

Brushed DC motor drive circuit

MX608E

characteristic

Low standby current (less than 0.1uA)

Low on-resistance MOSFET power switch

- Power transistor design using MOS process
- 800 mA channel power transistor with an internal resistance of 0.48 ohms
- 200 mA channel power transistor with an internal resistance of 0.44 ohms

Under certain conditions, VCC can be left floating.

- The minimum high-level voltage of the input signal is greater than 2.4V.

Smaller input current

- Integrated approximately 15K pairs of underground pull-up resistors
- VCC is properly connected; the 3V drive signal averages 195uA.

Current

- VCC is floating, 3V drive signal averages 330uA input current.

flow

Built-in overheat protection circuit with hysteresis (TSD)

Antistatic rating: 3KV (HBM)

Application Scope

• Toy motor powered by 2-6 AA/AAA dry cell batteries

• Toy motor powered by 2-6 nickel-metal hydride/nickel-cadmium rechargeable batteries

move

• Motor driven by 1-2 lithium batteries

Typical application diagram

Electronic lock

Overview

This product adopts an H-bridge circuit structure design and features high reliability.

The power transistor technology is particularly suitable for driving inductive loads such as coils and motors.

The circuit integrates N-channel and P-channel power MOSFETs, operating...

Voltage range covers 2V to 9.6V. Under conditions of 27°C and VDD=6.5V...

The maximum continuous output current reaches 1.1A, and the maximum peak output current reaches...

Up to 1.5A.

This single-channel device is a power device and has a certain internal resistance. The circuit...

The heat generation is related to the load current, the on-resistance of the power transistor, and the ambient temperature.

Closely related. The circuit design includes a chip-level temperature detection circuit for real-time...

Monitor the internal heat of the chip; when the internal temperature of the chip exceeds a set value...

(Typical value 150°C), generates a power transistor turn-off signal, shutting off the load power.

To prevent the temperature from rising continuously due to abnormal use, thereby causing...

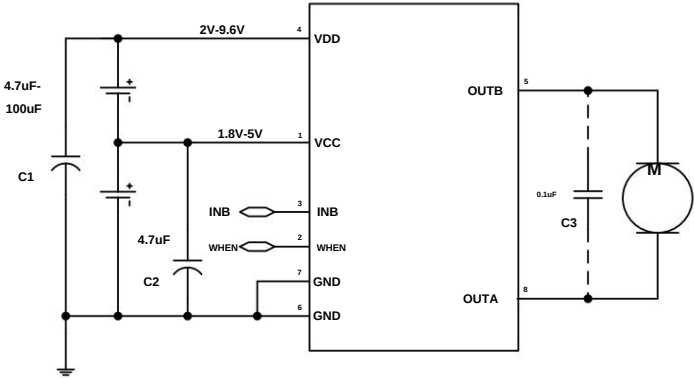
The plastic encapsulation could cause serious safety incidents such as smoke and fire. The chip is internally mounted.

A temperature hysteresis circuit is used to ensure that the circuit returns to a safe temperature before...

This allows for the re-control of the power transistor.

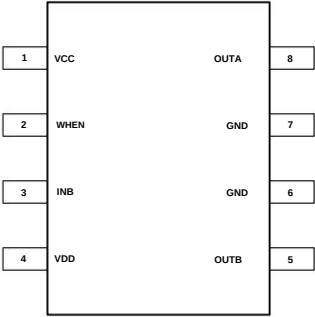
Ordering Information

Product Model	Packaging	Operating temperature
MX608E	SOP8	-20°C ~ 85°C



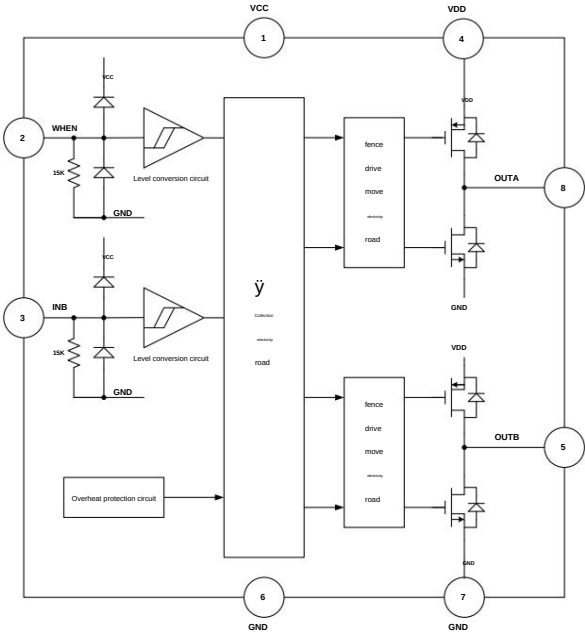
Pin arrangement

Pin Definitions



Pin Number	Pin Name	Input/Output	Pin Function Description
1	VCC		- Logic control power supply terminal
2	WHEN	I	Forward Logic Input
3	INB	I.	Invert Logic Input
4	VDD		- Power supply terminal
5	OUTB	O	Inverted output
6	GND		- Grounding terminal
7	GND		- Grounding terminal
8	OUTA	O	Forward output

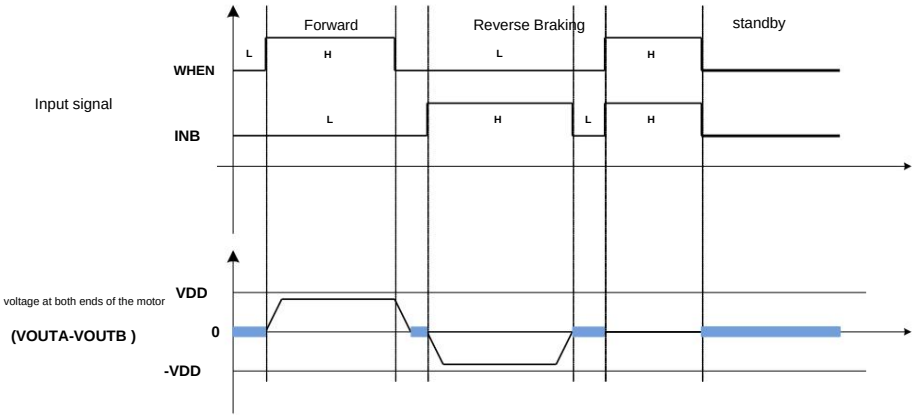
Functional block diagram



Logical truth table

WHEN	INB	OUTA	OUTB	Functions
L	L	stop	stop	include
H	L	H	L	standby
L	H	L	H	forward/
H	H	L	L	reverse rotation and brake.

Typical waveform diagram



Absolute maximum rating (TA=25℃)

	symbol	value	unit
Parameters: Maximum logic control power	VCC(MAX)	7	In
supply voltage, Maximum power,	VDD(MAX)	10	
Maximum applied output voltage,	VOUT(MAX)	VDD	
Maximum applied input voltage,	WIN(MAX)	VCC	
Maximum peak output current,	IOUT(PEAK)	1.5	A
Maximum power	PD	1	IN
dissipation, Junction-to-ambient thermal resistance, SOP8	θJA	123	°C/W
package, Operating	Topr	-20~+85	°C
	TJ	150	°C
temperature	Test	-55~+150	°C
range, Junction temperature, Storage temperature, Soldering temperature.	TLED	260°c, 10 seconds	
ESD (Note 3)		3000	In

Note: (1) The formula for calculating the maximum power consumption under different ambient temperatures is: PD=(150θJA-TA)/θJA

TA represents the ambient temperature at which the circuit operates, and θJA is the thermal resistance of the package. 150°c represents the highest operating junction temperature of the circuit.

(2) Calculation method for circuit power consumption: P = I² * R

Where P is the circuit power consumption, I is the continuous output current, and R is the circuit's on-resistance. The circuit power consumption P must be less than the maximum power consumption PD.

(3) Human model, 100pF capacitor discharged through 1.5KΩ resistor.

Recommended operating conditions (TA=25°c)

	Minimum value	Maximum value	Typical value (VDD=6.5V)	Maximum unit	
Parameters Logic and control power	VCC	1.8	-	5	In
supply voltage Power	VDD	2	-	9.6	In
supply voltage Continuous	IOUT		1.1		A

output current Note: (1) The logic control power supply VCC and the power supply VDD are completely independent internally and can be powered separately. When the logic control power supply VCC is de-energized, When both input signals are low, the circuit power supply VDD will enter a 0-current standby mode.

(2) The continuous output current test conditions are: the circuit is mounted on the PCB for testing, and the test PCB board size of SOP8 package is 22mm*18mm.

(3) The maximum continuous output current is related to the ambient temperature. The maximum continuous current of the circuit at an ambient temperature of 40°c is approximately less than that at an ambient temperature of 25°c.

7%°c

Electrical characteristic parameter table

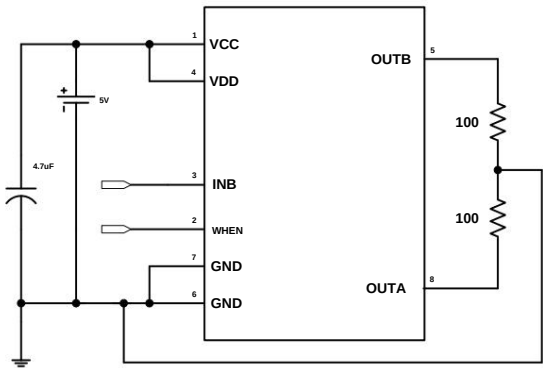
(TA=25℃, VCC=3V, VDD=6V unless otherwise specified)

parameters	Symbolic conditional		Minimum value	typical value	maximum value	unit
Power supply parameters						
VCC standby current	IVCCST	INA=INB= L;VCC=7V;	-	0	10	a
VDD standby current	IVDDST	VDD=10V; Output left floating	-	0	10	
VCC (Quiet Current) IVCC		INA=H OR INB=H; Output is left floating.	-	133	-	a
VDD Static power supply current IVDD		INA=H OR INB=H; Output floating input logic level	-	180	-	
-VCC normal connection voltage						
Input high level	VINH		0.6*VCC	-	-	In
Input low level	VINYL		-	-	0.6	
Input level Hysteresis	VHYS			0.4		
Input high level Current	INH	VINH=3V, VCC=3V		195		a
input Pull-down	ALSO	VINH=3V, VCC=3V		15		K Ω
resistor Input logic level -VCC Floating						
Input high level,	VINH		2.4	-	-	In
input low level,	VINYL		-	-	0.6	
input level hysteresis,	VHYS			0.4		
input high level, current	INH	VINH = 3V, VCC is floating.		330		a
input, pull-down	ALSO	VINH = 3V, VCC is floating.		15		K Ω
resistor, power transistor on-state resistance						
On-resistance	RON	IO=±200mA VDD=6.5V TA=25 $\dot{y}$		0.44		Oh
		IO=±800mA VDD=6.5V TA=25 $\dot{y}$		0.48		
Protection function parameters						
Thermal shutdown	TSD		-	150	-	$\dot{y}$
temperature point, thermal	TSDH		-	20	-	
shutdown temperature hysteresis time parameters (VCC=VDD=5V)						
Output rise time	tr	INB=GND,INA input 20kHz PWM signal		93		ns
Output fall time Input	tf	Connect OUTA to a 100-ohm load to GND.		17		
A to output A in the same direction	trr	INB=GND,INA input 20KHZ PWM signal		108		ns
Number delay	tff	Connect OUTA to a 100-ohm load to GND.		39		
Input A corresponds to the reverse signal of output B	trf	INB=5V, INA input 20kHz PWM signal		39		ns
Number delay	tfr	Connect OUTB to a 100-ohm load to GND.		104		

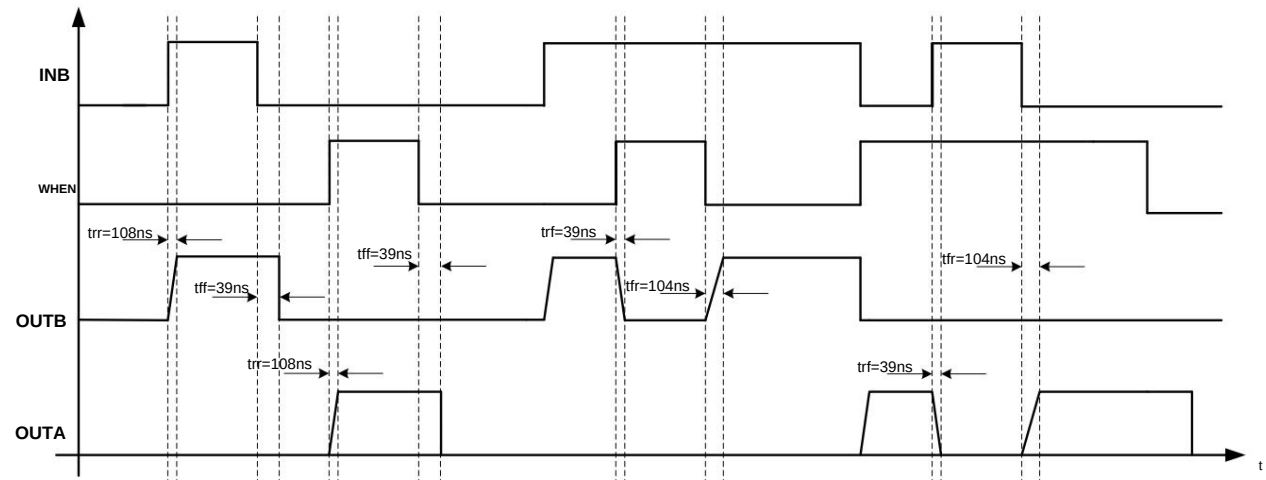
Note: 1. The delay of the input B to the output B in the same direction is the same as the delay of the input A to the output A in the same direction as in the table above.

2. The delay of the inverse signal from input B to output A is the same as the delay of the inverse signal from input A to output B in the table above.

Test Schematic

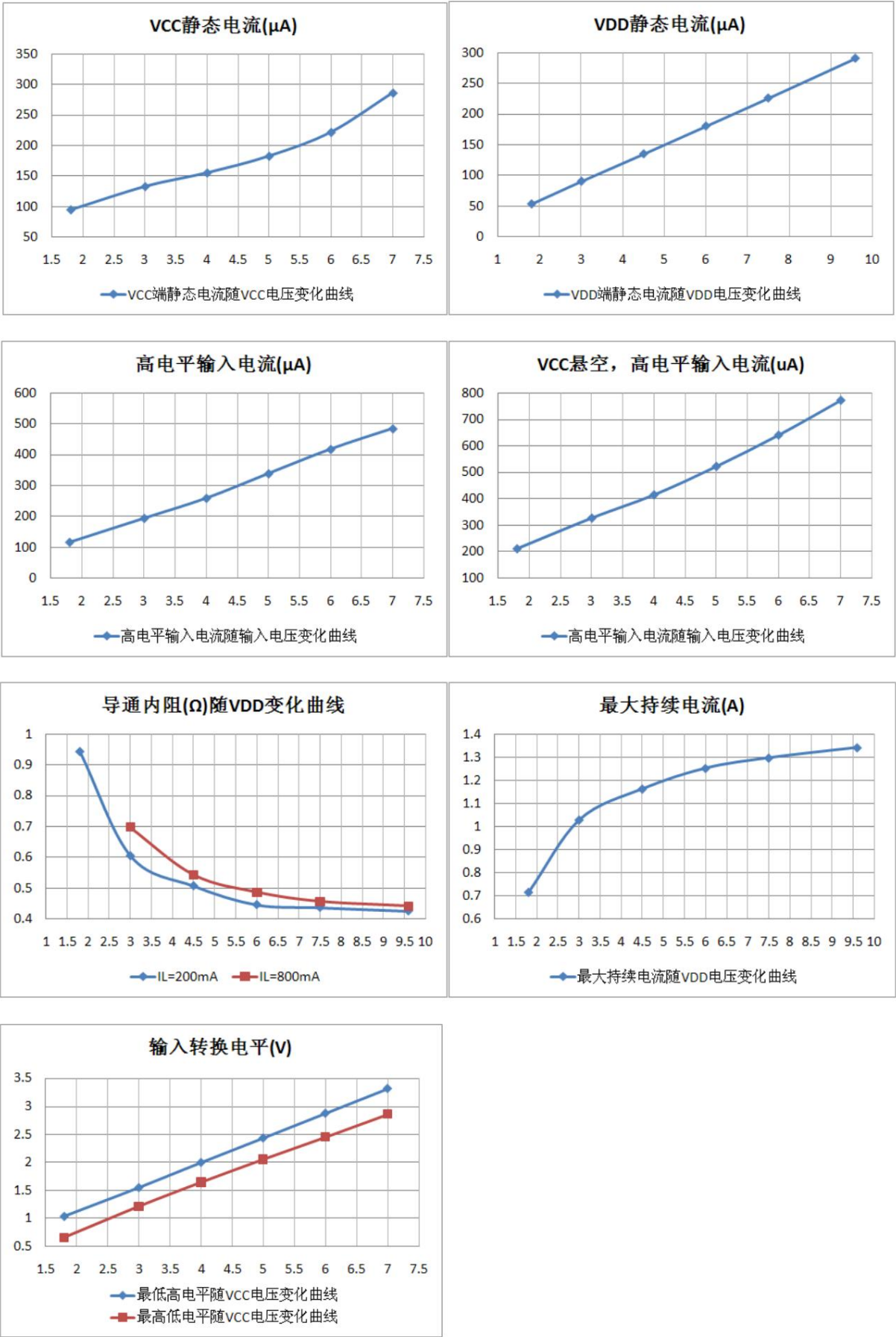


Time parameter test principle diagram



Time parameter definition

Electrical characteristic curves



Typical circuit diagram of motor drive application

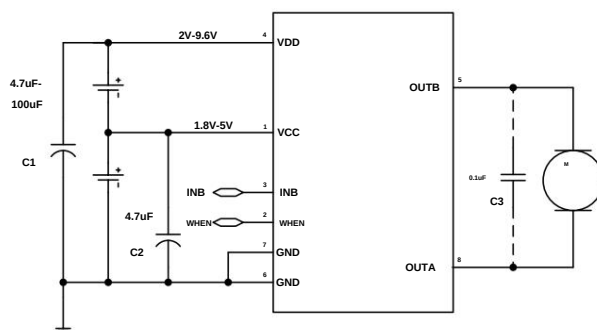


Figure 1 Typical application circuit diagram of MX608E

Special Notes:

In Figure 1, capacitor C1 is the decoupling capacitor between the power supply and ground. The capacitance value of capacitor C1 can be adjusted according to different application conditions.

There are different options, as detailed below:

A. Under the application conditions where VDD voltage is less than 7.2V (4 brand new dry batteries) and peak current does not exceed 1.5A, capacitor C1 can be omitted.

B. In applications where VDD voltage is between 7.2V and 9.6V and peak current exceeds 1.5A, capacitor C1 cannot be omitted and needs to be determined based on the actual situation.

For motors, the value of capacitor C1 should be selected between 47uF and 100uF.

C. The type of capacitor C1 is not limited; it can be a ceramic capacitor or an electrolytic capacitor.

The logic power supply VCC capacitor C2 must be at least 4.7uF to ground. In practical applications, it is not necessary to add a separate capacitor close to the chip.

It is shared with other control chips (RX2, MCU, etc.). If there is no capacitor between VCC and ground, when the circuit enters overheat protection mode due to overload, the electrical...

The circuit may enter a locked state. Once locked, the input signal state must be changed again for the circuit to return to normal. Only...

If there is more than 4.7uF of capacitance between VCC and ground, the circuit will not be locked out.

In Figure 1, the 0.1uF capacitor (C3) between OUTA and OUTB in the drive circuit represents the capacitor connected across the motor terminals and does not need to be added separately.

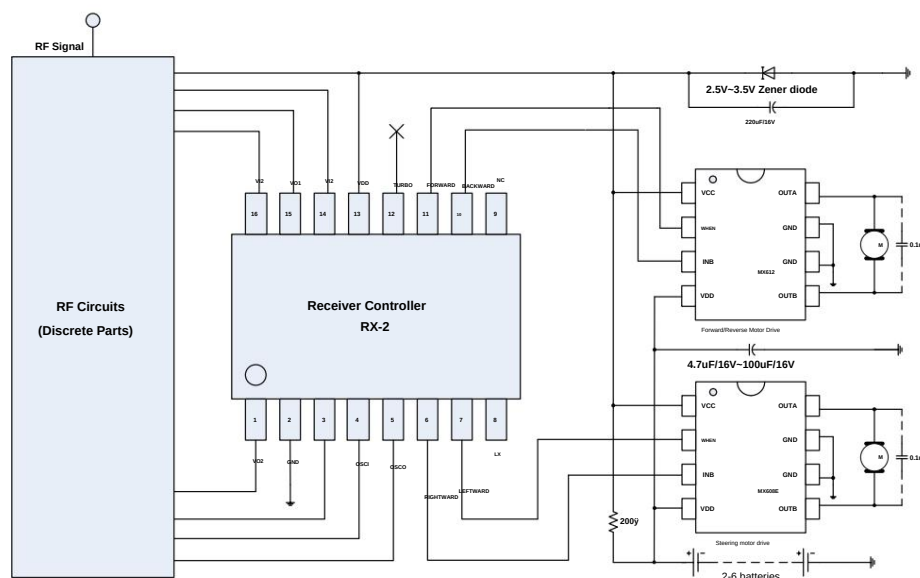


Figure 2. Circuit diagram for a 2-6 battery-powered toy remote control car motor drive application.

Figure 2 shows the motor drive application circuit diagram. Since the steering wheel drive current is relatively small, the MX608E can be selected as the drive circuit. (Rear wheel motor...)

For products with relatively large drive current, other products from our company, such as MX612 and MX618, can be selected according to specific requirements.

The VDD decoupling capacitor in Figure 2 should be selected based on the actual application. The higher the VDD voltage, the greater the motor current, and the higher the capacitor value should be.

The larger the value, the better. The capacitance value depends on the actual motor used; it is recommended that the value of capacitor C1 be between 4.7uF and 100uF.

In Figure 2, the 0.1uF capacitor between OUTA and OUTB in the drive circuit represents the capacitor connected across the motor terminals and does not need to be added separately.

VCC and VDD must be wired separately. VCC only accepts a static voltage of 5V or less and must share a power supply with the main control chip; otherwise, motor switching will fail.

The generated electromotive force may damage the logic section, so separate wiring is required even if the VDD voltage is below 5V.

Typical application circuit diagram of electronic lock

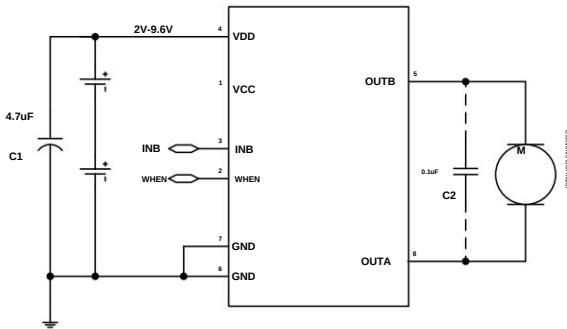


Figure 3 Typical application circuit diagram of MX608E electronic lock

When using the MX608E to drive the electronic lock switch, the logic power supply VCC is left floating, but the input high-level voltage is required to exceed 2.4V.

In Figure 3, capacitor C1 is the decoupling capacitor between the power supply VDD and ground. When applying it, capacitor C1 can be 4.7uF.

In Figure 3, the 0.1uF capacitor (C2) between OUTA and OUTB in the drive circuit represents the capacitor connected across the electronic lock motor and does not require a separate capacitor.

Add to.

Application Notes

1. Basic Working Mode

a) Standby mode

In standby mode, INA=INB=L. All internal circuitry, including the power transistor driver, is off. Circuit power consumption is extremely low.

The current. At this time, both OUTA and OUTB of the motor output are in a high-impedance state.

b) Forward rotation mode

The forward rotation mode is defined as follows: INA=H, INB=L. In this mode, the motor drive terminal OUTA outputs a high level, and the motor drive terminal OUTB outputs a low level.

When the motor drive current flows from OUTA into the motor and from OUTB to ground, the motor rotation at this time is defined as the forward rotation mode.

c) Reverse mode

The inversion mode is defined as follows: INA=L, INB=H. In this mode, the motor drive terminal OUTB outputs a high level, and the motor drive terminal OUTA outputs a low level.

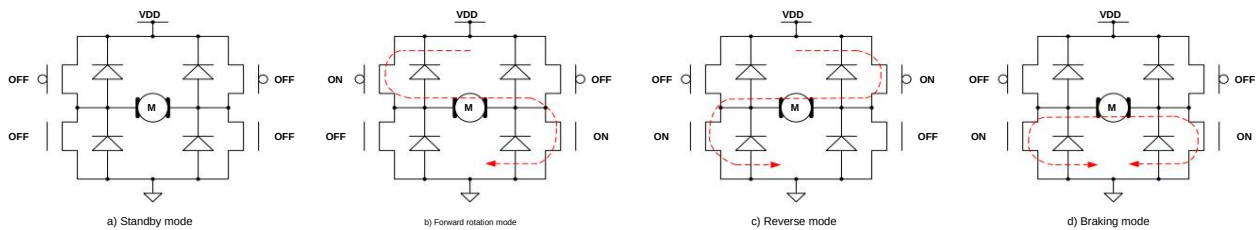
When the motor drive current flows from OUTB into the motor and from OUTA to ground, the rotation of the motor at this time is defined as the reverse mode.

d) Braking mode

The braking mode is defined as follows: INA=H, INB=H. At this time, both the motor drive terminals OUTA and OUTB output a low level, and the energy stored in the motor...

The current will be rapidly released through the NMOS transistor at OUTA or OUTB, and the motor will stop rotating within a short time. Note this in braking mode.

The lower circuit will consume static power.



e) PWM Mode A: When

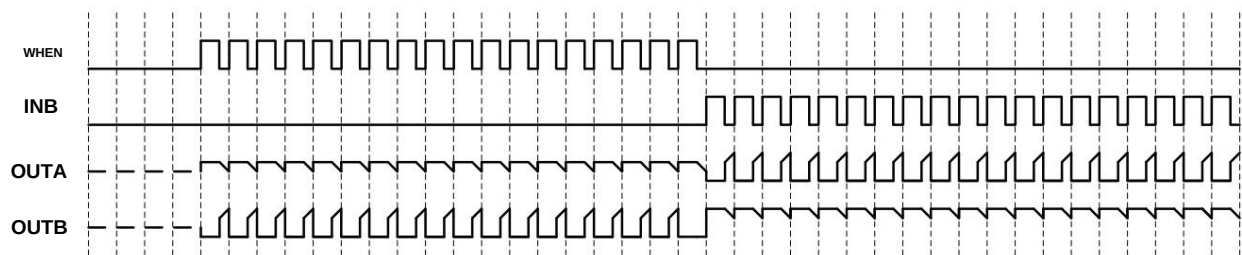
the input signal INA is a PWM signal and INB=0, or INA=0 and INB is a PWM signal, the motor's rotation speed will be controlled by the PWM signal.

The duty cycle is controlled. In this mode, the motor drive circuit switches between on and standby modes. In standby mode, all power...

With all the transistors off, the energy stored inside the motor can only be slowly released through the body diode of the power MOSFET.

Note: Due to the high impedance state during operation, the motor speed cannot be precisely controlled by the duty cycle of the PWM signal. If...

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



PWM Mode A Signal Waveform Diagram

f) PWM mode B

When the input signal INA is a PWM signal and INB=1, or when INA=1 and INB is a PWM signal, the motor's rotation speed will be affected by the PWM signal.

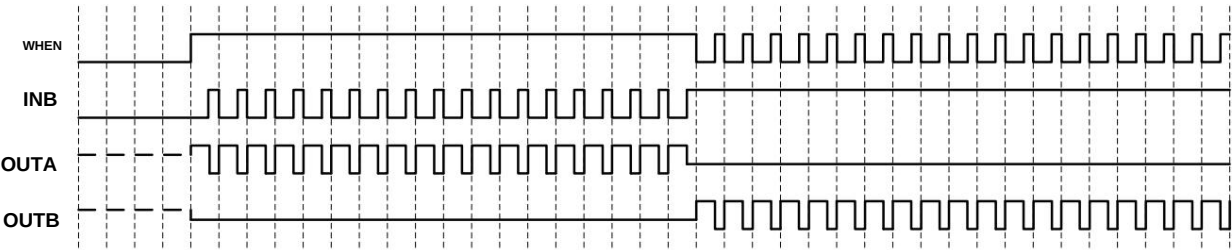
Signal duty cycle control. In this mode, the motor drive circuit output switches between on and off modes; in off mode, the motor stores...

Energy is rapidly released through the low-side NMOS transistor.

Note: Due to the braking state during operation, the motor energy can be released rapidly, and the motor speed can be precisely controlled by the duty cycle of the PWM signal.

While precise control is possible, it is important to note that if the PWM signal frequency is too low, the motor may enter braking mode and fail to rotate smoothly and continuously.

To reduce motor noise, it is recommended that the PWM signal frequency be greater than 10KHz and less than 50KHz.



PWM Mode B Signal Waveform Diagram

2. Anti-Common-Mode Conduction Circuit: In

a full-bridge drive circuit, the simultaneous conduction of the high-side PMOS power transistor and the low-side NMOS power transistor within the half-bridge is called common-mode conduction. Common-mode conduction results in a large transient current from power supply to ground, causing additional power loss and, in extreme cases, burning out the circuit. Common-mode conduction is avoided through a built-in dead time. A typical dead time is 300ns.

3. Overheat Protection Circuit: When the junction temperature of the drive circuit exceeds the preset temperature (typically 150 $^{\circ}$ C), the TSD circuit starts operating. At this time, the control

circuit forcibly shuts down all output

power transistors, and the drive circuit output enters a high-impedance state. The TSD circuit incorporates thermal hysteresis; the circuit returns to normal operation only when the junction temperature drops to the preset temperature (typically 130 $^{\circ}$ C).

4. Maximum Continuous Power Consumption of the Drive Circuit: This series of motor drive circuits are all designed with an overheat protection circuit. Therefore, when the power consumption of the drive circuit is too high, the circuit will enter a high-impedance state.

In shutdown mode, the motor will not function properly under thermal shutdown conditions. The formula for calculating the maximum continuous power consumption of the drive circuit is:

$$P_M = (150^{\circ}C - T_A) / \theta_{JA}, \text{ where } 150^{\circ}C \text{ is}$$

the preset temperature point of the thermal shutdown circuit, T_A is the ambient temperature ($^{\circ}$ C) of the circuit operation, and θ_{JA} is the junction-to-ambient thermal resistance (unit: $^{\circ}$ 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 is not directly related to the circuit's on-resistance. 5. Power Consumption of Drive Circuit The on-resistance of the power MOSFET inside 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: $P_D = I_L^2 \cdot R_{ON}$, where I_L represents the output current of the motor drive circuit, and R_{ON} represents the on-resistance of the power MOSFET. **Note: The on-**

resistance of the power MOSFET increases with increasing temperature. When calculating the maximum continuous output current and power consumption of the circuit,

it is necessary to consider the on-resistance.

The temperature characteristics of the conduction resistance must

be considered. 6. Maximum continuous output current of the drive circuit.

The maximum continuous output current of the drive circuit can be calculated based on its maximum continuous power consumption and the power consumption of the drive circuit itself. The calculation formula is as follows:

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

R_{ANT} here represents the on-resistance of the power MOSFET after considering 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 the on-resistance of the power MOSFET. 7. Selection of Motor Internal Resistance 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 stall current will be low.

If the current exceeds the maximum continuous output current that the motor drive circuit can withstand, it can easily cause the motor drive circuit to enter an overheating shutdown state, resulting in the toy car vibrating when running or repeatedly moving forward and backward. Therefore, the internal resistance of the motor must be considered when selecting a motor drive circuit.

Special Notes

1. Power supply and ground reversed

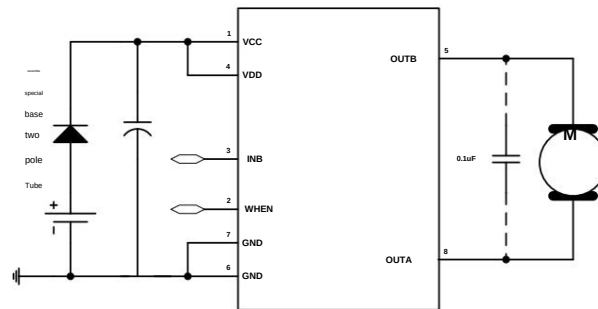
Reversing the power supply and ground wires in a circuit will damage the circuit and, in severe cases, cause the plastic casing to smoke. Consider connecting a resistor in series with the power supply terminal of the circuit.

Connecting a power Schottky diode to the positive terminal of the battery can prevent circuit damage caused by reverse battery connection. The maximum power Schottky diode...

The continuous current capability must be greater than the continuous current of the motor under stall conditions; otherwise, the Schottky diode will be damaged due to overheating. Power Schottky diodes...

The reverse breakdown voltage must be greater than the maximum supply voltage. If the reverse breakdown voltage is too low, the Schottky diode will break down when the battery is reverse-connected.

burn.



2. Power supply VDD decoupling capacitor to ground (C1)

The power supply VDD decoupling capacitor C1 required by the drive circuit (refer to application circuit diagram 1) has two main functions: 1) to absorb motor...

1) To release energy to the power supply, stabilize the power supply voltage, and prevent the circuit from breaking down due to overvoltage; 2) During motor startup or rapid forward/reverse switching.

Instantaneously, the motor requires a large instantaneous current to start quickly. Due to the battery's response speed and the long connection leads, it often cannot immediately output a large instantaneous current.

When a large transient current is encountered, the energy storage capacitor located near the motor drive circuit needs to release the transient large current.

Based on the energy storage characteristics of capacitors, the larger the capacitance value, the smaller the voltage fluctuation within the same time period. Therefore, in high-voltage and high-current applications...

The recommended value for capacitor C1 depends on the actual motor used, and is suggested to be between 4.7uF and 100uF.

3. Static electricity protection

The circuit's input/output ports utilize CMOS devices, which are sensitive to electrostatic discharge (ESD). Although ESD protection circuitry is included, potential issues may arise during transportation and packaging.

Anti-static measures should be taken during loading, processing, and storage, especially during processing.

4. Output to ground short circuit, output terminal short circuit

During normal operation, if a short circuit occurs between the high-level output terminal and ground, or between OUTA and OUTB, the internal circuit will...

A very large current is applied, generating a very large power consumption, triggering the internal overheat shutdown circuit, thus protecting the circuit from immediate burnout. However, due to the excessive current...

Thermal protection circuits only detect temperature and not transient current flowing through the circuit. When the output is short-circuited to ground, the current is extremely high, which can easily damage the circuit.

During use, avoid short-circuiting the output to ground. Incorporating current limiting measures during testing can prevent similar damage.

5. Output short circuit to power supply

During normal operation, the circuit will be damaged if a short circuit occurs between the low-level output terminal and the power supply.

6. Motor stall

During normal operation, if the load motor in the drive circuit stalls, and the stall current exceeds the maximum continuous current of the drive circuit...

If the stall current is significantly higher than the maximum peak current, the drive circuit will enter overheat protection mode to prevent circuit damage. However, if the stall current is much higher than the maximum peak current, the circuit is more susceptible to damage.

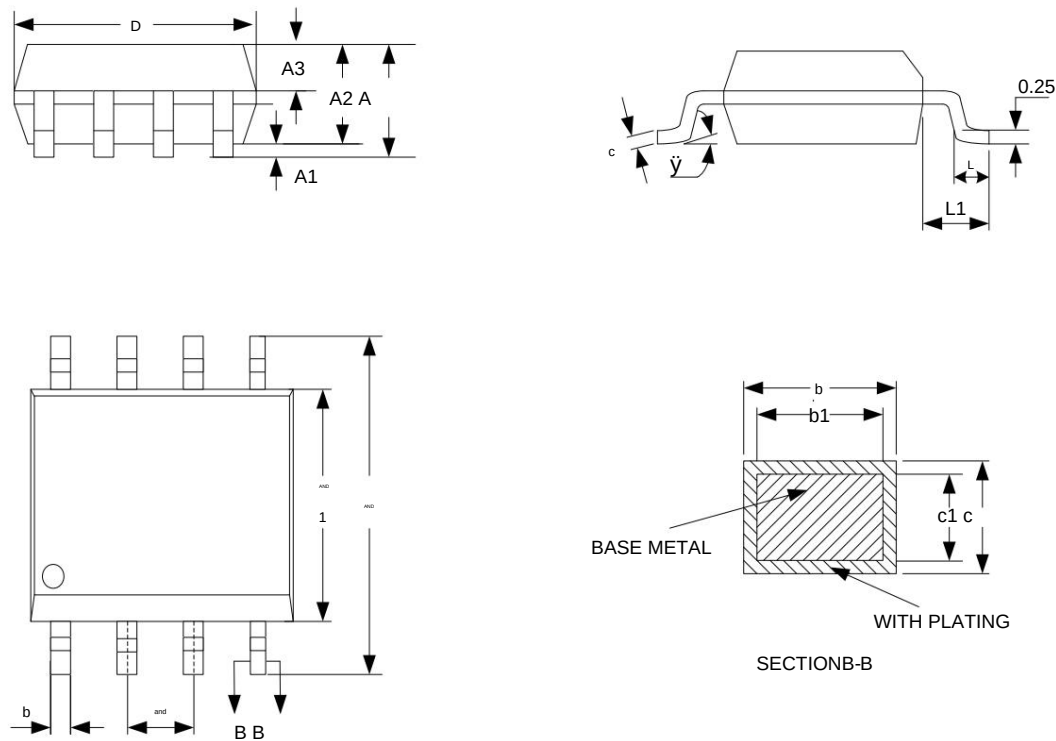
bad.

7. Peak current greatly exceeds rated value

The chip can also burn out when the voltage is close to or exceeds the maximum operating voltage and the peak current is much greater than the absolute maximum peak current.

Package outline dimensions

SOP8y



SYMBOL	MILLIMETER		
	MIN	NAME	MAX
A	-	-	1.77
A1	0.08	0.18	0.28
A2	1.20	1.40	1.60
A3	0.55	0.65	0.75
b	0.39	-	0.48
b1	0.38	0.41	0.43
c	0.21	-	0.26
c1	0.19	0.20	0.21
D	4.70	4.90	5.10
and	5.80	6.00	6.20
E1	3.70	3.90	4.10
and	1.27BSC		
L	0.50	0.65	0.80
L1	1.05BSC		
i	0	-	8°

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Version History

V1.0 Initial Version	2016-08-08
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