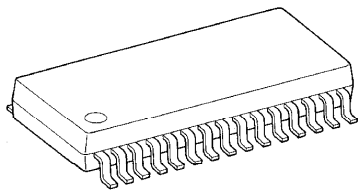
TOSHIBA BIPOLAR LINEAR INTEGRATED CIRCUIT MULTI-CHIP

TA8493F

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 TA8493F 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.



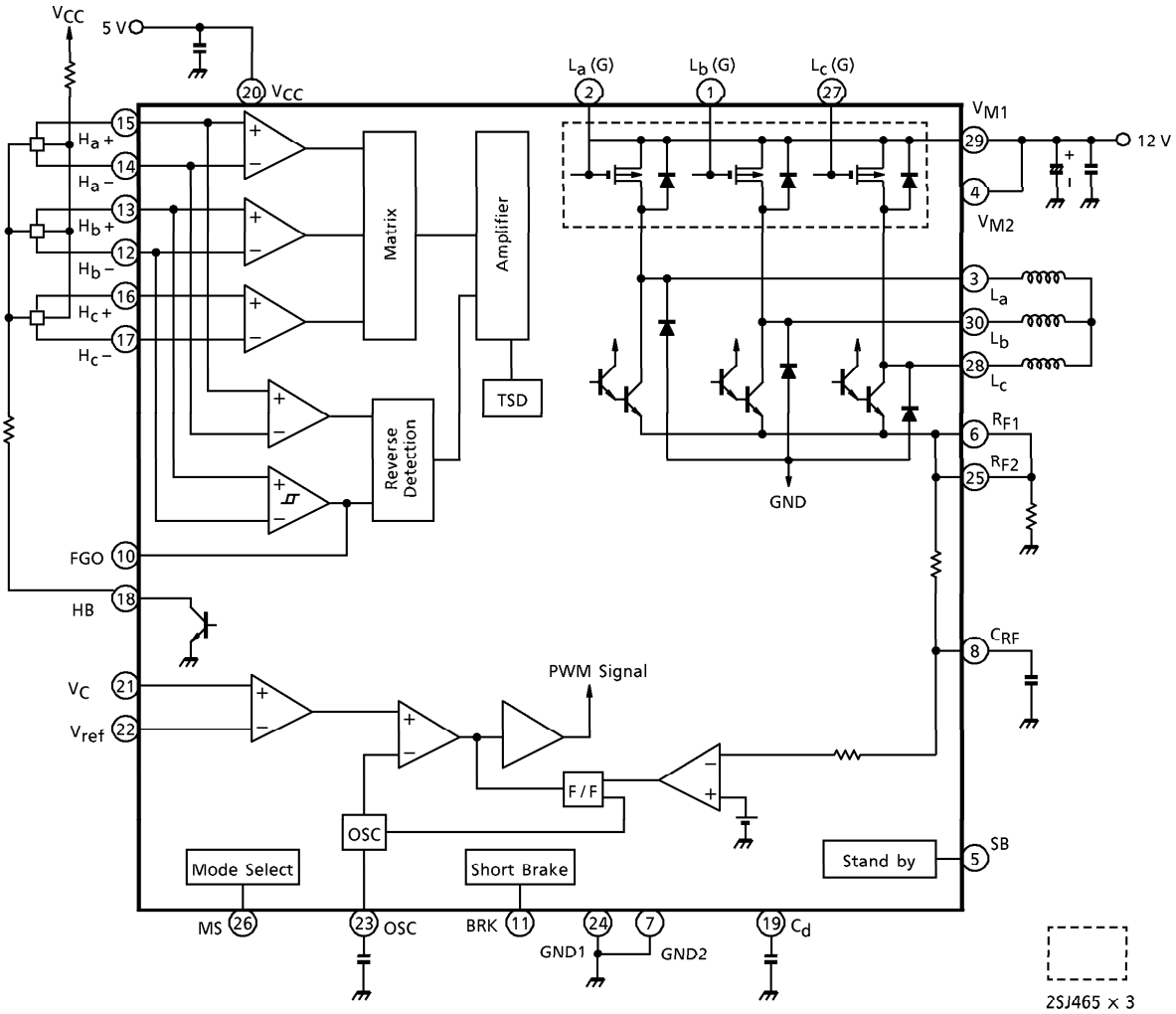
SSOP30-P-375-1.00

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 $R_F = 0.33\ \Omega$)
- 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	1.2	A
Power Dissipation	P_D (Note 1)	1.0	W
Junction Temperature	T_j	150	°C
Operating Temperature	T_{opr}	−20~75	°C
Storage Temperature	T_{stg}	−55~150	°C

(Note 1) : 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	ΔV_{OFF} (F)	2	CW mode, V_{ref} = 1.65 V, R_F = 0.33 Ω	20	50	150	mV
		ΔV_{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 μA	V_{CC} – 0.5	—	—	V
	Output Voltage (L)	$V_{OFG\ (L)}$		Sink current : 10 μA	—	—	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	μA
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

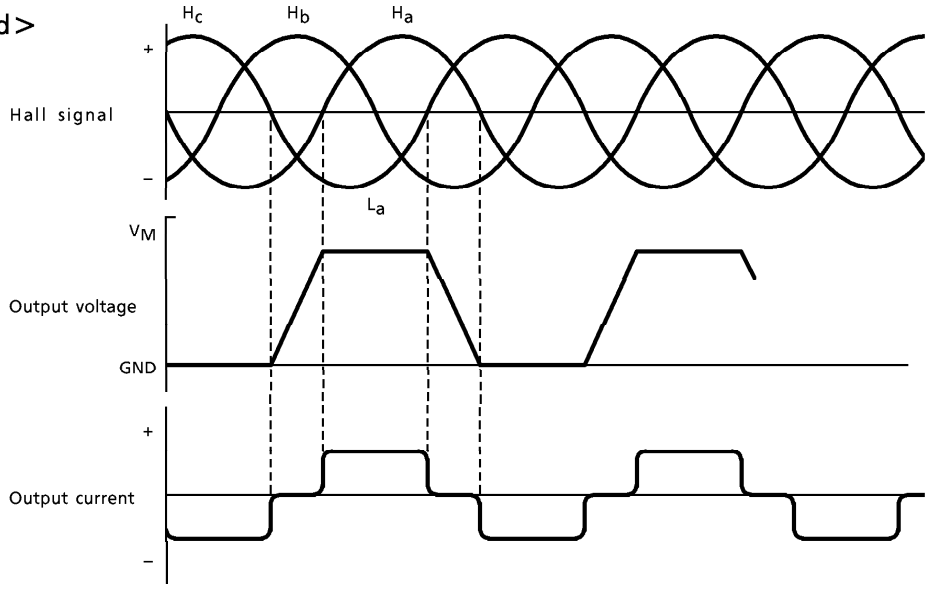
			FORWARD			REVERSE		
H_a	H_b	H_c	L_a	L_b	L_c	L_a	L_b	L_c
H	L	L	H	L	M	L	H	M
H	H	L	H	M	L	L	M	H
L	H	L	M	H	L	M	L	H
L	H	H	L	H	M	H	L	M
L	L	H	L	M	H	H	M	L
H	L	H	M	L	H	M	H	L

<Forward>
La = −(Hc − Ha)
Lb = −(Ha − Hb)
Lc = −(Hb − Hc)

<Reverse>
La = (Hc − Ha)
Lb = (Ha − Hb)
Lc = (Hb − Hc)

TIMING DIAGRAM

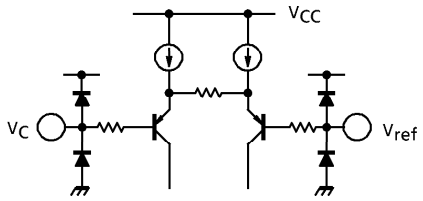
<Forward>



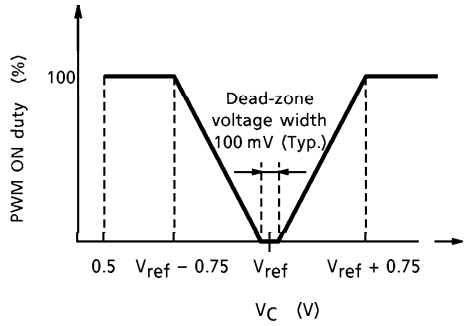
FUNCTIONAL DESCRIPTION

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

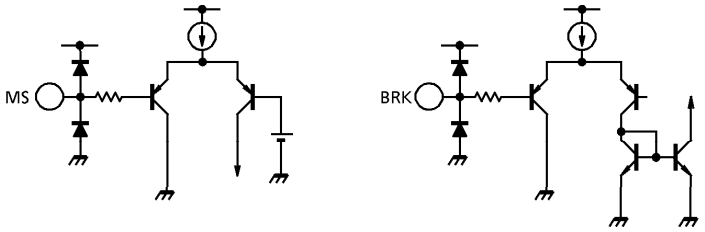
- Control amp input circuit



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

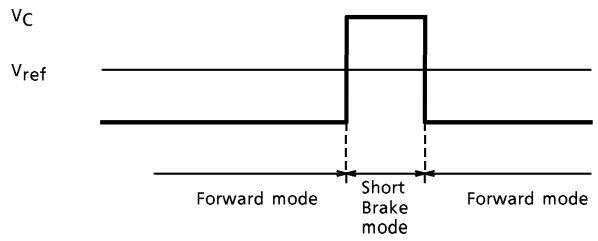
$V_C > V_{ref}$

		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)

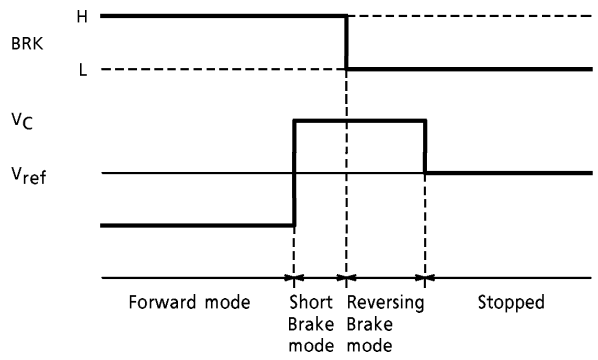
MS : H or L, BRK : H



(Reversing brake)

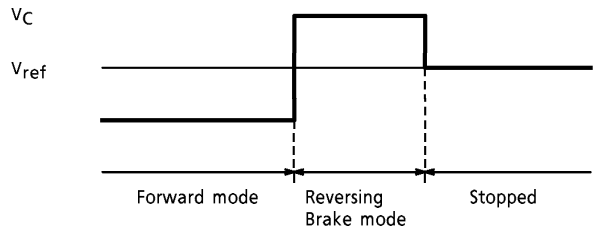
① When stopping the motor by applying a reversing brake after a short brake

MS : L



② When stopping the motor using Reversing Brake mode

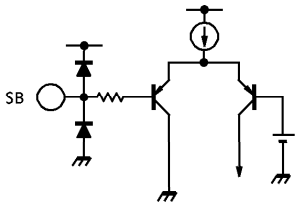
MS : L, BRK : L



(*) : 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.

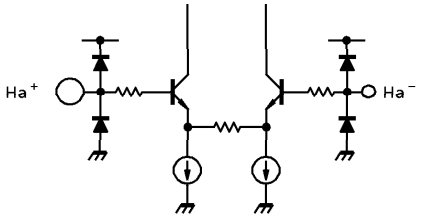
- Run / stop control circuit



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

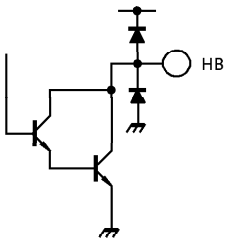
H : start
L : standby

- Hall amp circuit



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

- Hall element bias circuit

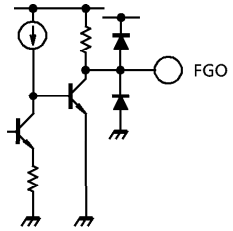


The hall element bias current is turned off when the driver IC is in standby state.
Make sure that the negative hall bias line is connected to the HB pin.
The remaining voltage is as follows :

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



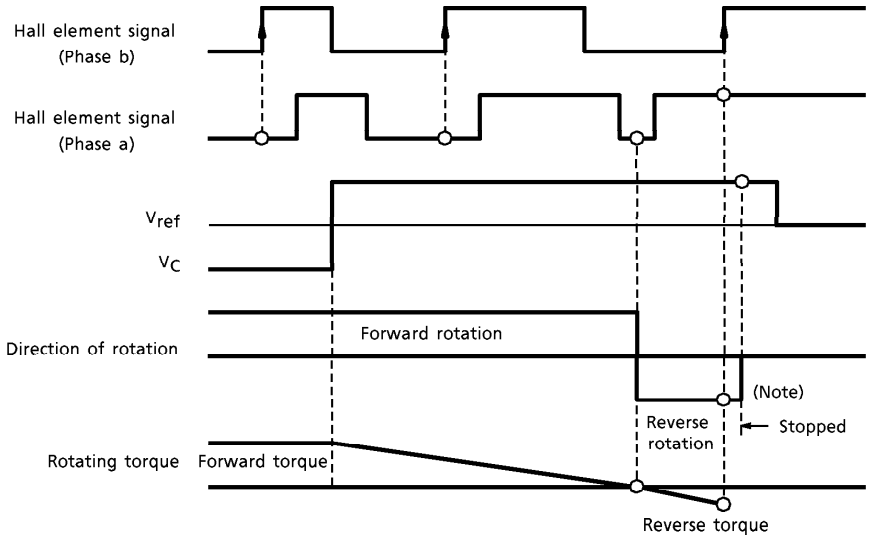
This circuit uses a hall element signal which is output to FGO after a Schmitt stage.
The FG amp has a hysteresis of 20 [mV_{p-p}] (typ.) and its output voltages are

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

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

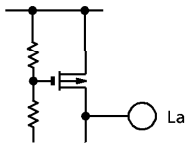
- Reverse rotation detection circuit

  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.

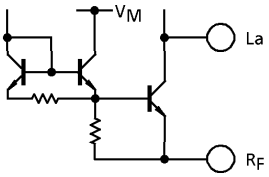


(Note) : Due to its inertial force, the motor does not stop immediately after the torque is reduced to 0.

- Output circuit

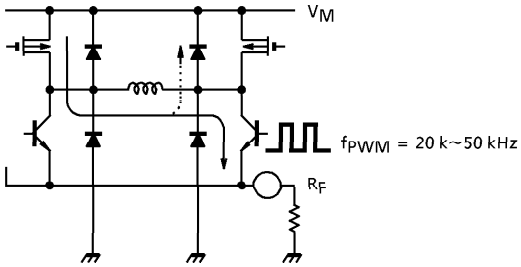


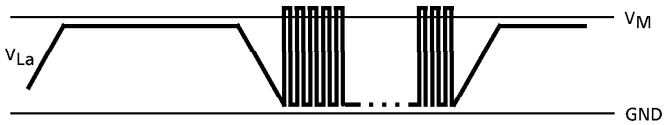
(Upper stage)



(Lower stage)

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.

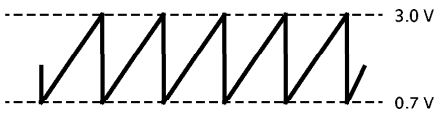




- Triangular wave oscillator circuit

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.

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



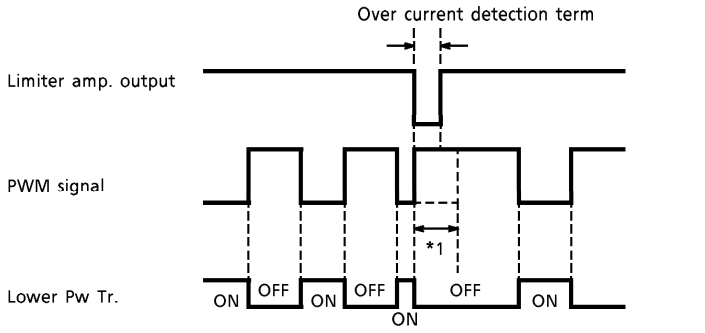
Taking into account efficiency considerations and the effects of noise, Toshiba recommends using the IC with an oscillation frequency of 20 kHz~50 kHz.

- Current limiter circuit

  The current limit value is determined by the equation below.

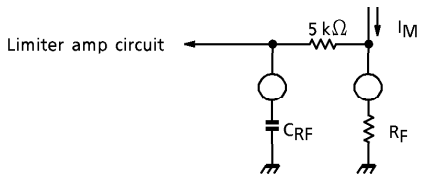
$$I_{LIM} \fallingdotseq \frac{0.3}{R_F + 0.1} \text{ [A] (Typ.)}$$

  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)

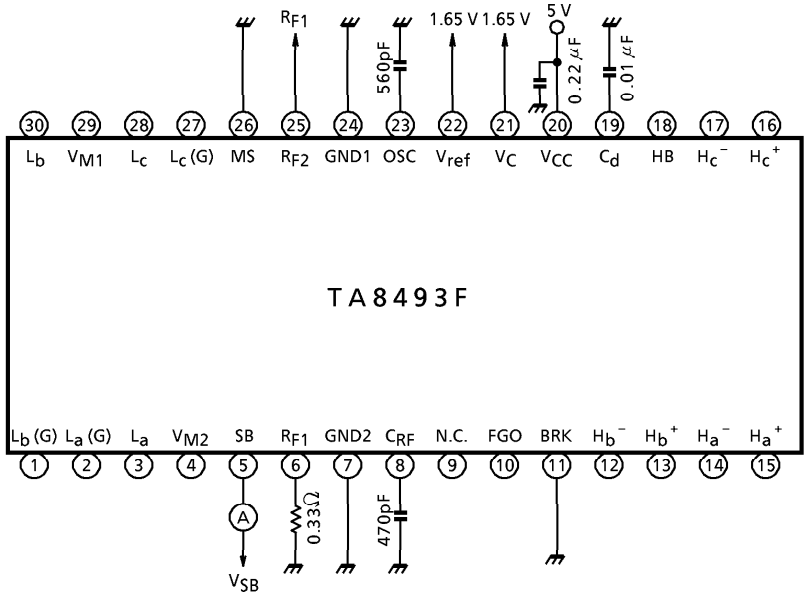
EXTERNAL PARTS

TERMINAL No.	FUNCTION	RECOMMENDED VALUE	REMARKS
C_1	Power supply line oscillation prevention	0.22 μF	—
C_2	Power supply line noise prevention	100 pF~1000 pF	(Note 1)
C_3	Power supply line noise prevention	10 μF~33 μF	(Note 1)
C_4	Filter	470 pF	—
C_5	Forward / reverse changeover gain adjustment	0.01 μF	(Note 2)
C_6	Triangular wave oscillation	470 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.

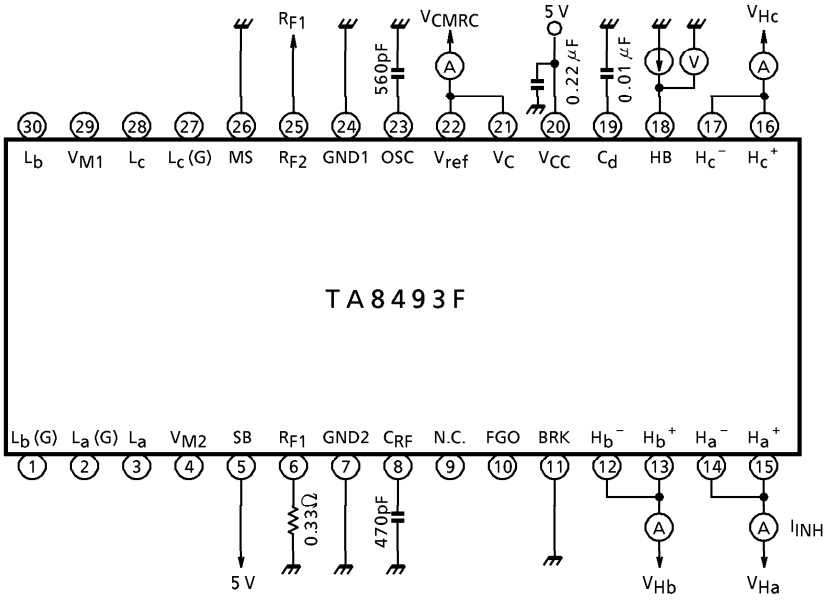
TEST CIRCUIT

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



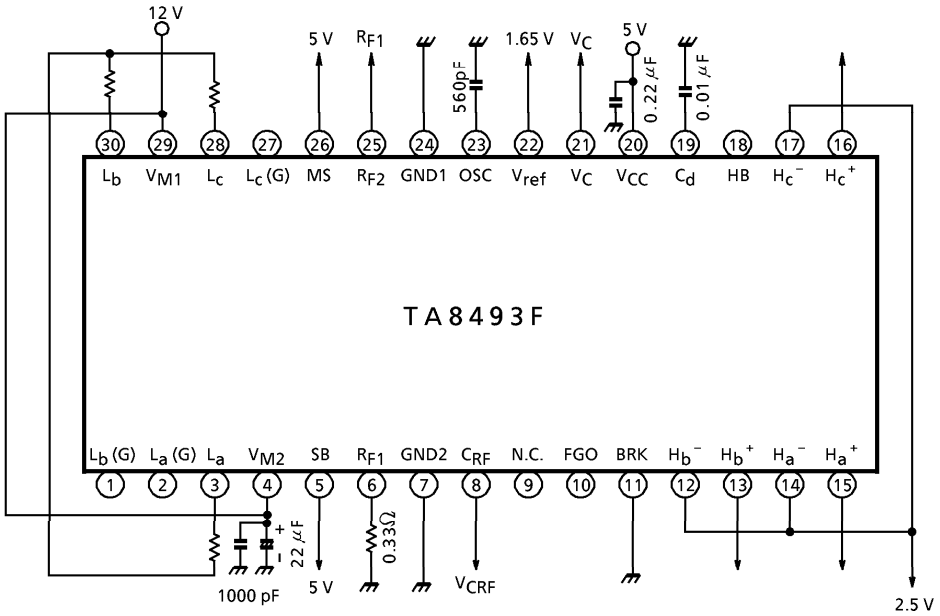
- I_{CC1} : V_{SB} = 0.5 V
- I_{CC2} : V_{SB} = 3.0 V
- $V_{INS\,(H)}$, $V_{INS\,(L)}$: Judged by the gap between I_{CC1} and I_{CC2}
- I_{INS} : V_{INS} = 0 V

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



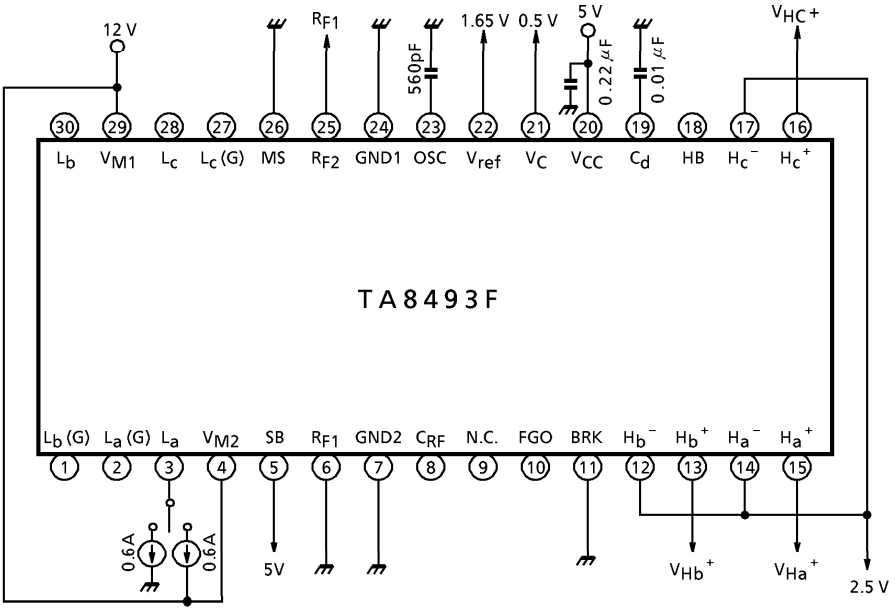
- I_{INH} : Total of a phase negative and positive input current.
  $V_{Ha} = V_{Hb} = V_{Hc} = 2.5\,V$
- V_{CMRH} : Measure the I_{INH} gap between $V_{Ha} = 1.5\,V$ and $V_{Ha} = 4.0\,V$.
  b and c phase are measured the same method.
- V_{HB} : $I_{HB} = 10\,mA$
- V_{INC} : Total of V_C and V_{ref}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



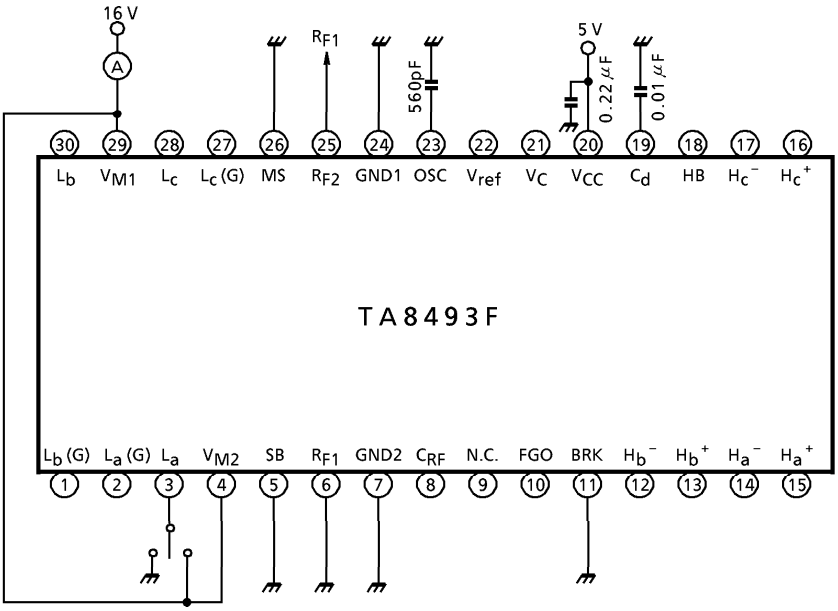
- $\Delta V_{OFF\,(F)}$: Measure V_{RF} at V_C = 1 .63 V / 1.5 V.
- $\Delta V_{OFF\,(R)}$: Measure V_{RF} at V_C = 1.67 V / 1.8 V.
- V_{LIM} : Switch the V_{CRF} from 0V to 0.4V.
  Measure the V_{CRF} at the point when output voltage level changes from low (L) to high (H)

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



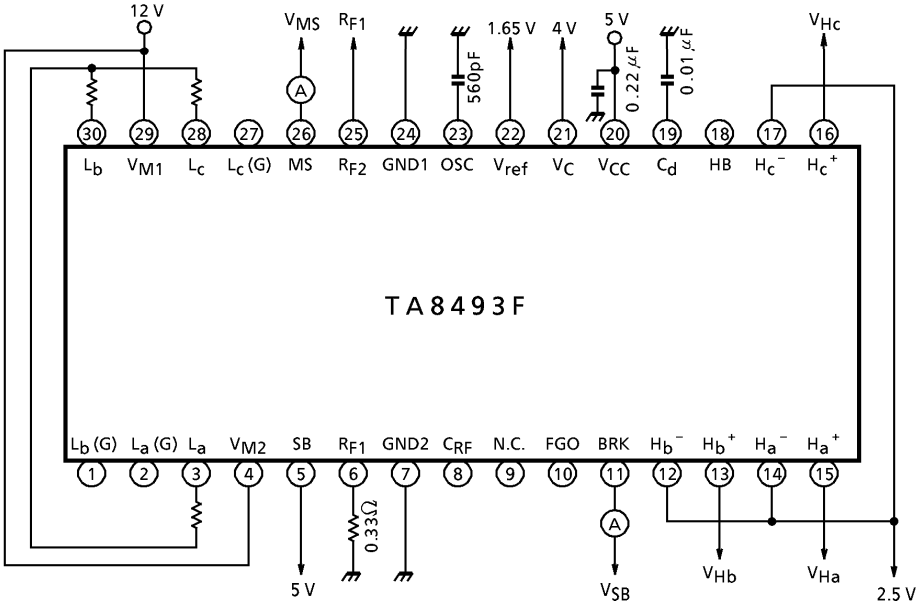
- $R_{ON\,(U)}$: Determined output function by V_{Ha}^+, V_{Hb}^+, V_{Hc}^+ (2.45 V / 2.55 V). Measure voltage value between V_M and L_a, and change to resistance valve. b phase and c phase are measured the same method.
- $V_{sat\,(L)}$: Determined output function by V_{Ha}^+, V_{Hb}^+, V_{Hc}^+ (2.45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

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



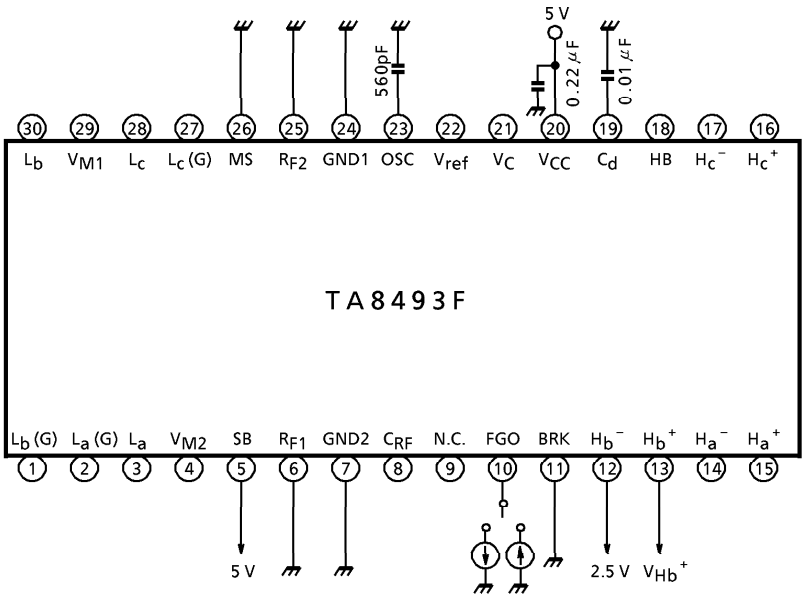
- $I_{L\,(U)}$: Measure I_M when L_a and GND are shorted. b phase and c phase are measured the same method.
- $I_{L\,(L)}$: Measure I_M when V_M and L_a are shorted. b phase and c phase are measured the same method.

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



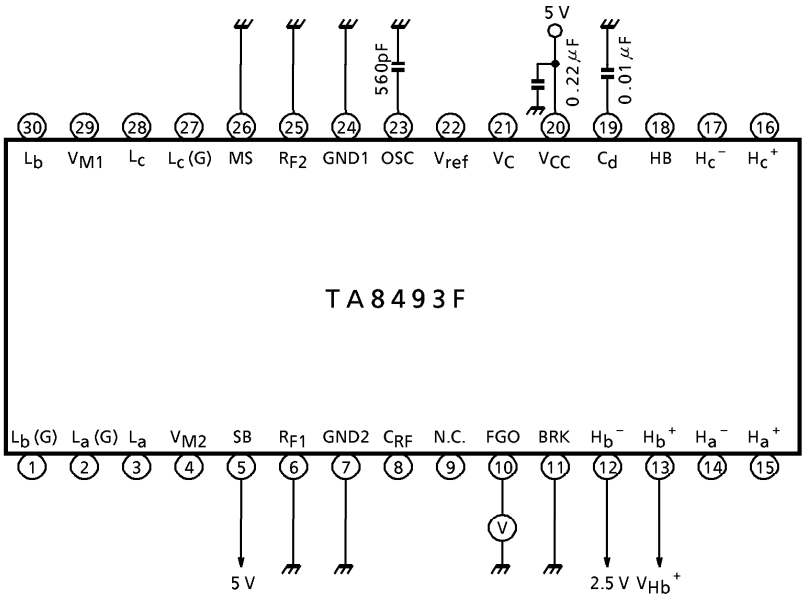
- $V_{MS\,(H)}$: V_{MS} = 3.0 V, V_{BRK} = 0 V, verify that output function is reverse mode.
- $V_{MS\,(L)}$: V_{MS} = 0.5 V, V_{BRK} = 0 V, switch from foward mode to reverse mode by V_{Ha}, V_{Hb} V_{Hc}. Verify that V_{RF} changes to zero.
- $I_{MS\,(L)}$: V_{MS} = 0 V, V_{BRK} = 0 V
- $V_{BRK\,(H)}$: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



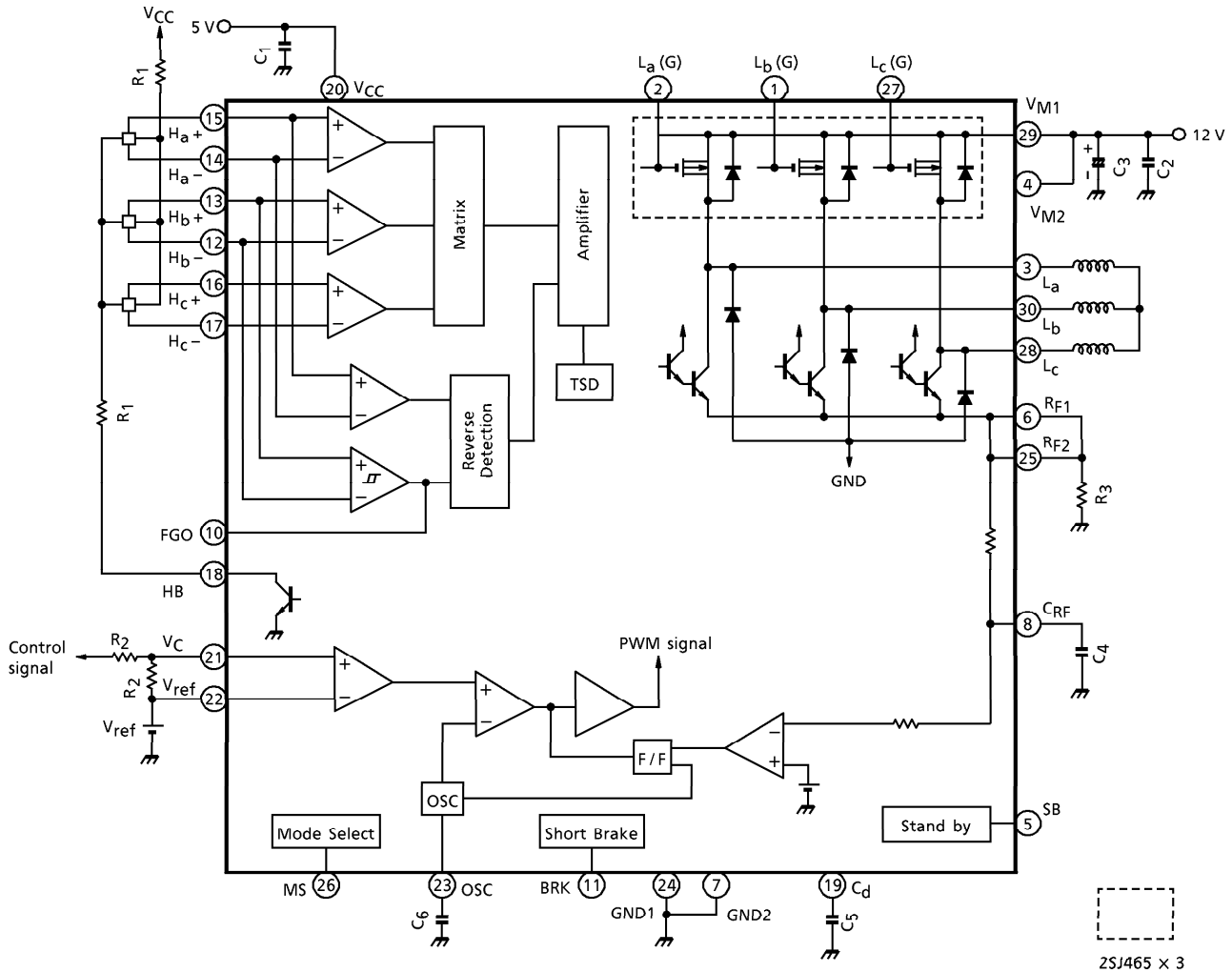
- $V_{OFG\,(H)}$: V_{Hb^+} = 2.53 V, I_{FGO} = 10 μA (source)
- $V_{OFG\,(L)}$: V_{Hb^+} = 2.47 V, I_{FGO} = 10 μA (sink)

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.

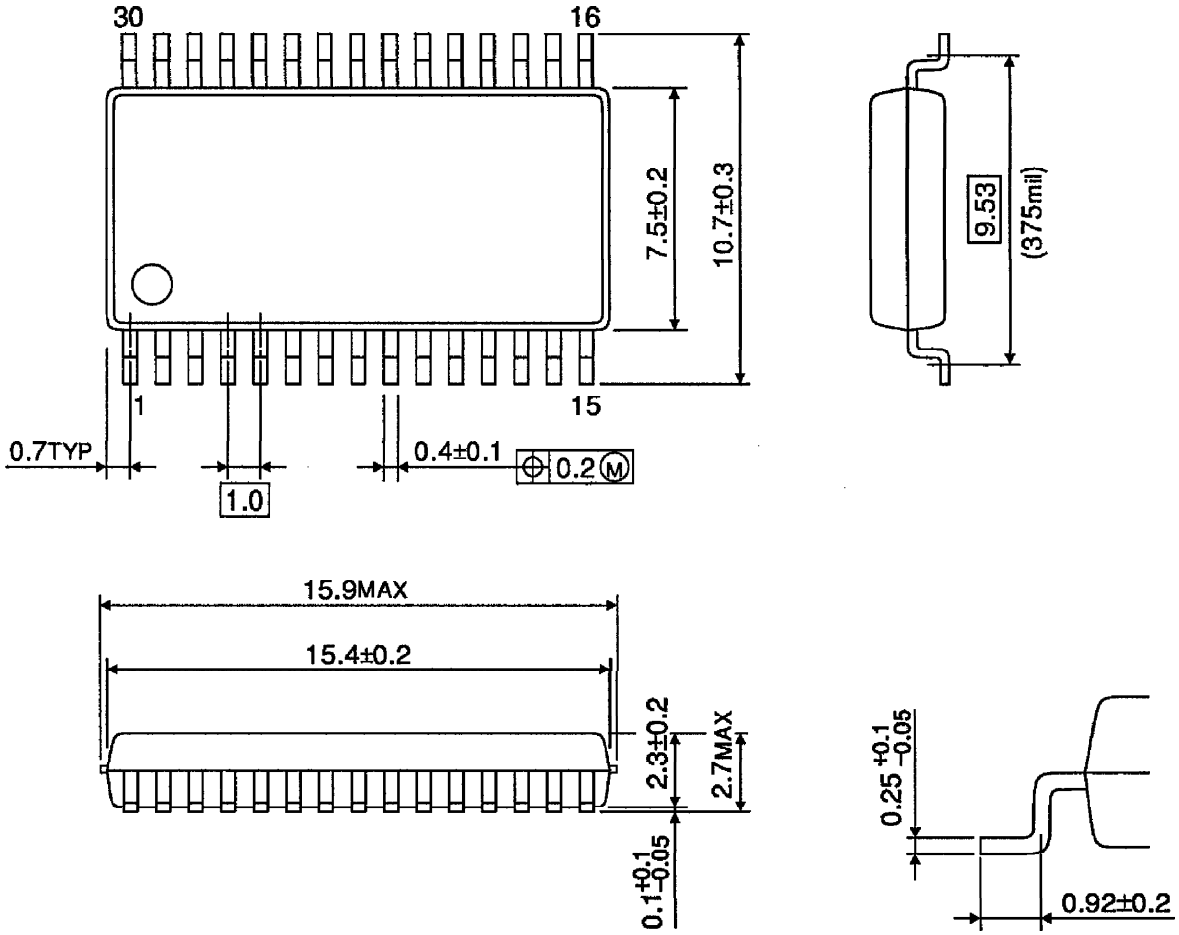
APPLICATION CIRCUIT



(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.

PACKAGE DIMENSIONS

SSOP30-P-375-1.00 Unit : mm



Weight : 0.63 g (Typ.)