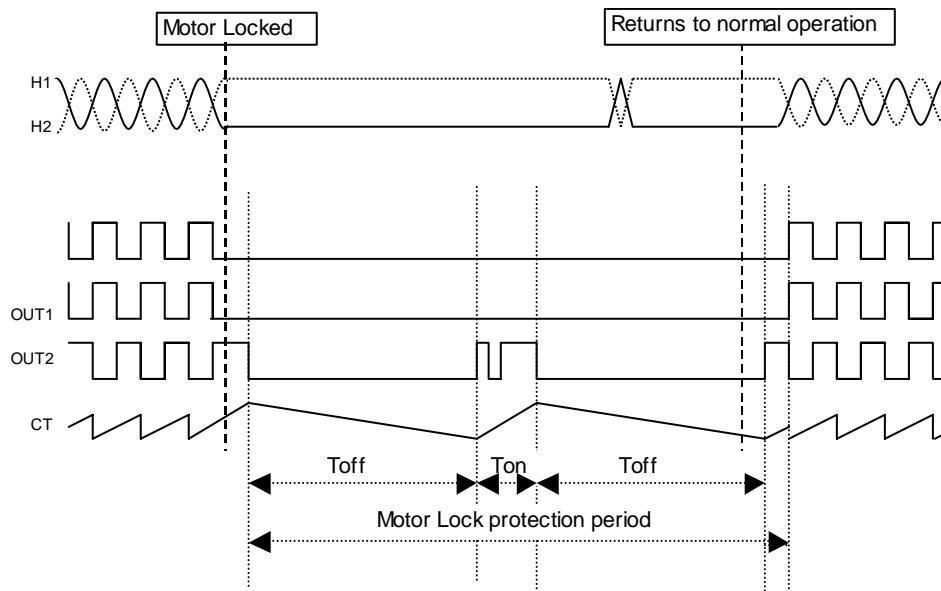
$$T_{OFF} = C2 \frac{Vch - Vcl}{Idc} [\text{sec}]$$

Where C2 is 0.47uF:

$$T_{OFF} = 0.47 \times 10^{-6} \times \frac{2.5 - 0.7}{0.4 \times 10^{-6}} = 2.47[\text{sec}]$$

In actual application, Lock detection time (Ton) is affected by the mechanical time constant of a motor. Therefore, constant start up must be confirmed in actual evaluation taking operating variations (i.e. Temperature, Voltage change and so on) in consideration.

A typical value of C2 is either 0.47uF or 1uF depending on a motor.



#### Lock Protection

Lock Alert Out (LA: Pin 3) is a open collector output and R3 is a pull up resistor. A typical value of R3 is 10kΩ.

### 3. Design of hall element bias resistance (R1 and R2)

Hall amplifier is a differential amplifier with hysteresis characteristics (24mV typical).

The common-mode input voltage is between 1.5V and Vcc-2V and the input signal must be within the range.

Non-excitation hall bias voltage is to be set at a half of VCC for effective use of common-mode input voltage range. Therefore the same value of hall bias resistors is selected for R1 and R2.

Given that the bias current is set to be 5mA by HW101A datasheet, R1 and R2 can be determined as follows:

$$R1 + R2 = \frac{Vcc}{I_{bias}} = \frac{12}{5 \times 10^{-3}} = 2.4k\Omega$$

$$R1 = R2 = 1.2k\Omega$$

The output voltage of hall elements is influenced by the bias current and magnetic flux density of hall elements. The optimum input voltage of NJM2644 is 100mVp-p and higher. With such input voltage, the highest efficiency can be obtained.

#### 4. Design of Power Transistor base resistance (**R4 and R5**)

HFE of 2SD2457 (Panasonic) is 80 from its datasheet. Given that  $I_o$  is 300mA, the base current of TR1 is 3.75mA. R4 is given by:

$$R4 = \frac{VCC - VBE - VCE}{IB}$$

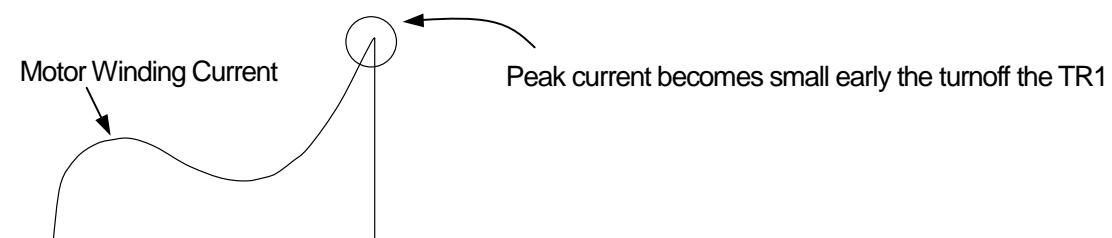
$$R4 = \frac{12 - 0.7 - 1.5}{3.75 \times 10^{-3}} = 2.61 \times 10^3 = 2.6k\Omega$$

Where; VCC is 12V, VCE of NJM2644 is 1.5V, VBE of TR1 is 0.7V

The pull down resistance R5 (connected to TR1) influences turn-off time of TR1.

Faster Turn-off time of TR1 reduces peak current of motor winding current resulting in lower echo fan noise (often called as Echo noise) during operation.

A typical R5 value is ranging from  $1k\Omega$  to  $10k\Omega$ . As explained the above, it is highly recommended to determine the value with actual application for better noise performance.



#### 5. Design of spike killer for power transistor (**ZD1 and ZD2**)

Zenner diodes (often referred as spike killer) are used for limiting kick back voltage of motor winding generated when power transistors (TR1 and TR2) turned off from on.

There are two methodologies to consume kick back voltage:

##### 1) **By insertion of ZD1** (zenner diode connected between Base and Emitter of TR1)

Energy of kick back voltage is consumed by TR1(or TR2). When ZD1 is in operation, Collector voltage is sum of  $V_{be}$  and ZD1. Therefore, breakdown voltage of ZD1 must be lower than that of TR1.

## 2) By insertion of ZD2 (zenner diode connected between Collector and Emitter of TR1)

Energy of kick back voltage is consumed by ZD2. To protect TR1, breakdown voltage of ZD2 must be lower than that of TR1.

This method is generally used when Energy of kick back voltage is large. In such application, power rating of ZD must take in consideration.

## 6. VCC input (Design of Ra and Ca)

Ra and Ca must be used if VCC exceeds operating voltage range of NJM2644.

Example) VCC 15V Application

Given that current consumption of NJM2644 is 4mA (at VCC=12V), Ra is given by:

$$Ra = \frac{15 - 12}{4 \times 10^{-3}} = 0.75k\Omega$$

Ca is used if NJM2644 is oscillated or shows unstable operation. A typical value Ca is from 0.01 $\mu$ F to 0.1 $\mu$ F. A ceramic type is recommended and it must be place near VCC and Gnd.

Inserting Ra and Ca also improves ESD immunity.

## 7. Protection from active power on and off (D2)

If an application requires active power on and off, TR1 (TR2) may be damaged or resulted in destruction.

In such application, adding diode between motor winding and Gnd will reduce the damage.

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