TMI8180A 3.8A Brushed DC Motor Driver with Current Sensing and Regulation

FEATURES

- N-Channel H-bridge Motor Driver:
  Drives One Bidirectional Brushed DC Motor, Two Unidirectional Brushed DC Motors, or Other Resistive and Inductive Loads
- Wide 4.5V to 37V Operating Voltage
- Up to 3.8A Peak Current
- Integrated Current Sensing and Regulation
- Supports 1.8V, 3.3V, 5V Logic Inputs
- Ultra-Low Power Sleep Mode
- VM Under voltage Lockout (UVLO)
- Integrated protection features
  - Over current Protection (OCP)
  - Thermal Shutdown (TSD)
- ESOP8 Small Package and Footprint

APPLICATIONS

- Major and Small Home Appliances
- Vacuum, Humanoid and Toy Robotics
- Printers and Scanners
- Smart Meters
- ATMs, Currency Counters and EPOS
- Ventilators
- Surgical equipment
- Electronic hospital bed and bed control
- Fitness machine

GENERAL DESCRIPTION

The TMI8180A is a motor driver for wide variety of applications. The device integrates N-channel H-bridge, charge pump regulator, current sensing and regulation, current proportional output, and protection circuitry. The charge pump improves efficiency by allowing for high side N-channels MOSFETs and 100% duty cycle support.

Integrated current sensing allows for the driver to regulate the motor current during start up and high load events. A current limit can be set with an adjustable external voltage reference. Additionally, the device provides an output current proportional to the motor load current. This can be used to detect motor stall or change in load conditions.

A low-power sleep mode is provided to achieve ultra- low quiescent current draw. When using TMI8180A, it is necessary to ensure that nSLP becomes logic high at least 3ms after power-on. The device is fully protected from faults and short circuits, including undervoltage lockout (UVLO), output over-current protection (OCP), and device thermal shutdown (TSD).

TYPICAL APPILCATION

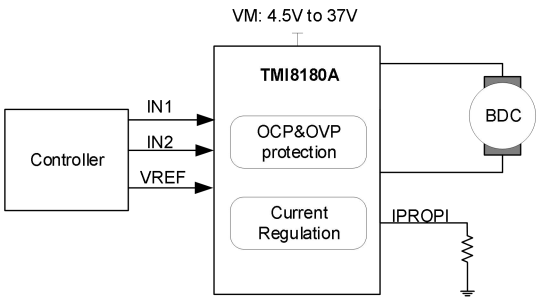
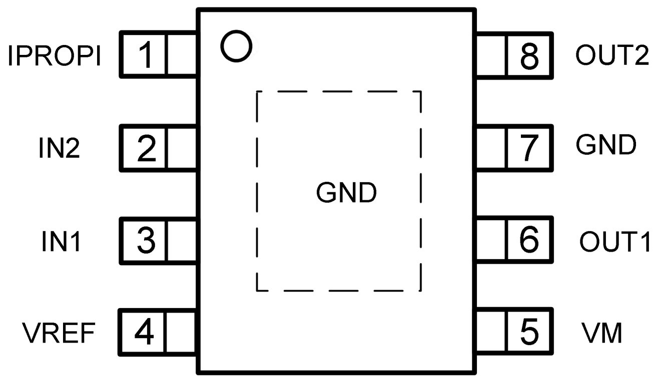


Figure 1. Basic Application Circuit

ABSOLUTE MAXIMUM RATINGS (Note 1)

Parameter	Min	Max	Unit
Power supply voltage (VM)	-0.3	40	V
Logic input voltage (IN1, IN2)	-0.3	6	V
Reference input pin voltage (VREF)	-0.3	6	V
Output pin voltage (OUT1, OUT2)	-0.7	VM+0.7	V
Proportional current output pin voltage (IPROPI)	-0.3	6	V
T_A, Junction temperature,	-40	125	°C
T_J, operating junction temperature (Note 2)	-40	150	°C
Storage temperature	-40	150	°C

PACKAGE/ORDER INFORMATION



ESOP8(Top View)

Top Mark: TMI8180A/XXXXX (TMI8180A: Device Code, XXXXX: Inside Code)

Part Number	Package	Top mark	Quantity/ Reel
TMI8180A	ESOP8	TMI8180A XXXXX	3000

TMI8180A device is Pb-free and RoHS compliant.

PIN FUNCTIONS

Pin	Name	Function
1	IPROPI	Analog current output proportional to load current.
2	IN2	Logic inputs. Controls the H-bridge output. Has internal pulldowns.
3	IN1	Logic inputs. Controls the H-bridge output. Has internal pulldowns.
4	VREF	External reference voltage input to set internal current regulation limit.
5	VM	4.5 to 37V power supply input. Connect a 0.1μF bypass capacitor to ground, as well as a sufficient bulk capacitance rated for VM.
6	OUT1	H-bridge output. Connect to the motor or other load.
7	GND	Device power ground. Connect to system ground. .
8	OUT2	H-bridge output. Connect to the motor or other load.
9	E-PAD	Thermal pad. Connect to board ground. For good thermal dissipation, use large ground planes on multiple layers, and multiple nearby vias connecting those planes.

ESD RATING

Items	Description	Value	Unit
V_{ESD}	Human Body Model for all pins	±2000	V

JEDEC specification JS-001

RECOMMENDED OPERATING CONDITIONS

Items	Description	Min	Max	Unit
VM	Power supply voltage range	4.5	37	V
VIN	Logic input voltage	0	5.5	V
f_{PWM}	PWM frequency	0	100	kHz
V_{OD}	Open drain pullup voltage	0	5.5	V
I_{OD}	Open drain output current	0	5	mA
I_{OUT}	Peak output current	0	4.5	A
I_{IPROPI}	Current sense output current	0	3	mA
V_{VREF}	Current limit reference voltage	0	3.6	V

ELECTRICAL CHARACTERISTICS

T_A = 25°C, (unless otherwise noted.)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY (VM)						
VM operating voltage	VM		4.5		37	V
VM operating current	I_{VM}	VM = 24V		3	7	mA
VM sleep current	I_{VMQ}	VM = 24V,IN1= IN2=0V(sleep entered after 1ms)			5	μA
Turn-on time (Note 3)	t_{WAKE}	Control signal to active mode		1	1.5	ms
Turn-off time	t_{SLEEP}	Control signal to sleep mode			250	μs
Output dead time	t_{DEAD}	Body diode conducting		300		ns
LOGIC-LEVEL INPUTS (IN1, IN2, nSLP)						
Input logic low voltage	V_{IL}		0		0.7	V
Input logic high voltage	V_{IH}		1.5		5.5	V
Input logic hysteresis	V_{HYS}			0.25		V
Input logic low current	I_{IL}	VIN = 0V	–5		6	μA
Input logic high current	I_{IH}	VIN = 5V		50	75	μA
Pulldown resistance	R_{PD}	Pull down to GND		100		kΩ
Power-on sequence	t_{PS}	nSLP enable after power-on	3			ms
MOTOR DRIVER OUTPUTS (OUT1, OUT2)						
High-side FET on resistance	$R_{(ON)\_High}$	VM = 24 V, I_{OUT} = 1A,		250		mΩ
Low-side FET on resistance	$R_{(ON)\_Low}$	VM = 24 V, I_{OUT} = 1A,		240		mΩ
Output dead time	t_{DEAD}	Body diode conducting		300		ns
Output rise time	t_{RISE}	VM = 24 V, OUTx rising 10% to 90%		165		ns
Output fall time	t_{FALL}	VM = 24 V, OUTx falling 90% to 10%		150		ns
Input to output propagation delay	t_{PD}			650		ns
Body diode forward voltage	V_d	I_{OUT} = 1A		0.9		V
CURRENT REGULATION						
Current mirror scaling factor	A_{VIPRO}			1500		μA/A
Current mirror scaling error	A_{ERR}	I_{OUT} < 0.15 A, 5.5 V ≤ V_{VM} ≤ 37 V	-7.5		7.5	mA
		0.15 A ≤ I_{OUT} < 0.5 A, 5.5 V ≤ V_{VM} ≤ 37 V	-5		5	%
		0.5 A ≤ I_{OUT} ≤ 2 A, 5.5 V ≤ V_{VM} ≤ 37 V, ESOP, –40℃ ≤ T_J < 125℃	-4		4	%
PWM off-time	t_{OFF}			25		μs
Current sense delay time	t_{DELAY}			2.1		μs
Current regulation deglitch time	t_{DEG}			1.2		μs
PWM blanking time	t_{BLANK}			3.5		μs

ELECTRICAL CHARACTERISTICS (Continued)

T_A = 25°C, (unless otherwise noted.)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
PROTECTION CIRCUITS						
VM undervoltage lockout	V_{UVLO_fall}	VM falls until UVLO triggers			4.2	V
	V_{UVLO_rise}	VM rises until operation recovers	4.6			V
VM undervoltage hysteresis	V_{UV_HYS}	Rising to falling		140		mV
OCP trip level	I_{OCP}		3.5	4.5		A
Overcurrent deglitch time	t_{OCP}			5		μs
Overcurrent retry time	t_{RETRY}			3		ms
Thermal shutdown threshold	T_{SD} (Note 4)			160		°C
Thermal shutdown hysteresis	T_{HYS} (Note 4)			30		°C

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + P_D \times \theta_{JA}$. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_{D\,(MAX)} = (T_{J(MAX)}-T_A)/\theta_{JA}$.

Note 3: t_{WAKE} applies when the device initially powers up, and when it exits sleep mode.

Note 4: Thermal shutdown threshold and hysteresis are guaranteed by design.

OPERATION

Overview

The TMI8180A device is a brushed DC motor driver that operates from 4.5V to 37V supporting a wide range of output load currents for various types of motors and loads. The device integrates an H-bridge output power stage and this allows for driving a single bidirectional brushed DC motor, two unidirectional brushed DC motors, or other output load configurations. The device integrates a charge pump regulator to support more efficient high-side N-channel MOSFETs and 100% duty cycle operation. The device operates with a single power supply input (VM) which can be directly connected to a battery or DC voltage supply. The device enters a low-power sleep mode by bringing both inputs low.

The TMI8180A device also integrates output current sensing using current mirrors on the low-side power MOSFETs. A proportional current is then sent out on the IPROPI pin and can be converted to a proportional voltage using an external resistor (R_{IPROPI}). The integrated current sensing allows the TMI8180A to limit the output current with a fixed off-time PWM chopping scheme and provide load information to the external controller to detect change in load or stall conditions. The integrated current sensing out performs traditional external shunt resistor sensing by providing current information even during the off-time slow decay recirculating period and removing the need for an external power shunt resistor. The off-time PWM current regulation level can be configured during motor operation through the VREF pin to limit the load current accordingly to the system demands.

A variety of integrated protection features protect the device in the case of a system fault. These include undervoltage lockout (UVLO), charge pump undervoltage (CPUV), overcurrent protection (OCP), and overtemperature shutdown (TSD).

PWM Control Mode

The TMI8180A device is designed to work under PWM mode. The truth table for PWM mode is shown in Table 1.

Table 1. PWM Control Mode

IN1	IN2	OUT1	OUT2	DESCRIPTION
0	0	High-Z	High-Z	Coast
0	1	L	H	Reverse(Current OUT2 → OUT1)
1	0	H	L	Forward(Current OUT1 → OUT2)
1	1	L	L	Brake;low-side slow decay

Current Sensing

The TMI8180A integrates current sensing, regulation, and feedback. These features allow for the device to sense the output current without an external sense resistor or sense circuitry reducing system size, cost, and complexity. This also allows for the device to limit the output current in the case of motor stall or high torque events and give detailed feedback to the controller about the load current through a current proportional output.

Current Regulation

The TMI8180A device integrates current regulation using a fixed off-time current chopping scheme. The internal current regulation can be disabled by tying IPROPI to GND and setting the VREF pin voltage greater than GND (if current feedback isn't required) or if current feedback is required, setting V_{VREF} and R_{IPROPI} such that V_{IPROPI} never reaches the V_{VREF} threshold.

In TMI8180A, motor peak current can be limited by the analog reference input VREF and the resistance of external sense resistor on the IPROPI pin according to the below equation:

$$I_{TRIP}\ (A) = \frac{VREF\ (V)}{A_{IPROPI}(\mu A/A) \times R_{IPROPI}(\Omega)}$$

For example, if V_{VREF} = 3 V, R_{IPROPI} = 2000 Ω, and A_{IPROPI} = 1500 μA/A, then I_{TRIP} will be approximately 1.0 A.

VM Undervoltage Lockout (UVLO)

If at any time the voltage on the VM pin falls below the undervoltage-lockout threshold voltage, all FETs in the H-bridge will be disabled. Operation resumes when VM rises above the UVLO threshold.

Overcurrent Protection (OCP)

If the output current exceeds the OCP threshold, I_{OCP}, for longer than t_{OCP}, all FETs in the H-bridge are disabled.

As to TMI8180A, after a duration of t_{RETRY}, the H-bridge is re-enabled according to the state of the INx pins. If the overcurrent fault is still present, the cycle repeats, otherwise normal device operation resumes.

Active Mode

After the supply voltage on the VM pin has crossed the undervoltage threshold VUVLO, the INx pins are in a state other than IN1 = 0 & IN2 = 0, and t_{WAKE} has elapsed, the device enters active mode. In this mode, the H-bridge, charge pump, and internal logic are active and the device is ready to receive inputs. Table 2 summarizes the TMI8180A functional modes described in this section.

Table 2. Modes of Operation

MODE	CONDITION	H-BRIDGE
Active Mode	IN1 or IN2 = logic high	Operating
Low-Power Sleep Mode	IN1 = IN2 = logic low	Disabled

Low-Power Sleep Mode

When the IN1 and IN2 pins are both low for time tSLEEP, the TMI8180A device enters a low-power sleep mode. In sleep mode, the outputs remain High-Z and the device draws minimal current from the supply pin (IVMQ). If the device is powered up while all inputs are low, it immediately enters sleep mode. After any of the input pins are set high for longer than the duration of tWAKE, the device becomes fully operational. Figure.2 shows an example timing diagram for entering and leaving sleep mode.

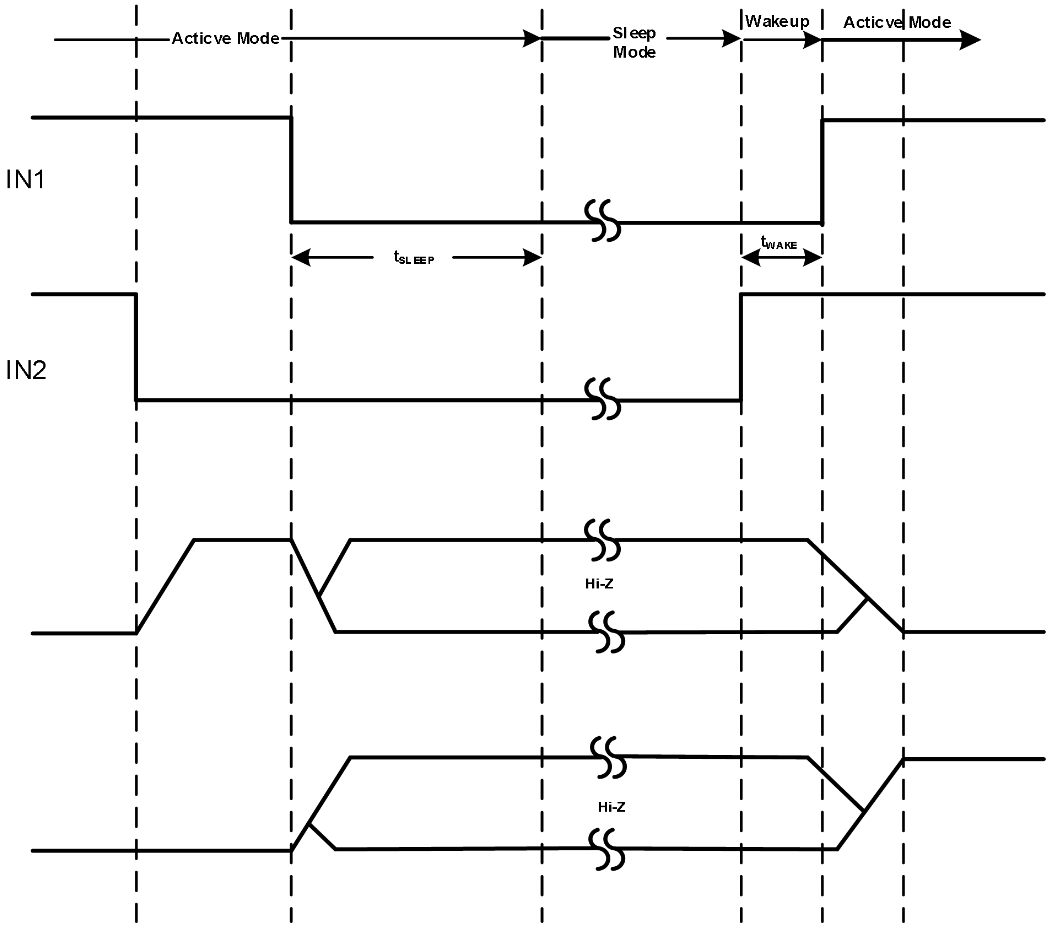


Figure 2.Sleep Mode Entry and Wakeup Timing Diagram

Thermal Shutdown (TSD)

If the die temperature exceeds safe limits, all FETs in the H-bridge are disabled. After the die temperature has fallen to a safe level, operation automatically resumes.

Control with Current Regulation

This scheme uses all of the capabilities of the device. The I_{TRIP} current is set above the normal operating current, and high enough to achieve an adequate spin-up time, but low enough to constrain current to a desired level. Motor speed is controlled by the duty cycle of one of the inputs, while the other input is static. Brake or slow decay is typically used during the off-time.

Control Without Current Regulation

If current regulation is not required, the IPROPI pin should be directly connected to the PCB ground plane. The VREF voltage must still be 0.3V to 5 V, and larger voltages provide greater noise margin. This mode provides the highest-possible peak current which is up to 3.5 A for a few hundred milliseconds (depending on PCB characteristics and the ambient temperature). If current exceeds 3.5 A, the device might reach overcurrent protection (OCP) or overtemperature shutdown (TSD). If that happens, the device disables and protects itself for about 2ms (t_{RETRY}) and then resumes normal operation.

Static Inputs with Current Regulation

The IN1 and IN2 pins can be set high and low for 100% duty cycle drive, and I_{TRIP} can be used to control the current of the motor, speed, and torque capability.

APPLICATION INFORMATION

Application information

The TMI8180A devices are typically used to drive one brushed DC motor as below:

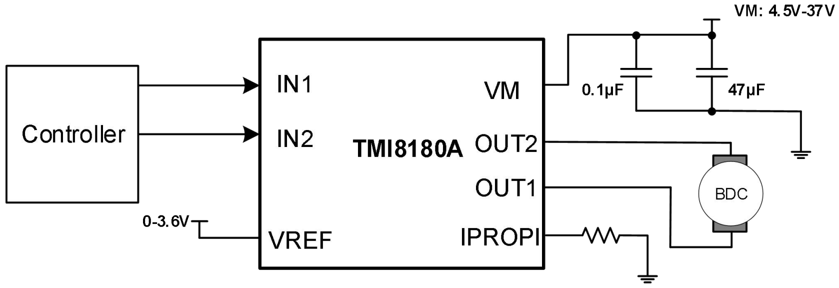


Figure 3. TMI8180A Typical Application

Block Diagram

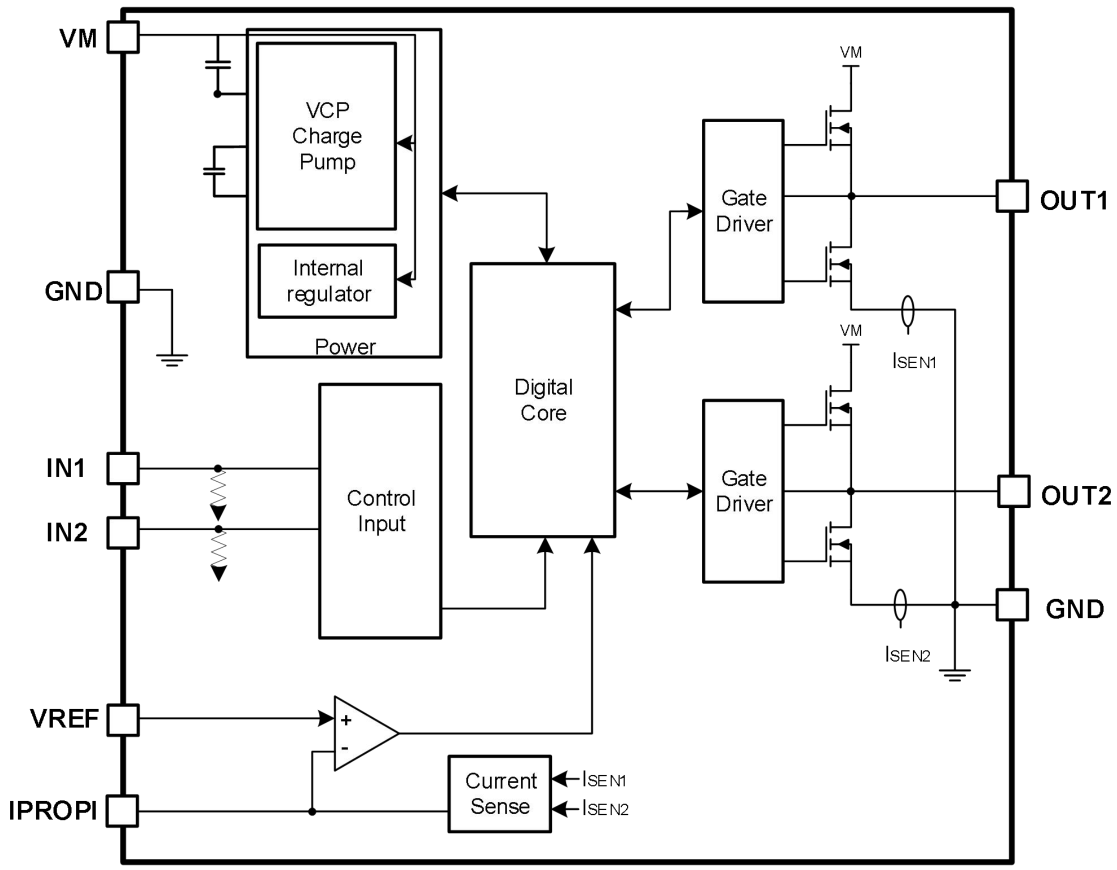
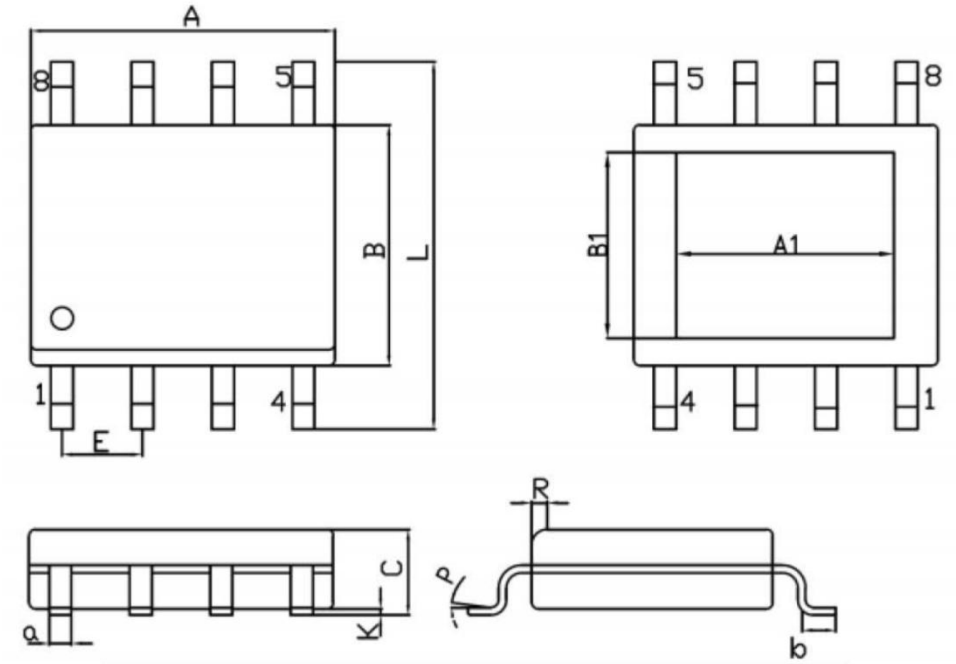


Figure 4. TMI8180A Block Diagram

PACKAGE INFORMATION

ESOP8



Unit: mm

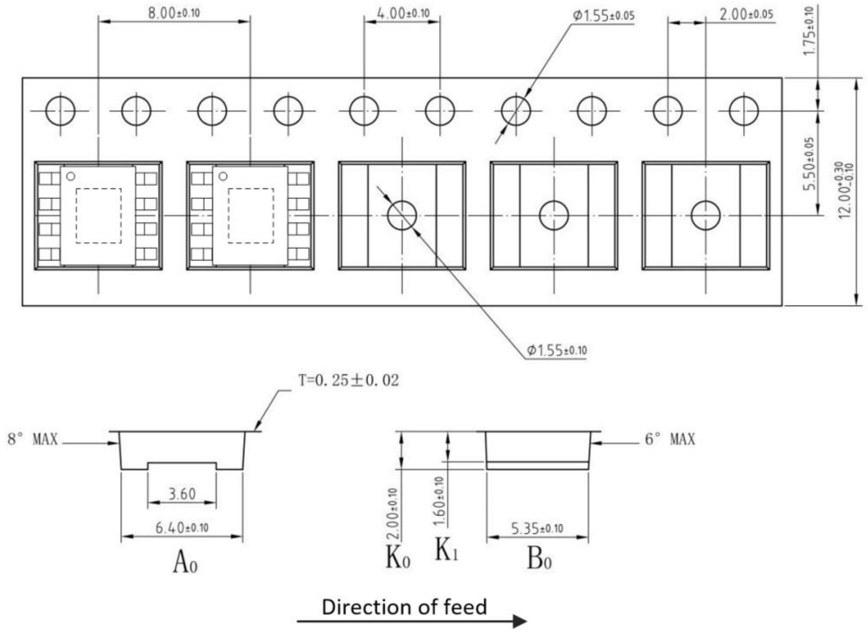
Symbol	Dimensions In Millimeters		Symbol	Dimensions In Millimeters	
	Min	Max		Min	Max
A	4.70	5.10	C	1.35	1.75
B	3.70	4.10	a	0.35	0.49
L	6.00	6.40	R	0.30	0.60
E	1.27 BSC		P	0°	7°
K	0.02	0.10	b	0.40	1.25
A1	3.1	3.5	B1	2.2	2.6

Note:

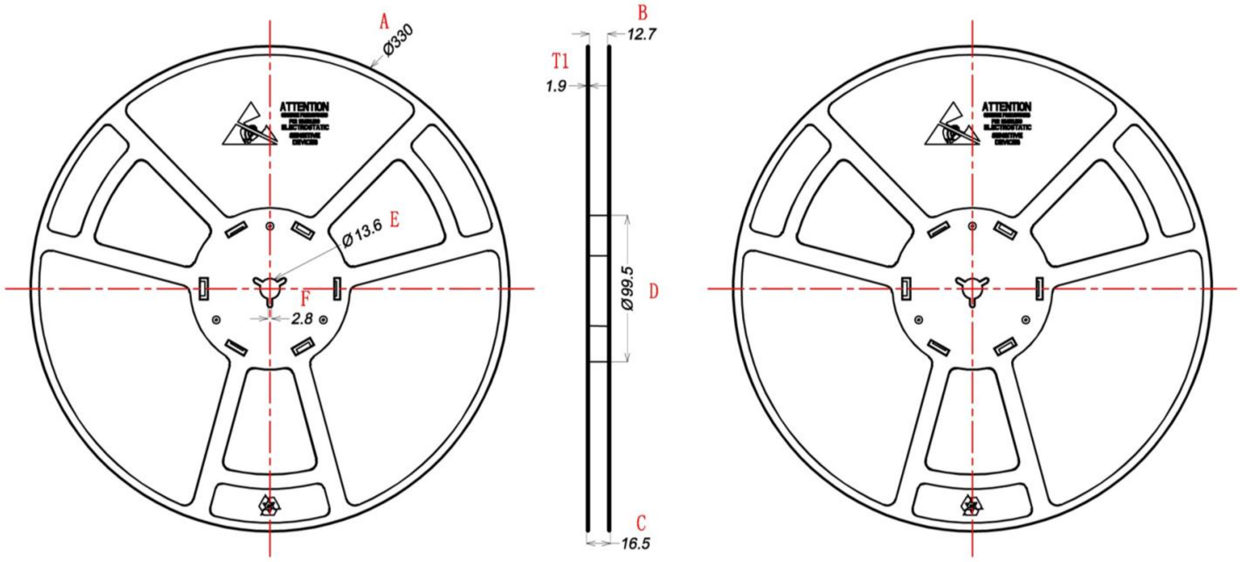
1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.
5) Pin 1 is lower left pin when reading top mark from left to right.

TAPE AND REEL INFORMATION

TAPE DIMENSIONS: ESOP8



REEL DIMENSIONS: ESOP8



Unit: mm

A	B	C	D	E	F	T1
Ø 330±1	12.7±0.5	16.5±0.3	Ø 99.5±0.5	Ø 13.6±0.2	2.8±0.2	1.9±0.2

Note:

1) All Dimensions are in Millimeter
2) Quantity of Units per Reel is 3000
3) MSL level is level 3.

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