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 two channels usingNGroove andPGroove powerMOSFETsDesignedhThe bridge drive circuit is suitable for driving the steering wheel and the rear wheel of the electric toy car. The circuit has a wide operating voltage range (from2Varrive9.6V), internally 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 reaches1.6A, the maximum peak output current reaches3.5A, when a single channel works, the maximum continuous output current capability reaches2.3A, the maximum peak output current reaches3.5A.

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 value150℃), the internal circuit will immediately turn 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 control of the circuit is not allowed until the circuit returns to a safe temperature.

characteristic

- Low standby current (less than0.1uA);
- Low quiescent operating current;
- Integratedhbridge drive circuit;
- Built-in anti-common state conduction circuit;
- low on-resistance powerMOSFETsTube;
- Built-in thermal protection circuit with hysteresis (TSD);
- Antistatic grade:3KV (HBM).

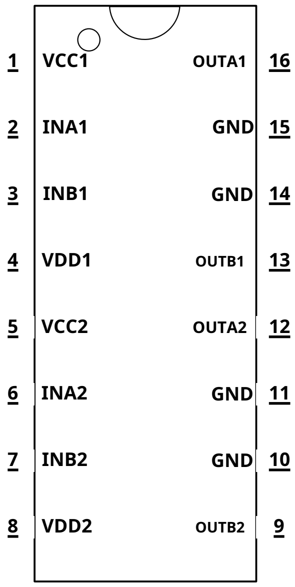
typical application

- 2-6FestivalAA/AAAToy motor drives powered by dry batteries;
- 2-6Nickel-metal hydride/nickel-cadmium rechargeable battery-powered toy motor drives;
- 1-2Lithium-ion battery-powered motor drive

Ordering Information

Product number	encapsulation	Operating temperature
MX1919	DIP16	- 20℃ ~85℃

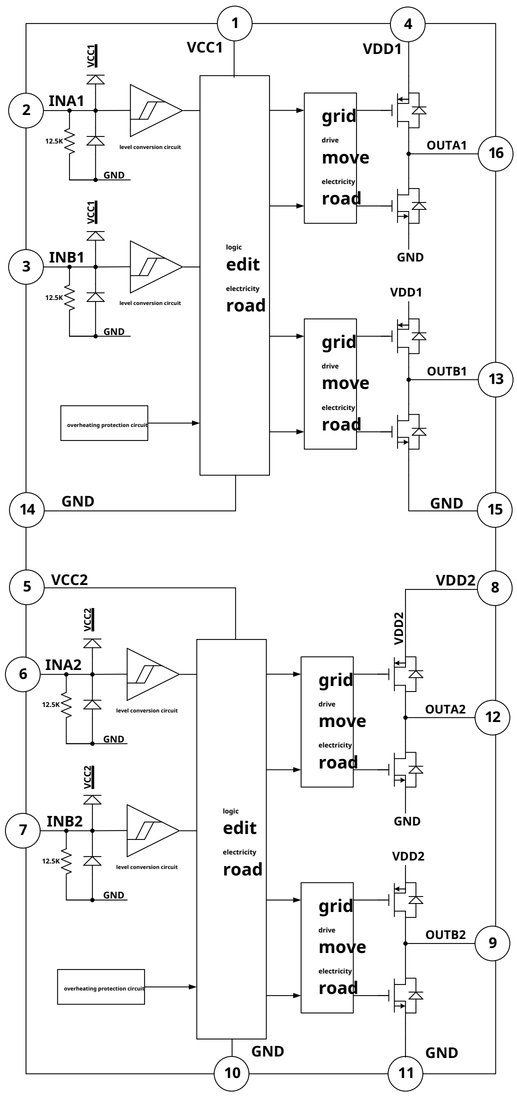
pinout



pin definition

pin number	pin name	input Output	Pin function description
1	VCC1	-	1Channel logic control power terminal
2	INA1	I	1Channel forward logic input
3	INB1	I	1Channel inversion logic input
4	VDD1	-	1Channel power supply terminal
5	VCC2	-	2Channel logic control power terminal
6	INA2	I	2Channel forward logic input
7	INB2	I	2Channel logic input
8	VDD2	-	2Channel power supply terminal
9	OUTB2	O	2Channel inversion output
10	GND	-	ground terminal
11	GND	-	ground terminal
12	OUTA2	O	2Channel forward output
13	OUTB1	O	1Channel inversion output
14	GND	-	ground terminal
15	GND	-	ground terminal
16	OUTA1	O	1Channel forward output

Functional block diagram

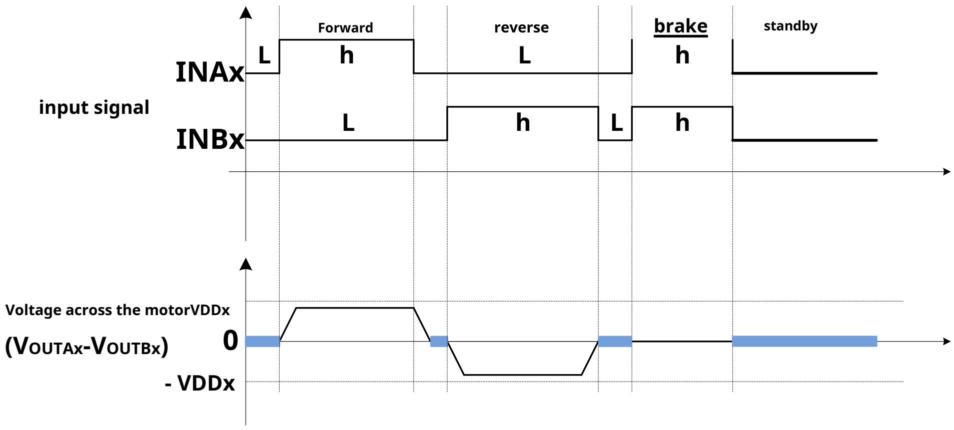


logic truth table

INAx	INBx	OUTAx	OUTBx	Function
L	L	Z	Z	standby
h	L	h	L	Forward
L	h	L	h	reverse
h	h	L	L	brake

Note:xrepresent1or2.

Typical Waveform Diagram



Note:xrepresent1or2.

Absolute Maximum Ratings (T_A=25°C)

parameter		symbol	value	unit
Maximum Logic Control Supply Voltage		VCCx(MAX)	7	V
Maximum power supply voltage		VDDx(MAX)	10	
Maximum Applied Output Voltage		VOUT(MAX)	VDDx	
Maximum Applied Input Voltage		VIN(MAX)	VCCx	
Maximum peak output current	1aisle	IOUT(PEAK)	3.5	A
	2aisle		3.5	
Maximum power consumption		$P_{D.}$	2	W
Junction to Ambient Thermal Resistance	DIP16encapsulation	θ_{JAD}	70	°C/W
range of working temperature		T_{opr}	- 20~+85	℃
junction temperature		T_J	150	℃
Storage temperature		Tstg	- 55~+150	℃
soldering temperature		T_{led}	260°C,10Second	
ESD(Note3)			3000	V

Note:(1),xrepresent1or2.

(2), The formula for calculating the maximum power consumption at different ambient temperatures is:$P_{D.}$=(150℃-T_A)/θ_{JA}

T_AIndicates the ambient temperature of the circuit, $\theta_{JA}$is the thermal resistance of the package.150℃ indicates the maximum operating junction temperature of the circuit.

(3), Calculation method of circuit power consumption:P =I^2R

inPis the power consumption of the circuit,Iis the continuous output current,Ris the on-resistance of the circuit. Circuit power consumptionPmust be less than the maximum power dissipation$P_{D.}$

(4), mannequin,100pFcapacitance through1.5KΩResistor discharge.

Recommended working conditions (T_A=25°C)

parameter		symbol	minimum value	Typical value (VDD=6.5V)	maximum value	unit
Logic and Control Supply Voltage		VCCx	1.8	- -	5	V
power supply voltage		VDDx	2	- -	9.6	V
Simultaneously work on each channel	1aisle	I_{OUT1}		1.6		A
Continuous output current	2aisle	I_{OUT2}		1.6		
work individually per channel	1aisle	I_{OUT1}		2.3		
Continuous output current	2aisle	I_{OUT2}		2.3		

Note:(1),xrepresent1or2.

(2), logic control power supplyVCCwith power supplyVDDThe interior is completely independent and can be powered separately. When the logic controls the powerVCCAfter power off,

The circuit will enter standby mode.

(3), The continuous output current test condition is: the circuit is mounted onPCBon the test.

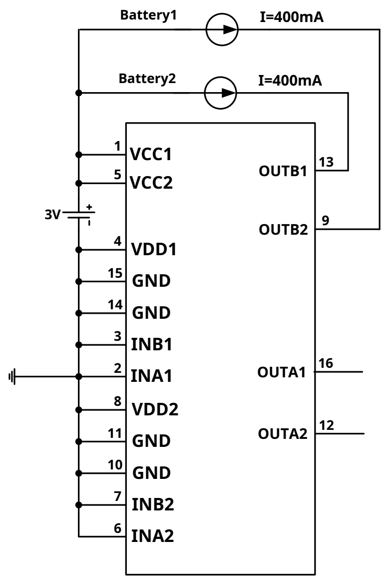
Electrical characteristic parameter table

(T_A=25°C,VCCx=3V, VDDx=6Vunless otherwise specified)

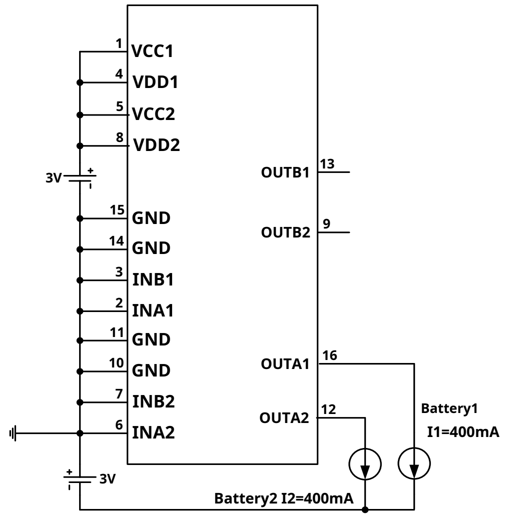
parameter	symbol	condition	minimum value	typical value	maximum value	unit
Power parameters						
VCCxstand-by current	I_{VCCST}	INAx=INBx=L;VCCx=7V;	- -	0	10	uA
VDDxstand-by current	I_{VDDST}	VDDx=10V;output floating	- -	0	10	
VCCxQuiescent Supply Current	I_{VCCx}	INAx=H OR INBx=H;output floating	- -	182	- -	uA
VDDxQuiescent Supply Current	I_{VDDx}	INAx=H OR INBx=H;output floating	- -	83	- -	
Input logic level						
input high level	V_{INH}		2	- -	- -	V
input low level	V_{INL}		- -	- -	0.8	
Input level hysteresis	V_{HYS}			0.6		
Input high level current	I_{INH}	V_{INH}=2.5V, VCCx=3V		191		uA
Input pull-down resistor	R_{IN}	V_{INH}=3V, VCCx=3V		12		KΩ
Power tube internal resistance						
1Channel conduction internal resistance	R_{ON1}	IO=±200mA VDD1=6V TA=25℃		0.32		Ω
		IO=±1.5A VDD1=6.5V TA=25℃		0.41		
2Channel conduction internal resistance	R_{ON2}	IO=±200mA VDD1=6V TA=25℃		0.32		
		IO=±1.5A VDD1=6.5V TA=25℃		0.41		
Protection function parameters						
Thermal Shutdown Temperature Point	TSD		- -	150	- -	℃
Thermal Shutdown Temperature Hysteresis	TSDH		- -	20	- -	
powerMOSFETsBody Diode Conduction Characteristics-1aisle						
PMOSbody diode	V_{PD}	I=400mA, VCC1=3V, VDD1=INA1=INB1=0V		0.76		V
NMOSbody diode	V_{ND}	I=-400mA, VCC1=VDD1=3V, INA1=INB1=0V		0.75		
powerMOSFETsBody Diode Conduction Characteristics-2aisle						
PMOSbody diode	V_{PD}	I=400mA, VCC1=3V, VDD1=INA1=INB1=0V		0.76		V
NMOSbody diode	V_{ND}	I=-400mA, VCC1=VDD1=3V, INA1=INB1=0V		0.75		
Motor Drive Time Parameters-1aisle						
output rise time	t_r	INB1=H,INA1input pulse signal		300		ns
output fall time	t_f	The signal duty cycle is50%		10		
output delay time	t_{rf}	The signal frequency is20KHz		40		
output delay time	t_{fr}	load motor internal resistance1.3Ω,motor idling		240		
Motor Drive Time Parameters-2aisle						
output rise time	t_r	INB1=H,INA1input pulse signal		300		ns
output fall time	t_f	The signal duty cycle is50%		10		
output delay time	t_{rf}	The signal frequency is20KHz		40		
output delay time	t_{fr}	load motor internal resistance1.3Ω,motor idling		240		

Note:xrepresent1or2.

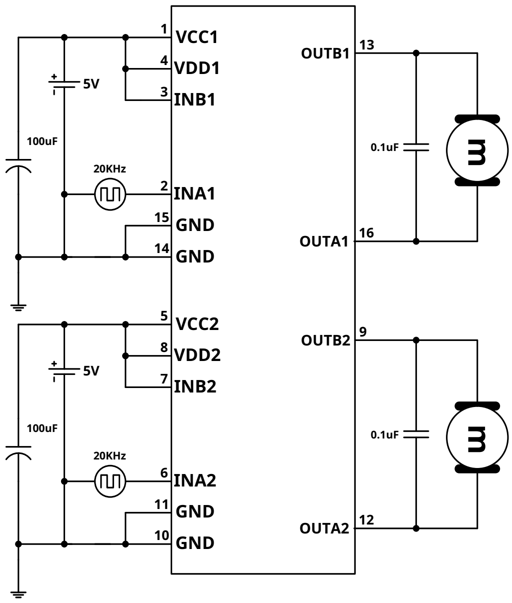
Test schematic



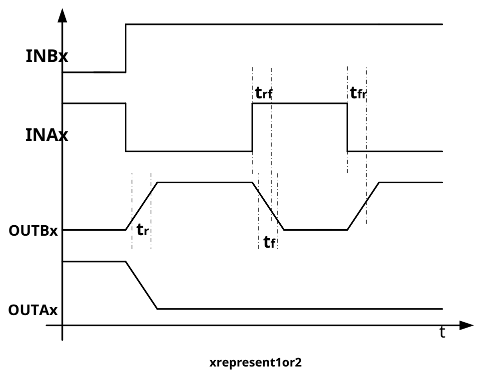
PMOSSchematic diagram of body diode conduction voltage test



NMOSSchematic diagram of body diode conduction voltage test

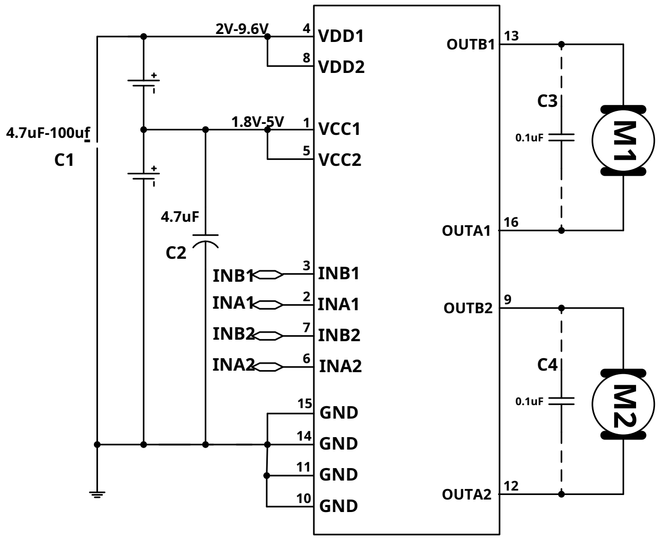


Schematic diagram of time parameter test



Time parameter definition

Typical Application Circuit Diagram



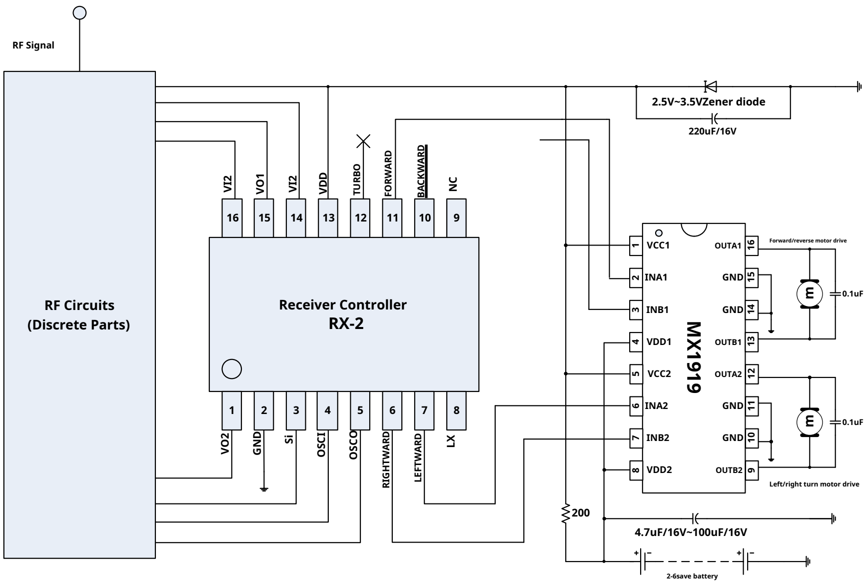
picture1 MX1919Typical Application Circuit Diagram

special attention items:

picture1power supply inVDD1,VDD2decoupling capacitor to ground (C1)The capacitance value should be adjusted according to the specific application,VDD1,VDD2The higher the voltage, the greater the output peak current,C1The larger the value, but the capacitanceC1A value of at least4.7uF. In high voltage, high current application conditions, it is recommended that the capacitorC1value100uF.

logic powerVCC1,VCC2Capacitance to groundC2must require at least4.7uF, there is no need to add a separate capacitor close to the chip in practical applications, and it can be used with other control chips (RX2,MCU)Wait for sharing. ifVCC1,VCC2Without any capacitance to ground, when the circuit enters thermal 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. if only VCC1,VCC2over ground4.7uFCapacitor, the circuit will not appear locked state.

picture1Middle drive circuitOUTAxandOUTBx(x=1,2)between0.1uFcapacitance(C3,C4)It means the capacitor connected to both ends of the motor, and it does not need to be added separately.



picture2 2-6Battery-powered toy remote control car motor drive application circuit diagram

as shown in the picture2shown in the motor drive application circuit diagram,MX1919of1channel with2The driving current of the channel is the same, and the front and rear wheel motors and the front wheel steering motor can be driven according to actual needs.

picture2middleVDD1,VDD2The capacitance value of the ground decoupling capacitor should be selected according to the actual usage.VDD1,VDD2The higher the voltage, the greater the motor current and the greater the capacitance value. capacitance must be greater than4.7uF.

application note

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 outputOUTAxandOUTBxare in a high-impedance state.

b)forward mode

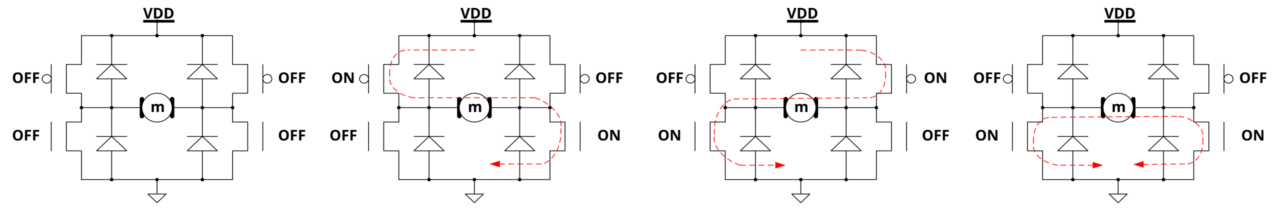
Forward mode is defined as:INAx=H,INBx=L, at this time the motor drive endOUTAxOutput high level, motor drive terminalOUTBxWhen the output is low, the motor drive current is fromOUTAxinto the motor, fromOUTBxFlow to the ground, at this time the rotation of the motor is defined as forward rotation mode.

c)reverse pattern

The reversal pattern is defined as:INAx=L,INBx=H, at this time the motor drive endOUTBxOutput high level, motor drive terminalOUTAxWhen the output is low, the motor drive current is fromOUTBxinto the motor, fromOUTAxFlow to the ground, at this time the rotation of the motor is defined as the reverse mode.

d)brake mode

The brake mode is defined as:INAx=H,INBx=H, at this time the motor drive endOUTAxas well asOUTBxBoth output low level, the energy stored in the motor will pass throughOUTAxendNMOStube orOUTBxendNMOSWith a quick release, the motor will stop turning in a short time. Note that the circuit will consume static power in brake mode.

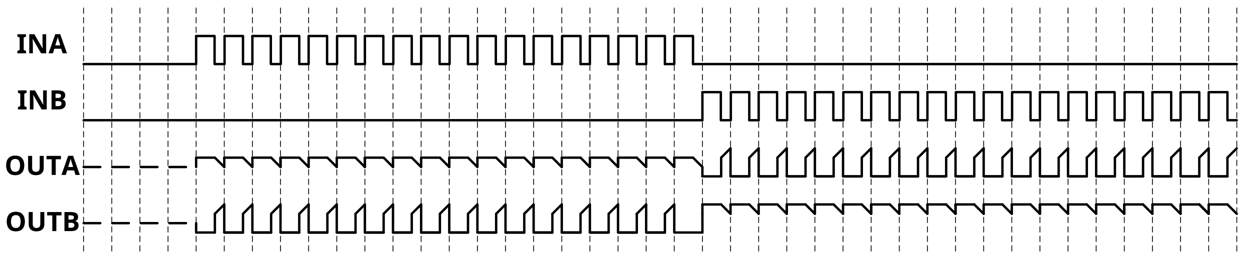


a)standby mode　b)forward mode　c)reverse pattern　d)brake mode

e) PWMmodelA

When the input signalINAxforPWMSignal,INBx=0orINAx=0,INBxforPWMsignal, the rotation speed of the motor will be affected byPWM Signal duty cycle control. In this mode, the motor drive circuit is switched between conduction and standby mode. In standby mode, all power tubes are in the off state, and the energy stored in the motor can only pass through the powerMOSFETsThe body diode slowly releases.

Note: Due to the high resistance state in the working state, the speed of the motor cannot pass throughPWMThe duty cycle of the signal is precisely controlled. ifPWM If the frequency of the signal is too high, the motor will fail to start.

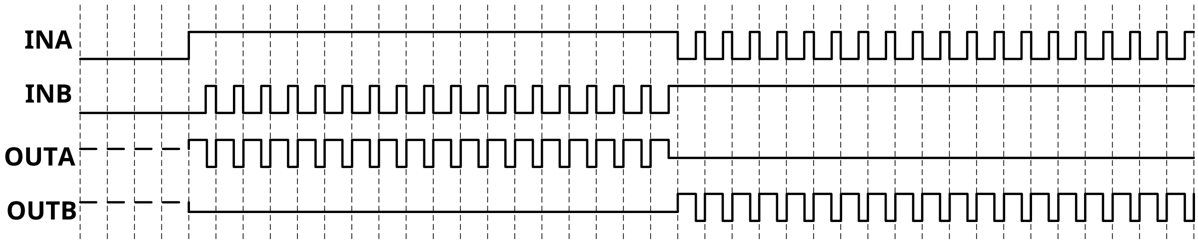


PWMmodelASignal Waveform Diagram

f) PWMmodelB

When the input signalINAxforPWMSignal,INBx=1orINAx=1,INBxforPWMsignal, the rotational speed of the motor will be affected by thePWM Signal duty cycle control. In this mode, the output of the motor drive circuit is between conduction and brake mode. In the brake mode, the energy stored by the motor passes through the low-sideNMOSTube quick release.

Note: Due to the braking state in the working state, the energy of the motor can be released quickly, and the speed of the motor can pass throughPWMThe duty cycle of the signal is precisely controlled, but care must be taken ifPWMIf the signal frequency is too low, the motor will not be able to rotate continuously and smoothly due to entering the braking mode. To reduce motor noise, it is recommendedPWMSignal frequency greater than10KHz, less than50KHz.



PWMmodelBSignal Waveform Diagram

2, Anti-common state conduction circuit

In a full-bridge drive circuit, the high-sidePMOSpower tube and low sideNMOSThe state in which the power tubes are turned on at the same time is called the common 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 is300ns. **3, overheating protection circuit**

When the driving circuit junction temperature exceeds the preset temperature (typical value150℃),TSDThe 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.TSDThermal hysteresis is designed in the circuit, only when the junction temperature of the circuit drops to the preset temperature (typ.130℃), the circuit returns to normal working condition.

4, The maximum continuous power consumption of the drive circuit

This series of motor drive circuits are designed with an overheating protection circuit inside, so when the power consumption of the drive circuit is too large, the circuit will enter the thermal shutdown mode, and 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:

$$P_m=(150℃-T_A)/\theta_{JA}$$

in150℃ is the preset temperature point of the thermal shutdown circuit,T_AAmbient temperature for circuit work (°C), $\theta_{JA}$is the thermal resistance from junction to ambient of the circuit (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, drive circuit power consumption

Motor drive circuit internal powerMOSFETsThe conduction internal resistance is the main factor affecting the power consumption of the drive circuit. The formula for calculating the power consumption of the drive circuit is:P

$_{D.}$=I$_2$ $_L$wxya$_{ON}$

inI_LIndicates the output current of the motor drive circuit,R_{ON}Indicates powerMOSFETsconduction internal resistance.

Note: PowerMOSFETsThe internal conduction resistance of the circuit increases with the increase of temperature, and the temperature characteristics of the internal conduction 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

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

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

one of themR_{ONT}For the power after considering the temperature characteristicsMOSFETsconduction internal resistance. Note: The maximum continuous output current of the drive circuit depends on the ambient temperature, package type, heat dissipation design and powerMOSFETsThe conduction internal resistance and other factors are related.

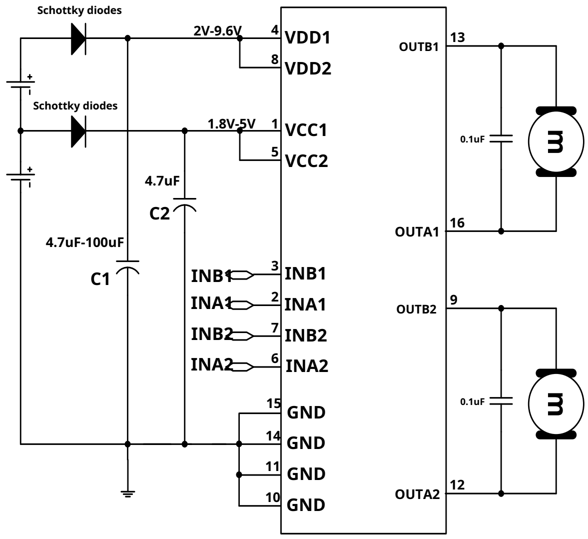
7, Motor internal resistance selection

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, and the locked-rotor 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 is running or There will be vibration when moving forward and backward repeatedly. When selecting a motor drive circuit, the internal resistance of the motor must be considered. Note:x represent1or2.

special attention items

1, Reverse connection between power supply and ground

Reversely connecting the power supply of the circuit to the ground wire will cause damage to the circuit, 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 supplyVDD1,VDD2decoupling capacitor to ground (C1)

The drive circuit requires an added power supplyVDD1,VDD2decoupling capacitor to groundC1(Refer to the application circuit diagram1)There are two main functions:1), Absorb the energy released by the motor to the power supply, stabilize the power supply voltage, and avoid circuit breakdown due to overvoltage;2), At the moment of starting the motor or switching between fast forward and reverse rotation, the motor needs a momentary 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 it is recommended to use capacitors under the application conditions of high voltage and high current.C1value100uF, it is recommended to select the capacitor value according to the specific application, but the capacitorC1The value needs to be at least4.7uF. 3,Static Protection

The input/output ports of the circuit employ aCMOSdevices that 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, output short circuit to ground, output short circuit

During normal operation, when the high-level output of the circuit is short-circuited with the ground orOUTAxandOUTBxIf a short circuit occurs at both ends, a huge current will pass through the circuit, resulting in a huge power consumption, which will trigger the overheating shutdown circuit inside the circuit, so as to protect 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

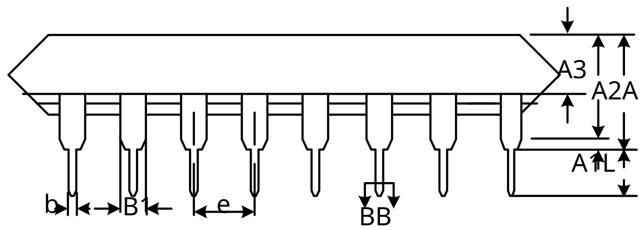
During normal operation, when the low-level output terminal of the circuit is short-circuited with the power supply, the circuit will be damaged. 6, motor stall

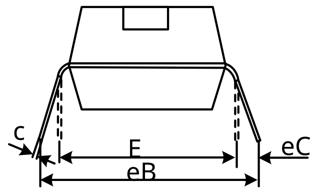
In normal operation, when the load motor of the drive circuit is locked, if the locked rotor current exceeds the maximum continuous current of the drive circuit, the drive circuit will enter the overheating protection mode to prevent circuit damage. But if the locked-rotor current is much greater than the maximum peak current, the circuit is more likely to be damaged. 7, the peak current greatly exceeds the rated value

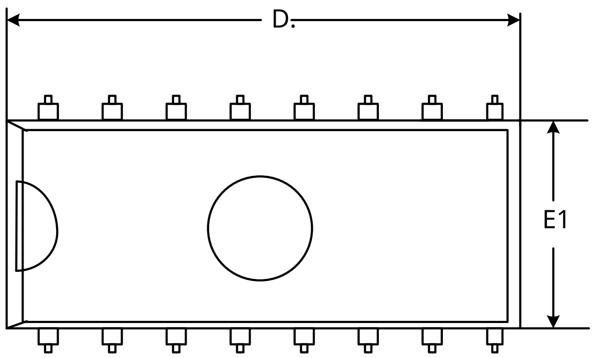
When it is close to or exceeds the maximum operating voltage and the peak current greatly exceeds the absolute maximum peak current, it will also cause the chip to burn. Note:xrepresent1or2.

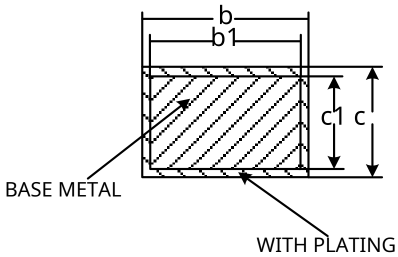
Package Outline Dimensions

DIP16:









SECTION BB

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