MP6630

5.5V, Three-Phase Fan Driver for Notebook

DESCRIPTION

The MP6630 is a 3-phase, brushless DC motor driver with integrated power MOSFETs for notebook fan drivers. The input voltage ranges from 2V to 5.5V.

The device controls the motor speed through a PWM signal on the PWM pin. It features an embedded single Hall sensor for robust start-up performance and 180° full-wave sine-wave control, which provides high efficiency, a low speed ripple, and low vibration across the full speed range.

The MP6630 also has a rotational speed detector. The FG pin is an open-drain output that detects rotational speed.

Protection features include under-voltage lockout (UVLO), locked-rotor protection, over-current protection (OCP), and thermal shutdown protection.

The MP6630 is available in a UTQNF-8 (2mmx3mm) package.

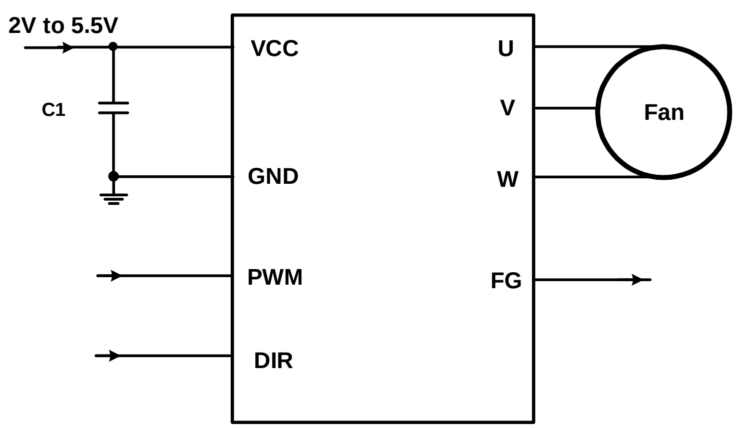
FEATURES

- Wide 2V to 5.5V Operating Input Range
- 180° Full-Wave Sine-Wave Control for High Efficiency and Low Speed Vibration
- Embedded Single Hall Sensor to Ensure Robust Start-Up
- Integrated Power MOSFETs
- 0.5s / 5s Rotor Lock and Retry Protection
- 1kHz to 100kHz PWM Input Range
- Direction Input
- 2.6s Soft-Start Time
- Fixed 25kHz Output Switching Frequency
- Output for Speed Indication (FG)
- Standby Mode to Save Power
- Thermal Protection and Auto-Recovery
- Typically 2.3A of Maximum Peak Current
- Available in a UTQNF-8 (2mmx3mm) Package

APPLICATIONS

- Notebook Fans

TYPICAL APPLICATION



ORDERING INFORMATION

Part Number*	Package	Top Marking	MSL Rating
MP6630GDU-xxxx**	UTQFN-8 (2mmx3mm)	*See Below*	*1*

* For Tape & Reel, add suffix -Z (e.g. MP6630GDU-Z).

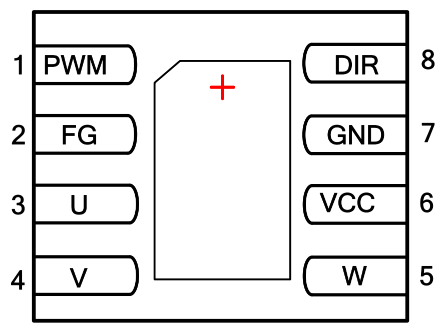
** “xxxx” is the configuration code identifier. The first four digits of the suffix (xxxx) can be a hexadecimal value between 0 and F. Work with an MPS FAE to create this unique number for non-default functions. The default function value is “0000”, and the hall polarity opposite of 0000 is “0001”. See the Hall Polarity Selection section on page 11 for more details.

TOP MARKING

BGV: Product code of MP6630GDU
Y: Year code
LLL: Lot number

PACKAGE REFERENCE

TOP VIEW



UTQFN-8 (2mmx3mm)

PIN FUNCTIONS

Pin #	Name	Description
1	PWM	**Rotational speed control for PWM input pin.** For maximum PWM resolution, set the PWM duty cycle from 1kHz to 100kHz. Pull up to LDO internally using a 100kΩ resistor.
2	FG	**Open drain.** Output for rotational speed detection.
3	U	**U phase terminal.**
4	V	**V phase terminal.**
5	W	**W phase terminal.**
6	VCC	**Input power pin.**
7	GND	**Ground pin.**
8	DIR	**Direction control pin.** Pull DIR low for forward rotation; pull it high for reverse rotation. Pulled low by an internal resistor.

ABSOLUTE MAXIMUM RATINGS [1]

V_{CC}, $V_{U/V/W}$......................................-0.3V to +16V
FG, PWM, DIR.............................-0.3V to +6.5V
Continuous power dissipation (T_A = 25°C) [2]
.... 1.9W
Junction temperature ....150°C
Lead temperature ....260°C
Storage temperature .... -60°C to +150°C

ESD Ratings

Human-body model (HBM) .... ±2000V
Charged-device model (CDM) .... ±2000V

Recommended Operating Conditions [3]

Supply voltage (V_{CC}) ....2V to 5.5V
Operating junction temp (T_J) .... -40°C to +125°C

Thermal Resistance [4]

	θ_{JA}	θ_{JC}	
UTQFN-8 (2mmx3mm)………..	65…....	13…	°C/W

Notes:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX) - T_A) / θ_{JA}. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device is not guaranteed to function outside of its operating conditions.
4) Measured on JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

V_{CC} = 5V, T_J = -40°C to +125°C, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
Input UVLO rising threshold	V_{UVLO}			1.7	1.8	V
Input UVLO hysteresis				0.1		V
Operating supply current	I_{CC}	PWM duty<16%		5.9	7	mA
Standby supply current	I_{CC}	PWM remains low		60	100	μA
PWM/DIR input high voltage	V_{LOGIC_H}		1.5			V
PWM/DIR input low voltage	V_{LOGIC_L}				0.4	V
PWM input internal pull-high resistance	R_{PWM}			100		kΩ
DIR internal pull-down resistance	R_{DIR}			100		kΩ
High-side switch on resistance	R_{HSON_U}	I_O = 100mA		0.4		Ω
	R_{HSON_V}			0.390		Ω
	R_{HSON_W}			0.358		Ω
Low-side switch on resistance	R_{LSON_U}	I_O = 100mA		0.434		Ω
	R_{LSON_V}			0.405		Ω
	R_{LSON_W}			0.402		Ω
Phase A zero-current detection			-2	0	+2	mA
Cycle-by-cycle current limit	I_{OCP}			1.4		A
Maximum current limit protection	I_{LMT}	Full-scale	1.5	2.3	3.1	A
PWM output frequency	f_S	T_J = 25°C	24.5	25	25.5	kHz
FG output low-level voltage	V_{FG_L}	I_{FG} = 3mA, V_{PULL} = 5V			0.35	V
Rotor-lock detection time	t_{RD}		0.448	0.5	0.552	s
Rotor-lock retry time	t_{RE}		4.48	5	5.52	s
Minimum recommended magnetic field (5)					±2	mT
Thermal shutdown threshold (5)				160		°C
Thermal shutdown hysteresis (5)				20		°C

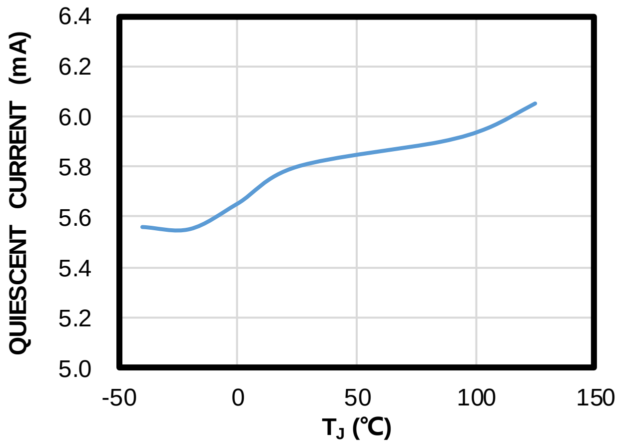
Note:

5) Guaranteed by design.

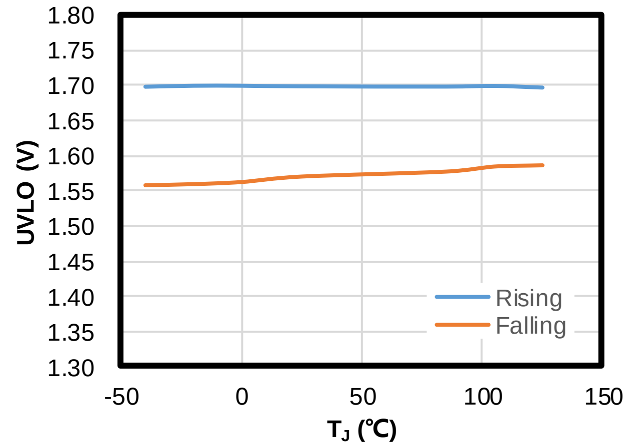
TYPICAL PERFORMANCE CHARACTERISTICS

V_{CC} = 5V, T_A = 25°C, tested with fan unit, unless otherwise noted.

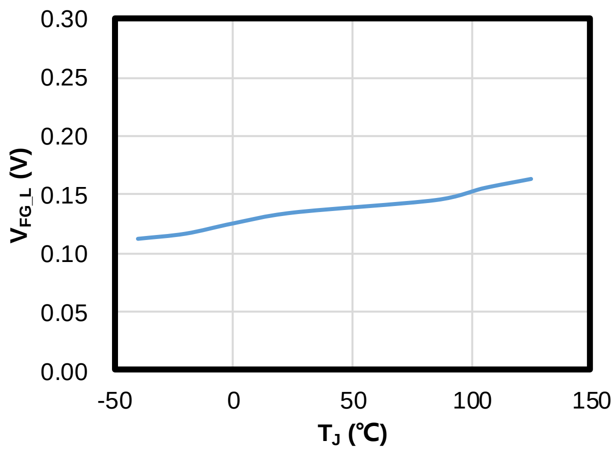
Quiescent Current vs. T_J



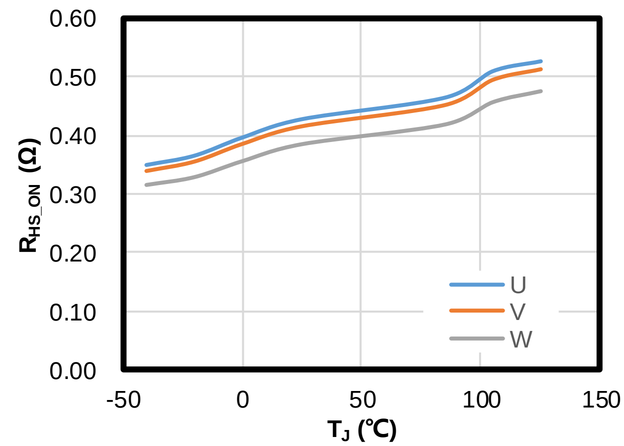
UVLO vs. T_J



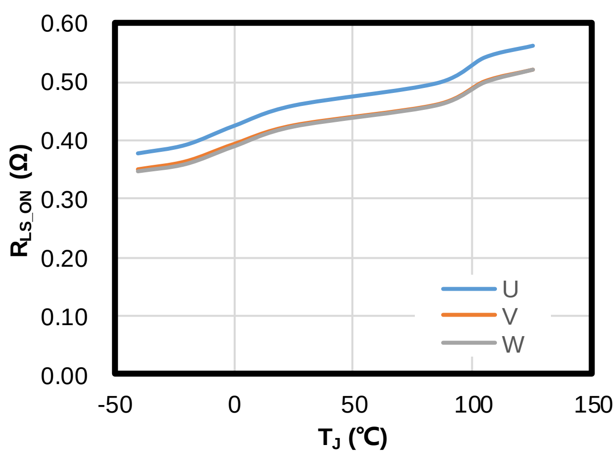
V_{FG_L} vs. T_J



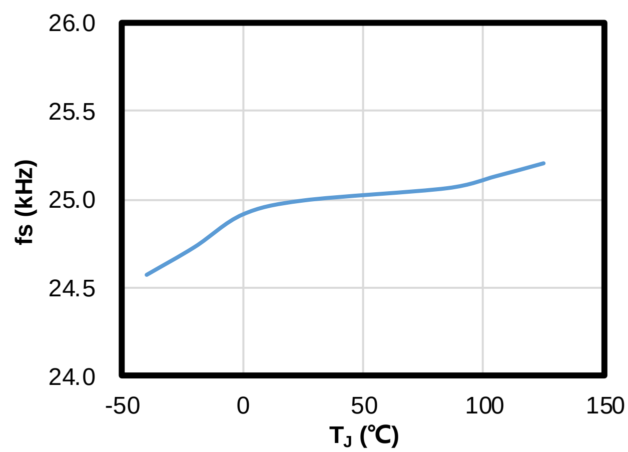
R_{HS_ON} vs. T_J



R_{LS_ON} vs. T_J



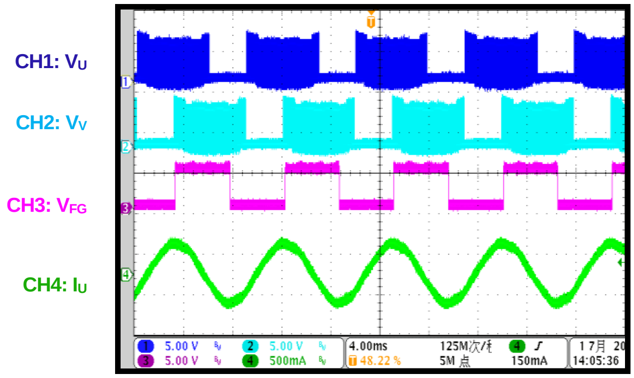
f_S vs. T_J



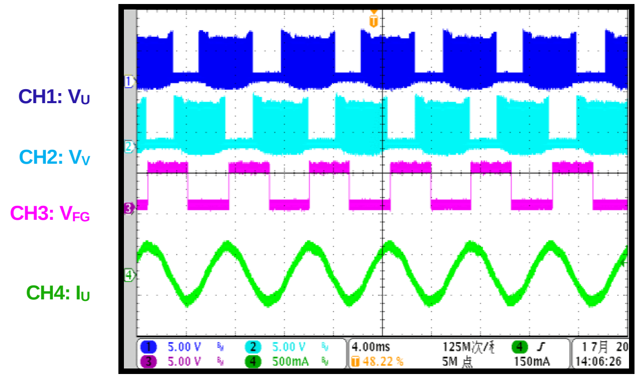
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{CC} = 5V, T_A = 25°C, tested with fan unit, unless otherwise noted.

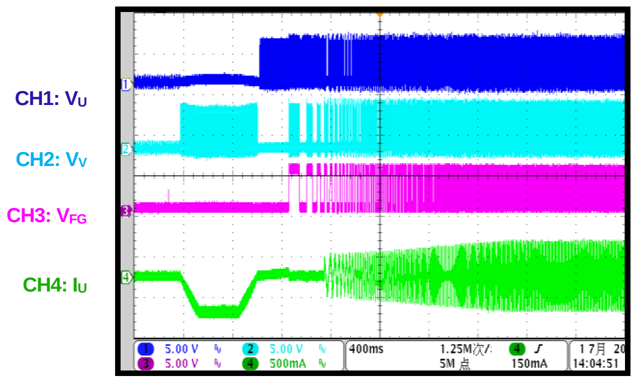
Normal Operation
PWM = high, DIR = low, counterclockwise (CCW)



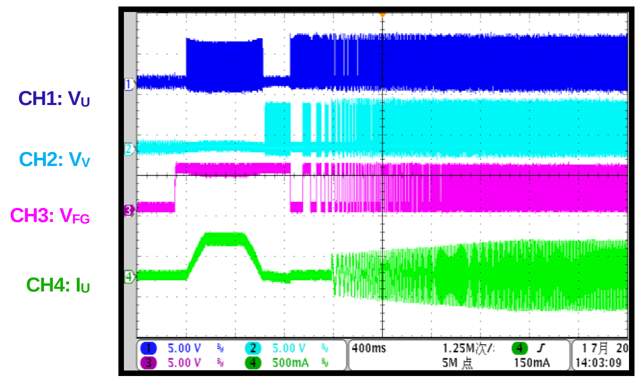
Normal Operation
PWM = high, DIR = high, clockwise (CW)



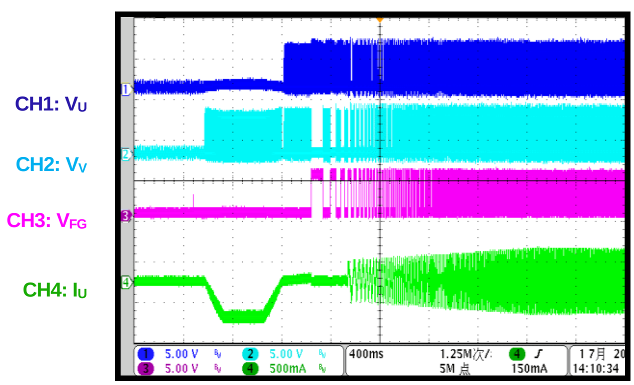
Start-Up with VCC
PWM = high, DIR = low, CCW, initial FG low



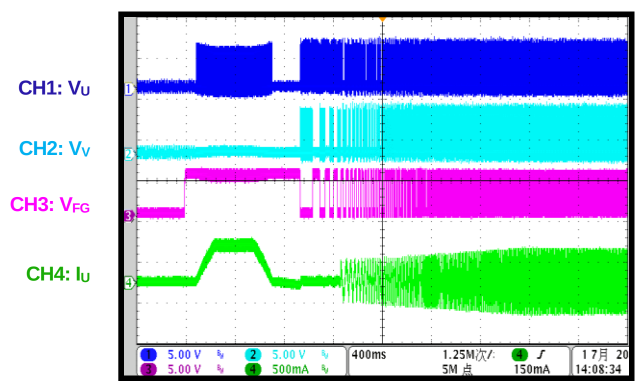
Start-Up with VCC
PWM = high, DIR = low, CCW, initial FG high



Start-Up with VCC
PWM = high, DIR = high, CW, initial FG low



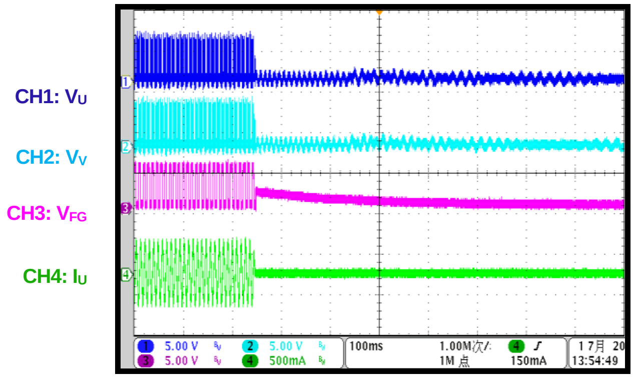
Start-Up with VCC
PWM = high, DIR = high, CW, initial FG high



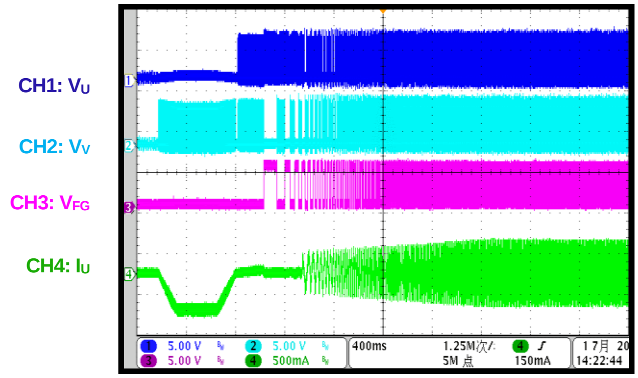
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{CC} = 5V, T_A = 25°C, tested with fan unit, unless otherwise noted.

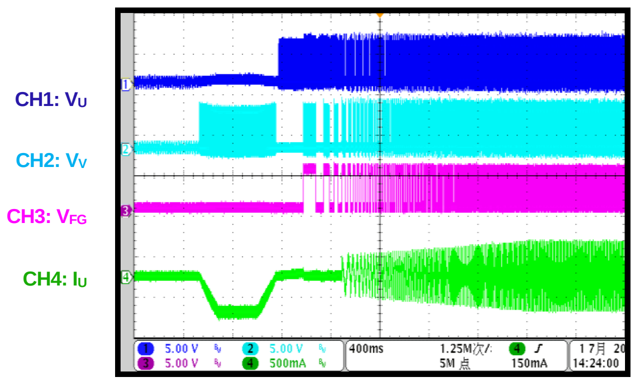
Shutdown with VCC
PWM = high, DIR = low, CCW



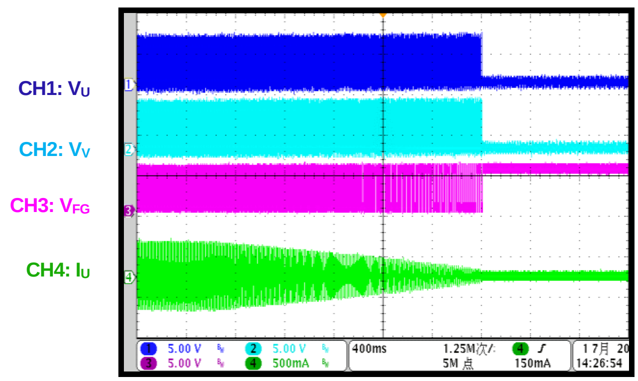
Start-Up with PWM
PWM duty jumps from 1% to 100%, DIR = low, CCW, initial FG low



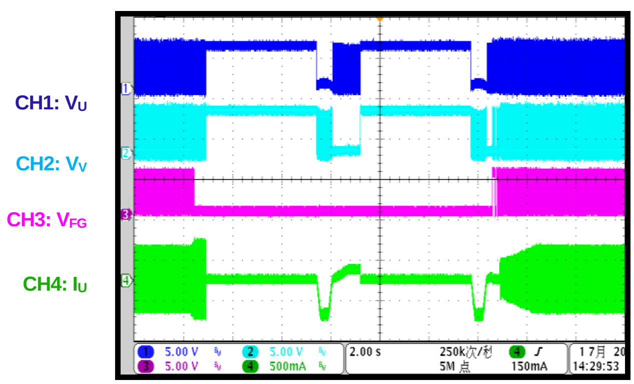
Start-Up with PWM
PWM duty jumps from 1% to 100%, DIR = high, CW, initial FG low



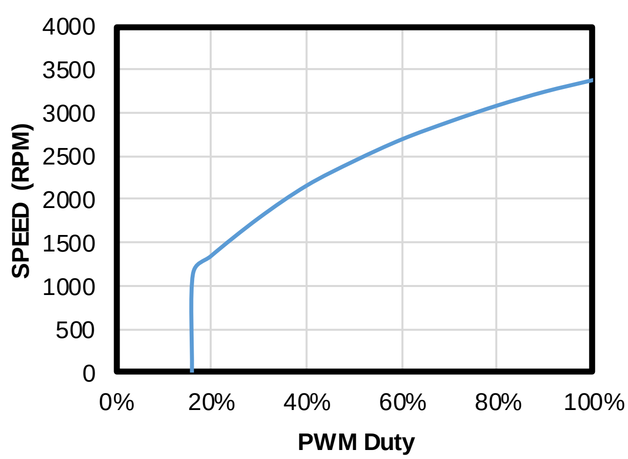
Shutdown with PWM
PWM duty jump from 100% to 0%, DIR = low, CCW, IC enter into stand-by mode



Rotor Lock and Release
PWM = high, DIR = low, CCW



Fan Speed vs. PWM Duty Cycle



FUNCTIONAL BLOCK DIAGRAM

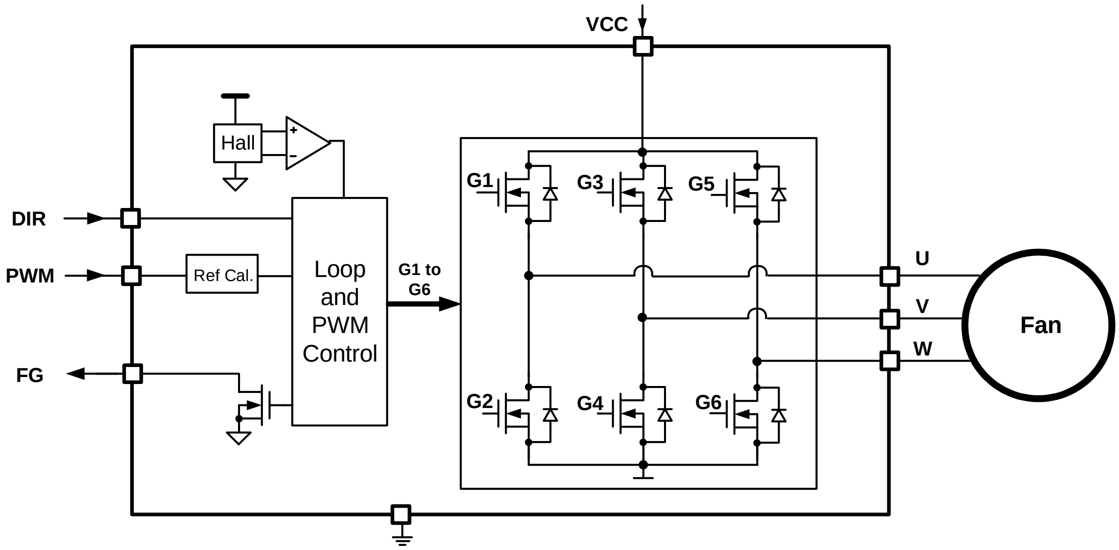


Figure 1: Functional Block Diagram

OPERATION

The MP6630 is a three-phase, brushless DC motor driver with integrated power MOSFETs and a single Hall-effect sensor. Using the PWM pin, the IC detects the PWM duty cycle for speed control. It optimizes efficiency and ripple speed over a full speed range. The Hall sensor is embedded for robust start-up performance. The output of the FG pin indicates rotational speed.

Protection features include under-voltage lockout (UVLO), locked-rotor protection, over-current protection (OCP), and thermal shutdown.

Speed Control

The PWM signal on the PWM pin accepts a wide input frequency range (1kHz to 100kHz). The IC adjusts motor speed by detecting the PWM duty cycle.

In this mode, the output duty cycles for terminals U, V, and W are directly based on the PWM input duty cycle.

When the PWM input duty cycle is below 16%, the output duty cycle remains at 0%. When the PWM input duty cycle exceeds 17.2%, the output duty cycle follows the input PWM duty cycle.

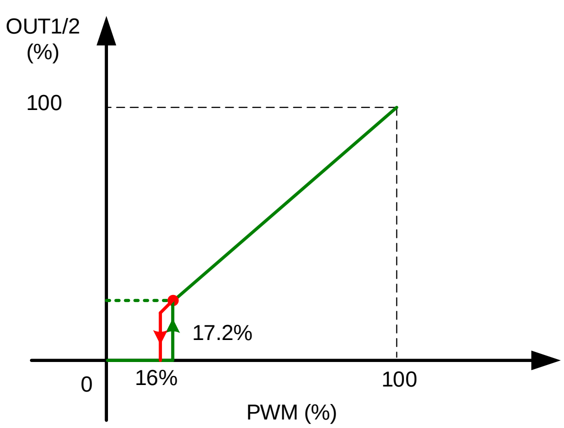


Figure 2: Minimum Input PWM Duty

Soft Start (SS)

To reduce the input inrush current during start-up, the MP6630 provides a soft start (SS) mechanism. The SS time for the PWM input reference is 2.6s.

Rotor Initial Positioning

Before start-up, the MP6630 undergoes initial rotor positioning to align the rotor with a known position. The total aligning time takes about 500ms.

Rotational Direction

The rotational direction is controlled by the signal applied on the DIR pin. Pull DIR high to force the fan into reverse rotation; pull it low for forward rotation. The DIR pin is internally pulled low by a resistor.

Do not change the DIR polarity while the fan is in rotation.

Oscillator Frequency

The internal high-frequency oscillator is fixed to 12.8MHz, and the switching frequency is about 25kHz.

Maximum Current Limit Protection

When the phase current exceeds 2.3A after a 1.5µs blanking time, all MOSFETs turn off immediately. After a minimum 93ms delay, the IC is re-enabled automatically.

Speed Indication Output

The FG signal on the FG pin outputs an internal Hall changing signal for speed indication.

FG is an open-drain output, and must be externally pulled up during normal operation.

Locked-Rotor Protection

When the motor rotor is locked, the hall edge is not detected within 0.5s, the locked-rotor protection is triggered, the MP6630 turns on all high-side MOSFETs and turns off all low-side MOSFETs. The IC auto-restarts after the 5s recovery time.

Thermal Shutdown

If the MP6630's die temperature rises above 160°C, all MOSFETs turn off. Once the die temperature drops below 140°C, the IC resumes operation.

Under-Voltage Lockout (UVLO)

When the voltage on the VCC pin (V_{CC}) falls below the under-voltage lockout (UVLO) threshold, all circuitry in the device is disabled and the internal logic is reset. Operation resumes when V_{CC} rises above the UVLO threshold.

Standby Mode

When the PWM input is kept low for longer than 84ms and the output duty is zero, the MP6630 enters standby mode. In standby mode, only PWM input detection is active. When the IC detects a high-level PWM, the IC resumes normal operation.

Hall Sensor Location

Figure 3 shows the internal Hall sensor cell location.

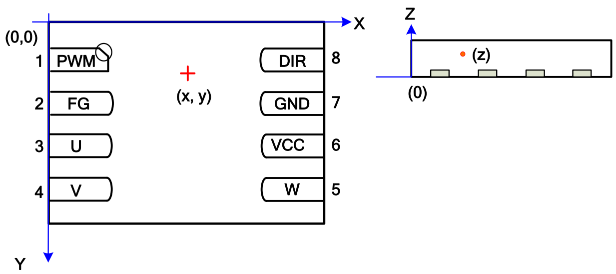


Figure 3: Hall Position

Where x = 1500μm ± 30μm, y = 550μm ± 30μm, and z = 380μm ± 25μm.

APPLICATION INFORMATION

Selecting the Input Capacitor

Place an input capacitor (C1) near VCC to maintain a stable input voltage, and to reduce input switching voltage noise and ripple. The input capacitor's impedance must be low at the switching frequency. Ceramic capacitors with X7R dielectrics are recommended for their low-ESR characteristics.

Ensure that the ceramic capacitance is based on the voltage rating. The DC bias voltage and value can lose up to 50% of its capacitance at its voltage rating. Leave a sufficient voltage rating margin when selecting the capacitor.

For most applications, a ceramic capacitor with a minimum 1μF capacitance is sufficient. If required for an application, add an additional, large electrolytic capacitor to absorb inductor energy.

Input Clamping TVS

High voltage spikes are created when energy stored in the motor inductor charges back to the input capacitor's side. To avoid these spikes, add a voltage-clamping transient voltage suppressor (TVS) diode.

Hall Polarity Selection

There are two parts for the MP6630 with different Hall polarities. "-0000" and "-0001" are based on the stator's winding direction and where the IC is mounted in relation to the PCB.

Magnetic south is generated at the stator if the winding direction current goes from U to the common node (COM).

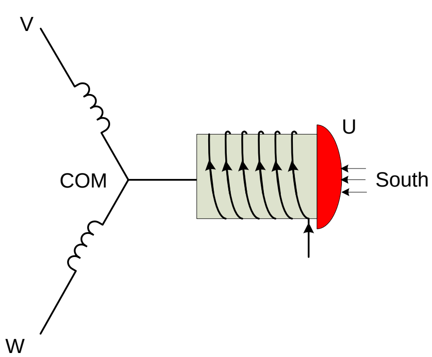


Figure 4: Magnetic South with Winding Direction

Use -0000 if the IC is mounted on the top side of the PCB (see Figure 5).

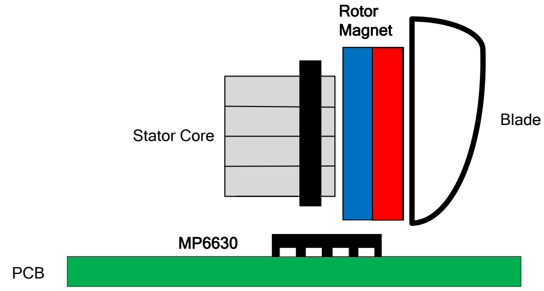


Figure 5: The MP6630 on the Top of the PCB (Side View)

Use -0001 if the IC is mounted on the bottom side of the PCB (see Figure 6).

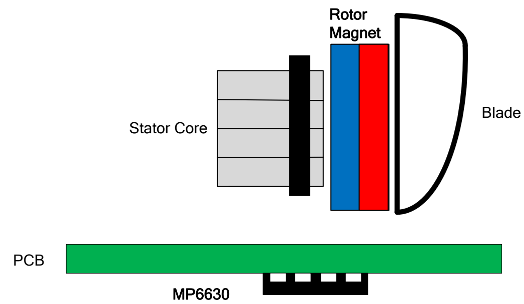


Figure 6: The MP6630 on the Bottom of the PCB (Side View)

Magnetic north is generated if the winding direction is different when the current flows from U to COM (see Figure 7).

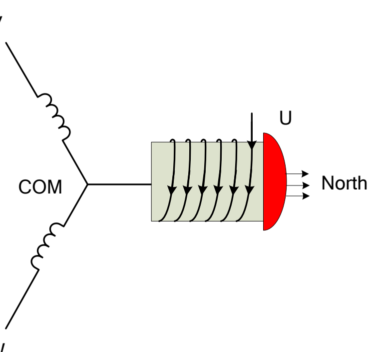


Figure 7: Magnetic North with Winding Direction

Use -0001 if IC is mounted on the top of the PCB (see Figure 8).

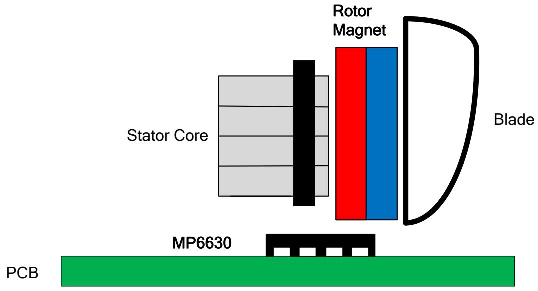


Figure 8: The MP6630 on the Top of the PCB (Side View)

Use -0000 if the IC is mounted on the bottom of the PCB (see Figure 9).

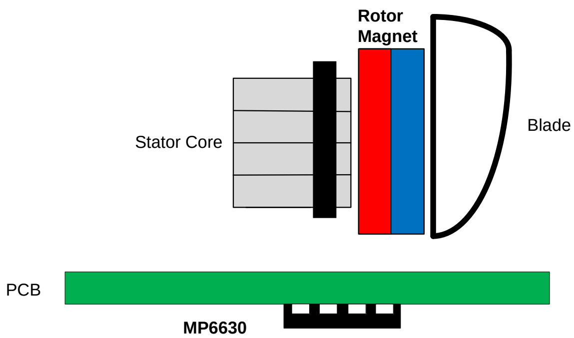


Figure 9: The MP6630 on the Bottom of the PCB (Side View)

Hall Position Consideration

The Internal hall element of MP6630 requires right magnetic field for normal operation. Please follow the two steps for PCB layout work.

Step 1: Ensure the MP6630 picks up the highest magnetic field possible. Generally, the inner surface of the rotor magnet provides highest magnetic field strength. The MP6630 Hall element should align with the inner surface of rotor magnet (see Figure 10).

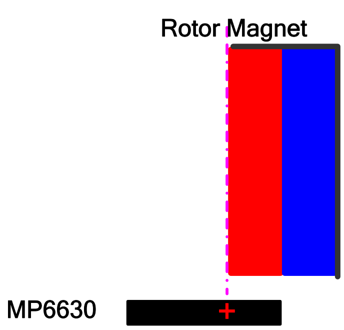


Figure 10: Aligning the Hall Element with the Inner Surface of the Rotor Magnet (Side View)

Step 2: Align the Hall element of MP6630 with the central line of winding V and winding W to achieve maximum operating efficiency (see Figure 11).

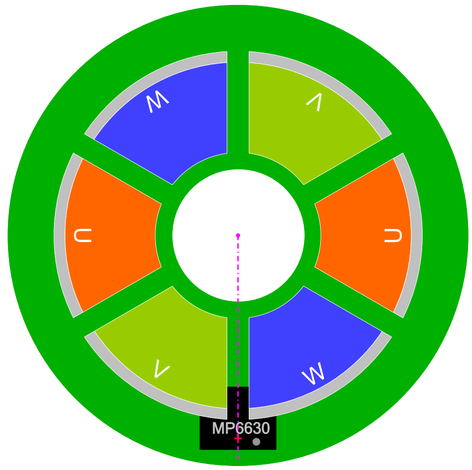


Figure 11: Aligning the Hall Element with the Central V and W Lines (Top View)

TYPICAL APPLICATION CIRCUIT

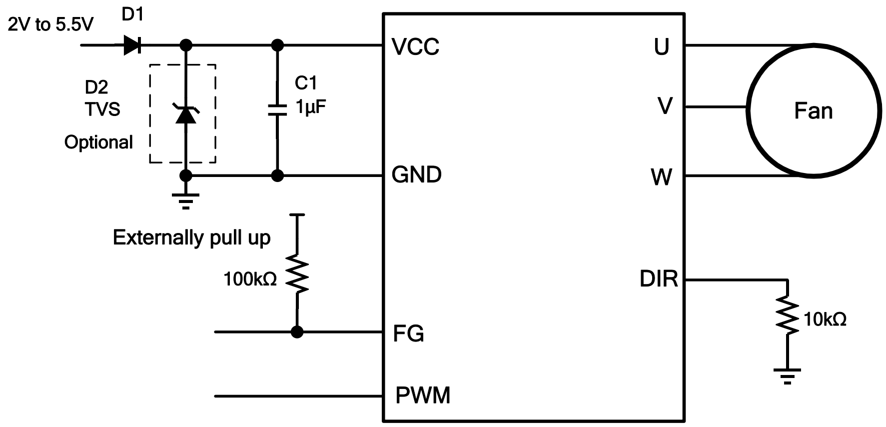
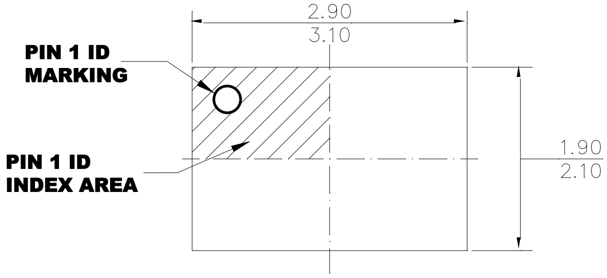


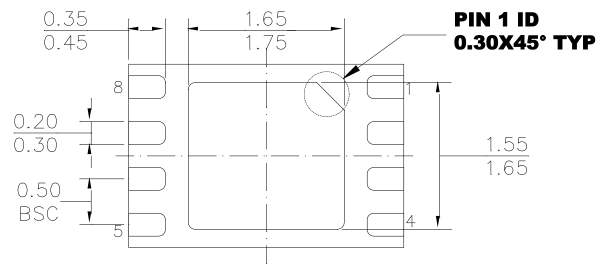
Figure 11: MP6630 Typical Application Circuit

PACKAGE INFORMATION

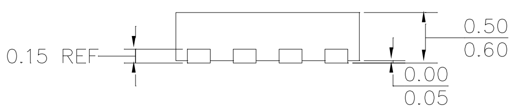
UTQFN-8 (2mmx3mm)



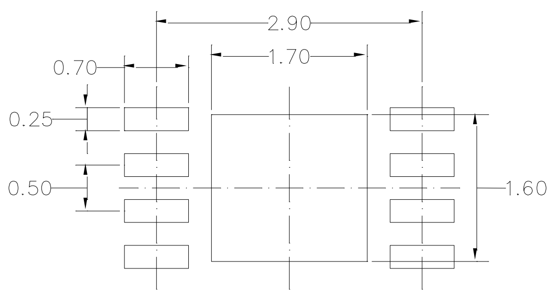
TOP VIEW



BOTTOM VIEW



SIDE VIEW

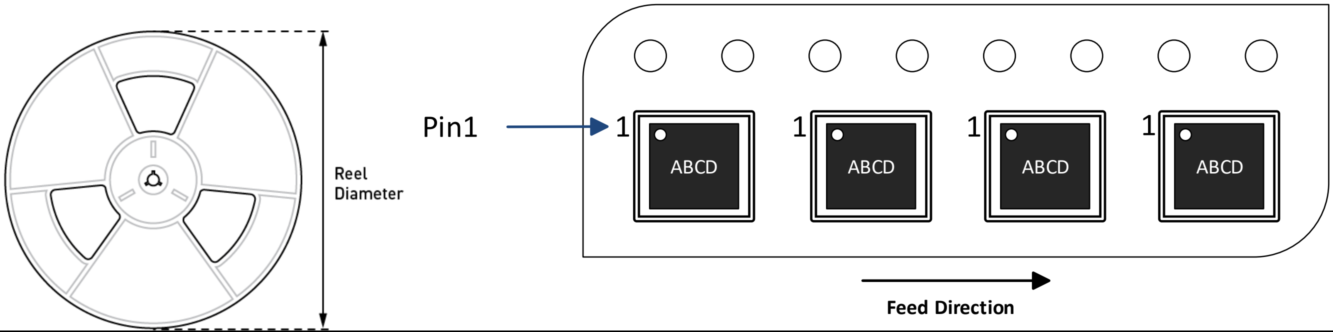


RECOMMENDED LAND PATTERN

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
3) LEAD COPLANARITY SHALL BE 0.08 MILLIMETERS MAX.
4) JEDEC REFERENCE IS MO-220.
5) DRAWING IS NOT TO SCALE.

CARRIER INFORMATION



Part Number	Package Description	Quantity/Reel	Quantity/Tube	Reel Diameter	Carrier Tape Width	Carrier Tape Pitch	Trailer Leader/ Reel
MP6630GDU-xxxx**	UTQFN-8 (2mmx3mm)	5000	N/A	13 in.	12 mm	8 mm	125&125

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	3/11/2020	Initial Release	-
1.1	4/12/2023	Formatting updates to header	All
		Formatting updates	1
		• Updated “–Z” to “-Z” • Updated ** description	2
		Updated ESD Ratings	3
		• Added minimum and maximum values for lock detection time • Added minimum, typical, and maximum values for lock retry time • Added Cycle-by-cycle current limit • Updated “over-current limit protection” to “maximum current limit protection”	4
		Updated “Current Limit Protection” section to “Maximum Current Limit Protection”	9
1.2	11/9/2023	Removed “500mA” from header	All
		• Added “180° full-wave” to Description and Features sections • Added “Typically 2.3A of Maximum Peak Current” to Features section	1