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HEROIC technology

DESCRIPTION

The HR8833 provides a dual bridge motor driver solution for toys, printers, and other mechatronic applications.

The device has two H-bridge drivers, and can drive two DC brush motors, a bipolar stepper motor, solenoids, or other inductive loads.

The output driver block of each H-bridge consists of N-channel power MOSFET's configured as an H-bridge to drive the motor windings. Each H-bridge includes circuitry to regulate or limit the winding current.

Internal shutdown functions with a fault output pin are provided for over current protection, short circuit protection, under voltage lockout and overtemperature. A low-power sleep mode is also provided.

The HR8833 is packaged in a 16-pin TSSOP package with PowerPAD™. The second package is SOP16.

APPLICATIONS

- Battery-Powered Toys
- POS Printers
- Video Security Cameras
- Office Automation Machines
- Gaming Machines
- Robotics

FEATURES

- Dual-H-Bridge Current-Control Motor Driver
- Capable of Driving Two DC Motors or One Stepper Motor
- Low MOSFET On-Resistance: HS + LS 400 mΩ
- Output Current:
  TSSOP16:1.5-A RMS per H-Bridge
  SOP16:   1.4-A RMS per H-Bridge
- Outputs Can Be Paralleled for 3-A RMS
- Wide Power Supply Voltage Range: 2.7 V – 12.8 V
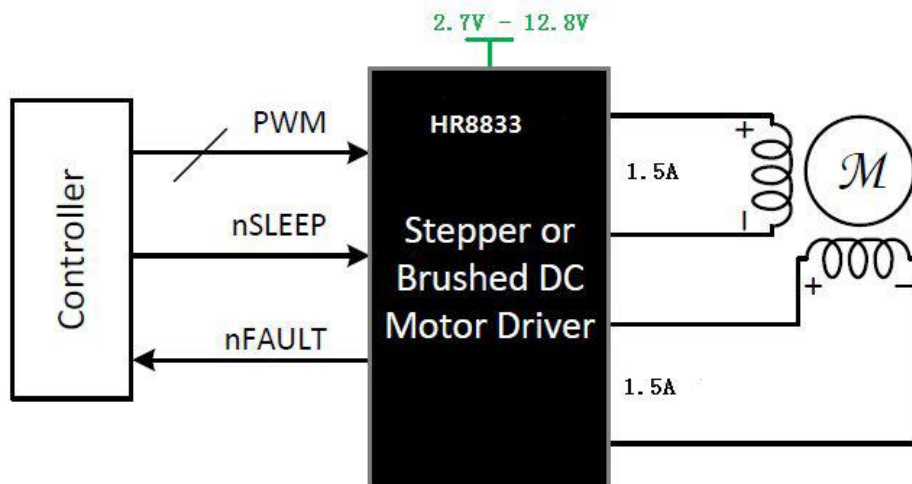- PWM Winding Current Regulation/Limiting

PACKAGE
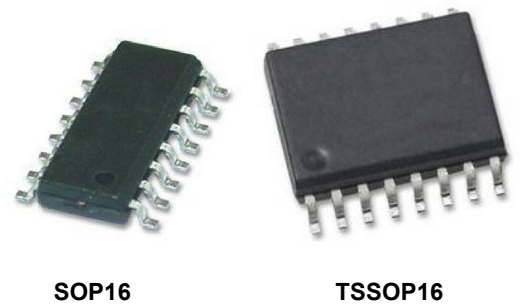
SOP16   **TSSOP16**

ORDERING INFORMATION

Part Number	Package
HR8833MTE	TSSOP16 with exposed thermal pad
HR8833SP	SOP16

2.7V – 12.8V

Controller — PWM — HR8833 Stepper or Brushed DC Motor Driver — 1.5A — M

nSLEEP

nFAULT

1.5A

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Functional Block Diagram
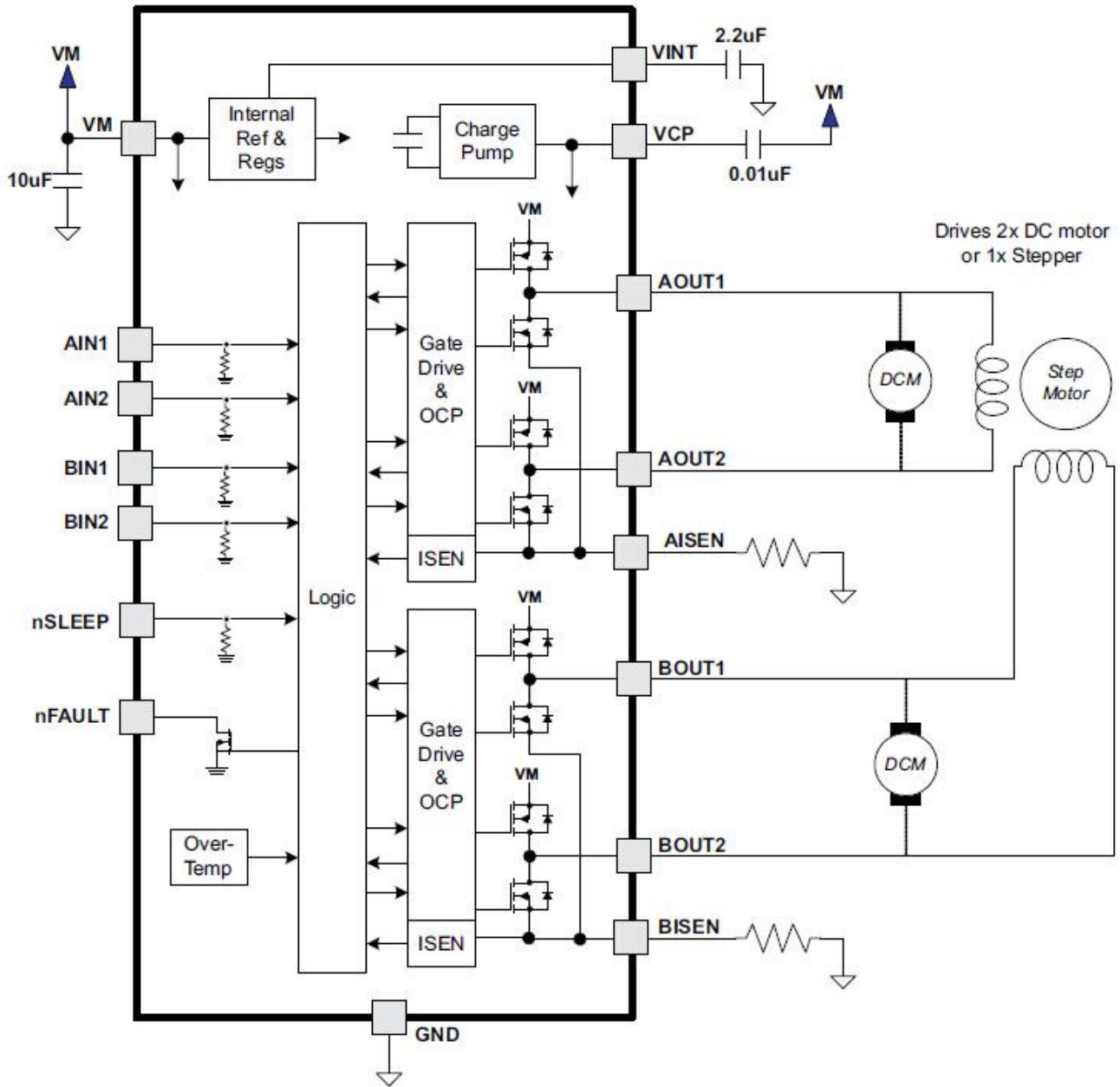
ABSOLUTE MAXIMUM RATINGS at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Load Supply Voltage	VM		-0.3 – 13	V
Output Current	I_{OUT}		±1.5	A
Logic Input voltage	V_{IN}		-0.7 to 7	V
Sense Voltage	V_{SENSE}		-0.3 to 0.5	V
Operating Ambient Temperature	T_A	Range S	-20 to 85	°C
Maximum Junction	$T_J(max)$		150	°C
Storage Temperature	T_{stg}		-55 to 150	°C

RECOMMENDED OPERATING CONDITIONS at Ta = 25°C

		Min	NOM	Max	Unit
Load Supply Voltage Range	VM	2.7	-	12.8	V
Logic Input Voltage Range	VIN	0	-	5.75	V
Continuous RMS or DC output current per bridge	IOUT TSSOP16	0		1.5	A
	IOUT SOP16	0		1.4	

NOTE:

1. Load Supply Voltage Range: HR8833 can be powered with a supply voltage from 2.7 to 12.8 V for step motor. When DC motor, you should keep the load supply voltage below 10.8V.

2. Take care the distinguish of PIN between two package.

ELECTRICAL CHARACTERISTICS at Ta = 25°C, VM= 5 V

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY						
IVM	VM operating supply current	VM = 5 V, xIN1 = 0 V, xIN2 = 0 V		1.7	3	mA
IVMQ	VM sleep mode supply current	VM = 5 V		1.6	2.5	uA
VUVLO	VM undervoltage lockout voltage	VM falling			2.6	V
VHYS	VM undervoltage lockout hysteresis			90		mV
LOGIC-LEVEL INPUTS						
VIL	Input low voltage	nSLEEP			0.5	V
		All other pins			0.7	
VIH	Input High voltage	nSLEEP	2.5			V
		All other pins	2			
VHYS	Input hysteresis			0.4		V
RPD	Input pull-down resistance	nSLEEP		500		kΩ
		All except nSLEEP		150		
IIL	Input low current	VIN = 0			1	uA
IIH	Input high current	VIN = 3.3 V, nSLEEP		6.6	13	uA
		VIN = 3.3 V, all except nSLEEP		16.5	33	
tDEG	Input deglitch time			450		ns
nFAULT OUTPUT (OPEN-DRAIN OUTPUT)						
VOL	Output low voltage	IO = 5 mA			0.5	V
IOH	Output high leakage current	VO = 3.3 V			1	uA
H-BRIDGE FETS						
RDS(ON)	HS FET on resistance	VM = 5 V, I O = 500 mA		200		mΩ
		VM = 2.7 V, I O = 500 mA		250		
	LS FET on resistance	VM = 5 V, I O = 500 mA		180		
		VM = 2.7 V, I O = 500 mA		220		
IOFF	IOFF	VM = 5 V, VOUT = 0 V	-1		1	uA
MOTOR DRIVER						
fPWM	Current control PWM frequency	Internal PWM frequency		50		kHz

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tR	Rise time	VM =5V, 16Ω to GND, 10% to 90%		240		ns
tF	Fall time	VM =5V, 16Ω to GND, 10% to 90%		200		ns
tPROP	Propagation delay INx to OUTx	VM = 5 V		0.9		us
tDEAD	Dead time	VM = 5 V		340		ns
PROTECTION CIRCUITS						
IOCP	Overcurrent protection trip level		2.5			A
tDEG	OCP Deglitch time			2.25		us
tOCP	Overcurrent protection period			1.35		ms
tTSD	Thermal shutdown temperature	Die temperature	150	160	180	℃
CURRENT CONTROL						
VTRIP	xISEN trip voltage		160	200	240	mV
tBLANK	Current sense blanking time			2.6		us
SLEEP MODE						
tWAKE	Startup time	nSLEEP inactive high to H-bridge on		0.2	1	ms

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FUNCTIONAL DESCRIPTION

The HR8833 device is an integrated motor driver solution for brushed DC or bipolar stepper motors. The device integrates two NMOS H-bridges and current regulation circuitry. The HR8833 can be powered with a supply voltage from 2.7 to 12.8 V and can provide an output current up to 1.5 A RMS.

A simple PWM interface allows easy interfacing to the controller circuit.

The current regulation is a 13-μs fixed off-time slow decay.

The device includes a low-power sleep mode, which lets the system save power when not driving the motor.

PWM Motor Drivers

HR8833 contains two identical H-bridge motor drivers with current-control PWM circuitry. A block diagram of the circuitry is shown below:
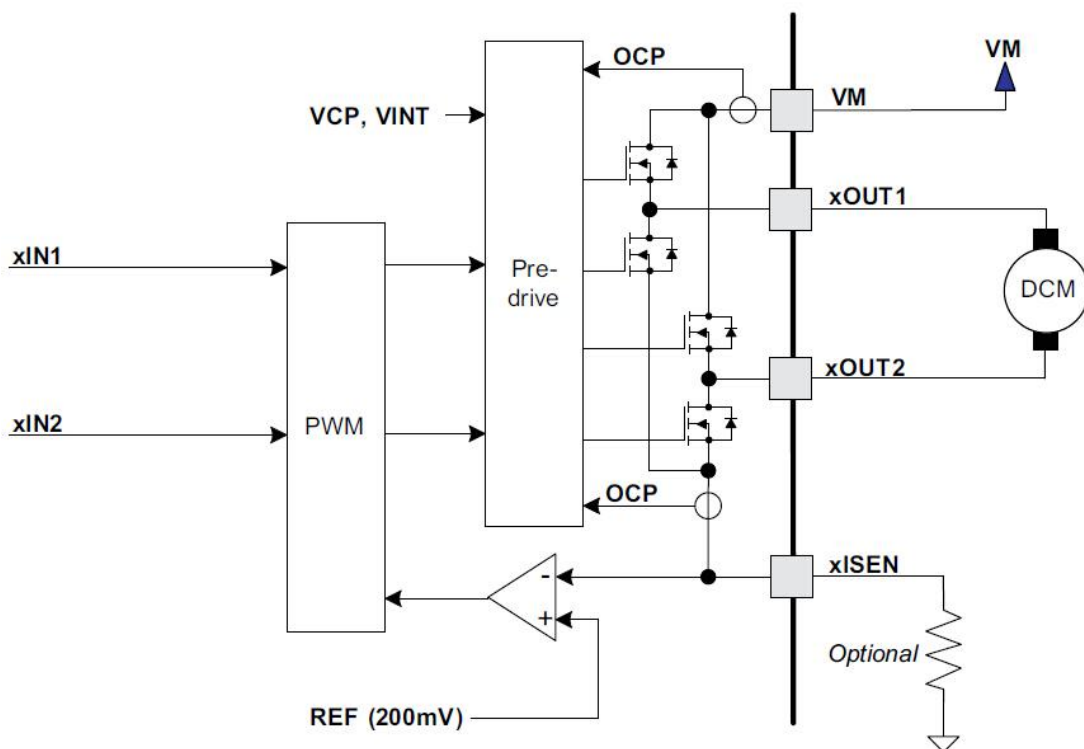
H-Bridge and Current-Chopping Circuitry

Bridge Control and Decay Modes

The AIN1 and AIN2 input pins control the state of the AOUT1 and AOUT2 outputs; similarly, the BIN1 and BIN2 input pins control the state of the BOUT1 and BOUT2 outputs. Below table shows the logic.

| xIN1	xIN2	xOUT1	xOUT2	FUNCTION
0	0	Z	Z	Coast / fast decay
0	1	L	H	Reverse
1	0	H	L	Forward
1	1	L	L	Brake / slow decay

H-Bridge Logic

The inputs can also be used for PWM control of the motor speed. When controlling a winding with PWM, when the drive current is interrupted, the inductive nature of the motor requires that the current must continue to flow.This is called recirculation current. To handle this recirculation current, the H-bridge can operate in two different states, fast decay or slow decay. In fast decay mode, the H-bridge is disabled and recirculation current flows through the body diodes; in slow decay, the motor winding is shorted.

To PWM using fast decay, the PWM signal is applied to one xIN pin while the other is held low; to use slow decay, one xIN pin is held high.

PWM Control of Motor Speed

xIN1	xIN2	FUNCTION
PWM	0	Forward PWM, fast decay
1	PWM	Forward PWM, slow decay
0	PWM	Reverse PWM, fast decay
PWM	1	Reverse PWM, slow decay

Below figure shows the current paths in different drive and decay mode.
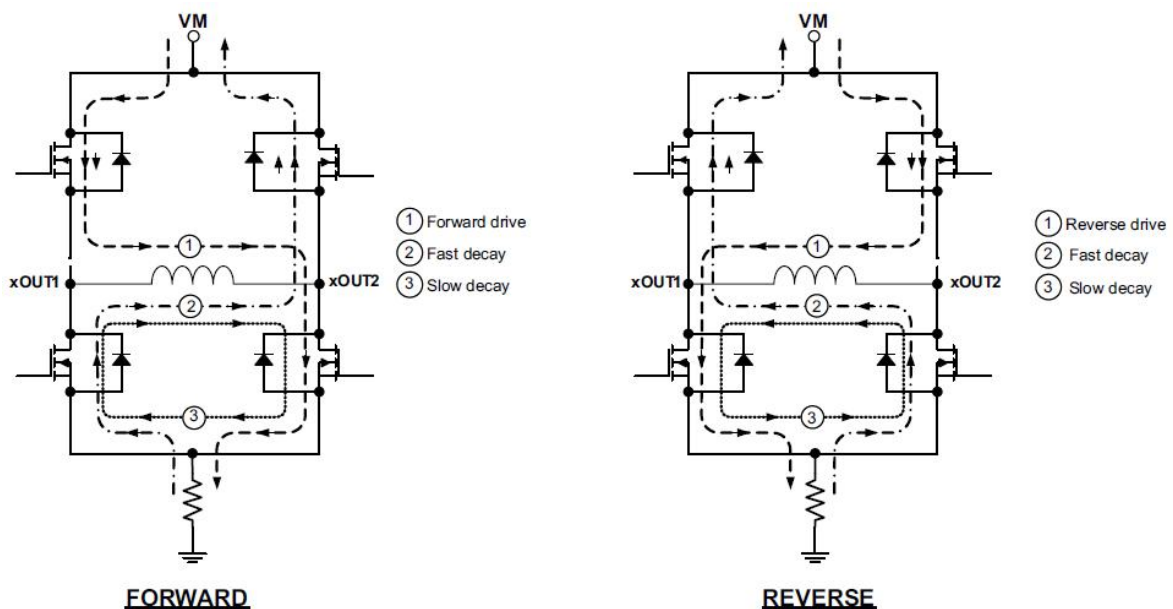
Drive and Decay Modes

Current Control

The current through the motor windings may be limited, or controlled, by a fixed-frequency PWM current regulation, or current chopping. For DC motors, current control is used to limit the start-up and stall current of the motor. For stepper motors, current control is often used at all times.

When an H-bridge is enabled, current rises through the winding at a rate dependent on the DC voltage and inductance of the winding. If the current reaches the current chopping threshold, the bridge disables the current until the beginning of the next PWM cycle. Note that immediately after the current is enabled, the voltage on the xISEN pin is ignored for a fixed period of time before enabling the current sense circuitry. This blanking time is fixed at 2.6 µs. This blanking time also sets the minimum on time of the PWM when operating in current chopping mode.

The PWM chopping current is set by a comparator which compares the voltage across a current sense resistor connected to the xISEN pins with a reference voltage. The reference voltage is fixed at 200 mV.

The chopping current is calculated in next equation：

$$I_{CHOP} = \frac{200\ mV}{R_{XISEN}}$$

Example:

If a 1-Ω sense resistor is used, the chopping current will be 200 mV/1 Ω = 200 mA.

Once the chopping current threshold is reached, the H-bridge switches to slow decay mode. Winding current is re-circulated by enabling both of the low-side FETs in the bridge. This state is held until the beginning of the next fixed-frequency PWM cycle.

Note that if current control is not needed, the xISEN pins should be connected directly to ground.

nSLEEP Operation

Driving nSLEEP low will put the device into a low power sleep state. In this state, the H-bridges are disabled, the gate drive charge pump is stopped, all internal logic is reset, and all internal clocks are stopped. All inputs are ignored until nSLEEP returns inactive high. When returning from sleep mode, some time (up to 1 ms) needs to pass before the motor driver becomes fully operational. To make the board design simple, the nSLEEP can be pulled up to the supply (VM). It is recommended to use a pullup resistor when this is done. This resistor limits the current to the input in case VM is higher than 6.5 V. Internally, the nSLEEP pin has a 500-kΩ resistor to GND. It also has a clamping zener diode that clamps the voltage at the pin at 6.5 V. Currents greater than 250 µA can cause damage to the input structure. Hence the recommended pullup resistor would be between 20 kΩ and 75 kΩ.

Protection Circuits

The HR8833 is fully protected against undervoltage, overcurrent and overtemperature events.

Overcurrent Protection (OCP)

An analog current limit circuit on each FET limits the current through the FET by limiting the gate drive. If this analog current limit persists for longer than the OCP deglitch time, all FETs in the H-bridge will be disabled and the nFAULT pin will be driven low. The driver will be re-enabled after the OCP retry period (tOCP) has passed. nFAULT becomes high again at this time. If the fault condition is still present, the cycle repeats. If the fault is no longer present, normal operation resumes and nFAULT remains deasserted. Please note that only the H-bridge in which the OCP is detected will be disabled while the other bridge will function normally.

Overcurrent conditions are detected independently on both high and low side devices; i.e., a short to ground, supply, or across the motor winding will all result in an overcurrent shutdown. Note that overcurrent protection does not use the current sense circuitry used for PWM current control, so functions even without presence of the xISEN resistors.

Thermal Shutdown (TSD)

If the die temperature exceeds safe limits, all FETs in the H-bridge will be disabled and the nFAULT pin will be driven low. Once the die temperature has fallen to a safe level operation will automatically resume.

## Undervoltage Lockout (UVLO)

If at any time the voltage on the VM pin falls below the undervoltage lockout threshold voltage, all circuitry in the device will be disabled, and all internal logic will be reset. Operation will resume when VM rises above the UVLO threshold. nFAULT is driven low in the event of an undervoltage condition.

APPLICATIONS INFORMATION

Parallel Mode

The two H-bridges in the HR8833 can be connected in parallel for double the current of a single H-bridge. The internal dead time in the HR8833 prevents any risk of cross-conduction (shoot-through) between the two bridges due to timing differences between the two bridges. The drawing below shows the connections.

Note, below example is basis on TSSOP16 package.
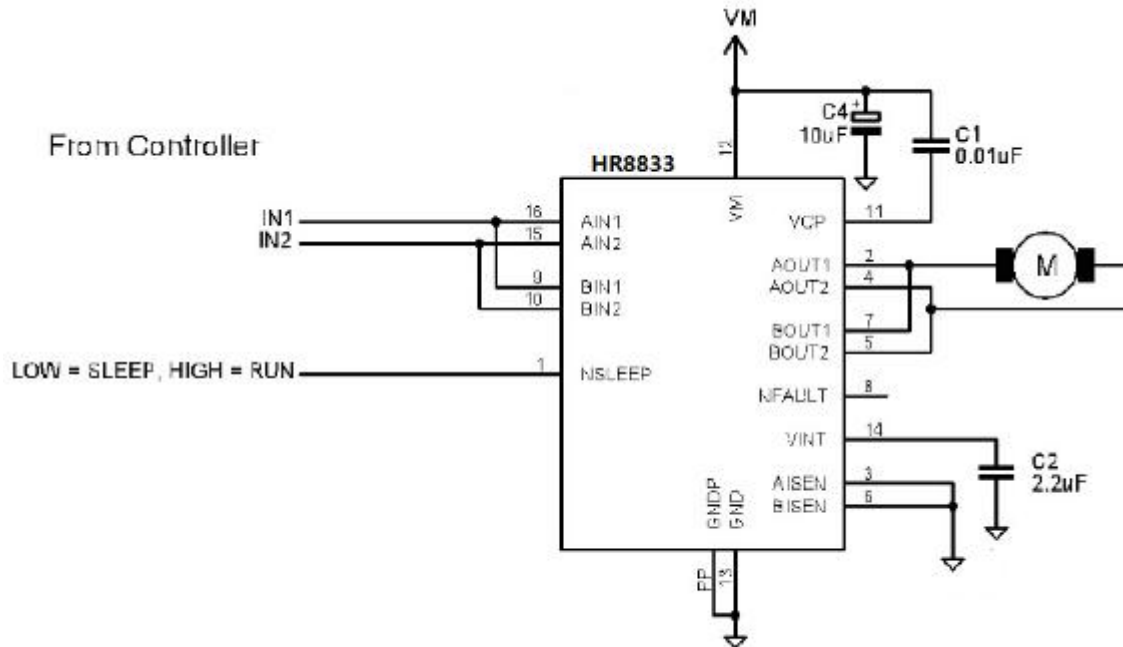
Parallel Mode

THERMAL INFORMATION

Maximum Output Current

In actual operation, the maximum output current achievable with a motor driver is a function of die temperature. This in turn is greatly affected by ambient temperature and PCB design. Basically, the maximum motor current will be the amount of current that results in a power dissipation level that, along with the thermal resistance of the package and PCB, keeps the die at a low enough temperature to stay out of thermal shutdown.

The dissipation ratings given in the datasheet can be used as a guide to calculate the approximate maximum power dissipation that can be expected to be possible without entering thermal shutdown for several different PCB constructions. However, for accurate data, the actual PCB design must be analyzed via measurement or thermal simulation.

Thermal Protection

The HR8833 has thermal shutdown (TSD) as described above. If the die temperature exceeds approximately 150°C, the device will be disabled until the temperature drops by 45°C.

Any tendency of the device to enter TSD is an indication of either excessive power dissipation, insufficient heatsinking, or too high an ambient temperature.

Power Dissipation

Power dissipation in the HR8833 is dominated by the DC power dissipated in the output FET resistance, or

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RDS(ON). There is additional power dissipated due to PWM switching losses, which are dependent on PWM frequency, rise and fall times, and VM supply voltages. These switching losses are typically on the order of 10% to 30% of the DC power dissipation.

The DC power dissipation of one H-bridge can be roughly estimated by next equation:

$$P_{TOT} = (HS - R_{DS(ON)} \bullet I_{OUT(RMS)}{}^2) + (LS - R_{DS(ON)} \bullet I_{OUT(RMS)}{}^2)$$

where PTOT is the total power dissipation, HS - RDS(ON) is the resistance of the high side FET, LS - RDS(ON) is the resistance of the low side FET, and IOUT(RMS) is the RMS output current being applied to the motor.

Note that RDS(ON) increases with temperature, so as the device heats, the power dissipation increases. This must be taken into consideration when sizing the heatsink.

Heatsinking

The PowerPAD packages use an exposed pad to remove heat from the device. For proper operation, this pad must be thermally connected to copper on the PCB to dissipate heat. On a multi-layer PCB with a ground plane, this can be accomplished by adding a number of vias to connect the thermal pad to the ground plane. On PCBs without internal planes, copper area can be added on either side of the PCB to dissipate heat. If the copper area is on the opposite side of the PCB from the device, thermal vias are used to transfer the heat between top and bottom layers.

Layout Guidelines

Bypass the VM terminal to GND using a low-ESR ceramic bypass capacitor with a recommended value of 10 μF rated for VM. This capacitor should be placed as close to the VM pin as possible with a thick trace or ground plane connection to the device GND pin and PowerPAD.
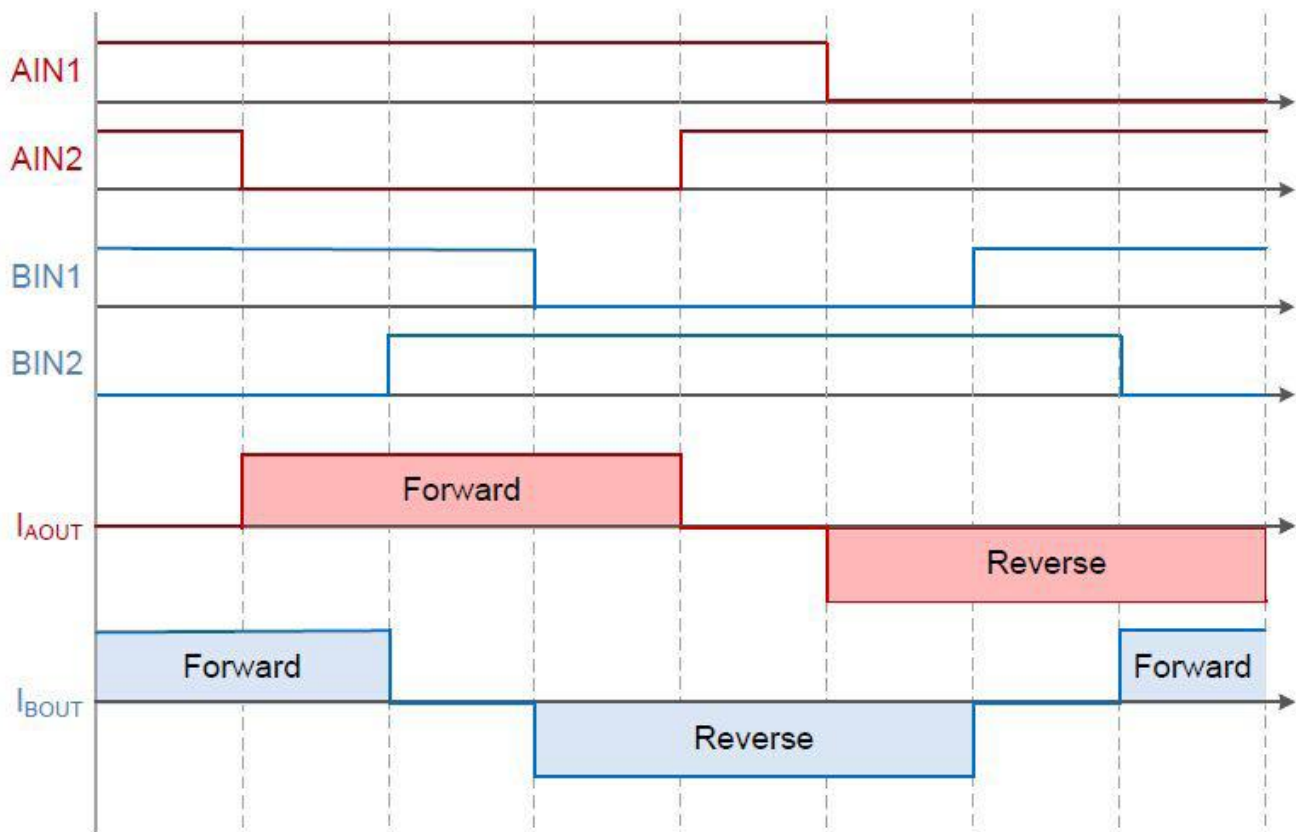
Bypass VINT to ground with a ceramic capacitor rated 6.3 V. Place this bypassing capacitor as close to the pin as possible.
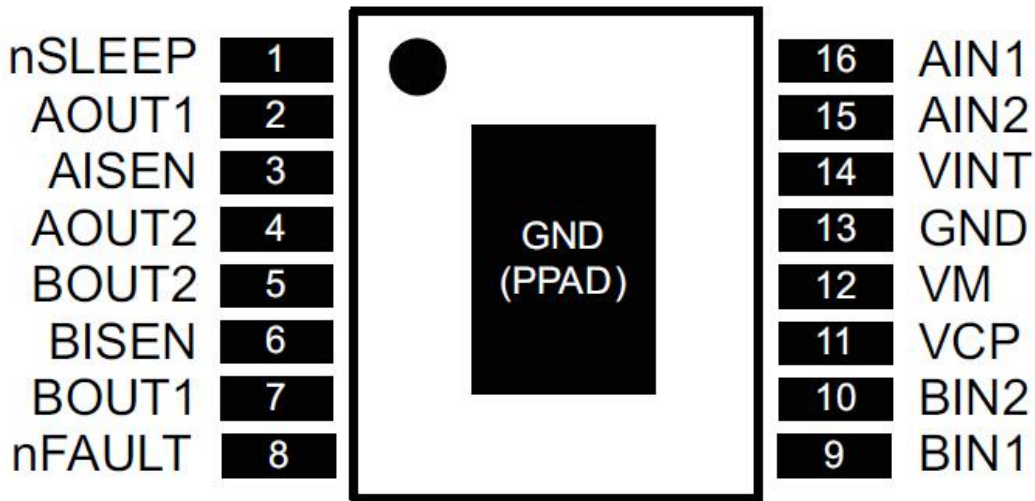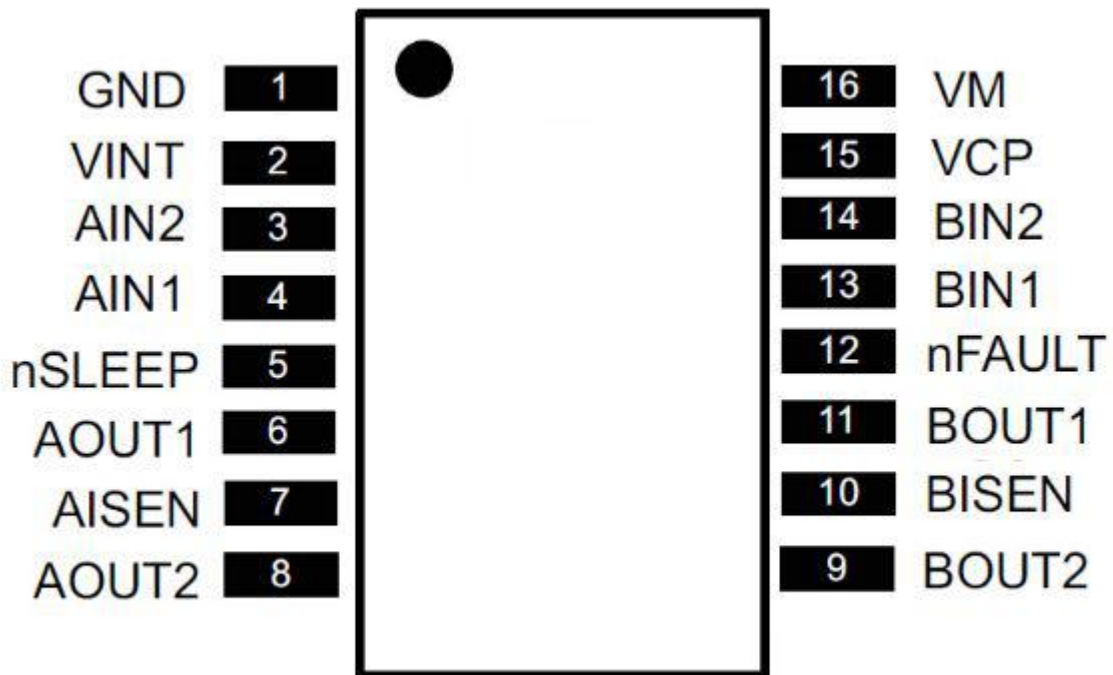
Layout Example
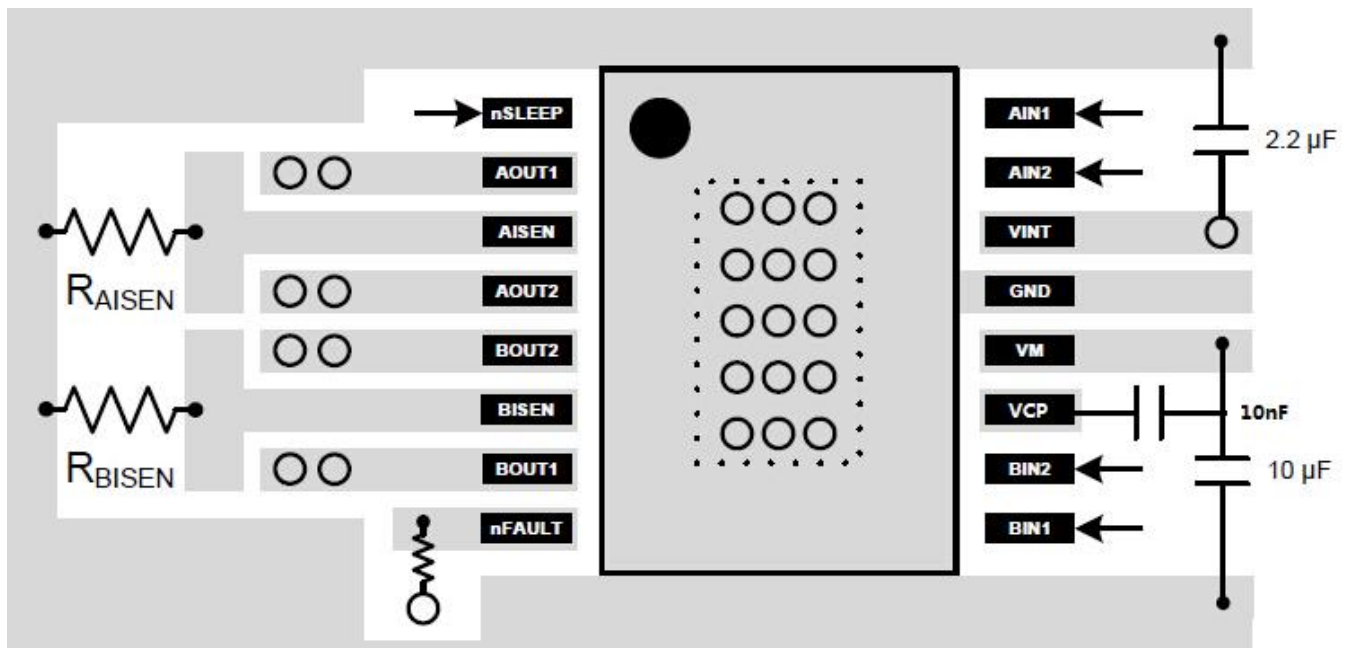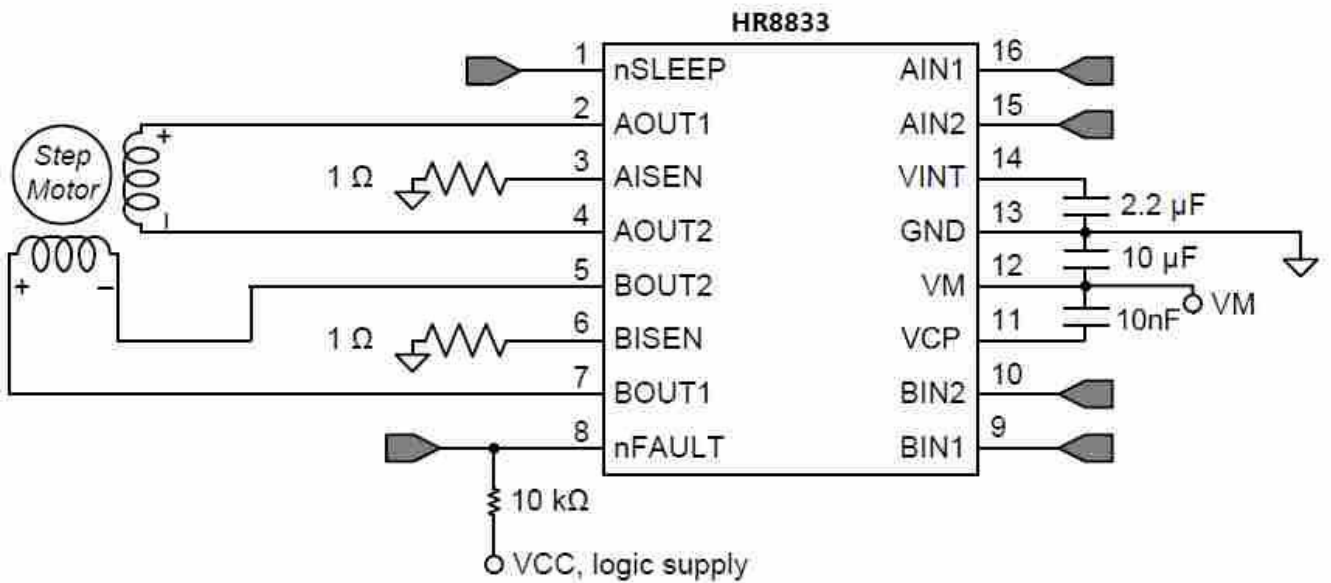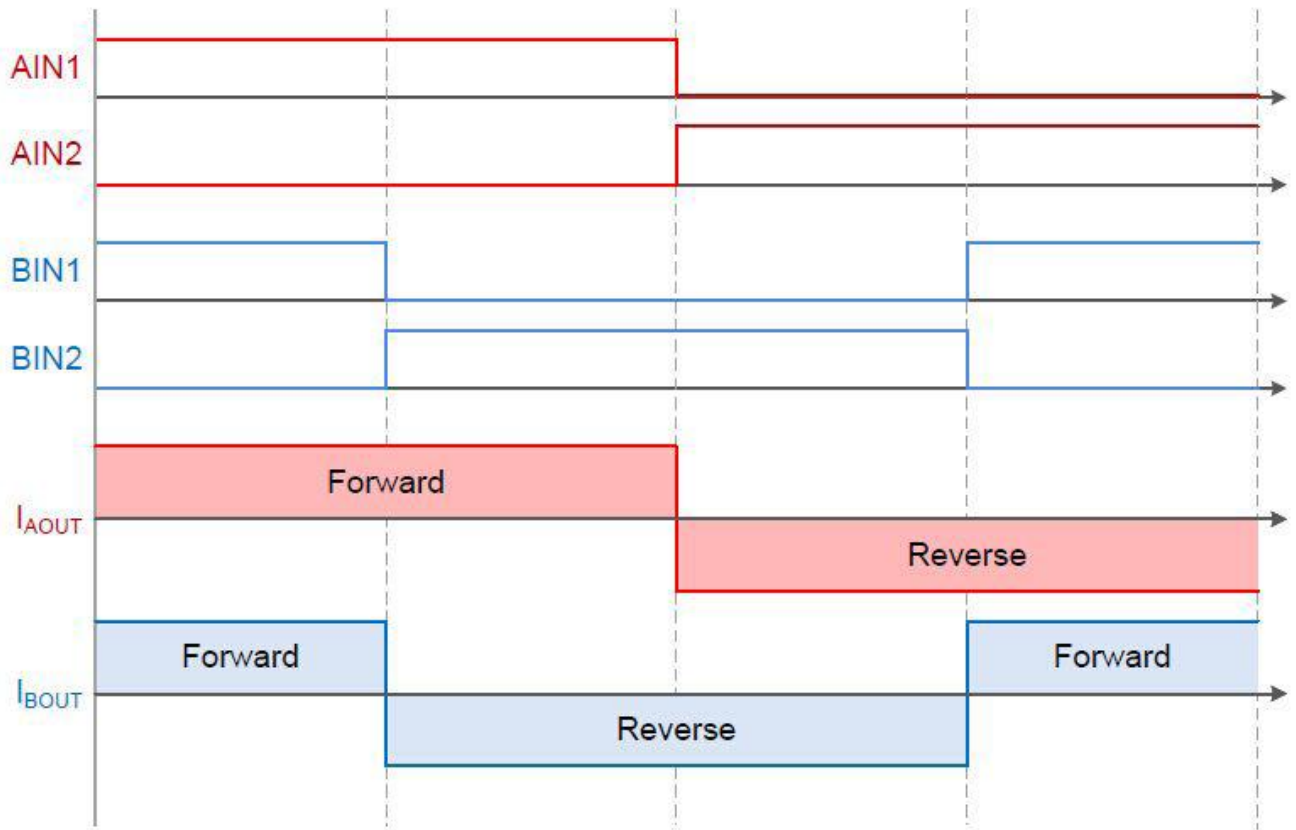
FULL STEP

HALF STEP

Pin-out Diagram

TOP VIEW


TSSOP16

SOP16

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Terminal List Table

NAME	PIN		Pin Description	EXTERNAL COMPONENTS
	TSSOP	SOP		OR CONNECTIONS
POWER AND GROUND				
GND	13	1	Device ground	Both the GND pin and device PowerPAD must be connected
PPAD	-	-		to ground
VM	12	16	Device power supply	Connect to motor supply. A 10uF (minimum) ceramic bypass capacitor to GND is recommended.
VINT	14	2	Internal supply	Bypass to GND with 2.2uF, 6.3-V capacitor
VCP	11	15	High-side gate	Connect a 0.01uF, 16V (minimum) X7R ceramic capacitor to
CONTROL				
AIN1	16	4	Bridge A input 1	Logic input controls state of AOUT1. Internal pulldown.
AIN2	15	3	Bridge A input 2	Logic input controls state of AOUT2. Internal pulldown.
BIN1	9	13	Bridge B input 1	Logic input controls state of BOUT1. Internal pulldown.
BIN2	10	14	Bridge B input 2	Logic input controls state of BOUT2. Internal pulldown.
nSLEEP	1	5	Sleep mode input	Logic high to enable device, logic low to enter low-power sleep mode
STATUS				
nFAULT	8	12	Fault output	Logic low when in fault condition (overtemp, overovercurrent)
OUTPUT				
AISEN	3	7	Bridge A ground / Isense	Connect to current sense resistor for bridge A, or GND if current control
BISEN	6	10	Bridge B ground / Isense	Connect to current sense resistor for bridge B, or GND if current control
AOUT1	2	6	Bridge A output 1	Connect to motor winding A
AOUT2	4	8	Bridge A output 2	
BOUT1	7	11	Bridge B output 1	Connect to motor winding B
BOUT2	5	9	Bridge B output 2	

TSSOP16 with exposed thermal pad
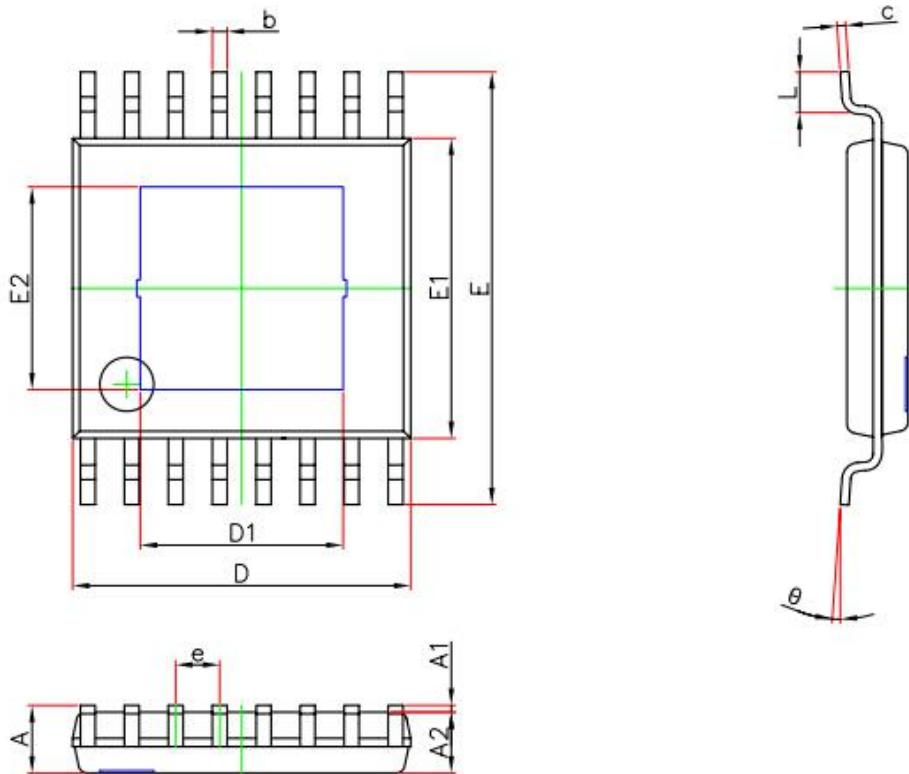
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	—	1.200	—	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.900	5.100	0.193	0.201
D1	2.900	3.100	0.114	0.122
E	6.250	6.550	0.246	0.258
E1	4.300	4.500	0.169	0.177
E2	2.900	3.100	0.114	0.122
e	0.650(BSC)		0.026(BSC)	
L	0.450	0.750	0.018	0.030
θ	0°	8°	0°	8°

HEROIC technology

SOP16

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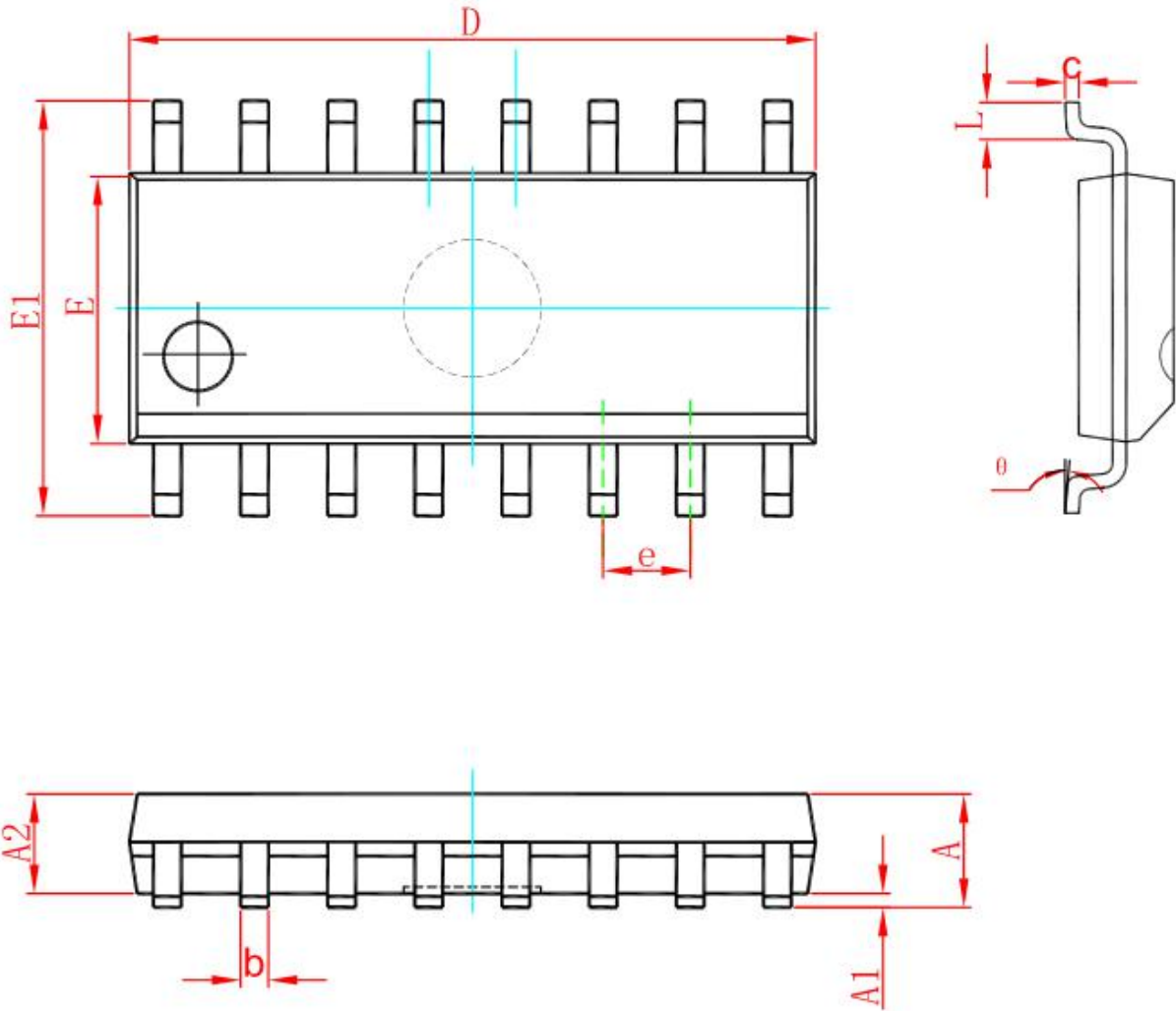
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	9.800	10.200	0.386	0.402
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

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嘉兴禾润电子科技有限公司

Jiaxing Heroic Electronic Technology Co., Ltd.

地址：　　浙江省嘉兴市凌公塘路3339号JRC大厦A座三层

Add:　　　A 3rd floor, JRC Building, No. 3339, LingGongTang Road, Jiaxing, Zhejiang Province

销售/Sales:　　0573-82583866

支持/Support:　　0573-82586151

传真/Fax:　　0573-82585078

E-mail:　　sales@heroic.com.cn

网址/Website:　　www.heroic.com.cn