MICROCHIP

MTD6508

3-Phase Sinusoidal Sensorless Brushless DC Fan Motor Driver

Features

- 180° Sinusoidal Drive for High Efficiency and Low Acoustic Noise
- Position Sensorless BLDC Drivers (no Hall Effect Sensor required)
- Integrated Power Transistors
- Supports 2V to 5.5V Power Supplies
- Variable Programming Resistor (R_{PROG}) Setting to fit Motor Constant (K_M) Range from 3.25 mV/Hz to 52 mV/Hz
- Speed Control through Power Supply Modulation (PSM) and/or Pulse-Width Modulation (PWM)
- Built-in Frequency Generator: FG, FG/3 Output Signal (FG/2 and FG/6 Option are available upon request)
- Output PWM Slew Rate Control Programmable with an External Resistor for Start-up (Adjustable version)
- Phase Target Selection for Regulation (Adjustable Version)
- Start-up Strength Selection (Adjustable Version)
- Start-up Output Current Controlled by PWM
- Output Current Soft Start
- Built-in Lock-up Protection and Automatic Recovery Circuit
- Built-in Overcurrent Limitation
- Built-in Thermal Shutdown Protection
- Built-in Overvoltage Protection
- Low Minimal Start-up Speed for Low-Speed Operation
- Packages:
  - 10-Lead 3 mm x 3 mm x 0.5 mm UDFN
  - 16-Lead 4 mm x 4 mm x 0.5 mm UQFN (Adjustable version)

Applications

- Notebook CPU Cooling Fans
- 5V 3-Phase BLDC Motors

Description

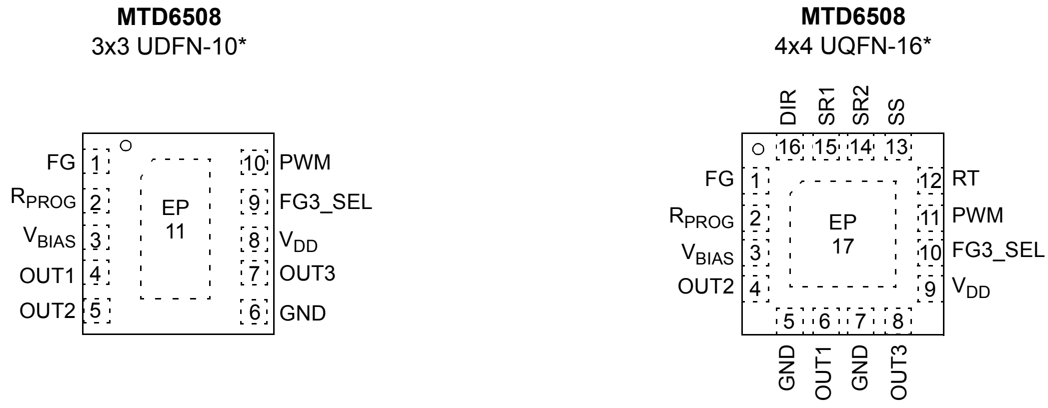
The MTD6508 device is a 3-phase, full-wave sensorless driver for brushless DC (BLDC) motors. It features a 180° sinusoidal drive, high torque output and silent drive. With adaptive features, parameters and a wide range of power supplies (2V to 5.5V), the MTD6508 is intended to cover a broad range of motor characteristics while requiring minimum external components. Speed control can be achieved through either power supply modulation (PSM) or pulse-width modulation (PWM).

Compact packaging and a minimal bill of materials make the MTD6508 device extremely cost-efficient in fan applications. For example, the CPU cooling fans in notebook computers require designs that provide low acoustic noise, low mechanical vibration and are highly efficient. The frequency generator (FG) output enables precision speed control in closed-loop applications.

The MTD6508 device includes Lock-up Protection mode to turn off the output current when the motor is in a lock condition, with an automatic recovery feature to restart the fan when the lock condition is removed. Motor overcurrent limitation and thermal shutdown protection are included for safety-enhanced operations.

The MTD6508 is available in compact, thermally-enhanced, 10-Lead 3 mm x 3 mm x 0.5 mm UDFN packages and 16-Lead 4 mm x 4 mm x 0.5 mm UQFN packages.

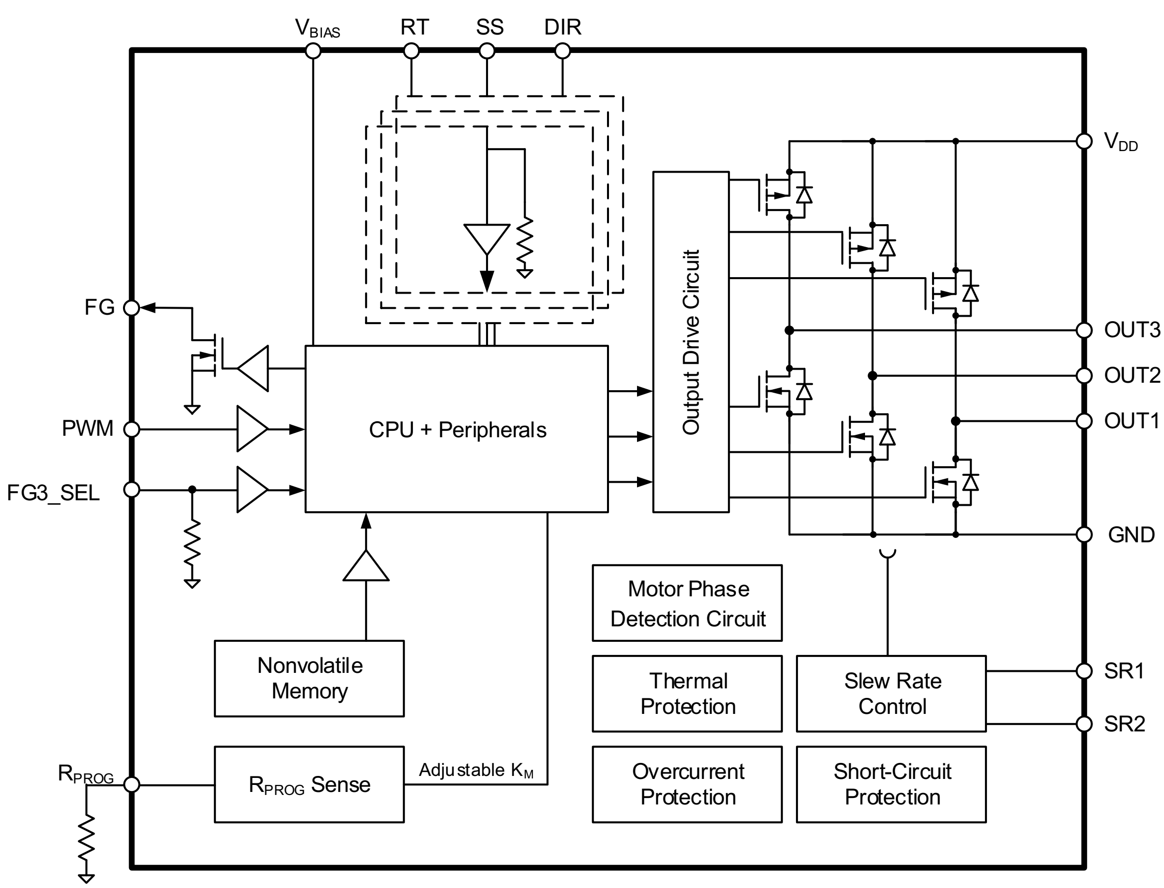
Package Types



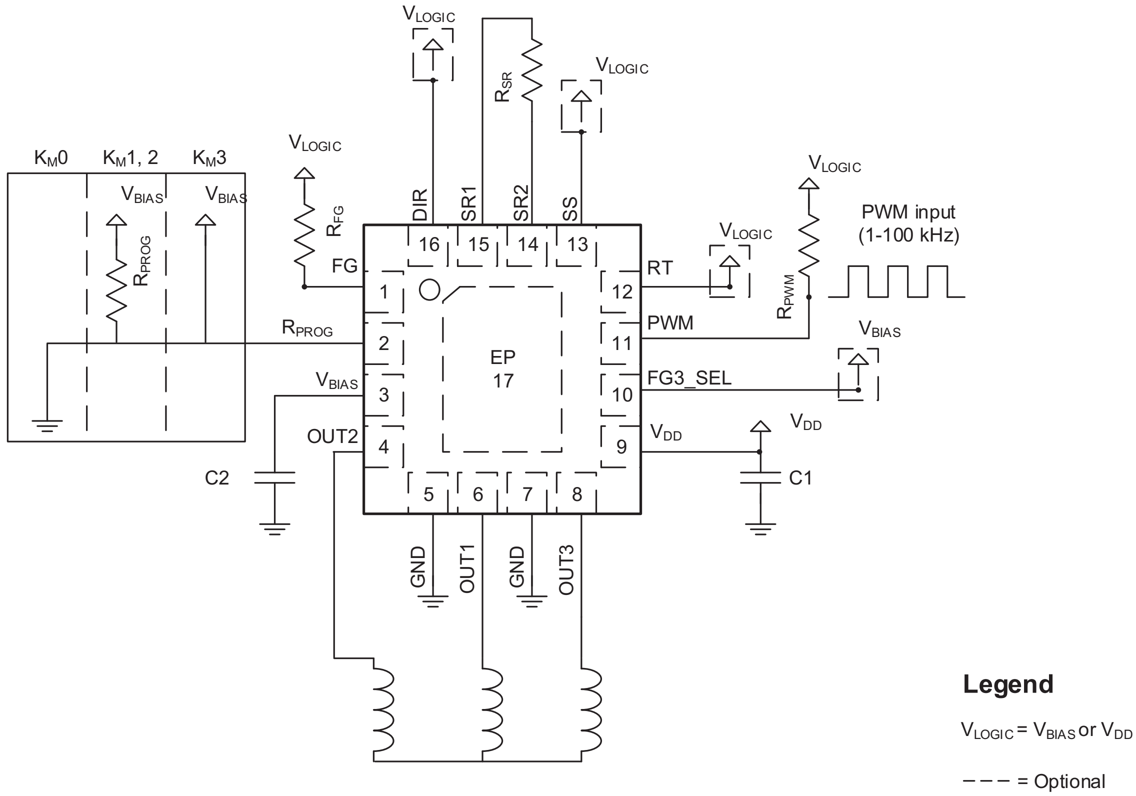
Note: The DIR, SS and RT pins that are not available on UDFN-10 Package are internally pulled down. SR1 and SR2 are connected by a fixed internal resistor (25 kΩ).

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

Functional Block Diagram



Typical Application



Recommended External Components for Typical Application

Element	Type/Value	Comment
C1	≥1 µF	Connect as close as possible to IC input pin
C2	≥1 µF	Connect as close as possible to IC input pin
R_{FG}	≥10 kΩ	Connect to V_{logic} on microcontroller side (FG Pull-Up)
R_{PWM}	100 kΩ	Connect to V_{logic} on microcontroller side (PWM Pull-Up)
R_{PROG}	3.9 kΩ or 24 kΩ	Select appropriate programming resistor value, see Table 4-1
R_{SR}	4.7 kΩ-47 kΩ	Select appropriate output PWM slew rate, see Table 4-2

NOTES:

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

Power Supply Voltage (V_{DD_MAX}) .... -0.7 to +7.0V
Maximum Output Voltage (V_{OUT_MAX}) .... -0.7 to +7.0V
Maximum Output Current (I_{OUT_MAX})[(1)] ....1000 mA
FG Maximum Output Voltage (V_{FG_MAX}) .... -0.7 to +7.0V
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 +7.0V
Allowable Power Dissipation (P_{D_MAX})[(2)] 1.5W
Maximum Junction Temperature (T_J) .... +150°C
ESD protection on all pins ....≥2 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: I_{OUT} is also internally limited, according to the limits defined in the Electrical Characteristics table.

2: Reference Printed Circuit Board (PCB) according to JEDEC standard EIA/JESD 51-9.

ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise specified, all limits are established for V_{DD} = 2.0V to 5.5V, T_A = +25°C

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Power Supply Voltage	V_{DD}	2	—	5.5	V	
Power Supply Current	I_{VDD}	—	5	10	mA	V_{DD} = 5V
Standby Current	I_{VDD_STB}	—	15	25	µA	PWM = 0V, V_{DD} = 5V (Standby mode)
OUTX High Resistance	$R_{ON(H)}$	—	0.75	—	Ω	I_{OUT} = 0.5A, V_{DD} = 5V
OUTX Low Resistance	$R_{ON(L)}$	—	0.75	—	Ω	I_{OUT} = 0.5A, V_{DD} = 5V
OUTX Total Resistance	$R_{ON(H+L)}$	—	1.5	—	Ω	I_{OUT} = 0.5A, V_{DD} = 5V
V_{BIAS} Internal Supply Voltage	V_{BIAS}	—	3	—	V	V_{DD} = 3.2V to 5.5V
		—	V_{DD} – 0.2	—	V	V_{DD} < 3.2V
PWM Input Frequency	f_{PWM}	1	—	100	kHz	
PWM Input H Level	V_{PWM_H}	0.55 ∗ V_{DD}	—	V_{DD}	V	V_{DD} ≥ 4.5V
PWM Input L Level	V_{PWM_L}	0	—	0.2 ∗ V_{DD}	V	V_{DD} ≥ 4.5V
FG3_SEL Input H Level	$V_{FG3\_SEL\_H}$	V_{BIAS} – 0.5	—	V_{BIAS}	V	V_{DD} ≥ 4.5V
FG3_SEL Input L Level	$V_{FG3\_SEL\_L}$	0	—	0.2 ∗ V_{DD}	V	V_{DD} ≥ 4.5V
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	—	10	µA	V_{FG} = 5.5V
Lock Protection Operating Time	T_{RUN}	—	0.5	1	s	
Lock Protection Waiting Time	T_{WAIT}	5	5.5	6	s	**Note 1**
Overcurrent Protection	I_{OC_MOT}	—	750	—	mA	**Note 2**

Note 1: Related to the internal oscillator frequency (see Figure 2-1)

2: 750 mA is the standard option for MTD6508. Additional overcurrent protection levels are available upon request. Please contact factory for different overcurrent protection values.

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Specifications: Unless otherwise specified, all limits are established for V_{DD} = 2.0V to 5.5V, T_A = +25°C						
Parameters	**Sym.**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
Overvoltage Protection	V_{OV}	—	7.2	—	V	
Short Protection on High Side	$I_{OC\_SW\_H}$	—	2.57	—	A	
Short Protection on Low Side	$I_{OC\_SW\_L}$	—	-2.83	—	A	
Thermal Shutdown	T_{SD}	—	170	—	°C	
Thermal Shutdown Hysteresis	T_{SD_HYS}	—	25	—	°C	

Note 1: Related to the internal oscillator frequency (see Figure 2-1)

2: 750 mA is the standard option for MTD6508. Additional overcurrent protection levels are available upon request. Please contact factory for different overcurrent protection values.

TEMPERATURE SPECIFICATIONS

Electrical Specifications: Unless otherwise specified, all limits are established for V_{DD} = 2.0V to 5.5V, 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	
Thermal Package Resistances						
Thermal Resistance, 10L-UDFN, 3x3	θ_{JA}	—	68	—	°C/W	
	θ_{JC}	—	11	—	°C/W	
Thermal Resistance, 16L-UQFN, 4x4	θ_{JA}	—	31.8	—	°C/W	
	θ_{JC}	—	10	—	°C/W	

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 indicated, T_A = +25°C, V_{DD} = 2.0V to 5.5V, OUT1, 2, 3 and PWM open.

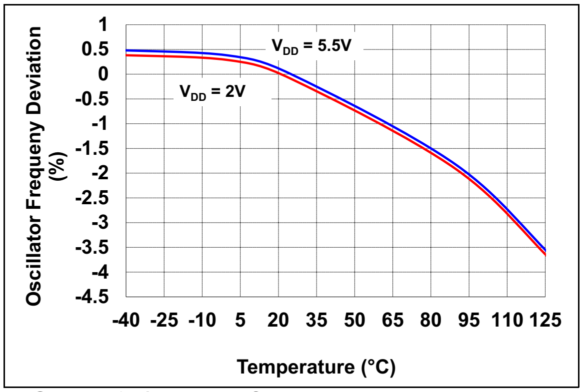


FIGURE 2-1: *Oscillator Frequency Deviation vs. Temperature.*

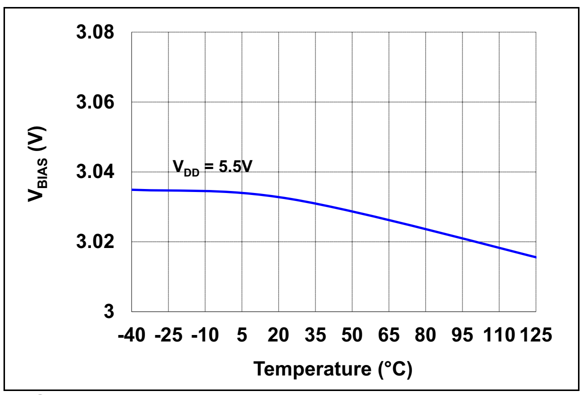


FIGURE 2-2: *Internal Regulated Voltage (V_{BIAS}) vs Temperature.*

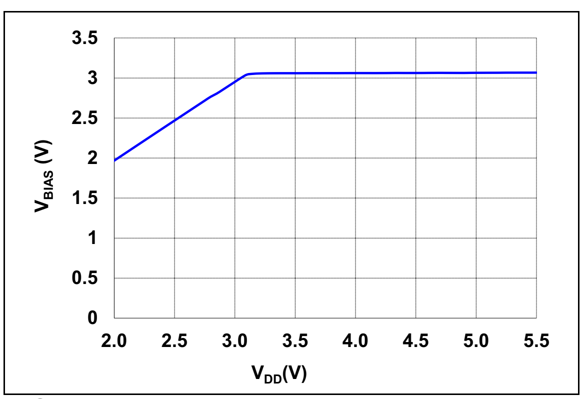


FIGURE 2-3: *Internal Regulated Voltage (V_{BIAS}) vs Supply Voltage (V_{DD}).*

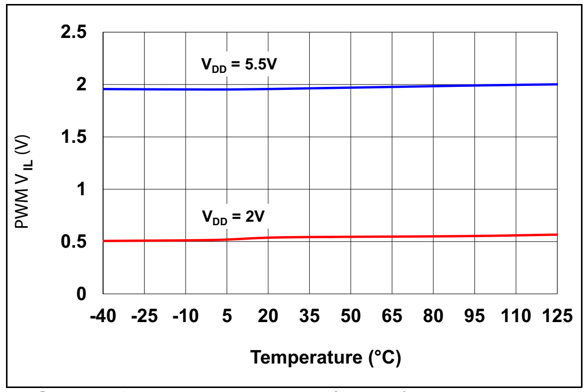


FIGURE 2-4: *Inputs (PWM) V_{IL} vs. Temperature.*

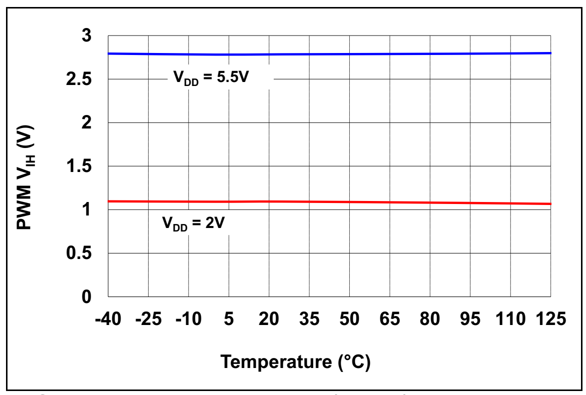


FIGURE 2-5: *Inputs (PWM) V_{IH} vs. Temperature.*

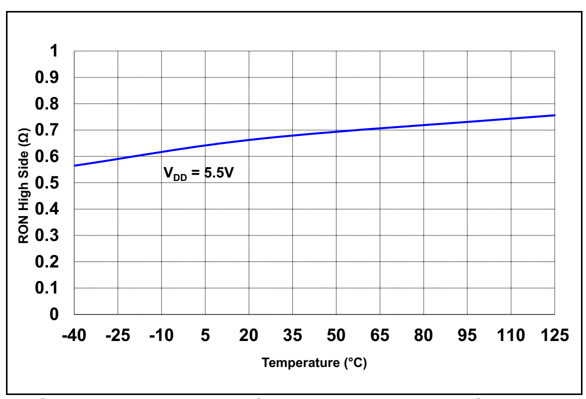


FIGURE 2-6: *Outputs R_{ON} High-Side Resistance vs. Temperature.*

Note: Unless indicated, T_A = +25°C, V_{DD} = 2.0V to 5.5V, OUT1, 2, 3 and PWM open.

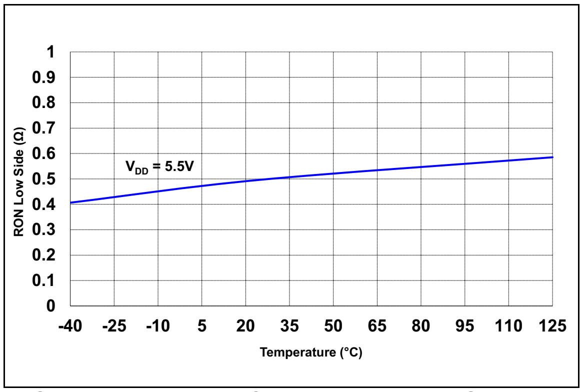


FIGURE 2-7: *Outputs R_{ON} Low-Side Resistance vs. Temperature.*

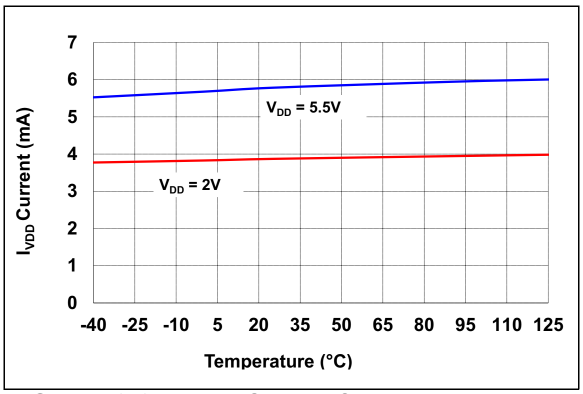


FIGURE 2-8: *Supply Current vs. Temperature.*

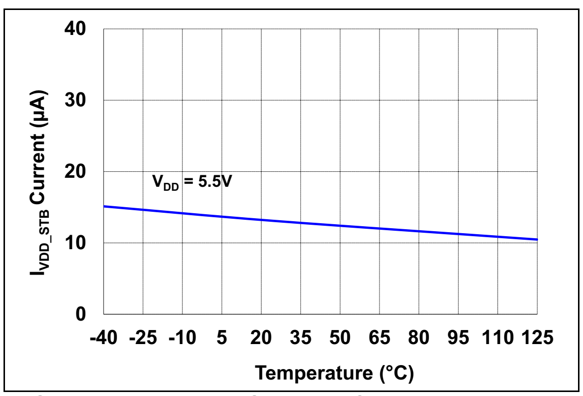


FIGURE 2-9: *Standby Current vs. Temperature.*

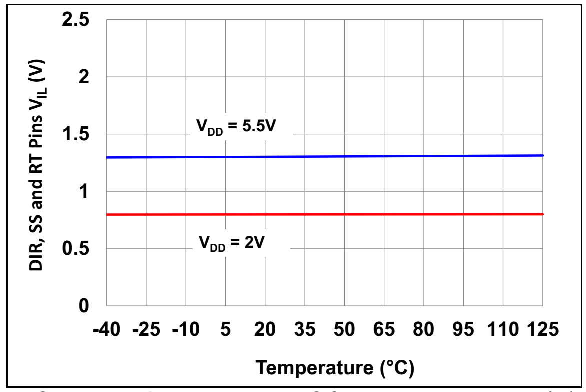


FIGURE 2-10: *DIR, SS and RT Pins V_{IL} (V) vs. Temperature.*

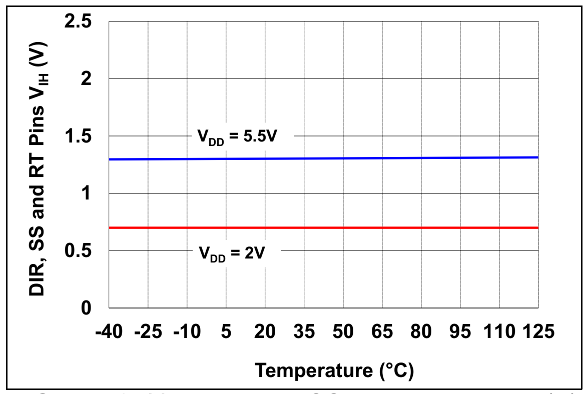


FIGURE 2-11: *DIR, SS and RT Pins V_{IH} (V) vs. Temperature.*

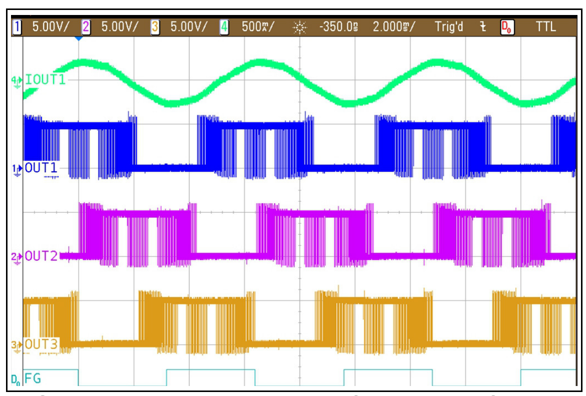


FIGURE 2-12: *Typical Outputs on Closed Loop.*

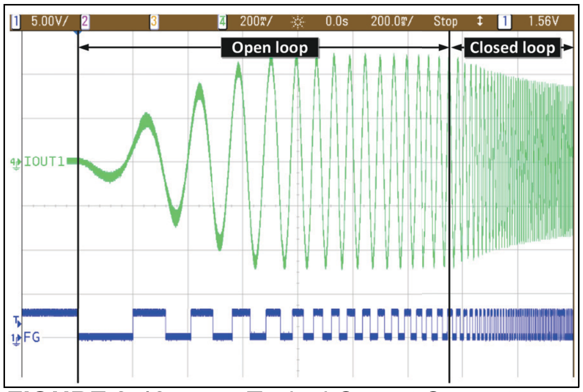


FIGURE 2-13: Typical Output Current on Start-up.

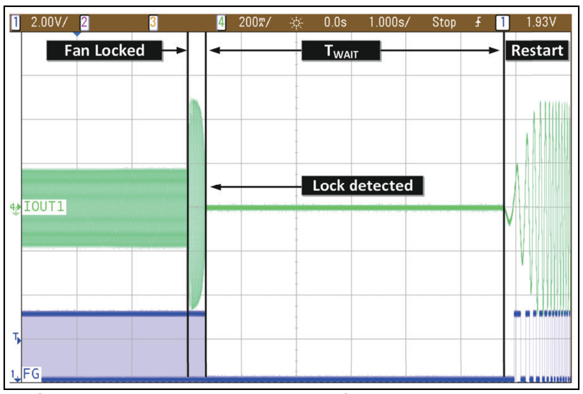


FIGURE 2-14: Typical Outputs on Locked Motor While Running.

3.0 PIN DESCRIPTIONS

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

TABLE 3-1: PIN FUNCTION TABLE

MTD6508		Name	Type	Function
3x3 UDFN	4x4 UQFN			
1	1	FG	O	Motor Speed Indication Output Pin
2	2	R_{PROG}	I	K_M Parameter Setting with External Resistors Pin (do not leave floating)
3	3	V_{BIAS}	O	3V Internal Regulator Output Pin (for decoupling only)
5	4	OUT2	O	Single-Phase Coil Output Pin
6	5	GND	P	Negative Voltage Supply Pin (ground)
4	6	OUT1	O	Single-Phase Coil Output Pin
6	7	GND	P	Negative Voltage Supply Pin (ground)
7	8	OUT3	O	Single-Phase Coil Output Pin
8	9	V_{DD}	P	Positive Voltage Supply for Motor Driver Pin
9	10	FG3_SEL	I	FG Frequency Divider Selection Pin: - FG signal divided by three: connect this pin to V_{BIAS} - FG normal signal: connect this pin to GND or leave floating
10	11	PWM	I	PWM Input Signal for Close-Loop Speed Control Pin (do not leave floating)
—	12	RT	I	Regulation Target Pin – phase target selection for regulation: - Normal regulation: connect this pin to GND or leave floating - Low load regulation: connect this pin to V_{BIAS} or V_{DD} - Pin not available on UDFN-10 option; selection fixed to normal regulation
—	13	SS	I	Strong Start Pin – start-up strength selection: - Soft open-loop start-up (reduced current) – during the start-up open-loop, the output amplitude is defined by the input PWM duty cycle: connect this pin to GND or leave floating - Strong open-loop start-up – during the start-up open-loop, the output amplitude is fixed to 100%: connect this pin to V_{BIAS} or V_{DD} - Pin not available on UDFN-10 option; selection fixed to soft open-loop start-up
—	14	SR2	O	Start-up Output PWM Slew Rate Control Pin 2 (High side) - Pin not available on UDFN-10 option; selection fixed to 250 ns (25 kΩ)
—	15	SR1	I	Start-up Output PWM Slew Rate Control Pin 1 (Low side) - Pin not available on UDFN-10 option; selection fixed to 250 ns (25 kΩ)
—	16	DIR	I	Motor Rotation Direction Pin (DIR function): - Forward direction: connect this pin to GND or leave floating - Reverse direction: connect this pin to V_{BIAS} or V_{DD} - Pin not available on UDFN-10 option; selection fixed to forward direction
11	17	EP	N/A	Exposed Pad Pin; connect to ground plane on the PCB for enhanced thermal performance

Note: I = Input, O = Output, P = Power

4.0 FUNCTIONAL DESCRIPTION

The MTD6508 generates a full-wave signal to drive a 3-phase BLDC motor. High efficiency and low power consumption are achieved due to CMOS transistors and a synchronous rectification drive type.

4.1 Speed Control

The rotational speed of the motor can be controlled either through the PWM digital input signal or by acting directly on the power supply (V_{DD}). When the PWM signal is High, the motor rotates at full speed. When the PWM signal is low, the IC outputs are set to high-impedance and the motor is stopped.

By changing the PWM duty cycle, the speed can be adjusted. Thus, the user has maximum freedom to choose the PWM system frequency within a wide range (from 1 kHz to 100 kHz).

The PWM pin should not be floating. It can be connected to an external pull-up resistor connected to V_{DD}.

When the PWM duty cycle is below 5%, MTD6508 directly stops the drive (output High Z) and will restart only if the PWM duty cycle is above 5%. If MTD6508 is not in standby mode (PWM duty cycle = 0%), it will not restart unless a “waiting time” (T_{WAIT}) has been spent in order to allow the fan to break enough before the next start-up. T_{WAIT} begins as soon as the PWM duty cycle falls below 5%.

The output transistor activation always occurs at a fixed rate of 30 kHz, which is outside the range of audible frequencies.

Note 1:	The PWM frequency has no direct effect on the motor speed, and is asynchronous with the activation of the output transistors.

4.2 Frequency Generator Function

The Frequency Generator output (FG) is a Hall effect 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 an out-of-sync situation is detected by the driver, this output is set to high-impedance until the motor is restarted. The pin should be left open when it is not used.

EQUATION 4-1:

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

Where:

P = Total number of poles in the motor

S = Total number of slots in the motor

If the FG3_SEL pin is enabled, the rotor speed rotation per minute (RPM) has to be multiplied by three, because the FG signal frequency will be divided by three.

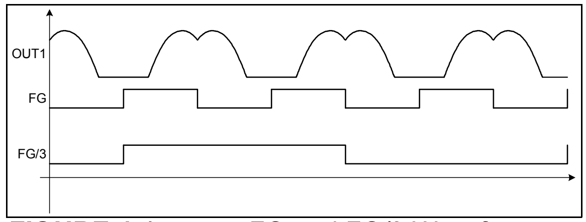


FIGURE 4-1: *FG and FG/3 Waveform.*

4.3 Lock-Up Protection and Automatic Restart

If the motor is blocked and cannot rotate freely, a lock-up protection circuit detects it and disables the driver by setting its outputs to high-impedance to prevent the motor coil from burnout. After a “waiting time” (T_{WAIT}), the lock-up protection is released and normal operation resumes for a given time (T_{RUN}). If 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 required.

4.4 Overcurrent Protection

The motor peak current is limited by the driver to 750 mA (standard value), thus limiting the maximum power dissipation in the coils.

4.5 Thermal Shutdown

The MTD6508 has a thermal protection function which detects when the die temperature exceeds T_J = +170°C. When this temperature is reached, the circuit enters the Thermal Shutdown mode and the outputs OUT1, OUT2 and OUT3 are disabled (high-impedance): avoiding the IC destruction and allowing the circuit to cool down. When the junction temperature (T_J) drops below +145°C, normal operation resumes.

The thermal detection circuit has +25°C hysteresis.

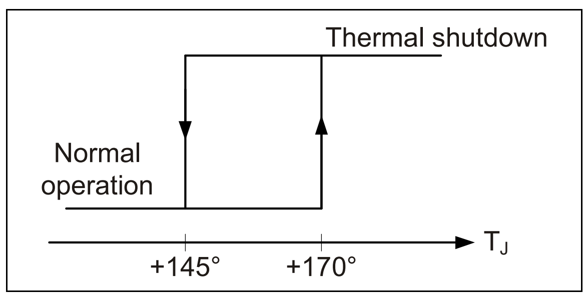


FIGURE 4-2: *Thermal Protection Hysteresis.*

4.6 Overvoltage Shutdown

The MTD6508 has an overvoltage protection function which detects when the V_{DD} voltage exceeds V_{OV} = +7.2V. In Overvoltage condition, outputs OUT1, OUT2 and OUT3 are disabled (high impedance).

4.7 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.

4.8 Back Electromotive Force (BEMF) Coefficient Setting

K_M is the electromechanical coupling coefficient of the motor (also referred to as “motor constant” or “BEMF constant”). Depending on the conventions in use, the exact definition of K_M and its measurement criteria can vary among motor manufacturers. To accommodate various motor applications, the MTD6508 provides options to facilitate various BEMF coefficients.

The MTD6508 defines the BEMF coefficient (K_M) as the peak value of the phase-to-phase BEMF voltage, normalized to the electrical speed of the motor. The following table offers methods to set the K_M value for the MTD6508 device.

TABLE 4-1: K_M SETTINGS

K_M Option	K_M (mV/Hz) Range Phase-to-Phase		R_{PROG}
	Min.	Max.	
K_M0	3.25	6.5	GND
K_M1	6.5	13	24 kΩ
K_M2	13	26	3.9 kΩ
K_M3	26	52	V_{BIAS}

R_{PROG} sensing is actually a sequence that is controlled by the firmware. For any given R_{PROG}, the internal control block will output the corresponding K_M range.

4.9 Start-up Output PWM Slew Rate Control

In order to reduce vibration, the output PWM slew rate can be adjusted with R_{SR} during start-up. Refer to Table 4-2 when choosing the R_{SR} value. A rate that is too slow can decrease the efficiency of the IC. The recommended R_{SR} range is from 4.7 kΩ to 47 kΩ. The R_{SR} will be connected between pins SR1 and SR2. Once the start-up open loop is finished, the MTD6508 will automatically switch to a fixed slew rate, corresponding to 10 kΩ or 100 ns (typical).

TABLE 4-2: SLEW RATE SETTINGS

R_{SR}. Value	Output PWM Transition Time for 10 to 90%	Comment
	Rising/Falling edge	
x kΩ	x ∗ 10.64 ns	Transition rate equation
4.7 kΩ	50 ns	Fast transition
10 kΩ	100 ns	Typical transition
47 kΩ	500 ns	Slow transition

Note: Slew rate adjustment on start-up can only be done in the adjustable version of the MTD6508.

4.10 Motor Rotation Direction Pin (DIR)*

The current-carrying order of the outputs depends on the DIR pin state “Rotation Direction”, and is described in Table 4-3. The DIR pin level is latched after power-on or after exiting standby mode. The DIR pin is not designed for dynamic direction change during operation. The pin is internally connected to GND on the non-adjustable version.

TABLE 4-3: MOTOR ROTATION DIRECTION OPTIONS

DIR Pin State	Rotation Direction	Outputs Activation Sequence
Connected to GND or Floating	Forward	OUT1 -> OUT2 -> OUT3
Connected to V_{BIAS} or V_{DD}	Reverse	OUT3 -> OUT2 -> OUT1

***On adjustable version only**

4.11 Strong Start Pin (SS)*

The sinusoidal start-up open-loop phase current amplitude can be defined by the PWM input duty cycle or fixed at 100%. Table 4-4 describes both start-up options. This pin is internally connected to GND on the non-adjustable version.

TABLE 4-4: START-UP OPEN-LOOP CURRENT AMPLITUDE OPTIONS

SS Pin State	Start-up Open-Loop Current Amplitude
Connected to GND or Floating	Soft open-loop start-up (reduced current) – during the start-up open loop, the output amplitude is defined by the input PWM duty cycle (start-up without speed overshoot, with respect to the target speed set by PWM).
Connected to V_{BIAS} or V_{DD}	Strong open-loop start-up – during the start-up open loop, the output amplitude is fixed at 100% (start-up with maximal torque.

***On adjustable version only**

4.12 Regulation Target Pin (RT)*

The RT pin adjusts the phase regulation parameters to allow more stability in applications using 3-Phase BLDC motors attached to a light load. The low-load phase regulation option reduces the speed correction gain by 75% in order to produce smoother behavior. Table 4-5 describes the phase regulation options. The RT pin is internally connected to GND on the non-adjustable version.

TABLE 4-5: PHASE REGULATION OPTIONS

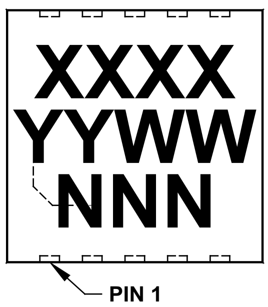
RT Pin State	Phase Regulation Target Options
Connected to GND or Floating	Optimized for typical load (Fan, Pump)
Connected to V_{BIAS} or V_{DD}	Optimized for low load (Motor with light rotor and low air resistance while operating)

***On adjustable version only**

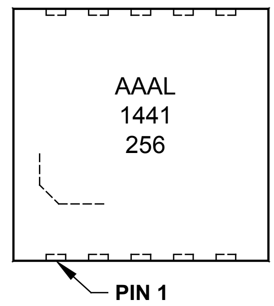
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

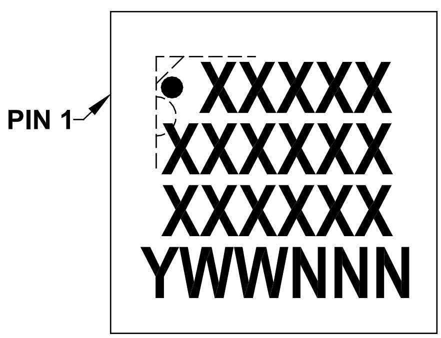
10-Lead UDFN (3x3x0.5 mm)



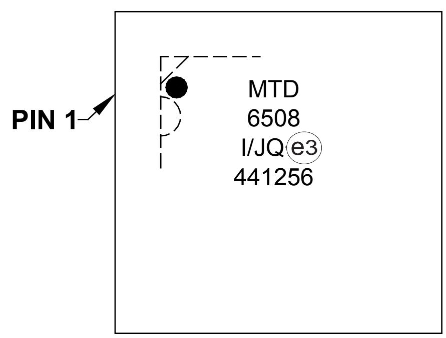
Example



16-Lead UQFN (4x4x0.5 mm)



Example

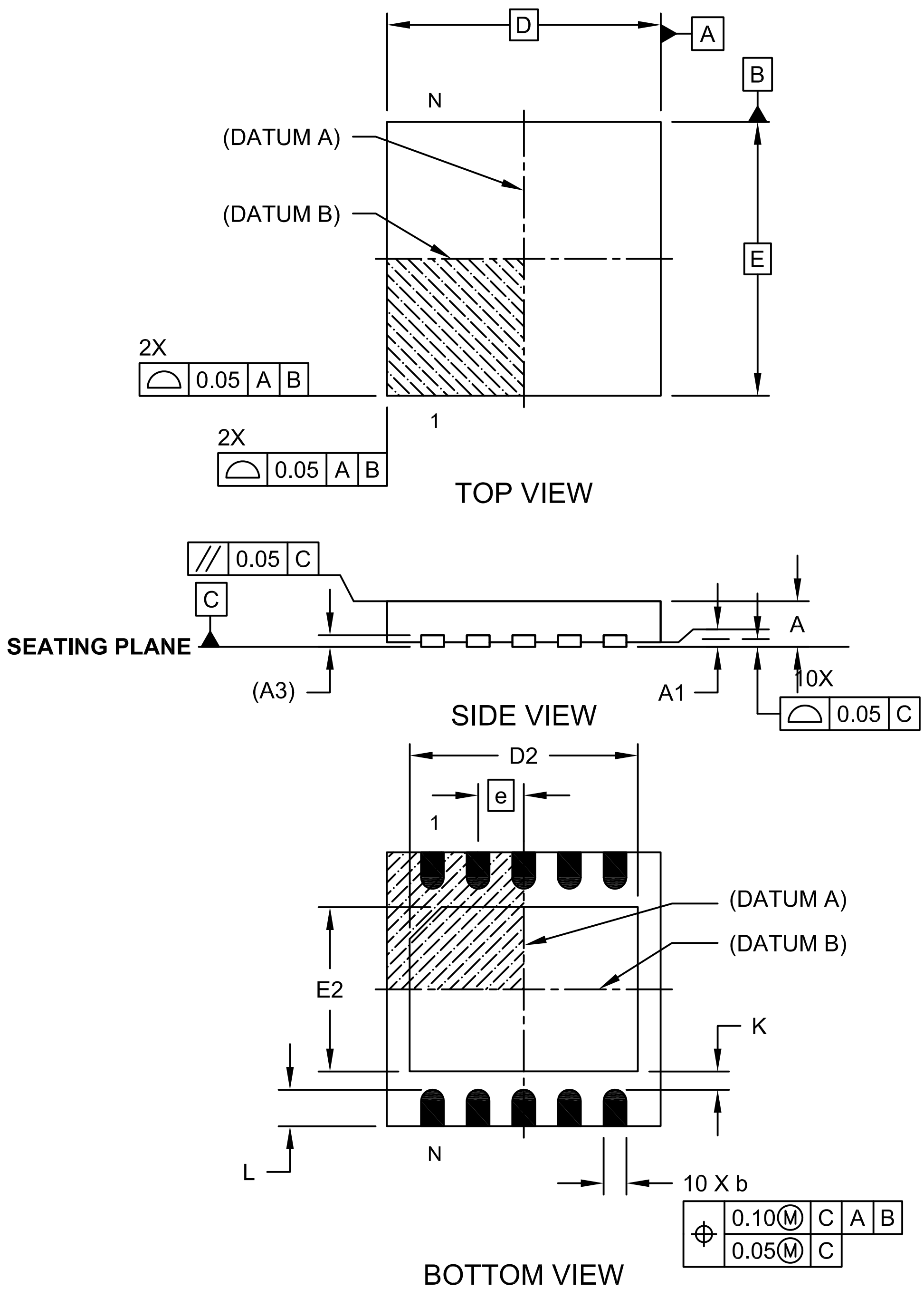


Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The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

10-Lead Ultra-thin Dual Flatpack No-Lead (NA[Y]) – 3x3x0.5 mm Body [UDFN]

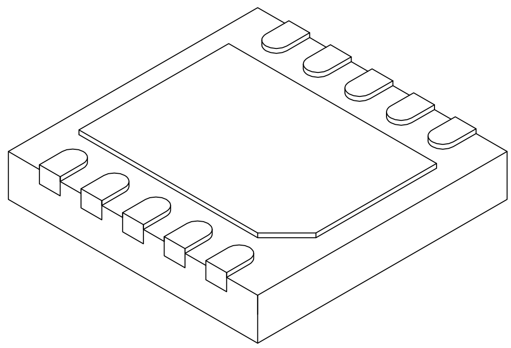
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-194A Sheet 1 of 2

10-Lead Ultra-thin Dual Flatpack No-Lead (NA[Y]) – 3x3x0.5 mm Body [UDFN]

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



	Units	MILLIMETERS		
Dimension	Limits	MIN	NOM	MAX
Number of Pins	N		10	
Pitch	e		0.50 BSC	
Overall Height	A	0.45	0.50	0.55
Standoff	A1	0.00	-	0.05
Overall Length	D		3.00 BSC	
Overall Width	E		3.00 BSC	
Exposed Pad Length	D2	2.40	2.50	2.60
Exposed Pad Width	E2	1.70	1.80	1.90
Terminal Thickness	(A3)		0.127 REF	
Terminal Width	b	0.20	0.25	0.30
Terminal Length	L	0.30	0.40	0.50
Terminal-to-Exposed Pad	K	0.20	-	-

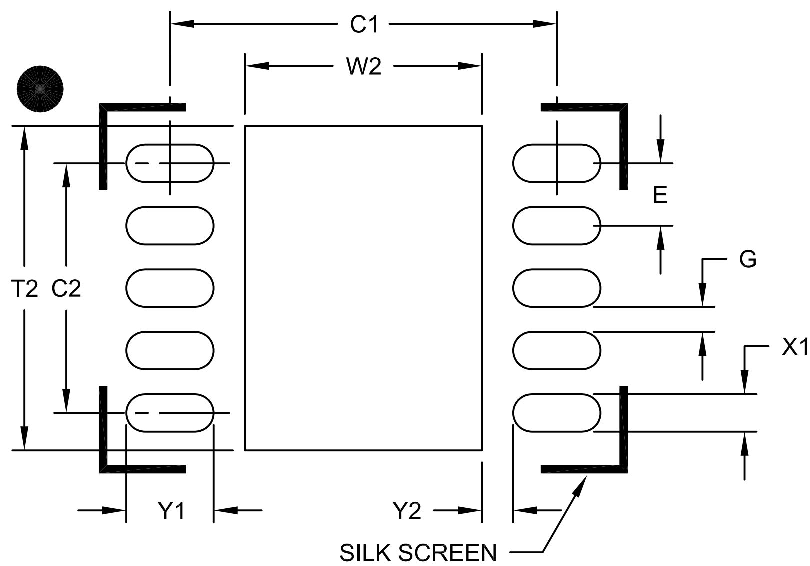
Notes:

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.
2. 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 C04-194A Sheet 2 of 2

10-Lead Ultra-thin Dual Flatpack, No Lead Package (NA[Y]) - 3x3 mm Body (UDFN)

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
Terminal Pitch	E	0.50 BSC		
Optional Center Pad Width	W2			1.90
Optional Center Pad Length	T2			2.60
Terminal Pad Spacing	C1		3.10	
Terminal Pad Spacing	C2		2.00	
Terminal Pad Width (X10)	X1			0.30
Terminal Pad Length (X10)	Y1			0.70
Terminal Pad to Center (X10)	Y2	0.25		
Distance Between Pads	G	0.20		

Notes:

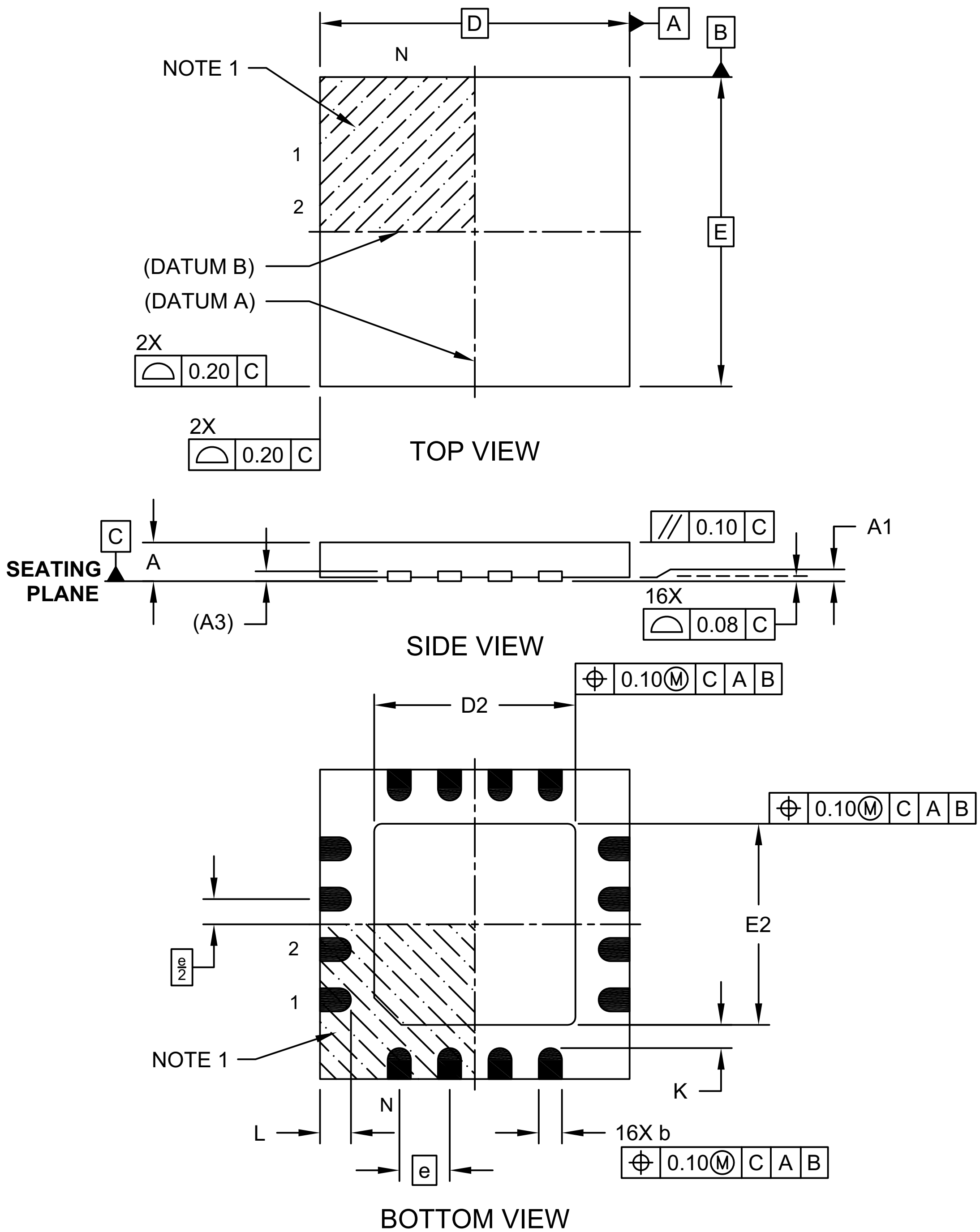
1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2194A

16-Lead Ultra Thin Plastic Quad Flat, No Lead Package (JQ) - 4x4x0.5 mm Body [UQFN]

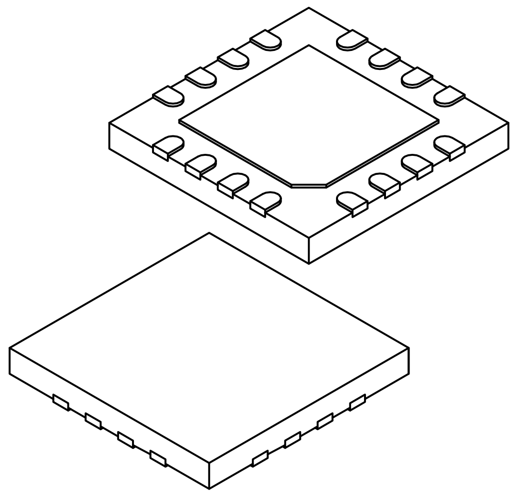
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-257A Sheet 1 of 2

16-Lead Ultra Thin Plastic Quad Flat, No Lead Package (JQ) - 4x4x0.5 mm Body [UQFN]

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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		16	
Pitch	e		0.65 BSC	
Overall Height	A	0.45	0.50	0.55
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.127 REF	
Overall Width	E		4.00 BSC	
Exposed Pad Width	E2	2.50	2.60	2.70
Overall Length	D		4.00 BSC	
Exposed Pad Length	D2	2.50	2.60	2.70
Terminal Width	b	0.25	0.30	0.35
Terminal Length	L	0.30	0.40	0.50
Terminal-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 is saw singulated
3. Dimensioning and tolerancing per ASME Y14.5M

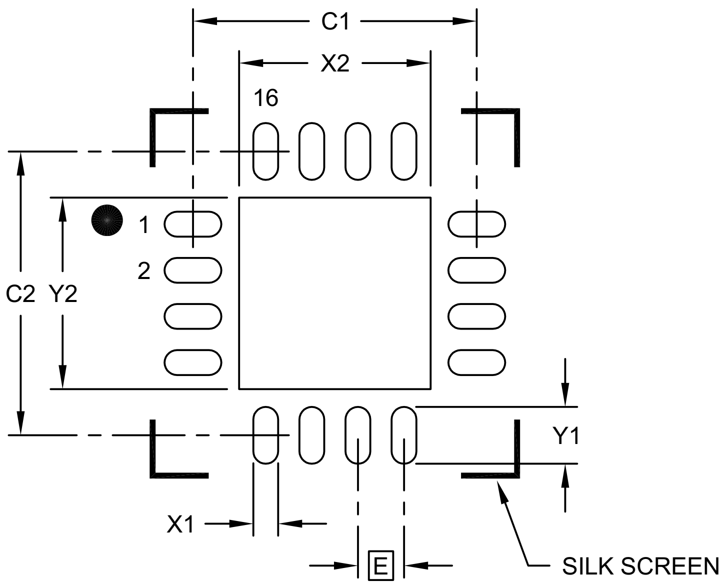
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-257A Sheet 2 of 2

16-Lead Ultra Thin Plastic Quad Flat, No Lead Package (JQ) - 4x4x0.5 mm Body [UQFN]

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		0.65 BSC	
Optional Center Pad Width	X2			2.70
Optional Center Pad Length	Y2			2.70
Contact Pad Spacing	C1		4.00	
Contact Pad Spacing	C2		4.00	
Contact Pad Width (X16)	X1			0.35
Contact Pad Length (X16)	Y1			0.80

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing C04-2257A

APPENDIX A: REVISION HISTORY

Revision A (April 2015)

- 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.	T[(1)]	-X	/XX
Device	Tape & Reel	Temperature	Package

Device:	MTD6508:		3-Phase Brushless DC, Sinusoidal Sensorless Fan Motor Driver
Temperature Range:	E	=	-40°C to +125°C (Extended)
Package:	JQ	=	Ultra Thin Plastic Quad Flat, No-Lead Package (JQ) – 4x4x0.5 mm Body, 16-Lead UQFN
	NA	=	Ultra-thin Dual Flatpack, No-Lead Package (NA[Y]) – 3x3x0.5 mm Body, 10-Lead UDFN

Examples:

a) MTD6508-ADJE/JQ Extended Temperature 16LD 4x4 UQFN package

b) MTD6508T-E/NA Tape and Reel, Extended Temperature 10LD 3x3 UDFN package

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is nto printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

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ISO/TS 16949

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