40V/7A DC Motor Driver

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 6V to 40V Operating Voltage
- 7A Peak Current Drive
- Integrated Current Sensing and Regulation
- PH/EN Input Control Mode
- Supports 1.8V, 3.3V, 5V Logic Inputs
- Ultra-Low Power Sleep Mode
- VM Undervoltage Lockout (UVLO)
- Over Current Protection (OCP)
- Thermal Shutdown (TSD)
- Automatic Fault Recovery and Indicator Pin
- Small Packages
  - TMI8130A: ETSSOP24

APPLICATIONS

- Brushed DC Motors
- Major Small Home Appliances
- Vacuum, Humanoid and Toy Robotics
- Printers and Scanners
- Smart Meters
- ATMs, Currency Counters and EPOS
- Servo Motors and Actuators

GENERAL DESCRIPTION

The TMI8130A is a motor driver for wide variety of end applications. The device integrates an H-bridge,charge pump regulator,current sensing and regulation, current proportional output, and protection circuitry. The charge pump improves efficiency by allowing for both high and low 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 by shutting down most of the internal circuitry. The device is fully protected from faults and short circuits, including undervoltage lockout (UVLO), output over-current protection (OCP), and device thermal shutdown (TSD). Fault conditions are indicated on nFAULT.

TYPICAL APPILCATION

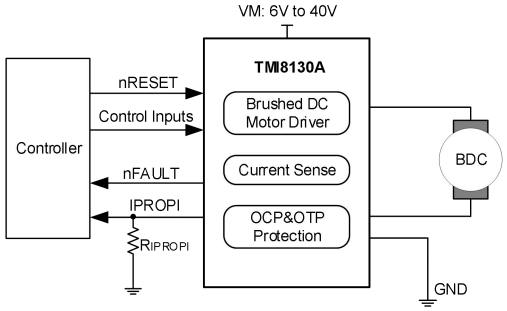


Figure 1. Basic Application Circuit

ABSOLUTE MAXIMUM RATINGS (Note 1)

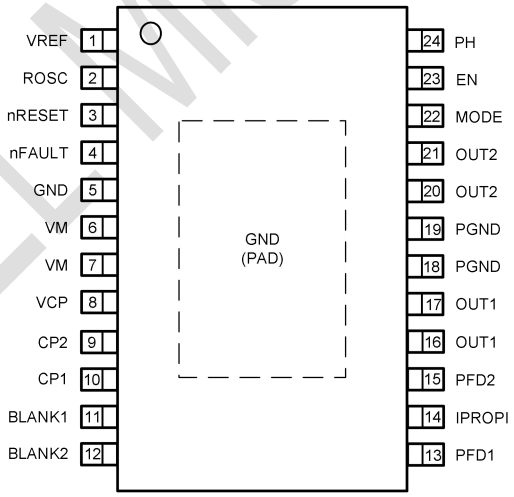
Parameter	Min	Max	Unit
Power supply voltage (VM)	-0.3	45	V
Voltage difference between ground pins (GND, PGND)	-0.3	0.3	V
Logic input voltage (EN, PH, IMODE, nRESET, PFDx, BLANKx)	-0.3	6	V
Reference input pin voltage (VREF)	-0.3	6	V
Open-drain output pin voltage (nFAULT)	-0.3	6	V
Current sense input pin voltage (IPROPI)	-0.5	1	V
Output pin voltage (OUT1, OUT2)	-0.7	VM+0.7	V
Output Peak current	0	7	A
T_A, Operating ambient temperature	-40	125	°C
T_J, operating junction temperature (Note 2)	-40	150	°C
Storage temperature	-40	150	°C

ESD RATING

Items	Description	Value	Unit
V_{ESD}	Human body model for all pins	±2000	V
	Charged device model (CDM)	±1000	V

JEDEC specification JS-001

PACKAGE/ORDER INFORMATION



ETSSOP24(Top View)

Part Number	Package	Top mark	Quantity/ Reel
TMI8130A	ETSSOP24	TMI8130A XXXXX	4,000

The TMI8130A devices is Pb-free and RoHS compliant.

PIN FUNCTIONS

PIN	Name	Function
1	VREF	Bridge current set reference input.
2	ROSC	Timing set. Externally programmable Fixed Off-Time.
3	nRESET	Sleep mode input. Logic high to enable device, logic low to enter low-power sleep mode.
4	nFAULT	Fault. Logic low when in fault condition.
5	GND	Device ground.
6,7	VM	Bridge power supply, Connect a 0.1μF bypass capacitor to ground, as well as a sufficient bulk capacitance rated for VM.
8	VCP	High-side gate drive voltage. Connect a 0.1μF ceramic capacitor and 1 MΩ resistor to VM.
9	CP2	Charge pump flying capacitor.Connect a 0.1μF/50V capacitor between CP1 and CP2.
10	CP1	
11	BLANK1	Timing set. Externally programmable Blank Time.
12	BLANK2	
13	PFD1	Set Decay mode for Fixed Off-Time.
14	IPROPI	Analog current output proportional to load current.
15	PFD2	Set Decay mode for Fixed Off-Time.
16,17	OUT1	H-bridge output. Connect directly to the motor or other inductive load.
18,19	PGND	Device power ground. Connect to system ground.
20,21	OUT2	H-bridge output. Connect directly to the motor or other inductive load.
22	MODE	Control Input.
23	EN	H-bridge control input. Internal pulldown resistor.
24	PH	H-bridge control input. Internal pulldown resistor.

RECOMM ENDED OPERATING CONDITIONS

Items	Description	Min	Max	Unit
VM	Power supply voltage range	6	40	V
Logic	Logic input voltage	0	5.5	V
VREF	Current limit reference voltage	0	3.6	V
I_{OUT}	Peak output current	0	7	A

ELECTRICAL CHARACTERISTICS

T_A = 25°C (Unless Otherwise Noted)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY (VM)						
VM operating voltage	VM		6		40	V
VM operating current	I_{VM}	VM = 24V		1.8	2.0	mA
VM sleep current	$I_{VMSLEEP}$	VM = 24V, nRESET = 0V			1	μA
LOGIC LEVEL INPUTS						
Input low voltage	V_{IL}				0.8	V
Input high voltage	V_{IH}		1.8			V
Input hysteresis	V_{HYS}			150		mV
Input low current	I_{IL}	VIN = 0V	-5		5	μA
Input high current	I_{IH}	VIN = 5V	-50		50	μA
Input pull-up resistor	R_{PU}	PFD1, MODE (to 5V INT)		100		kΩ
Input pull-down resistor	R_{PD}	nRESET, PFD2, BLANK1, BLANK2, EN, PH		100		kΩ
Sleep low voltage	$V_{IN(STANDBY)}$	Standby Mode			0.4	V
nFAULT OUTPUT (OPEN DRAIN OUTPUT)						
Output low voltage	V_{OL}	I_O = 5 mA			0.5	V
Output high leakage current	I_{OH}	V_O = 3.3 V			5	μA
H-BRIDGE FETS						
HS FET on resistance	$R_{DS(ON)}$	VM = 24 V, I_O = 1 A		0.08		Ω
LS FET on resistance	$R_{DS(ON)}$	VM = 24 V, I_O = 1 A		0.08		Ω
Off-state leakage current	I_{OFF}		-10		10	μA
MOTOR DRIVER						
Internal PWM frequency	f_{PWM}			60		kHz
Rise time	t_R	VM=24V,RLoad=50Ω+160μH	20	40	200	ns
Fall time	t_F	VM=24V,RLoad=50Ω+160μH	20	60	200	ns
Dead time	t_{DEAD}			400		ns
PWM Timing						
Blank Time	t_{BLK}	BLANKx = 00 & 11, Relative to Target	-20	0	20	%
		BLANKx = 01 & 10, Relative to Target	-30	0	30	%
Fixed Off-Time	t_{OFF}	Relative to Target, ROSC=8K to 80K	-20	0	20	%

ELECTRICAL CHARACTERISTICS (Continued)

TA = 25°C (Unless Otherwise Noted)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VREF input current	I_{VREF}		-5	<1	5	μA
VREF input range	V_{REF}	External Sense Resistor	0		4	V
		Internal Mode (RSENSE=0)	0		2	V
Current mirror scaling factor	A_{VIPRO}			500		μA/A
Current mirror scaling error	A_{ERR}	I_{OUT} < 0.4 A, 6 V ≤ V_{VM} ≤ 40 V	-30		30	mA
		0.4 A ≤ I_{OUT} < 1 A, 6 V ≤ V_{VM} ≤ 40 V	-7.5		7.5	%
		1 A ≤ I_{OUT} ≤ 3.5 A, 6 V ≤ V_{VM} ≤40 V,	-6		6	%
PROTECTION CIRCUITS						
VM undervoltage lockout	V_{UVLO_rise}	VM rises until operation recovers	4.7			V
VM undervoltage hysteresis	V_{UV_hys}	Rising to falling		150		mV
Overcurrent protection trip level	I_{OCP}			8		A
Overcurrent deglitch time	t_{DEG}			3		μs
Thermal shutdown temperature	T_{SD} (Note 3)		150	170	180	°C
Thermal shutdown hysteresis	T_{HYS} (Note 3)			30		°C

Note 1: Stresses beyond those listed under Absolute Maximum Rating may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Condition. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

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: Thermal shutdown threshold and hysteresis are guaranteed by design.

OPERATION

Overview

The TMI8130A is designed to operate DC motors.The output drivers are capable of 40V and 7A peak operating currents.Actually 100% steady state DC current capability depends on thermal capability of the package,PCB,and ambient temperature.N-channel MOS drivers feature internal synchronous rectification to reduce power dissipation.Peak current can be regulated by fixed off-time pulse width modulated (PWM) control circuitry.

Protection circuitry includes thermal shutdown,and protection against shorted loads,or against output shorts to ground or supply.Undervoltage lockout prevents damage by keeping the outputs off until the driver has enough power supply voltage to operate normally.

Control Mode

nRESET	PHASE	ENABLE	MODE	I > ICL	OUT1	OUT2	FUNCTION
1	1	1	x	0	H	L	Forward
1	0	1	x	0	L	H	Reverse
1	x	0	1	0	L	L	Brake (slow decay)
1	1	0	0	0	L	H	Fast Decay SR(Note 4)
1	0	0	0	0	H	L	Fast Decay SR(Note 4)
1	1	1	x	1	L	H/L	Chop(Note 4)
1	0	1	x	1	H/L	L	Chop(Note 4)
0	x	x	x	x	Z	Z	Standby Mode

Note 4: Outputs change to Hi-Z state when load current approaches zero.

Current Sensing

The TMI8130A 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 TMI8130A 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 TMI8130A, 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} = 2.5V, R_{IPROPI} = 2000Ω, and A_{IPROPI} = 500μA/A, then I_{TRIP} will be approximately 2.5A.

The TMI8130A device integrates current regulation using either a fixed off-time scheme. This allows the devices to limit the output current in case of motor stall, high torque, or other high current load events.

In the fixed off-time mode, the H-bridge enters a brake/low-side slow decay state (both low-side MOSFETs ON) for t_{OFF} duration after I_{OUT} exceeds I_{TRIP}. If I_{OUT} is still greater than I_{TRIP}, the H-bridge will enter another period of brake/low-side slow decay for t_{OFF}.

The fixed off-time mode allows for a simple current chopping scheme without involvement from the external controller. This is shown in Figure 2. Fixed off-time mode will support 100% duty cycle current regulation since the H-bridge automatically enables after the t_{OFF} period and does not require a new control input edge on the EN or PH pins to reset the outputs.

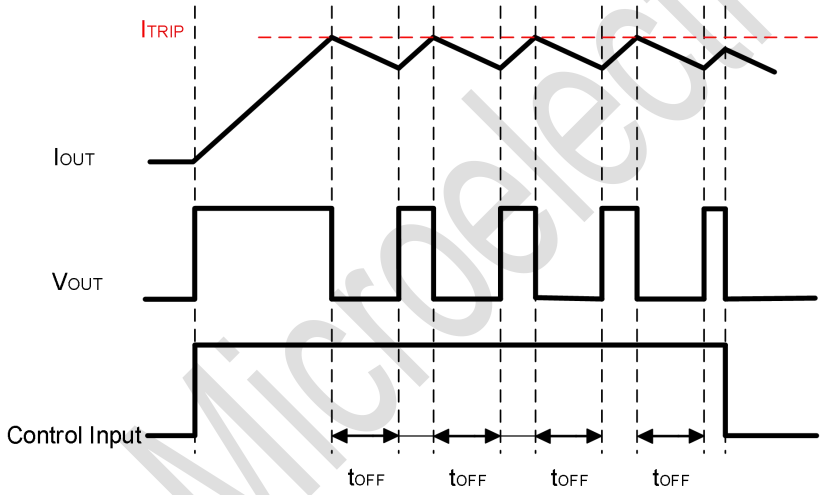


Figure 2. Off-Time Current-Regulation

Blank Function

The internal current sense circuit is ignored at beginning of PWM transitions so as not to falsely sense overcurrent events due to motor capacitance. The blank time can be adjusted as follows depending to allow high or low capacitive loads to be optimized. This blanking time sets the minimum on time of the PWM.

BLANK2	BLANK1	t (μs)
0	0	3
0	1	1
1	0	2
1	1	6

ROSC Function

Resistor tied to ground will set the fixed off-time that occurs during current limit operation. Off-time is set by the following equation:

$$Toff = R_{OSC}/825 \quad \text{(Where } T_{off} \text{ is in microseconds)}$$

R_{OSC} is allowed in the range 8kΩ to 80kΩ .

If R_{OSC} is connected to GND or >3.5V then T_{off} will default to 26μs.

PFD Function

Percent fast decay is determined by state of PFD logic inputs as shown below. After current limit event, load current will recirculate in slow decay, fast decay, or mixed decay mode.

PFD2	PFD1	PFD
0	0	0%
0	1	15%
1	0	50%
1	1	100%

Standby Mode

Low power standby mode is activated when all nRESET is logic low.Low power standby mode disables most of the internal circuitry,including the charge pump and the regulator.When the TMI8130A is coming out of standby mode,the charge pump should be allowed to reach its regulated voltage (a maximum delay of 200μs) before PH and EN input control commands are issued to the device.

Overcurrent Protection (OCP)

A current monitor will protect the IC from damage due to output shorts. If a short is detected, the IC will latch the fault and disable the outputs. The fault latch is cleared by coming out of standby mode or power cycle of VM. During OCP events, the absolute maximum ratings may be exceeded for a short time before the device latches off.

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.

nFAULT Output.

The fault pin is driven low to indicate OCP fault event.The fault pin is not used for normal current limit or supply undervoltage.

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.

Static Inputs with Current Regulation

The PH and EN 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.

VM Control

In some systems,varying VM as a means of changing motor speed is desirable.

APPLICATION INFORMATION

Application information

The TMI8130A device is typically used to drive one brushed DC motor as below.

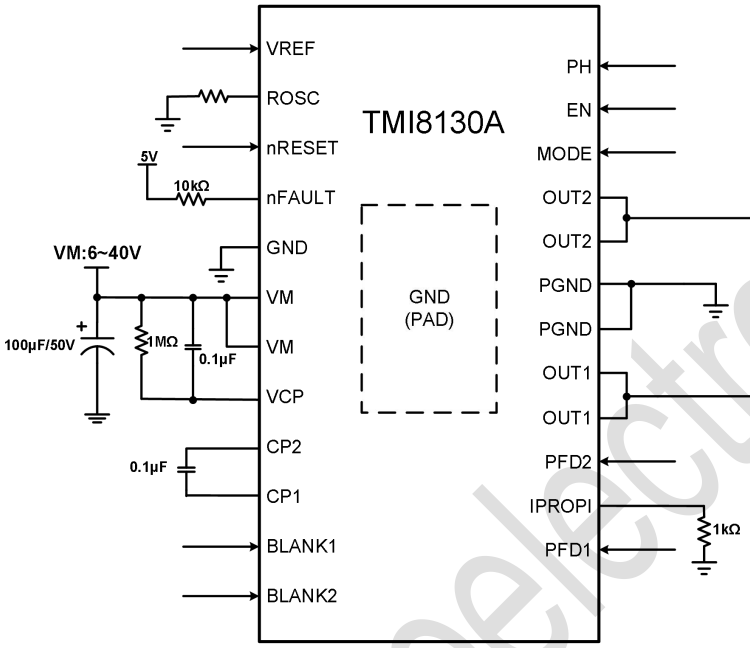


Figure 3. TMI8130A Typical Application

Block Diagram

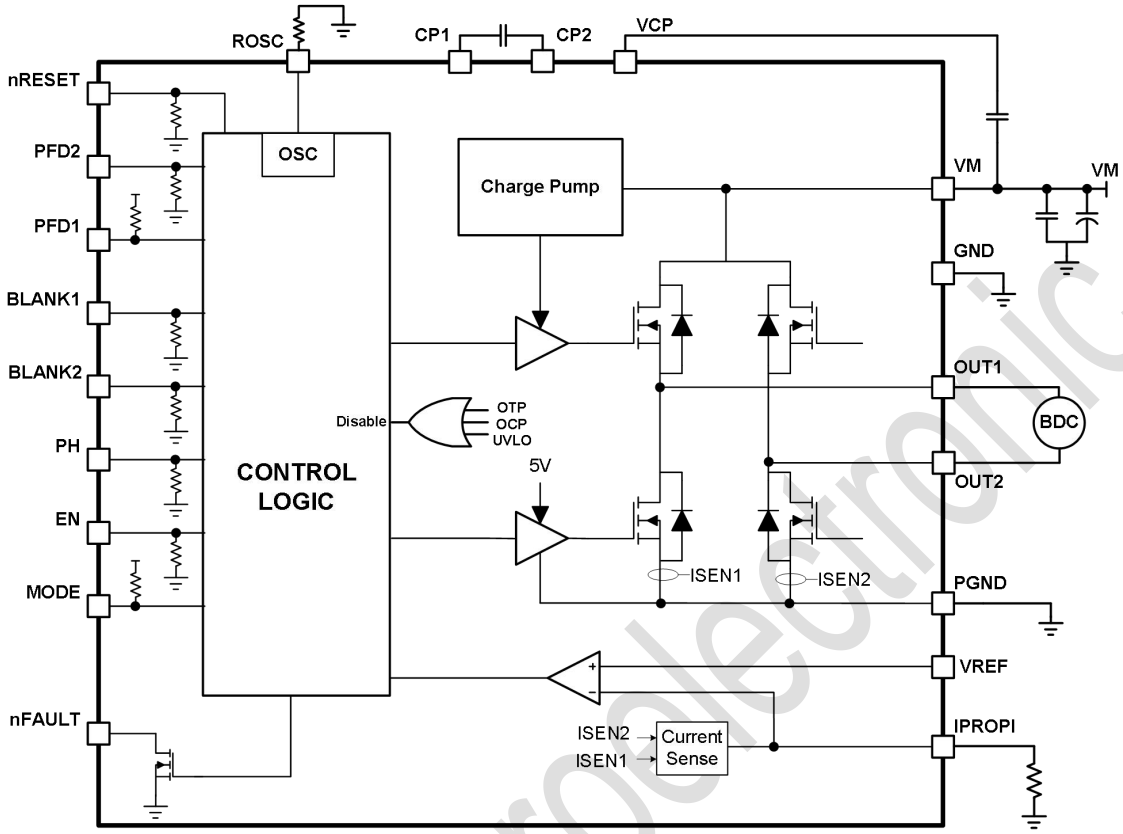
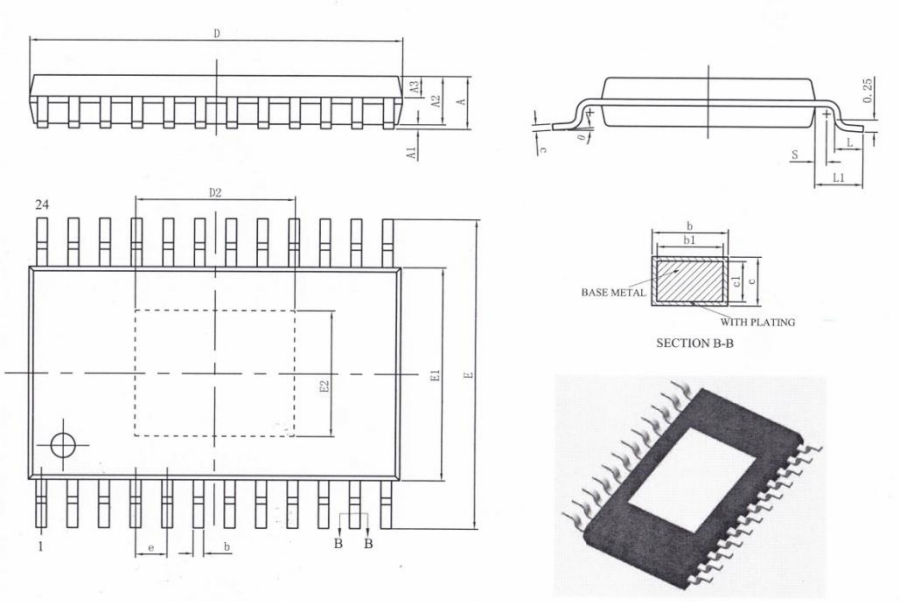


Figure 4. TMI8130A Block Diagram

PACKAGE INFORMATION

ETSSOP24



Unit: mm

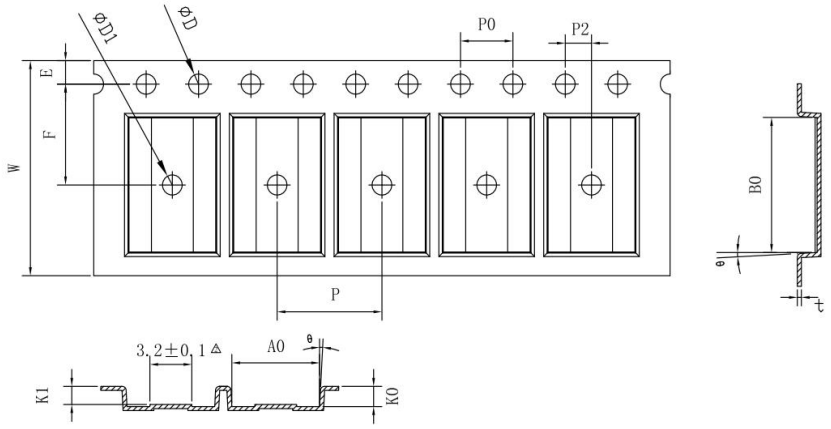
Symbol	Dimensions In Millimeters			Symbol	Dimensions In Millimeters		
	Min	NOM	Max		Min	NOM	Max
A	-	-	1.20	D2	3.95	-	4.15
A1	0.05	-	0.15	E	6.20	6.40	6.60
A2	0.80	1.00	1.05	E1	4.30	4.40	4.50
A3	0.39	0.44	0.49	e	0.65BSC		
b	0.20	-	0.29	L	0.45	0.60	0.75
b1	0.19	0.22	0.25	L1	1.00BSC		
c	0.13	-	0.18	θ	0°	-	8°
c1	0.12	0.13	0.14	E2	2.75	-	2.95
D	7.70	7.80	7.90				

Note:

1) All dimensions are in millmeters.
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.

TYPE AND REEL INFORMATION

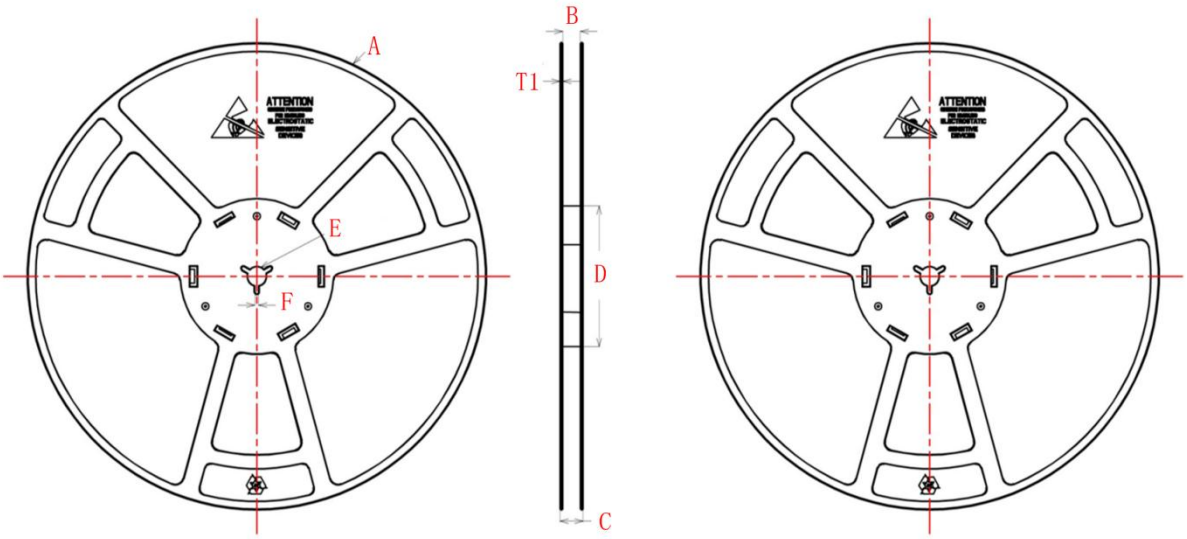
TAPE DIMENSIONS: ETSSOP24



Unit: mm

Symbol	Dimensions	Symbol	Dimensions	Symbol	Dimensions	Symbol	Dimensions
A0	6.70±0.10	θ	5° TYP	E	1.75±0.10	D1	1.55MIN
B0	10.05±0.10	t	0.30±0.05	F	7.50±0.10	P0	4.00±0.10
K0	1.50±0.10	W	16.00±0.30	P2	2.00±0.10	10P0	40.00±0.20
K1	1.35±0.10	P	8.00±0.10	D	1.50±0.10		

REEL DIMENSIONS: ETSSOP24



Unit: mm

A	B	C	D	E	F	T1
Ø 330±1.0	$12.4^{+1.0}_{-0.0}$	$17.6^{+1.0}_{-0.0}$	Ø 100.0±0.5	Ø 13.0±0.2	1.9±0.4	1.9±0.2

Note:

1) All Dimensions are in Millimeter
2) Quantity of Units per Reel is 4000
3) MSL level is level 3.

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