# Reversible motor driver

## BA6950FS

The BA6950FS is a reversible-motor driver suited for brush motors. Two logic inputs allow four output modes: forward, reverse, stop (standby), and brake. The rotational speed of motor can be set arbitrarily by changing the voltage applied to the motor with control pins. The IC can also drive a motor at a constant speed by using a built-in current feedback amplifier.

●Applications

VCRs, audio equipment

●Features

1) Two logic inputs allow four output modes: forward, reverse, stop (standby), and brake.
2) Motor speed variable with voltage control signals.
3) Built-in current feedback amplifier allows constant motor speed.
4) Control gain can be set arbitrarily by using external resistors.
5) Built-in thermal shutdown circuit.

●Absolute maximum ratings (Ta = 25°C)

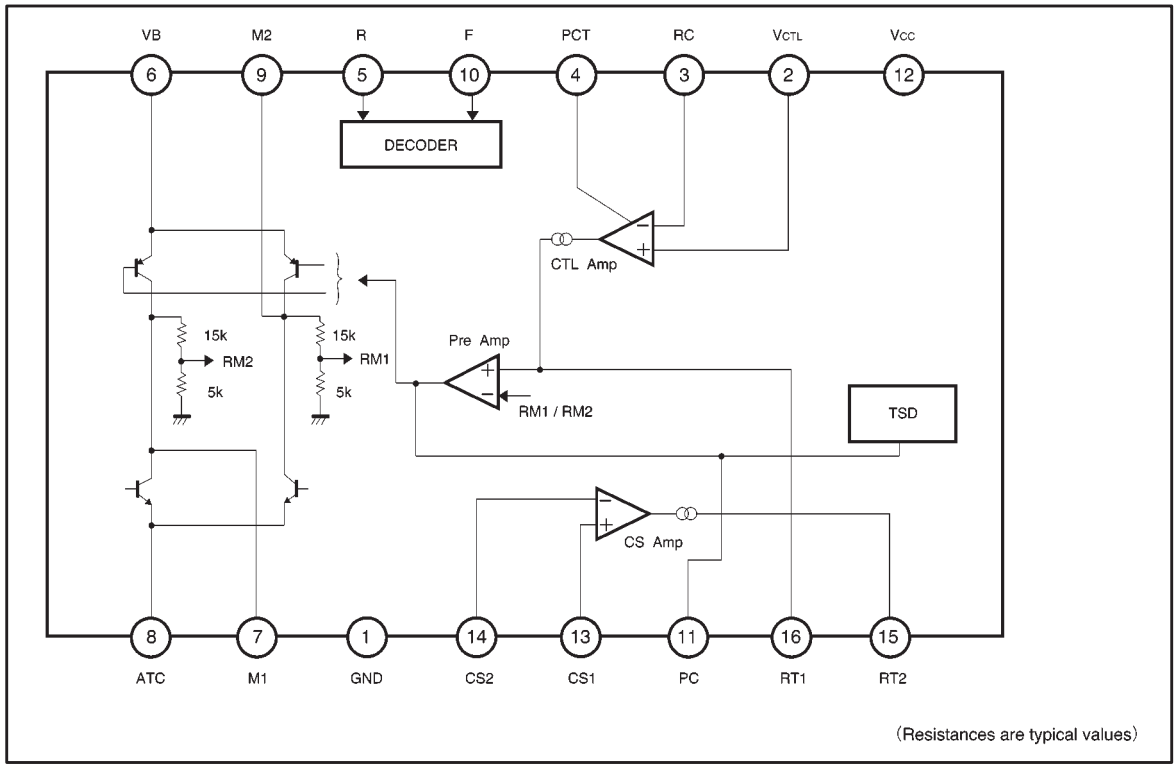
| Parameter | Symbol | Limits | Unit |
|---|---|---|---|
| Applied voltage | $V_{CC}$ | 8 | V |
| Applied voltage | VB | 18 | V |
| Power dissipation | Pd | 800*1 | mW |
| Operating temperature | Topr | −20～+75 | ℃ |
| Storage temperature | Tstg | −55～+150 | ℃ |
| Output current | $I_{OUT}$ | 400*2 | mA |

*1 When mounted on a glass epoxy board (90 × 50 × 1.6 mm).
Reduced by 6.4 mW for each increase in Ta of 1 ℃ over 25℃.
*2 Should not exceed Pd or ASO values.

●Recommended operating conditions (Ta = 25°C)

| Parameter | Symbol | Range | Unit |
|---|---|---|---|
| Oprating power supply voltage | $V_{CC}$ | 3～6 | V |
| | VB | 3～16 | V |
| | $V_{CTL}$ | 0～($V_{CC}$−1.8V) | V |

●Block diagram




●Pin descriptions

| Pin No. | Pin name | Function |
|---|---|---|
| 1 | GND | GND |
| 2 | $V_{CTL}$ | Control signal input |
| 3 | RC | Resistor connection for control gain setting |
| 4 | PCT | Capacitor connection for control phase compensation |
| 5 | $R_{IN}$ | Logic input |
| 6 | VB | Driver power supply |
| 7 | M1 | Motor output |
| 8 | ATC | Resistor connection for output current detection |
| 9 | M2 | Motor output |
| 10 | $F_{IN}$ | Logic input |
| 11 | PC | Capacitor connection for current feedback phase compensation |
| 12 | $V_{CC}$ | Signal power supply |
| 13 | CS1 | Resistor connection for CSAMP gain setting |
| 14 | CS2 | Resistor connection for CSAMP gain setting |
| 15 | RT2 | Resistor connection for control gain setting |
| 16 | RT1 | Resistor connection for control gain setting |

●Input/output circuit (resistances, in Ω, are typical values)

(1) R and F inputs (pins 5 and 10)

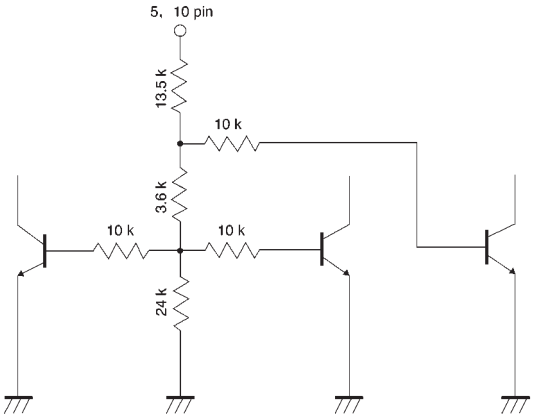



Fig.1

(3) Motor output (pins 6, 7, 8, and 9)

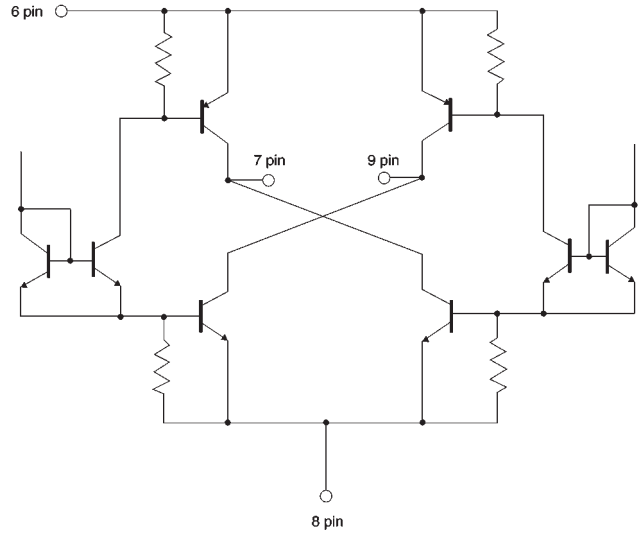



Fig.3

(2) CTL amplifier (pins 2 and 3)

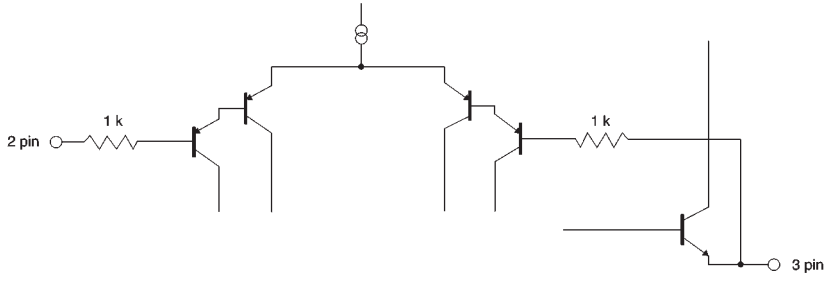



Fig.2

●Electrical characteristics (unless otherwise noted, Ta = 25°C, $V_{CC}$ = 4.8V, VB = 4.8V)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Supply current 1 | $I_{CC1}$ | — | 4.0 | 6.0 | mA | ($R_{IN}$, $F_{IN}$) = (L, H) or (H, L), $V_{CTL}$=0V |
| Supply current 2 | $I_{CC2}$ | — | 0.7 | 1.5 | mA | ($R_{IN}$, $F_{IN}$) = (L, L), $V_{CTL}$=0V |
| Supply current 3 | $I_{Boff}$ | — | 0 | 1.0 | μA | IB when $V_{CC}$ = 0 V |
| HIGH level R / F voltage | $V_{R/F\,H}$ | 2.0 | — | — | V | |
| LOW level R / F voltage | $V_{R/F\,L}$ | — | — | 0.8 | V | |
| Input high level current | $I_{R/F\,H}$ | — | 80 | 135 | μA | $R_{IN}$=2V, $F_{IN}$=2V |
| CTL amplifier offset | $V_{CTL\,ofs}$ | −5.0 | — | +5.0 | mV | ($V_{CTL}$ - RC) when $V_{CTL}$ =0 V, 1 V |
| CTL amplifier gain | $V_{CTL\,Ga}$ | 40 | 46 | 52 | μA / V | $\Delta I_{RT1}$ / 1 when $V_{CTL}$ =2 V, 1 V |
| CTL output mirror ratio 1 | $I_{CTLR1}$ | 0.85 | 1 | 1.15 | ratio | $I_{RT1}$ / $I_{RC}$ when $I_{RC}$ =20 μA |
| CTL output mirror ratio 2 | $I_{CTLR2}$ | 0.90 | 1 | 1.10 | ratio | $I_{RT1}$ / $I_{RC}$ when $I_{RC}$ =200 μA |
| CS amplifier offset | CS ofs | −5.0 | — | +5.0 | mV | (CS1 - CS2) when CS1 =0 V, 0.1 V |
| CS output mirror ratio 1 | $I_{CSR1}$ | 0.85 | 1 | 1.15 | ratio | $I_{RT2}$ / $I_{CS2}$ when $I_{CS2}$ =20 μA |
| CS output mirror ratio 2 | $I_{CSR2}$ | 0.90 | 1 | 1.10 | ratio | $I_{RT2}$ / $I_{CS2}$ when $I_{CS2}$ =200 μA |
| Output high level voltage | $V_H$ | 2.0 | 4.6 | — | V | M1, M2 voltage when $V_{CTL}$ =0.2 V |
| Low-side output saturation voltage | $V_{OL}$ | — | 0.07 | 0.2 | V | RT1 = $V_{CC}$ when $I_O$ =50mA |
| High-side output saturation voltage | $V_{OH}$ | — | 0.09 | 0.3 | V | RT1 = $V_{CC}$ when $I_O$ =50mA |

◎Not designed for radiation resistance.

●Circuit operation

(1) Input section ($F_{IN}$, $R_{IN}$)

Control signals are input from these pins. Current flows from M2 to M1 (forward mode) when $F_{IN}$ is HIGH and $R_{IN}$ is LOW, and from M1 to M2 (reverse mode) when $R_{IN}$ is HIGH and $F_{IN}$ is LOW. Putting $F_{IN}$ and $R_{IN}$ both HIGH results in the brake mode in which the high-side output transistor is turned off to shut down the motor driving current and the low-side output transistor is turned ON to absorb the counter-electromotive force of the motor, so that a brake is put on the motor. When $F_{IN}$ and $R_{IN}$ are both LOW, both M1 and M2 are left open and the motor stops.

Input/output truth table

| $F_{IN}$ | $R_{IN}$ | M1 | M2 | Mode |
|---|---|---|---|---|
| H | L | L | H | Forward |
| L | H | H | L | Reverse |
| H | H | L | L | Brake |
| L | L | OPEN | | Standby |

(2) Output section (M1, M2)

Two logic inputs control the motor by changing the status of bridge-configured transistors.

(3) Output high level voltage

Values of current, voltage, and HIGH level output voltage can be set as follows by using external resistors (refer to the application circuit of Fig. 4).

• I16 pin ($I_{RT1}$)

I16 pin ($I_{RT1}$) = V2 pin/R1 ••• ①

• I15 pin ($I_{RT2}$)

I15 pin ($I_{RT2}$) = I8 pin × R5/R4 ••• ②

• V16 pin ($V_{RT1}$)

V16 pin = R3 × (I16 pin + I15 pin) + R2 × I16 pin ••• ③

• V7, 9 pin (M1, M2 voltage; high-side voltage)

V7, 9 pin = 4 × V16 pin (Typ.) ••• ④

(4) Current feedback amplifier

The pin-8 current is increased when the motor rotational speed is reduced by loading, and the current feedback amplifier increases the pin-15 current according to equation ②. Because the pin-16 voltage then increases according to equation ③, the HIGH level output voltage also increases according to equation ④. In this way, the rotational speed is kept constant by increasing the voltage applied to the motor.

●Application example

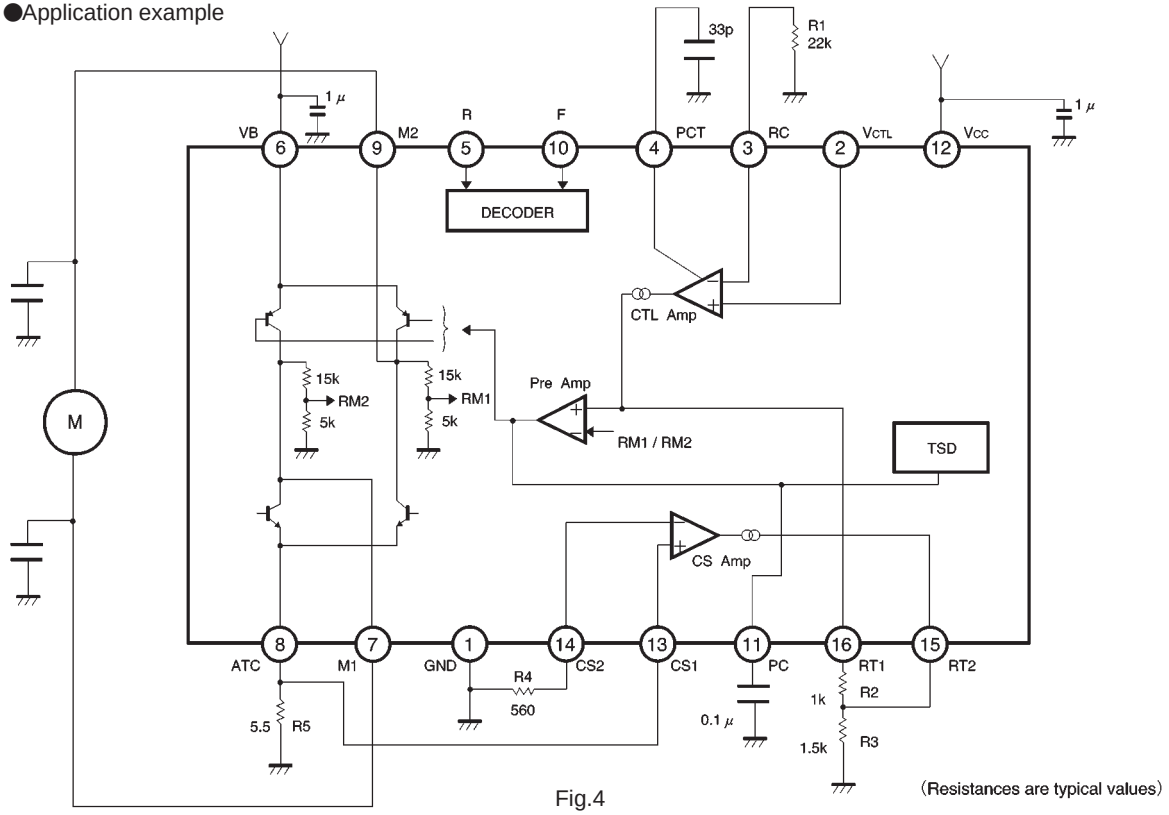



Fig.4

●Operation notes

(1) Thermal shutdown circuit

The thermal shutdown (TSD) circuit turns off all driver outputs when the IC junction temperature rises above 175°C (Typ.). The temperature difference between the activation and deactivation settings is about 20°C.

•Temperature setting of TSD

| | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| TSD activation temperature | 150 | 175 | 200 | ℃ |
| Hysteresis width | — | 20 | — | ℃ |

(2) Control logic and control signal input pins

Voltage should never be applied to the control logic input pins (pins 5 and 10) or the control signal input pin (pin 2) when the $V_{CC}$ voltage is not applied to the IC. Similarly, the voltage on each input pin should not exceed any applied $V_{CC}$ voltage.

(3) PCB arrangement

When changing the rotational direction of a motor, a large current of up to a few hundred milliamperes can flow between the motor power supply (pin 6) and RNF (pin 8). Depending on the application, this large output current may flow back to input pins, resulting in output oscillation or other malfunctions. Make sure that your design does not allow a common impedance between the large current output lines and the input section. Suppress the power supply impedance to low levels, otherwise output oscillation may occur.

(4) Package power

The power dissipated by the IC varies widely with the supply voltage and the output current. Give full consideration to the package power dissipation rating when setting the supply voltage and the output current.

(5) The input pins (pins 5 and 10) have temperature-dependent characteristics. Take the temperature effect into consideration when using the IC.

(6) To eliminate motor noise, connect a capacitor between M1 (pin 7) and GND and between M2 (pin 9) and GND.

●Electrical characteristic curves

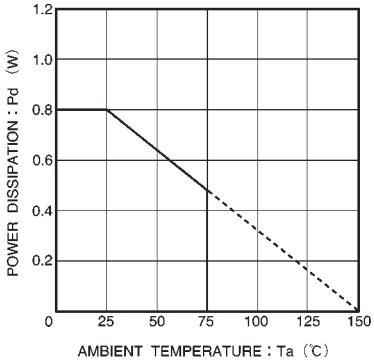



Fig.5 Temperature dependence of power dissipation

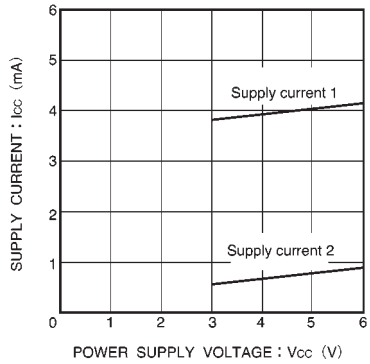



Fig.6 Supply current vs. power supply voltage

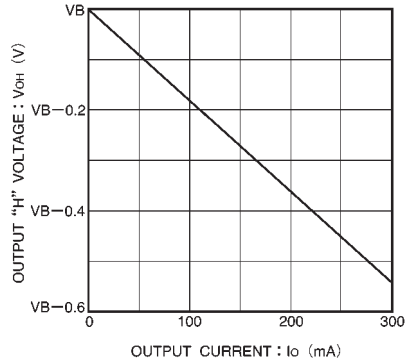



Fig.7 Output high level voltage vs. output current

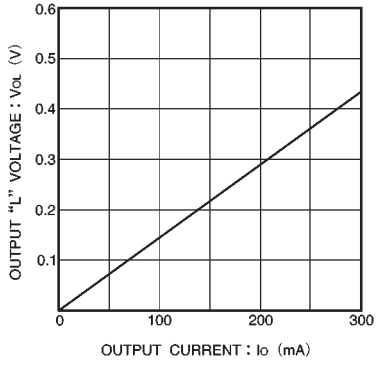
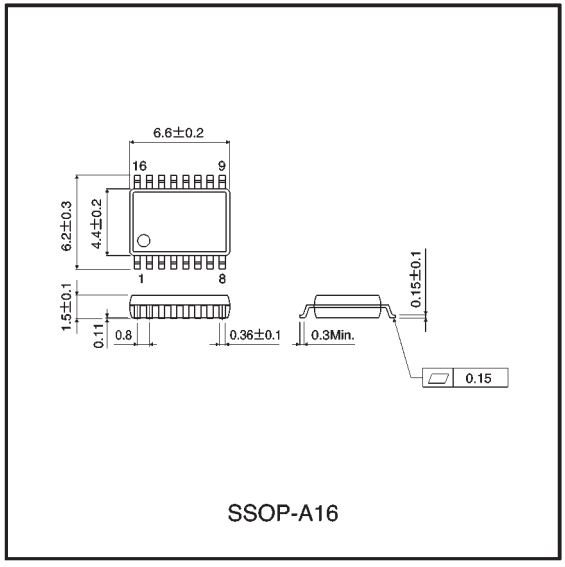



Fig.8 Output low level voltage vs. output current

●External dimensions (Units: mm)




SSOP-A16