

Two-phase Unipolar DC Brushless Motor Pre-Driver IC

■ GENERAL DESCRIPTION

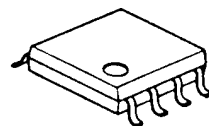
The NJM2641 is a 2-phase DC brushless motor pre-driver IC.

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 FG output pre-driver NJM2644.

It is suitable for 12V fan motor applications.

■ PACKAGE OUTLINE



NJM2641M

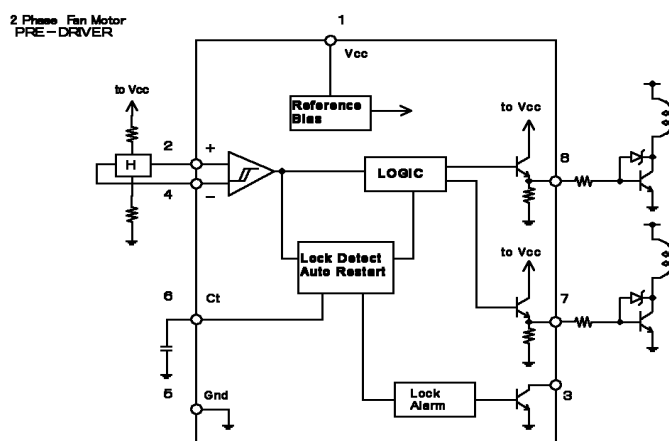


NJM2641RB1

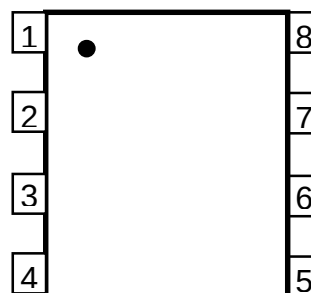
■ FEATURES

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

■ BLOCK DIAGRAM



■ PIN FUNCTION



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

■ ABSOLUTE MAXIMUM RATINGS

(Ta=25°C)

PARAMETER	SYMBOL	RATINGS	UNIT	NOTE
Supply Voltage	V_{CC}	15	V	-
Hall Input Voltage Range	V_{IH}	-0.3 ~ V_{CC}	V	-
Output Current (Peak)	I_{OUT}	70	mA	-
Lock Alarm Output Voltage	V_{OLA}	15	V	-
Hall Input Differential Voltage	V_{IHD}	2	V	-
Lock Alarm Output Current	I_{OLA}	20	mA	-
Operating Temperature Range	T_{opr}	-40 ~ 85	°C	-
Operating Junction Temperature Range	T_{oj}	-40 ~ 150	°C	-
Storage Temperature Range	T_{stg}	-55 ~ 150	°C	-
Power Dissipation	P_D	300(DMP8) / 375(EMP8) / 400(TVSP8)	mW	Device itself

■ RECOMMENDED OPERATING CONDITIONS

(Ta=25°C)

PARAMETER	SYMBOL	RATINGS	UNIT (unit)	NOTE
Supply Voltage	V_{CC}	4 ~ 14	V	-
Hall Input Voltage Common Mode Voltage	V_{ICM}	1.5 ~ $V_{CC}-2$	V	-
Junction Temperature	T_j	-40 ~ 125	°C	-

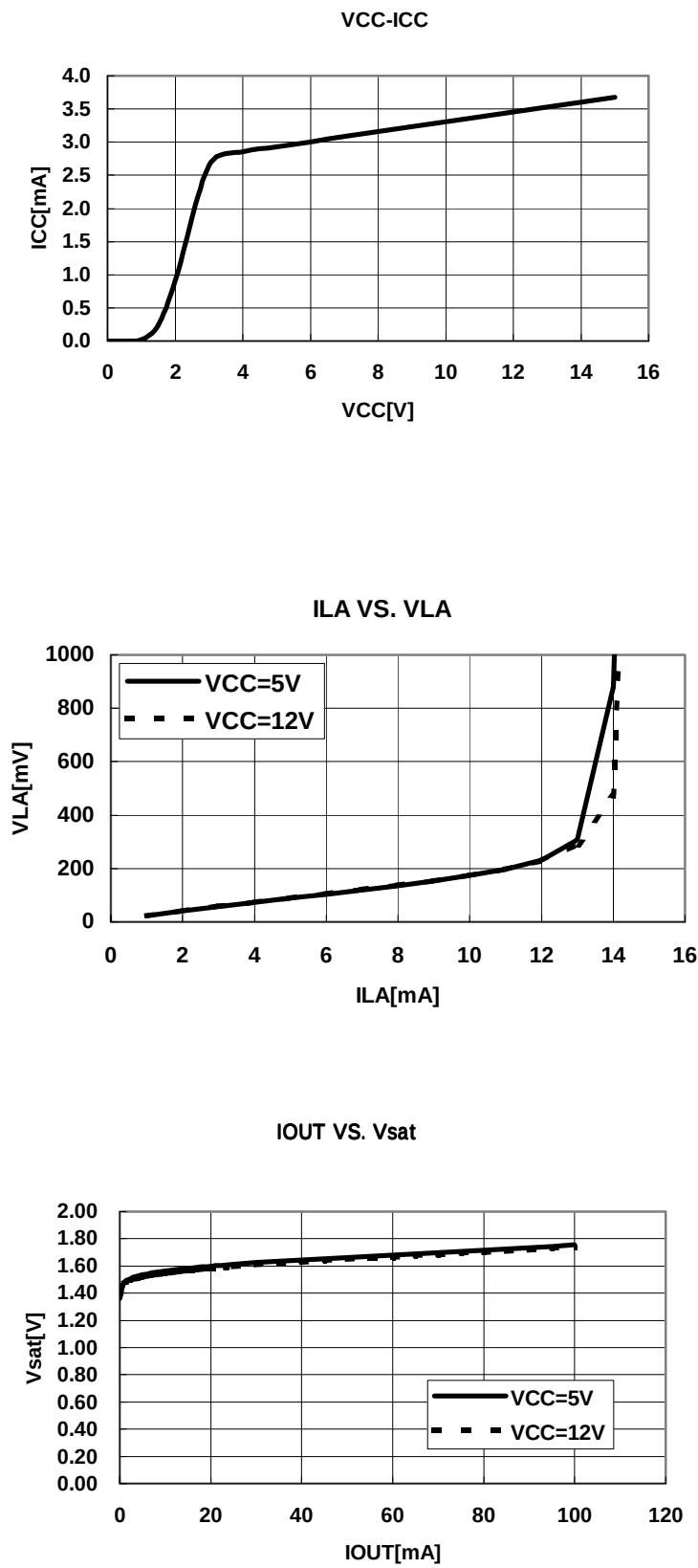
■ ELECTRICAL CHARACTERISTICS

($V_{DD}=12V$, $T_a=25^{\circ}C$)

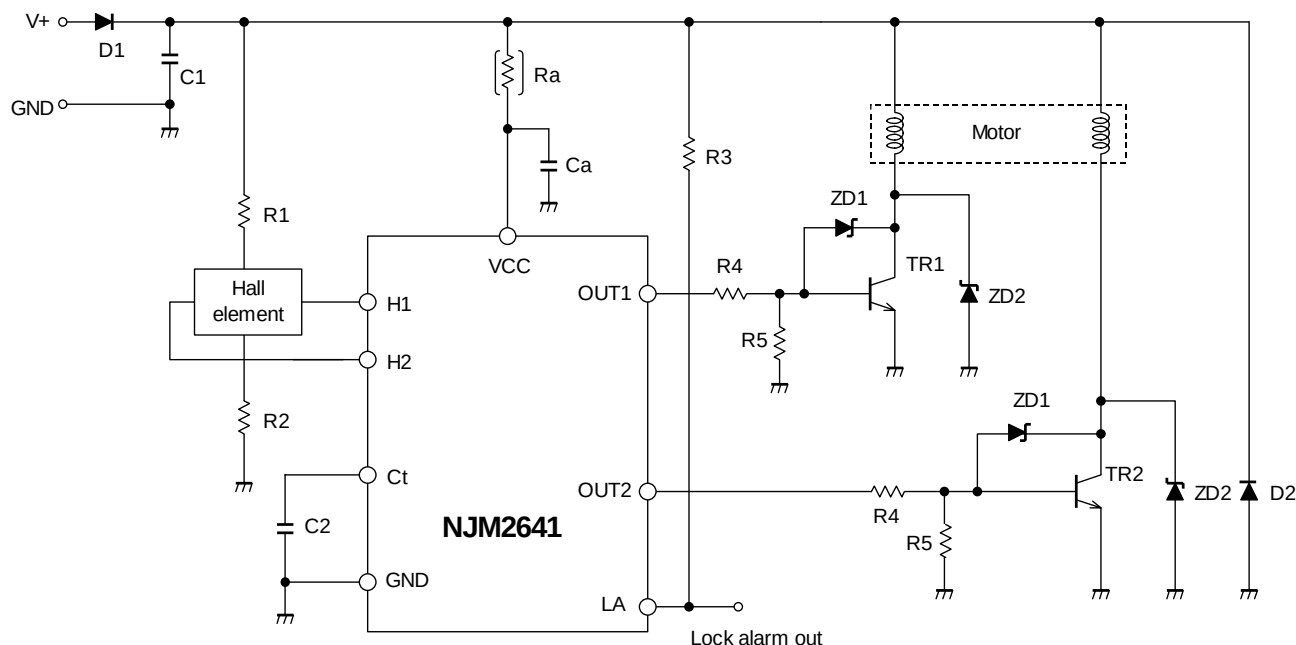
PARAMETER	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Current	I_{CC}	$V_{CC}=12V$	-	3.0	4.0	mA
		$V_{CC}=5V$	-	2.8	3.75	
Hall Input Hysteresis Range	V_{HYS}	-	8	20	32	mV
Hall Amplifier Input Bias Current	I_B	-	-	1.0	-	μA
Output Voltage	V_{OUT}	$I_{OUT}=20mA$	-	$V_{CC}-1.5$	-	V
Output Leak Current	I_{LEAK}	$V_{CC}=14V$	-	1	10	μA
Lock Alarm Output Voltage	V_{LA}	Lock Alarm ON, $I_{LA}=5mA$	-	-	0.5	V
Lock Alarm Leak Current	$I_{LA-LEAK}$	$V_{LA}=14V$	-	-	5	μA
Ct Charge Current	I_{CHG}	$V_{CT}=1.5V$	-	4.0	-	μA
Ct Discharge Current	I_{DCHG}	$V_{CT}=1.5V$	-	0.4	-	μA
Charge / Discharge Current Ratio	I_{CHG} / I_{DCHG}	-	4.0	5.5	8.0	
Ct H-level Cense Voltage	V_{CH}	-	2.2	2.5	2.8	V
Ct L-level Cense Voltage	V_{CL}	-	0.6	0.7	0.8	V
Auto Protection Release ON Time	T_{ON}	$C_t=0.47\mu F$	-	0.25	-	s
Auto Protection Release OFF Time	T_{OFF}	$C_t=0.47\mu F$	-	2.5	-	s



TYPICAL CHARACTERISTICS



[Application Circuit Example]



Hall Elements: HW101A (AKE)
TR1, TR2: 2SD2475 (Panasonic)

Optimize the value in actual operating conditions if necessary. D1 is a diode for protection against reverse voltage supply. Silicon rectifier diode (WO3C, 10D1 and equivalent) is appropriate.

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; Lock Alert Out (LA: 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:

$$T_{ON} = C2 \frac{V_{ch} - V_{cl}}{I_c} [\text{sec}]$$

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:

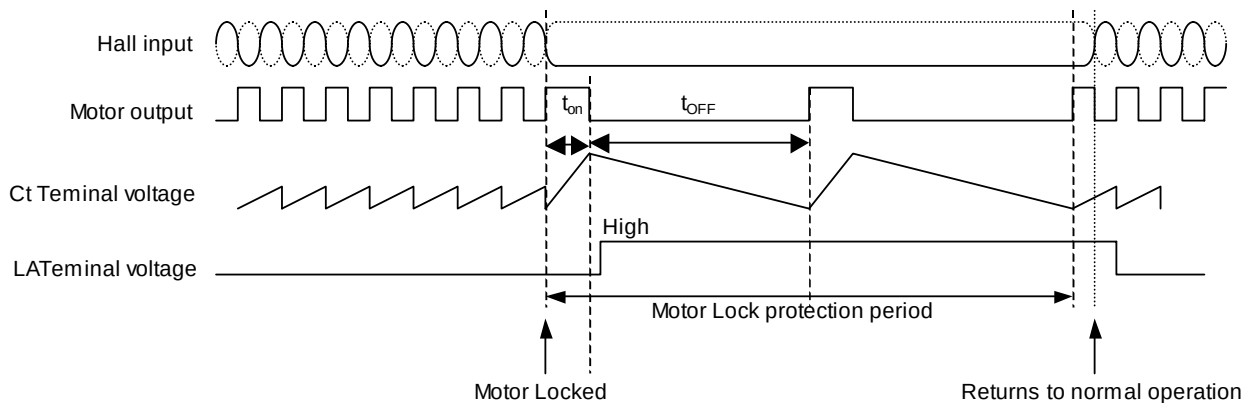
$$T_{OFF} = C2 \frac{V_{ch} - V_{cl}}{I_{dc}} [\text{sec}]$$

Where C2 is 0.47uF:

$$T_{OFF} = 0.47 \times 10^{-6} \times \frac{2.8 - 0.7}{0.4 \times 10^{-6}} = 2.47 [\text{sec}]$$

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.

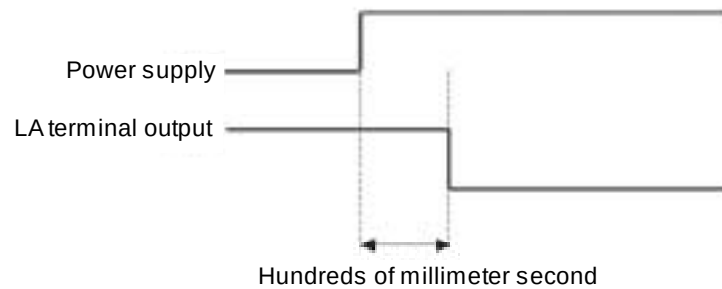
A typical value of C2 is either 0.47uF or 1uF depending on a motor.



Lock Protection

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

It must be noted that Lock Alert Out stays at a H state during a few hundred milliseconds from power up as shown in the picture below.



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

Hall amplifier is a differential amplifier with hysteresis characteristics (20mV typical).

The common-mode input voltage is between 1.5V and $V_{CC}-2V$ and the input signal must be within the range.

Non-excitation hall bias voltage is to be set at a half of V_{CC} 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:

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

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

The output voltage of hall elements is influenced by the bias current and magnetic flux density of hall elements.

The optimum input voltage of NJM2641 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 2SD2475 (Panasonic) is 80 from its datasheet. Given that I_o is 300mA, the base current of TR1 is 3.75mA. R4 is given by:

$$R4 = \frac{V_{CC} - V_{BE} - V_{CE}}{I_B}$$

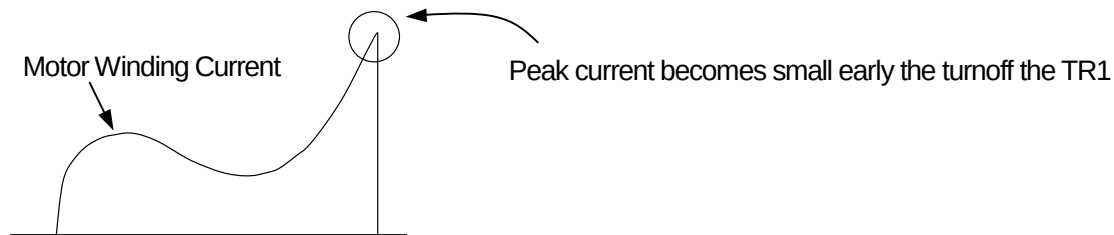
$$R4 = \frac{12 - 0.7 - 1.5}{3.75 \times 10^{-3}} = 2.61 \times 10^3 = 2.61k\Omega$$

Where; V_{CC} is 12V, V_{CE} of NJM2641 is 1.5V, V_{BE} 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 Ω to 10k Ω . 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 is (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 Vbe 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 NJM2641.

Example) VCC 15V Application

Given that current consumption of NJM2641 is 4mA (at VCC=12V), Ra is given by:

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

Ca is used if NJM2641 is oscillated or shows unstable operation. A typical value Ca is from 0.01 μ F to 0.1 μ 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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