# Unipolar Stepper Motor Driver

## FEATURES

- Unipolar Stepper Motor Driver
- Integrated Clamp Diode
- STEP/DIR Control
- Under Well Heat Dissipation: Maximum Driving Current: 2A for Each Channel
- Power Supply: 7.2V~50V
- eTSSOP16 Package

## APPLICATIONS

- Unipolar Stepper Motor

## PRODUCT SPECIFICATION

| Part Number | Package | Marking |
|---|---|---|
| MS31805TE | eTSSOP16 | MS31805TE |

## PRODUCT DESCRIPTION

The MS31805TE is a unipolar stepper motor driver with overcurrent protection function. It integrates four-channel, low-side driver with overcurrent protection function. The MS31805TE integrates clamp diode to clamp the voltage generated by inductance load regeneration.

The MS31805TE integrates stepper driver and allows simple STEP/DIR control mode. It also supports three step modes: 2 phase (full step). 1-2 phase (1/2 step)，1 phase (Wave Drive).

The MS31805TE can provide up to 2A continuous current for each channel under well heat dissipation. When all channels are enabled, maximum 1A continuous current is available.

The integrated protection functions include undervoltage lockout, overcurrent protection, short-circuit protection and thermal shutdown. And the specific fault is indicated by fault output pin.

The MS31805TE is available in eTSSOP16 package.

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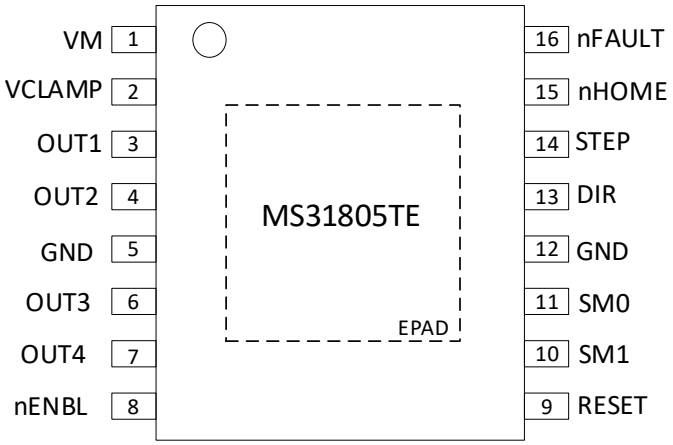
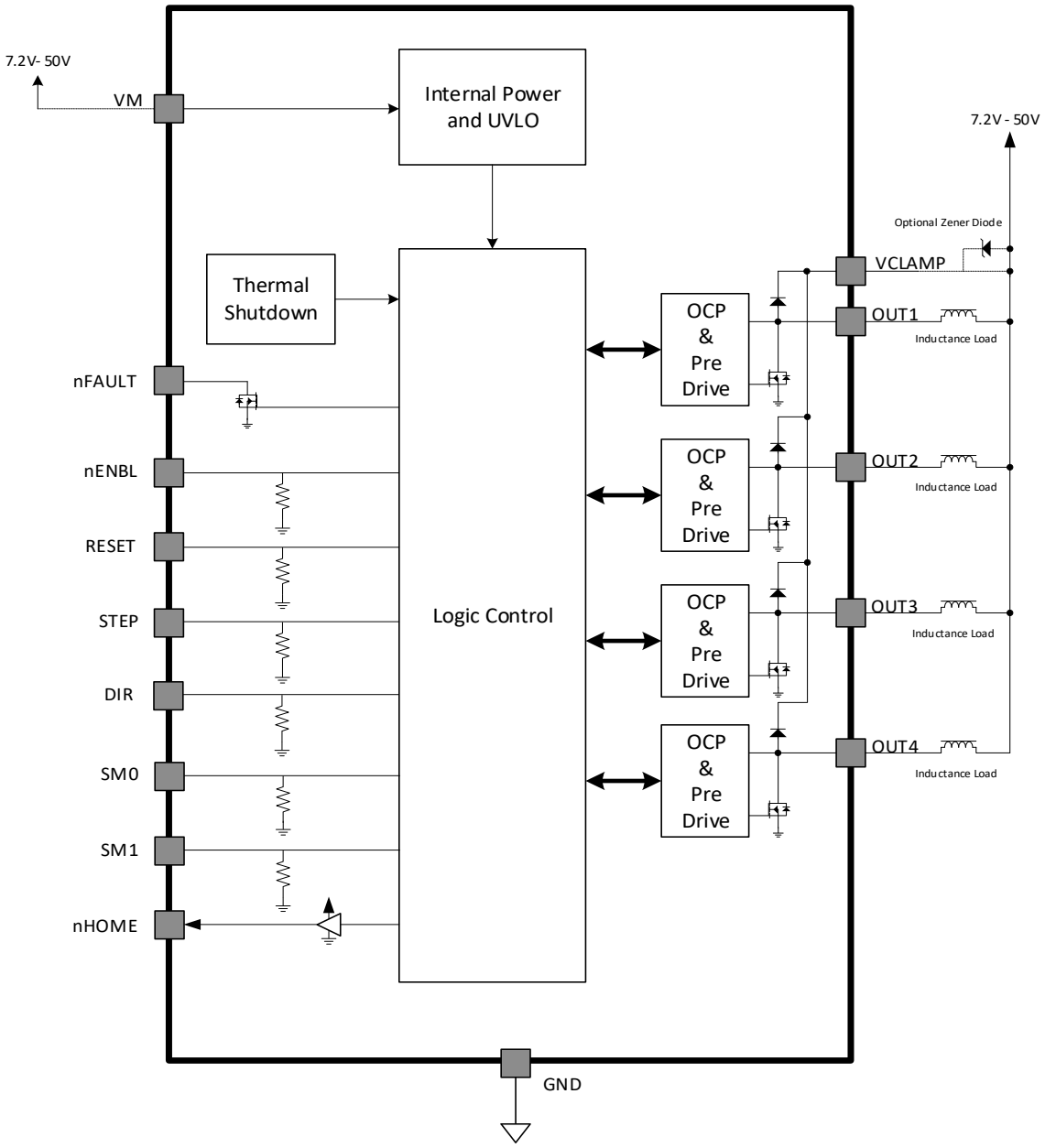
## PIN CONFIGURATION




## PIN DESCRIPTION

| Pin | Name | Type | Description |
|---|---|---|---|
| 1 | VM | - | Power Supply, connected to motor power |
| 2 | VCLAMP | - | Output Clamp Voltage, connected to VM or by Zener diode |
| 3 | OUT1 | O | Output 1 |
| 4 | OUT2 | O | Output 2 |
| 5 | GND | - | Ground |
| 6 | OUT3 | O | Output 3 |
| 7 | OUT4 | O | Output 4 |
| 8 | nENBL | I | Enable Input, Low Active. Internal 100kΩ Pull-down Resistor |
| 9 | RESET | I | Reset Input. Reset internal logic and OCP when it is high-level. Internal 100kΩ Pull-down Resistor |
| 10 | SM1 | I | SM1:SM0: Set Step Mode<br>00: 2 Phase (Full Step)<br>01: 1-2 Phase (1/2 Step)<br>10: 1 Phase (Wave Drive)<br>11: Reserved |
| 11 | SM0 | I | |
| 12 | GND | - | Ground |
| 13 | DIR | I | Direction Control Signal. Internal 100kΩ Pull-down Resistor |
| 14 | STEP | I | Step Signal, Rising Edge Active. Internal 100kΩ Pull-down Resistor |
| 15 | nHOME | OD | Output 0 when motor is located in initial position |
| 16 | nFAULT | OD | Fault Indication. Low-level when fault occurs |
| - | EPAD | - | Thermal Pad, recommended to ground |

## BLOCK DIAGRAM



## ABSOLUTE MAXIMUM RATINGS

Any exceeding absolute maximum rating application causes permanent damage to device. Because long-time absolute operation state affects device reliability. Absolute ratings just conclude from a series of extreme tests. It doesn't represent chip can operate normally in these extreme conditions.

| Parameter | Symbol | Ratings | Unit |
|---|---|---|---|
| Power Supply | $V_M$ | -0.3 ~ 55 | V |
| | $V_{CLAMP}$ | -0.3 ~ 55 | V |
| VOUTx | $V_{OUTx}$ | -0.3 ~ 55 | V |
| Digital Input Voltage | $V_{INRANGE}$ | -0.3 ~ 5.5 | V |
| Digital Output Voltage | $V_{OUTRANGE}$ | -0.3 ~ 5.5 | V |
| Peak Clamp Diode Current | $I_{PD}$ | 2 | A |
| RMS Clamp Diode Current | $I_{RMSPD}$ | 1 | A |
| Open-drain Output Current | $I_{OD}$ | 0 ~ 20 | mA |
| Open-drain Output Voltage | $V_{OD}$ | -0.3 ~ 5.5 | V |
| Junction Temperature | $T_J$ | -40 ~ 150 | °C |
| Storage Temperature | $T_{STG}$ | -65 ~ +150 | °C |
| ESD(HBM) | $V_{ESD}$ | ±8k | V |

## RECOMMENDED OPERATING CONDITIONS

| Parameter | | Symbol | Range | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| Power Supply | | $V_M$ | 7.2 | | 50 | V |
| | | $V_{CLAMP}$ | 0 | | 50 | V |
| Output Current | (Single Channel On) | $I_{OUT}$ | | | 2 | A |
| | (Four Channels On) | | | | 1 | A |

## ELECTRICAL CHARACTERISTICS

Within power supply and operating temperature ranges. The operating conditions are $V_M$=24V and $T_A$=25°C for all typical values.

**Power Supply**

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Power Supply Current | $I_{VM}$ | | | 1.6 | | mA |
| Undervoltage Lockout | $V_{UVLO}$ | $V_M$ rising | | | 7 | V |

**Logic Input**

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Input Low-level Voltage | $V_{IL}$ | No load | | | 0.7 | V |
| Input High-level Voltage | $V_{IH}$ | No load | 2 | | | V |
| Input Hysteresis | $V_{HYS}$ | No load | | 0.3 | | V |
| Input Low-level Current | $I_{IL}$ | $V_{IN}$ = 0V, No load | -20 | | 20 | μA |
| Input High-level Current | $I_{IH}$ | $V_{IN}$ = 3.3V, No load | | | 100 | μA |
| Pull-down Resistor | $R_{PD}$ | | | 100 | | kΩ |

**nFAULT Open-drain Output**

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output Low-level Voltage | $V_{OL}$ | $I_O$ = 5mA | | | 0.4 | V |
| Output Leakage Current | $I_{OH}$ | $V_O$ =3.3V | | | 1 | μA |

**nHOME Output**

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output Low-level Voltage | $V_{OL}$ | $I_O$=5mA | | | 0.5 | V |
| Output High-level Voltage | $V_{OH}$ | $V_M$=24V | | 4.7 | | V |
| Output Source Current | $I_{SOURCE}$ | $V_M$=24V | | | 1 | mA |
| Output Sink Current | $I_{SINK}$ | $V_M$=24V | | | 5 | mA |

**Low-side MOS**

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| On-Resistance | $R_{DSON}$ | $V_M$ = 24V, $I_O$ = 700mA, $T_J$ = 25°C | | 420 | 700 | mΩ |
| | | $V_M$ = 24V, $I_O$ = 700mA, $T_J$ = 85°C | | 550 | 800 | mΩ |
| | | $V_M$ = 24V, $I_O$ = 700mA, $T_J$ = 125°C | | 650 | 950 | mΩ |
| Output Leakage Current | $I_{OFF}$ | | -50 | | 50 | μA |

**Regeneration Diode**

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Forward Voltage | $V_F$ | $V_M$ = 24V, $I_O$ = 700mA, $T_J$ = 25°C | | 0.9 | | V |
| Reverse Leakage Current | $I_R$ | $V_M$ = 24V,$T_J$ = 25°C | -50 | | 50 | μA |

**Output**

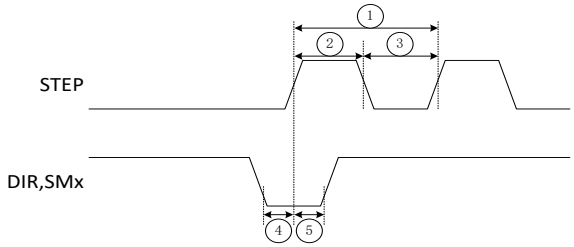
| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Rise Time | $t_R$ | $V_M$ = 24V, $I_O$ = 700mA, $T_J$ = 25°C, Resistive load | 50 | | 300 | ns |
| Fall Time | $t_F$ | $V_M$ = 24V, $I_O$ = 700mA, $T_J$ = 25°C, Resistive load | 50 | | 300 | ns |
| Maximum Switch Frequency | $f_{chop}$ | | | | 500 | kHz |

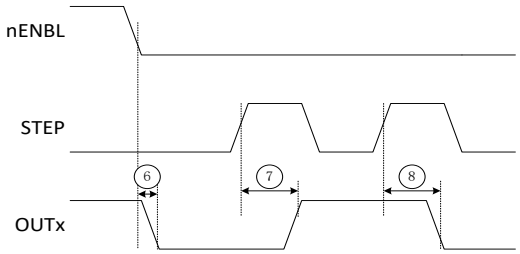
**Protection Circuit**

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Overcurrent Protection Point | $I_{OCP}$ | | 2.2 | 2.7 | 4 | A |
| Overcurrent Protection Detection Time | $t_{OCP}$ | | | 3.6 | | μs |
| Overcurrent Protection Retry Time | $t_{RETRY}$ | | | 1.2 | | ms |
| Thermal Shutdown Point | $T_{TSD}$ | Temperature rising | 145 | 160 | 175 | °C |

**Timing**

| Number | Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| 1 | STEP Frequency | $f_{STEP}$ | | | 250 | kHz |
| 2 | STEP High Time | $t_{WH(STEP)}$ | 1.9 | | | μs |
| 3 | STEP Low Time | $t_{WL(STEP)}$ | 1.9 | | | μs |
| 4 | Setup Time, DIR or SMx to STEP | $t_{SU(STEP)}$ | 1 | | | μs |
| 5 | Hold Time, DIR or SMx to STEP | $t_{H(STEP)}$ | 1 | | | μs |
| 6 | Enable Time, nENBL to Output | $t_{OE(ENABLE)}$ | | | 50 | μs |
| 7 | Delay Time, STEP Enable Output Low to High | $t_{PD(L-H)}$ | | | 500 | μs |
| 8 | Delay Time, STEP Enable Output High to Low | $t_{PD(H-L)}$ | | | 500 | μs |
| - | RESET Pulse Width | $t_{RESET}$ | 20 | | | μs |


1
2
3
STEP
DIR,SMx
4
5


nENBL
STEP
6
7
8
OUTx

## TYPICAL CHARACTERISTICS CURVES

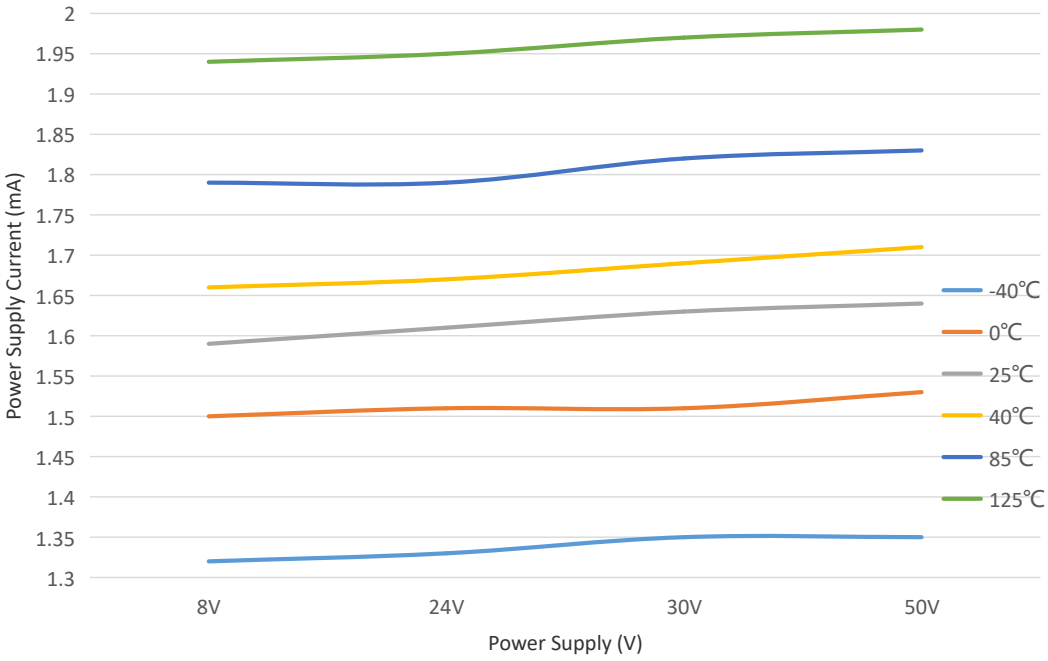



Figure 1. Power Supply Current VS. Power Supply

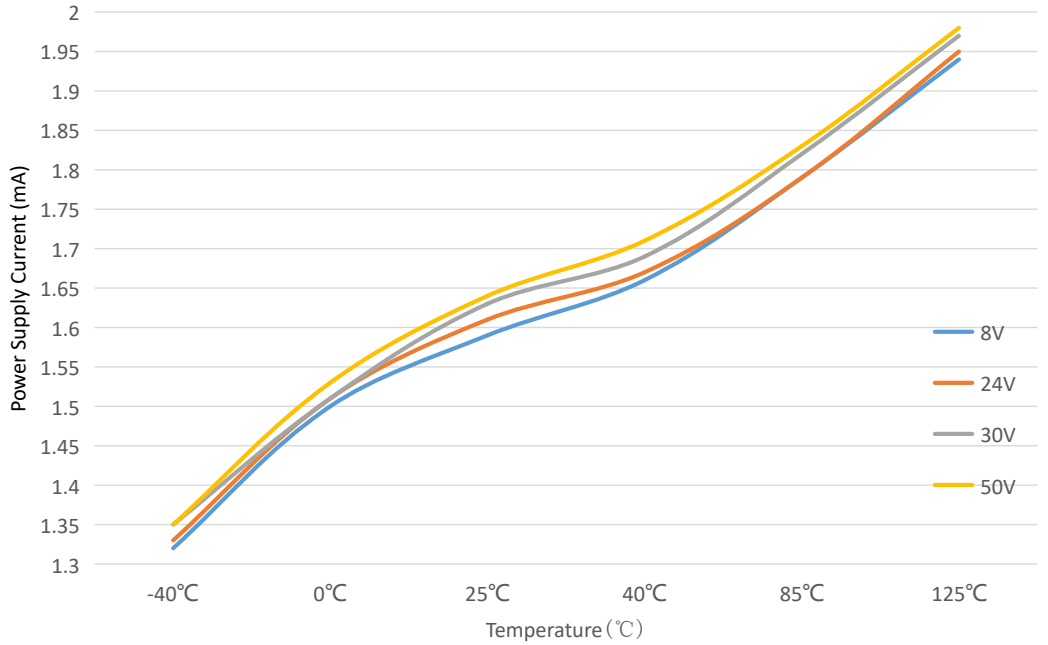



Figure 2. Power Supply Current VS. Temperature

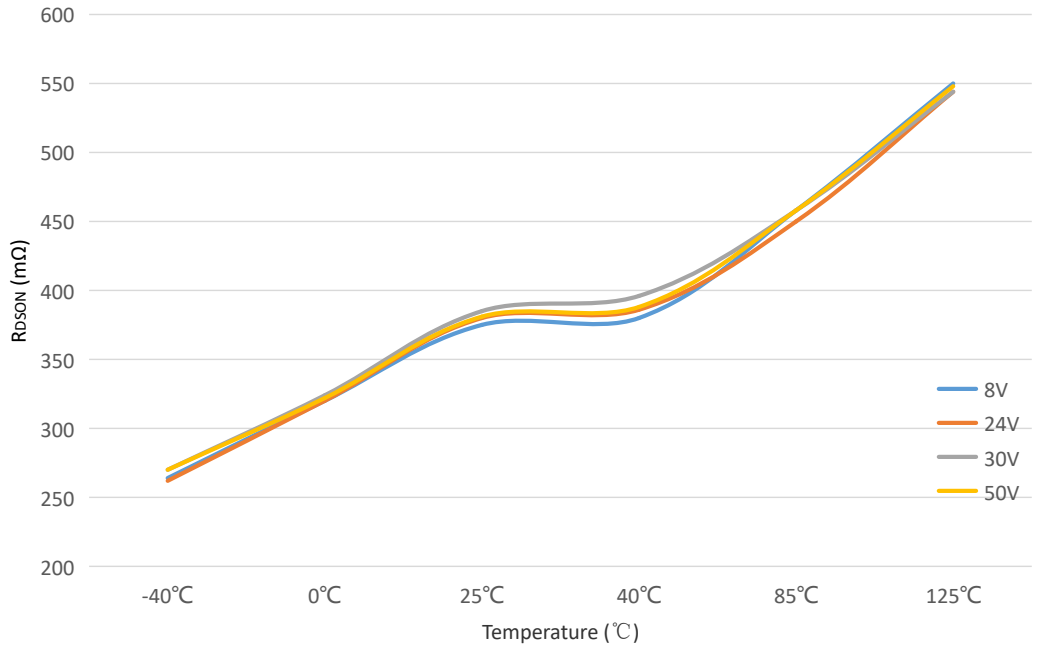



Figure 3. $R_{DSON}$ VS. Temperature

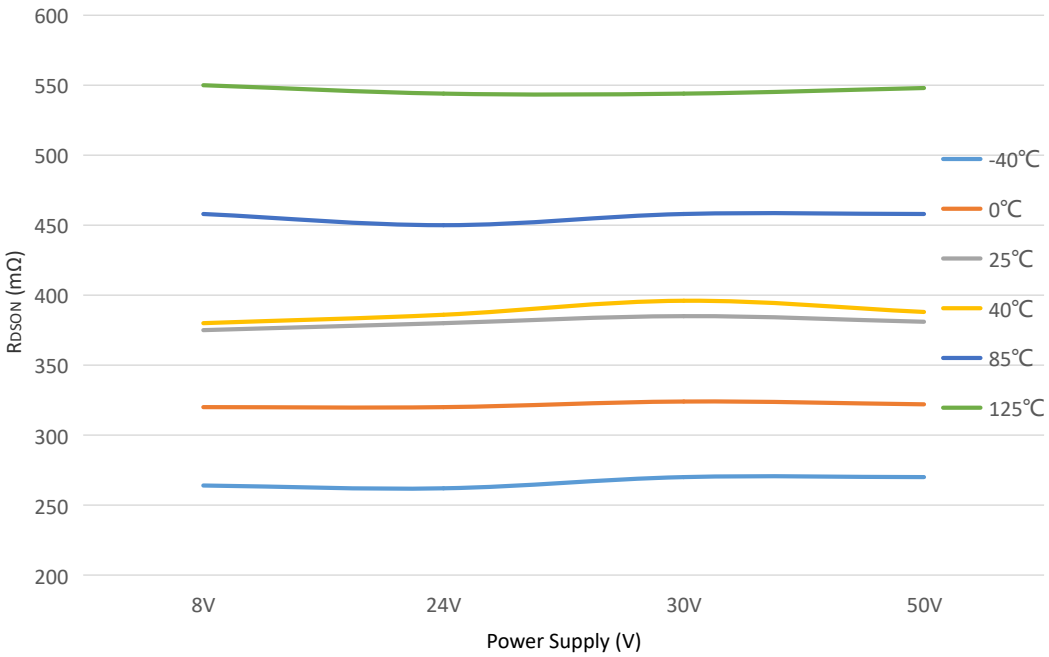



Figure 4. $R_{DSON}$ VS. Power Supply

## FUNCTION DESCRIPTION

### 1. Overview

The MS31805TE is a unipolar stepper motor driver. The MS31805TE can be controlled by STEP/DIR interface. And different microstep modes are controlled by SM0 and SM1 interface.

The MS31805TE integrates clamp diode to clamp the voltage generated by inductance load regeneration.

The integrated protection functions include undervoltage lockout, overcurrent protection, short-circuit protection and thermal shutdown.

### 2. Output Driver

The MS31805TE includes four low-side drivers with protection functions. Each output integrates a clamp diode, which is connected to common pin, VCLAMP.

VCLAMP can be connected to VM. It can also be connected to a Zener or TVS diode to VM, allowing the switch voltage to exceed VM. Thus it can be beneficial to drive loads requiring fast decay, such as unipolar stepper motor.

Output voltage cannot exceed the maximum output voltage limit.

### 3. Protection Circuit

The MS31805TE has protection functions: undervoltage lockout, overcurrent protection and thermal shutdown. When these functions are triggered, shutdown operation is performed to protect the chip and motor.

#### 3.1 Undervoltage Lockout

When VM pin voltage is less than undervoltage lockout threshold, all channels of the MS31805TE are disabled and internal logic is reset. When VM rises to above ULVO, the MS31805TE will recover normal operation.

#### 3.2 Overcurrent Protection

Overcurrent protections on all output drivers limit the driving current by disabling the gate drive. If overcurrent limit time exceeds $t_{OCP}$ (approximately 3.6μs), the output will be disabled and the nFAULT pin will be pulled low. The driver will remain disabled within $t_{RETRY}$ (approximately 1.2ms).

Current recoveries and the fault will be automatically removed after $t_{RETRY}$. If RESET pin is activated or VM is reset, the fault will be removed immediately.

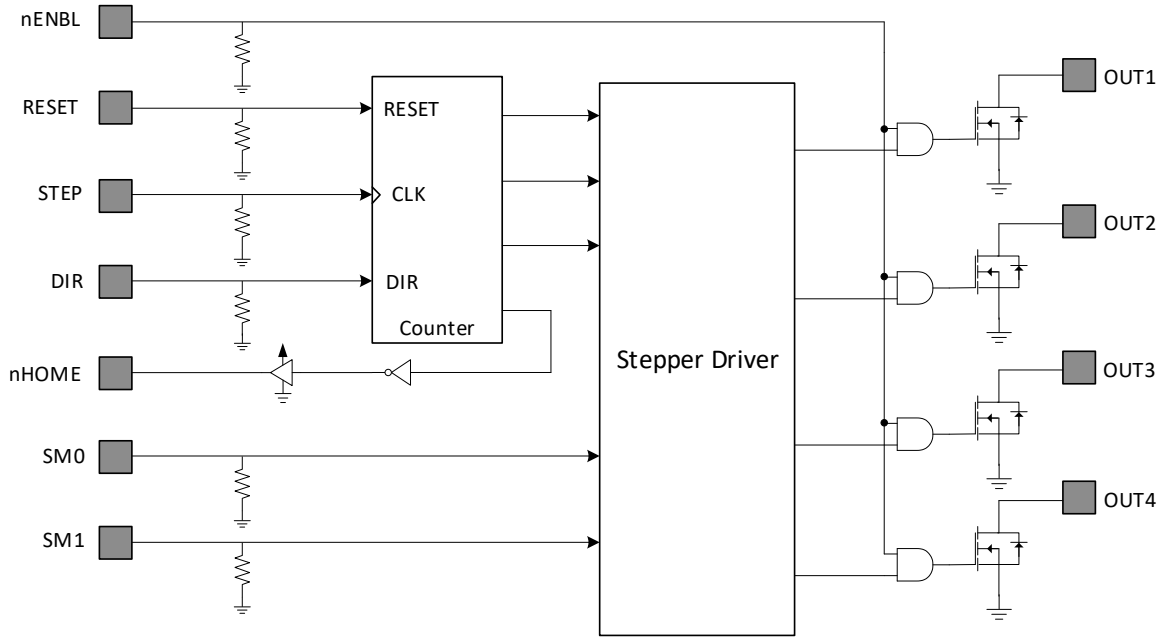
#### 3.3 Thermal Shutdown

When chip temperature exceeds temperature limit, thermal shutdown is triggered, output is off and fault indication pin is pulled down. If chip temperature is normal, the fault is automatically removed and operation is recovered.

## 4. Function Description

### 4.1 Stepper Driver

The MS31805TE integrates a stepper driver and allows simple STEP/DIR control. Different step modes are selected by SM0 and SM1 interface.

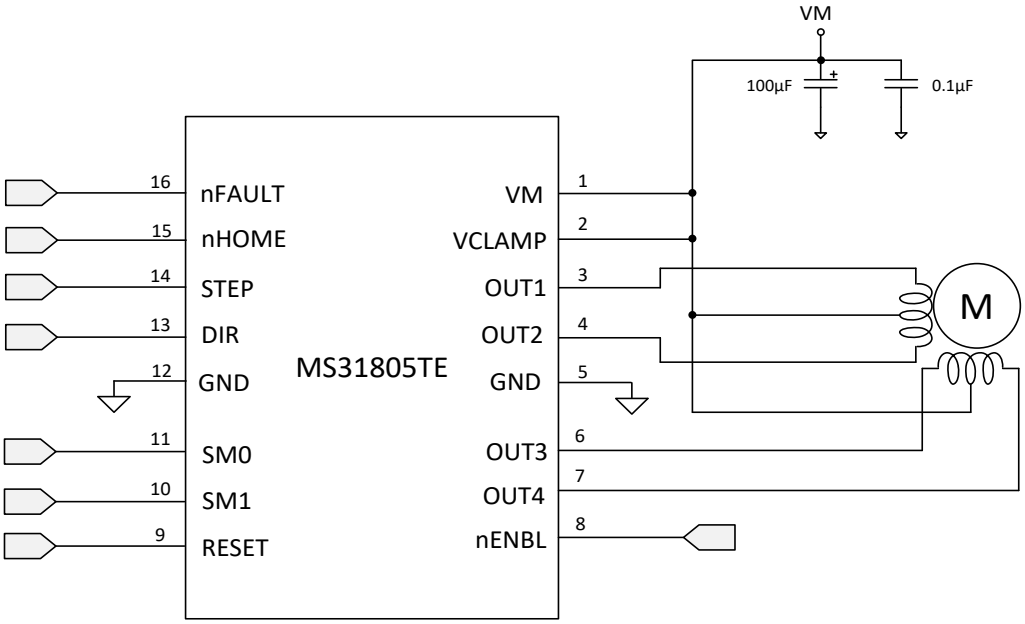



### 4.2 nENBL and Reset Operation

nENBL pin can enable or disable output driver. Driver can only be enabled when nENBL must be low. nENBL pin contains a pull-down resistor. When nENBL is high-level, internal logic is reset and all inputs are ignored. The MS31805TE provides automatic power-up reset function internally. No operation is performed on RESET pin when power-up.

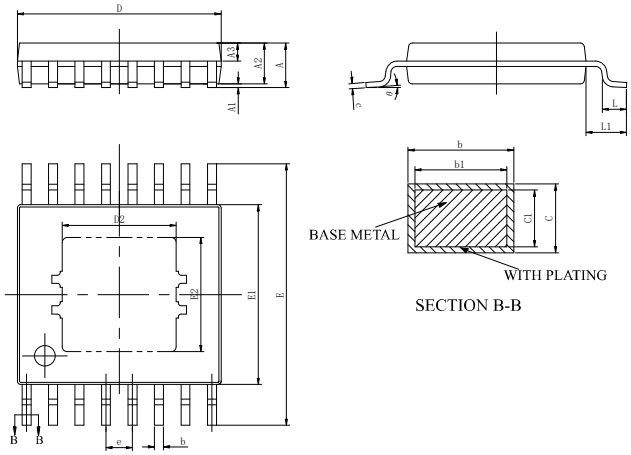
## TYPICAL APPLICATION DIAGRAM

The typical application is for driving unipolar stepper motor as follows.



## PACKAGE OUTLINE DIMENSIONS

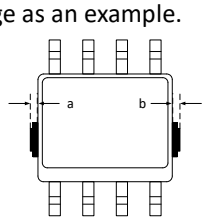
**eTSSOP16**




| Symbol | Dimensions in Millimeters | | |
|---|---|---|---|
| | Min | Typ | Max |
| A | - | - | 1.20 |
| A1 | 0.00 | - | 0.15 |
| A2 | 0.90 | 1.00 | 1.05 |
| A3 | 0.39 | 0.44 | 0.49 |
| b | 0.20 | - | 0.28 |
| b1 | 0.19 | 0.22 | 0.25 |
| c | 0.13 | - | 0.17 |
| c1 | 0.12 | 0.13 | 0.14 |
| D | 4.90 | 5.00 | 5.10 |
| E | 6.20 | 6.40 | 6.60 |
| E1 | 4.30 | 4.40 | 4.50 |
| e | 0.65 BSC | | |
| D2 | 2.80 REF | | |
| L | 0.45 | - | 0.75 |
| L1 | 1.00 BSC | | |
| θ | 0 | - | 8° |
| E2 | 2.10 REF | | |

Note: In addition to the package size, a and b are allowed to have the maximum size of 0.15mm for waste glue simultaneously.

The diagram is as follows: taking SOP8 package as an example.



## MARKING and PACKAGING SPECIFICATION

### 1. Marking Drawing Description


Product Name : MS31805TE

Product Code : XXXXXXX

### 2. Marking Drawing Demand

Laser printing, contents in the middle, font type Arial.

### 3. Packaging Specification

| Device | Package | Piece/Reel | Reel/Box | Piece /Box | Box/Carton | Piece/Carton |
|---|---|---|---|---|---|---|
| MS31805TE | eTSSOP16 | 3000 | 1 | 3000 | 8 | 24000 |

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**MOS CIRCUIT OPERATION PRECAUTIONS**

Static electricity can be generated in many places. The following precautions can be taken to effectively prevent the damage of MOS circuit caused by electrostatic discharge:

1. The operator shall ground through the anti-static wristband.
2. The equipment shell must be grounded.
3. The tools used in the assembly process must be grounded.
4. Must use conductor packaging or anti-static materials packaging or transportation.

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