Single-Phase Full-Wave Fan Motor Driver

General Description

The RT8723 is a single-phase driver IC for fan motors. Rotation speed is controlled by supply voltage modulation and PWM input signal. In the supply voltage control application, the fan speed slope is adjustable by the external voltage input. The RT8723 provides several protection features including the standby mode, thermal shutdown, lock protection, the over-current protection and also the under-voltage protection. In standby and thermal shutdown mode, supply current is less than 100µA. The rotation frequency is generated by FG output.

Features

- **Low Supply Current**
- **PWM Supply Voltage Control Fan Speed**
- **Adjustable Voltage Control Fan Speed**
- **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**

Ordering Information

RT8723□□

- Package Type
  QU : UDFN-10L 3x3 (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.

Applications

- Single Phase Fan Motor for Notebook or PC

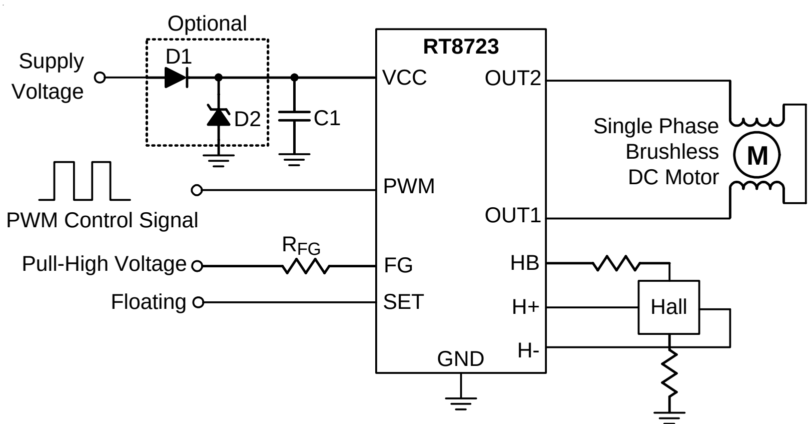
Marking Information

2M=YM
DNN

2M= : Product Code

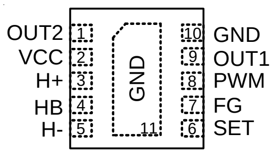
YMDNN : Date Code

Simplified Application Circuit



Pin Configurations

(TOP VIEW)

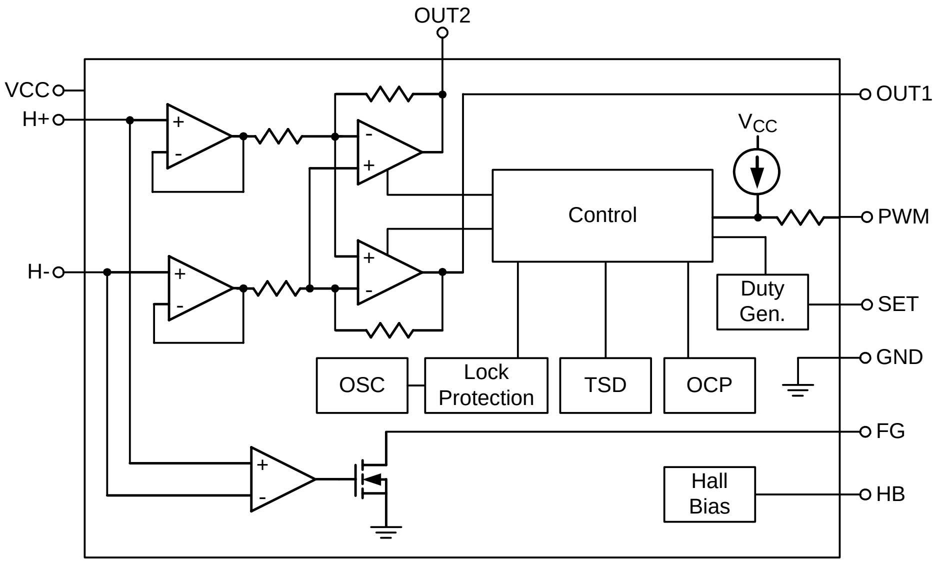


UDFN-10L 3x3

Function Pin Description

Pin No.	Pin Name	Pin Function
1	OUT2	Output of H-Bridge for DC Motor.
2	VCC	Power Supply Input.
3	H+	Positive Hall Input.
4	HB	Hall Bias Voltage Output.
5	H–	Negative Hall Input.
6	SET	Speed Slop Setting.
7	FG	Output for Rotation Speed. This is an open drain output.
8	PWM	PWM Signal Input.
9	OUT1	Output of H-Bridge for DC Motor.
10, 11 (Exposed Pad)	GND	Power Ground. The Exposed Pad should be soldered to a large PCB and connected to GND for maximum thermal dissipation.

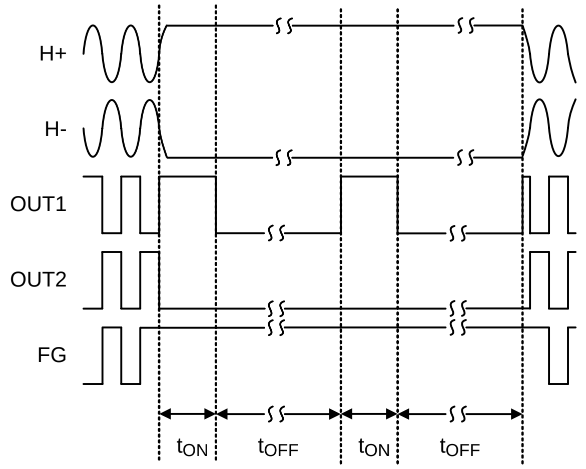
Function Block Diagram



Operation

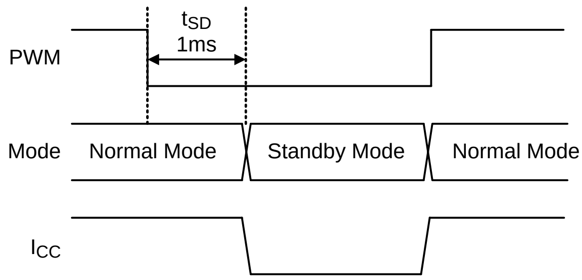
Lockup Protection and Automatic Restart

When the motor is locked, a lock detection circuit will detect this situation within a time duration (T_{ON}, typical 0.5s), and the driver will try to restart the motor. If restart failed, the circuit will disable the output drivers regardless of the duty ratio of the PWM to prevent the motor coil from burnout. After another time duration (T_{OFF}, typical 5s), the IC will automatically try to restart the motor. 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 external PWM input is pulled low.



Quick Start and Standby Mode

The operation mode of RT8723 is determined by the external PWM input. During the power up, if the PWM input remains at a low-level voltage, the IC will enter the low power standby mode. If the PWM input is kept at a high-level voltage or is a pulse signal, the IC will operate in the normal mode. On the other hand, during the normal operation, when the PWM input is set to a low-level voltage for more than 1ms (typ.), the IC will enter the low-power standby mode. Once the PWM input is pulled up again, the IC will be activated immediately for normal operations. In the standby mode, supply current is around 100μA.



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
- PWM Input Voltage, PWM ---------- –0.3V to 6V
- Output Voltage, OUT1, OUT2, FG ---------- –0.3V to 6V
- Maximum Output Current, OUT1, OUT2 ---------- 1A
- Power Dissipation, P_D @ T_A = 25°C, θ_{JA} = 150°C
  UDFN-10L 3x3 (One-Layer) ---------- 0.6W
  UDFN-10L 3x3 (Two-Layer) ---------- 2.83W
- Package Thermal Resistance (Note 2)
  UDFN-10L 3x3 (One-Layer), θ_{JA} ---------- 206.9°C/W
  UDFN-10L 3x3 (One-Layer), θ_{JC} ---------- 6.3°C/W
  UDFN-10L 3x3 (Two-Layer), θ_{JA} ---------- 44.2°C/W
  UDFN-10L 3x3 (Two-Layer), θ_{JC} ---------- 6.3°C/W
- Junction Temperature ---------- 150°C
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Storage Temperature Range ---------- –65°C to 150°C

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}
- PWM Input Voltage, PWM ---------- 0V to V_{CC}
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 105°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
Standby Current		I_{CC2}	Standby Mode (PWM = 0)	--	100	200	μA
PWM Input Voltage	High-Level	V_{PWM_H}	@PWM Mode	1.8	--	V_{CC} + 0.5	V
	Low-Level	V_{PWM_L}	@PWM Mode	0	--	0.7	
PWM Input Frequency		f_{PWM}	@PWM Mode	2	--	50	kHz
PWM Input Leakage	High-Level	I_{PWM_H}	V_{PWM} = V_{CC}, @PWM Mode	--	0	5	μA
	Low-Level	I_{PWM_L}	V_{PWM} = 0, @PWM Mode	–30	–10	--	

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Input-Output Gain		G_{IO}	V_{OUT}/H+ – H- (Ratio)	42	44.6	47	dB
Input Offset Voltage		V_{HOFS}		--	--	±6	mV
Input Hysteresis Voltage		V_{Hys}		±5	±10	±15	mV
Output Voltage		V_{OUT}	I_{OUT} = 250mA	--	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} = V_{CC}	--	--	1	μA
Hall Bias Voltage		V_{HB}	I_{HB} = –5mA	1.26	1.3	1.34	V
SET Input Leakage	High-Level	I_{SET_H}	V_{SET} = V_{CC}, @ADJ Mode	--	--	1	μA
	Low-Level	I_{SET_L}	V_{SET} = 0V, @ADJ Mode	--	--	1	
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				--	160	--	°C
Thermal Shutdown Hysteresis				--	30	--	°C
Supply Voltage Threshold		V_{CC_TH}		3	3.5	4	V
Quick Start							
Standby Detection Time		t_{SD}		0.7	1	1.3	ms
Quick Start Enable Time		t_{QS}		--	30	--	μs

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 one/two-layer test board per JEDEC 51-3. θ_{JC} is measured at the exposed pad of the package.

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

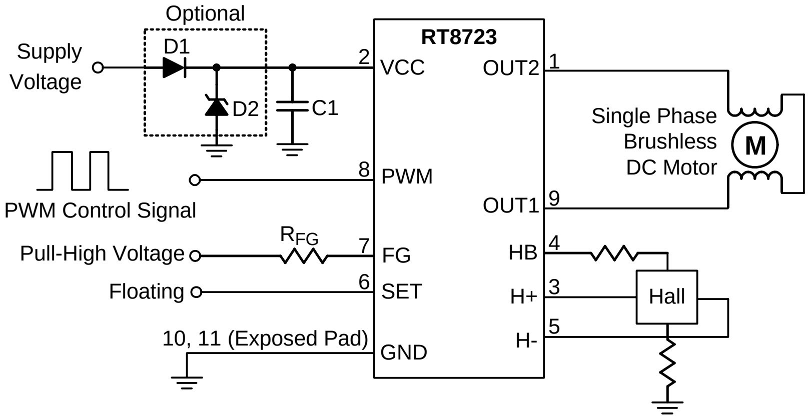


Figure 1. Fan Speed Controlled by Direct PWM Input, it's known as "PWM Mode".

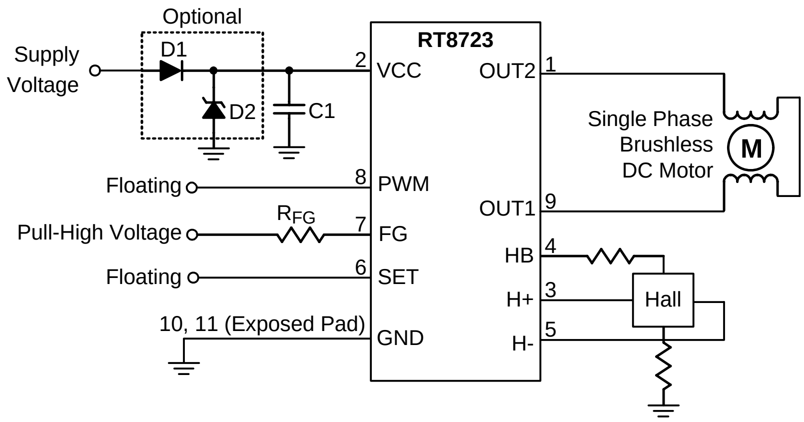


Figure 2. Fan Speed Controlled by Supply Voltage, it's known as "VCC Mode".

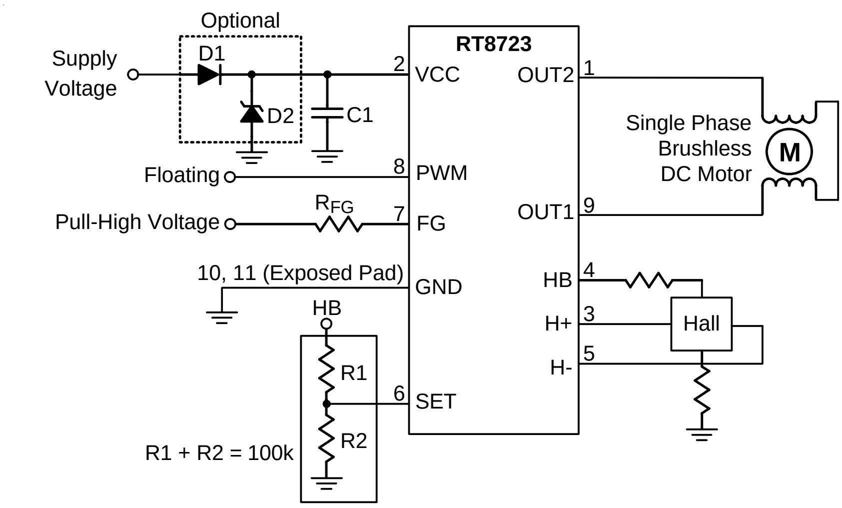


Figure 3. Fan Speed Controlled by Supply Voltage with Slop Setting, it's known as "ADJ Mode".

Application Information

Speed Control

The motor speed can be controlled by the supply voltage and external PWM input pin. 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 RT8723 provides the function to adjust the motor speed slope of the supply voltage region. Input the SET pin voltage will slow down the speed at the lower supply voltage by modulating 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 speed will be controlled by the external PWM input, as in PWM mode. When the PWM input is fixed at a high level voltage or floating, the motor will rotate with full speed, as in VCC mode. When the PWM input is fixed at a low level voltage, the motor will decelerate to stop. When a switching signal is sent as the PWM input, the duty ratio of the input signal will be input to adjust the switching duty ratio to the output drivers. The switching frequency of the output drivers is dependent on the input PWM frequency.

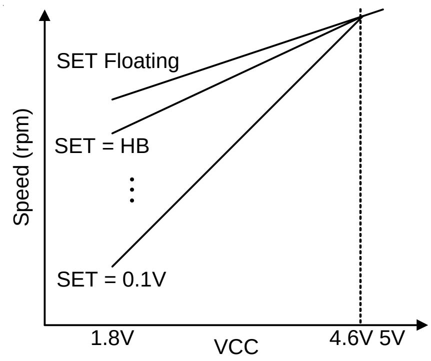


Figure 4. Fan Speed Controlled by Supply Voltage

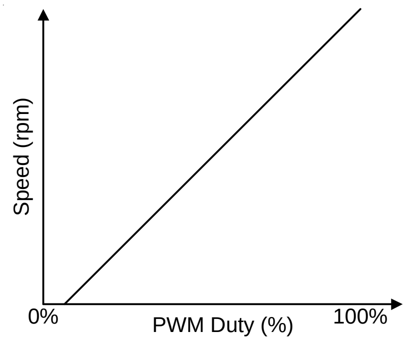


Figure 5. Fan Speed Controlled by External PWM Input Duty

Thermal Shutdown

The RT8723 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.

Over-Current Protection

The RT8723 includes an Over-Current Protection (OCP) feature to prevent the large supply current form supply voltage to output. When the over-current occur, 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.

PWM Speed Control

The motor speed can be controlled by the external signal at PWM pin and the supply input voltage. When a PWM signal is provided to the PWM pin, the driver output will follow the duty ratio of the PWM input signal. The switching frequency of the driver is dependent on the PWM input frequency. Therefore, the motor speed is controlled by the PWM signal. The available PWM input frequency range is from 2kHz to 50kHz. When the PWM input is fixed at a high-level voltage (>1.8V) or floating, the motor will rotate with full speed. When the PWM input is fixed at a low-level voltage (<0.7V), the motor will decelerate to stop. In standby mode, the supply current can be reduced to 100μA.

Quick Start Function

If the PWM is pulled low for a delay time, t_{SD}, the RT8723 will enter standby mode. Once a PWM signal is detected, the RT8723 will provide outputs after a delay time, t_{QS}.

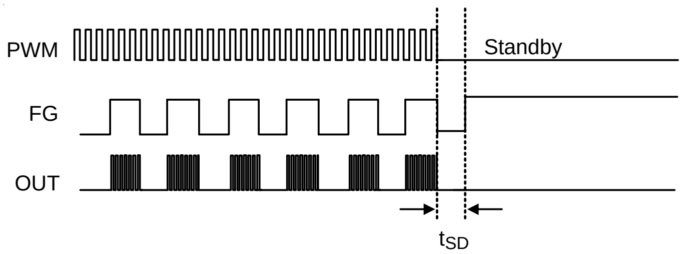


Figure 6

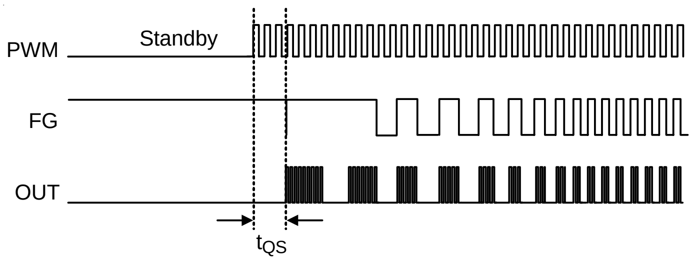


Figure 7

Force Start-Up Control

The motor speed is controlled by the external PMW signal. In order to successfully start the motor with lower PWM duty, a start-up mechanism is applied to check if output duty from the external PWM signal 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 duty, an internal PWM signal with higher duty will be adopted to drive the motor. The internal PWM duty varies according to input voltage VCC ($V_{CC} \geq 3.5V$, duty = 50%; $V_{CC} < 3.5V$, duty = 100%).

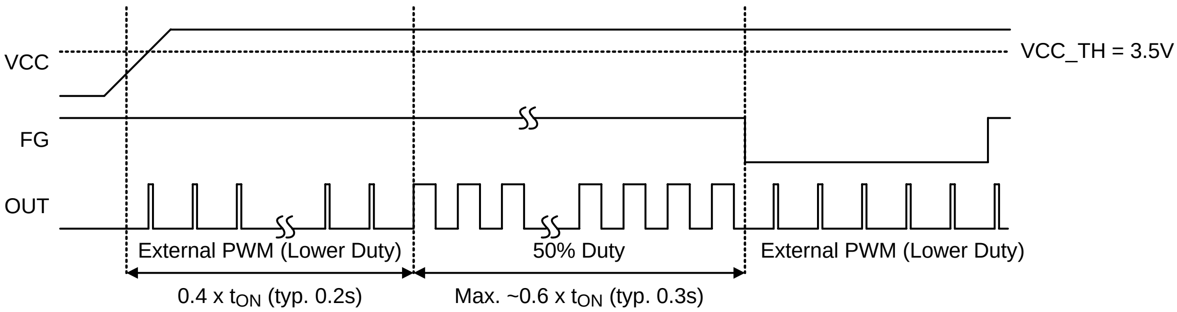


Figure 8. Forced Start-Up when VCC > VCC_TH

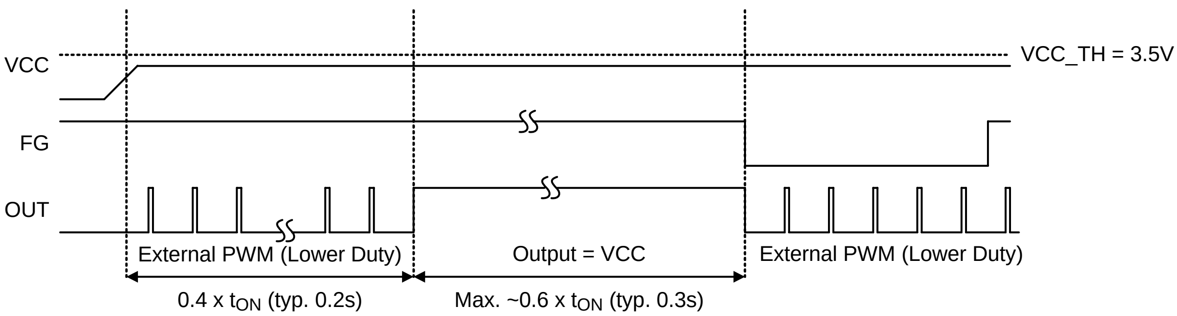


Figure 9. Forced Start-Up-1 when VCC ≤ VCC_TH

FG Output when Motor is in the Lock State

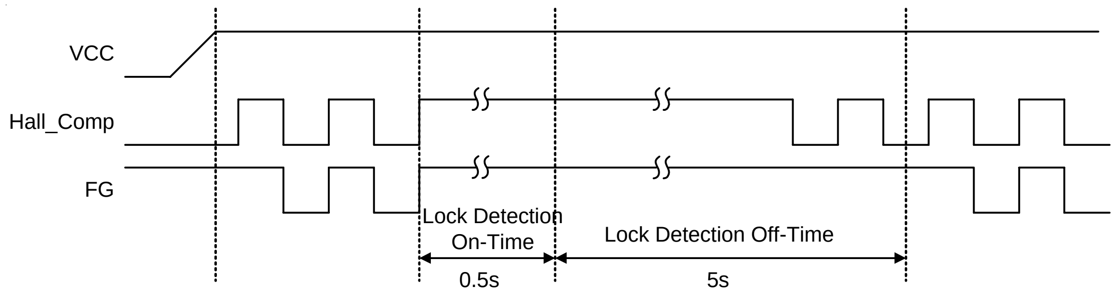


Figure 10. FG Output when Motor is in the Lock State

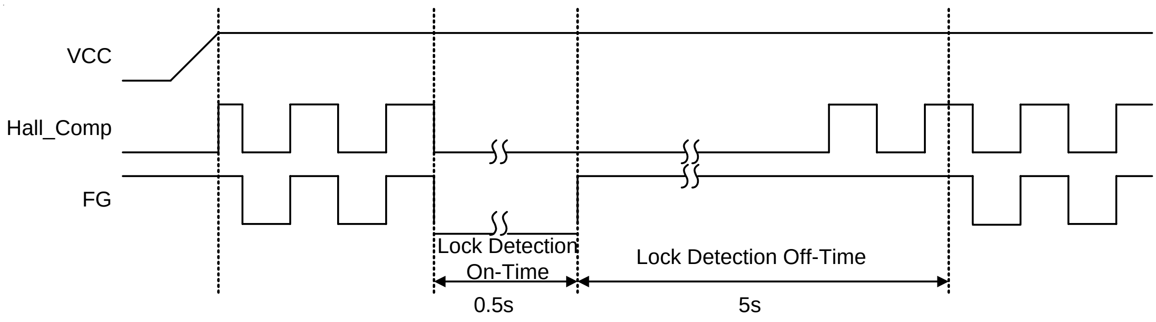


Figure 11. FG Output when Motor is in the Lock State-1

Truth Table

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

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-10L 3x3 package, the thermal resistance, θ_{JA}, is 0.48°C/W on a standard JEDEC 51-3 one-layer thermal test board. For UDFN-10L 3x3 package, the thermal resistance, θ_{JA}, is 2.26°C/W on a standard JEDEC 51-3 two-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) / (206.9°C/W) = 0.48W for UDFN-10L 3x3 package (One-Layer)

$P_{D(MAX)}$ = (125°C − 25°C) / (44.2°C/W) = 2.26W for UDFN-10L 3x3 package (Two-Layer)

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 12 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

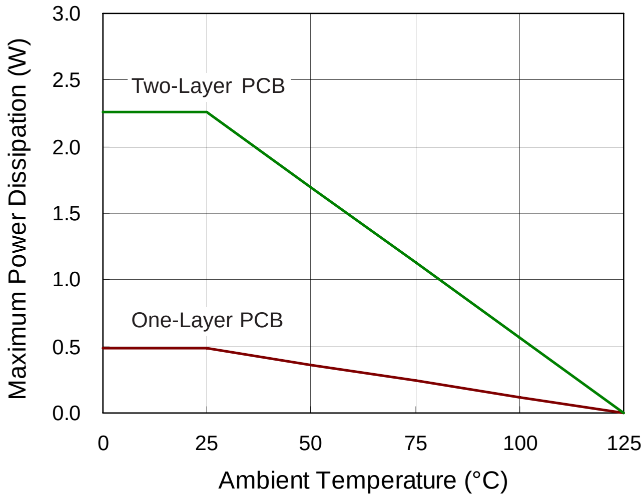
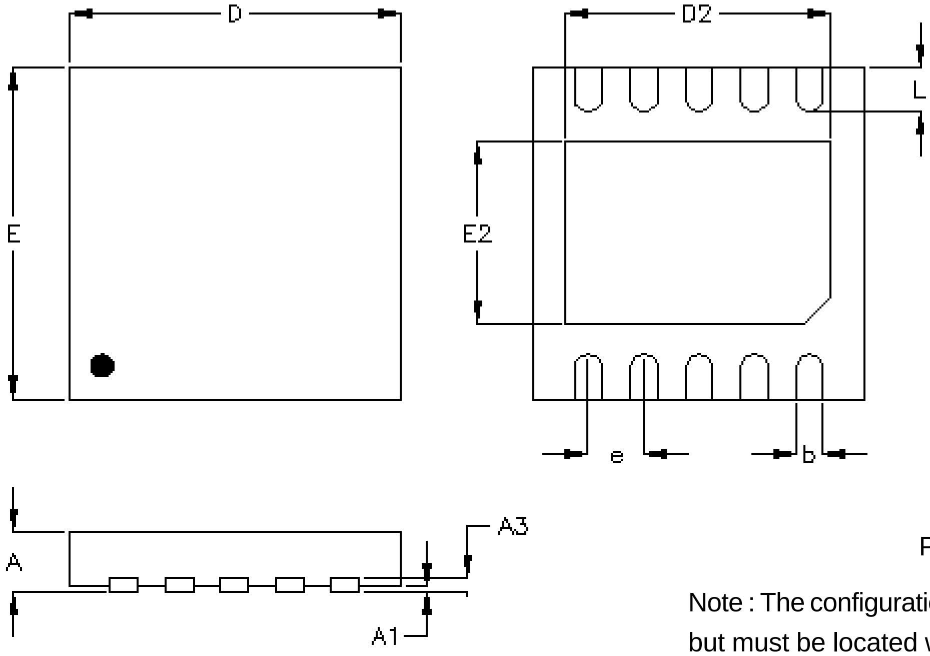
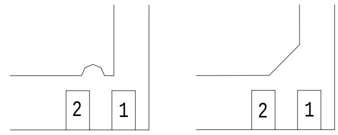


Figure 12. Derating Curve of Maximum Power Dissipation

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	0.180	0.300	0.007	0.012
D	2.950	3.050	0.116	0.120
D2	2.350	2.450	0.093	0.096
E	2.950	3.050	0.116	0.120
E2	1.600	1.700	0.063	0.067
e	0.500		0.020	
L	0.350	0.450	0.014	0.018

U-Type 10L DFN 3x3 Package

Richtek Technology Corporation

14F, No. 8, Tai Yuen 1st Street, Chupei City

Hsinchu, Taiwan, R.O.C.

Tel: (8863)5526789