MTD6501C/D/G

3-Phase Brushless DC Sinusoidal Sensorless Fan Motor Driver

Features

- Position Sensorless BLDC Drivers (No Hall Sensor Required)
- 180° Sinusoidal Drive, for High Efficiency and Low Acoustic Noise
- Support 2V to 14V Power Supplies
- Speed Control Through PAM and/or PWM
- Built-in Frequency Generator (FG Output Signal)
- Built-in Lock-up Protection and Automatic Recovery Circuit (External Capacitor not Necessary)
- Built-in Over Current Limitation and Short Circuit Protection
- Built-in Thermal Shutdown Protection
- Thermally Enhanced SOP-8 Package for MTD6501C and MTD6501G (Maximum Output Current – 800 mA);
- MSOP-10L Package for MTD6501D (Maximum Output Current – 500 mA)
- 20 kHz PWM Output Frequency for MTD6501C/D and 23 kHz for MTD6501G
- Boost Mode (Optional Back Electromotive Force (BEMF) Pre-amplification in MTD6501D)
- No External Tuning Required

The MTD6501C/D/G devices are formerly products of Advanced Silicon.

Description

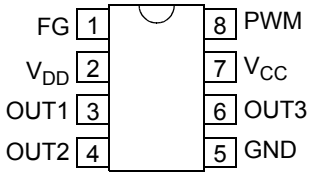
The MTD6501C/D/G devices are 3-phase, full-wave drivers for brushless sensorless DC motors. They feature 180° sinusoidal drive, high torque output, and silent drive. Due to their adaptive features and wide power-supply range capabilities (2V to 14V), they are intended to cover a wide range of motor characteristics, while requiring no external tuning from the user. Speed control can be achieved through either power supply modulation or pulse-width modulation (using the PWM digital input pin).

Due to the compact packaging and minimum bill of materials (power transistors incorporated, no Hall sensor, no external tuning), they are best suited for low-cost fan applications requiring high efficiency and low acoustic noise, such as CPU cooling fans. Frequency generator output enables precision speed control in closed-loop applications. The MTD6501C/D/G drivers include 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 run when the lock condition is removed. Motor overcurrent limitation, short-circuit protection and thermal-shutdown protection are also included.

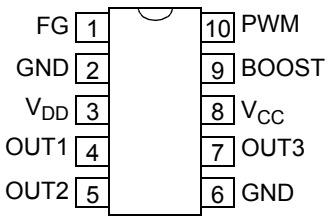
The MTD6501C and the MTD6501G are available in a compact thermally-enhanced SOP-8 package, while the MTD6501D is available in the MSOP-10L package.

Package Types

MTD6501C, MTD6501G
SOP-8

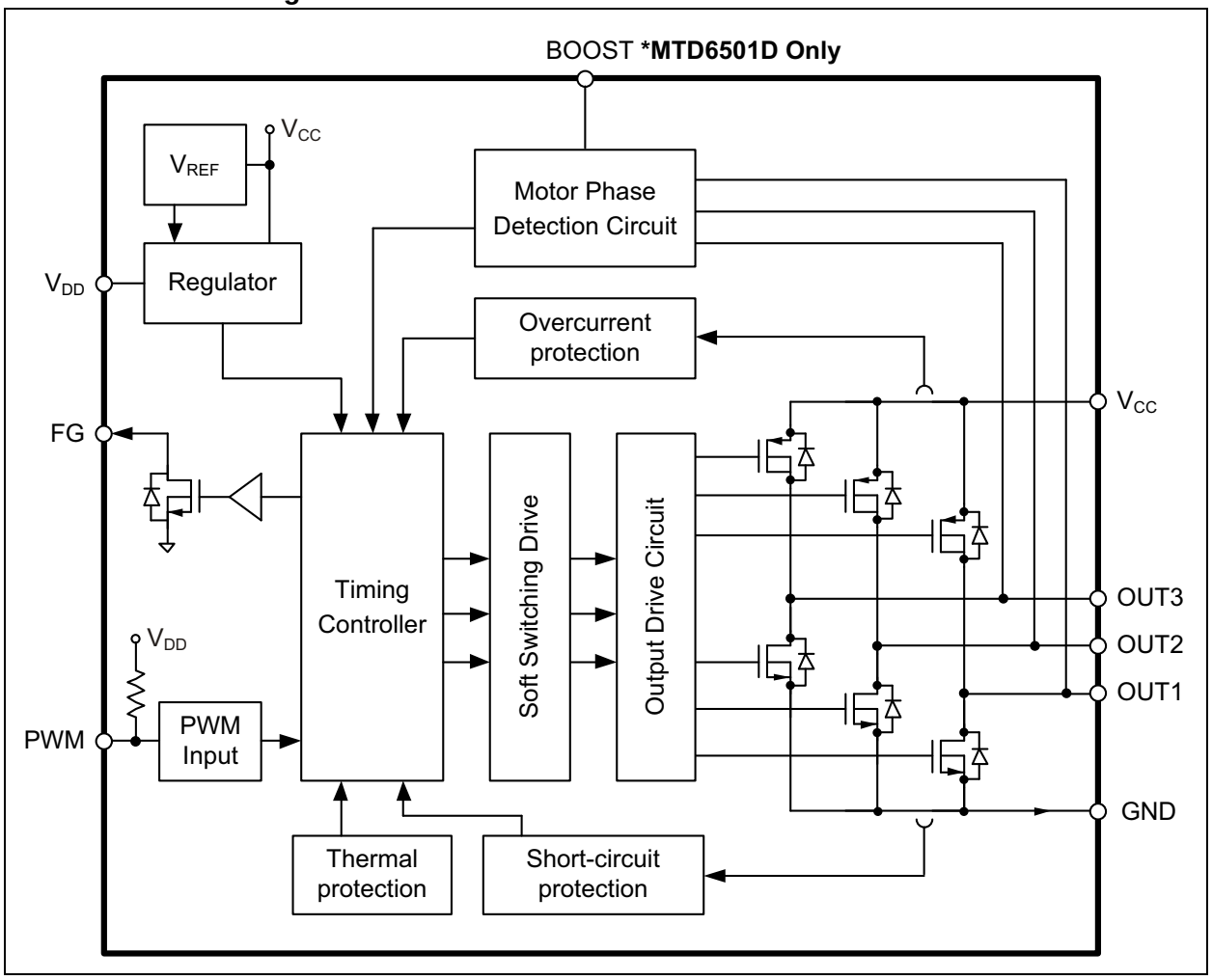


MTD6501D
MSOP



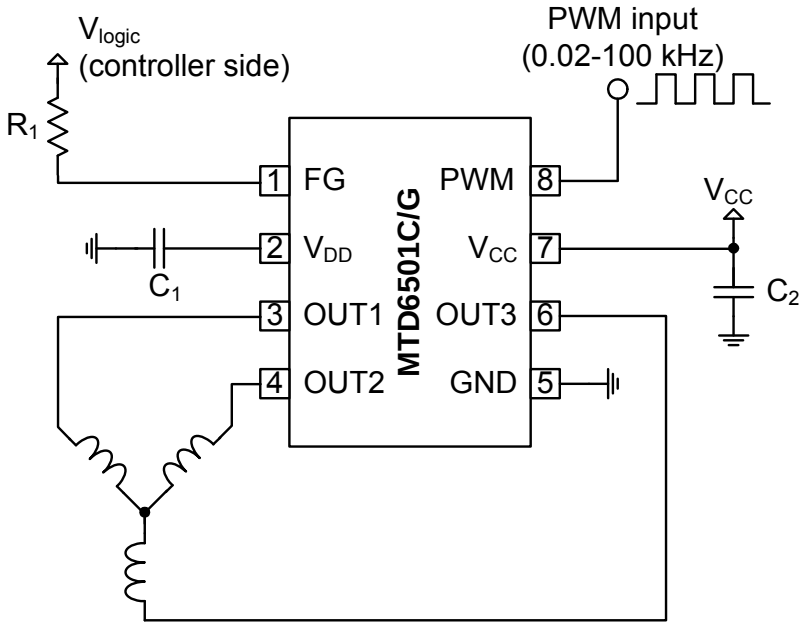
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Functional Block Diagram



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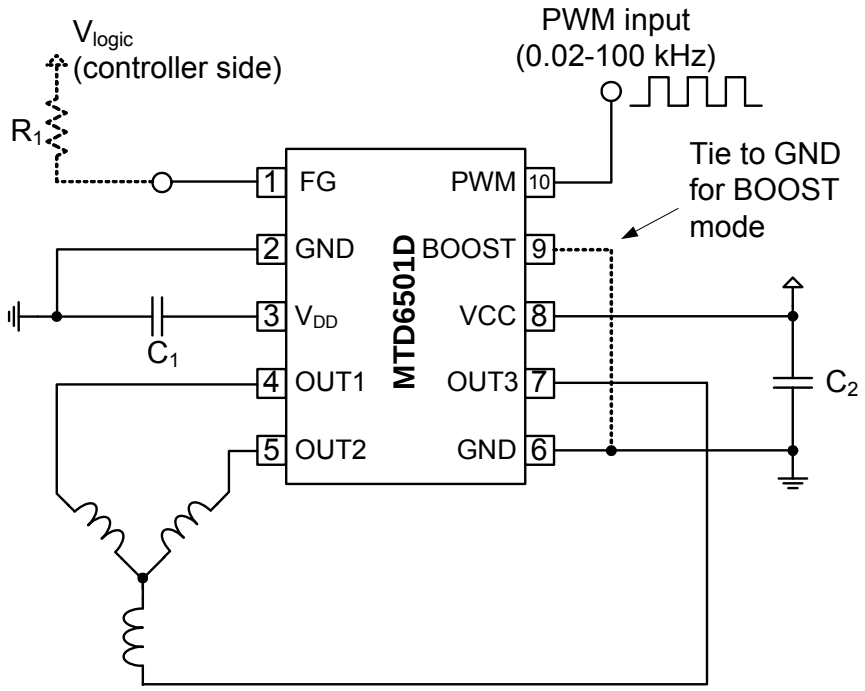
Typical Application – Fan Motor Driver Using the MTD6501C or MTD6501G



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	≥1 µF	Connect as close as possible to IC input pins
R_1	≥10 kΩ	Connect to V_{logic} on controller side

Typical Application – Fan Motor Driver Using the MTD6501D



Recommended External Components for Typical Application

Element	Type/Value	Comment
C1	≥1 µF	Connect as close as possible to IC input pins
C2	≥1 µF	Connect as close as possible to IC input pins
R1	≥10 kΩ	Connect to Vlogic on controller side

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1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

Power Supply Voltage (V_{CC_MAX}) ..... -0.7 to +15.3V
Maximum OUT1, 2, 3 Output Voltage (V_{OUT_MAX}) .....
.....-0.7 to +15.3V+0.7V
FG Maximum Output Voltage (V_{FG_MAX}) ..... -0.7 to +15.3V
Maximum Output Current[3,4] (I_{OUT_MAX}).....800 mA
Maximum Output Current[3,5] (I_{OUT_MAX}).....500 mA
FG Maximum Output Voltage (V_{FG_MAX}) ..... -0.7 to +15.3V
FG Maximum Output Current (I_{FG_MAX}).....5.0 mA
V_{DD} Maximum Voltage (V_{DD_MAX}) ..... -0.7 to +4.0V
PWM Maximum Voltage (V_{PWM_MAX}) ..... -0.7 to +4.0V
Allowable Power Dissipation[1,2,4](P_{D_MAX}).....1.0W
Allowable Power Dissipation[1,2,5](P_{D_MAX}).....0.5W
Max Junction Temperature (T_J).....+150°C

† **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).

4: MTD6501C and MTD6501G

5: MTD6501D

ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise specified, all limits are established for V_{CC} = 5.0V, T_A = +25°C

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Power Supply Voltage	V_{CC}	2	—	14	V	
Power Supply Current	I_{VCC}	—	10	—	mA	Rotation Mode
			5			Lock-Protection Mode
OUTx High Resistance	$R_{ON(H)}$	—	0.75	1	Ω	I_{OUT} = 0.5A, V_{CC} = 3.3V to 14V
OUTx Low Resistance	$R_{ON(L)}$	—	0.75	1	Ω	I_{OUT} = -0.5A, V_{CC} = 3.3V to 14V
OUTx Total Resistance	$R_{ON(H+L)}$	—	1.5	2	Ω	I_{OUT} = 0.5A, V_{CC} = 3.3V to 14V
V_{DD} Output Voltage	V_{DD}	—	3	—	V	V_{CC} = 3.3V to 14V
			V_{CC} – 0.2		V	V_{CC} < 3.3V
PWM Input Frequency	f_{PWM}	0.02	—	100	kHz	—
PWM Input H Level	V_{PWM_H}	0.8*V_{DD}	—	3.6	V	—
PWM Input L Level	V_{PWM_L}	0	—	0.2*V_{DD}	V	—
PWM Internal Pull-Up Current	I_{PWM_L}	17	34	—	µA	PWM = GND, V_{CC} = 3.3V to 14V
		8	17	—	µA	PWM = GND, V_{CC} < 3.3V
PWM Output Frequency	f_{PWM_O}	—	20	—	kHz	**MTD6501C** and **MTD6501D**
			23		kHz	**MTD6501G**
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}	4.5	5	5.5	s	—
Thermal Shutdown	T_{SD}	—	170	—	°C	—
Thermal Shutdown Hysteresis	T_{SD_HYS}	—	25	—	°C	—

TEMPERATURE SPECIFICATIONS

Electrical Specifications: Unless otherwise specified, all limits are established for V_{CC} = 5.0V, T_A = +25°C						
Parameters	**Sym.**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
Temperature Ranges						
Operating Temperature	T_{OPR}	-30	—	+95	°C	
Storage Temperature Range	T_{STG}	-55	—	+150	°C	

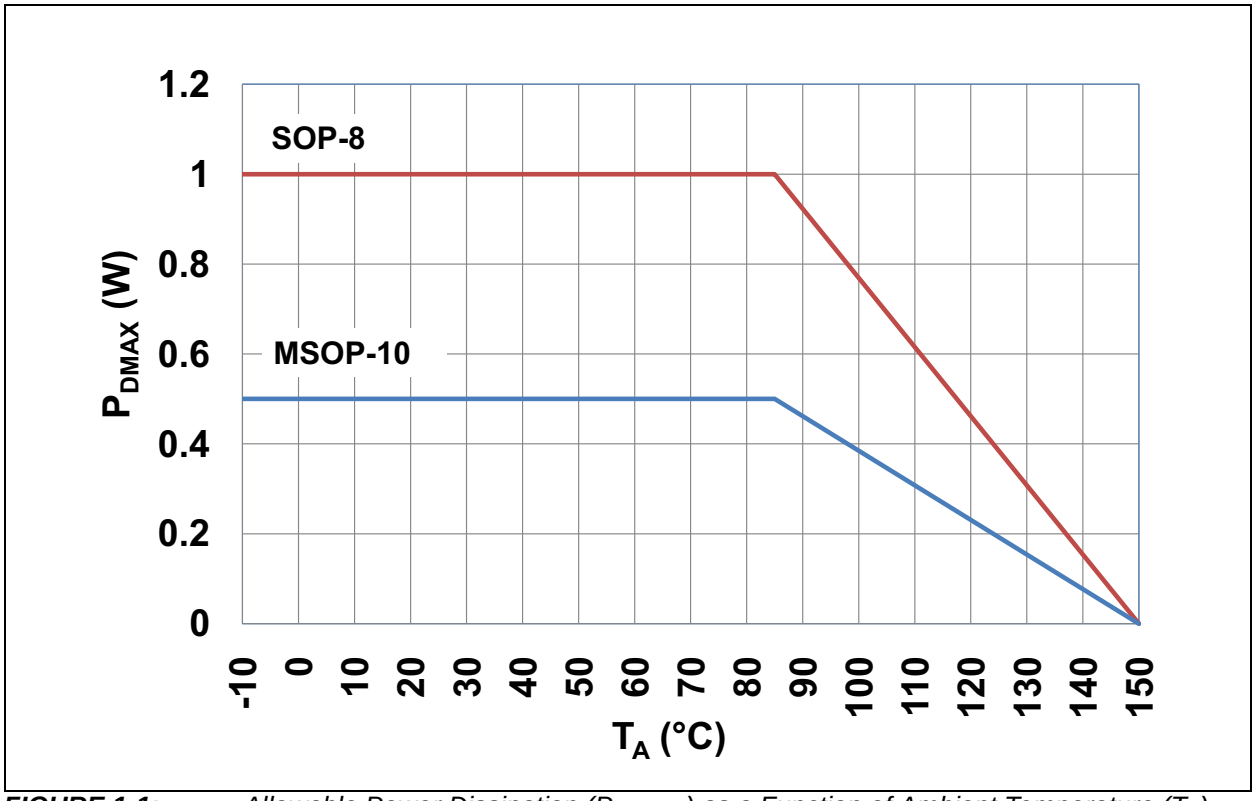


FIGURE 1-1: *Allowable Power Dissipation (P_{D_MAX}) as a Function of Ambient Temperature (T_A).*

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2.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 2-1.

TABLE 2-1: MTD6501C/D/G PIN FUNCTION TABLE

MTD6501C, MTD6501G	MTD6501D	Type	Symbol	Description
SOP-8	MSOP			
1	1	O	FG	Motor speed indication output
2	3	P	V_{DD}	Internal regulator output (for decoupling only)
3	4	O	OUT1	Single-phase coil output pin
4	5	O	OUT2	Single-phase coil output pin
5	2, 6	P	GND	Negative voltage supply (ground)
6	7	O	OUT3	Single-phase coil output pin
7	8	P	V_{CC}	Positive voltage supply for motor driver
8	10	I	PWM	PWM input signal for speed control
N/A	9	I	BOOST	Boost mode selection: • Pin floating for Normal mode • Pin tied to GND for Boost mode

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

NOTES:

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3.0 FUNCTIONAL DESCRIPTION

The MTD6501C/D/G 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.

3.1 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_{CC}). 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 IC 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 of the range of audible frequencies. The MTD6501C and MTD6501D typical output frequency is 20 kHz. The MTD6501G output frequency is 23 kHz.

3.2 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, the speed in RPMs is 30 FG frequency (Hz).

3.3 Lockup 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 disables the driver (by setting its outputs to high-impedance) in order 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}). 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.

3.4 Overcurrent Protection and Short Circuit Detection

The motor peak current is limited by the driver to a fixed value (defined internally), thus limiting the maximum power dissipation in the coils. The detection of a short-circuit situation immediately sets the driver outputs to high-impedance, in order to avoid permanent damage to the IC.

3.5 Thermal Shutdown

The MTD6501C/D/G have 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 disabled (high-impedance), avoiding IC destruction and allowing the circuit to cool down. Once the junction temperature (T_{SD}) has dropped below +145°C, the normal operation resumes (thermal detection circuit has +25°C hysteresis function).

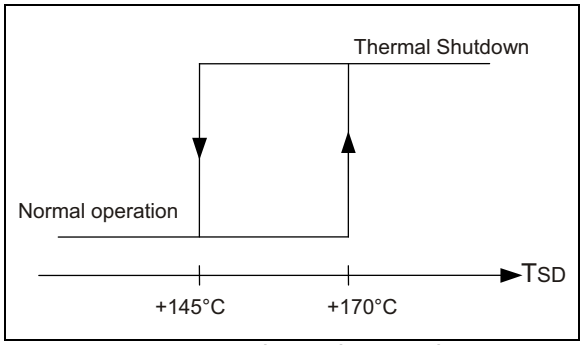


FIGURE 3-1: *Thermal Protection Hysteresis.*

3.6 Internal Voltage Regulator

V_{DD} voltage is generated internally and is used to supply internal logical blocks. The V_{DD} 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.

3.7 Boost Mode (MTD6501D)

The Boost mode is an optional BEMF pre-amplification by a factor of three. The intention of Boost mode is to compensate for motors with a low coupling coefficient (= BEMF coefficient), thus allowing it to cover an even wider range of motor characteristics. Notice that Boost mode impacts the mechanical performance of the motor altogether. In Boost mode, the speed of the motor will adjust faster to variations of the control (V_{CC} or PWM) and/or of the load, including at start-up. However, when the BEMF is amplified too much, the mechanical performance (in terms of vibration and acoustic noise) may start degrading. Thus, Boost mode may be inappropriate for motors that already have a good coupling coefficient. The optimum choice between normal mode and Boost mode depends both on the application requirements and on the motor characteristics.

Refer to Table 3-1 for usage of Boost pin 9; leaving this pin floating results in the normal mode of operation, while tying this pin to GND activates Boost mode (active low feature, internal pull-up).

TABLE 3-1: POSSIBLE MODES OF OPERATION BASED ON THE BOOST PIN CONNECTION

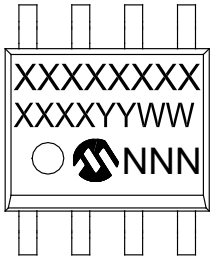
BOOST Pin	Mode of Operation
Floating	Normal
Tied to GND	Boost

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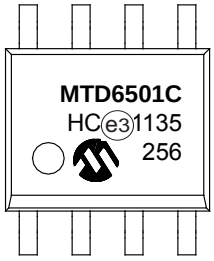
4.0 PACKAGING INFORMATION

4.1 Package Marking Information

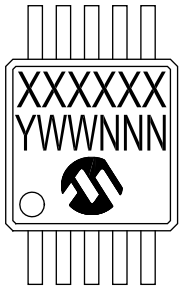
8-Lead SOP (3.90 mm) **(MTD6501C, MTD6501G)**



Example



10-Lead MSOP **(MTD6501D)**



Example

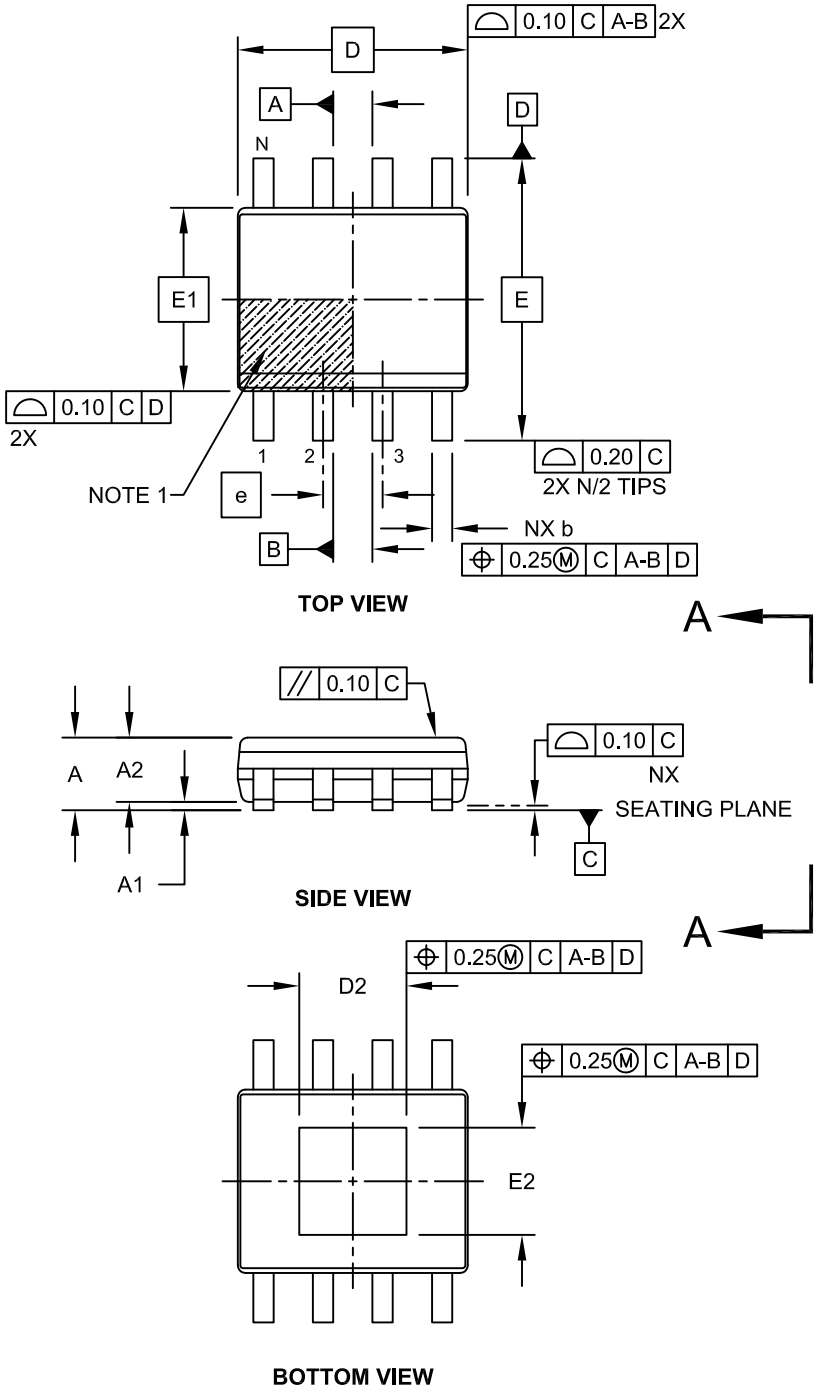


Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free 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 Thermally Enhanced Plastic Small Outline (SE) - Narrow, 3.90 mm Body [SOP]

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

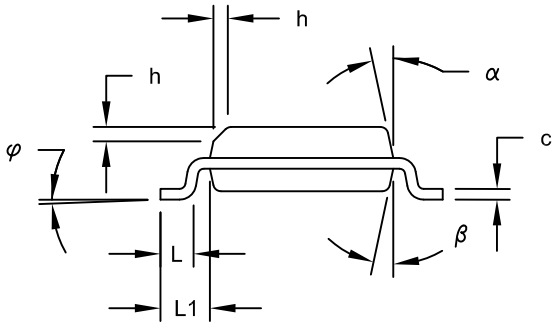


Microchip Technology Drawing No. C04-121A Sheet 1 of 2

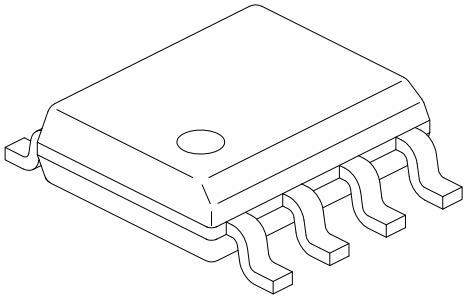
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8-Lead Thermally Enhanced Plastic Small Outline (SE) - Narrow, 3.90 mm Body [SOP]

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



VIEW A-A



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		8	
Pitch	e		1.27	
Overall Height	A	-	-	1.75
Molded Package Thickness	A2	1.25	-	-
Standoff §	A1	0.00	-	0.15
Overall Width	E	5.80	6.00	6.20
Molded Package Width	E1	3.80	3.90	4.00
Overall Length	D	4.70	4.90	5.10
Exposed Pad Width	E2	2.19	2.29	2.39
Exposed Pad Length	D2	2.19	2.29	2.39
Chamfer (Optional)	h	0.25	-	0.50
Foot Length	L	0.40	-	1.27
Footprint	L1	1.04	1.04	1.04
Foot Angle	φ	0°	-	8°
Lead Thickness	c	0.17	-	0.25
Lead Width	b	0.31	-	0.51
Mold Draft Angle Top	α	5°	-	15°
Mold Draft Angle Bottom	β	5°	-	15°

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
4. Dimensioning and tolerancing per ASME Y14.5M

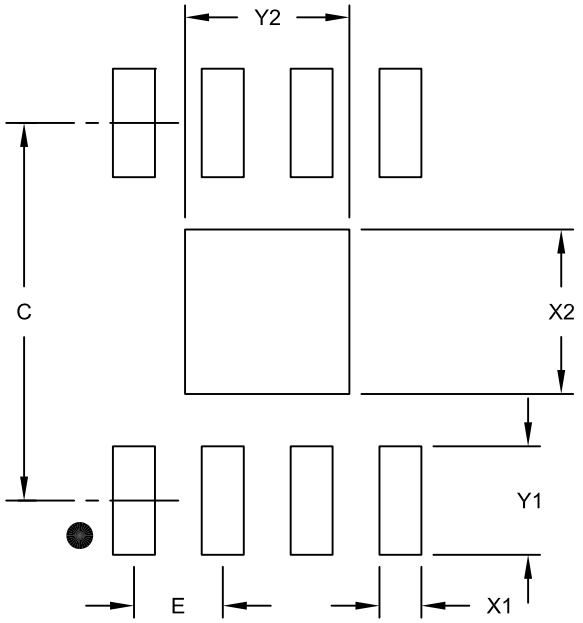
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

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

Microchip Technology Drawing No. C04-121A Sheet 2 of 2

8-Lead Thermally Enhanced Plastic Small Outline (SE) - Narrow, 3.90 mm Body [SOP]

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		1.27 BSC	
Contact Pad Spacing	C		5.40	
Contact Pad Width (X8)	X1			0.60
Contact Pad Length (X8)	Y1			1.55
Exposed Pad Width	X2			2.35
Exposed Pad Length	Y2			2.35

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

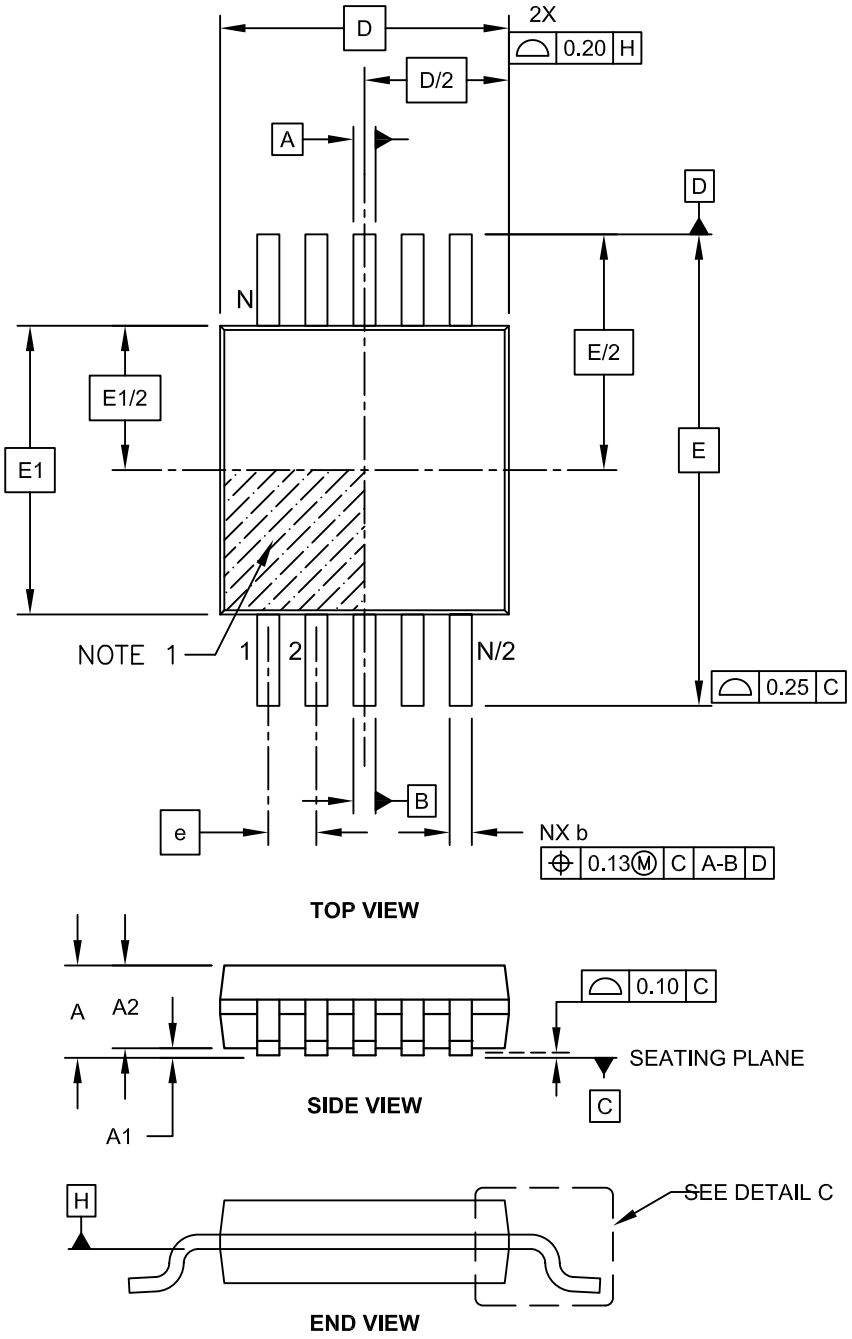
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2121A

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10-Lead Plastic Micro Small Outline Package (MS) [MSOP]

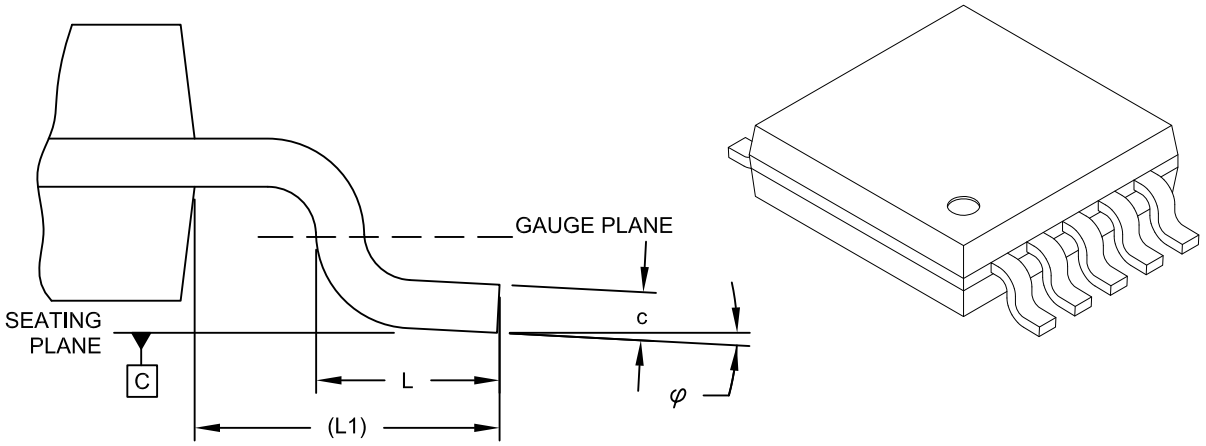
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-021C Sheet 1 of 2

10-Lead Plastic Micro Small Outline Package (MS) [MSOP]

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



DETAIL C

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		10	
Pitch	e		0.50 BSC	
Overall Height	A	-	-	1.10
Molded Package Thickness	A2	0.75	0.85	0.95
Standoff	A1	0.00	-	0.15
Overall Width	E		4.90 BSC	
Molded Package Width	E1		3.00 BSC	
Overall Length	D		3.00 BSC	
Foot Length	L	0.40	0.60	0.80
Footprint	L1		0.95 REF	
Foot Angle	φ	0°	-	8°
Lead Thickness	c	0.08	-	0.23
Lead Width	b	0.15	-	0.33

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
3. Dimensioning and tolerancing per ASME Y14.5M.

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

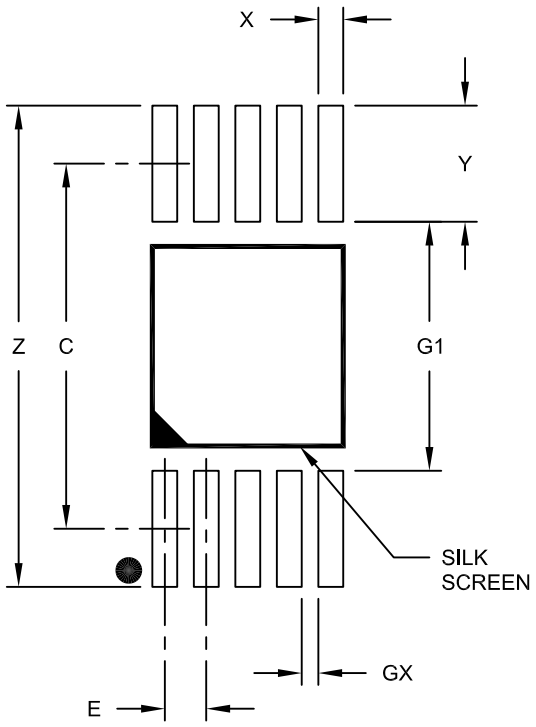
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-021C Sheet 2 of 2

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10-Lead Plastic Micro Small Outline Package (MS) [MSOP]

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		0.50 BSC	
Contact Pad Spacing	C		4.40	
Overall Width	Z			5.80
Contact Pad Width (X10)	X1			0.30
Contact Pad Length (X10)	Y1			1.40
Distance Between Pads	G1	3.00		
Distance Between Pads	GX	0.20		

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2021A

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NOTES:

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APPENDIX A: REVISION HISTORY

Revision B (May 2012)

The following is the list of modifications:

1. Added the MTD6501G device to the family and related information throughout the document.
2. Updated the **Temperature Specifications** table.
3. Sorted the information in Table 2-1.
4. Corrected Frequency Generator output to open drain in **Section 3.2 "Frequency Generator Function"**.
5. Renamed **Section 4.0 "Packaging Information"**. Added **Section 4.1 "Package Marking Information"**.
6. Added **Product Identification System** section.
7. Other minor typographical corrections.

Revision A (September 2010)

- Original data sheet for the MTD6501C/D/G family of devices.

NOTES:

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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	XX
Device	Tube/Tape and Reel	Package

Device	MTD6501C-H:	3-Phase BLDC Sinusoidal Sensorless Fan Motor Driver (I_{OUT} maximum 800 mA, PWM 20 kHz) (Tube)
	MTD6501C-L:	3-Phase BLDC Sinusoidal Sensorless Fan Motor Driver (I_{OUT} maximum 800 mA, PWM 20 kHz) (Tape and Reel)
	MTD6501D-H:	3-Phase BLDC Sinusoidal Sensorless Fan Motor Driver (I_{OUT} maximum 500 mA, PWM 20 kHz, Boost option) (Tube)
	MTD6501D-L:	3-Phase BLDC Sinusoidal Sensorless Fan Motor Driver (I_{OUT} maximum 500 mA, PWM 20 kHz, Boost option) (Tape and Reel)
	MTD6501G-H:	3-Phase BLDC Sinusoidal Sensorless Fan Motor Driver (I_{OUT} maximum 800 mA, PWM 23 kHz) (Tube)
	MTD6501G-L:	3-Phase BLDC Sinusoidal Sensorless Fan Motor Driver (I_{OUT} maximum 800 mA, PWM 23 kHz) (Tape and Reel)
Package	C1* =	8-Lead Plastic Small Outline – Thermally Enhanced Package (SOP)
	=	10-Lead Plastic Micro Small Outline Package (MSOP)

* These devices are formerly products of Advanced Silicon

Examples:

a)	MTD6501C-HC1	Tube, 8LD SOP Package
b)	MTD6501C-LC1	Tape and Reel, 8LD SOP Package
c)	MTD6501D-HC1	Tube, 10LD MSOP Package
d)	MTD6501D-LC1	Tape and Reel, 10LD MSOP Package
e)	MTD6501G-HC1	Tube, 8LD SOP Package
f)	MTD6501G-LC1	Tape and Reel, 8LD SOP Package

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