# LB1843V

**Monolithic Digital IC**

# Low-saturation, current-controlled bidirectional motor driver Application Note

**ON Semiconductor®**

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## Overview

The LB1843V is a low-saturation bidirectional motor driver with output current limitation and detection functions. This design is ideal for controlling the loading motor in a video camera.

## Function

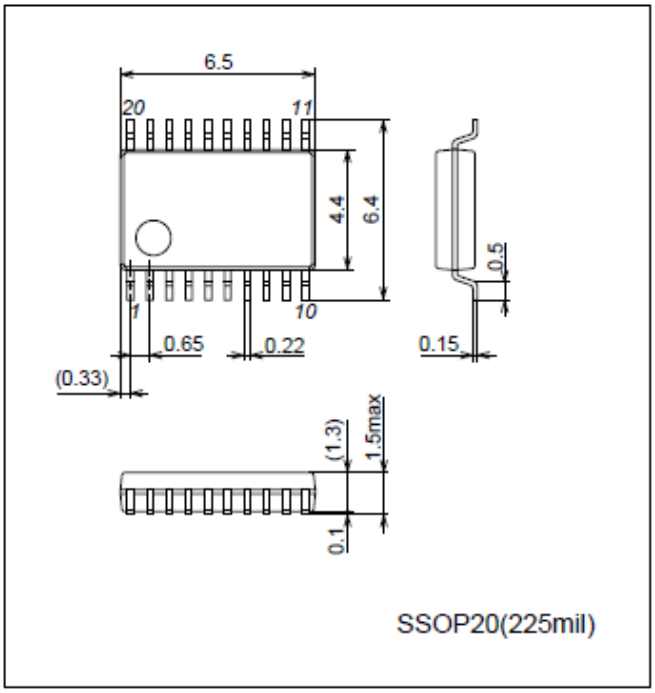
- Output current limiter and detector built in.
- Low-saturation voltage bidirectional bridge circuit built in: VOsat = 0.40 V typ. at 400 mA.
- Practically no current drain (0.1 μA or less) in standby mode.
- Input-linked reference voltage built in . Thermal shutdown circuit built in.
- Requires little space, since few external components are needed and the IC is contained in a small SSOP-20 package

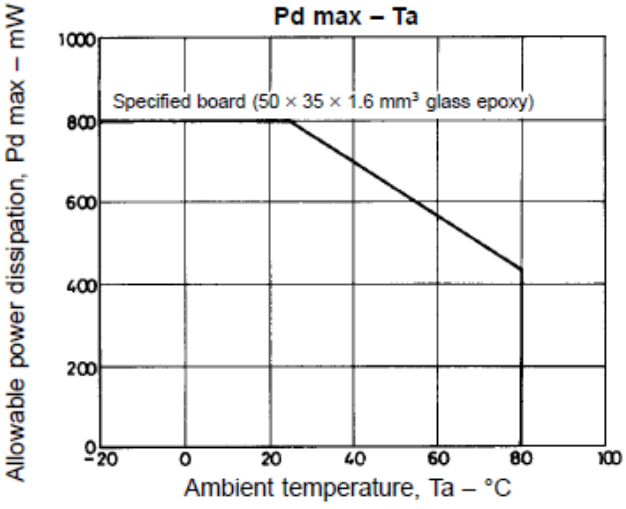
## Typical Applications

- Toy
- Portable Printer
- Battery Operated Devices
- Camera
- Scanner

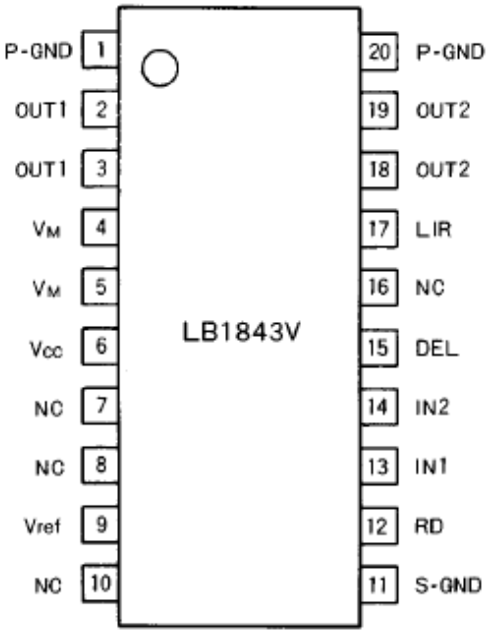
## Package Dimensions

unit : mm (typ)



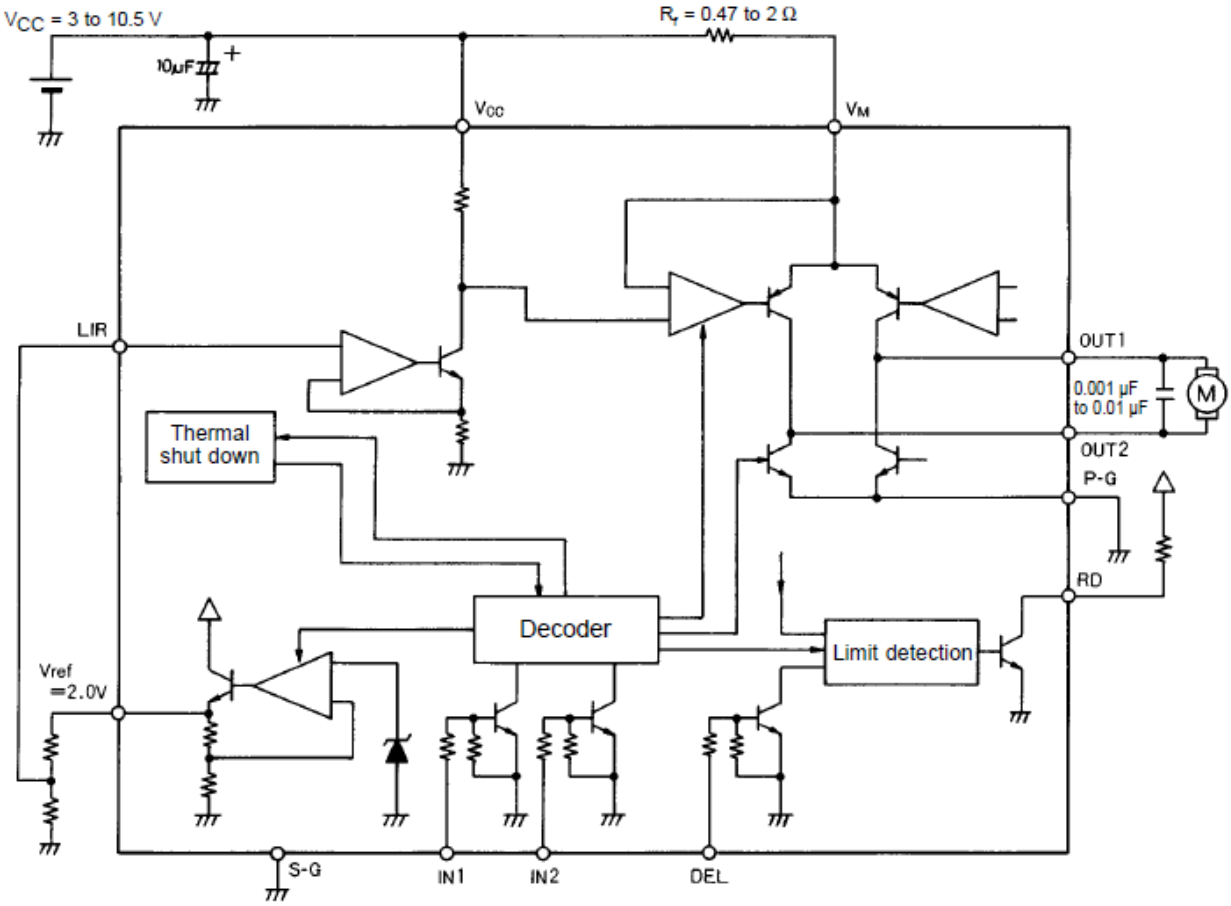
## Pin Assignment




Top view

Notes:
- Connect both $V_M$ pins (motor power supply/sensing pins).
- Connect both P-GND pins (motor power supply GND pins).
- Connect S-GND (control power supply GND pin) to the microcontroller's GND.

## Application Circuit Example



**Cautions:**

$V_{CC}$ and P-GND lines suffer substantial fluctuation in the current quantity, causing a problem of line oscillation in certain cases. In this case, take following points into account:

(1) Use a thick and short wiring to reduce the wiring inductance.

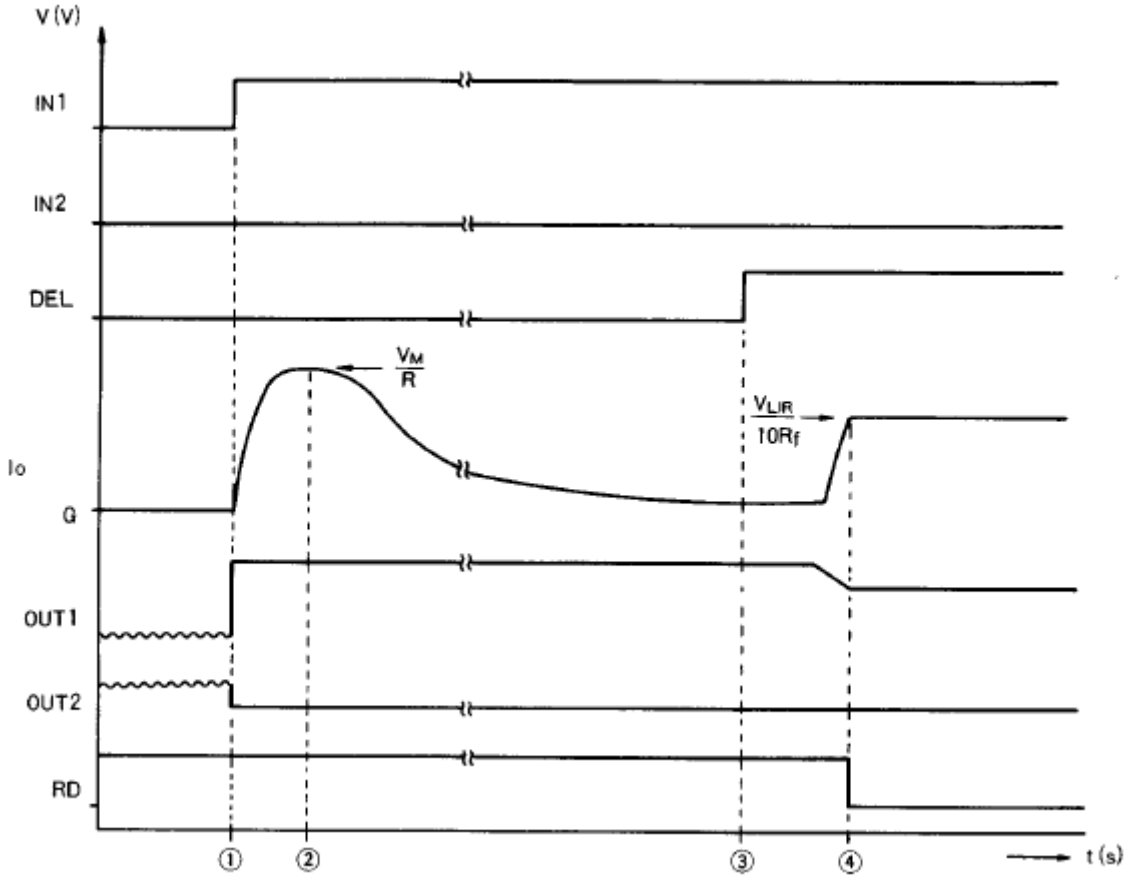
(2) Insert a capacitor with satisfactory frequency characteristics near IC.

*) Electrostatic capacitor (10uF) is used to stabilize power. Requirement for capacitance value varies depends on substrate wiring, motor, and power. The recommendation range of the capacitor is approximately 0.1μF to 10μF.

Please check supply voltage waveform when motor is under operation and use a capacitor for stable operation.

(3) Connect S-GND to the control system GND on the CPU side and P-GND to the power system GND.

**Sample Application Timing Chart**




**Sample application timing chart**

1) Connect a DC motor (RL = R) between OUT1 and OUT2, and with the RD pin pulled up, input a forward rotation signal (IN1 = high, IN2 = low).
   Because the output is used in the saturated state at startup, set the DEL input to low.
2) The DC motor starts up, and the startup current (IST = VM/R) flows to the motor.
3) The DC motor rotates in the normal state. At this point, set the DEL input to high.
4) If the DC motor locks, the motor current IM increases to the point of Ilimit (= VLIR/(10Rf)), the output current limiter operates to limit the output current. At the same time, RD is output low from the set current detection circuit.

**Reference voltage (Vref)**

The Vref output is linked to the input; if either IN1 or IN2 is high, the reference voltage is output.

**Output current limiter**

The schematic for the output current limiter is shown below.

The output set current is set according to the reference voltage VLIR applied to the LIR pin. When VLIR is applied, 1/10 of that voltage is generated at both ends of RS in the diagram; this voltage is input on the positive (+) side of the current setting amplifier.

The motor current IM generates voltage equal to (IM ´ Rf) at both ends of the external resistor Rf. This voltage is input to the negative (–) side of the same amplifier, and the differential amplifier functions and the output transistors are driven so that these inputs become equal.

The set current value in this instance is determined by the following equation:

Ilimit = VLIR/(10Rf) [A]

**Set current detector**

(1) When DEL = high

If the motor current IM has not reached the set current Ilimit, the input voltage on the negative (–) side of the amplifier is greater than the input voltage on the positive (+) side. As a result, the drive current increases and the output PNP transistors reach the saturation state. If this state is detected, the detection signal is sent to the set current detector, and the RD output goes high.

If the motor current IM reaches the set current Ilimit, the output PNP transistor enters the controlled state, and the RD output goes low.

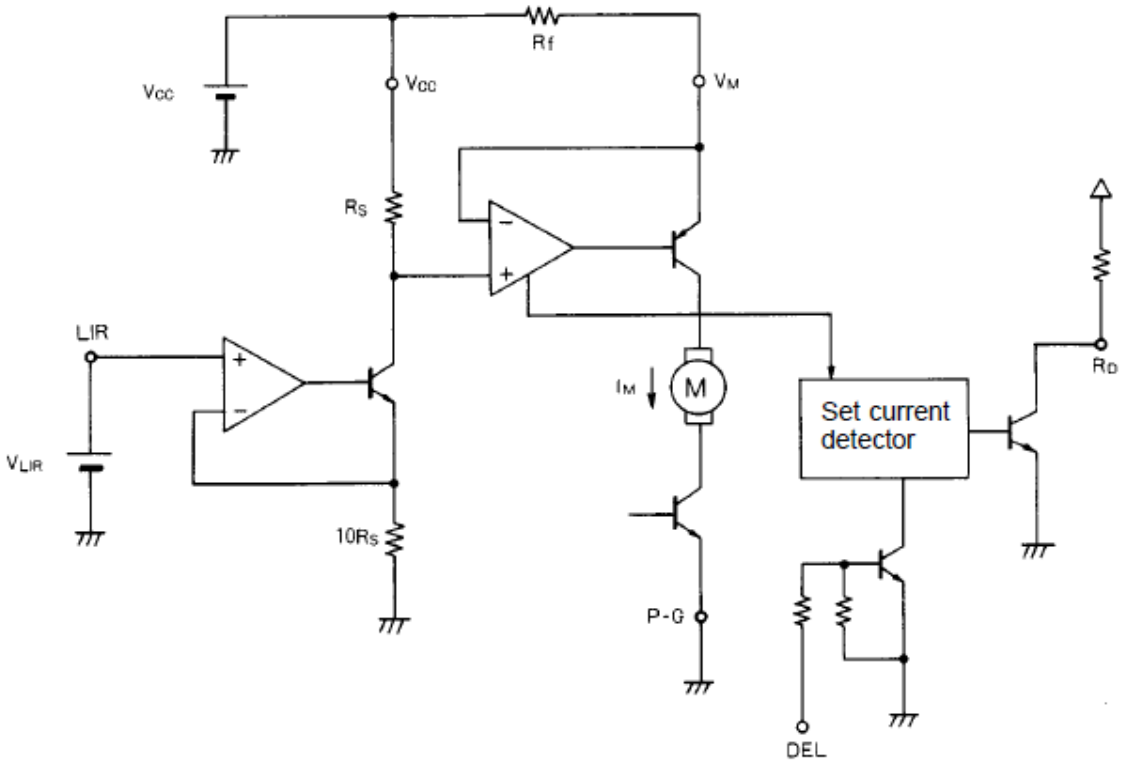
(2) When DEL = low

Because the operation of the current setting amplifier is cancelled when a low signal is input to the DEL pin, the output PNP transistors reach the saturation state and the RD output goes high, just as in the case described above.

The following table summarizes the states described above.

| DEL | OUT output | RD |
|---|---|---|
| H | Limit | L |
| | Non-limit | Off |
| L | Saturated | Off |

**Output Current Limiter and Set Current Detector Block Diagram**



## Specifications

### Absolute Maximum Ratings at Ta = 25°C

| Parameter | Symbol | Conditions | Ratings | Unit |
|---|---|---|---|---|
| Maximum supply voltage | $V_{CC}$ max | | 10.5 | V |
| Output current | $I_m$ max | | 800 | mA |
| Applied input voltage | $V_{IN}$ | | -0.3 to +10 | V |
| Allowable power dissipation | Pd max | With board (50x35x1.6mm) | 800 | mW |
| Operating temperature | Topr | | -20 to +80 | °C |
| Storage temperature | Tstg | | -40 to +150 | °C |

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 those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

### Recommended Operating Conditions at Ta = 25°C

| Parameter | Symbol | Conditions | Ratings | | | Unit |
|---|---|---|---|---|---|---|
| | | | min | typ | max | |
| Supply voltage | $V_{CC}$ | | 3.0 | | 9.0 | V |
| $V_M$ voltage | $V_M$ | | 2.2 | | $V_{CC}$ | V |
| High-level input voltage | $V_{IH}$ | | 3.0 | | 9.0 | V |
| Low-level input voltage | $V_{IL}$ | | -0.3 | | +0.7 | V |
| LIR input voltage | $V_{LIR}$ | | 0.5 | | $V_{CC}$-1.0 | V |
| Output current limitation | I limit | | 50 | | 350 | mA |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

### Electrical Characteristics at Ta = 25°C, $V_{CC}$ = 7.2V

| Parameter | Symbol | Conditions | Ratings | | | Unit |
|---|---|---|---|---|---|---|
| | | | min | typ | max | |
| Supply current | $I_{CC}0$ | During standby | | 0.1 | 10 | μA |
| | $I_{CC}1$ | During bidirectional operation, no load | | 9 | 13 | mA |
| | $I_{CC}2$ | During braking | | 12 | 18 | mA |
| Output saturation voltage (upper side + lower side) | Vsat1 | $I_O$ = 200mA | | 0.20 | 0.30 | V |
| | Vsat2 | $I_O$ = 400mA | | 0.40 | 0.60 | V |
| Reference voltage | Vref | Ivref = 1mA | 1.85 | 2.0 | 2.15 | V |
| Set output current | I limit | Resistance between $V_{CC}$ and $V_M$=1Ω, When LIR=2V | 165 | 185 | 205 | mA |
| Input current | $I_{IN}$ | $V_{IN}$ = 5V | | 90 | 150 | μA |
| RD saturation voltage | $V_{RD}$sat | $I_O$ = 1mA | | | 0.3 | V |

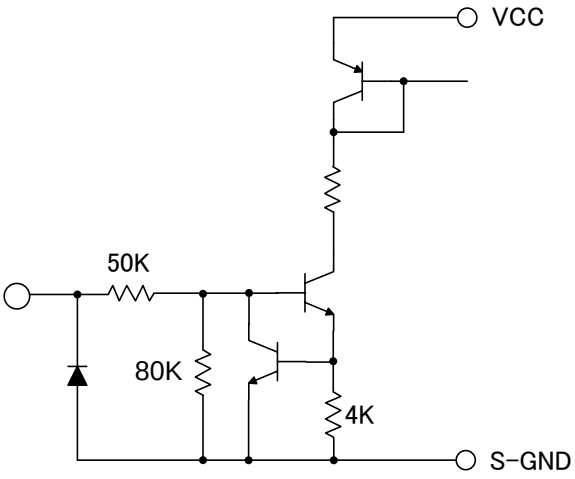
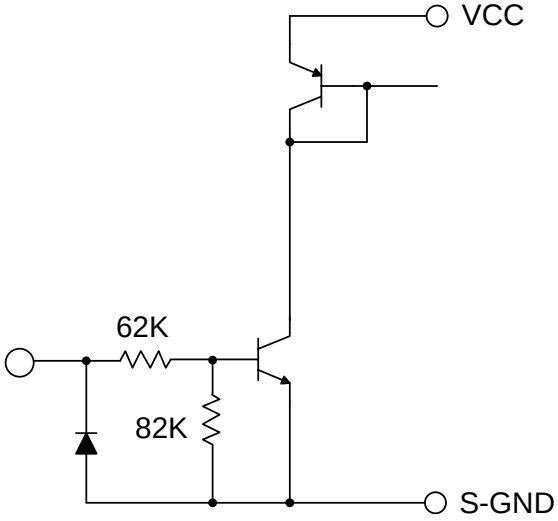
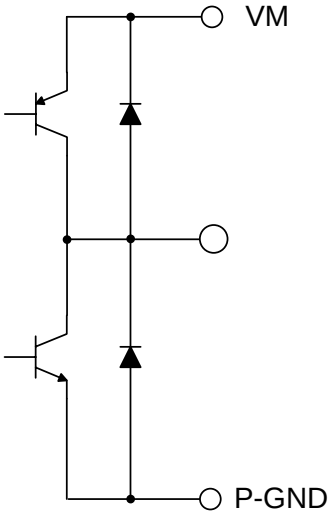
Output current limit is determined by the following equation (Rf is the sensing resistance between $V_{CC}$ and $V_M$):

I limit = $V_{LIR}$ / 10Rf (A)

The input range for $V_{LIR}$ is 0.5 to $V_{CC}$ – 1.0(V)

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

## Pin Functions

| Pin No. | Pin name | Pin Function | Equivalent Circuit |
|---|---|---|---|
| 13<br>14 | IN1<br>IN2 | Control signal input pin<br>Control signal input pin |  |
| 15 | DEL | Control signal input pin |  |
| 4,5<br>2,3<br>18,19 | VM<br>OUT1<br>OUT2 | Output current detect pin<br>Out pin<br>Out pin |  |

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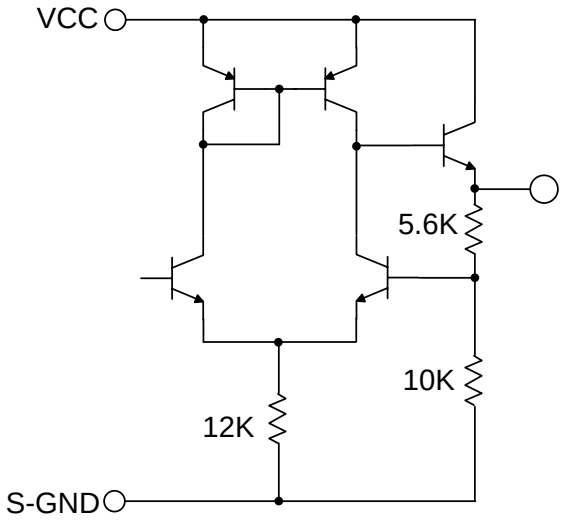
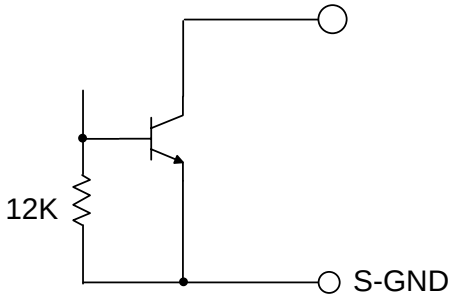
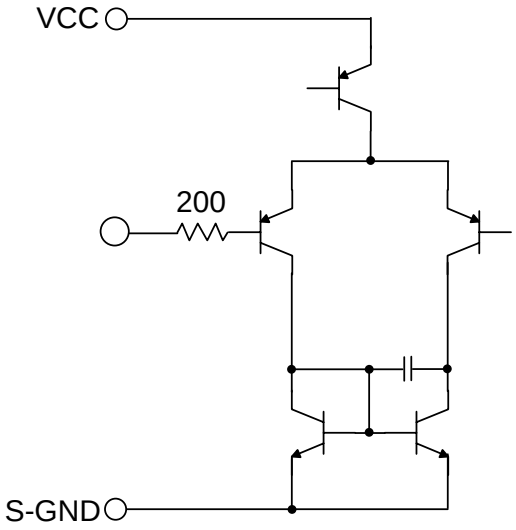
| | | | |
|---|---|---|---|
| 9 | Vref | Reference voltage output pin |  |
| 12 | RD | Lock detect signal output pin |  |
| 17 | LIR | Output current setting pin |  |
| 6 | $V_{CC}$ | Power supply voltage pin | |
| 11 | S-GND | Signal ground pin | |
| 1,20 | P-GND | Power ground pin | |
| 7,8,10,16 | NC | No connect | |

### Truth Table

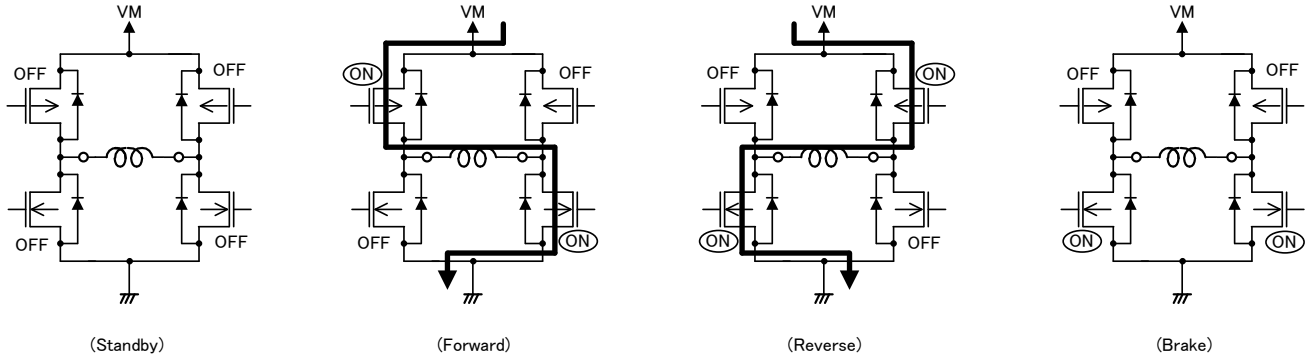
| Input | | Output | | Mode |
|---|---|---|---|---|
| IN1 | IN2 | OUT1 | OUT2 | |
| L | L | Off | Off | Standby |
| H | L | H | L | Forward |
| L | H | L | H | Reverse |
| H | H | L | L | Brake |

### Output Current Limitation and Detector Output

| DEL | OUT output | RD |
|---|---|---|
| H | Limit | L |
| | Non-limit | Off |
| L | Saturated | Off |

### Operation explanation

- Output stage transistor function




- Thermal protection function
  LB1843V incorporates thermal shutdown circuitry. When junction temperature Tj exceeds 180°C, the output current flowing between OUT1 and OUT2 is reduced; therefore, the heat generation is reduced.
  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.

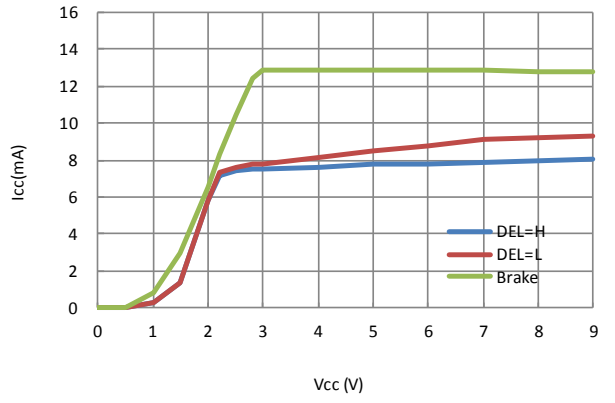



Figure 1 Icc vs Vcc (VIN=3V,LIR=Vref,Rf=0.5ohm,no load)

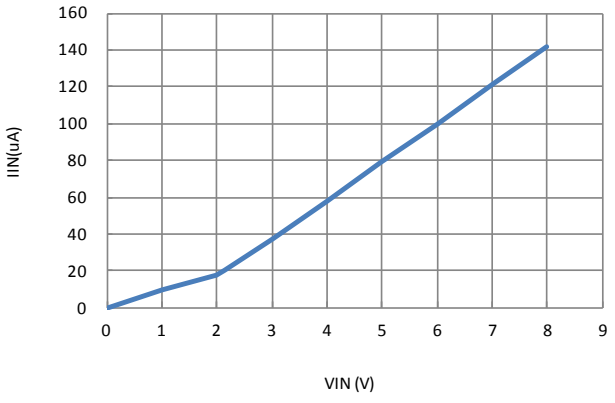



Figure 2 IIN vs VIN (Vcc=6V)

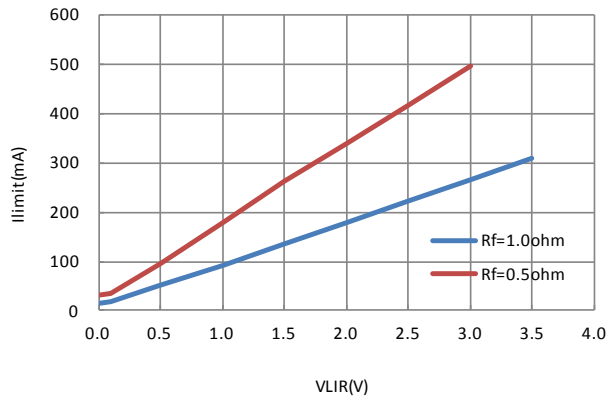



Figure 3 Ilimit vs VLIR (Vcc=6.0V,RL=10ohm)

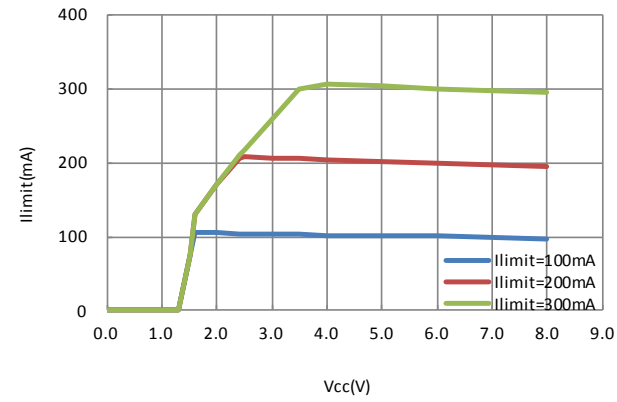



Figure 4 Ilimit vs Vcc (VIN=3V,DEL=3V,RL=10ohm,Rf=0.5ohm)

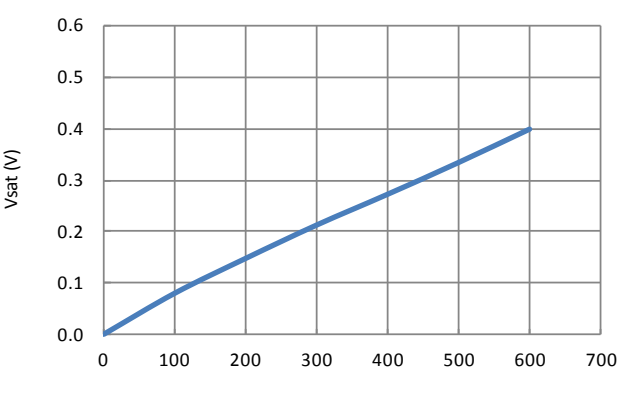



Figure 5 Vsat vs Io (Vcc=6V,VIN=3V,DEL=L,LIR=Vref)

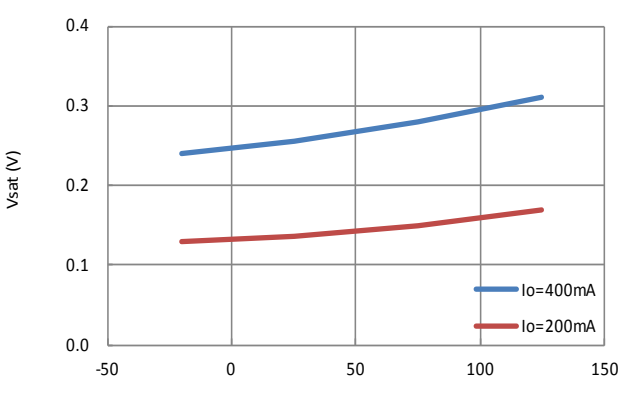



Figure 6 Vsat)vs Temperature (Vcc=6V,VIN=3V,DEL=L,LIR=Vref)

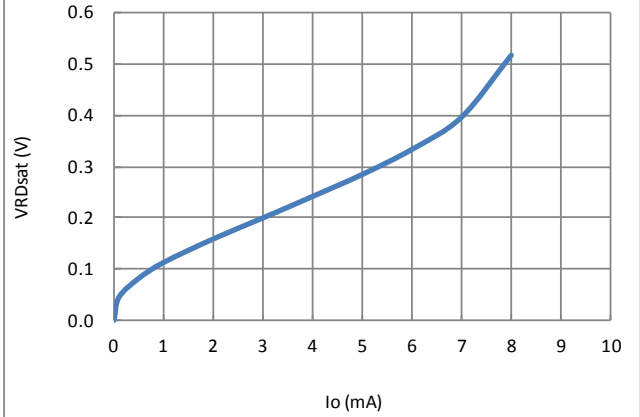



**Figure 7 VRDsat vs Io (Vcc=6V,VIN=3V,DEL=H,LIR=Vref)**

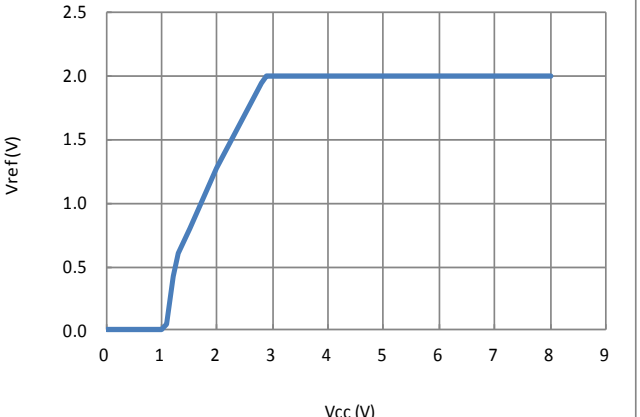
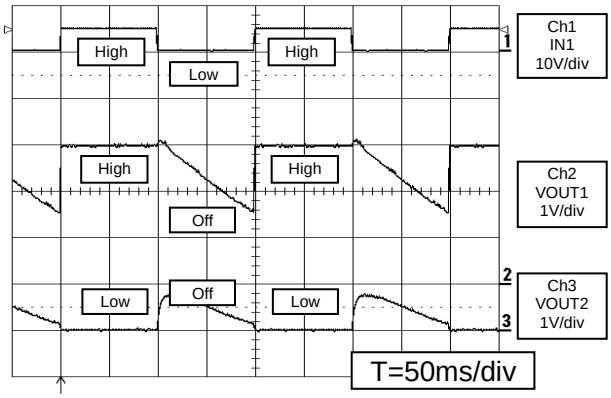



**Figure 8 Vref vs Vcc (VIN=3V)**

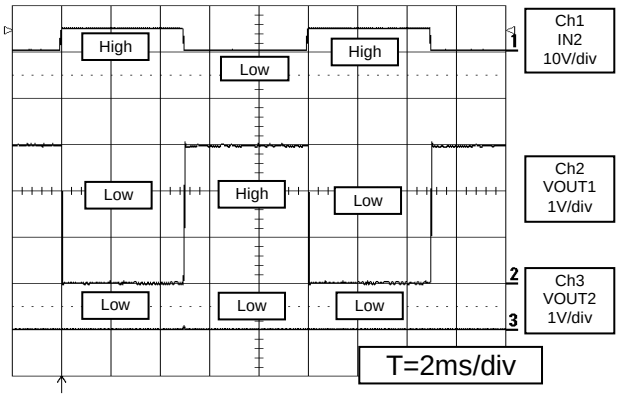
**Waveform example**

*Please refer to the following test circuit diagram 1.

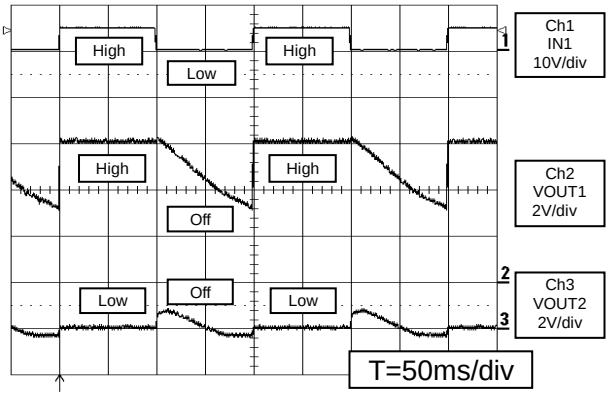
- No load VCC=3V IN2="L"



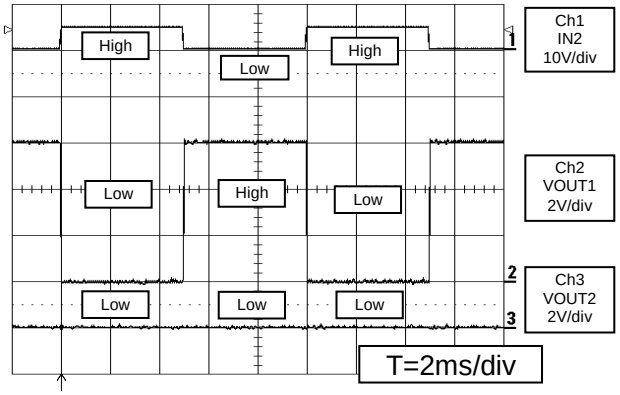

- No load VCC=3V IN1="H"




- No load VCC=6V IN2="L"

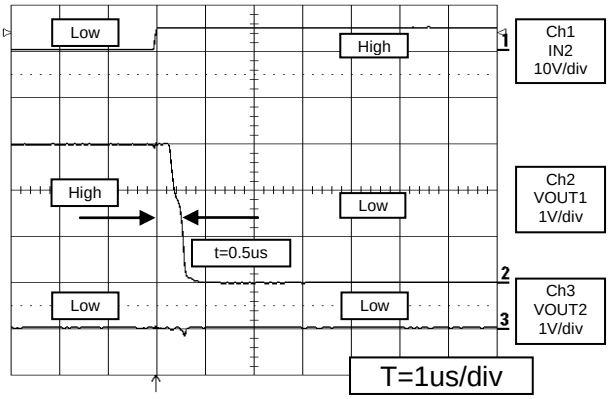



- No load VCC=6V IN1="H"



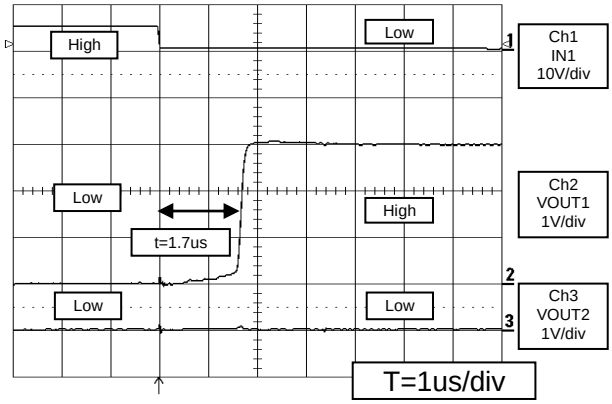

- No load VCC=3V IN1="H"

Time scale expansion "fall time"

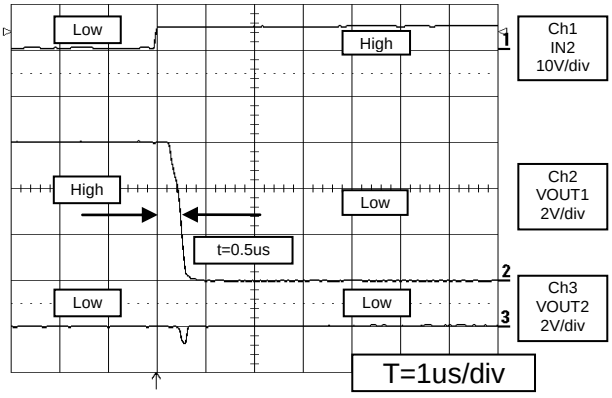



- No load VCC=3V IN1="H"

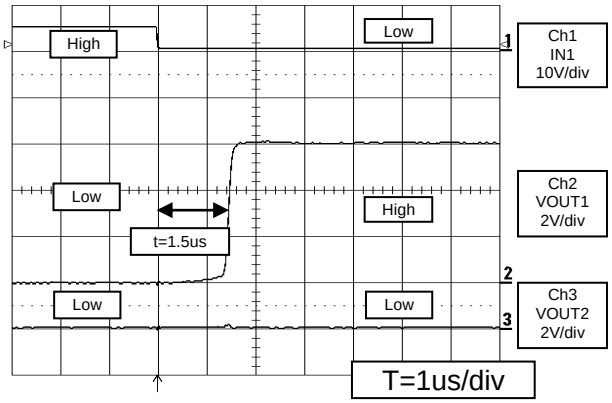
Time scale expansion "rise time"



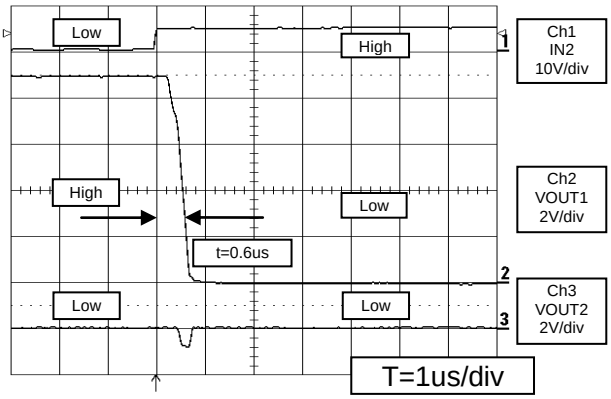
- No load VCC=6V IN1="H"
  Time scale expansion "fall time"



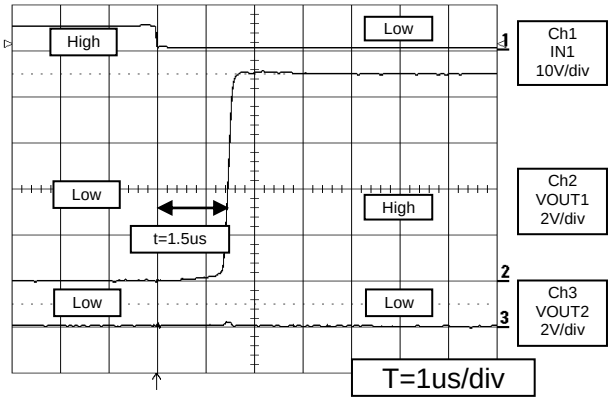

- No load VCC=6V IN1="H"
  Time scale expansion "rise time"



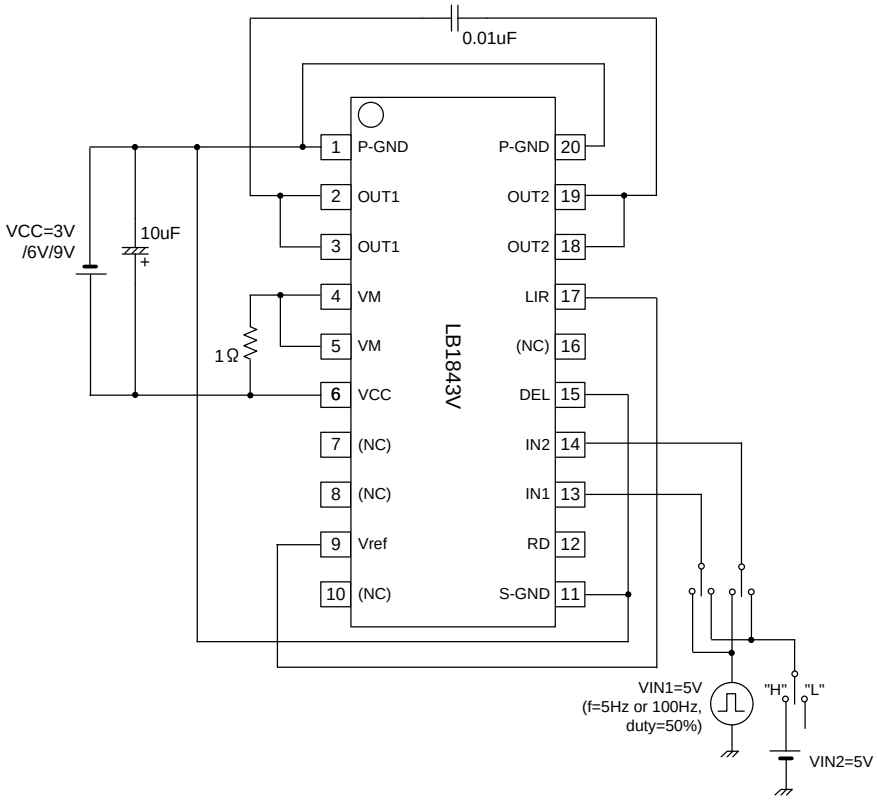

- No load VCC=9V IN1="H"
  Time scale expansion "fall time"




- No load VCC=9V IN1="H"
  Time scale expansion "rise time"

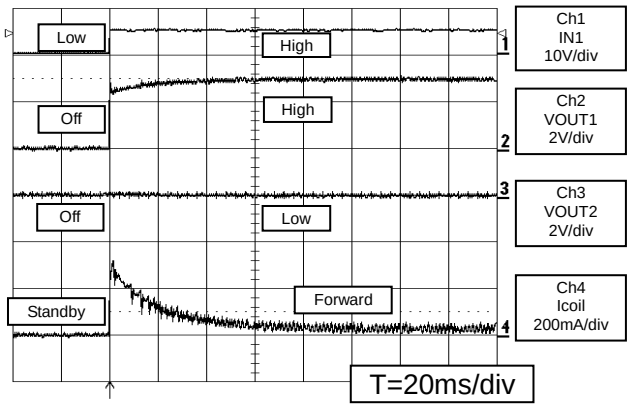



(Test circuit diagram 1)



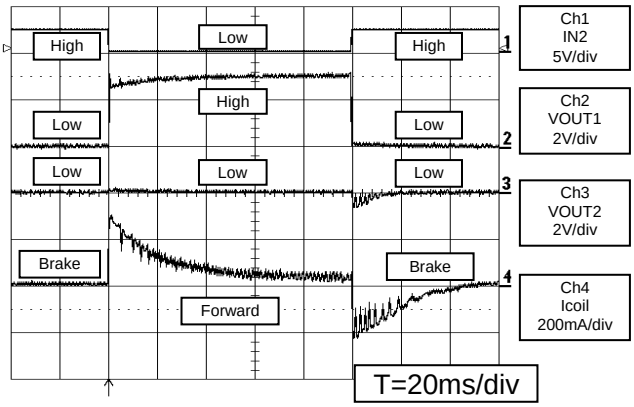
*Please refer to the following test circuit diagram 2.

- DC motor load VCC=3V IN2="L"
  Current waveform example "motor start"



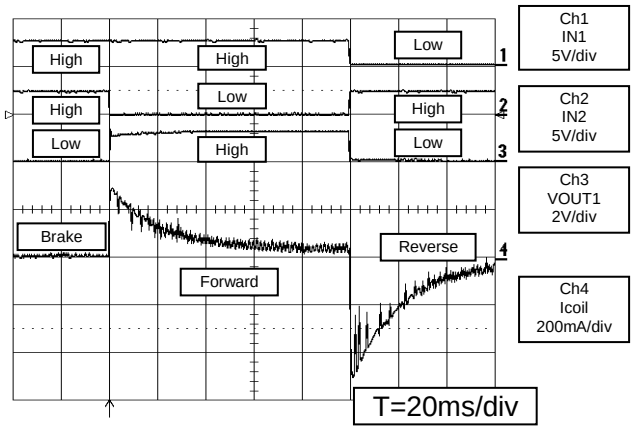

When DC motor starts up, the current value becomes high. However, rotation of DC motor starts, induced voltage Ea is generated and current decreases according to the rotation frequency.
If a coil resistance is set to Rcoil and motor voltage is set to VCC, then motor current is obtained as follows:
Im = (VCC-Ea)/Rcoil.

- DC motor load VCC=3V IN1="H"
  Current waveform example "brake current"



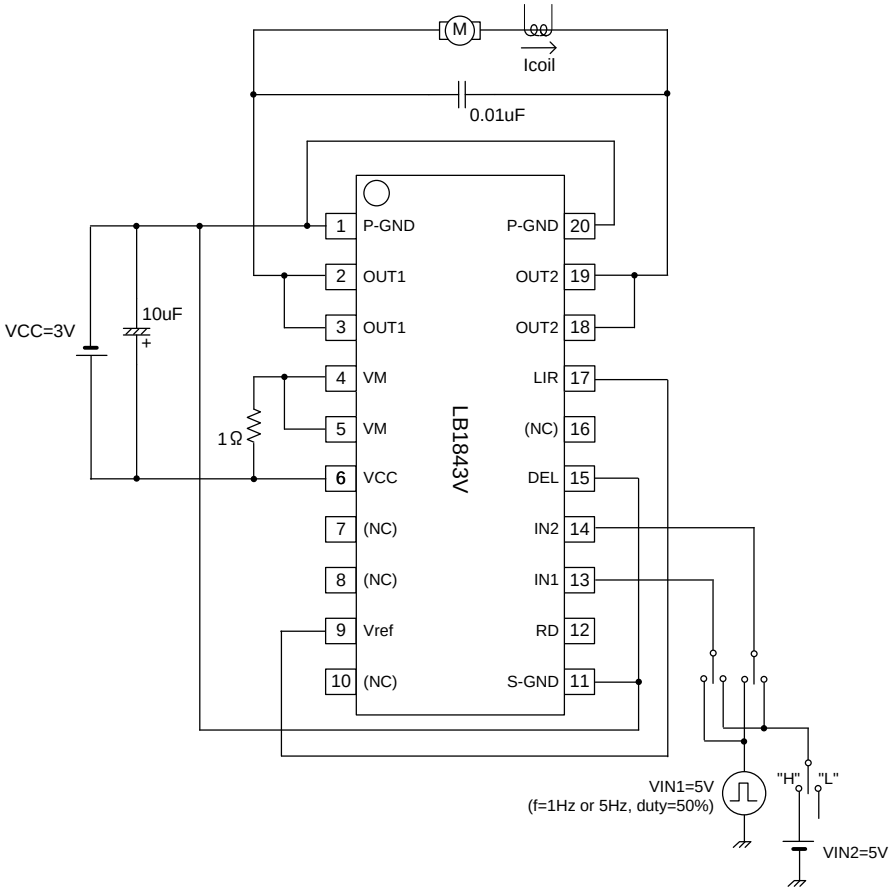

When DC motor is under rotation, if brake mode is set, then DC motor becomes short-brake status, and speed falls rapidly.
In this case, current Im (Im = Ea / Rcoil) flows to the opposite direction by the induced voltage Ea generated during motor rotation. If DC motor stops rotation, then Ea=0, and current becomes 0.

- DC motor load VCC =3V
  Current waveform example “active reverse brake current”

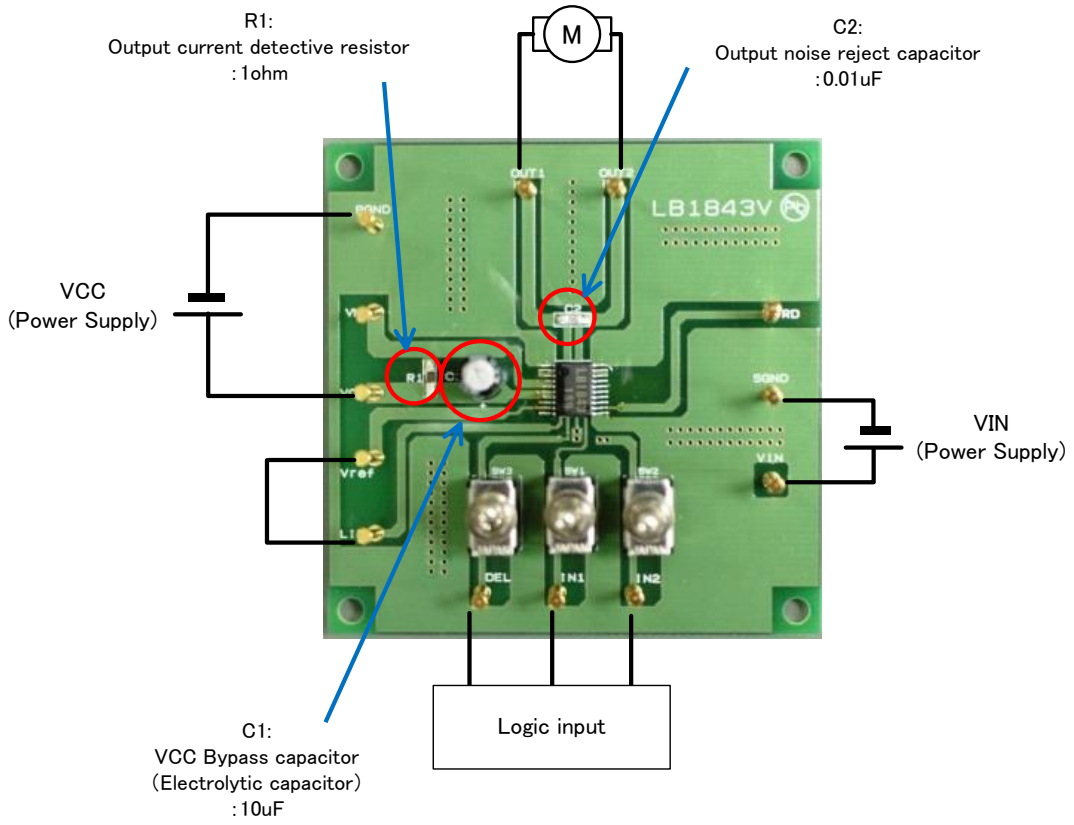



If rotation direction is switched while DC motor is rotating, then torque of reverse-rotation is generated, the speed of motor rotation becomes slow and reverse rotation is performed.
In this case, since voltage of VCC is added to induced voltage Ea generated during motor rotation, the motor current flows into the motor coil which is obtained as follows: Im= (VCC+Ea) / Rcoil.
When you switch from forward to reverse, if the current exceeds Iomax, make sure to set brake mode until the induced voltage is reduced between forward and reverse.

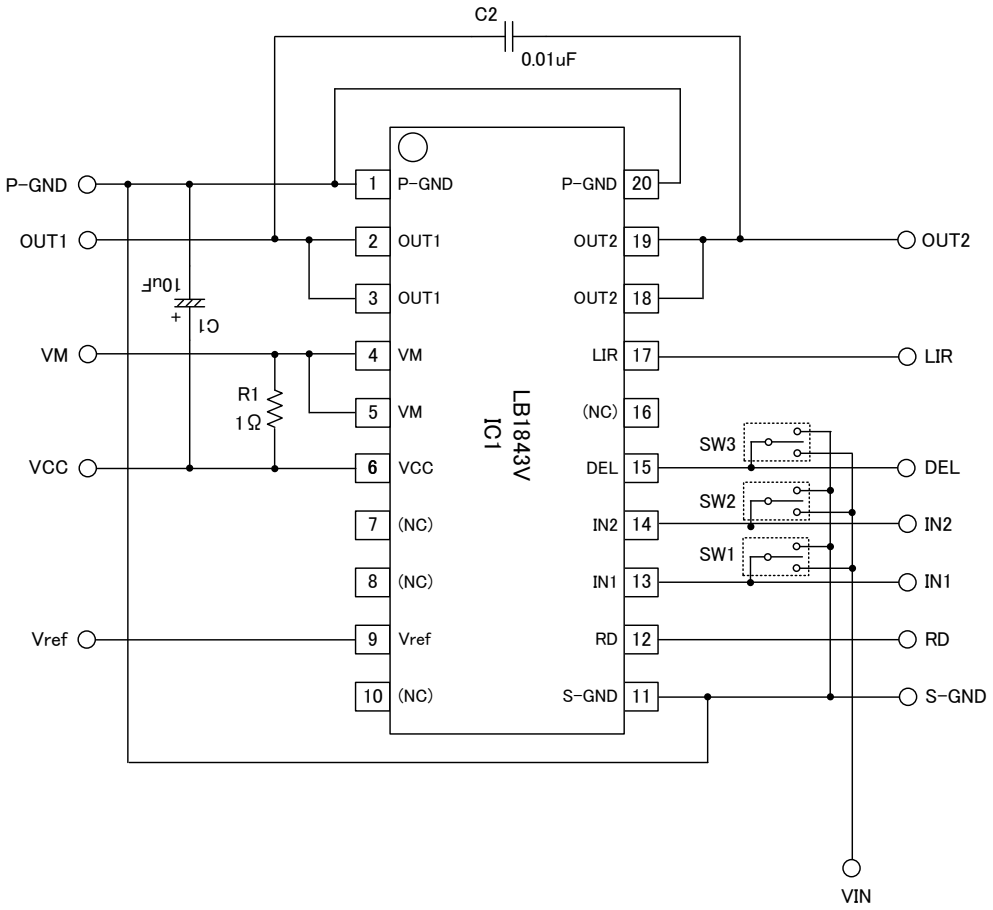
(Test circuit diagram 2)



## Evaluation board description




(Circuit diagram of the evaluation board)



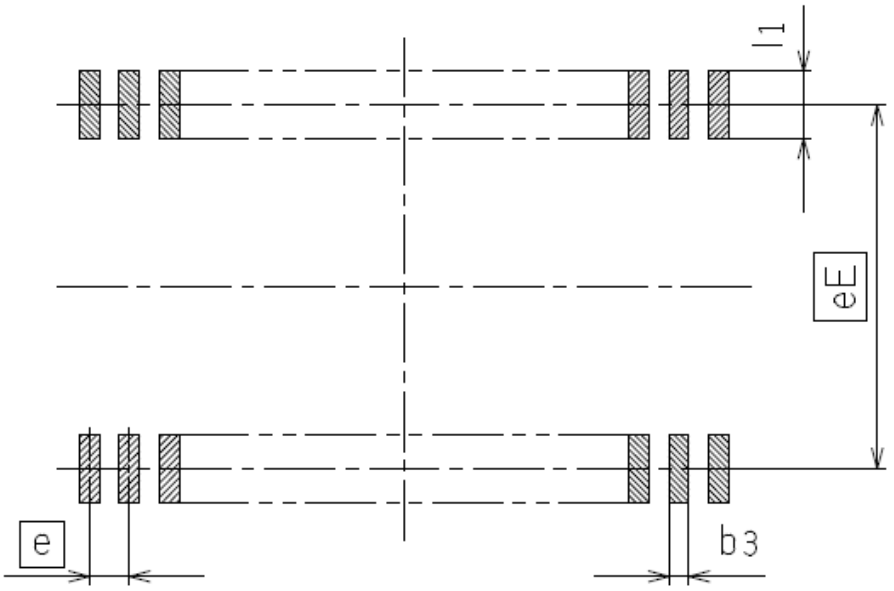

*VIN terminal is a power supply input terminal for switches.
5V are to impress it and can perform the setting that is in a state by the switch operation and logic input.

- Operation method
  Power supply injection order: VCC → VIN

- Truth value table

| Input | | Output | | Mode |
|---|---|---|---|---|
| IN1 | IN2 | OUT1 | OUT2 | |
| L | L | Off | Off | Standby |
| H | L | H | L | Forward |
| L | H | L | H | Reverse |
| H | H | L | L | Brake |

## Recommended Soldering Footprint




SSOP (Unit:mm)

| Reference symbol | Packages name | | | |
|---|---|---|---|---|
| | SSOP16/20(225mil) | SSOP18(225mil) | SSOP20J/24/30(225mil) | |
| eE | 5.80 | 5.80 | 5.80 | |
| e | 0.65 | 0.80 | 0.50 | |
| $b_3$ | 0.32 | 0.42 | 0.32 | |
| $l_1$ | 1.00 | 1.00 | 1.00 | |
| | | | | |