MTD6502B

5V 3-Phase BLDC 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 5.5V Power Supplies
- Direction Control:
  - Forward direction: connect DIR pin to GND or leave floating
  - Reverse direction: connect DIR pin to V_{DD}
- Speed Control through Power Supply Modulation (PSM) and/or Pulse-Width Modulation (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
- Built-in Thermal Shutdown Protection
- No External Tuning Required
- Available Packages:
  - 3 mm x 3 mm TDFN-10

Applications:

- Notebook CPU Cooling Fans
- 5V 3-Phase Brushless DC Motors

Description:

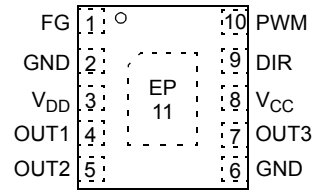
The MTD6502B device is a 3-phase full-wave driver for brushless sensorless DC motors. It features 180° sinusoidal drive, high torque output and silent drive. With adaptive features, parameters and a wide range of power-supplies (2V to 5.5V), the MTD6502B device is intended to cover a wide range of motor characteristics, while requiring minimum external components. Speed control can be achieved through either power supply modulation or pulse-width modulation (using the PWM digital input pin).

With the compact packaging and minimum bill-of-material (integrated power transistors, no Hall sensor, no external tuning), the MTD6502B is best suited for low-cost fan applications requiring high efficiency and low acoustic noise, such as notebook CPU cooling fans. Frequency generator (FG) output enables the precision speed control in closed-loop applications. The MTD6502B 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 run when the lock condition is removed. The motor overcurrent limitation and thermal-shutdown protection are included for safety-enhanced operations.

The MTD6502B is available in a compact thermally-enhanced 3 mm x 3 mm TDFN package.

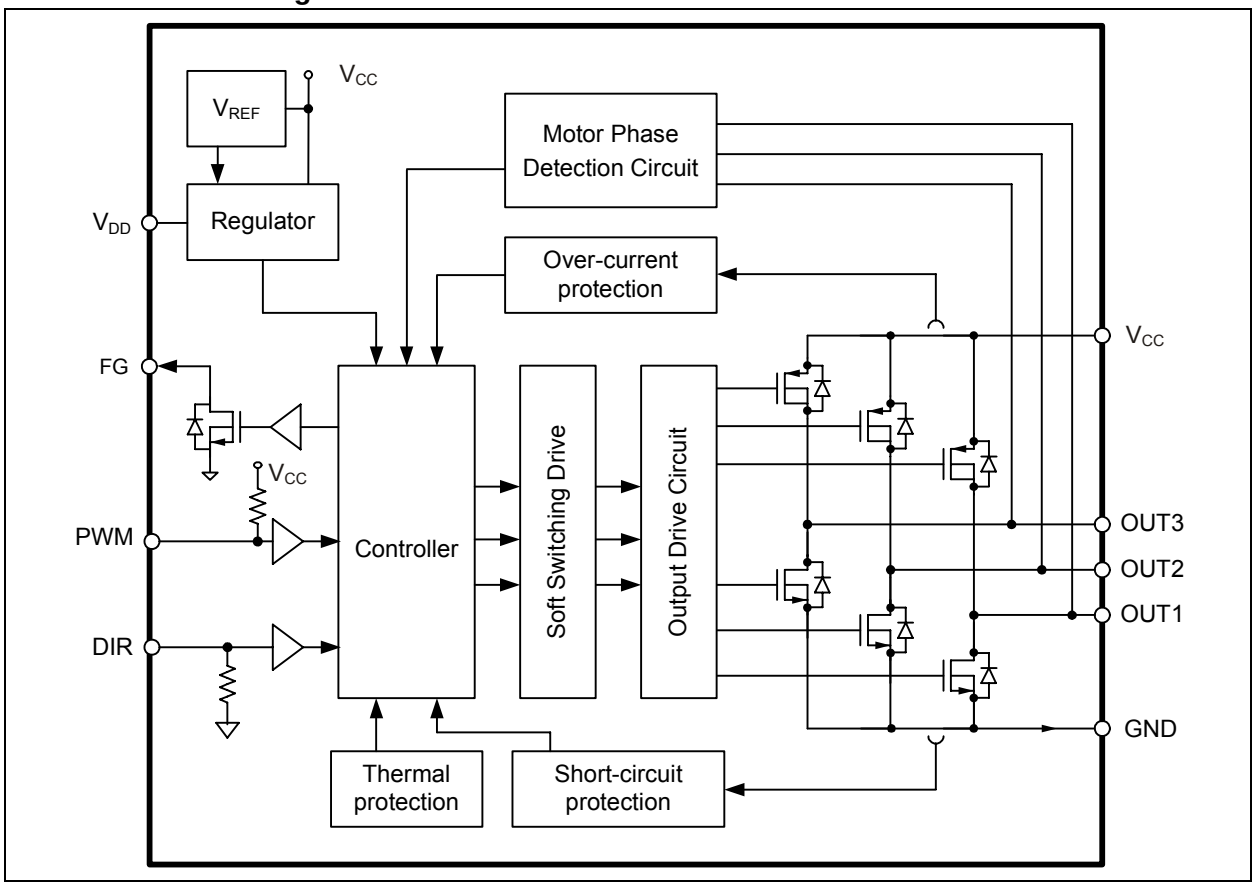
Package Types

MTD6502B
3x3 TDFN*

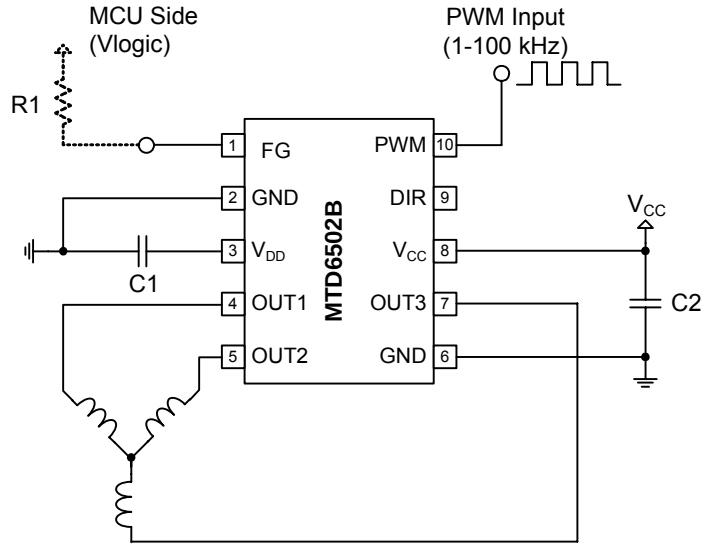


* Includes Exposed Thermal Pad (EP); see Table 2-1.

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 pins
C2	≥1 µF	Connect as close as possible to IC input pins
R1	≥10 kΩ	Connect to Vlogic on microcontroller side

NOTES:

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

Power Supply Voltage (V_{CC_MAX}) ..... -0.7 to +7.0V
Maximum Output Voltage (V_{OUT_MAX}) ..... -0.7 to +7.0V
Maximum Output Current[2] (I_{OUT_MAX}) .....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_{DD} Maximum Voltage (V_{DD_MAX}) ..... -0.7 to +4.0V
PWM Maximum Voltage (V_{PWM_MAX}) ..... -0.7 to +7.0V
Allowable Power Dissipation[2] (P_{D_MAX}).....1.5W
Maximum 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: I_{OUT} is also internally limited, according to limits defined in the Electrical Characteristics.

ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise specified, all limits are established for T_A = +25°C

Parameters	Sym	Min	Typ	Max	Units	Conditions
Power Supply Voltage	V_{CC}	2	—	5.5	V	
Power Supply Current	I_{VCC}	—	50	—	µA	PWM = 0, V_{CC} = 5V
OUTx High Resistance	$R_{ON(H)}$	—	0.75	1	Ω	I_{OUT} = 0.5A, V_{CC} = 5V
OUTx Low Resistance	$R_{ON(L)}$	—	0.75	1	Ω	I_{OUT} = 0.5A, V_{CC} = 5V
OUTx Total Resistance	$R_{ON(H+L)}$	—	1.5	2	Ω	I_{OUT} = 0.5A, V_{CC} = 5V
V_{DD} Output Voltage	V_{DD}	—	3	—	V	V_{CC} = 3.3V to 5.5V
		—	V_{CC} – 0.2	—	V	V_{CC} < 3.3V
PWM Input Frequency	f_{PWM}	1	—	100	kHz	
PWM Input H Level	V_{PWM_H}	0.55*V_{CC}	—	V_{CC}	V	
PWM Input L Level	V_{PWM_L}	0	—	0.2*V_{CC}	V	
PWM Internal Pull-Up Current	I_{PWM_L}	—	—	55	µA	PWM = 0
DIR Internal Pull-Down Current	I_{DIR}	—	20	—	µA	
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} = 5.5V
Lock Protection Operating Time	T_{RUN}	—	0.5	—	s	
Lock Protection Waiting Time	T_{WAIT}	4.5	5	5.5	s	
Overcurrent Protection	I_{OC_MOT}	—	750	—	mA	
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}	-40	—	+125	°C	
Storage Temperature Range	T_{STG}	-55	—	+150	°C	
Thermal Package Resistances						
Thermal Resistance, 10L-TDFN	θ_{JA}	—	68	—	°C/W	

2.0 PIN DESCRIPTIONS

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

TABLE 2-1: MTD6502B PIN FUNCTION TABLE

MTD6502B 3x3 TDFN	Type	Name	Function
1	O	FG	Motor speed indication output
2, 6	—	GND	Negative voltage supply (ground)
3	—	V_{DD}	Internal regulator output (for decoupling only)
4	O	OUT1	Single phase coil output pin
5	O	OUT2	Single phase coil output pin
7	O	OUT3	Single phase coil output pin
8	—	V_{CC}	Positive voltage supply for motor driver
9	I	DIR	Motor Rotation Direction: - Forward direction: connect pin to GND or leave floating - Reverse direction: connect pin to V_{DD}
10	I	PWM	PWM input signal for speed control
11	—	EP	Exposed Thermal Pad (EP)

Legend: I = Input; O = Output

NOTES:

3.0 FUNCTIONAL DESCRIPTION

The MTD6502B generates a full-wave signal to drive a 3-phase sensorless BLDC motor. High efficiency and low-power consumption are achieved due to the CMOS transistors and synchronous rectification drive type.

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 the maximum freedom to choose the PWM system frequency within a wide range (from 1 kHz to 100 kHz), while the output transistor activation always occurs at a fixed rate (20 kHz, or 30 kHz), which is outside of the range of audible frequencies.

Note:	The standard output frequency is 30 kHz. The 20 kHz output frequency option is available upon request.

3.2 Motor Rotation Direction

The current carrying order of the outputs depends on the DIR pin state (Rotation Direction) according to Table 3-1.

TABLE 3-1: MOTOR ROTATION DIRECTION OPTIONS (DIR PIN)

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

3.3 Frequency Generator Function

The Frequency Generator output (FG) is a “Hall-sensor equivalent” digital output, that gives information to an external controller about the speed and phase of the motor. The FG pin is an open collector 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.

Note:	FG/2 option is available upon request for 8-pole applications.

3.4 Lock-up Protection and Automatic Restart

If the motor is blocked and cannot rotate freely, 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}). 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 needed.

3.5 Overcurrent Protection

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

3.6 Thermal Shutdown

The MTD6502B has a thermal protection function which detects when the die temperature exceeds T_J = +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 the IC destruction and allowing the circuit to cool down. Once the junction temperature (T_J) has dropped below +145°C, the normal operation resumes (thermal detection circuit has +25°C hysteresis function).

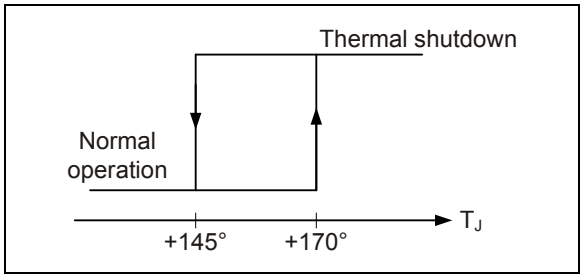


FIGURE 3-1: *Thermal Protection Hysteresis.*

3.7 Internal Voltage Regulator

V_{DD} voltage is generated internally and is used to supply the 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.

3.8 BEMF Coefficient Setting

Km is the electro-mechanical coupling coefficient of the motor (also referred to as “motor constant” or “BEMF constant”). Depending on the conventions in use, there may be some inconsistency in the exact definition of Km and its measurement criteria among different motor manufacturers. In order to work with various motor applications, the MTD6502B offers various options to adopt a wide range of BEMF coefficient. The BEMF coefficient (Km) is defined as the peak value of the phase-to-phase BEMF voltage, normalized to the electrical speed of the motor.

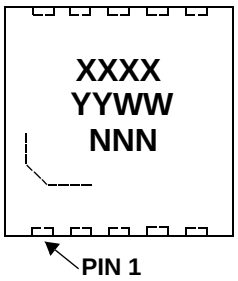
TABLE 3-2: KM OPTIONS

Km (mV/Hz) Range Phase-to-Phase		Option
Min	Max	
3.25	6.5	0
6.5	13	1
13	26	2

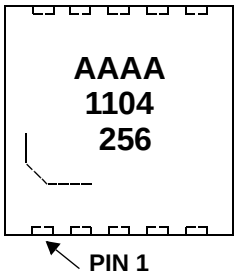
4.0 PACKAGING INFORMATION

4.1 Package Marking Information

10-Lead TDFN (3x3x0.9 mm)



Example



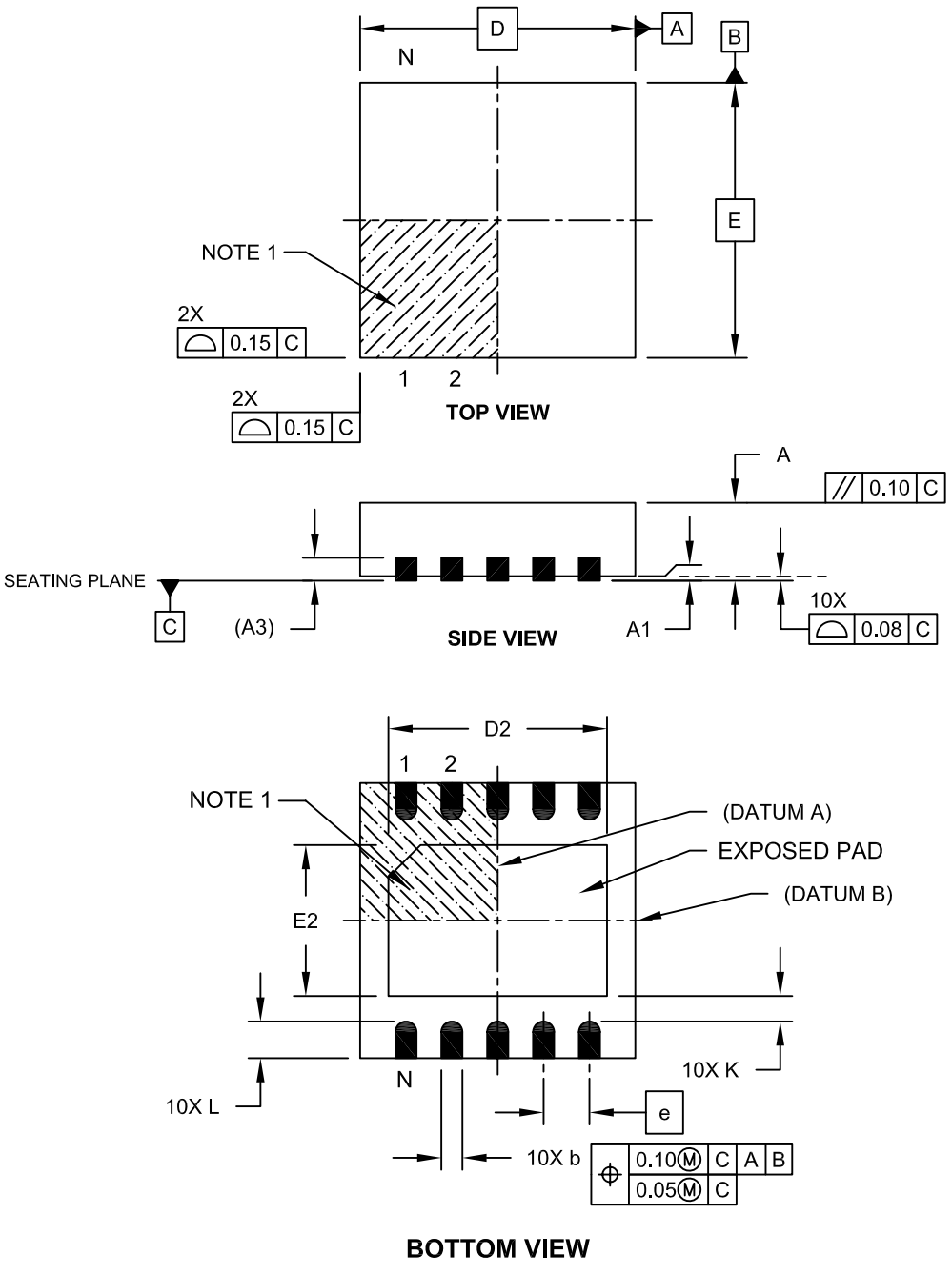
Device	Code
MTD6502B-LC1-00	AAAA
MTD6502B-LC1-01	AAAB
MTD6502B-LC1-02	AAAC

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 Thin Plastic Dual Flat, No Lead Package (MN) - 3x3x0.8mm Body [TDFN]

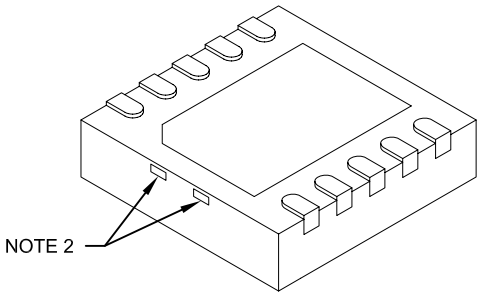
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-185A Sheet 1 of 2

10-Lead Thin Plastic Dual Flat, No Lead Package (MN) - 3x3x0.8mm Body [TDFN]

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	0.70	0.75	0.80
Standoff	A1	0.00	0.02	0.05
Contact Thickness	A3		0.20 REF	
Overall Length	D		3.00 BSC	
Exposed Pad Length	D2	2.20	2.30	2.35
Overall Width	E		3.00 BSC	
Exposed Pad Width	E2	1.55	1.65	1.70
Contact Width	b	0.18	0.25	0.30
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 No. C04-0185A Sheet 2 of 2

NOTES:

APPENDIX A: REVISION HISTORY

Revision B (May 2011)

- Updated PWM Input H Level value in the Electrical Characteristics table.

Revision A (March 2011)

- 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	XX	-XX
Device	Tape&Reel	Package	Km Range Value

Device:	MTD6502B-L:	3-Phase BLDC Sinusoidal Sensorless Fan Motor Driver (Tape and Reel)
Package:	C1 =	Plastic Dual Flat, No Lead Package, 3x3x0.9 mm Body (TDFN)
Km Range Value:	See Table 3-2 for details.	

Examples:

a)	MTD6502B-LC1-00	Tape and Reel, 10LD TDFN Pkg, Km Range Value = 0
b)	MTD6502B-LC1-01	Tape and Reel, 10LD TDFN Pkg, Km Range Value = 1
c)	MTD6502B-LC1-02	Tape and Reel, 10LD TDFN Pkg, Km Range Value = 2

NOTES:

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