

#### DESCRIPTION

The MP6630H is a 3-phase brushless DC motor driver with integrated power MOSFETs and single Hall-effect sensor. The input voltage ranges from 2V to 16V.

The device controls the motor speed through the PWM signal on the PWM pin. It features a single, embedded Hall-effect sensor for robust start-up performance. It also features 180° full-wave sinusoidal drive for high efficiency, and low-speed ripple and vibration over the full speed range.

The MP6630H also has a rotational speed detector. The rotational speed detector (the FG/RD pin) is the output of an open drain. This pin is also selectable for lock indication output.

Rich protections are implemented in the MP6630H, such as under-voltage lockout (UVLO), locked-rotor protection, over-current protection (OCP), and thermal shutdown protection.

The MP6630H is available in a UTQFN-8 (2mmx3mm) package.

#### FEATURES

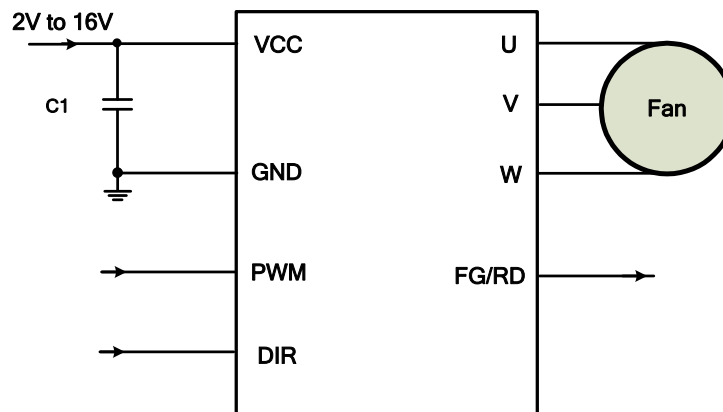
- Wide 2V to 16V Operating Input Range
- 180° Full-Wave Sinusoidal Drive for High Efficiency and Low-Speed Vibration
- Embedded Single Hall Sensor to Ensure Robust Start-Up
- Integrated Power MOSFETs: About 400mΩ Each
- 0.5s/5s Rotor Lock and Retry Protection
- 1kHz to 100kHz PWM Input Range
- Direction Input
- Soft Start
- Fixed 25kHz Output Switching Frequency
- Selectable Output for Speed Indication (FG) and Lock Indication (RD)
- Standby Mode to Save Power
- Thermal Protection and Auto-Recovery
- Typically 2.3A of Maximum Peak Current
- Available in a UTQFN-8 (2mmx3mm) Package

#### APPLICATIONS

- 3-Phase BLDC Fans
- Gaming Fans

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#### TYPICAL APPLICATION



### ORDERING INFORMATION

Part Number*	Package	Top Marking	MSL Rating
MP6630HGDU-xxxx**	UTQFN-8 (2mmx3mm)	See Below	1

\* For Tape & Reel, add suffix -Z (e.g. MP6630HGDU-xxxx-Z).

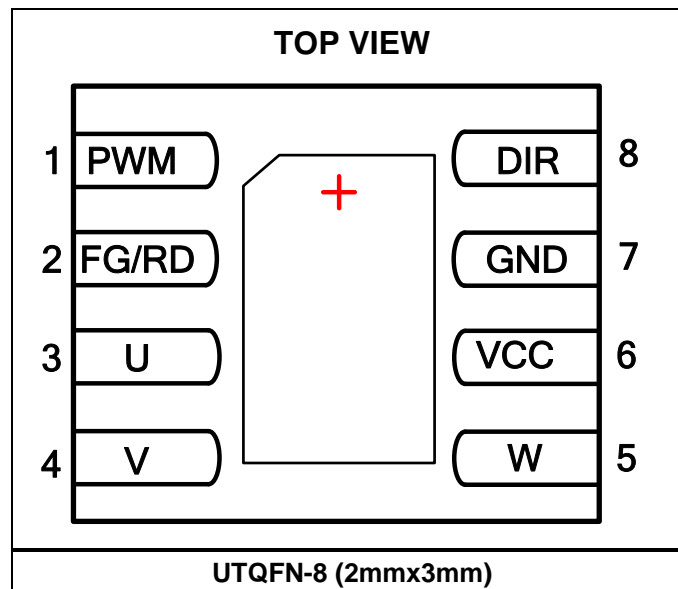
\*\* “xxxx” is the configuration code identifier. The first four digits of the suffix (xxxx) can be a hexadecimal value between 0 and F. Work with an MPS FAE to create this unique number for non-default functionality. The default function value is -0000.

### TOP MARKING

\_\_\_\_\_  
**BLTY**  
**LLL**

BLT: Product code of MP6630HGDU-xxxx  
 Y: Year code  
 LLL: Lot number

### PACKAGE REFERENCE



## PIN FUNCTIONS

Pin #	Name	Description
1	PWM	<b>Rotational speed control and PWM input pin.</b> 1kHz to 100kHz is the recommended maximum PWM resolution. Internally pull PWM up to the internal LDO with a 100kΩ resistor.
2	FG/RD	<b>Speed or rotor lock indication.</b> Open-drain output. FG/RD can be used for speed indication (FG) or rotor lock indication (RD).
3	U	<b>U phase terminal.</b>
4	V	<b>V phase terminal.</b>
5	W	<b>W phase terminal.</b>
6	VCC	<b>Input power pin.</b> VCC requires a bypass capacitor placed as close to VCC and GND as possible.
7	GND	<b>Ground pin.</b>
8	DIR	<b>Direction control pin.</b> Internally pull DIR low with a 100kΩ resistor.

### ABSOLUTE MAXIMUM RATINGS <sup>(1)</sup>

V<sub>CC</sub>, V<sub>UVW</sub>, FG/RD, PWM, DIR ..... -0.3V to +18V  
 Continuous power dissipation (T<sub>A</sub> = 25°C) <sup>(2)</sup>  
 ..... 1.9W  
 Junction temperature ..... 150°C  
 Lead temperature ..... 260°C  
 Storage temperature ..... -60°C to +150°C

### ESD Rating

Human body model (HBM) ..... ±1500V  
 Charged device model (CDM) ..... ±2000V

### Recommended Operating Conditions <sup>(3)</sup>

Supply voltage (V<sub>CC</sub>) ..... 2V to 16V  
 Operating junction temp (T<sub>J</sub>) .... -40°C to +125°C

**Thermal Resistance <sup>(4)</sup>    θ<sub>JA</sub>    θ<sub>JC</sub>**  
 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<sub>J</sub> (MAX), the junction-to-ambient thermal resistance, θ<sub>JA</sub>, and the ambient temperature, T<sub>A</sub>. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P<sub>D</sub> (MAX) = (T<sub>J</sub> (MAX) - T<sub>A</sub>) / θ<sub>JA</sub>. 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

$V_{CC} = 12V$ ,  $T_J = -40^{\circ}C$  to  $+125^{\circ}C$ , 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	$I_{CC}$			6	7	mA
Standby supply current	$I_{CC}$	PWM = low > 100ms		225	300	$\mu A$
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		k $\Omega$
DIR internal pull-down resistance	$R_{DIR}$			100		k $\Omega$
HS switch on resistance	$R_{HSON\_U}$	$I_O = 100mA$ , $T_J = 25^{\circ}C$		400		m $\Omega$
	$R_{HSON\_V}$			390		
	$R_{HSON\_W}$			358		
LS switch on resistance	$R_{LSON\_U}$	$I_O = 100mA$ , $T_J = 25^{\circ}C$		434		m $\Omega$
	$R_{LSON\_V}$			405		
	$R_{LSON\_W}$			402		
Phase A zero-current detection	$I_{ZCD}$		-2	0	+2	mA
Maximum current limit	$I_{LMT}$	Full scale		2.3		A
PWM output frequency	$f_{SW}$	$T_J = 25^{\circ}C$	24.5	25	25.5	kHz
FG output low-level voltage	$V_{FG\_L}$	$I_{FG/RD} = 3mA$ , $V_{PULL} = 5V$			0.35	V
Rotor-lock detection time	$t_{RD}$			0.5		s
Minimum recommended magnetic field <sup>(5)</sup>					$\pm 2$	mT
Thermal shutdown threshold <sup>(5)</sup>				160		$^{\circ}C$
Thermal shutdown hysteresis <sup>(5)</sup>				20		$^{\circ}C$

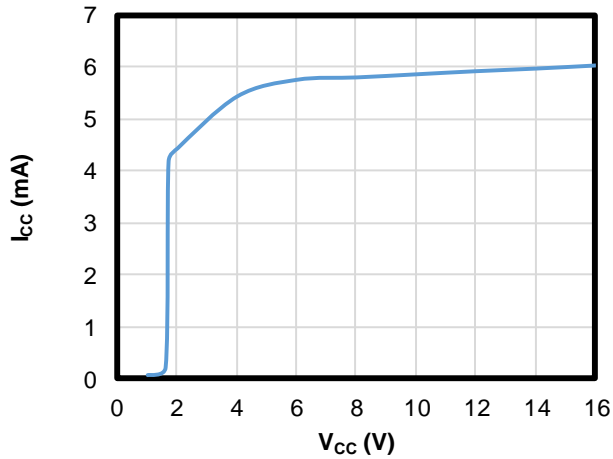
**Note:**

5) Guaranteed by design.

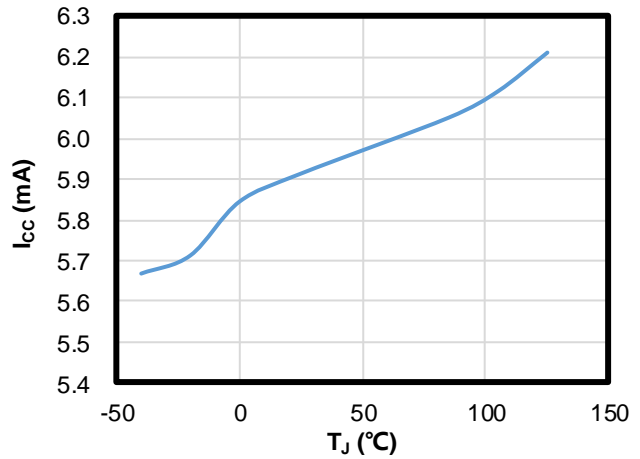
## TYPICAL PERFORMANCE CHARACTERISTICS

$V_{CC} = 12V$ ,  $T_A = 25^\circ C$ , unless otherwise noted.

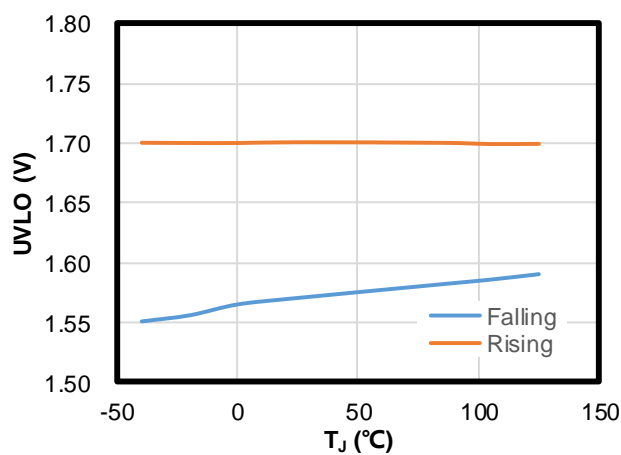
**Supply Current vs.  $V_{CC}$**



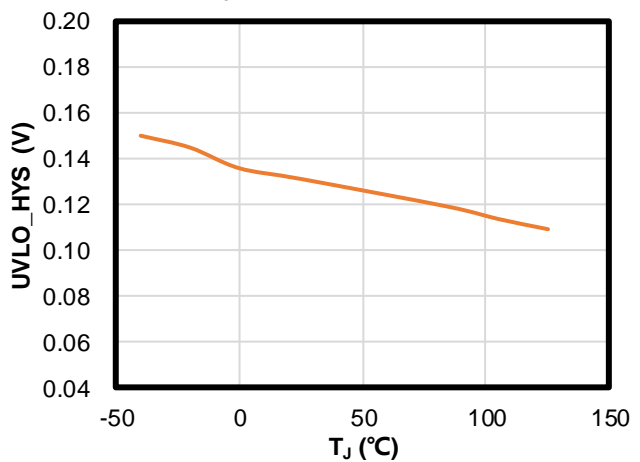
**Supply Current vs.  $T_J$**



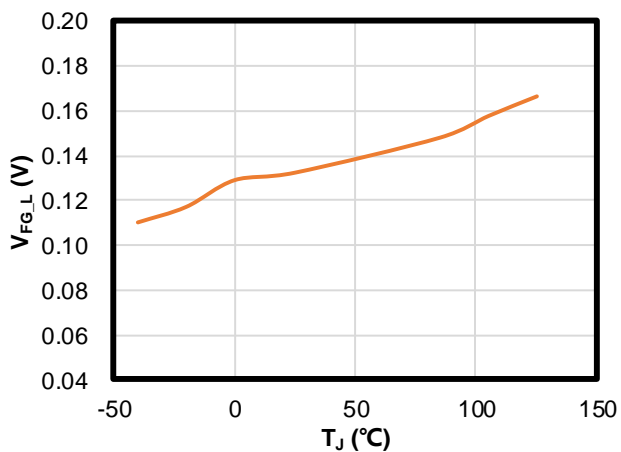
**UVLO vs.  $T_J$**



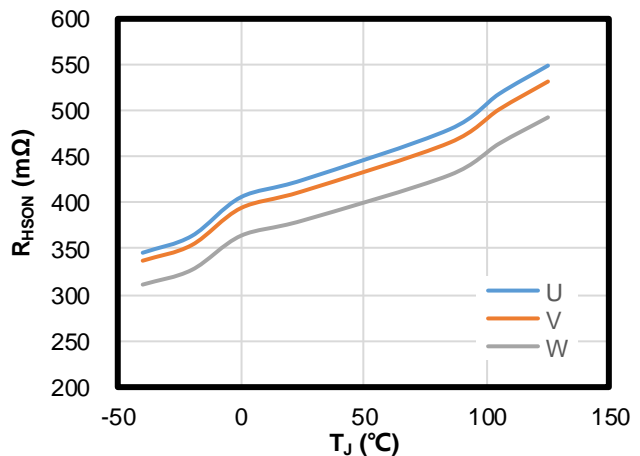
**UVLO Hysteresis vs.  $T_J$**



**FG Low-Level Output Voltage vs.  $T_J$**

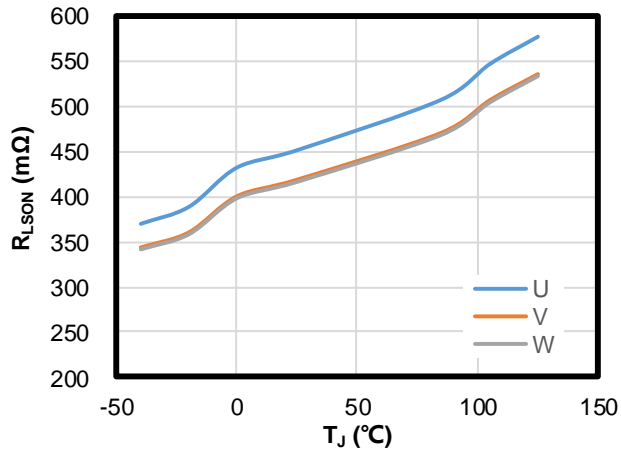
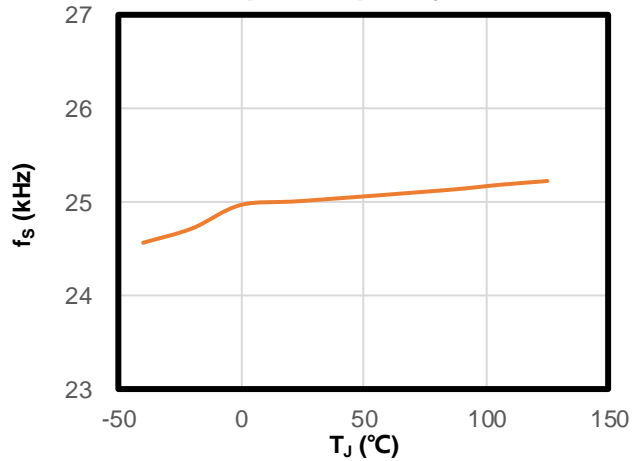


**HS Switch On Resistance vs.  $T_J$**

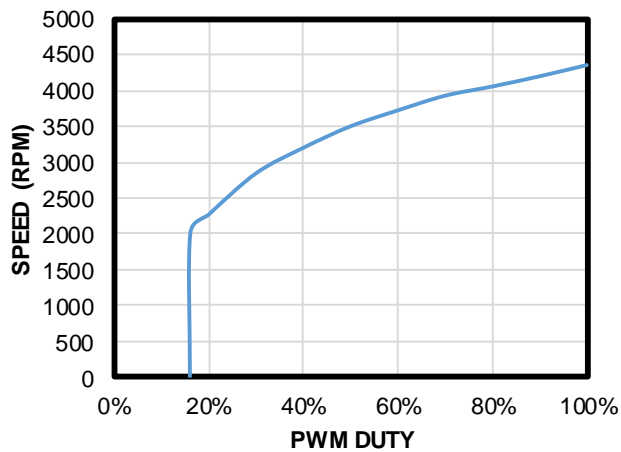


**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

$V_{CC} = 12V$ ,  $T_A = 25^\circ C$ , unless otherwise noted.

**LS On Resistance vs.  $T_J$** 

**PWM Output Frequency vs.  $T_J$** 

**Fan Speed vs. PWM Duty**

Tested with fan unit

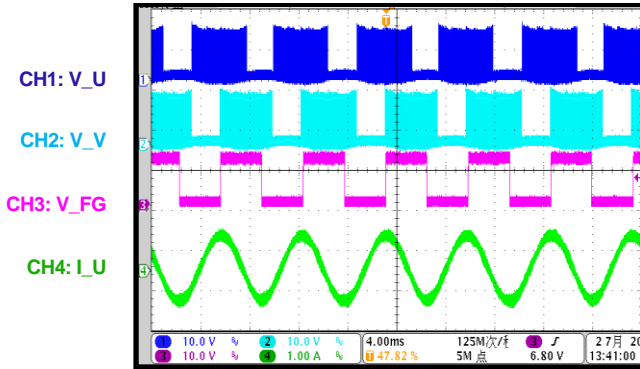


## TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

$V_{CC} = 12V$ ,  $T_A = 25^{\circ}C$ , unless otherwise noted.

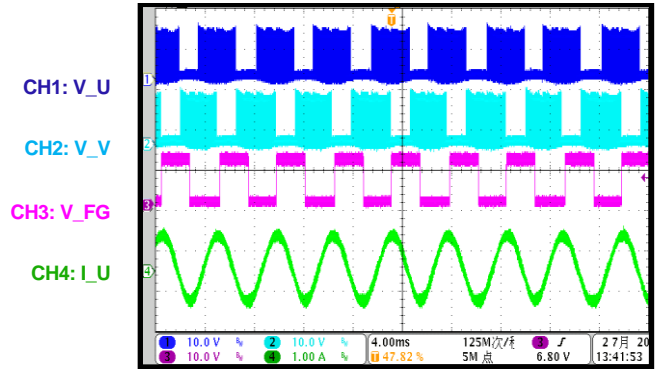
### Normal Operation

PWM = high, DIR = low, counter-clockwise (CCW)



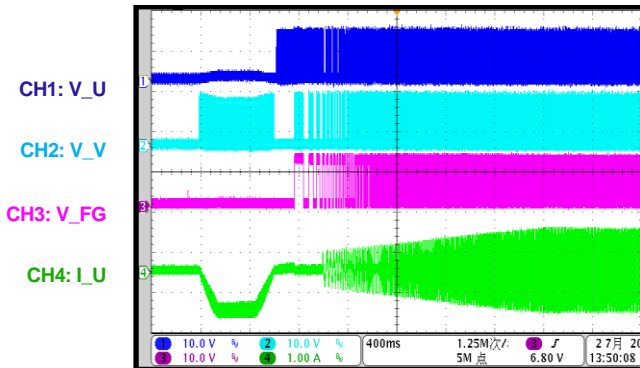
### Normal Operation

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



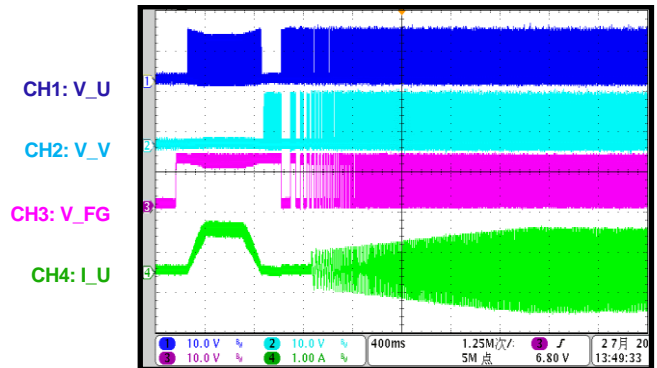
### Start-Up with VCC

PWM = high, DIR = low, CCW, initial FG low



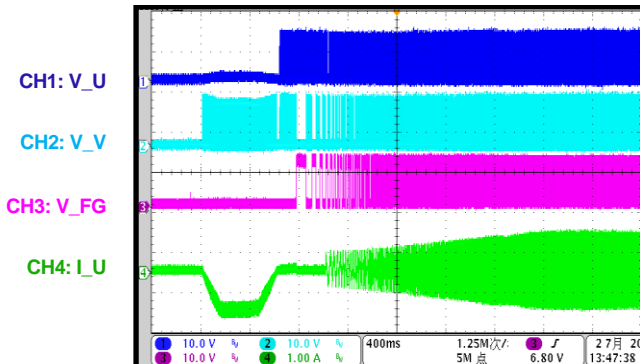
### Start-Up with VCC

PWM = high, DIR = low, CCW, initial FG high



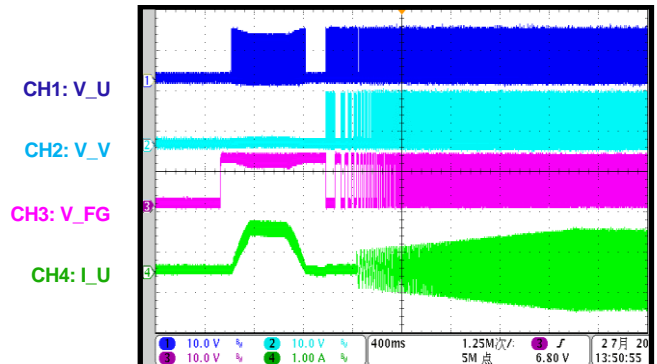
### Start-Up with VCC

PWM = high, DIR = high, CW, initial FG low



### Start-Up with VCC

PWM = high, DIR = high, CW, initial FG high

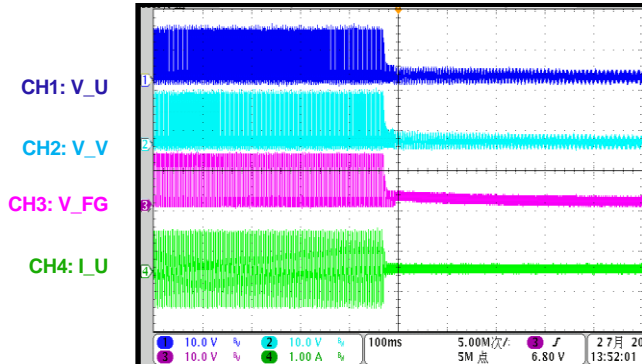


## TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

$V_{CC} = 12V$ ,  $T_A = 25^\circ C$ , unless otherwise noted.

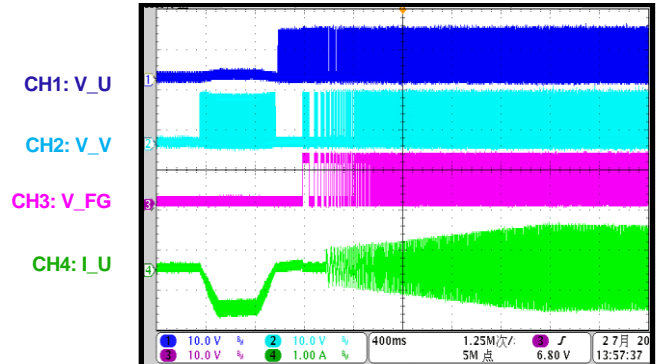
### Shutdown with VCC

PWM = high, DIR = low, CCW



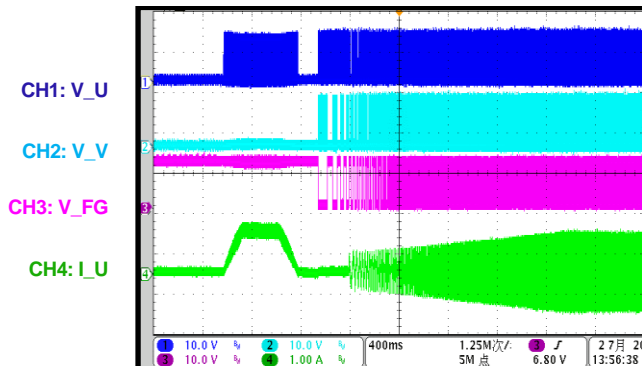
### Start-Up with PWM

PWM duty jumps from 1% to 100%, DIR = low, CCW, initial FG low



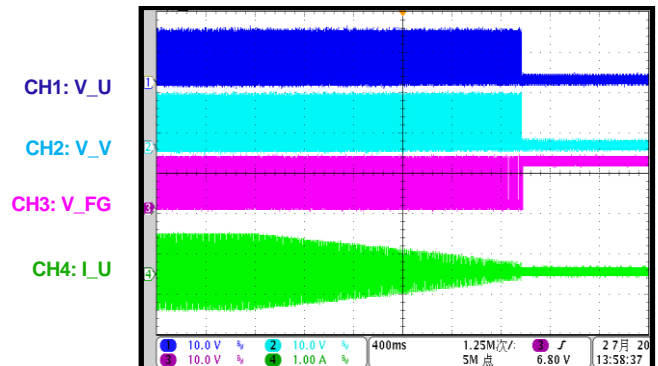
### Start-Up with PWM

PWM duty jumps from 1% to 100%, DIR = high, CW, initial FG high



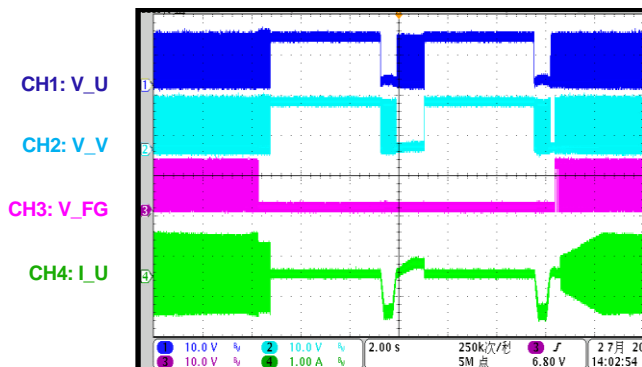
### Shutdown with PWM

PWM duty jump from 100% to 0, DIR = low, CCW, IC enters standby mode



### Rotor-Lock and Release

PWM = high, DIR = low, CCW





### FUNCTIONAL BLOCK DIAGRAM

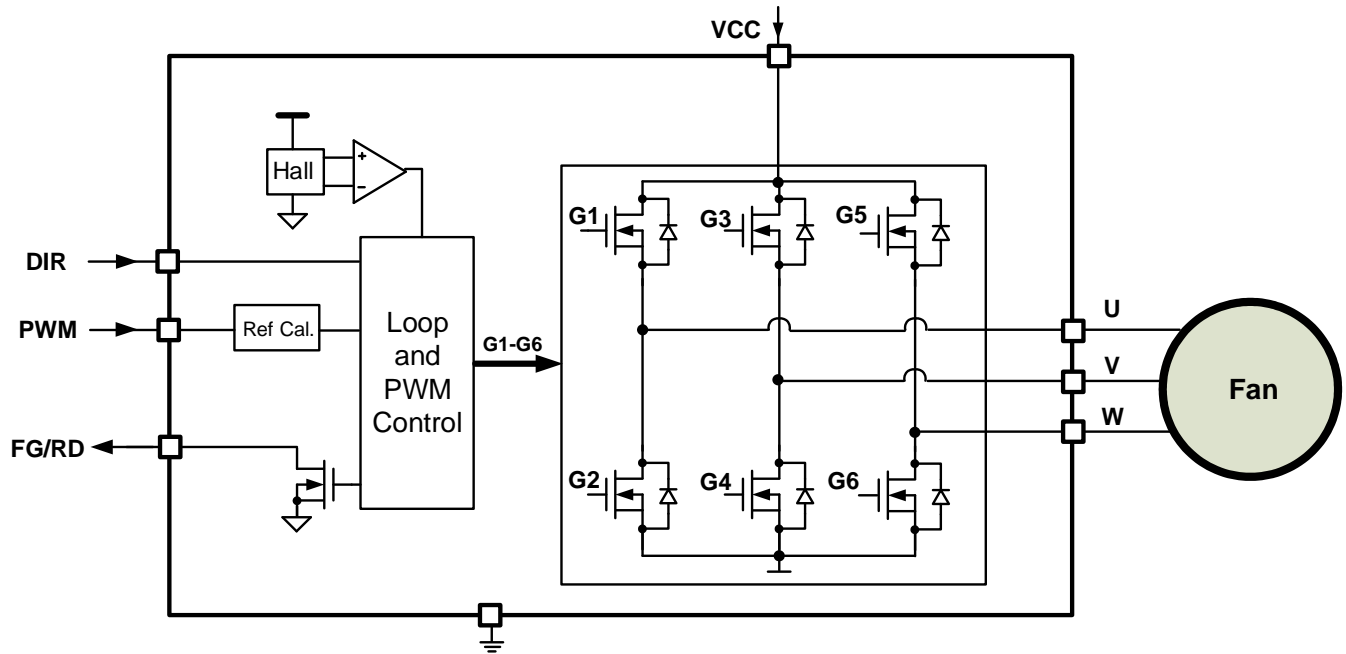


Figure 1: Functional Block Diagram

## OPERATION

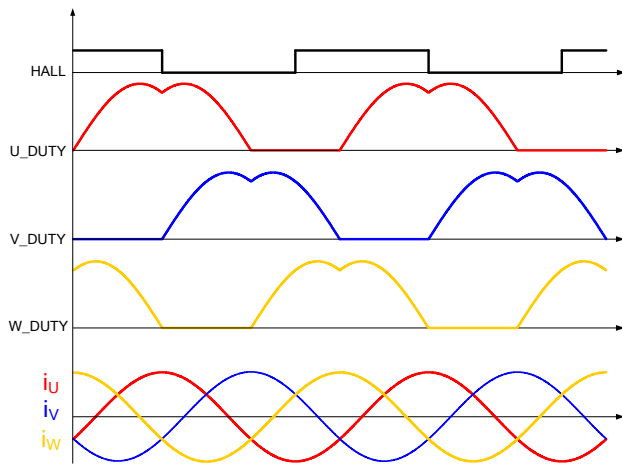
The MP6630H is a three-phase, brushless DC motor driver with integrated power MOSFETs and a single Hall-effect sensor. The IC detects the PWM duty on the PWM pin for speed control. This optimizes efficiency and ripple speed over the full speed range. The embedded Hall-effect sensor provides robust start-up performance.

Speed indication and rotor-lock indication signals are selectable outputs on the FG/RD pin.

Rich protection functions are embedded in the MP6630H, such as under-voltage lockout (UVLO), rotor-lock protection, over-current protection (OCP), and thermal shutdown protection.

### 180° Full-wave Sinusoidal Drive

An embedded Hall sensor is integrated in MP6630H, which is used to rotor position detection. The 180° full-wave sinusoid drive is employed as showing in figure 2.



**Figure 2: 180° Full-Wave Sinusoidal Drive**

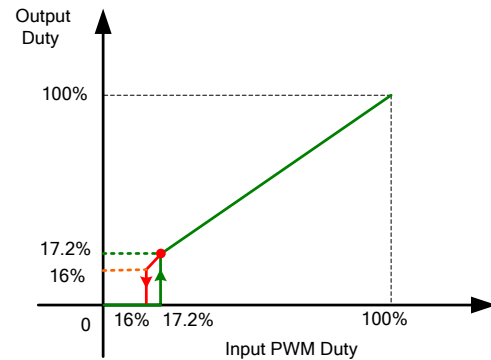
### Speed Control

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 signal duty cycle.

In this mode, the OUTU/V/W maximum output duty cycle directly depends on the PWM input duty. When the PWM input duty exceeds the starting duty set by DMIN[5:0], the fan keeps rotating. When the PWM input duty is below the starting duty with 1.2% hysteresis, the fan stops

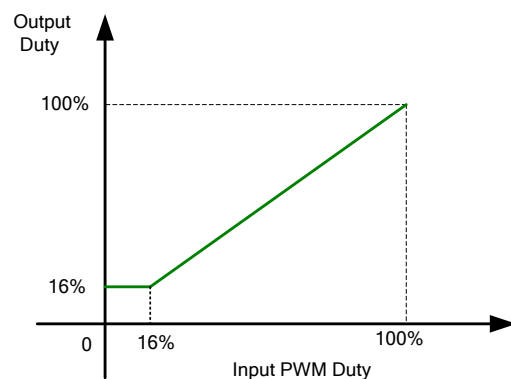
rotating, or keeps the minimum speed depending on the SPD\_ZERO bit.

For example, if SPD\_ZERO = 1, and DMIN[5:0] = 0x16 (17.2%), the fan stops rotating when the input duty is below 16%. If the input duty exceeds 17.2% (hysteresis 1.2%), the fan starts rotating.



**Figure 3: Minimum Duty when SPD\_ZERO = 1**

If SPD\_ZERO = 0 in the previous example, the fan maintains a minimum speed when the input duty is below 16%.



**Figure 4: Minimum Duty when SPD\_ZERO = 0**

### Soft-Start Time

To smoothly change the fan speed and reduce the input inrush current during start-up, the MP6630H provides a soft-start time and speed reference. The output duty ramps up or down by following the TSS bit. The soft-start timer can be configured to 2.6s (default) or 5.2s.

### Initial Rotor Positioning

At the beginning of start-up, the MP6630H initiates rotor positioning to align the rotor with a known position. The aligning time is about 320ms.

### Pre-Startup

After rotor alignment, the MP6630H enters a pre-startup stage, and a certain voltage vector is used to make fan rotate. In the pre-startup stage, the output duty is increased step by step. The time between two steps is 5.13ms.

### Speed Indication Output

The FG signal on the FG/RD pin outputs an internal Hall change signal for speed indication. A 1x or 1/2x Hall frequency output can be selected. The FG/RD pin is an open drain, and must be externally pulled high during normal operation.

### Direction Control

The DIR pin is used to control the rotating direction. If DIR is pulled low, the fan moves in forward rotation. If DIR is pulled high, the fan moves in reverse rotation.

The DIR pin is internally pulled low by a resistor. To stop noise from affecting the DIR pin's polarity, pull DIR low or high with a resistor.

Do not change the fan's direction while it is rotating. This could cause the fan to vibrate or stop entirely.

### Maximum Current Limit Protection

If a phase current exceeds 2.3A for a 1.5µs blanking time, all MOSFETs turn off immediately. The IC is re-enabled automatically after a minimum 93ms.

### Rotor-Lock Protection

If the motor's rotor is locked, the MP6630H shuts down all high-side MOSFETs (HS-FETs). The HS-FETs turn on once a Hall edge goes undetected for 0.5ms. Meanwhile, if FG/RD is set as rotor-lock indicator, the FG/RD output is pulled low for fault indication. The IC auto-restarts after a 5s recovery time.

### Thermal Shutdown

If the die temperature of MP6630H exceeds 160°C, all MOSFETs turn off. Once the die temperature drops below 140°C, the IC resumes normal operation.

### Under-Voltage Lockout (UVLO)

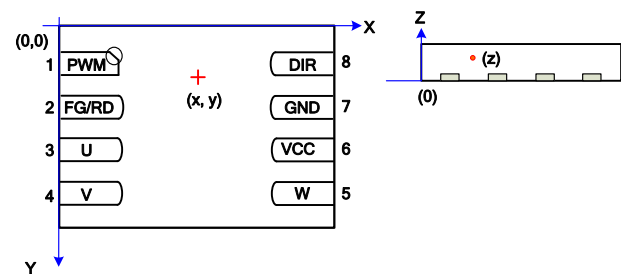
If the voltage on the VCC pin falls below the under-voltage lockout (UVLO) threshold, all circuitry in the device is disabled and the internal logic is reset. Normal operation resumes when VCC rises above the UVLO threshold.

### Standby Mode

If the PWM input is kept low for longer than 100ms, the MP6630H enters standby mode when the fan stops rotating. In standby mode, only PWM input detection and online test mode detection are active. When the IC detects PWM at a high level again, the IC restarts and resumes normal operation.

### Hall Sensor Location

Figure 5 shows the internal Hall sensor cell location.



**Figure 5: Hall Position**

Where  $x = 1500\mu\text{m} \pm 30\mu\text{m}$ ,  $y = 550\mu\text{m} \pm 0\mu\text{m}$ , and  $z = 380\mu\text{m} \pm 25\mu\text{m}$ .

## APPLICATION INFORMATION

### Selecting the Input Capacitor

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

Ensure that the ceramic capacitance is dependent on the voltage rating. The DC bias voltage can lose as much as 50% of its capacitance at its rated voltage rating. Leave a sufficient voltage rating margin when selecting the component.

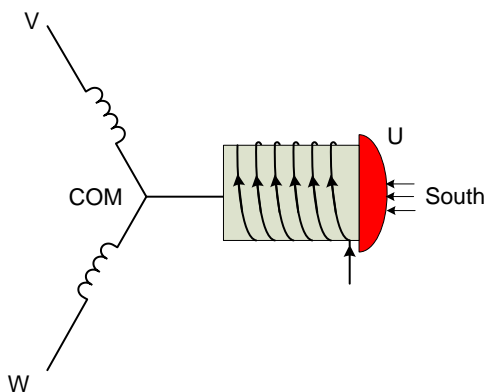
For most applications, a 10µF ceramic capacitor is sufficient. If required for the application, add an additional, large electrolytic capacitor to absorb inductor energy.

### Input Clamping TVS

High-voltage spikes are caused by the energy stored in the motor inductor charging back to the input capacitor side. To avoid these spikes, add a voltage-clamping transient voltage suppressor (TVS) diode. For a 12V application, an 15V/SOD-123 package TVS diode is sufficient.

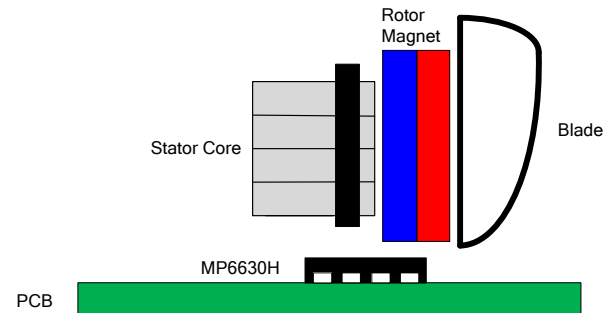
### Hall Polarity Selection

The Hall polarity can be configured. The Hall polarity depends on the winding direction and where the IC is mounted (the top or bottom of the PCB). Magnetic south is generated at the stator if the winding direction is normal and the current goes from U to the common node (COM) (see Figure 6).



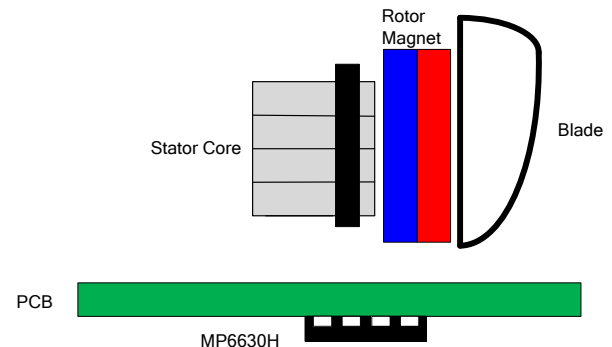
**Figure 6: Magnetic South with Winding Direction**

If the IC is mounted to the top side of the PCB, use the default Hall polarity (HAL\_POL = 0) (see Figure 7).



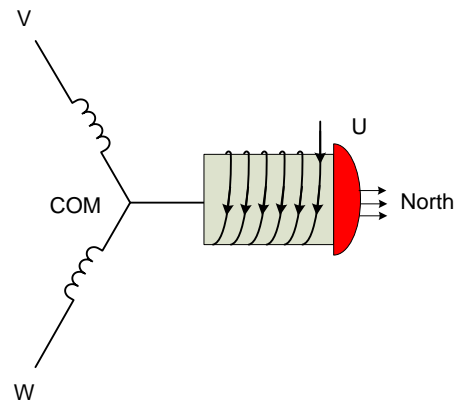
**Figure 7: Side View of MP6630H on Top of PCB**

If the IC is mounted on the bottom side of the PCB, use the opposite Hall polarity (HAL\_POL = 1) (see Figure 8).



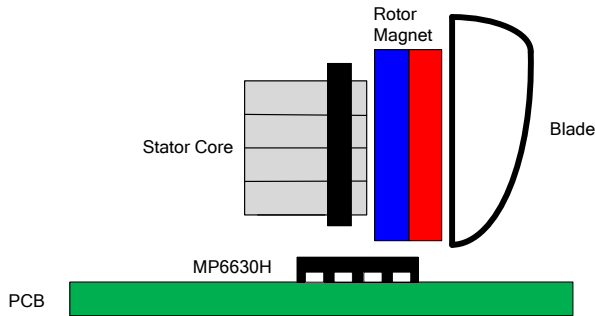
**Figure 8: Side View of MP6630H on Bottom of PCB**

If the winding direction is different, and the current flows from U to the common node (COM), magnetic north is generated at stator (see Figure 9).



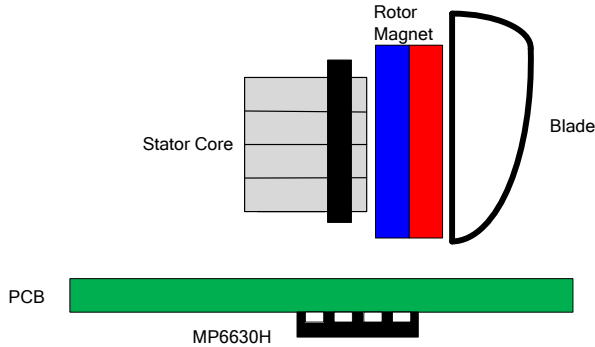
**Figure 9: Magnetic North with Winding Direction**

If the IC is mounted on the top of the PCB with different winding, use opposite Hall polarity (HAL\_POL = 1) (see Figure 10).



**Figure 10: Side View of MP6630H on Top of PCB with Different Winding**

If the IC is mounted on the bottom of the PCB with different winding, use the default Hall polarity (HAL\_POL = 0) (see Figure 11).



**Figure 11: Side View of MP6630H on Bottom of PCB with Different Winding**

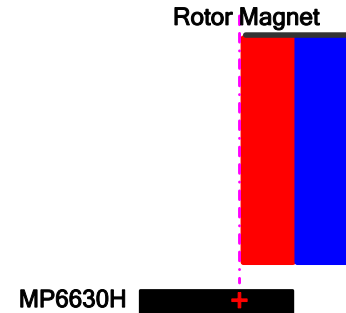
### PCB Layout Guidelines

The internal Hall element requires the correct magnetic field for normal operation. For the best results, refer to Figure 12 and Figure 13, and follow the guidelines below:

1. Ensure the MP6630H is aligned with the highest magnetic field possible. Generally,

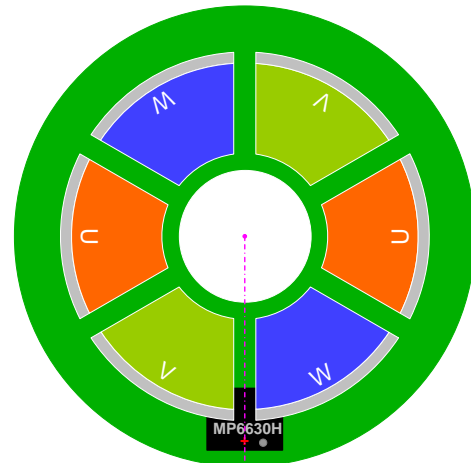
the inner surface of the rotor magnet provides the highest magnetic field strength.

2. Align the internal Hall element with the inner surface of the rotor magnet (see Figure 12).



**Figure 12: Aligning the Hall Element with Inner Surface of Rotor Magnet (Side View)**

3. Align the internal Hall element with the central line of winding V and winding W to achieve maximum operating efficiency (see Figure 13).



**Figure 13: Aligning the Hall Element along the Central Line of Winding V and Winding W (Top View)**

**REGISTER MAP**

Addr	Default	D7	D6	D5	D4	D3	D2	D1	D0
0x00	0x56	TSS	SPD_ZERO	DMIN					
0x01	0x60	NA			HAL_POL	NA		FGRD	

**Register Table 1**

Addr: 0x00				
Bit	Bit Name	Access	Default	Description
7	TSS	OTP/REG	0	Soft-start timer. The timer for the output duty reference, from 0% to 100%, or 100% to 0%. 0: 2.6s 1: 5.2s
6	SPD_ZERO	OTP/REG	1	Zero-speed enable bits. There is 1.2% hysteresis for the starting duty. 0: Disable. The motor does not stop when the duty is below the starting duty 1: Enable. The motor stops when the duty is below the starting duty
5:0	DMIN[5:0]	OTP/REG	0x16	Starting duty set bits. U/V/W starts to output duty when the input duty exceeds the starting duty. The default duty is 17.2% with a 1.2% hysteresis. The starting duty can be calculated with the following equation:  Starting duty = DMIN / 128

**Register Table 2**

Addr: 0x01				
Bit	Bit Name	Access	Default	Description
7:4	N/A	RESERVED	0110	Reserved.
3	HAL_POL	OTP/REG	0	Hall polarity set bit (see page 12 for more details). 0: Default 1: Opposite Hall output
2	N/A	RESERVED	0	Reserved.
1:0	FGRD[1:0]	OTP/REG	00	FG/RD set bit. This bit sets the output signal on the FG/RD pin. 00: 1x FG output 01: 1/2x FG output 10: RD

### TYPICAL APPLICATION CIRCUIT

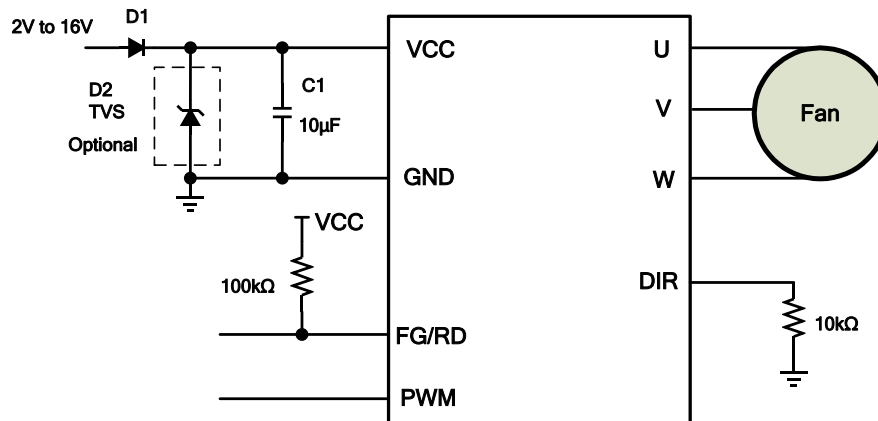
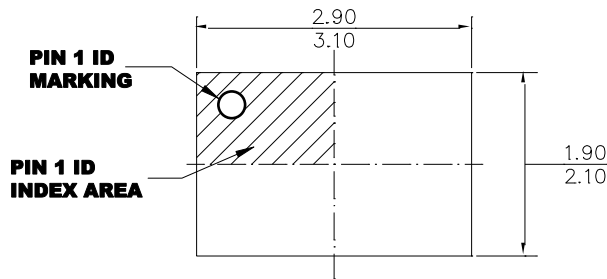


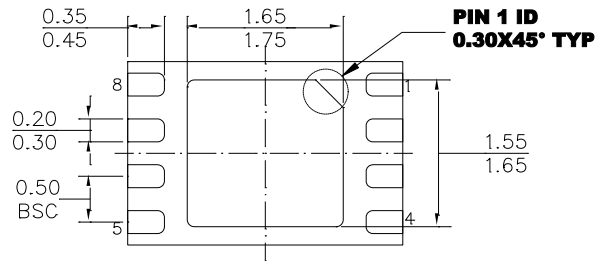
Figure 14: Typical Application Circuit

## PACKAGE INFORMATION

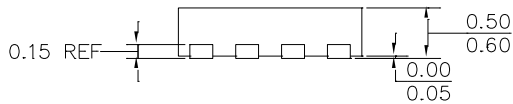
### UTQFN-8 (2mmx3mm)



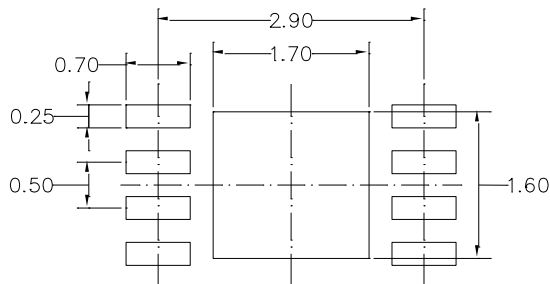
**TOP VIEW**



**BOTTOM VIEW**



**SIDE VIEW**



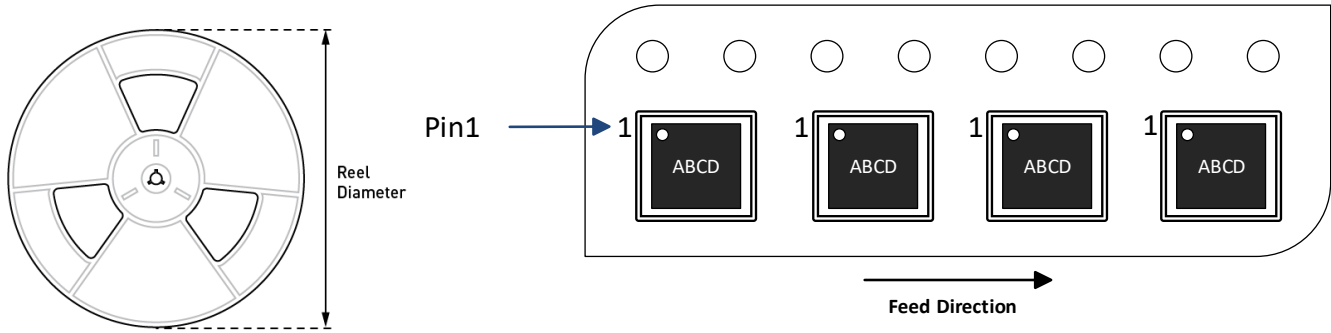
**RECOMMENDED LAND PATTERN**

#### 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
MP6630HGDU-xxxx**	UTQFN-8 (2mmx3mm)	5000	N/A	13in	12mm	8mm	125 & 125

## REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	4/27/2020	Initial Release	-
1.01	8/17/2020	Add “180° full-wave sinusoidal drive” description	1, 10
1.1	12/4/2023	Updated “Typically 2.3A of Maximum Peak Current” in the Features section	1
		Updated “-Z” to “-Z”	2
		Corrected formatting in Revision History	18

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