Single-Phase Full-Wave Fan Motor Driver

General Description

The RT8720B is a single-phase driver IC for fan motors. Rotation speed is controlled by supply voltage modulation. In the supply voltage control application, the fan speed slope is adjustable by the external voltage input. The RT8720B provides several protection features including lock protection, thermal shutdown, over-current protection and under-voltage protection. In thermal shutdown mode, the supply current is less than 100μA. The rotation frequency is generated by FG output.

Ordering Information

RT8720B□□

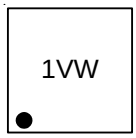
- Package Type
  QU : UDFN-8SL 2x2 (U-Type)
- Lead Plating System
  G : Green (Halogen Free and Pb Free)

Note :

Richtek products are :

- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.

Marking Information



1V : Product Code

W : Date Code

Features

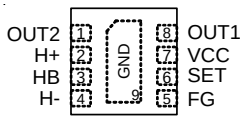
- **Low Supply Current**
- **Adjustable Voltage Control Fan Speed**
- **Supply Voltage Speed Control**
- **Smart Force Start-up Function**
- **Built-in Lock Protection**
- **Built-in Thermal Shutdown**
- **Built-in Over-Current Protection**
- **Built-in Frequency Generator with FG Output Signal**
- **Include Hall Bias Circuit**
- **RoHS Compliant and Halogen Free**

Applications

- Single-Phase Fan Motor for Notebook or PC

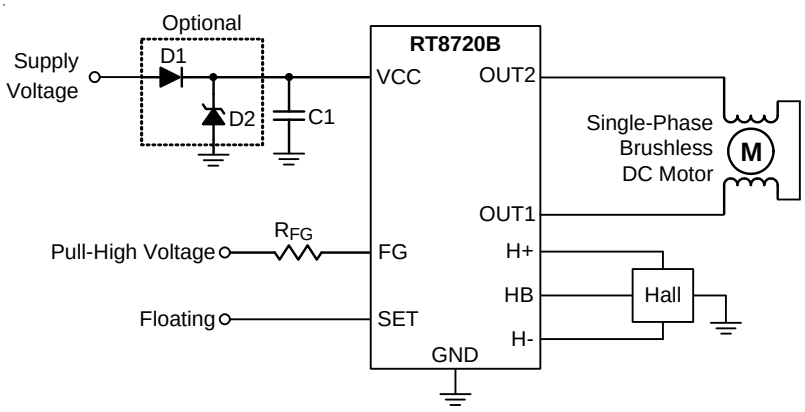
Pin Configurations

(TOP VIEW)



UDFN-8SL 2x2

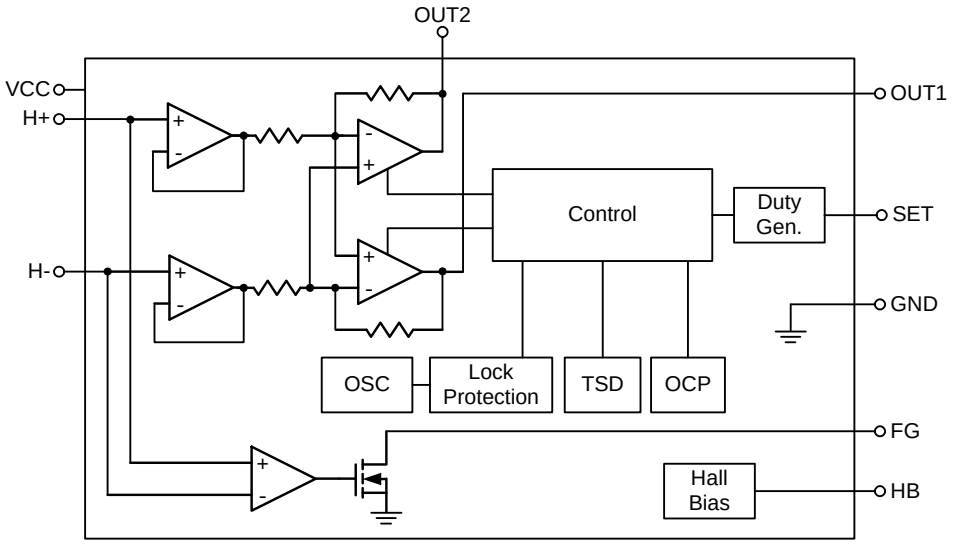
Simplified Application Circuit



Function Pin Description

Pin No.	Pin Name	Pin Function
1	OUT2	Output of H-Bridge for DC Motor.
2	H+	Positive Hall Input.
3	HB	Hall Bias Voltage Output.
4	H–	Negative Hall Input.
5	FG	Output for Rotation Speed. This is an open drain output.
6	SET	Speed Slop Setting.
7	VCC	Power Supply Input.
8	OUT1	Output of H-Bridge for DC Motor.
9 (Exposed Pad)	GND	Power Ground. The Exposed Pad should be soldered to a large PCB and connected to GND for maximum thermal dissipation.

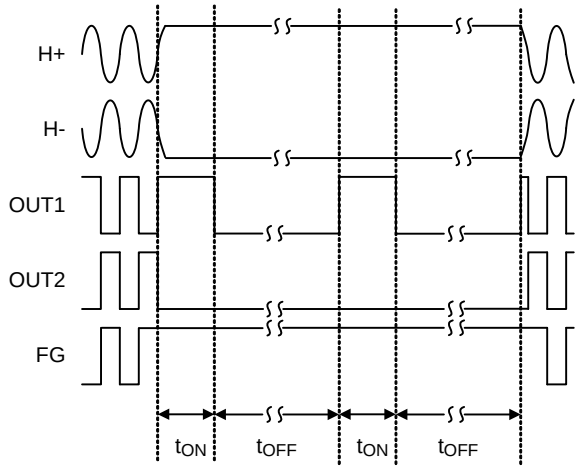
Function Block Diagram



Operation

Motor Lock Protection and Automatic Restart

When the motor is locked, the RT8720B will try to re-start the motor within 0.5 seconds typically (t_{ON}). If the motor fails to re-start, the driver will disable the output regardless of the PWM duty ratio to prevent the motor coil from burnout. After the lock off-time of 5 seconds in typical (t_{OFF}), the driver will try to restart the motor again. If the motor is still locked, then the iteration of the lock detection and restart will be repeated until the lock condition is released or the PWM input is pulled low.



Absolute Maximum Ratings (Note 1)

- Supply Input Voltage, VCC (<300ns) ---------- –0.3V to 10V
- Hall Input Voltage Range, H+, H– ---------- –0.3V to 6V
- SET Input Voltage, SET ---------- –0.3V to 6V
- Output Voltage, OUT1, OUT2, FG ---------- –0.3V to 7V
- Maximum Output Current, OUT1, OUT2 ---------- 1A
- Power Dissipation, P_D @ T_A = 25°C
  UDFN-8SL 2x2 ---------- 2.78W
- Package Thermal Resistance (Note 2)
  UDFN-8SL 2x2, θ_{JA} ---------- 35.9°C/W
- Junction Temperature ---------- 150°C
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 3)
  HBM (Human Body Model) ---------- 4kV

Recommended Operating Conditions (Note 4)

- Supply Input Voltage, VCC ---------- 1.8V to 5.5V
- Hall Input Voltage, H+, H– ---------- 0.4V to (V_{CC} – 1.1V)
- SET Input Voltage, SET ---------- 0.1V to V_{HB}
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{CC} = 5V, T_A = 25°C, Unless Otherwise specification)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Operating Current		I_{CC1}	Rotation Mode and Lock Protection Mode	--	3.5	5	mA
SET Input Leakage	High-Level	I_{SET_H}	V_{SET} = V_{CC}	--	--	1	µA
	Low-Level	I_{SET_L}	V_{SET} = 0	--	--	1	
Input-Output Gain		G_{IO}	V_{OUT} / H+ – H- (Ratio)	42	44.6	47	dB
Output Voltage		V_O	I_O = 250mA, Upper and Lower Total	--	0.2	0.4	V
FG Pin Low Voltage		V_{FG}	I_{FG} = 5mA	--	0.1	0.2	V
FG Pin Leak Current		I_{FG}	V_{FG} = 5V	--	--	1	µA
Input Offset Voltage		V_{HOFS}		--	--	±6	mV
Input Hysteresis Voltage		V_{Hys}		±5	±10	±15	mV
Lock Detection On-Time		t_{ON}		0.35	0.5	0.65	s
Lock Detection Off-Time		t_{OFF}		3.5	5	6.5	s
Thermal Shutdown Threshold				--	160	--	°C

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Thermal Shutdown Hysteresis			--	30	--	°C
Hall Bias Voltage	V_{HB}	I_{HB} = −5mA	1.26	1.3	1.34	V
Supply Voltage Threshold	V_{CC_TH}		3	3.5	4	V

Note 1. Stresses beyond those listed "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2. θ_{JA} is measured at T_A = 25°C on a high effective thermal conductivity four-layer test board per JEDEC 51-7.

Note 3. Devices are ESD sensitive. Handling precaution is recommended.

Note 4. The device is not guaranteed to function outside its operating conditions.

Typical Application Circuit

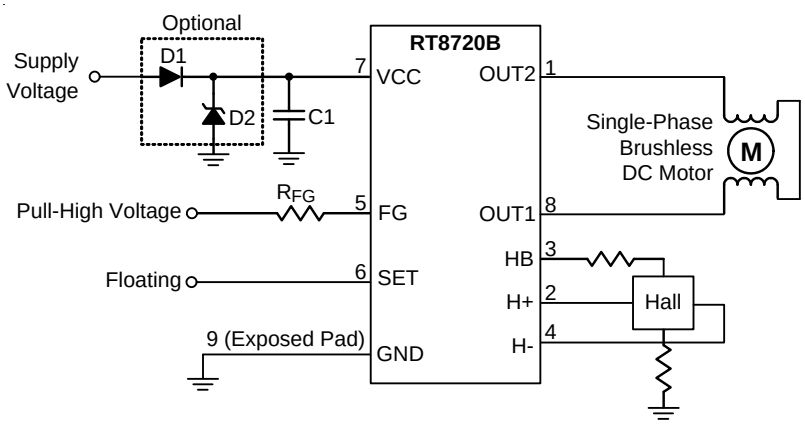


Figure 1. Fan Speed Controlled by Supply Voltage, it's known as "VCC Mode".

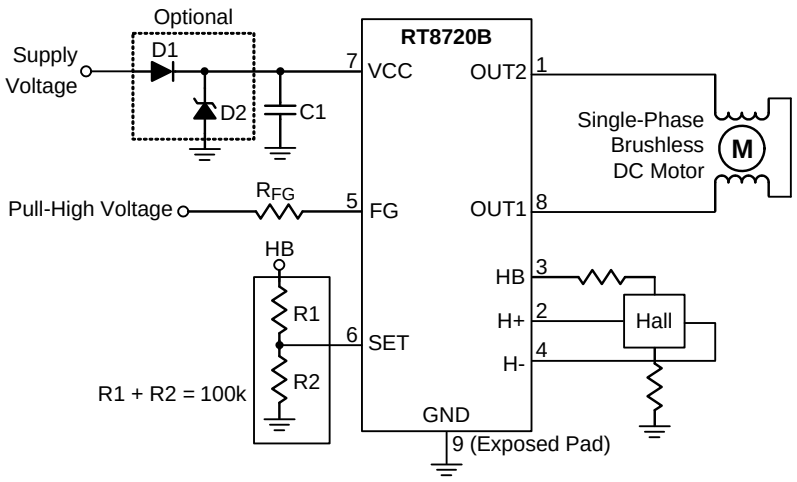


Figure 2. Fan Speed Controlled by Supply Voltage with Slop Setting, it's known as "ADJ Mode".

Application Information

Frequency Generator (FG)

The FG pin is an open drain output. A pull-up resistor (1kΩ to 10kΩ) is recommended to be connected from this pin to a high level voltage (<5.5V) for frequency generator function.

Thermal Shutdown

The RT8720B provides a thermal shutdown function to prevent overheating due to excessive power dissipation. The function shuts down the switching operation when the junction temperature exceeds 160°C. Once the junction temperature cools down by around 30°C, the main converter will automatically resume switching. To maintain continuous operation, the junction temperature should be kept below 130°C.

Speed Control

The motor speed can be controlled by the supply voltage. When the SET pin input is fixed at a voltage level, the motor speed will be controlled by the supply voltage. In "ADJ Mode" application, the RT8720B provides the function to adjust the motor speed slope of the supply voltage region. Input the SET pin voltage will modulating slow down the speed at the lower supply voltage by modulated the output switching duty, and the switching output frequency is equal to internal clock, f_{INT_CLK}. When the SET pin input is floating, the motor will rotate with full speed, as in VCC mode.

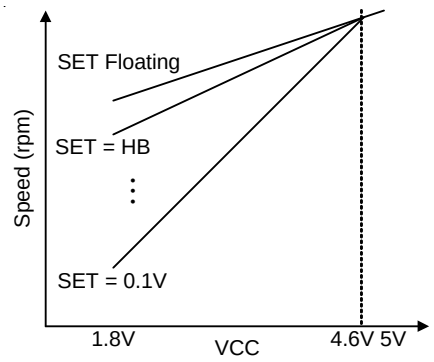


Figure 3. Fan Speed Controlled by Supply Voltage

Over-Current Protection

The RT8720B includes an Over-Current Protection (OCP) feature to prevent the large supply current form supply voltage to output. When the over-current occurs, the circuit will disable the output and the motor rotor will stop. After a time duration (T_{OFF}, typical 5s), the IC will automatically try to restart the motor. If the supply current is still larger, the output will be shut down immediately.

Force Start-Up Control

The motor speed is controlled by the external SET pin. In order to successfully start the motor with lower output duty, a start-up mechanism is applied to check if output duty from the external SET voltage can drive the motor to rotate in a period (0.4 x t_{ON}, typ. 0.2s). If it cannot drive the motor to rotate because of its low output duty, an internal PWM signal with higher duty will be adopted to drive the motor. The internal PWM duty = 100%.

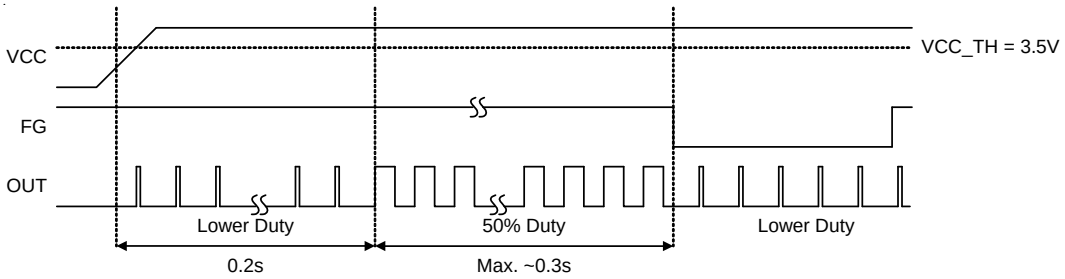


Figure 4. Forced Start-Up when VCC > VCC_TH

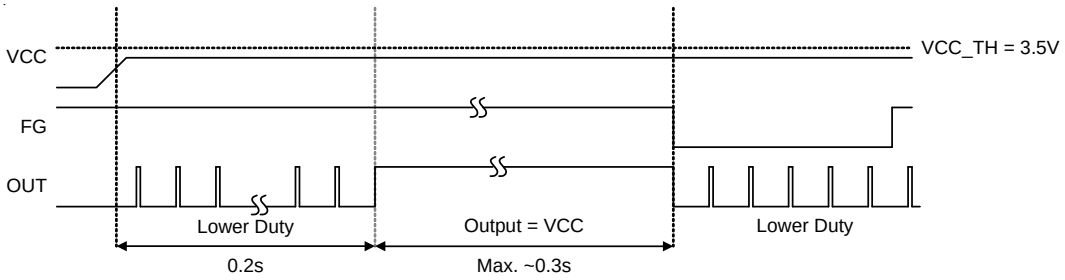


Figure 5. Forced Start-Up-1 when VCC ≤ VCC_TH

FG Output when Motor is in the Lock State

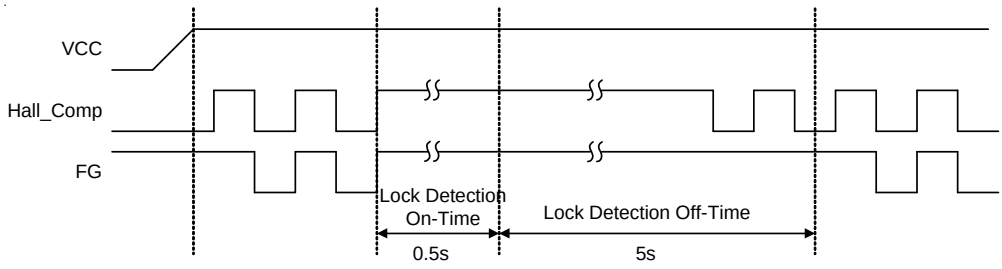


Figure 6. FG Output when Motor is in the Lock State

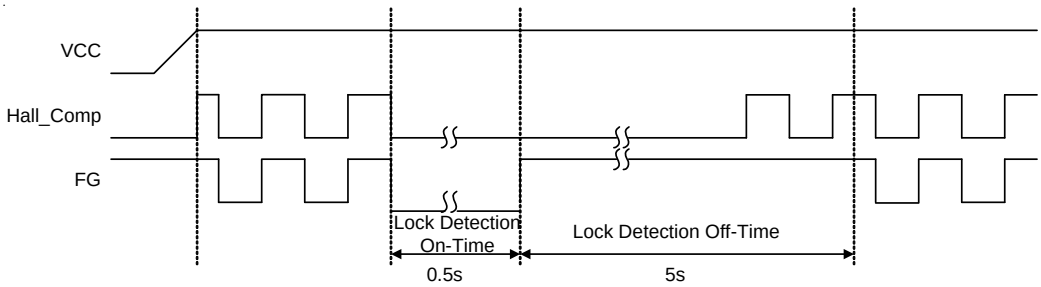


Figure 7. FG Output when Motor is in the Lock State-1

Truth Table

H+	H-	OUT1	OUT2	FG	Mode
H	L	H	L	L (Output : ON)	Operation Mode
L	H	L	H	Z (Output : OFF)	
H	L	L	L	Z (Output : OFF)	Lock Mode
L	H	L	L	Z (Output : OFF)	

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula :

$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction to ambient thermal resistance.

For recommended operating condition specifications, the maximum junction temperature is 125°C. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For UDFN-8SL 2x2 package, the thermal resistance, θ_{JA}, is 35.9°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by the following formula :

$P_{D(MAX)}$ = (125°C – 25°C) / (35.9°C/W) = 2.78W for UDFN-8SL 2x2 package

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. The derating curve in Figure 8 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

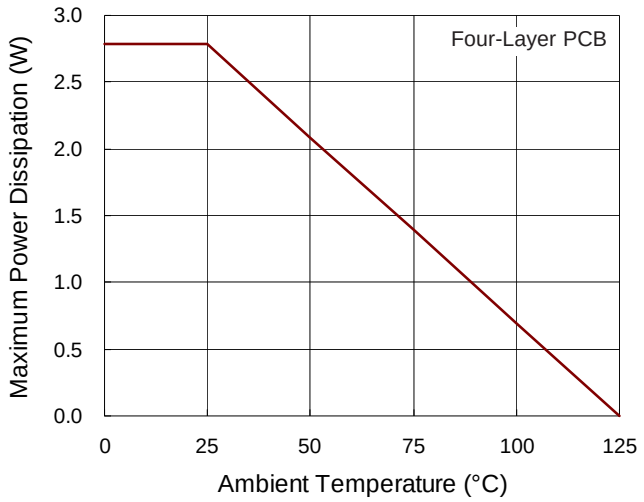
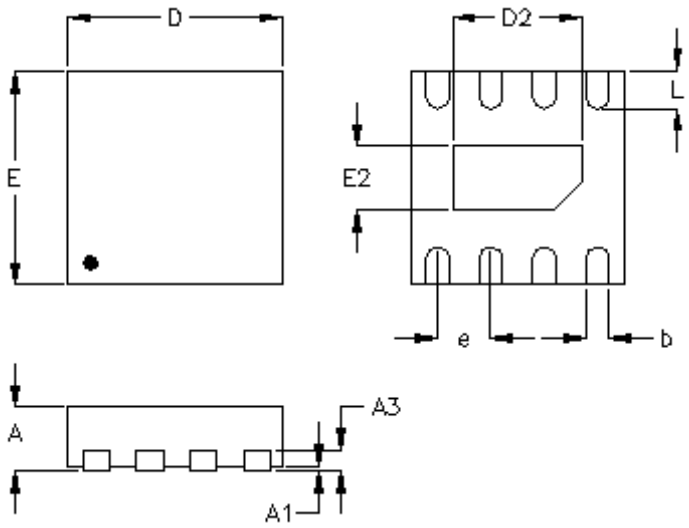
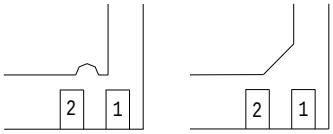


Figure 8. Derating Curve of Maximum Power Dissipation

Outline Dimension





DETAIL A

Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.500	0.600	0.020	0.024
A1	0.000	0.050	0.000	0.002
A3	0.100	0.175	0.004	0.007
b	0.200	0.300	0.008	0.012
D	1.900	2.100	0.075	0.083
D2	1.650	1.750	0.065	0.069
E	1.900	2.100	0.075	0.083
E2	0.850	0.950	0.033	0.037
e	0.500		0.020	
L	0.250	0.350	0.010	0.014

U-Type 8SL DFN 2x2 Package

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