Application Note: SY6703

High Efficiency H-Bridge Motor Driver IC

General Description

The SY6703 is a dual H-bridge motor driver solution for toys, printers, and other mechatronic applications. The SY6703 operates with a power-supply voltage range from 2.5V to 16V, and 1.5A RMS maximum output current.

The device can drive two DC brush motors, a bipolar stepper motor, solenoids, or other inductive loads. The highly integrated H-bridge driver block consists of two H-bridges with internal logic control, gate drive, over current protection and charge pump circuit. Each H-bridge includes circuitry to regulate or limit the winding current.

The SY6703 provides internal shutdown functions with a fault output pin are provided for over current protection, short circuit protection, under voltage lockout and thermal shutdown. A low-power sleep mode is also provided. The device is packaged in two different types: a 16-pin TSSOP, a 16-pin QFN package.

Features

- Dual H-bridge Motor Driver
- Maximum Drive Current of 1.5A RMS Current for Each H-bridge
- Power Supply Voltage Range from 2.5V to 16V
- PWM (IN/IN) Interface
- PWM Winding Current Regulation/Limit
- Internal OCP/SCP/UVL and thermal shutdown
- Multiple Packages Choice: TSSOP-16E/QFN4×4-16

Applications

- POS Printers
- DSLR Lenses
- Video Security Cameras
- Toys
- Robotics
- Game Machines
- Office Automation Machines

Ordering Information

SY6703 □(□□)□

- Temperature Code
- Package Code
- Optional Spec Code

Ordering Number	Package type	Note
SY6703HFC	TSSOP-16E	
SY6703QIC	QFN4×4-16	

Typical Applications

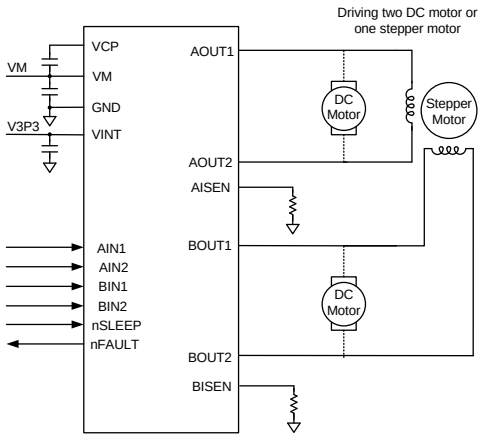
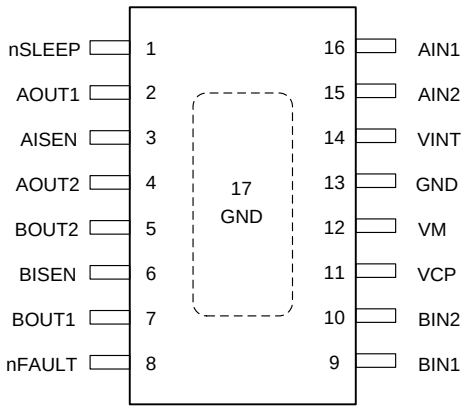
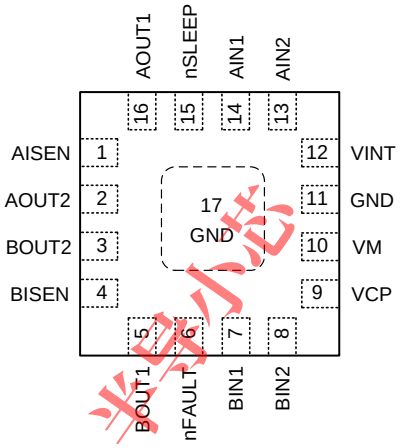


Figure1. Schematic Diagram

Pinout (top view)



TSSOP-16E



QFN4×4-16

Part Number	Package type	Top Mark①
SY6703HFC	TSSOP-16E	**AZR*xyz***
SY6703QIC	QFN4×4-16	**BGS*xyz***

Note①： ***x=year code, y=week code, z= lot number code.***

Name	Number		Description
	TSSOP-16E	QFN4×4-16	
nSLEEP	1	15	Sleep mode pin. Logic low puts device in low-power sleep mode, this pin has a internal pull-down resistor
AOUT1	2	16	Bridge A output 1 pin. Connect this pin to motor winding.
AISEN	3	1	Bridge A current sense pin. Connect a resistor between this pin and GND for current control, or connect to GND if current control is not needed
AOUT2	4	2	Bridge A output 2 pin. Connect this pin to motor winding.
BOUT2	5	3	Bridge B output 2 pin. Connect this pin to motor winding.
BISEN	6	4	Bridge B current sense pin. Connect a resistor between this pin and GND for current control, or connect to GND if current control is not needed
BOUT1	7	5	Bridge B output 1 pin. Connect this pin to motor winding.
nFAULT	8	6	Fault state output pin. Logic low if fault is detected.
BIN1	9	7	Bridge B input 1 pin. Control the state of bridge B, this pin has an internal pull-down resistor.
BIN2	10	8	Bridge B input 2 pin. Control the state of bridge B, this pin has an internal pull-down resistor
VCP	11	9	Internal charge pump voltage for high side gate driver. Connect a ceramic capacitor to VM.
VM	12	10	Motor power supply pin. Decouple this pin to GND pin with 10uF ceramic cap.
GND	13	11	Device ground pin.
VINT	14	12	Internal logic and driver supply. Connect this pin with a ceramic capacitor to GND.
AIN2	15	13	Bridge a input 2 pin. Control the state of bridge A, this pin has an internal pull-down resistor.
AIN1	16	14	Bridge A input 1 pin. Control the state of bridge A, this pin has an internal pull-down resistor.
GND	17	17	Ground pin for thermal dissipation.

Block Diagram

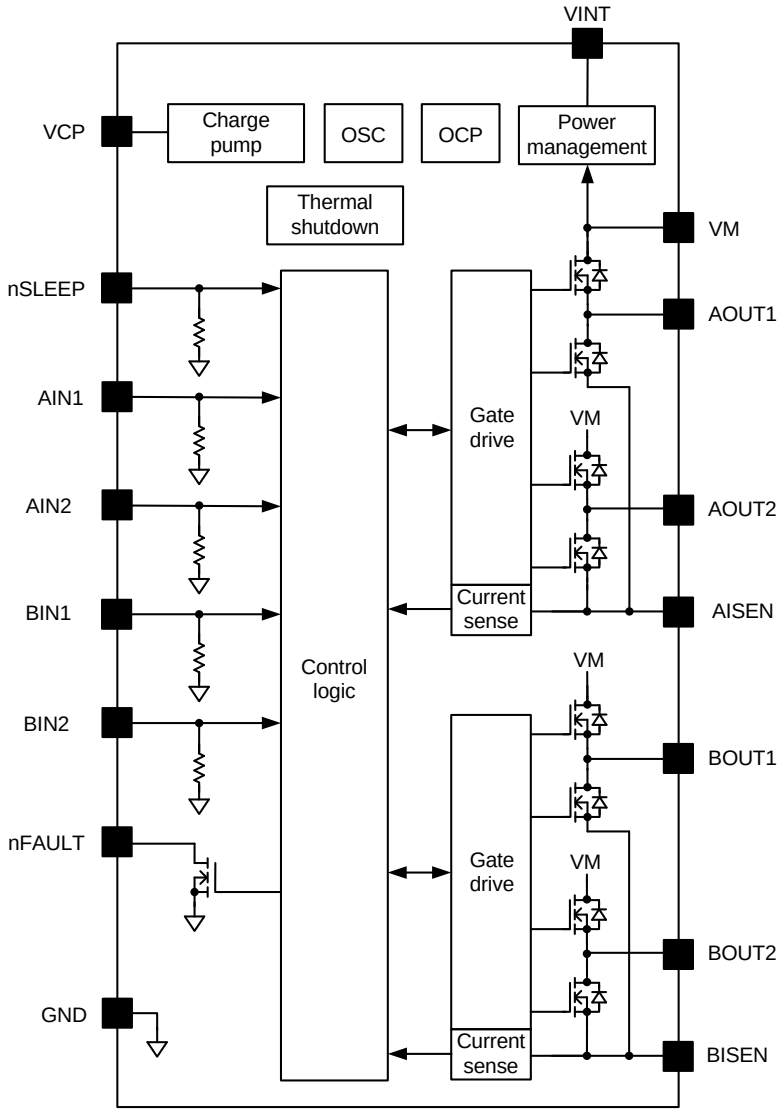


Figure2. Block Diagram

Absolute Maximum Ratings (Note 1)

VM, OUT1, OUT2, nFAULT, nSLEEP ---------- 16V
VCP ---------- VM+3.3V
xIN1, xIN2 ---------- -0.3V to 6V
xISEN ---------- -0.3V to 0.5V
Junction Temperature (T_J) ---------- -40℃ to +150℃
Storage Temperature ---------- -65℃ to +150℃
Package Thermal Resistance
θ_{JA} (Note 2), TSSOP-16E/QFN4×4-16 ---------- 41/38℃/W
θ_{JC_TOP}, TSSOP-16E/QFN4×4-16 ---------- 33/35℃/W

Recommended Operating Conditions

VM, nSLEEP ---------- 2.5V to 12V
xIN1, xIN2 ---------- -0.1V to 5V
H-Bridge Output RMS Current (Note3) (Package TSSOP-16E/QFN4×4-16) ---------- 0A to 1.5A
Junction Temperature Range ---------- -40℃ to 125℃
Ambient Temperature Range ---------- -40℃ to 85℃

Electrical Characteristics

(T_A = 25℃, VM=5V, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Power Supplies						
VM Operating Supply Current	I_{VM}	VM=5V, xIN=0V, xIN2=0V		0.65	1.2	mA
VM Sleep Mode Current	I_{VMS}	nSLEEP=0V, VM=5V		1.8	2.5	μA
VM UVL Voltage	V_{UVLO_RISE}	VM Rising		2.0		V
	V_{UVLO_FALL}	VM Falling		1.9		V
VINT	V_{INT}	nSLEEP=3V,VM=5V	3	3.3		V
Logic Level Input						
Input Low Voltage	V_{IL}	nSLEEP			0.4	V
		All other pins			0.7	
Input High Voltage	V_{IH}	nSLEEP	2.5			V
		All other pins	2.2			
Input Low Current	I_{IL}	V_{IN}=0V			1	μA
Input High Current	I_{IH}	V_{IN}=3.3V, nSLEEP		5.3	12	μA
		V_{IN}=3.3V, all except nSLEEP		18	30	
Input Deglitch Time	t_{DEG}	(Note 4)		450		ns
nFAULT Output (Open-Drain Output)						
Output Low Voltage	V_{OL}	I_O=5mA			0.2	V
Output High Leakage Current	I_{OH}	V_O=3.3V			1	μA
H-Bridge MOSFETs						
High Side MOSFETs On Resistance	R_{dson}	V_M=5V, I_O=500mA, T_J=25℃		260		mΩ
Low Side MOSFETs On Resistance		V_M=5V, I_O=500mA, T_J=25℃		220		
Off-State Leakage Current	I_{OFF}	V_M=5V, VOUT=0V, T_J=25℃			±1	μA
Motor Driver						
Current Control PWM Frequency	f_{PWM}	Internal PWM Frequency		50		kHz
Rise Time	t_R	V_M=5V,16Ω to GND, 10% to 90% V_M,Note4		60		ns
Fall Time	t_F			50		ns
Propagation Delay INx to OUTx	t_{PROP}	V_M=5V, Note4		0.35		μs

Dead Time	t_{DEAD}	V_M=5V, Note4		100		ns
Protection						
Output Over Current Limit	I_{OCP}		1.8	3		A
Over Current Retry Time	t_{OCPR}			1.5		ms
OCP Deglitch Time	t_{DEG}	Note 4		180		ns
Thermal Shutdown Temperature	T_{SD}			160		℃
Thermal Shutdown hysteresis	T_{HYS}			20		℃
Current Control						
xISEN Trip Voltage	V_{TRIP}		160	200	240	mV
Current Sense Blanking Time	t_{BLANK}			3.0		μs

Note 1: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

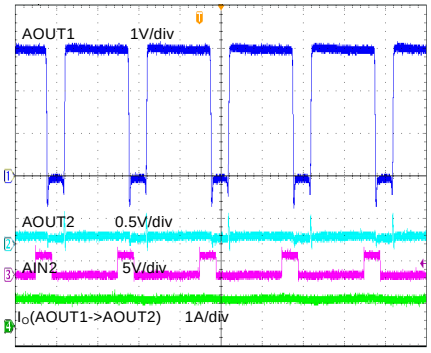
Note 2: θ_{JA} is measured in the natural convection at T_A = 25℃ on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

Note 3: Power dissipation and thermal limits must be observed.

Note 4: Guaranteed by design.

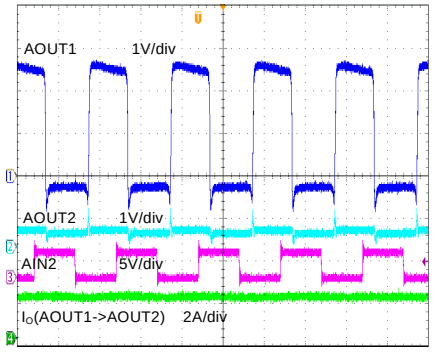
Typical performance characteristics

Operation Waveform
(VM=3.3V, AIN1=high, Io=0.5A, AISEN connect to GND)



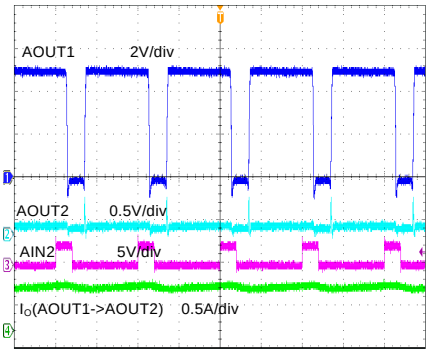
Time (2μs/div)

Operation Waveform
(VM=3.3V, AIN1=high, Io=1.8A, AISEN connect to GND)



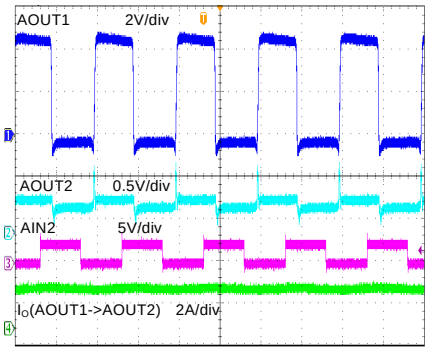
Time (2μs/div)

Operation Waveform
(VM=5V, AIN1=high, Io=0.5A, AISEN connect to GND)



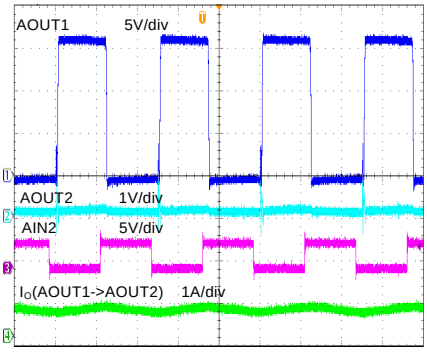
Time (2μs/div)

Operation Waveform
(VM=5V, AIN1=high, Io=1.8A, AISEN connect to GND)



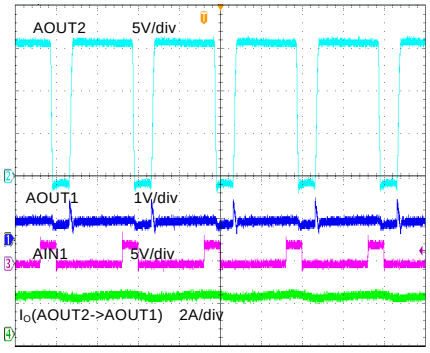
Time (2μs/div)

Operation Waveform
(VM=16V, AIN1=high, Io=0.5A, AISEN connect to GND)



Time (4μs/div)

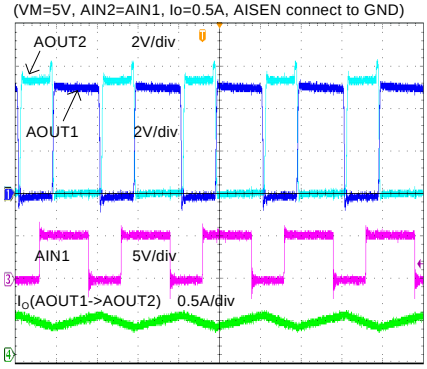
Operation Waveform
(VM=16V, AIN2=high, Io=1.8A, AISEN connect to GND)



Time (2μs/div)

Operation Waveform

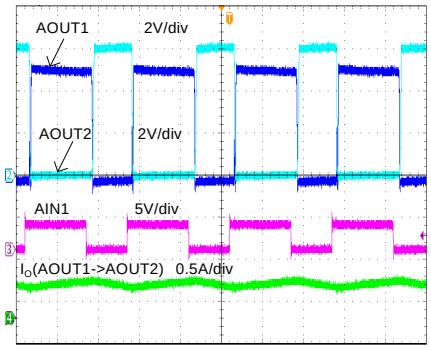
(VM=5V, AIN2=AIN1, Io=0.5A, AISEN connect to GND)



Time (2μs/div)

Operation Waveform

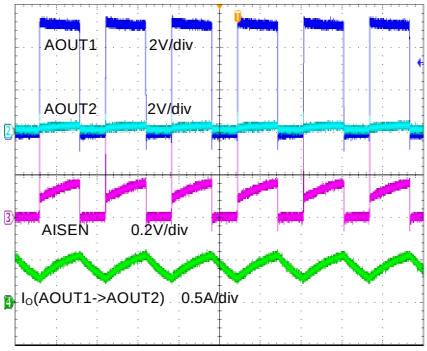
(VM=5V, AIN2=0, Io=0.5A, AISEN connect to GND)



Time (4μs/div)

Current Regulation

(VM=5V, AIN1=1, AIN2=0, Rsense=0.35Ω)



Time (10μs/div)

Functional Description

PWM Motor Drivers

SY6703 contains two identical H-bridge motor drivers with current-control PWM circuitry. A block diagram of the circuitry is shown below:

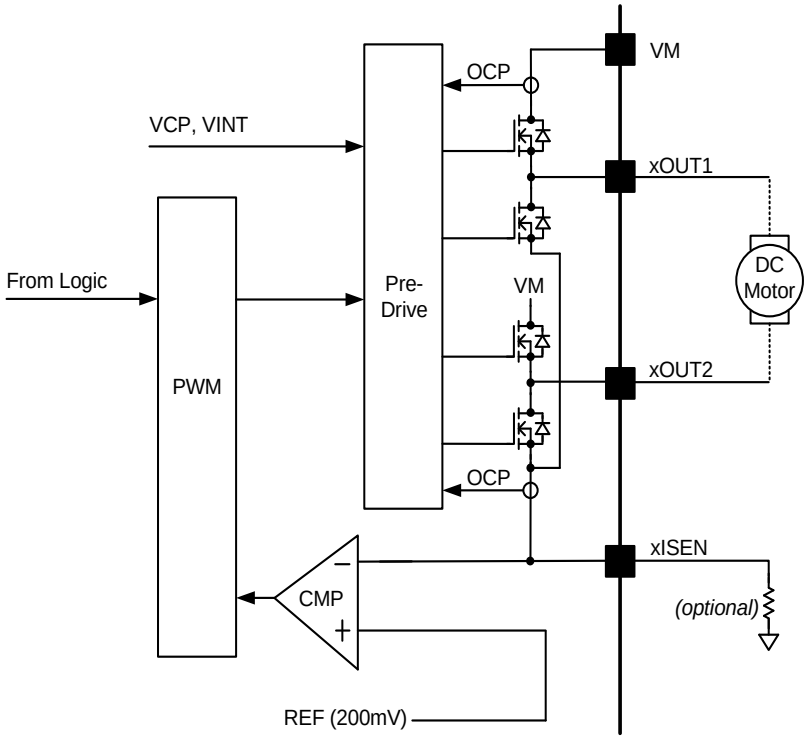


Figure3. Motor Control Circuitry

H-Bridge Driving Control

The Bridge is controlled by a PWM input interface, also called IN/IN interface. The following table shows the control logic of the device:

Table 1 H-Bridge 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

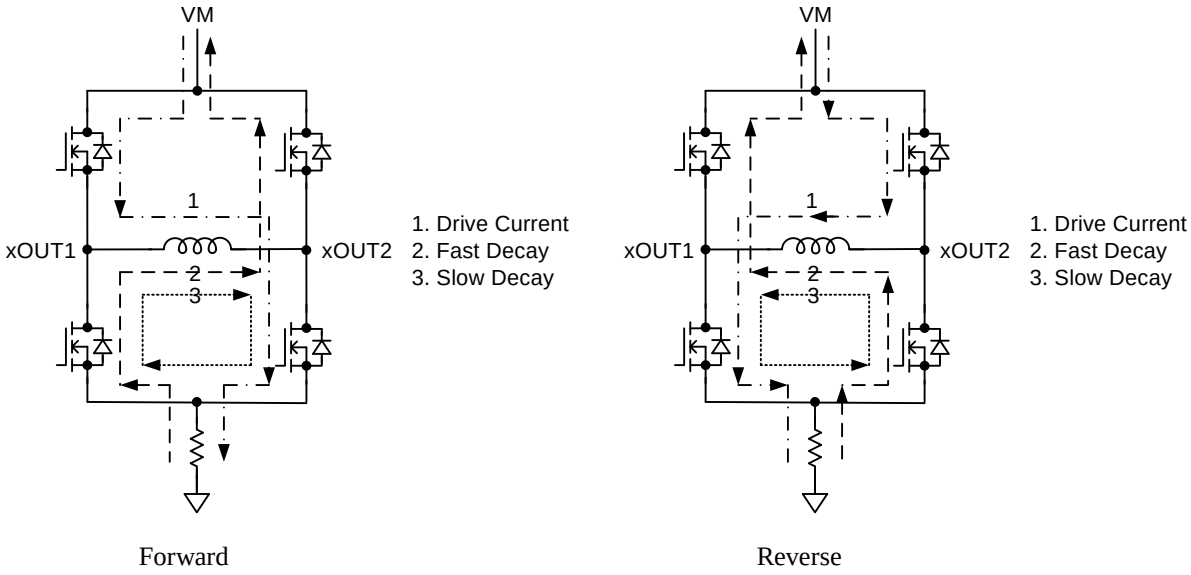
The inputs can also be used for PWM control of the motor speed. When controlling a winding with PWM and the drive current is interrupted, the inductive nature of the motor requires that the current must continue to flow. This is called recirculation current. To handle this recirculation current, the 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.

For 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.

Table 2 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

Figure 4 shows the current paths in different drive and decay modes.



Forward Reverse

Figure 4. Decay Mode

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 for limiting the start-up and stalling current of the motor. For stepper motors, current control is used frequently 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 will disable 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 about 3.1μs. 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 Equation 1.

$$I_{CHOP} = \frac{200mV}{R_{SENSE}} \quad (1)$$

Example:

If a 1Ω 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 will switch 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.

Sleep Mode

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 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).

Over Current 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 (t_{OCP}) 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. Please note that only the H-bridge in which the OCP is detected will be disabled while the other bridge will function normally.

Over current 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 over current shutdown. Over current protection does not use the current sense circuitry for PWM current control, it works even without presence of the xISEN resistors.

Thermal Shutdown (TSD)

If the die temperature exceeds safe limits, all MOSFETs in the H-bridge will be disabled. Once the die temperature has fallen to a safe level, operation automatically resumes.

Under Voltage Lockout (UVLO)

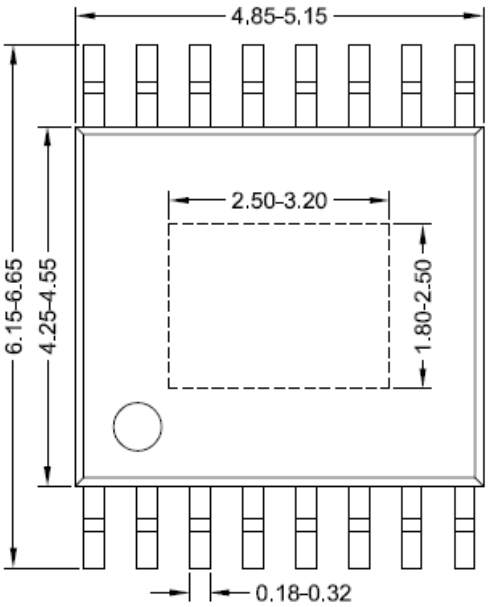
If at any time the voltage on the VM pin falls below the under voltage lockout threshold voltage, all circuitry in the device will be disabled, and all internal logic will be reset. Operation will resume when VM rises above the UVLO threshold. nFAULT is driven low in the event of an under voltage condition.

Maximum Output Current

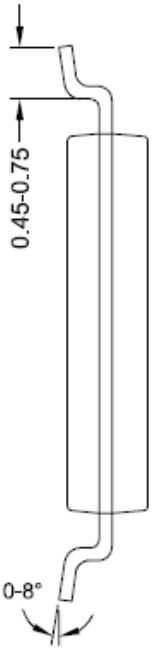
In actual operation, the maximum output current achievable with a motor driver is a function of die temperature. This in turn is greatly affected by ambient temperature and PCB design. Basically, the maximum motor current will be the amount of current that results in a power dissipation level that, along 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.

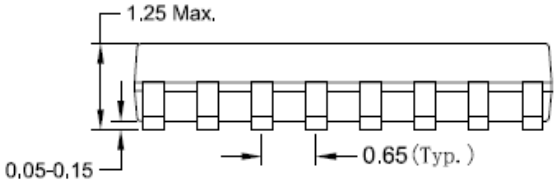
TSSOP16E Package Outline Drawing



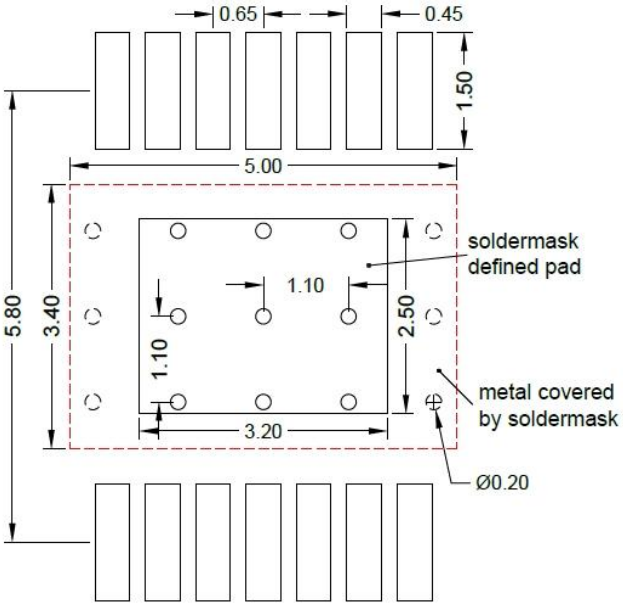
Top view



Side view A



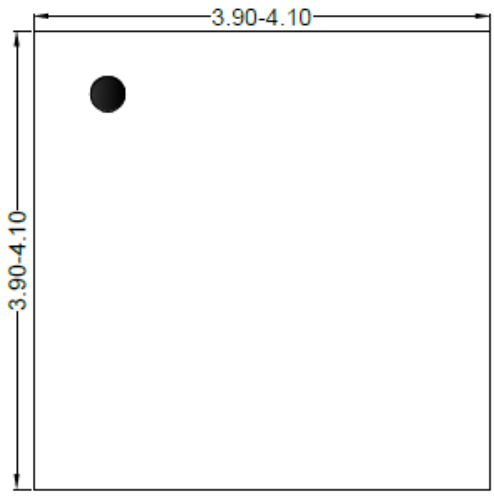
Side view B



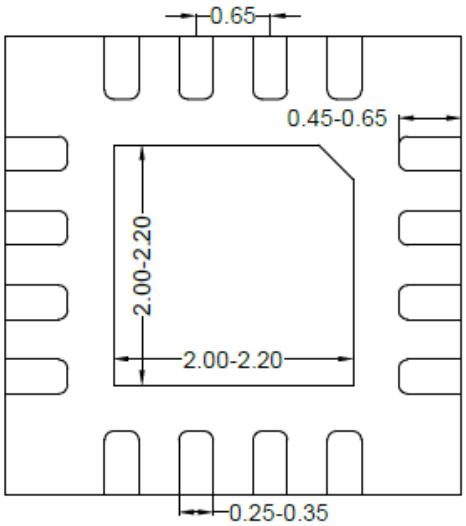
Recommended PCB layout
(Reference only)

Notes: **All dimension in millimeter and exclude mold flash & metal burr.**

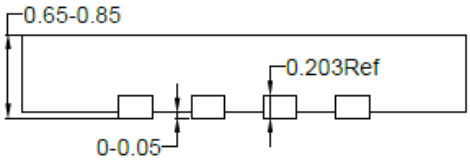
QFN4x4-16 Package Outline Drawing



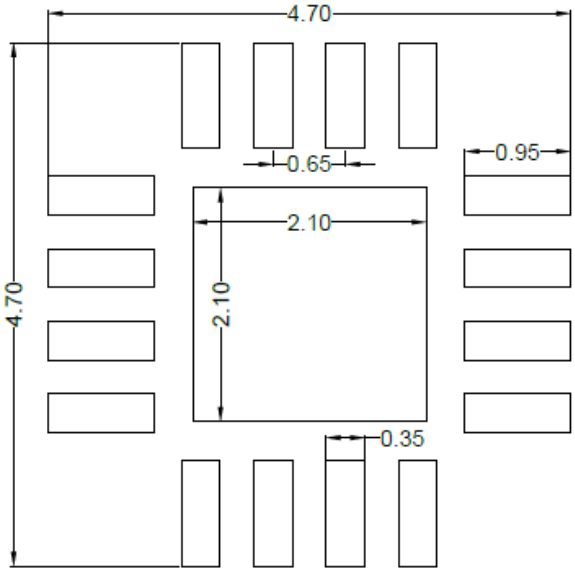
Top View



bottom View



Side View

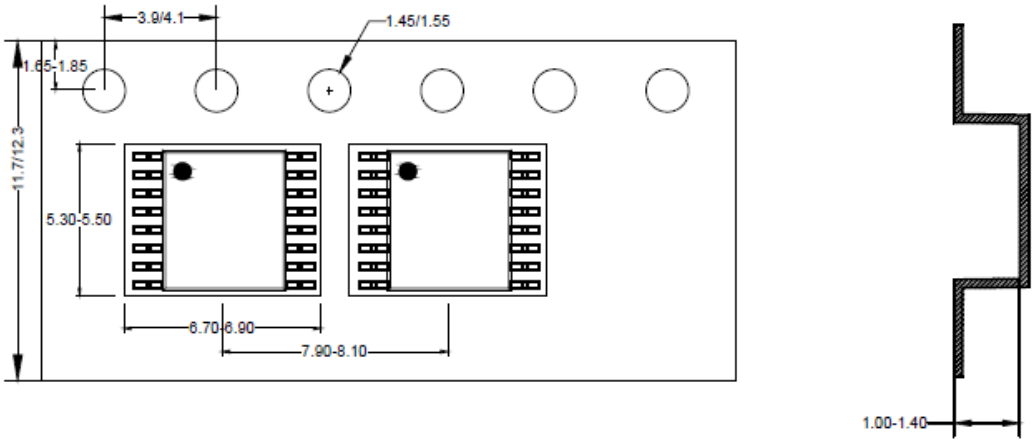


Recommended PCB layout
(Reference only)

Notes: **All dimension in millimeter and exclude mold flash & metal burr.**

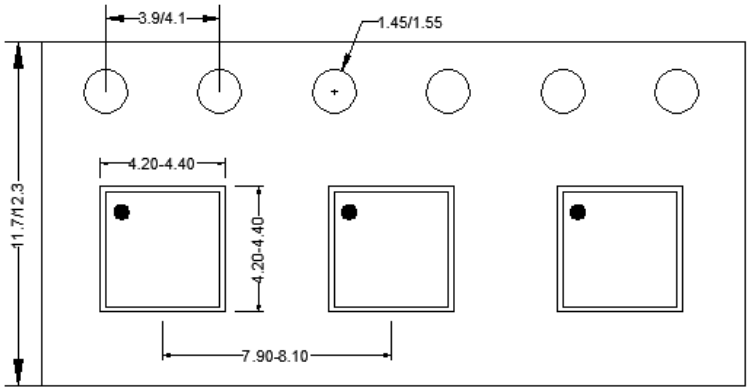
Taping & Reel Specification

1. TSSOP16E Taping orientation



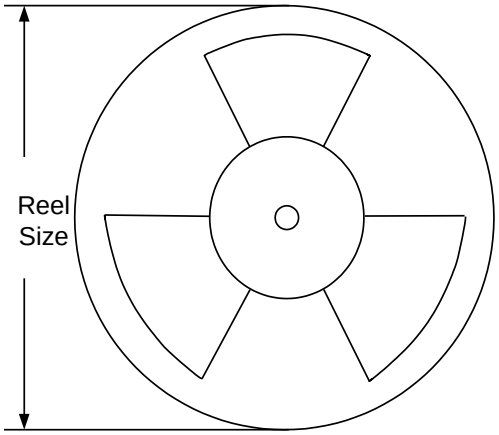
Feeding direction ⟶

2. QFN4x4 Taping orientation



Feeding direction ⟶

3. Carrier Tape & Reel specification for packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer * length(mm)	Leader * length (mm)	Qty per reel (pcs)
TSSOP16E	12	8	13"	400	400	3000
QFN4x4	12	8	13"	400	400	5000

4. Others: NA

Revision History

The revision history provided is for informational purpose only and is believed to be accurate, however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
June. 4, 2020	Revision 0.9A	Add the Recommended PCB layout information in page 11 and 12
July 10, 2018	Revision 0.9	Initial Release

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