LB1948MC

Bi-CMOS integrated circuit

12V Low Saturation Voltage Drive
Forward/Reverse Motor Driver
Application Note

ON Semiconductor®

http://onsemi.com

Overview

The LB1948MC is a 2-channel low saturation voltage forward/reverse motor driver IC. It is optimal for motor drive in 12V system products and can drive either two DC motors, one DC motor using parallel connection, or it can drive a stepping motor in Full-step and Half-step.

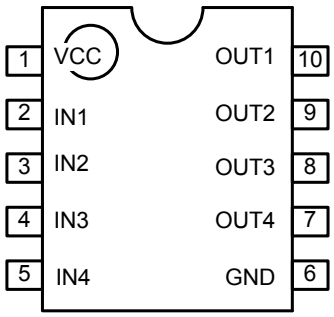
Function

- BIP output transistor adoption (Upper and lower total Vo(sat)=0.5V(typical) at Io=400mA)
- For one power supply (The control system power supply is unnecessary.)
- Our motor driver IC, LV8548MC, and compatible pin
- It is possible to connect it in parallel (parallel, connected operation of drive ch).
- The compact package (MFP10SK) is adopted
- V_{CC} max = 20v, I_O max = 0.8A
- Current consumption 0 when standing by
- Built-in brake function

Typical Applications

- Refrigerator
- Time Recorder
- Label Printer
- Vacuum Cleaner
- POS Printer
- TOY

Pin Assignment

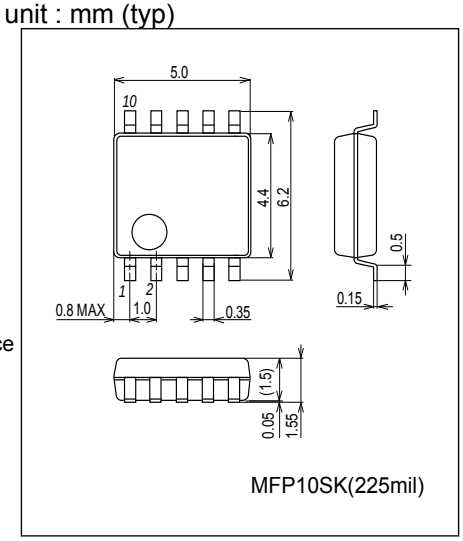


LB1948MC

(Top View)

Package Dimensions

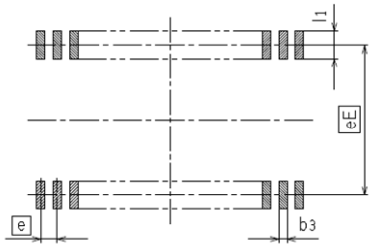
unit : mm (typ)



MFP10SK(225mil)

Caution: The package dimension is a reference value, which is not a guaranteed value.

Recommended Soldering Footprint



(Unit:mm)

Reference Symbol	MFP10SK(225mil)
eE	5.60
e	1.00
b3	0.47
l1	1.00

Block Diagram

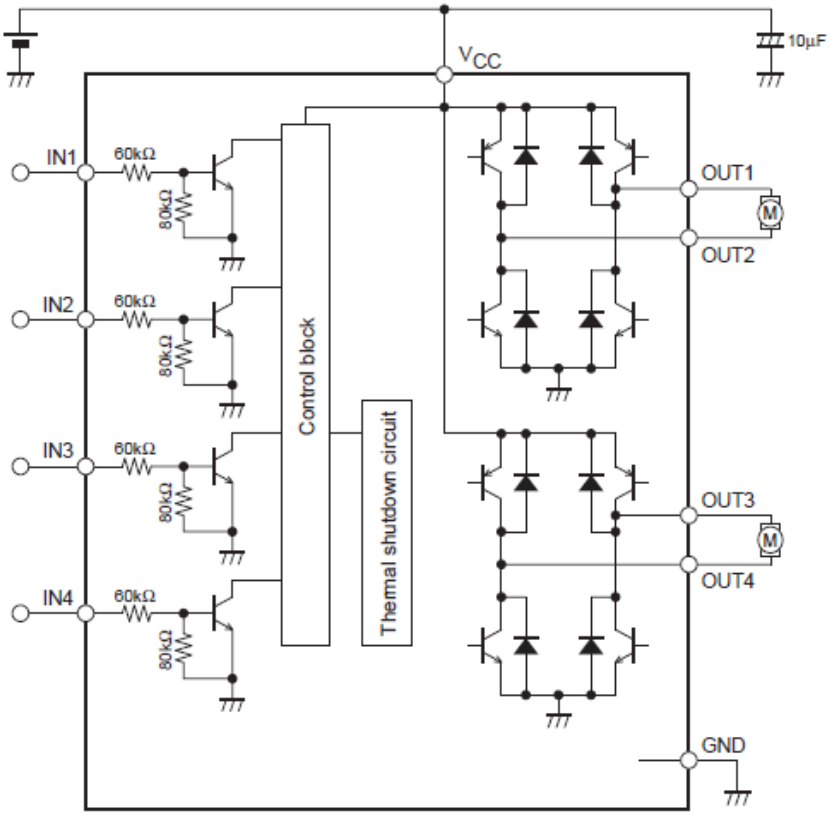


Figure1 Two DC motor drive

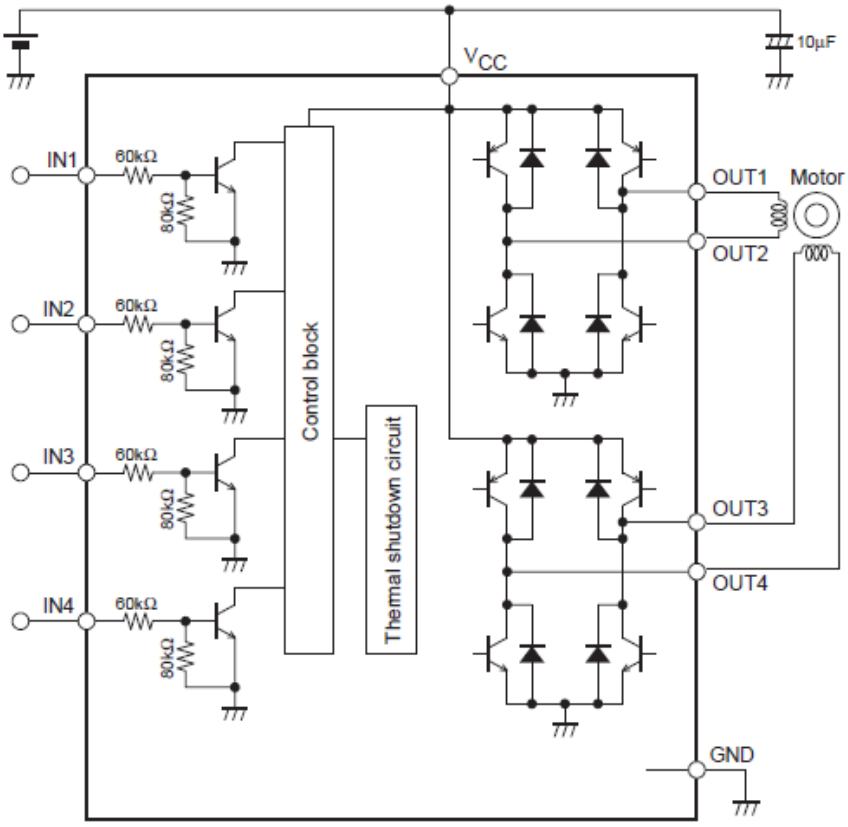


Figure2 One stepping motor drive

Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V_{CC} max		-0.3 to +20	V
Output voltage	VOUT		-0.3 to +20	V
Input voltage	V_{IN}		-0.3 to +18	V
Ground pin source current	IGND	Per channel	800	mA
Allowable power dissipation	Pd max1	Independent IC	350	mW
	Pd max2	*	870	mW
Operating temperature	Topr		-20 to +85	°C
Storage temperature	Tstg		-40 to +150	°C

*: When mounted on the specified printed circuit board (114.3mm ×76.1mm × 1.6mm), glass epoxy board

Caution 1) Absolute maximum ratings represent the value which cannot be exceeded for any length of time.
Caution 2) Even when the device is used within the range of absolute maximum ratings, as a result of continuous usage under high temperature, high current, high voltage, or drastic temperature change, the reliability of the IC may be degraded. Please contact us for the further details.

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply voltage	V_{CC}		2.5		16	V
Input high-level voltage	V_{IH}		1.8		10	V
Input low-level voltage	V_{IL}		-0.3		+0.7	V

Electrical Characteristics at Ta = 25°C, V_{CC} = 5V

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Current drain	$I_{CC}0$	IN1,2,3,4=0V(Standby mode)		0.1	10	μA
	$I_{CC}1$	*1 (Forward or reverse mode)		15	21	mA
	$I_{CC}2$	*2 (Brake mode)		30	40	μA
Output saturation voltage	$V_{O(sat)}1$	I_{OUT}=200mA (High side and low side)		0.25	0.35	V
	$V_{O(sat)}2$	I_{OUT}=400mA (High side and low side)		0.50	0.75	V
Input current	I_{IN}	V_{IN} = 5V		85	110	μA
Spark Killer Diode						
Reverse current	I_S(leak)				30	μA
Forward voltage	V_{SF}	I_{OUT}=400mA			1.7	V

*1: IN1/IN2/IN3/IN4=H/L/L/L or L/H/L/L or L/L/H/L or L/L/L/H.

*2: IN1/IN2/IN3/IN4=H/H/L/L or L/L/H/H.

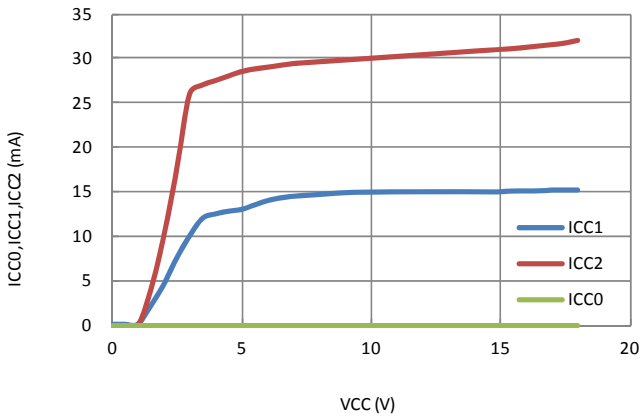


Figure 1 Current Drain vs VCC Voltage

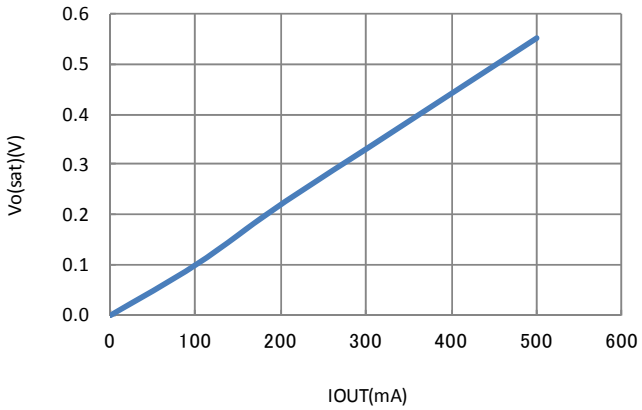


Figure 2 Vo(sat) vs IOUT (VCC=VIN=12V)

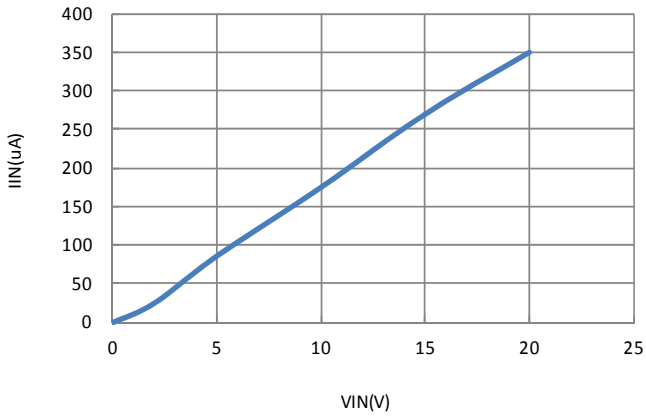


Figure 3 IIN vs VIN

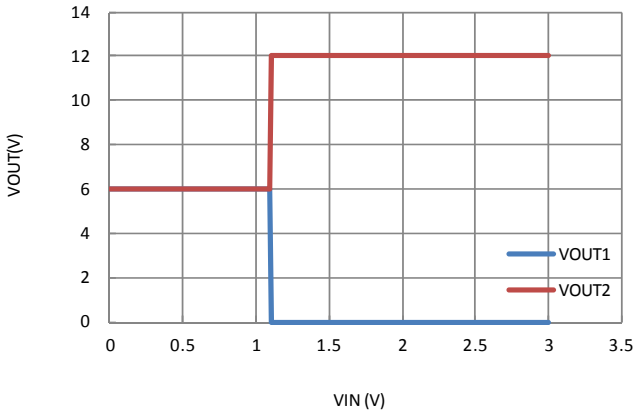


Figure 4 VOUT vs VIN (VCC=12V)

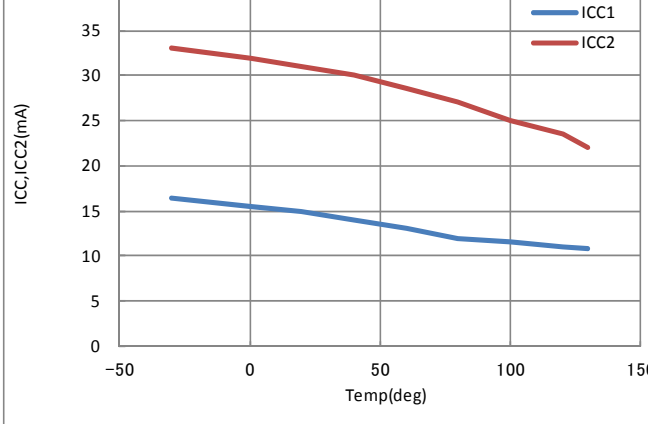


Figure 5 Current drain vs Temperature (VCC=5V)

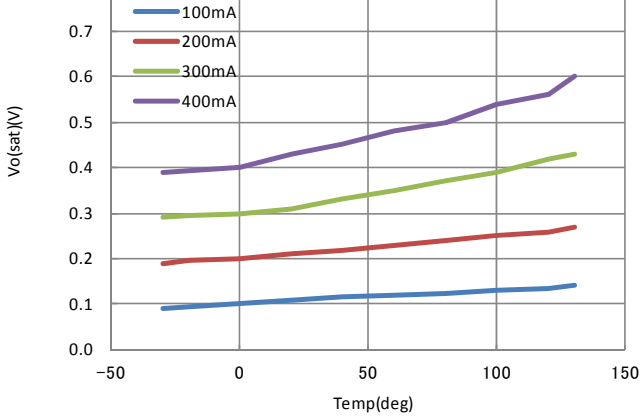
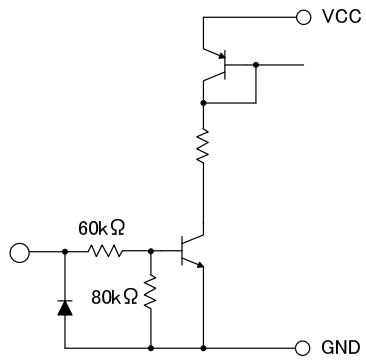
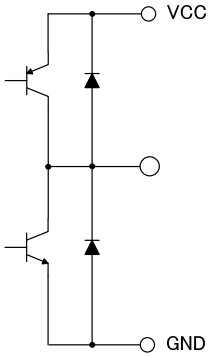


Figure 6 Vo(sat) vs Temperature (VCC=VIN=12V)

Pin function

Pin No.	Pin name	Pin function	Equivalent Circuit
1	V_{CC}	Power-supply voltage pin. V_{CC} voltage is impressed. The permissible operation voltage is from 2.5 to 16(V). The capacitor is connected for stabilization for GND pin (6pin).	
2	IN1	Motor drive control input pin. Driving control input pin of OUT1 (10pin) and OUT2 (9pin). It combines with IN2 pin (3pin) and it fights desperately. The digital input it, range of the "L" level input is 0 to 0.7(V), range of the "H" level input is from 1.8 to 10(V). Pull-down resistance 80(kΩ) is built into in the pin. It becomes a standby mode because all IN1, IN2, IN3, and IN4 pins are made "L", and the circuit current can be adjusted to 0.	
3	IN2	Motor drive control input pin. Driving control input pin of OUT1 (10pin) and OUT2 (9pin). It combines with IN1 pin (2pin) and it uses it. With built-in pull-down resistance.	
4	IN3	Motor drive control input pin. Driving control input pin of OUT3 (8pin) and OUT4 (7pin). It combines with IN4 pin (5pin) and it uses it. With built-in pull-down resistance.	
5	IN4	Motor drive control input pin. Driving control input pin of OUT3 (8pin) and OUT4 (7pin). It combines with IN3 pin (4pin) and it uses it. With built-in pull-down resistance.	
6	GND	Ground pin.	
7	OUT4	Driving output pin. The motor coil is connected between terminal OUT3 (8pin).	
8	OUT3	Driving output pin. The motor coil is connected between terminal OUT4 (7pin).	
9	OUT2	Driving output pin. The motor coil is connected between terminal OUT1 (10pin).	
10	OUT1	Driving output pin. The motor coil is connected between terminal OUT2 (9pin).	

Operation explanation

1. DCM output control logic

Input				Output				Remarks	
IN1	IN2	IN3	IN4	OUT1	OUT2	OUT3	OUT4		
L	L	L	L	OFF	OFF	OFF	OFF	Stand-by	
L	L			OFF	OFF			1CH	Stand-by
H	L			H	L				Forward
L	H			L	H				Reverse
H	H			L	L				Brake
		L	L			OFF	OFF	2CH	Stand-by
		H	L			H	L		Forward
		L	H			L	H		Reverse
		H	H			L	L		Brake

2. Thermal shutdown function

The thermal shutdown circuit is incorporated and the output is turned off when junction temperature Tj exceeds 200°C. As the temperature falls by hysteresis, the output turned on again (automatic restoration). The thermal shutdown circuit does not guarantee the protection of the final product because it operates when the temperature exceed the junction temperature of Tjmax=150°C.

TSD = 200°C (typ)

ΔTSD = 75°C (typ)

(1)Thermal shutdown temperature

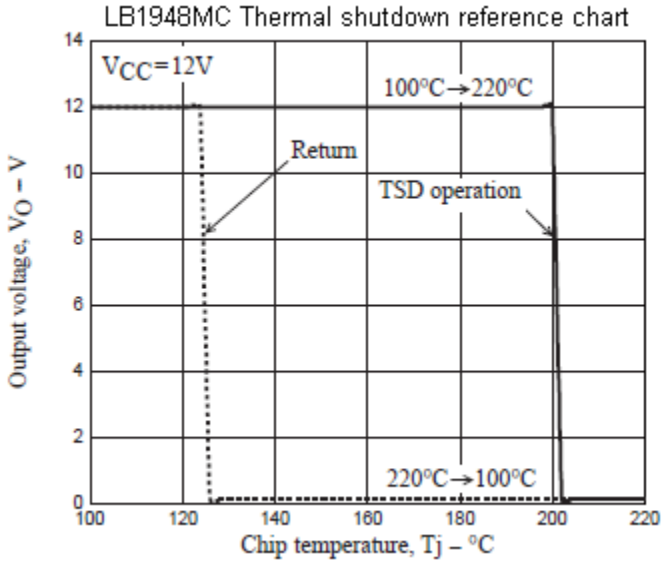
The thermal shutdown temperature Ttsd is 200±20°C with fluctuations.

(2)Thermal shutdown operation

The operation of the thermal shutdown circuit is shown in the figure below.

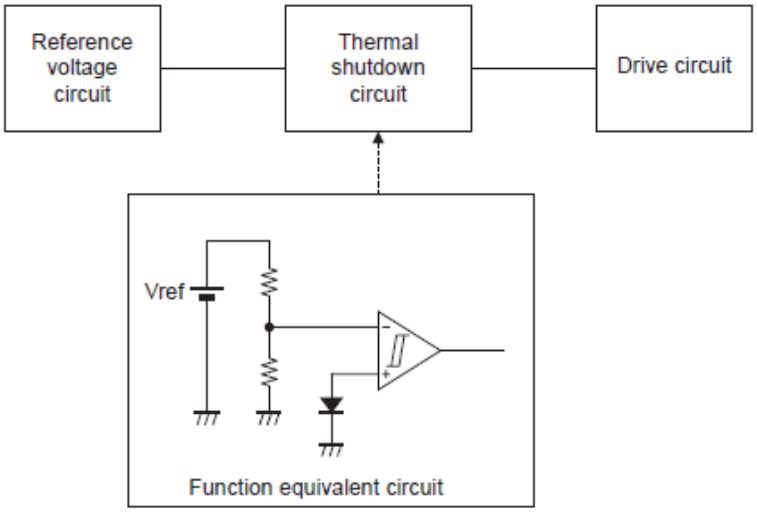
When the chip temperature Tj is in the direction of increasing (solid line), the output turns off at approximately 200°C.

When the chip temperature Tj is in the direction of decreasing (dotted line), the output turns on (returns) at approximately 125°C.



(Thermal shutdown circuit block diagram)

The thermal shutdown circuit compares the voltage of the heat sensitive element (diode) with the reference voltage and shuts off the drive circuit at a certain temperature to protect the IC chip from overheating.



Note: The above is an example of thermal shutdown circuits although ther are same differences from the actual internal circuit.

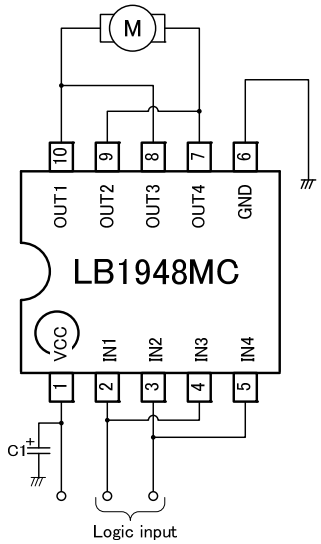
Design Documentation

(1)Voltage magnitude relationship

There are no restrictions on the magnitude relationships between the voltage applied to Vcc and IN1 to IN4.

(2)Parallel connection

The LB1948MC can be used as a single-channel H-bridge power supply by connecting IN1 to IN3, IN2 to IN4, OUT1 to OUT3, and OUT2 to OUT4 as shown in the figure.
(Iomax=1.6A, Vo(sat)=0.6V(typical) at Io=800mA)



(3)Observe the following points when designing the printed circuit board pattern layout.

- Make the Vcc and ground lines as wide and as short as possible to lower the wiring inductance.
- Insert bypass capacitors between Vcc and ground mounted as close as possible to the IC.
- Resistors of about 10KΩ must be inserted between the CPU output ports and the IN1 to IN4 pins if the microcontroller and the LB1948MC are mounted on different printed circuit boards and the ground potentials differ significantly.

Operation principal

- Full-Step Drive
  Motor advances 90 degree by inputting 1 step.

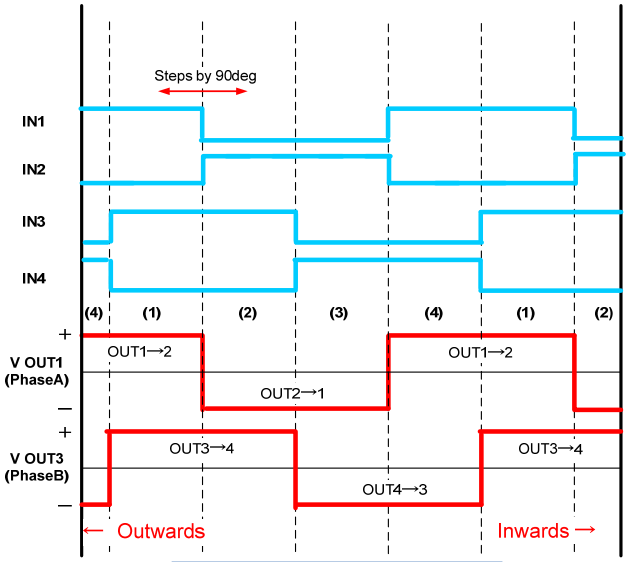


Figure 1. Full-Step Timing

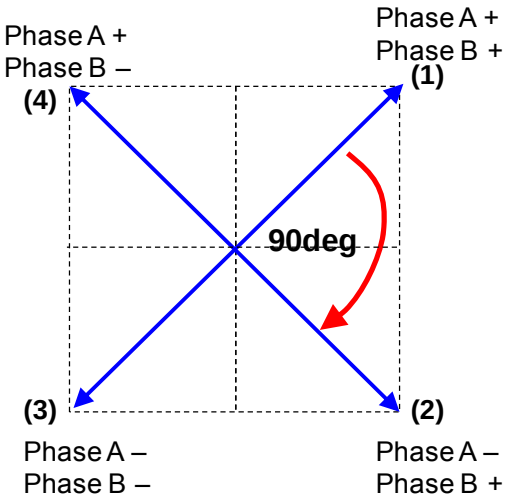


Figure 2. Motor electric angle
(Full Step Drive)

- Half-Step Drive
  Motor advances 45 degree by inputting 1 step.

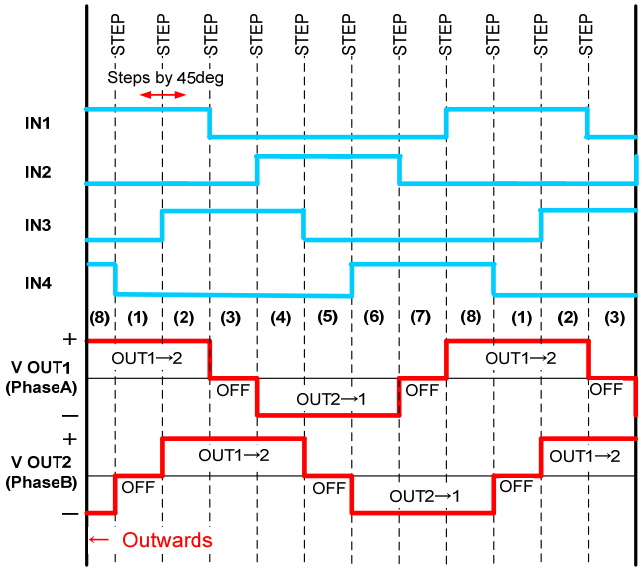


Figure 3. Half-Step Timing

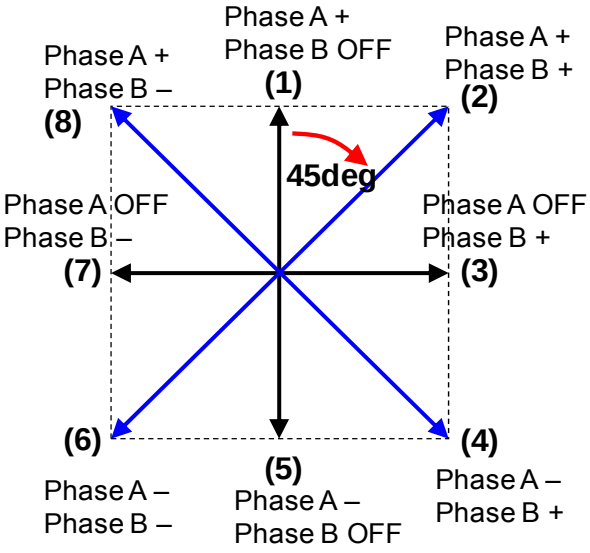
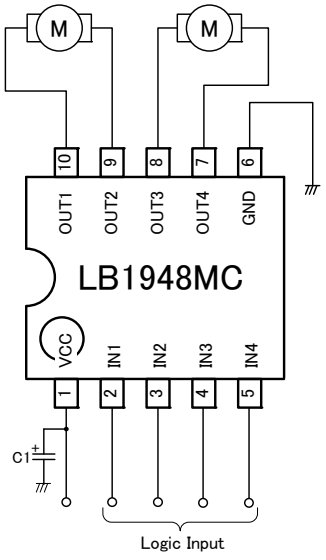


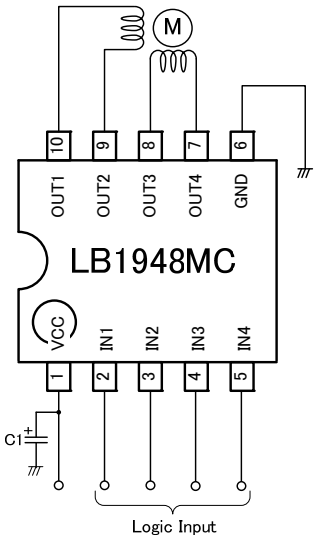
Figure 4. Motor electric angle
(Half Step Drive)

Application Circuit Example

1. Example of applied circuit when two DC motor driving

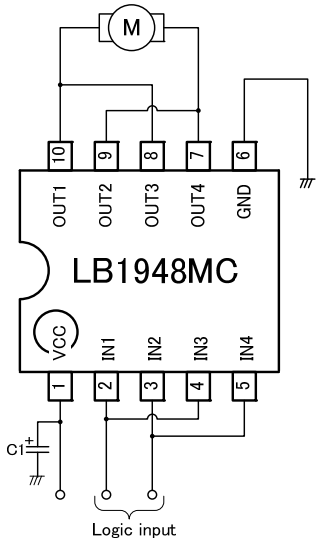


2. Example of applied circuit when one stepping motor driving



3. Example of applied circuit when connecting it in parallel

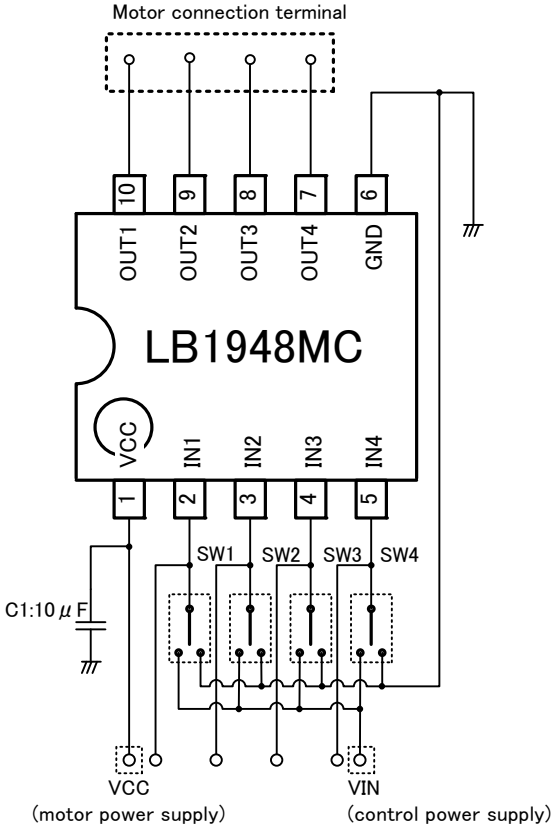
The use likened to H-Bridge 1ch is shown possible in the figure below by connecting IN1 with IN3, IN2 with IN4, OUT1 with OUT3, and OUT2 with OUT4. (I_O max = 1.6A, Upper and lower total Vo(sat)=0.6V(typ) at Io=800mA)



* Bypass capacitor (C1) connected between V_{CC}-GND of all examples of applied circuit recommends the electric field capacitor of 0.1μA to 10μA.
Confirm there is no problem in operation in the state of the motor load including the temperature property about the value of the capacitor.
Mount the position where the capacitor is mounted on nearest IC.

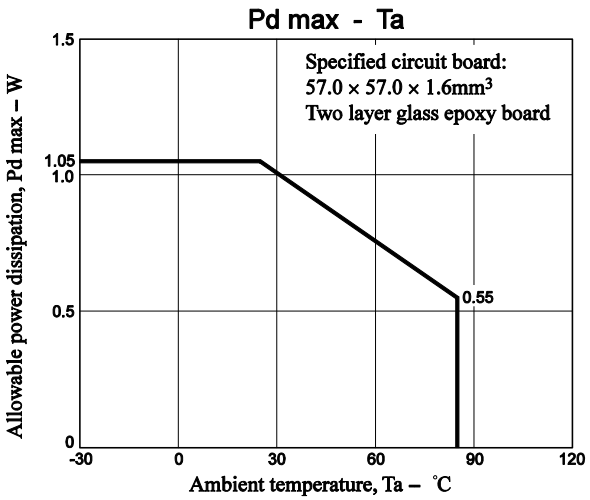
Evaluation Board Manual

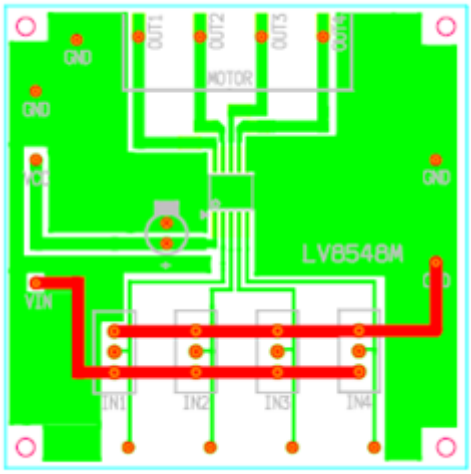
1. Evaluation Board circuit diagram



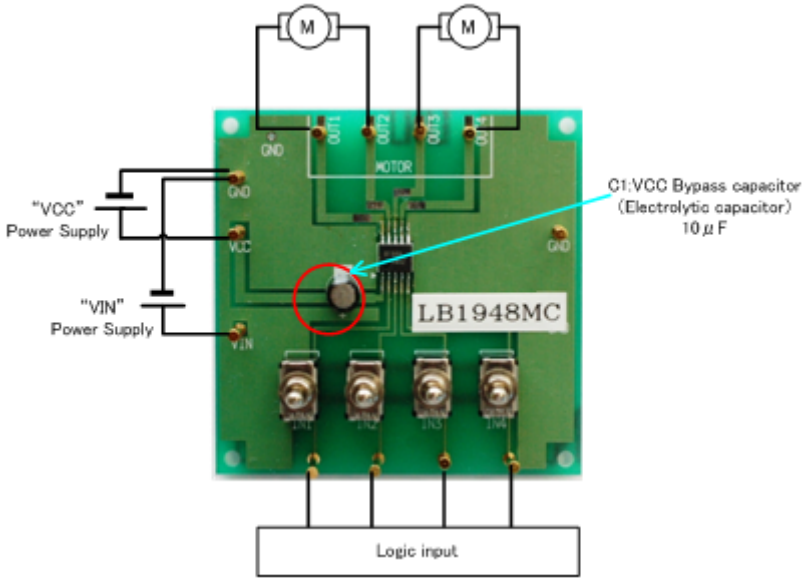
Bill of Materials for LB1948MC Evaluation Board

Designator	Qty	Description	Value	Tol	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free
IC1	1	Motor Driver			MFP10SK (225mil)	ON Semiconductor	LB1948MC	No	Yes
C1	1	VCC Bypass capacitor	10μF 50V	±20%		SUN Electronic Industries	50ME10HC	Yes	Yes
SW1-SW4	4	Switch				MIYAMA	MS-621-A01	Yes	Yes
TP1-TP12	12	Test points				MAC8	ST-1-3	Yes	Yes





2. Two DC motor drive



- Connect OUT1 and OUT2, OUT3 and OUT4 to a DC motor each.
- Connect the motor power supply with the terminal VCC, the control power supply with the terminal VIN. Connect the GND line with the terminal GND.
- DC motor becomes the predetermined output state corresponding to the input state by inputting a signal such as the following truth value table into IN1~IN4.
- See the table in p.6 for further information on input logic.

When you drive DC motor with LB1948MC, caution is required to switch motor rotation from forward to reverse because when doing so, electromotive force (EMF) is generated and in some cases, current can exceed the ratings which may lead to the destruction and malfunction of the IC .
Coil current (Iout) for each operation is obtained as follows when switching motor rotation from forward to reverse.

- Starting up motor operation
  Coil current Iout = (VCC – EMF) / coil resistance
  At startup, Iout is high because EMF is 0. As the motor starts to rotate, EMF becomes higher and Iout becomes lower.
- When switching motor rotation from forward to reverse:
  Coil current Iout = (VCC + EMF) / coil resistance
  When EMF is nearly equal to VCC at a max, make sure that the current does not exceed Iomax since a current which is about double the startup current may flow at reverse brake.
- Short brake:
  Coil current: Iout = EMF / coil resistance
  Since EMF is 0 when the rotation of motor stops, Iout is 0 as well.

When you switch motor rotation form forward to reverse, if Iout is higher than Iomax, you can operate short brake mode between forward and reverse either to slow down or stop the motor.

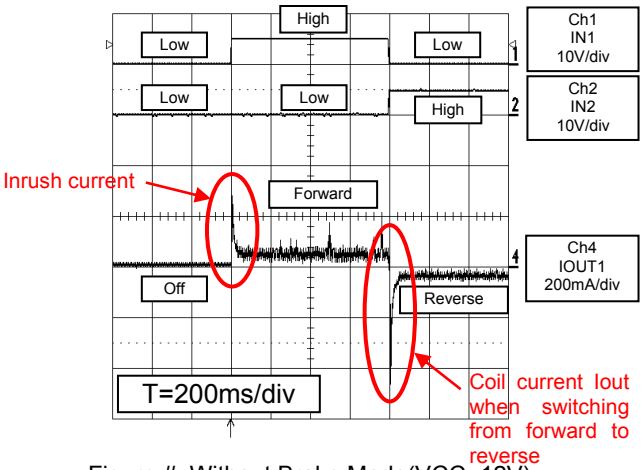


Figure # Without Brake Mode(VCC=12V)

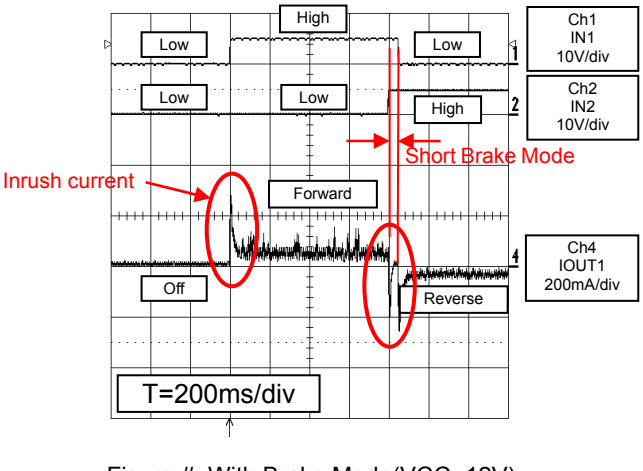
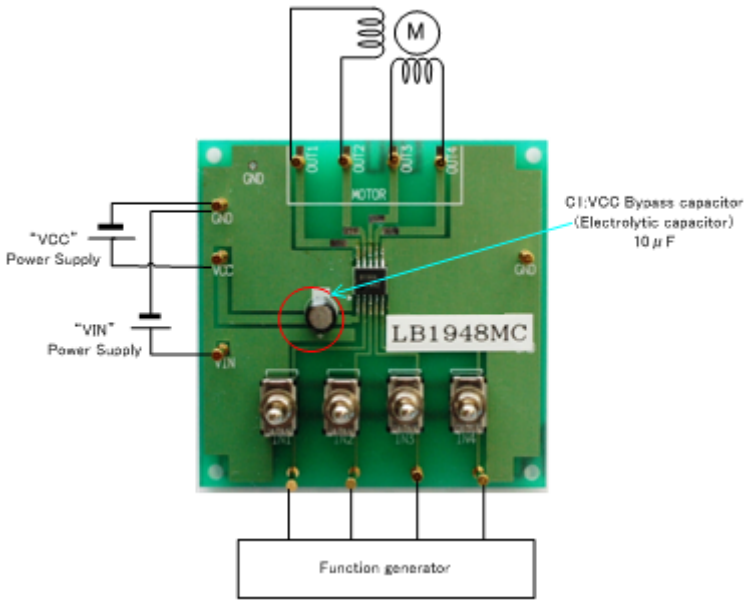


Figure # With Brake Mode(VCC=12V)

3. One stepping motor drive

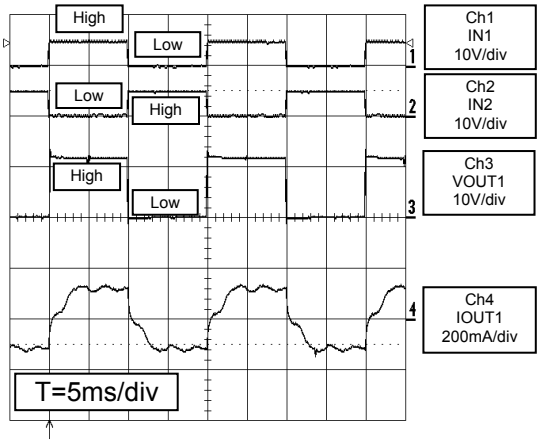


- Connect a stepping motor with OUT1, OUT2, OUT3 and OUT4.
- Connect the motor power supply with the terminal VCC, the control power supply with the terminal VIN. Connect the GND line with the terminal GND.
- STP motor drives it in a Full-Step, Half-Step by inputting a signal such as follows into IN1~IN4.
- For input signal to function generator, refer to p.8.
  To reverse motor rotation, make sure to input signal to outward direction.

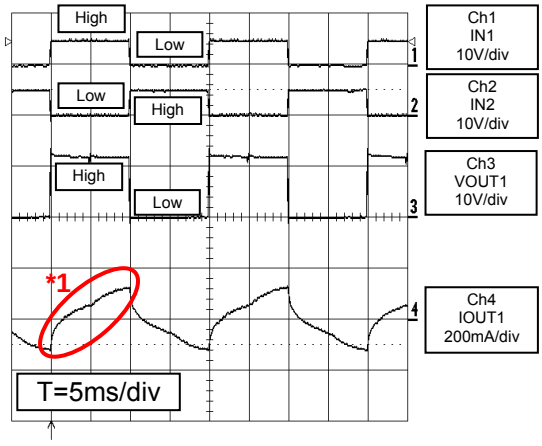
Waveform of LB1948MC evaluation board when driving stepping motor

- Full-Step Drive

LB1948MC Full-Step(VCC=12V, 200pps)



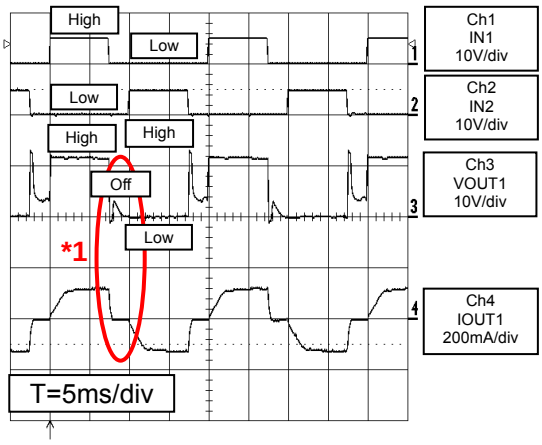
LB1948MC Full-Step(VCC=12V, 500pps)



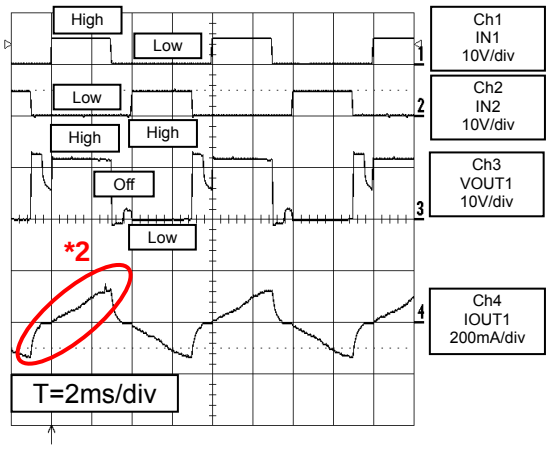
*1. When the motor rotation is at a high speed, current gradient increases by the inductance of motor (L).

- Half-Step Drive

LB1948MC Half-Step(VCC=12V, 200pps)



LB1948MC Half-Step(VCC=12V, 500pps)



*1.With Half-Step mode, voltage kick-back and electromotive force occur in current OFF period.
*2.When the motor rotation is at a high speed, current gradient increases by inductance of motor (L).