MCP8063

3-Phase Brushless Sinusoidal Sensorless Motor Driver

Features:

- Automotive AEC-Q100 Qualified, PPAP Available Upon Request
- Position Sensorless BLDC Drivers (No Hall Sensor Required)
- 180° Sinusoidal Drive for High Efficiency and Low Acoustic Noise
- Supports 2V to 14V Power Supplies
- Speed Control through PSM (Power Supply Modulation) and/or PWM (Pulse-Width Modulation)
- Built-in Frequency Generator (FG Output Signal)
- Built-in Lock-up Protection and Automatic Recovery Circuit (External Capacitor not Necessary)
- Built-in Overcurrent Limitation (1.5A)
- Built-in Thermal Shutdown Protection
- Thermally Enhanced 8L 4x4 DFN Package with Exposed Pad
- 23 kHz PWM Output Frequency
- No External Tuning Required
- Optimized for Fan Cooling Systems

Typical Applications:

- Silent Notebook CPU/GPU Cooling Fans
- Air Ventilation System
- 12V 3-Phase BLDC Motors

Description:

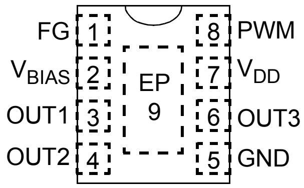
The MCP8063 device is a highly integrated 3-phase, full-wave sensorless driver for brushless motors. It features a 180° sinusoidal drive, high torque output, and silent drive. Its integrated features and the wide power supply range (2V to 14V) make the MCP8063 an ideal candidate for a broad range of motor characteristics, requiring no external tuning. Speed control can be achieved through either power supply modulation (PSM) or pulse-width modulation (PWM).

Due to the compact packaging and minimum bill of materials (power transistors integrated, no Hall sensor, no external tuning), the MCP8063 is optimized for fan applications that require high efficiency and low acoustic noise at competitive costs. Frequency generator output enables precision speed control in closed-loop applications. The MCP8063 driver includes a Lock-up Protection mode, which turns off the output current when the motor is under lock condition, and an automatic recovery that enables the fan to restart when the lock condition is removed. Features such as motor overcurrent limitation and thermal shutdown protection improve motor system reliability without additional efforts from design engineers.

The MCP8063 is available in a compact thermally-enhanced 8L 4x4 DFN package with Exposed Pad.

Package Types

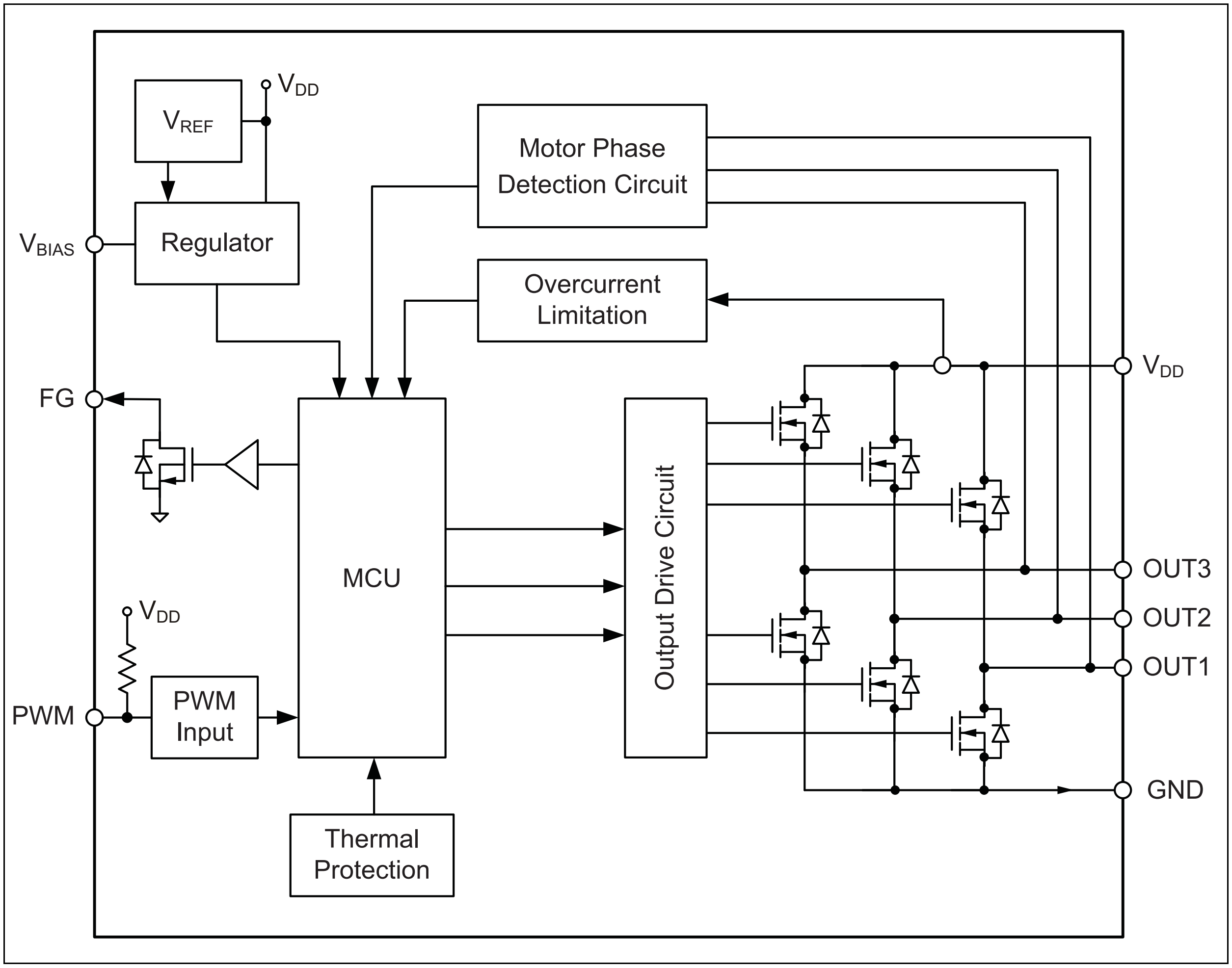
MCP8063
8L 4x4 DFN*



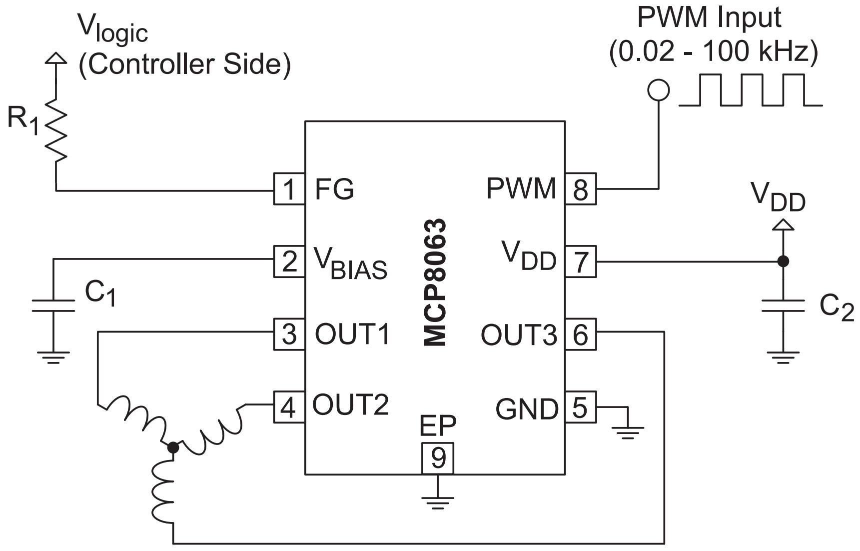
Top View

* Includes Exposed Thermal Pad (EP); see Table 3-1.

Functional Block Diagram



Typical Application – Fan Motor Driver Using the MCP8063



Recommended External Components for Typical Application

Element	Type/Value	Comment
C_1	≥1 µF	Connect as close as possible to IC input pins
C_2	≥10 µF	Connect as close as possible to IC input pins
R_1	≥10 kΩ	Connect to V_{logic} on controller side

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

Power Supply Voltage (V_{DD_MAX}) .... -0.7 to +15.3V
Maximum OUT1,2,3 Voltage (V_{OUT_MAX}) .... -0.7 to +16.0V
Maximum Output Current(3) (I_{OUT_MAX}) ....-1.7A to +1.7A
FG Maximum Output Voltage (V_{FG_MAX}) .... -0.7 to +15.3V
FG Maximum Output Current (I_{FG_MAX}) ....5.0 mA
V_{BIAS} Maximum Voltage (V_{BIAS_MAX}) .... -0.7 to +4.0V
PWM Maximum Voltage (V_{PWM_MAX}) .... -0.7 to +4.0V
Max Junction Temperature (T_J).................................. +150°C
HBM ESD protection on all pins...................................... 4 kV

† Notice: Stresses above those listed under "Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Note 1: Reference PCB, according to JEDEC standard EIA/JESD 51-9.

2: Derating applies for ambient temperatures outside the specified operating range (refer to Figure 1-1).

3: OUT1, OUT2, OUT3 (Continuous, 100% duty cycle).

ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise specified, all limits are established for V_{DD} = 12.0V, Temperature = +25°C.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Power Supply Voltage	V_{DD}	2	—	14	V	
Power Supply Current	I_{VDD}	—	10	—	mA	Rotation Mode
			5			Lock-Protection Mode
OUT1/2/3 High Resistance	$R_{ON(H)}$	—	0.6	1	Ω	I_{OUT} = 0.5A, V_{DD} = 3.3V to 14V (**Note 1**)
OUT1/2/3 Low Resistance	$R_{ON(L)}$	—	0.6	1	Ω	I_{OUT} = -0.5A, V_{DD} = 3.3V to 14V (**Note 1**)
OUT1/2/3 Total Resistance	$R_{ON(H+L)}$	—	1.2	2	Ω	I_{OUT} = 0.5A, V_{DD} = 3.3V to 14V (**Note 1**)
OUT1/2/3 Maximum Current Limitation	I_{OUT_LIM}	1.4	1.5	1.6	A	**Note 1**
V_{BIAS} Output Voltage	V_{BIAS}	—	3	—	V	V_{DD} = 3.3V to 14V
			V_{DD} – 0.2		V	V_{DD} < 3.3V
PWM Input Frequency	f_{PWM}	0.02	—	100	kHz	—
PWM Input H Level	V_{PWM_H}	0.8*V_{BIAS}	—	3.6	V	—
PWM Input L Level	V_{PWM_L}	0	—	0.2*V_{BIAS}	V	—
PWM Internal Pull-Up Current	I_{PWM_L}	17	34	—	µA	PWM = GND, V_{DD} = 3.3V to 14V
		8	17	—	µA	PWM = GND, V_{DD} < 3.3V
PWM Output Frequency	f_{PWM_O}	—	23	—	kHz	
FG Output Pin Low Level Voltage	V_{OL_FG}	—	—	0.25	V	I_{FG} = -1 mA
FG Output Pin Leakage Current	I_{LH_FG}	—	—	10	µA	V_{FG} = 14V
Lock Protection Operating Time	T_{RUN}	—	0.5	—	s	—
Lock Protection Waiting Time	T_{WAIT}	4.0	4.5	5.0	s	—
Thermal Shutdown	T_{SD}	—	170	—	°C	—
Thermal Shutdown Hysteresis	T_{SD_HYS}	—	25	—	°C	—

Note 1: Minimum and maximum parameter is not production tested and is specified by design and validation.

TEMPERATURE SPECIFICATIONS

Electrical Specifications: Unless otherwise specified, all limits are established for V_{DD} = 12.0V, T_A = +25°C.						
Parameters	**Sym.**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
Temperature Ranges						
Operating Temperature	T_{OPR}	-40	—	+125	°C	
Storage Temperature Range	T_{STG}	-55	—	+150	°C	
Package Thermal Resistances						
Thermal Resistance, 8L 4x4 DFN	θ_{JA}	—	48	—	°C/W	
	θ_{JC}	—	7	—	°C/W	

Note 1: Minimum and maximum parameter is not production tested and is specified by design and validation.

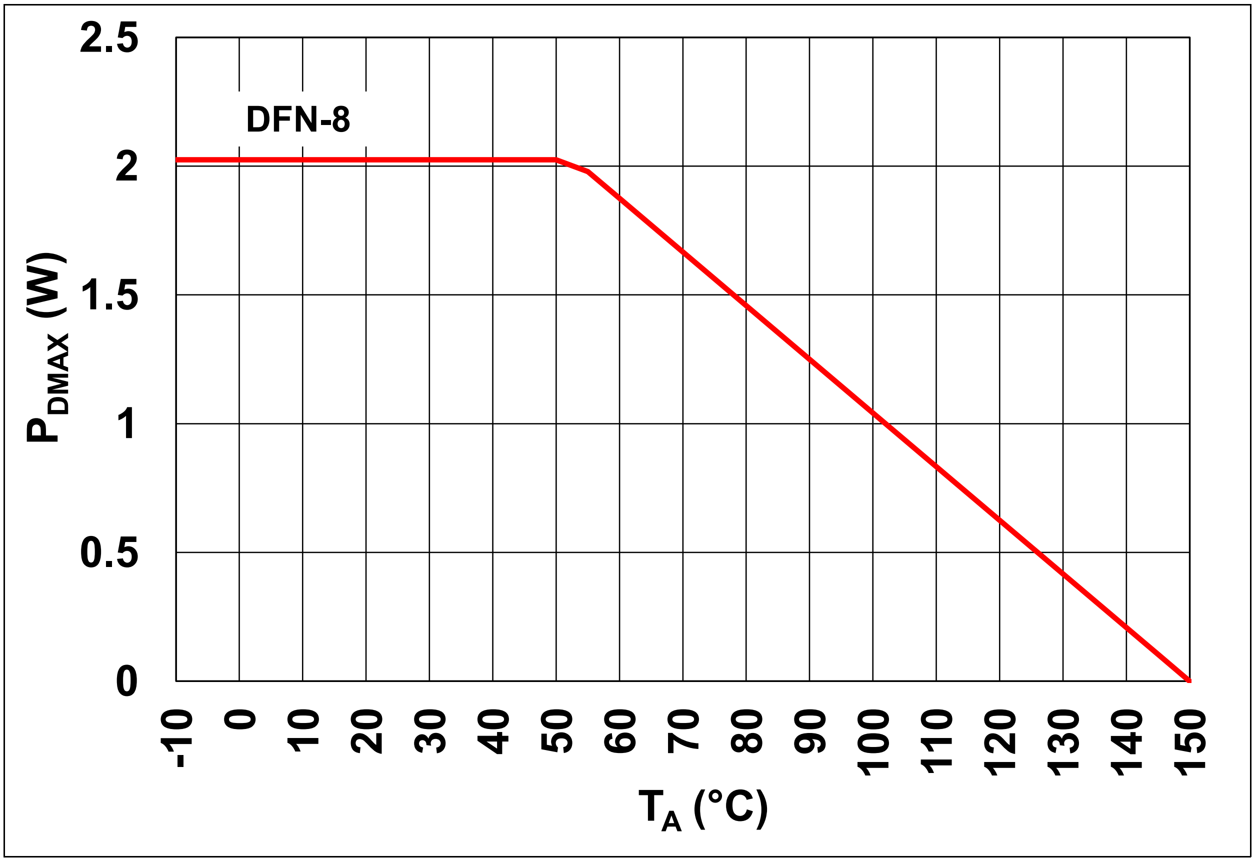


FIGURE 1-1: Allowable Power Dissipation (P_{D_MAX}) as a Function of Ambient Temperature (T_A).

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = 14V, OUT1, 2, 3 and PWM open.

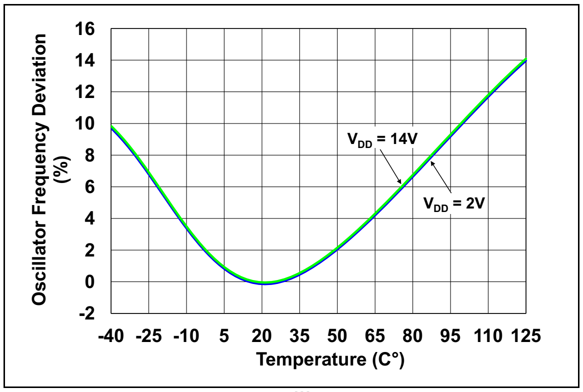


FIGURE 2-1: *Oscillator Frequency Deviation vs. Temperature.*

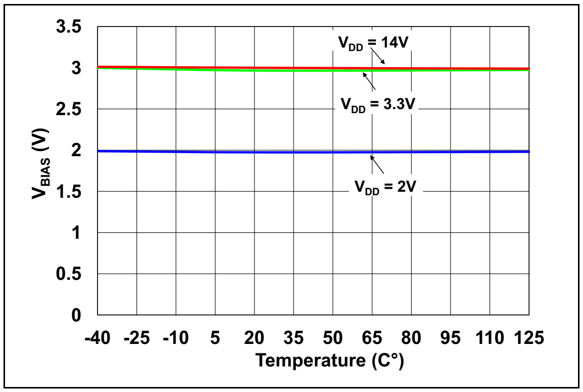


FIGURE 2-2: *Internal Regulated Voltage (V_{BIAS}) vs. Temperature.*

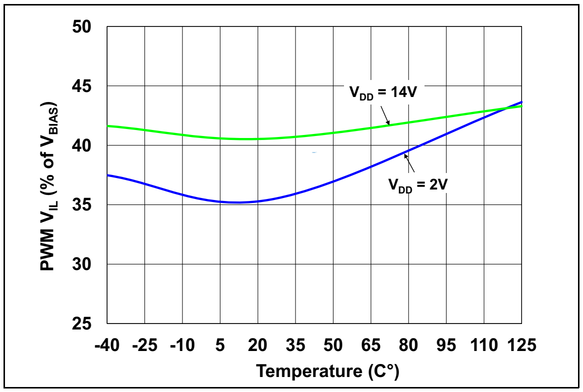


FIGURE 2-3: *Input (PWM) V_{IL} vs. Temperature.*

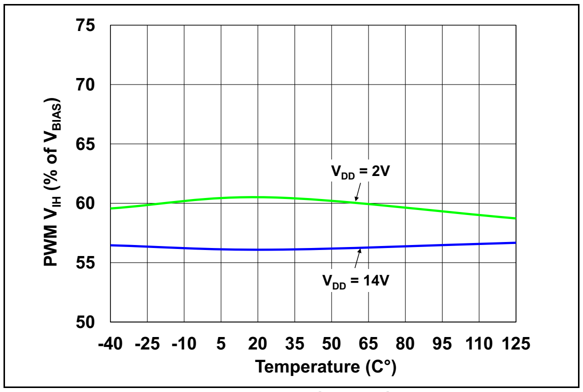


FIGURE 2-4: *Input (PWM) V_{IH} vs. Temperature.*

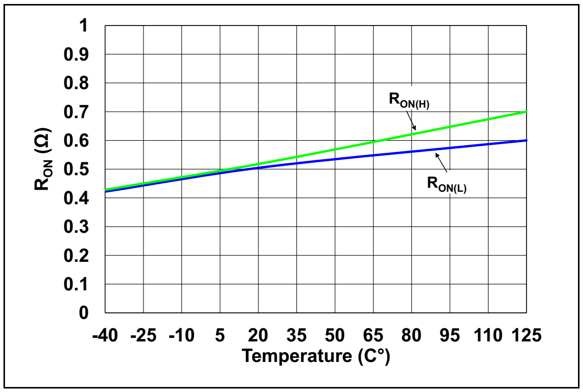


FIGURE 2-5: *Output R_{ON} Resistance vs. Temperature (V_{DD} = 3.3V).*

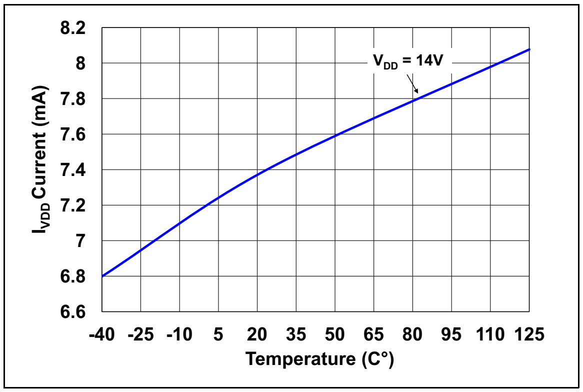


FIGURE 2-6: *Supply Current vs. Temperature.*

Note: Unless otherwise indicated, T_A = +25°C, V_{DD} = 14V, OUT1, 2, 3 and PWM open.

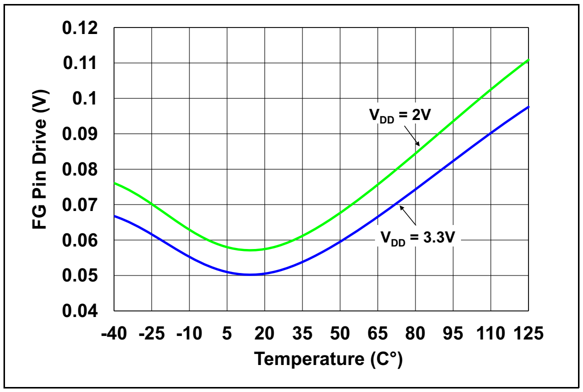


FIGURE 2-7: *FG Output Pin Low Level Voltage (I_{FG} = -1 mA).*

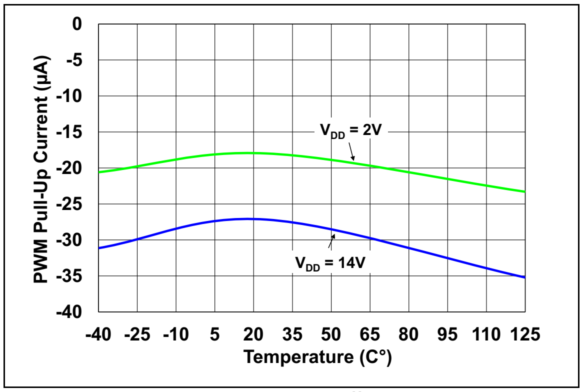


FIGURE 2-8: *PWM Pull-Up Current vs. Temperature.*

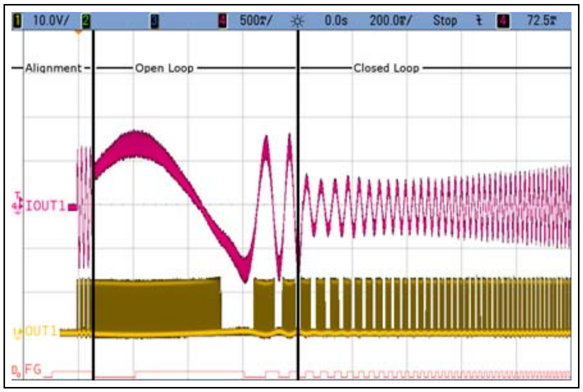


FIGURE 2-9: *Typical Output on Start-up.*

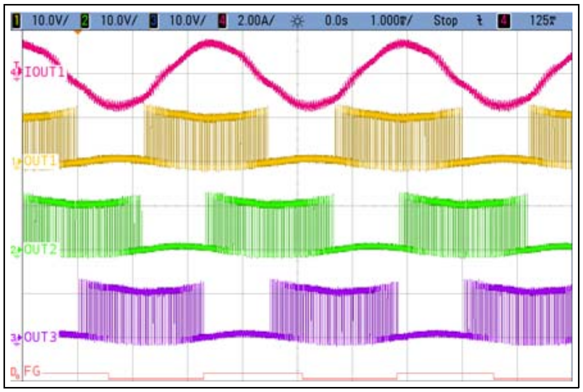


FIGURE 2-10: *Typical Outputs on Closed Loop.*

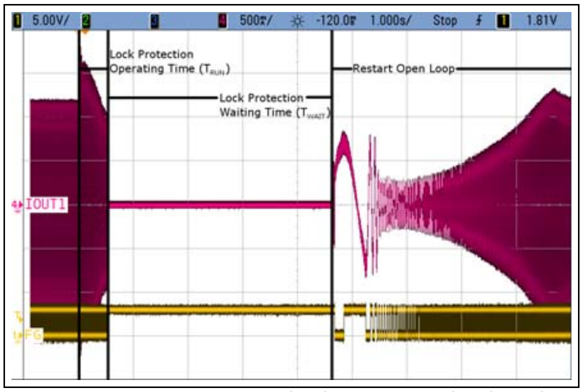


FIGURE 2-11: *Typical Rotor Lock Situation.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: MCP8063 PIN FUNCTION TABLE

MCP8063	Type	Symbol	Description
4x4 DFN			
1	O	FG	Motor speed indication output
2	P	V_{BIAS}	Internal regulator output (for decoupling only)
3	O	OUT1	Single-phase coil output pin
4	O	OUT2	Single-phase coil output pin
5	P	GND	Negative voltage supply (ground)
6	O	OUT3	Single-phase coil output pin
7	P	V_{DD}	Positive voltage supply for motor driver
8	I	PWM	PWM input signal for speed control
9	P	EP	Exposed pad is used for thermal dissipation. Connect to GND

Legend: I = Input; O = Output; P = Power

4.0 FUNCTIONAL DESCRIPTION

The MCP8063 devices generate a full-wave signal to drive a 3-phase sensorless BLDC motor. High efficiency and low power consumption are achieved due to DMOS transistors and synchronous rectification drive type. The current carrying order of the output is as follows: OUT1 → OUT2 → OUT3.

4.1 Speed Control

The rotational speed of the motor can be controlled either through the PWM digital input signal or by varying the power supply (V_{DD}). When the PWM signal is "High" (or left open), the motor rotates at full speed. When the PWM signal is "Low", the motor is stopped (and the driver outputs are set to high impedance). By changing the PWM duty cycle, the speed can be adjusted. Notice that the PWM frequency has no special meaning for the motor speed and is asynchronous with the activation of the output transistors. Thus, the user has maximum freedom to choose the PWM system frequency within a wide range (from 20 Hz to 100 kHz), while the output transistor activation always occurs at a fixed rate, which is outside the range of audible frequencies. The typical output frequency of MCP8063 is 23 kHz.

4.2 Frequency Generator Function

The Frequency Generator output is a "Hall-sensor equivalent" digital output, giving information to an external controller about the speed and phase of the motor. The FG pin is an open-drain output, connecting to a logical voltage level through an external pull-up resistor. When a lock (or out-of-sync) situation is detected by the driver, this output is set to high impedance until the motor is restarted. Leave the pin open when not used. The FG signal can be used to compute the motor speed in rotations per minute (RPM). Typically, for a four-pole BLDC fan (4P/6S), the speed in RPMs is 30 x FG frequency (Hz).

EQUATION 1-1:

$$\frac{FG \times 720}{(P \times S)} = Rotor\ speed\ RPM$$

Where:

P = Total number of poles in the motor

S = Total number of slots in the motor

4.3 Lock-up Protection and Automatic Restart

If the motor is stopped (blocked) or if it loses synchronization with the driver, a lock-up protection circuit detects this situation and ties the outputs to GND in order to dissipate the remaining energy from the rotor with a minimum of self heating. After a "waiting time" (T_{WAIT}), the lock-up protection is released and normal operation resumes for a given time (T_{RUN}). In case the motor is still blocked, a new period of waiting time is started. T_{WAIT} and T_{RUN} timings are fixed internally, so that no external capacitor is needed.

4.4 Overcurrent Limitation

The motor peak current is limited by the driver to a fixed value (defined internally), thus limiting the maximum power dissipation in the coils.

4.5 Thermal Shutdown

The MCP8063 has a thermal protection function which detects when the die temperature exceeds T_{SD} = +170°C. When this temperature is reached, the circuit enters Thermal Shutdown mode and the outputs OUT1, OUT2 and OUT3 are tied to GND in order to dissipate the remaining energy from the rotor with a minimum of self heating. Once the junction temperature (T_{SD}) has dropped below +145°C, the normal operation resumes (the thermal detection circuit has +25°C hysteresis function).

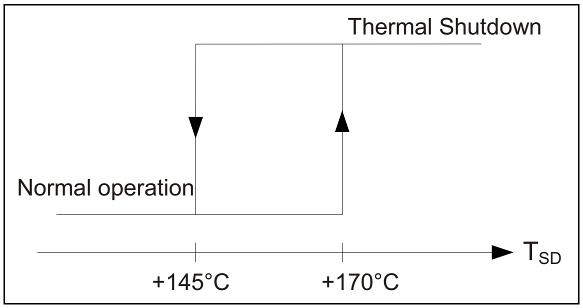


FIGURE 4-1: *Thermal Protection Hysteresis.*

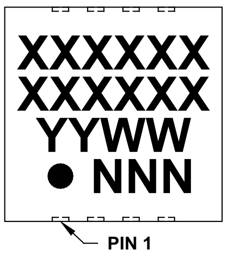
4.6 Internal Voltage Regulator

V_{BIAS} voltage is generated internally and is used to supply internal logical blocks. The V_{BIAS} pin is used to connect an external decoupling capacitor (1 µF or higher). Notice that this pin is for IC internal use and is not designed to supply DC current to external blocks.

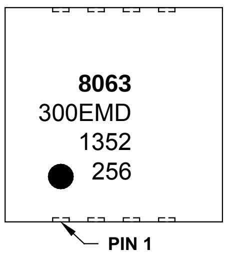
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

8-Lead DFN (4x4x0.9 mm)



Example

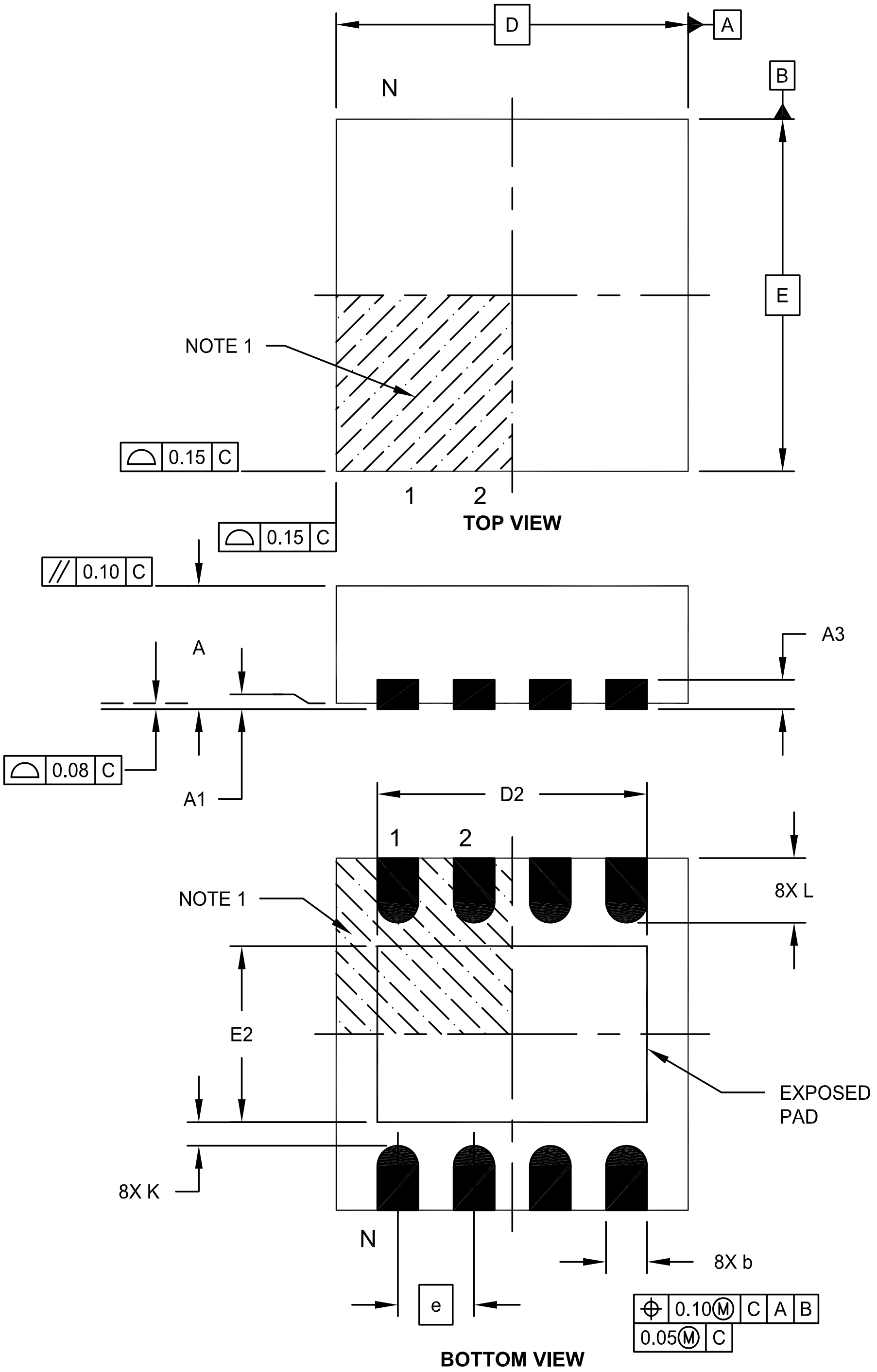


Legend:		
	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

8-Lead Plastic Dual Flat, No Lead Package (MD) – 4x4x0.9 mm Body [DFN]

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-131E Sheet 1 of 2

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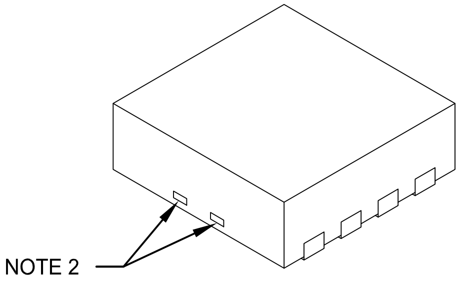


	Units	MILLIMETERS		
	Dimension Limits	MIN	NOM	MAX
Number of Pins	N	8		
Pitch	e	0.80 BSC		
Overall Height	A	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Contact Thickness	A3	0.20 REF		
Overall Length	D	4.00 BSC		
Exposed Pad Width	E2	2.60	2.70	2.80
Overall Width	E	4.00 BSC		
Exposed Pad Length	D2	3.40	3.50	3.60
Contact Width	b	0.25	0.30	0.35
Contact Length	L	0.30	0.40	0.50
Contact-to-Exposed Pad	K	0.20	-	-

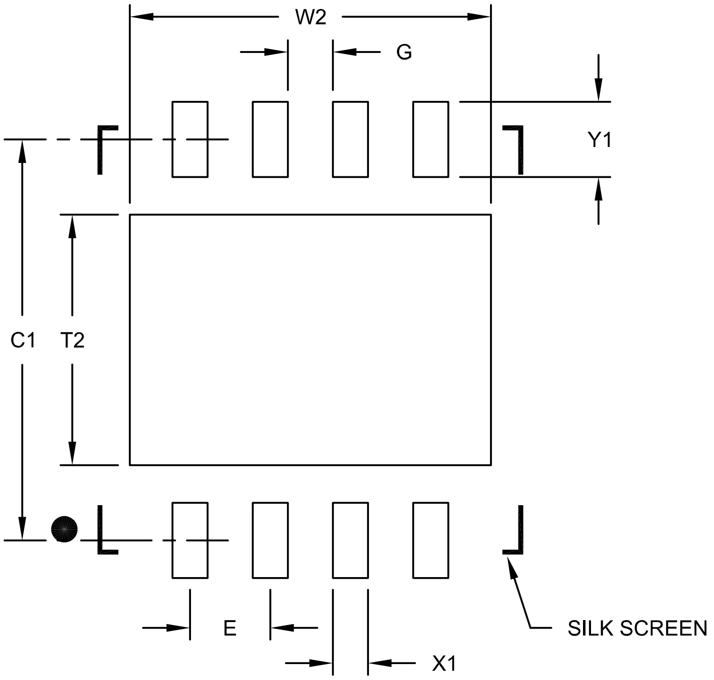
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package may have one or more exposed tie bars at ends.
3. Package is saw singulated
4. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-131E Sheet 2 of 2

8-Lead Plastic Dual Flat, No Lead Package (MD) - 4x4x0.9 mm Body [DFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	0.80 BSC		
Optional Center Pad Width	W2			3.60
Optional Center Pad Length	T2			2.50
Contact Pad Spacing	C1		4.00	
Contact Pad Width (X8)	X1			0.35
Contact Pad Length (X8)	Y1			0.75
Distance Between Pads	G	0.45		

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2131C

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (February 2014)

- Original Release of this Document.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

PART NO.	X	-X	XX
Device	**Tube/Tape and Reel**	**Temperature Range**	**Package**

Device:	MCP8063:	3-Phase BLDC Sinusoidal Sensorless Motor Driver
	MCP8063T:	3-Phase BLDC Sinusoidal Sensorless Motor Driver (Tape and Reel)
Temperature Range:	E =	-40°C to +125°C (Extended)
Package:	MD =	8-Lead Plastic Dual Flat, No Lead – 4x4x0.9 mm Body (DFN)

Examples:

a) MCP8063-E/MD: Extended temperature, 8LD 4x4 DFN package

b) MCP8063T-E/MD: Tape and Reel, Extended temperature, 8LD 4x4 DFN package

NOTES:

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