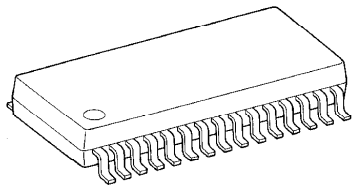
TOSHIBA BIPOLAR LINEAR INTEGRATED CIRCUIT MULTI-CHIP

# T A 8 4 9 3 B F

## 3-PHASE FULL WAVE BRUSHLESS DC MOTOR DRIVER IC FOR CD-ROM DRIVES

This 3-phase, full-wave, brushless DC motor driver IC has been developed for use in CD-ROM drive spindle motors. The TA8493BF contains in its upper stage a discrete power transistor (P-ch-MOS) and uses direct PWM control system, which enables the IC to provide superior thermal efficiency.
Furthermore, the multi-chip structure of this device facilitates dispersion of the heat generated inside the package, making it possible to suppress heat concentration.



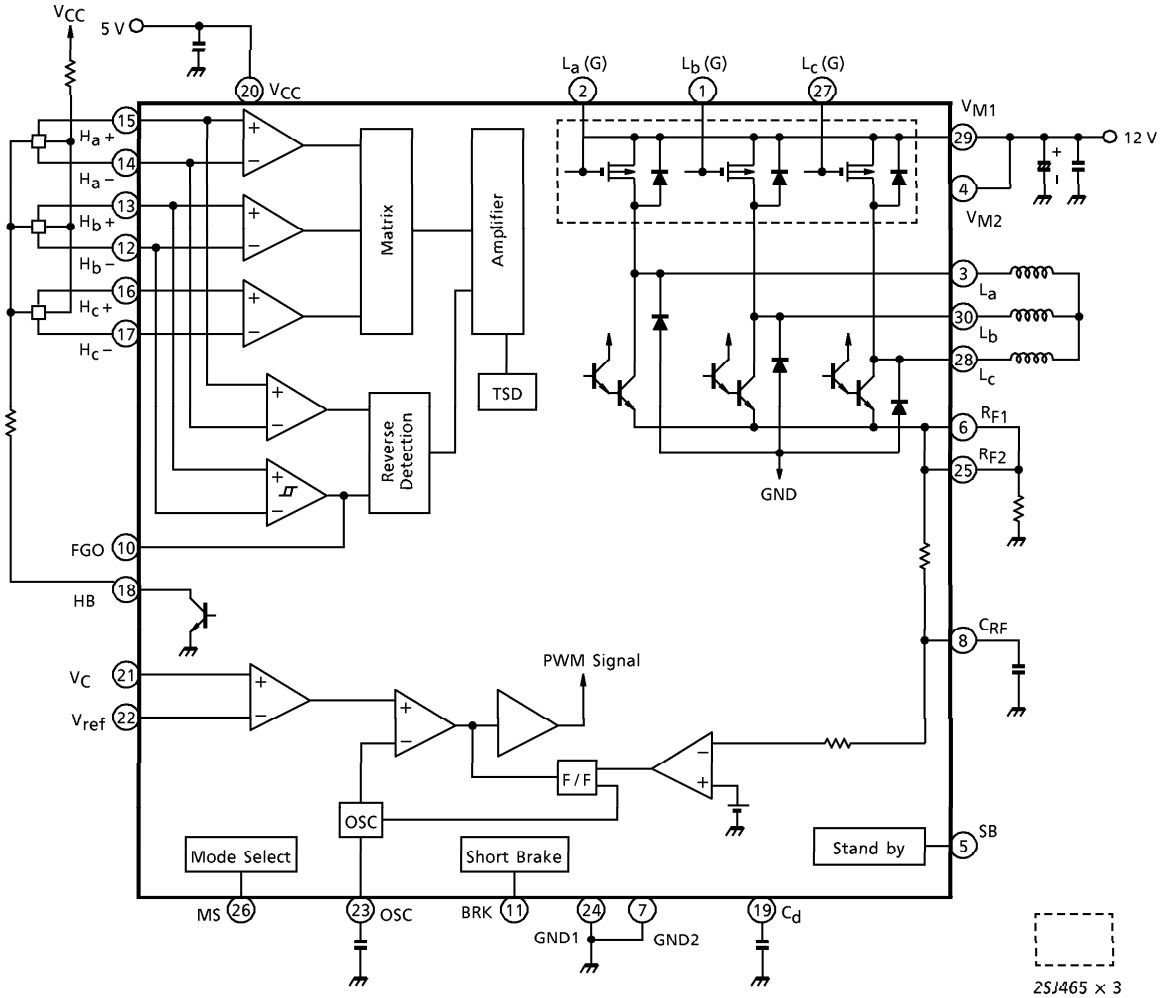
SSOP30-P-375-1.00

Weight : 0.63 g (typ.)

**FEATURES**

- Multi-chip structure (3 2SJ465 chips built-in)
- Direct PWM control system
- Built-in current limiter : $I_{LIM}$ = 0.7 A (typ.) (at $R_F$ = 0.33 Ω)
- Built-in reversing brake / short brake functions
- FG signal output (using hall element output signal)
- Built-in hall bias
- Built-in thermal shutdown circuit
- Package : MFP-30

## BLOCK DIAGRAM




9 pin : N.C.

**PIN ASSIGNMENT**

| TERMINAL No. | TERMINAL SYMBOL | FUNCTION | REMARKS |
|---|---|---|---|
| 1 | $L_b$ (G) | b-phase upper side power transistor (base) output terminal | Keep open. |
| 2 | $L_a$ (G) | a-phase upper side power transistor (base) output terminal | Keep open. |
| 3 | $L_a$ | a-phase output terminal | Connect to the coil. |
| 4 | $V_{M2}$ | Supply voltage terminal for motor drive | Connect to $V_{M1}$ externally. |
| 5 | SB | RUN / STOP control terminal | H : RUN, L : STOP |
| 6 | $R_{F1}$ | Output current detection terminal | Sets limiter current value. Connect to $R_{F2}$ externally and between this terminal and GND. |
| 7 | GND2 | GND | — |
| 8 | $C_{RF}$ | Output current filter terminal | Connect a capacitor between this terminal and GND. |
| 9 | N.C. | | |
| 10 | FGO | FG amplifier output terminal | Outputs a signal whose frequency is determined by the CD rotation frequency. |
| 11 | BRK | Brake mode select terminal | Output mode when $V_C > V_{ref}$ |
| 12 | $H_b^-$ | b-phase negative hall signal input terminal | Connect to hall element output terminal. |
| 13 | $H_b^+$ | b-phase positive hall signal input terminal | Connect to hall element output terminal. |
| 14 | $H_a^-$ | a-phase negative hall signal input terminal | Connect to hall element output terminal. |
| 15 | $H_a^+$ | a-phase positive hall signal input terminal | Connect to hall element output terminal. |
| 16 | $H_c^+$ | c-phase positive hall signal input terminal | Connect to hall element output terminal. |
| 17 | $H_c^-$ | a-phase negative hall signal input terminal | Connect to hall element output terminal. |
| 18 | HB | Hall element bias terminal | Open collector output. Connect to the negative side of hall element bias line. |
| 19 | Cd | Forward / reverse changeover gain adjustment terminal | Adjust a rotation direction changeover gain |
| 20 | $V_{CC}$ | Supply voltage terminal for control circuits | $V_{CC\ (opr)}$ = 4.5~5.5 V |

| TERMINAL No. | TERMINAL SYMBOL | FUNCTION | REMARKS |
|---|---|---|---|
| 21 | $V_C$ | Control amplifier input terminal | Use the control signal as input. |
| 22 | $V_{ref}$ | Control amplifier reference voltage input terminal | Use the reference voltage for the control amplifier as input. |
| 23 | OSC | Triangular wave oscillation terminal | Connect a capacitor between this terminal and GND. |
| 24 | GND1 | GND | — |
| 25 | $R_{F2}$ | Output current detection terminal | Sets limiter current value. Connect to $R_{F1}$ externally and between this terminal and GND. |
| 26 | MS | Mode select terminal | Determines output mode. |
| 27 | $L_c$ (G) | c-phase upper side power transistor (base) output terminal | Keep open. |
| 28 | $L_c$ | c-phase output terminal | Connect to the coil. |
| 29 | $V_{M1}$ | Supply voltage terminal for motor drive | Connect to $V_{M2}$ externally. |
| 30 | $L_b$ | b-phase output terminal | Connect to the coil. |

**ABSOLUTE MAXIMUM RATINGS** (Ta = 25°C)

| CHARACTERISTIC | SYMBOL | RATING | UNIT |
|---|---|---|---|
| Power Supply Voltage | $V_{CC}$ | 7 | V |
| | $V_M$ | 16 | |
| Output Current | $I_O$ | 1.5 | A |
| Power Dissipation | $P_D$ (Note) | 1.0 | W |
| Junction Temperature | $T_j$ | 150 | °C |
| Operating Temperature | $T_{opr}$ | −20~75 | °C |
| Storage Temperature | $T_{stg}$ | −55~150 | °C |

(Note ) : unmounted

**OPERATING VOLTAGE RANGE**

| CHARACTERISTIC | SYMBOL | OPERATING RANGE | UNIT |
|---|---|---|---|
| Power Supply Voltage | $V_{CC}$ | 4.5~5.5 | V |
| | $V_M$ | 8~14 | |

**ELECTRICAL CHARACTERISTICS** ($V_{CC}$ = 5 V, $V_M$ = 12 V, Ta = 25°C)

| CHARACTERISTIC | | SYMBOL | TEST CIR-CUIT | TEST CONDITION | MIN | TYP. | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| Supply Voltage | | $I_{CC1}$ | 1 | Stop mode | — | 0.3 | 0.8 | mA |
| | | $I_{CC2}$ | | Run mode, output open | — | 7 | 15 | |
| Hall Amp. | Input Current | $I_{INH}$ | 2 | $V_{CMRH}$ = 2.5 V, (Sink current) | — | — | 2 | μA |
| | Common Mode Input Voltage Range | $V_{CMRH}$ | | — | 1.5 | — | 4.0 | V |
| | Input Amplitude | $V_H$ | | — | 100 | — | — | $mV_{p-p}$ |
| Hall Element Bias Saturation Voltage | | $V_{HB}$ | 2 | $I_{HB}$ = 10 mA | — | 1.3 | 2.0 | V |
| Control Amp. | Common Mode Input Voltage Range | $V_{CMRC}$ | 2 | — | 0.5 | — | 4.0 | V |
| | Input Current | $I_{INC}$ | | $V_C = V_{ref}$ = 1.65 V, (Source current) | — | — | 5.0 | μA |
| | Dead Zone Voltage Width | $V_{DZ}$ | — | $V_{REF}$ = 1.65 V, $R_F$ = 0.33 Ω (Note) | — | 100 | — | mV |
| | Input Offset Voltage | $\Delta V_{OFF}$ (F) | 2 | CW mode, $V_{ref}$ = 1.65 V, $R_F$ = 0.33 Ω | 20 | 50 | 150 | mV |
| | | $\Delta V_{OFF}$ (R) | | CCW mode, $V_{ref}$ = 1.65 V, $R_F$ = 0.33 Ω | 20 | 50 | 150 | |
| Current Limit Amp. | Limit Current | $I_{LIM}$ | — | $R_F$ = 0.33 Ω (Note) | — | 700 | — | mA |
| | | $V_{LIM}$ | 3 | — | 0.25 | 0.3 | 0.35 | V |
| RUN / STOP Control Circuit | Input Voltage (H) | $V_{INS}$ (H) | 1 | (RUN) | 3.0 | — | $V_{CC}$ | V |
| | Input Voltage (L) | $V_{INS}$ (L) | | (STOP) | GND | — | 1.0 | |
| | Input Current | $I_{INS}$ (L) | | $V_{INS}$ = GND, (Source current) | — | — | 1 | μA |
| Output Circuit | Output Resistance (Upper Side) | $R_{ON}$ (U) | 4 | $I_o$ = 0.6 A | — | 0.5 | 1.0 | Ω |
| | Saturation Voltage (Lower Side) | $V_{sat}$ (L) | | $I_o$ = 0.6 A | — | 0.4 | 0.8 | V |
| | Cut-off Current (Upper Side) | $I_L$ (U) | 5 | $V_L$ = 16 V | — | — | 10 | μA |
| | Cut-off Current (Lower Side) | $I_L$ (L) | | $V_L$ = 16 V | — | — | 10 | |
| Mode Select Circuit | Input Voltage (H) | $V_{MS}$ (H) | 6 | CCW mode $V_C > V_{ref}$, BRK : L | 3.0 | — | $V_{CC}$ | V |
| | Input Voltage (L) | $V_{MS}$ (L) | | Reversing brake mode $V_C > V_{ref}$, BRK : L | — | — | 0.5 | |
| | Input Current | $I_{INMS}$ | | $V_{MS}$ = GND, (Source current) | — | — | 1 | μA |

(Note) : This is not tested.

| CHARACTERISTIC | | SYMBOL | TEST CIR-CUIT | TEST CONDITION | MIN | TYP. | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| FG Amp. | Hysteresis Voltage | $V_{HYS}$ | 8 | — | 5 | 20 | 45 | $mV_{p-p}$ |
| | Output Voltage (H) | $V_{OFG\ (H)}$ | 7 | Source current : 10 $\mu$A | $V_{CC}$ – 0.5 | — | — | V |
| | Output Voltage (L) | $V_{OFG\ (L)}$ | | Sink current : 10 $\mu$A | — | — | 0.5 | |
| Short Brake Circuit | Input Voltage (H) | $V_{BRK\ (H)}$ | 6 | — | 3.0 | — | $V_{CC}$ | V |
| | Input Voltage (L) | $V_{BRK\ (L)}$ | | — | — | — | 0.5 | |
| | Input Current | $I_{INBRK}$ | | $V_{BRK}$ = GND, (Source current) | — | — | 1 | $\mu$A |
| Triangular Oscillation Circuit | Oscillation Frequency | $f_{OSC}$ | — | C = 560 pF (Note) | — | 39 | — | kHz |
| Thermal Shut-down Operating Temperature | | $T_{SD}$ | — | Junction temperature (according to design specification) (Note) | — | 175 | — | °C |

(Note) : This is not tested.

**FUNCTION TABLE**

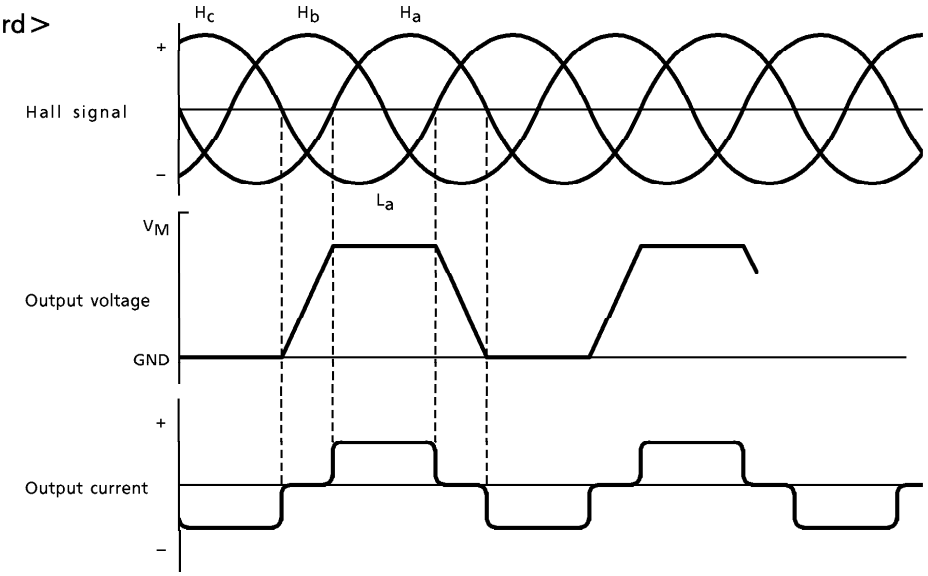
| | | | FORWARD | | | REVERSE | | |
|---|---|---|---|---|---|---|---|---|
| $H_a$ | $H_b$ | $H_c$ | $L_a$ | $L_b$ | $L_c$ | $L_a$ | $L_b$ | $L_c$ |
| H | L | L | H | L | M | L | H | M |
| H | H | L | H | M | L | L | M | H |
| L | H | L | M | H | L | M | L | H |
| L | H | H | L | H | M | H | L | M |
| L | L | H | L | M | H | H | M | L |
| H | L | H | M | L | H | M | H | L |

<Forward>
$L_a = -(H_c - H_a)$
$L_b = -(H_a - H_b)$
$L_c = -(H_b - H_c)$

<Reverse>
$L_a = (H_c - H_a)$
$L_b = (H_a - H_b)$
$L_c = (H_b - H_c)$

**TIMING DIAGRAM**

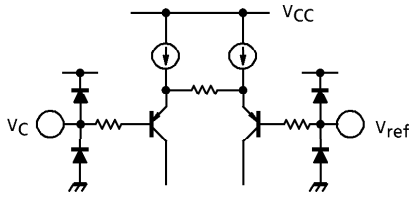
<Forward>



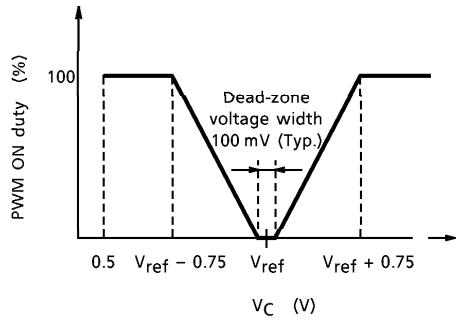
**FUNCTIONAL DESCRIPTION**

This IC is a 3-phase, full wave brushless DC motor driver of the direct PWM control type.

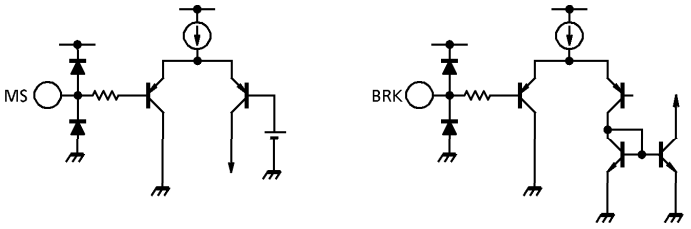
- Control amp input circuit




The common mode input voltage ranges for both $V_C$ and $V_{ref}$ are 0.5 to 4.0 V.
Relation between control input and PWM ON duty is shown below, PWM ON duty is 100% when $|V_{ref} - V_C|$ = 0.75 V (Typ.)
The input is provided with a dead-zone area whose voltage width is 100 mV (typ.)




- Mode select / short brake circuit



When $V_C > V_{ref}$, one of three modes (Reverse Rotation, Reversing Brake or Short Brake mode) can be selected by setting the MS and BRK pins appropriately.

<Function>

$V_C < V_{ref}$

| | | BRK | |
|---|---|---|---|
| | | H | L |
| MS | H | Forward | Forward |
| | L | Forward | Forward |

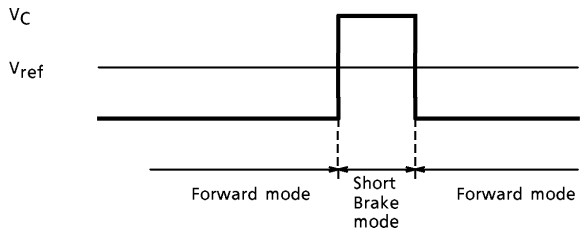
$V_C > V_{ref}$

| | | BRK | |
|---|---|---|---|
| | | H | L |
| MS | H | Short brake | Reverse |
| | L | Short brake | Reversing brake |

In Short Brake mode, the upper-stage power transistor is turned on and the lower-stage power transistor is turned off.
In Reversing Brake mode, all outputs are cut off after detection of reverse rotation, causing the motor to stop.

(Short brake)

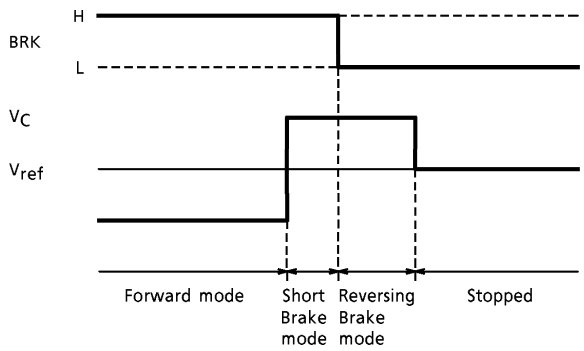
MS : H or L, BRK : H




(Reversing brake)

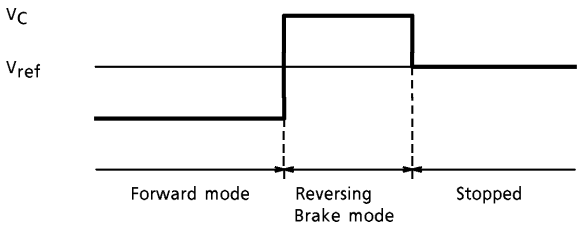
① When stopping the motor by applying a reversing brake after a short brake

MS : L



② When stopping the motor using Reversing Brake mode

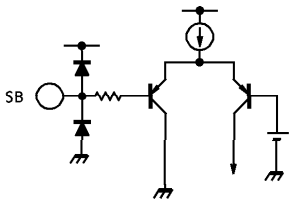
MS : L, BRK : L




(*) For an explanation of the Reversing Brake mode stopping sequence, refer to the explanation of the reverse rotation detection circuit.

The short brake generates less heat than the reversing brake. Therefore Toshiba recommends a combined use of the short and reversing brakes when stopping the motor.

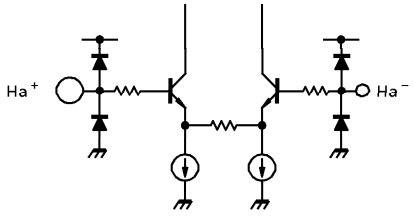
- Run / stop control circuit




When the driver IC is standing by, all of its circuits except the FG amp and the hall amp are turned off.

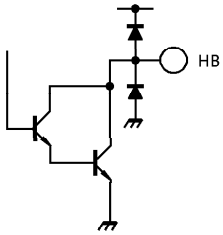
H : start
L : standby

- Hall amp circuit




The common mode input voltage range for $V_{CMRH}$ is 1.5 to 4.0 V.

- Hall element bias circuit

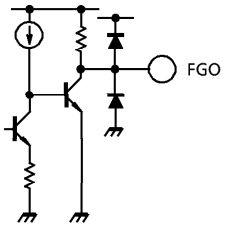



The hall element bias current is turned off when the driver IC is in standby state.
Make sure that the negative hall bias line is connected to the HB pin.
The remaining voltage is as follows :

$V_{HB}$ = 1.2 [V] (typ.) at $I_{HB}$ = 10 mA

Furthermore, this circuit cannot be used if FG output is necessary in standby state.
When the HB terminal is not used, the negative hall bias line must be connected to GND with a resistor in between.

- FG amp circuit



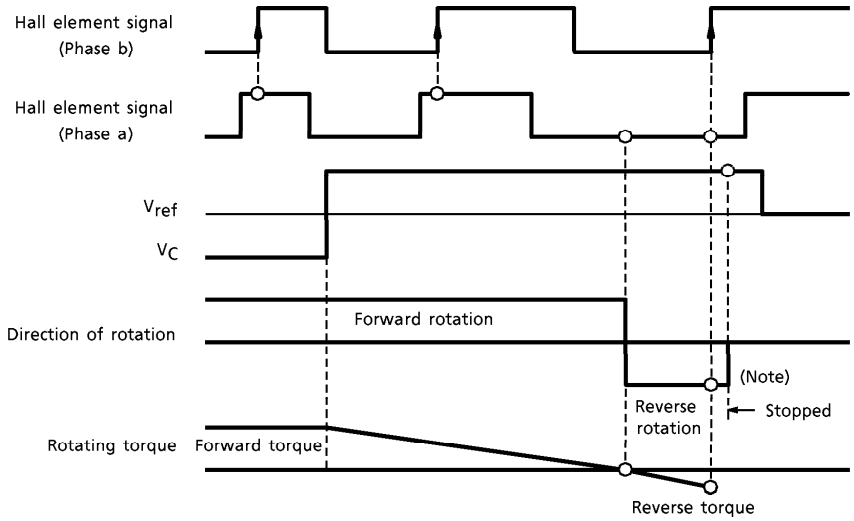

This circuit uses a hall element signal which is output to FGO after a Schmitt stage.
The FG amp has a hysteresis of 20 [$mV_{p-p}$] (typ.) and its output voltages are

High level : $V_{CC}$ – 0.5~$V_{CC}$ [V]
Low level : GND~0.5 [V] at $I_{OFG}$ = 10 $\mu$A

The FG amp is active when it is in standby state. When the hall element signal is input, the FG signal is output.

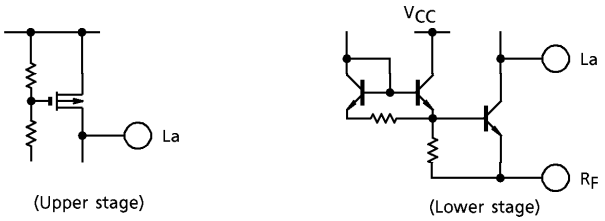
- Reverse rotation detection circuit

  By comparing the two phases of the Hall element signal, this circuit detects a state where the phases are inverted, at which time the torque is reduced to 0. The detection accuracy is determined by the number of pulses per rotation of Hall element output.

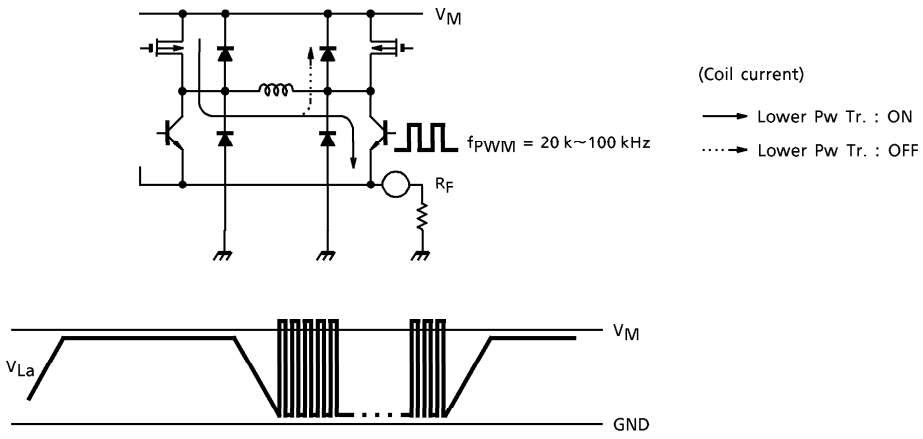



(Note) : Due to its inertial force, the motor does not stop immediately after the torque is reduced to 0.

- Output circuit




This circuit uses the system to chop the lower power transistors and resurrect coil current through upper stage diodes.
The upper-stage power transistors consists of Pch-MOS transistors (2SJ465), which give high torque efficiency.

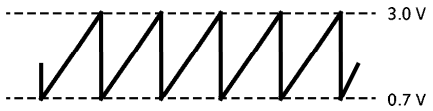



Lower-stage predrivers are supplied by $V_{CC}$ to reduce the power dissipation.

- Triangular wave oscillator circuit

Triangular waves are generated by connecting a capacitor between the OSC pin and GND.
This circuit is current output type, which makes PWM signal by comparing its output current with control amp output current.

$$f_{OSC}\,[Hz] = \frac{50 \times 10^{-6}\,[A]}{(3.0 - 0.7)\,[V] \times C\,[F]}$$



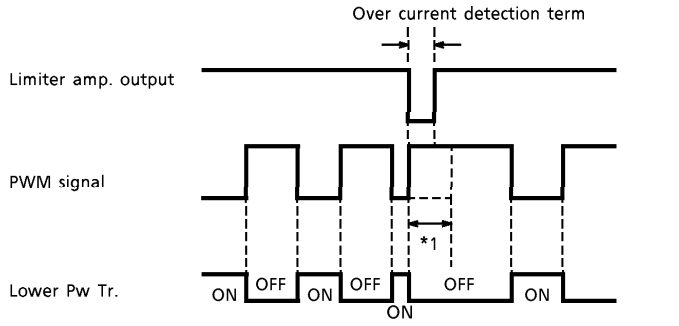

Taking into account efficiency considerations and the effects of noise, Toshiba recommends using the IC with an oscillation frequency of 20 kHz~100 kHz.

- Current limiter circuit

  The current limit value is determined by the equation below.

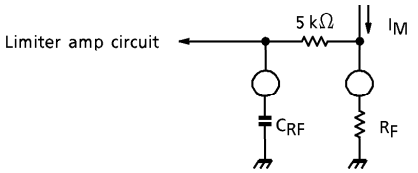
$$I_{LIM} \fallingdotseq \frac{0.3}{R_F + 0.1} \text{ [A] (Typ.)}$$

  This circuit cut off lower power transistors compulsorily when filtered $V_{RF}$ is more than reference voltage. (0.3 V)
  PWM signal cut off compulsorily is released from OFF state by next ON signal.




(*1) Keep "H" level in this term

  Consider inside resistance (5 kΩ) when setting the capacitance value ($C_{RF}$).




- Thermal shut down circuit
  The circuit turns off output when $T_j$ = 175°C (Typ.) (according to design specification)

**EXTERNAL PARTS**

| TERMINAL No. | FUNCTION | RECOMMENDED VALUE | REMARKS |
|---|---|---|---|
| $C_1$ | Power supply line oscillation prevention | 0.22 $\mu$F | — |
| $C_2$ | Power supply line noise prevention | 100 pF~1000 pF | (Note 1) |
| $C_3$ | Power supply line noise prevention | 10 $\mu$F~100 $\mu$F | (Note 1) |
| $C_4$ | Filter | 470 pF | — |
| $C_5$ | Forward / reverse changeover gain adjustment | 0.01 $\mu$F | (Note 2) |
| $C_6$ | Triangular wave oscillation | 220 pF~1000 pF | — |
| $R_1$ | Hall element bias | — | (Note 3) |
| $R_2$ | Control amp reference voltage | — | (Note 4) |
| $R_3$ | Output current detection | 0.25 Ω~0.5 Ω | — |

(Note 1) : Absorb switching noise by $C_2$ and $C_3$.

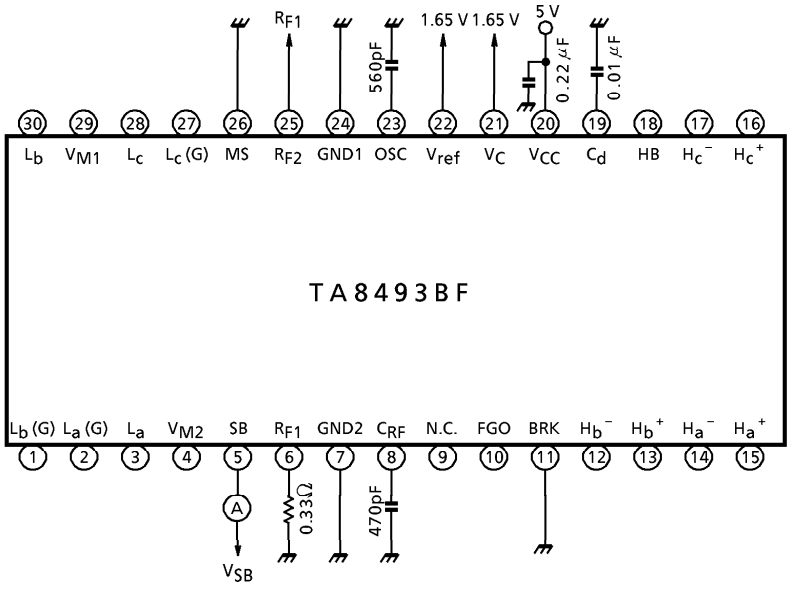
(Note 2) : This is used to adjust the rotation direction changeover gain.
This capacitance valve and the gain are in inverse.
This capacitance is to prevent from output through current.

(Note 3) : Be sure to set this bias so that the hall element output amplitude and common mode input voltage fall within the ranges specified in the table of electrical characteristic.

(Note 4) : The voltage must be set to fall within the common mode input voltage range of the control amp.

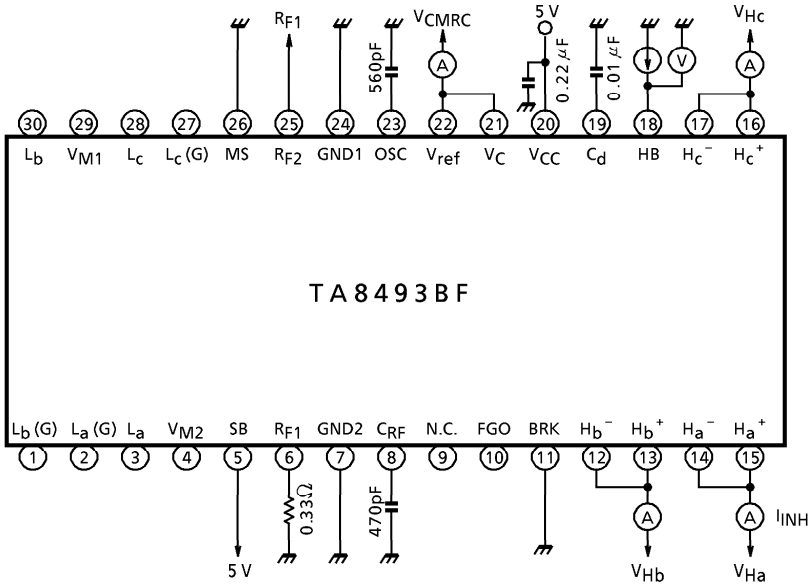
**TEST CIRCUIT**

1. $I_{CC1}$, $I_{CC2}$, $V_{INS\,(H)}$, $V_{INS\,(L)}$, $I_{INS}$



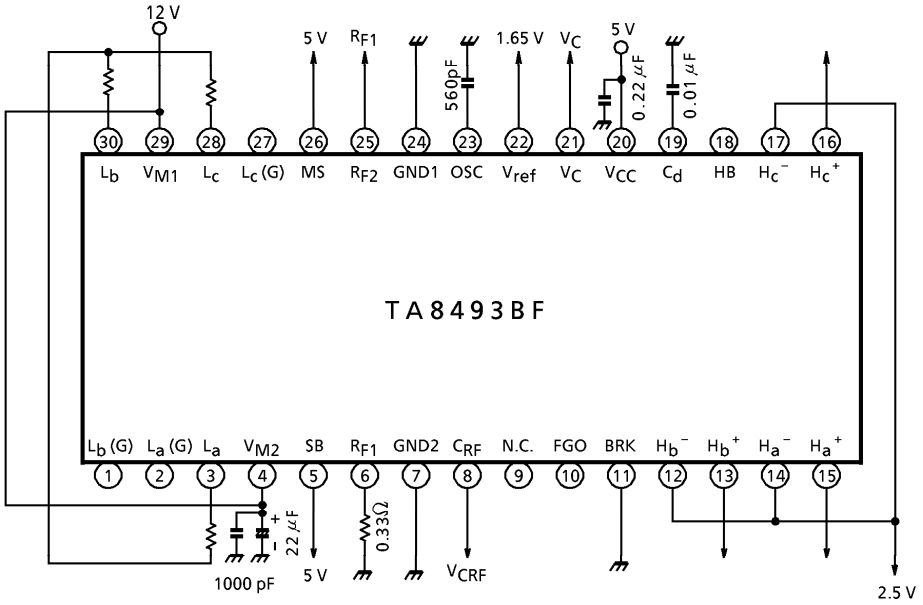

- $I_{CC1}$ : $V_{SB}$ = 0.5 V
- $I_{CC2}$ : $V_{SB}$ = 3.0 V
- $V_{INS\,(H)}$, $V_{INS\,(L)}$ : Judged by the gap between $I_{CC1}$ and $I_{CC2}$
- $I_{INS}$ : $V_{INS}$ = 0 V

2. $I_{INH}$, $I_{CMRH}$, $V_{HB}$ , $I_{INC}$, $V_{CMRC}$



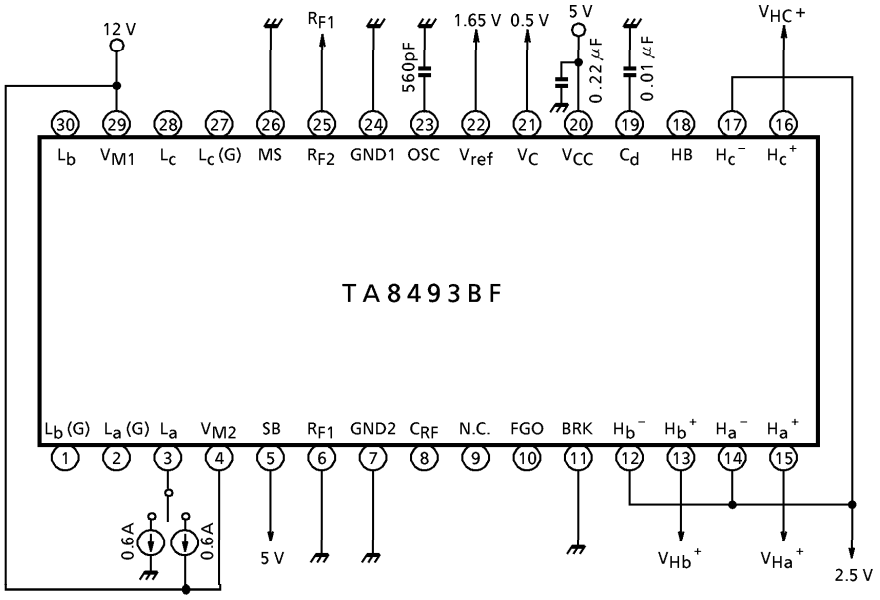

- $I_{INH}$ : Total of a phase negative and positive input current.
  $V_{Ha} = V_{Hb} = V_{Hc} = 2.5\,V$
- $V_{CMRH}$ : Measure the $I_{INH}$ gap between $V_{Ha} = 1.5\,V$ and $V_{Ha} = 4.0\,V$.
  b and c phase are measured the same method.
- $V_{HB}$ : $I_{HB} = 10\,mA$
- $V_{INC}$ : Total of $V_C$ and $V_{ref}$ input current. At $V_{CMRC} = 1.65\,V$.
- $V_{CMRC}$ : Measure the $I_{INC}$ gap between $V_{CMRC} = 0.5\,V$ and $V_{CMRC} = 4.0\,V$.

3. $\Delta V_{OFF\,(F)}$, $\Delta V_{OFF\,(R)}$, $V_{LIM}$



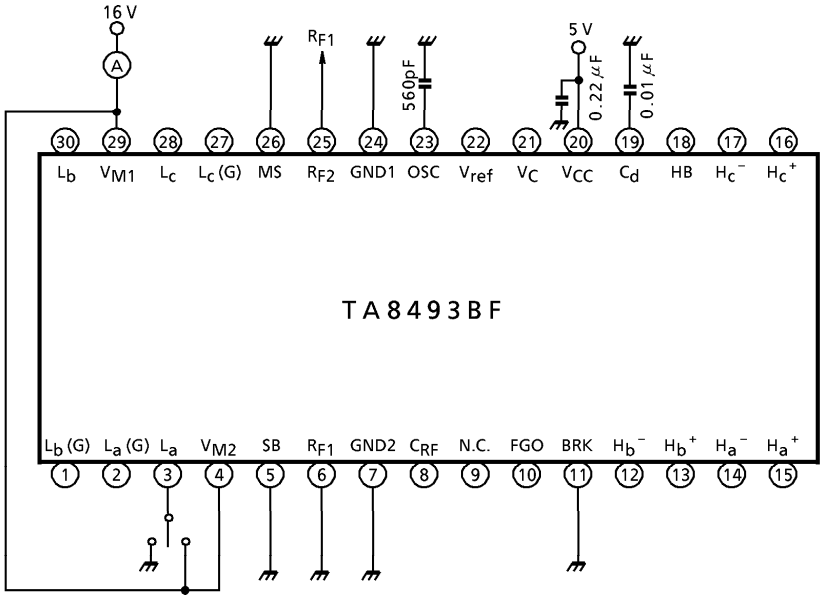

- $\Delta V_{OFF\,(F)}$ : Measure $V_{RF}$ at $V_C$ = 1.63 V / 1.5 V.
- $\Delta V_{OFF\,(R)}$ : Measure $V_{RF}$ at $V_C$ = 1.67 V / 1.8 V.
- $V_{LIM}$ : Switch the $V_{CRF}$ from 0 V to 0.4 V.
  Measure the $V_{CRF}$ at the point when output voltage level changes from high (H) to low (L)

4. $R_{ON\,(U)}$, $V_{sat\,(L)}$



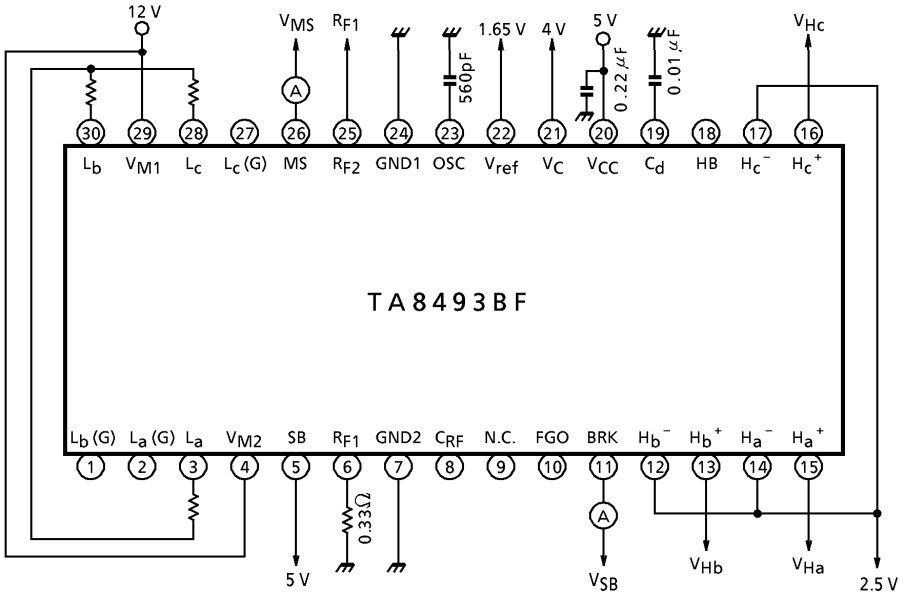

- $R_{ON\,(U)}$ : Determined output function by $V_{Ha}{}^{+}$, $V_{Hb}{}^{+}$, $V_{Hc}{}^{+}$ (2.45 V / 2.55 V). Measure voltage value between $V_M$ and $L_a$, and change to resistance valve. b phase and c phase are measured the same method.
- $V_{sat\,(L)}$ : Determined output function by $V_{Ha}{}^{+}$, $V_{Hb}{}^{+}$, $V_{Hc}{}^{+}$ (2.45 V / 2.55 V). Measure voltage value between $L_a$ and GND. b phase and c phase are measured the same method.

5. $I_{L\,(U)}$, $I_{L\,(L)}$



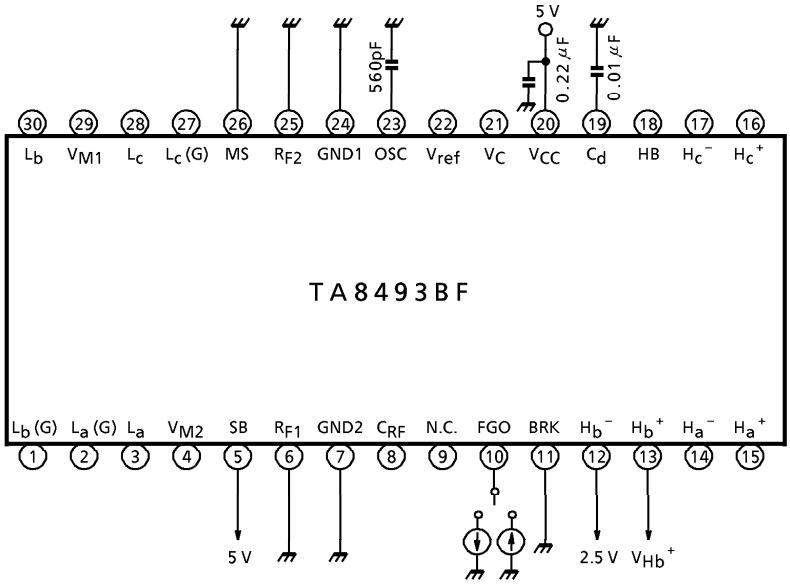

- $I_{L\,(U)}$ : Measure $I_M$ when $L_a$ and GND are shorted. b phase and c phase are measured the same method.
- $I_{L\,(L)}$ : Measure $I_M$ when $V_M$ and $L_a$ are shorted. b phase and c phase are measured the same method.

6. $V_{MS\,(H)}$, $V_{MS\,(L)}$, $I_{INS}$, $V_{BRK\,(H)}$, $V_{BRK\,(L)}$, $I_{INBRK}$



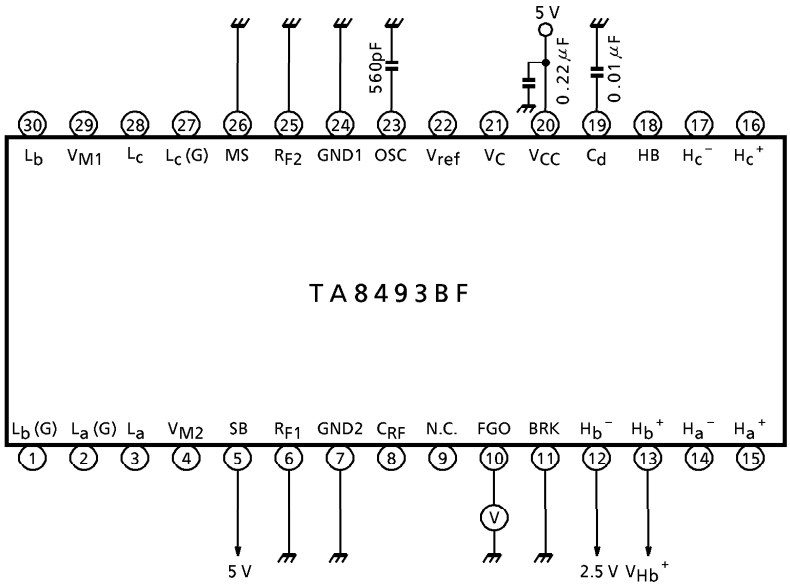

- $V_{MS\,(H)}$ : $V_{MS}$ = 3.0 V, $V_{BRK}$ = 0 V, verify that output function is reverse mode.
- $V_{MS\,(L)}$ : $V_{MS}$ = 0.5 V, $V_{BRK}$ = 0 V, switch from foward mode to reverse mode by $V_{Ha}$, $V_{Hb}$ $V_{Hc}$. Verify that $V_{RF}$ changes to zero.
- $I_{MS\,(L)}$ : $V_{MS}$ = 0 V, $V_{BRK}$ = 0 V
- $V_{BRK\,(H)}$ : $V_{MS}$ = 5 V, $V_{BRK}$ = 3.0 V, verify that $L_a$ = $L_b$ = $L_c$ : H
- $V_{BRK\,(L)}$ : $V_{MS}$ = 5 V, $V_{BRK}$ = 0.5 V, verify that output function is reverse mode.

7. $V_{OFG\ (H)}$, $V_{OFG\ (L)}$



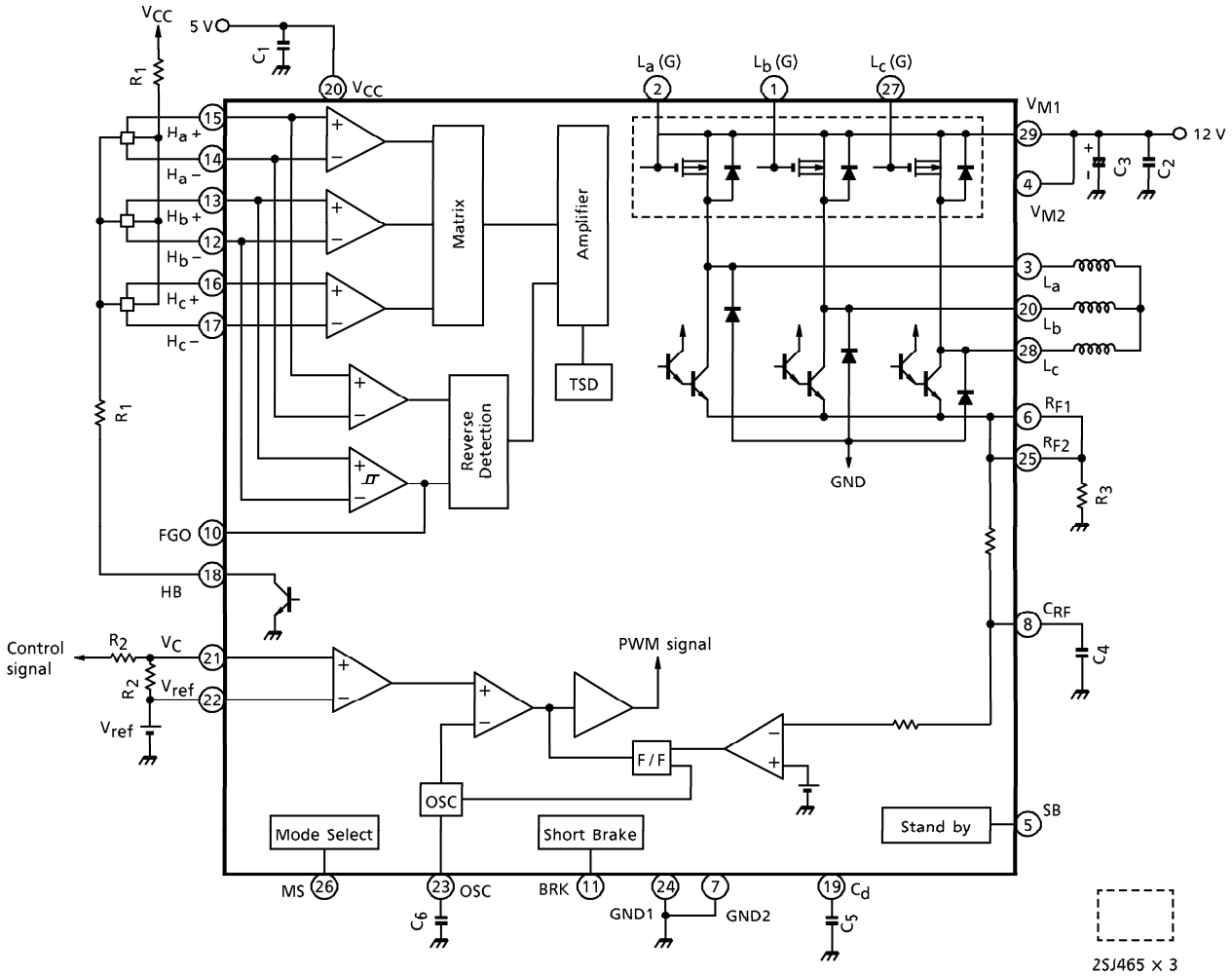

- $V_{OFG\ (H)}$ : $V_{Hb^+}$ = 2.53 V, $I_{FGO}$ = 10 μA (source)
- $V_{OFG\ (L)}$ : $V_{Hb^+}$ = 2.47 V, $I_{FGO}$ = 10 μA (sink)

8. $V_{HYS}$




- $V_{HYS}$ : Switch the $V_{Hb^+}$ from high (H) to low (L) and from (L) to (H). Measure the $V_{Hb^+}$ at the point when FGO function changes.

## APPLICATION CIRCUIT

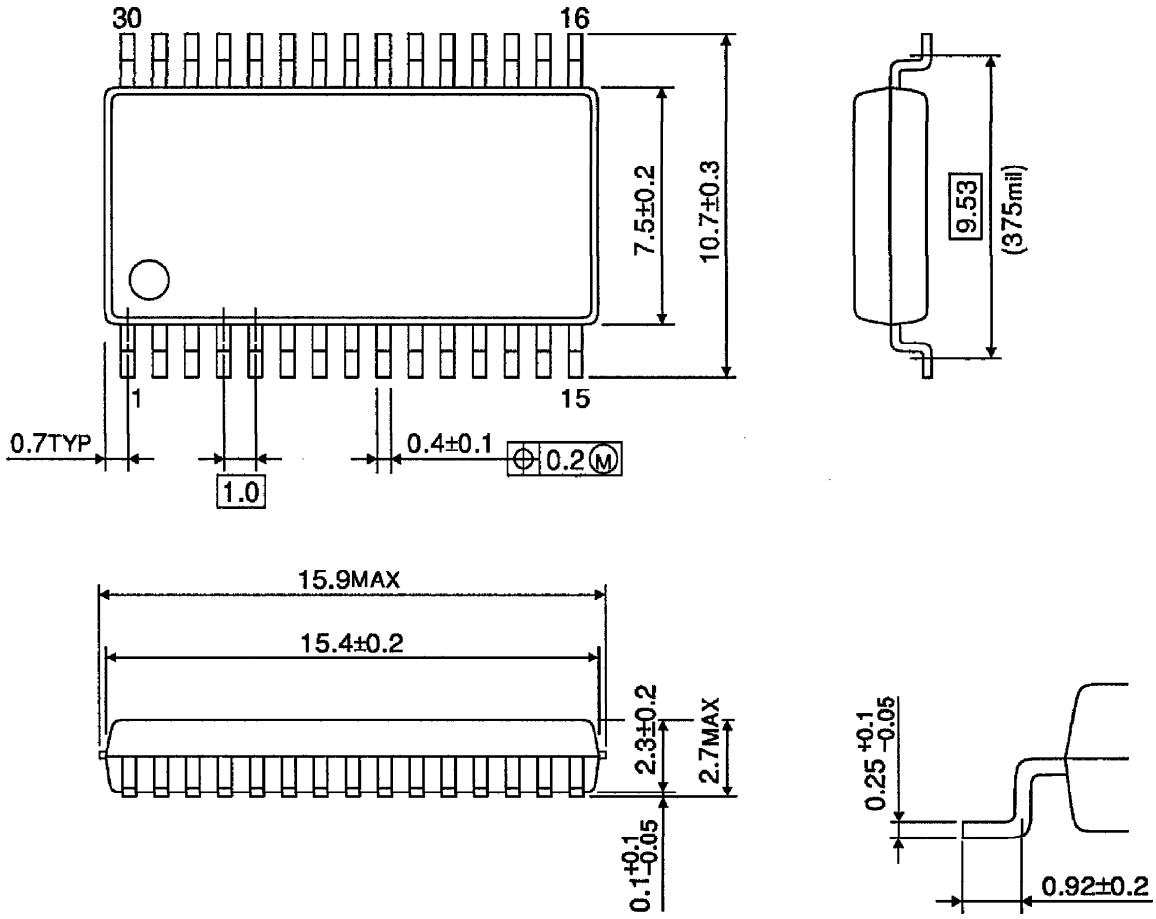



(Note) : Utmost care is necessary in the design of the output line, $V_{CC}$, $V_M$ and GND line since IC may be destroyed due to short-circuit between outputs, air contamination fault, or fault by improper grounding.

**OUTLINE DRAWING**

SSOP30-P-375-1.00

Unit : mm




Weight : 0.63 g (Typ.)