Brushed DC motor drive circuit

MX1919

Overview

This product provides an integrated brushed DC motor drive solution for battery powered toys, low voltage or battery powered motion control applications. The circuit integrates a two-channel H-bridge drive circuit designed with N-channel and P-channel power MOSFETs, which is suitable for driving the steering wheels and rear wheels of electric toy cars. The circuit has a wide operating voltage range (from 2V to 9.6V) and integrates two motor drive circuits with the same current capability. When two channels work at the same time, the maximum continuous output current capability of each channel reaches 1.6A, and the maximum peak output current reaches 3.5A. When a single channel works, the maximum continuous output current capability reaches 2.3A, and the maximum peak output current reaches 3.5A.

This drive circuit has a built-in overheat protection circuit. When the load current passing through the drive circuit is much greater than the maximum continuous current of the circuit, the junction temperature of the chip inside the circuit will rise rapidly due to the limitation of the heat dissipation capacity of the package. Once it exceeds the set value (typical value 150°C), the internal circuit will be shut down immediately. Cut off the output power tube, cut off the load current, and avoid safety hazards such as smoke and fire caused by the plastic package caused by continuous temperature rise. The built-in temperature hysteresis circuit ensures that the circuit is allowed to be controlled again after the circuit returns to a safe temperature.

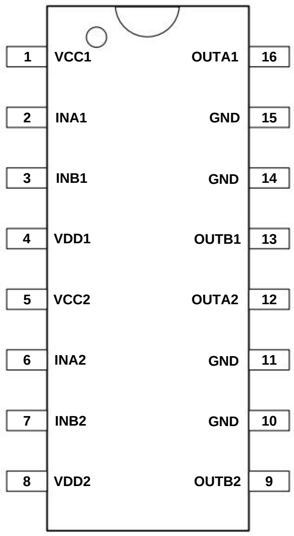
Features • Low standby current (less than 0.1uA); • Low static operating current; • Integrated H-bridge drive circuit; • Built-in anti-common state conduction circuit; • Power MOSFET with low internal resistance; Overheat protection circuit (TSD); • Anti-static level: 3KV (HBM).

Typical applications • 2-6 AA/AAA dry battery-powered toy motor drives; • 2-6 Ni-MH/Ni-Cd rechargeable battery-powered toy motor drives; • 1-2 Li-ion battery-powered motor drives

Ordering Information

Product number	encapsulation	Working
MX1919	DIP16	temperature -20ÿ ~ 85ÿ

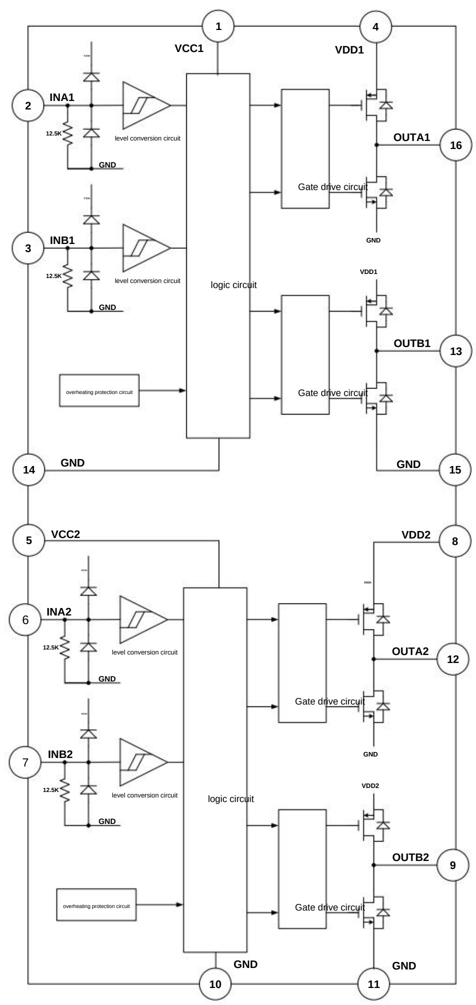
pinout



pin definition

Pin No.	Pin Name	Input/Output	Pin Function Description 1 Channel Logic Control
1	VCC1	-	Power Supply 1 Channel Forward
2	INA1	I	Rotation Logic Input 1 Channel
3	INB1	I	Reverse Logic Input 1 Channel
4	VDD1	-	Power Supply Terminal 2
5	VCC2	-	Channel Logic Control Power
6	INA2	I	Supply 2 Channel Forward
7	INB2	I	Rotation Logic Input 2
8	VDD2	-	Channels Logic input 2
9	OUTB2	o	channels power supply
10	GND		terminal 2 channels
11	GND		reverse output- ground
12	OUTA2	o	terminal- ground terminal
13	OUTB1	o	2 channels forward
14	GND		rotation output 1 channel
15	GND		reverse output- ground
16	OUTA1	o	terminal- ground terminal 1 channel forward rotation output

Functional block diagram

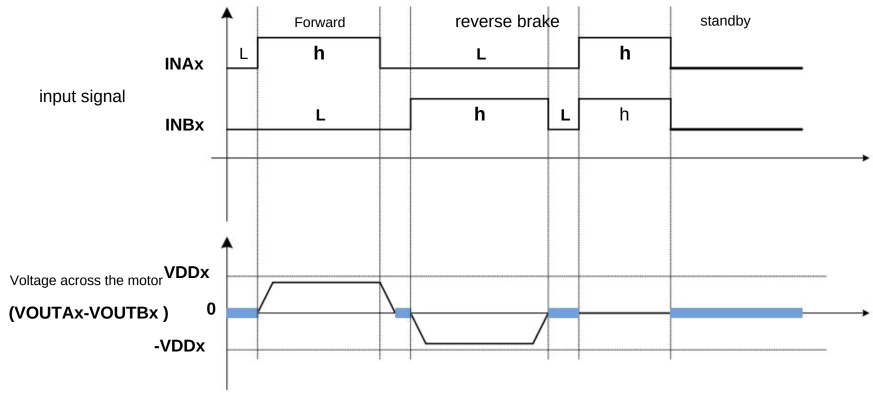


logic truth table

INAx	INBx	OUTAx	OUTBx	Function
L	L	Z	Z	standby
h	L	h	L	forward
L	h	L	h	and
h	h	L	L	reverse brake

Note: x stands for 1 or 2.

Typical Waveform Diagram



Note: x stands for 1 or 2.

Absolute Maximum Ratings (TA=25ÿ)

		symbol	value	unit
Parameters Maximum Logic Control		VCCx(MAX)	7	V
Supply Voltage Maximum		VDDx(MAX)	10	
Power Supply Voltage Maximum		VOUT(MAX)	VDDx	
Applied Output Voltage Maximum Applied Input Voltage		VIN(MAX)	VCCx	
Maximum peak output current	1 channel	IOUT(PEAK)	3.5	A
	2 channels		3.5	
Maximum Power		PD	2	W
Dissipation Junction to Ambient Thermal Resistance	DIP16 Package Operating	ÿJAD	70	°C/W
Temperature Range Junction		Topr	-20~+85	ÿ
		TJ	150	ÿ
Temperature Storage		Tstg	-55~+150	ÿ
Temperature Soldering Temperature		TLED	260°C, 10 seconds	
ESD (Note			3000	V

3) Note: (1), x stands for 1 or 2.

(2) The formula for calculating the maximum power consumption at different ambient temperatures is: PD=(150°C-TA)/ÿJA TA

represents the ambient temperature of the circuit, and ÿJA is the thermal resistance of the package. 150°C represents the highest operating junction temperature of

the circuit. (3) Calculation method of circuit power consumption: P =I2 R

Among them, P is the power consumption of the circuit, I is the continuous output current, and R is the on-resistance of the circuit. The circuit power dissipation P must be less than the maximum power dissipation PD

(4) Human body model, a 100pF capacitor is discharged through a 1.5Kÿ resistor.

Recommended operating conditions

		Signed	minimum	Typical value (VDD=6.5V)	unit of maxi	mum
(TA=25°C) parameters logic and		VCCx	1.8	--	5	V
control power supply		VDDx	2	--	9.6	V
voltage power supply voltage	work at the same time 1			1.6		A
channel per channel IOUT1 c	ontinuous output current 2			1.6		
channels IOUT2 work indepen	dently per channel 1			2.3		
channel IOUT1 continuous ou	tput current 2 channels			2.3		

IOUT2 Note: (1), x stands for 1 or 2.

(2) The logic control power supply VCC and the power supply VDD are completely independent and can be powered separately. When the logic control power supply VCC is powered off, the circuit will enter the standby

mode. (3) The continuous output current test condition is: the circuit is mounted on the PCB for testing.

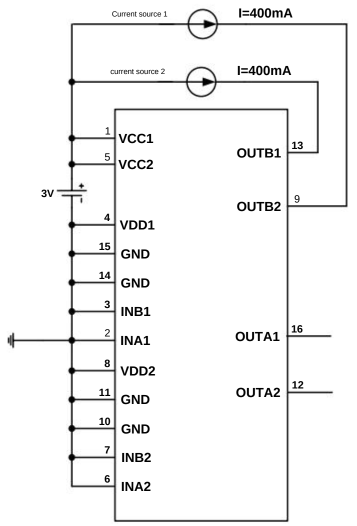
Electrical characteristic parameter table

(TA=25ÿ, VCCx=3V, VDDx=6V unless otherwise specified) Parameter

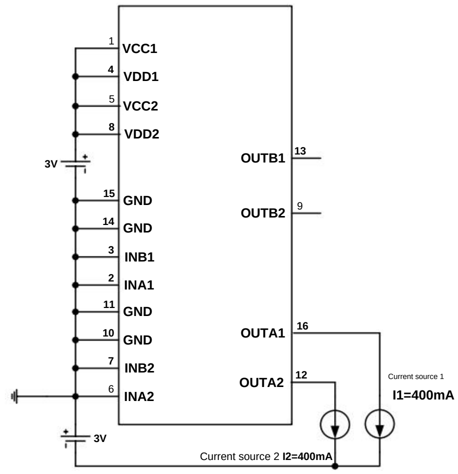
Symbol Conditions Power Supply Parameters			Min Typ Max Unit			
VCCx standby current	IVCCST	INAx=INBx=L;VCCx=7V;	--	0	10	uA
VDDx standby current	IVDDST	VDDx=10V; output floating	--	0	10	
VCCx quiescent supply current	VCCx	INAx=H OR INBx=H; output floating	--	182	--	uA
VDDx quiescent power supply current	IVDDx	INAx=H OR INBx=H; output floating input logic	--	83	--	
level input high level						
input low level	VINH		2	--	--	V
input level	VINL		--	--	0.8	
hysteresis input high	VHYS			0.6		
level current input pull-	IINH	VINH=2.5V, VCCx=3V		191		uA
down resistance	RIN	VINH=3V, VCCx=3V		12		Kÿ
power transistor conduction internal resistance						
1 channel conduction internal resistance	RON1	IO=±200mA VDD1=6V TA=25ÿ		0.32		ÿ
		IO=±1.5A VDD1=6.5V TA=25ÿ		0.41		
2-channel on-resistance	RON2	IO=±200mA VDD1=6V TA=25ÿ		0.32		
		IO=±1.5A VDD1=6.5V TA=25ÿ		0.41		
Protection Function Parameters						
Thermal Shutdown	TSD		--	150	--	ÿ
Temperature Point Thermal	TSDH		--	20	--	
Shutdown Temperature Hysteresis Power **MOSFET** Body Diode Conduction Characteristics-1 Channel						
PMOS body diode	VPD	I=400mA, VCC1=3V, VDD1=INA1=INB1=0V		0.76		V
NMOS body diode	VND	I=-400mA, VCC1=VDD1=3V, INA1=INB1=0V		0.75		
Power **MOSFET** body diode conduction characteristics - 2 channels						
PMOS body diode	VPD	I=400mA, VCC1=3V, VDD1=INA1=INB1=0V		0.76		V
NMOS body diode	VND	I=-400mA, VCC1=VDD1=3V, INA1=INB1=0V		0.75		
Motor drive time parameter-1						
channel output	tr	INB1=H, INA1 input pulse signal signal duty		300		ns
rise time output	tf	ratio is 50%, the signal frequency		10		
fall time output	trf	is 20KHz, the internal resistance		40		
delay time output	tfr	of the load motor is 1.3ÿ, and the motor is idling		240		
delay time motor drive time						
parameter-2	tr	INB1=H, INA1 input pulse signal signal duty		300		ns
channel output	tf	ratio is 50%, the signal frequency		10		
rise time output	trf	is 20KHz, the internal resistance		40		
fall time output	tfr	of the load motor is 1.3ÿ, and the motor is idling		240		

delay time output delay time Note: x stands for 1 or 2.

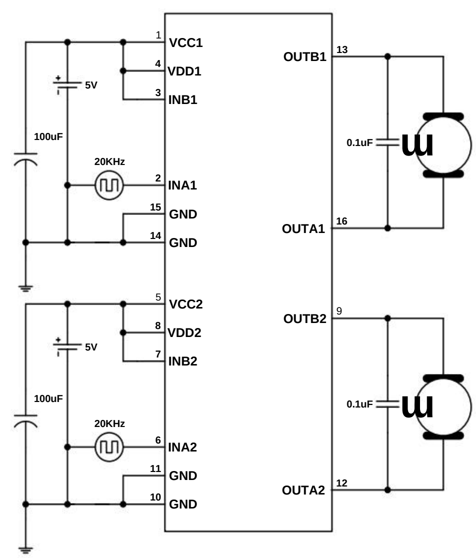
Test schematic



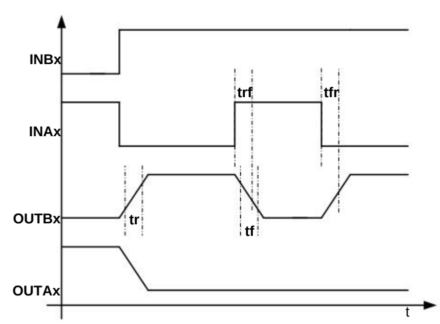
Schematic diagram of PMOS body diode conduction voltage test



Schematic diagram of NMOS body diode conduction voltage test



Schematic diagram of time parameter test



x stands for 1 or 2

Time parameter definition

Typical Application Circuit Diagram

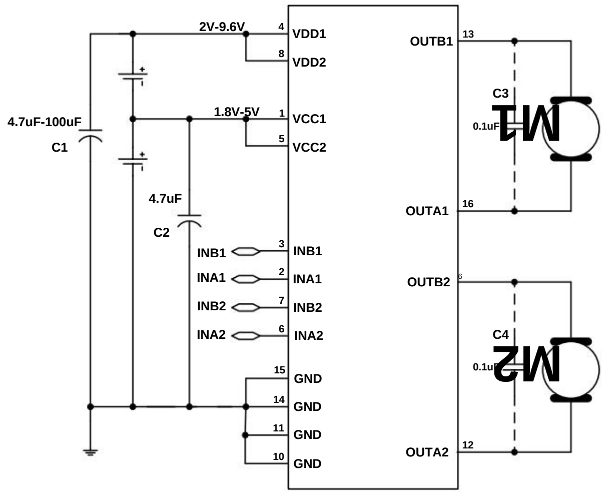


Figure 1 Typical application circuit diagram of MX1919

Special Notes: The decoupling

capacitor (C1) of the power supply VDD1 and VDD2 in Figure 1 should be adjusted according to the specific application. The higher the voltage of VDD1 and VDD2, the larger the output peak current, and the larger the value of C1. The value of capacitor C1 needs to be at least 4.7uF. Under the application conditions of high voltage and high current, it is recommended that the value of capacitor C1 be 100uF. The logic power supply VCC1, VCC2 ground capacitor C2 must be at least 4.7uF. In actual

application, there is no need to add a separate capacitor close to the chip, and it can be shared with other control chips (RX2, MCU). If there is no capacitance between VCC1 and VCC2 to ground, when the circuit enters overheating protection mode due to overload, the circuit may enter a locked state. After entering the locked state, the state of the input signal must be changed again before the circuit can return to normal. As long as VCC1 and VCC2 have more than 4.7uF capacitance to ground, the circuit will not appear locked.

The 0.1uF capacitors (C3, C4) between the drive circuit OUTAx and OUTBx (x=1,2) in Figure 1 represent the capacitors connected to both ends of the motor and do not need to be added separately.

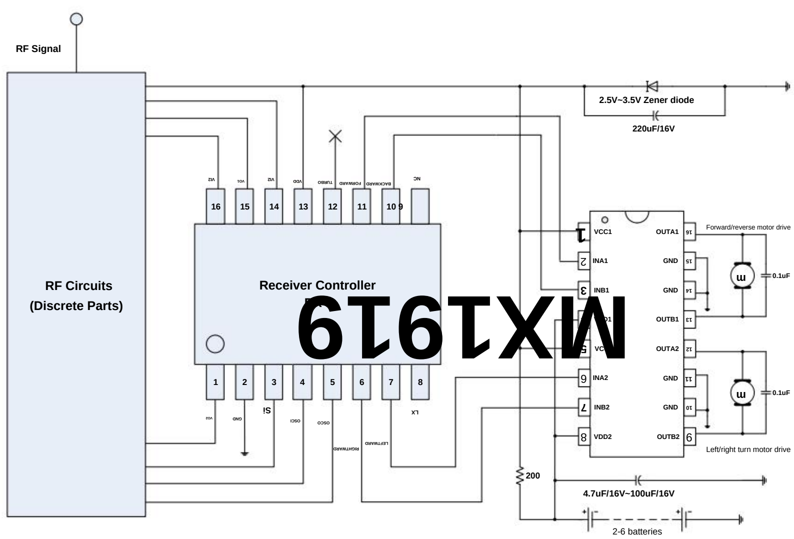


Figure 2 2-6 battery-powered toy remote control car motor drive application circuit diagram As shown in Figure 2, the

motor drive application circuit diagram, the drive current of channel 1 and channel 2 of MX1919 is as large, and can drive the front and rear wheel motors and the front wheel according to actual needs. Wheel steering motor.

The VDD1 and VDD2 ground decoupling capacitors in Figure 2 should be selected according to the actual usage. The higher the voltage of VDD1 and VDD2, the higher the motor current The larger the value, the larger the capacitance value. The capacitor must be greater than 4.7uF.

Application

Description 1. Basic working

mode a) Standby

mode In standby mode, INAx=INBx=L. All internal circuits including drive power tubes are in off state. The circuit draws very low current. At this time, the motor output terminals OUTAx and OUTBx are both in a high-impedance state. b) Forward rotation mode The definition of forward rotation mode

is: INAx=H, INBx=L,

at this time, the motor drive terminal OUTAx outputs a high level, and the motor drive terminal OUTBx outputs a low level

Usually, the motor drive current flows from OUTAx to the motor, and flows from OUTBx to the ground. At this time, the rotation of the motor is defined as forward rotation mode. c)

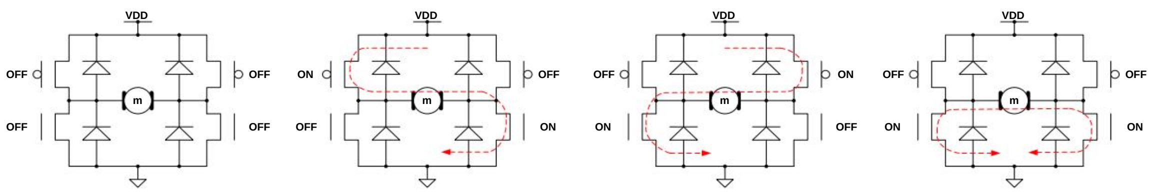
Inversion mode The

definition of inversion mode is: INAx=L, INBx=H, at this time, the motor drive terminal OUTBx outputs a high level, and the motor drive terminal OUTAx outputs a low level

Normally, the motor drive current flows from OUTBx to the motor, and flows from OUTAx to the ground. At this time, the rotation of the motor is defined as reverse mode. d) Braking

mode The definition

of braking mode is: INAx=H, INBx=H, at this time, the motor drive terminals OUTAx and OUTBx both output low level, and the energy stored in the motor will be released quickly through the NMOS tube at the OUTAx terminal or the NMOS at the OUTBx terminal. The motor will stop turning after a short time. Note that the circuit will consume static power in brake mode.



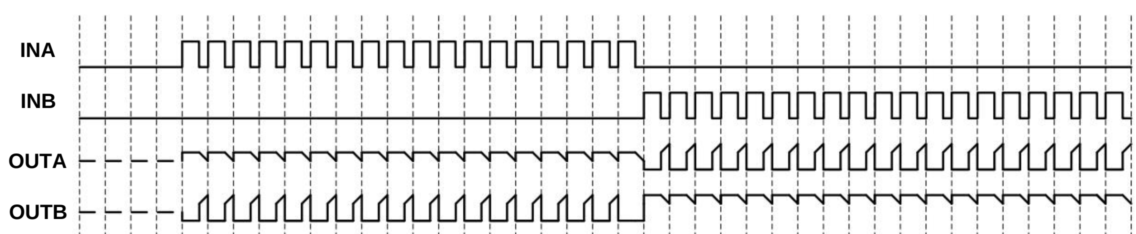
a) Standby mode b) Forward rotation mode c) Inversion mode d) Braking mode

e) PWM mode A When

the input signal INAx is a PWM signal, INBx=0 or INAx=0, and INBx is a PWM signal, the rotation speed of the motor will be controlled by the duty ratio of the PWM signal. In this mode, the motor drive circuit is switched between conduction and standby mode. In standby mode, all power transistors are in the off state, and the energy stored in the motor can only be released slowly through the body diode of the power MOSFET.

Note: Due to the high-resistance state in the working state, the motor speed cannot be precisely controlled by the duty cycle of the PWM signal. If PWM

If the frequency of the signal is too high, the motor will fail to start.

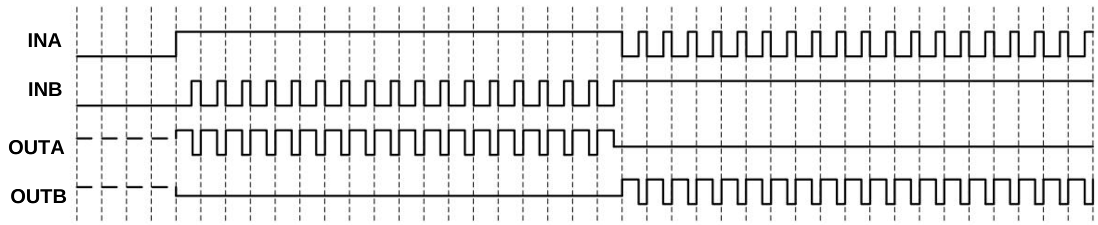


Schematic diagram of PWM mode A signal waveform

f) PWM mode **B** When

the input signal INAx is a PWM signal, INBx=1 or INAx=1, and INBx is a PWM signal, the rotation speed of the motor will be controlled by the duty ratio of the PWM signal. In this mode, the output of the motor drive circuit is between conduction and braking mode. In the braking mode, the energy stored in the motor is quickly released through the low-side NMOS tube.

Note: Due to the braking state in the working state, the motor energy can be released quickly, and the motor speed can be accurately controlled by the duty cycle of the PWM signal, but it must be noted that if the PWM signal frequency is too low, the motor will not be able to continue due to entering the braking mode. The phenomenon of smooth rotation. In order to reduce motor noise, it is recommended that the PWM signal frequency be greater than 10KHz and less than 50KHz.



Schematic diagram of PWM mode B signal waveform

2. Anti-common state conduction circuit

In the full-bridge drive circuit, the state in which the high-side PMOS power transistor and the low-side NMOS power transistor in the half-bridge are turned on at the same time is called the common state conduction state. Common state conduction will cause a large transient current from the power supply to the ground, which will cause additional power loss, and in extreme cases will burn the circuit. Common-state turn-on is avoided with built-in dead time. Typical dead time is 300ns. 3. Overheat protection circuit When the junction temperature of the drive circuit exceeds the preset temperature (typically 150°C), the TSD circuit starts to work.

At this time, the control circuit forcibly turns off all output power tubes, and the output of the drive circuit enters a high-impedance state. Thermal hysteresis is designed in the TSD circuit, only when the junction temperature of the circuit drops to the preset temperature (typical value 130°C), the circuit returns to the normal working state. 4. The maximum continuous power consumption of the drive circuit

This series of motor drive circuits are designed with an overheat protection circuit, so when the power consumption of the drive circuit is too large, the circuit will enter thermal shutdown.

In shutdown mode, the motor will not work normally in the thermal shutdown state. The formula for calculating the maximum continuous power consumption of the drive circuit is:

PM=(150°C-TA)/ÿJA where 150°C is

the preset temperature point of the thermal shutdown circuit, TA is the ambient temperature of the circuit (°C), and ÿJA is the junction of the circuit Thermal resistance to ambient (in °C/W). Note: The maximum continuous power consumption of the drive circuit is related to factors such as ambient temperature, package type, and heat dissipation design, and has no direct relationship with the internal resistance of the circuit. 5. Power consumption of the drive circuit

The conduction resistance of the

internal power MOSFET of the motor

drive circuit is the main factor affecting the power consumption of the drive circuit. The formula for calculating the power consumption of the drive circuit is: PD=IL where IL represents the output current of the motor drive circuit, and

RON represents the^2 wxya

on-resistance of the power MOSFET. Note: The on-resistance of a power MOSFET increases with temperature, and the temperature characteristics of the on-

resistance must be considered when calculating the maximum continuous output current and power consumption of the circuit. 6. The maximum continuous output current of the drive circuit

According to the maximum continuous power consumption of the drive circuit and the power consumption of the drive circuit, the maximum continuous output current of the drive circuit can be calculated. The calculation formula is:

$$I_L = \sqrt{(150 - T_A)/(\theta_{JA} * R_{ONT})}$$

Among them , RONT is the conduction internal resistance of the power MOSFET after considering the temperature

characteristics. Note: The maximum continuous output current of the drive circuit is related to factors such as ambient temperature, package type, heat dissipation design, and on-resistance of the power MOSFET. 7. Motor Internal Resistance Selection

The above analysis shows that the

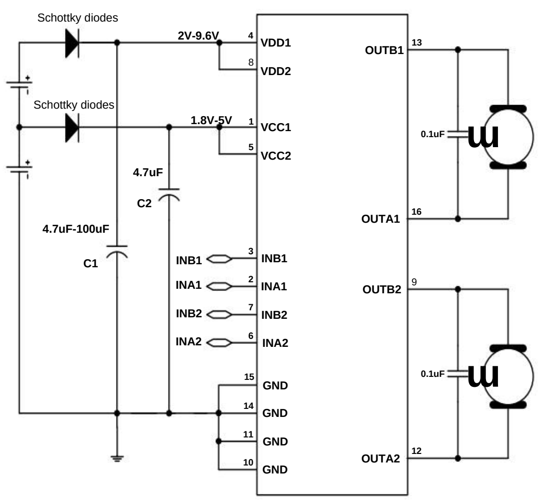
maximum continuous power consumption of the motor drive circuit is limited. If the internal resistance of the motor driven by the motor drive circuit is extremely small, its locked-rotor

If the current exceeds the maximum continuous output current that the motor drive circuit can withstand, it will easily cause the motor drive circuit to enter an overheating shutdown state, and the toy car will vibrate when it is running or repeatedly moving forward and backward. When selecting a motor drive circuit, the internal resistance of the motor must be considered. Note: x stands for 1 or 2.

Special precautions 1. Reverse

connection of power supply and

ground If the power supply and ground wire of the circuit are connected in reverse, the circuit will be damaged, and in severe cases, it will cause smoke from the plastic package. It can be considered to connect two power Schottky diodes in series to the positive terminal of the battery at the power supply end of the circuit to prevent circuit damage caused by reverse connection of the battery. The maximum continuous current capability of the power Schottky diode must be greater than the continuous current of the motor stall, otherwise the Schottky diode will be damaged due to overheating. The reverse breakdown voltage of the power Schottky diode must be greater than the maximum power supply voltage. If the reverse breakdown voltage is too small, the Schottky diode will break down and burn out when the battery is reversed.



2. Power supply VDD1, VDD2 ground decoupling capacitor (C1)

The decoupling capacitor C1 (refer to the application circuit diagram 1) of the power supply VDD1 and VDD2 added to the drive circuit has two main functions: 1) Absorb the energy released by the motor to the power supply, stabilize the power supply voltage, and prevent the circuit from being damaged due to overvoltage. Breakdown; 2) At the moment when the motor starts or switches between fast forward and reverse rotation, the motor needs an instantaneous high current to start quickly. Due to the response speed of the battery and the long connection leads, it is often impossible to output a large transient current immediately. At this time, it is necessary to rely on the energy storage capacitor near the motor drive circuit to release the transient large current.

According to the energy storage characteristics of capacitors, the larger the capacitor value, the smaller the voltage fluctuation in the same time, so under the application conditions of high voltage and high current It is recommended that the value of capacitor C1 be 100uF. It is recommended to select the value of the capacitor according to the specific application, but the value of the capacitor C1 needs to be at least 4.7uF. 3. The

input/output ports of the electrostatic protection circuit adopt CMOS devices, which are sensitive to electrostatic discharge. Although it is designed with an electrostatic protection circuit, anti-static measures should be taken during transportation, packaging, processing, and storage, especially anti-static during processing. 4. The output is short-circuited to ground and the

output terminal is short-circuited

During normal operation, when the high-level output terminal of the circuit is short-circuited with the ground wire or the two ends of OUTAx and OUTBx are short-circuited, a huge current will pass through the circuit, resulting in a huge power consumption, which will trigger the overheating shutdown inside the circuit circuit, thereby protecting the circuit from burning out immediately. However, because the overheating protection circuit only detects the temperature and does not detect the transient current passing through the circuit, the current will be extremely large when the output is short-circuited to ground, which may easily cause damage to the circuit, so avoid short-circuiting the output to ground during use. Adding current limiting measures during testing can avoid similar damages. 5. The

output is short-circuited to the power supply

During normal operation, when the low-level output terminal of the circuit is short-circuited with the power supply, the circuit will be damaged. 6. Motor stalling

During normal operation,

when the load motor of the driving circuit is stalled, if the stalling current exceeds the maximum continuous current of the driving circuit,

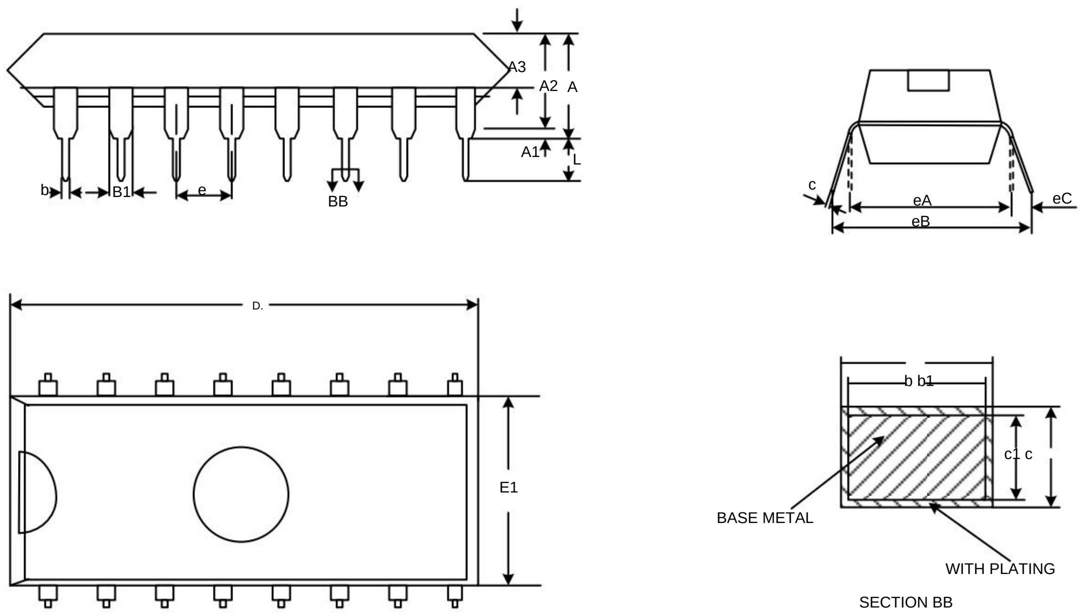
The drive circuit will enter overheating protection mode to prevent circuit damage. But if the locked-rotor current is much greater than the maximum peak current, the circuit is more likely to be damaged. 7. The peak current greatly exceeds the rated value

When it is close to or exceeds the maximum operating voltage and the peak current greatly exceeds the absolute maximum peak current, it will also cause the chip to burn.

Note: x stands for 1 or 2.

Package Outline Dimensions

DIP16:



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	3.60	3.80	4.00
A1	0.51	_	_
A2	3.10	3.30	3.50
A3	1.42	1.52	1.62
b	0.44	_	0.53
b1	0.43	0.46	0.48
B1	1.52BSC		
c	0.25	_	0.31
c1	0.24	0.25	0.26
D.	18.90	19.10	19.30
E1	6.15	6.35	6.55
e	2.54BSC		
E	7.62BSC		
eB	7.62	_	9.50
eC	0	_	0.94
L	3.00	_	_

Version

History V1.0 Initial Version