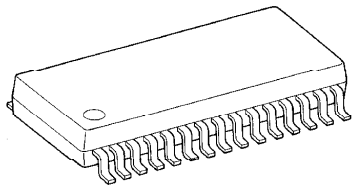
TOSHIBA BIPOLAR LINEAR INTEGRATED CIRCUIT MULTI-CHIP

TA8490F

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 TA8490F contains in its upper stage a discrete power transistor which, thanks to its low-saturation characteristic, 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.



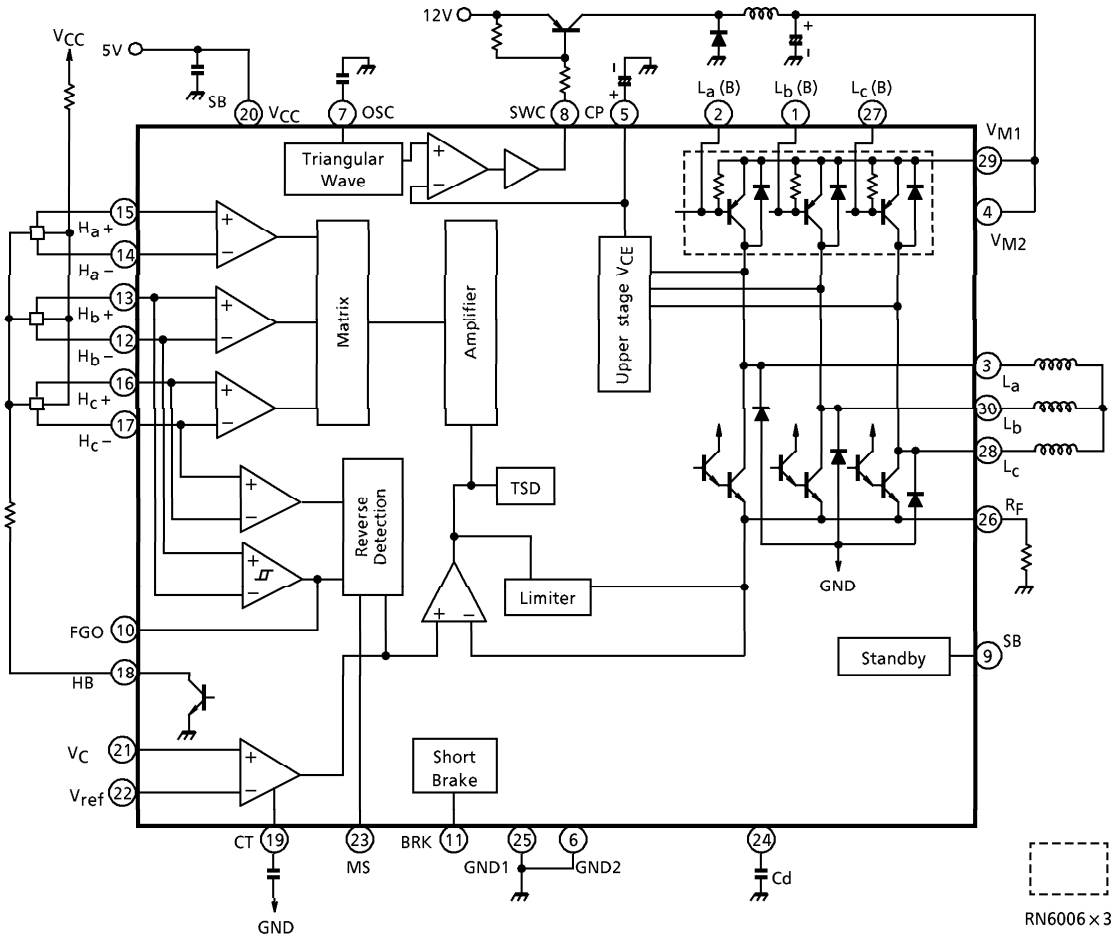
SSOP30-P-375-1.00

Weight : 0.63g (typ.)

FEATURES

- Multi-chip structure (3 RN6006 chips built-in)
- 3-phase, full-wave, semi-linear drive
- Current drive / current control
- Built-in current limiter : $I_{LIM} = 0.6A$ (typ.) (at $R_F = 0.3\Omega$)
- Built-in reversing brake / short brake functions
- FG signal output (using hall element output signal)
- Built-in switching regulator controller
- Built-in hall bias
- Built-in thermal shutdown circuit
- Package : MFP-30

BLOCK DIAGRAM



PIN ASSIGNMENT

TERMINAL No.	TERMINAL SYMBOL	FUNCTION	REMARKS
1	L_b (B)	b-phase upper side power transistor (base) output terminal	Keep open.
2	L_a (B)	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	CP	Switching power source system phase compensator terminal	Connect a capacitor between this terminal and GND.
6	GND2	GND	—
7	OSC	Triangular wave oscillation terminal	Connect a capacitor between this terminal and GND.
8	SWC	Switching regulator control signal output terminal	Connect to the base of the switching external transistor.
9	SB	RUN / STOP control terminal	H: RUN, L: STOP
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	CT	Control system phase compensator terminal	Connect a capacitor between this terminal and GND.
20	V_{CC}	Supply voltage terminal for control circuits	$V_{CC\ (opr)} = 4.5 \sim 5.5V$

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	MS	Mode select terminal	Determines output mode.
24	Cd	Forward / reverse changeover gain adjustment terminal	Adjust a rotation direction changeover gain
25	GND1	GND	—
26	R_F	Output current detection terminal	Sets limiter current value and current gain.
27	L_c (B)	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	3~14	

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

CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITION	MIN	TYP.	MAX	UNIT
Supply Voltage		I_{CC1}	1	Stop mode	—	2	4.5	mA
		I_{CC2}		Run mode, output open	—	7	15	
Hall Amp.	Input Current	I_{INH}	2	V_{CMRH} = 2.5V	—	—	2	μA
	Common Mode Input Voltage Range	V_{CMRH}		—	1.5	—	4.0	V
	Input Amplitude	V_H	—	—	60	—	—	mV_{p-p}
Hall Element Bias Saturation Voltage		V_{HB}	2	I_{HB} = 10mA	—	1.3	2.0	V
Control Amp.	Common Mode Input Voltage Range	V_{CMRC}	2	—	1.0	—	4.0	V
	Input Current	I_{INC}	2	$V_C = V_{ref}$ = 2.5V	—	—	5.0	μA
	Dead Zone Voltage Width	V_{DZ}	—	V_{REF} = 2.5V, R_F = 0.3Ω	—	100	—	mV
	Input Offset Voltage	ΔV_{OFF} (F)	3	CW mode, V_{ref} = 2.5V, R_F = 0.3Ω	20	50	150	mV
		ΔV_{OFF} (R)		CCW mode, V_{ref} = 2.5V, R_F = 0.3Ω	20	50	150	
Current Limit Amp.	Limit Current	I_{LIM}	3	R_F = 0.3Ω	480	600	720	mA
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	—	—	1	μA
Output Circuit	Saturation Voltage (Upper Side)	V_{sat} (U)	4	I_o = 0.6A	—	0.1	1.3	V
	Saturation Voltage (Lower Side)	V_{sat} (L)	4	I_o = 0.6A	—	0.6	1.0	
	Cut-off Current (Upper Side)	I_L (U)	5	V_L = 16V	—	—	10	μA
	Cut-off Current (Lower Side)	I_L (L)	5	V_L = 16V	—	—	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)	6	Reversing brake mode $V_C > V_{ref}$, BRK : L	—	—	0.5	
	Input Current	I_{INMS}	6	V_{MS} = GND	—	—	1	μA

CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITION	MIN	TYP.	MAX	UNIT
FG Amp.	Hysteresis Voltage	V_{HYS}	6	—	5	20	45	mV_{p-p}
	Output Voltage (H)	$V_{OFG\ (H)}$	7	Source current : 10μA	V_{CC} – 0.5	—	—	V
	Output Voltage (L)	$V_{OFG\ (L)}$	7	Sink current : 10μA	—	—	0.5	
Short Brake Circuit	Input Voltage (H)	$V_{BRK\ (H)}$	6	—	3.0	—	V_{CC}	V
	Input Voltage (L)	$V_{BRK\ (L)}$	6	—	—	—	0.5	
	Input Current	I_{INBRK}	6	V_{BRK} = GND	—	—	1	μA
Triangular Oscillation Circuit	Oscillation Frequency	f_{OSC}	—	C = 250pF (Note)	—	100	—	kHz
	Charge Current	I_{OSC}^{+}	7	V_{OSC} = 1.8V	50	100	200	μA
	Discharge Current	I_{OSC}^{-}	7	V_{OSC} = 3.2V	– 200	– 100	– 50	μA
SW-REG Control Circuit	Saturation Voltage	$V_{sat\text{-}sw}$	8	I_{sw} = 20mA	—	1.0	3.0	V
Thermal Shut-down Operating Temperature		T_{SD}	—	Junction temperature (according to design specification) (Note)	—	175	—	°C

(Note) this is not tested.

FUNCTION TABLE

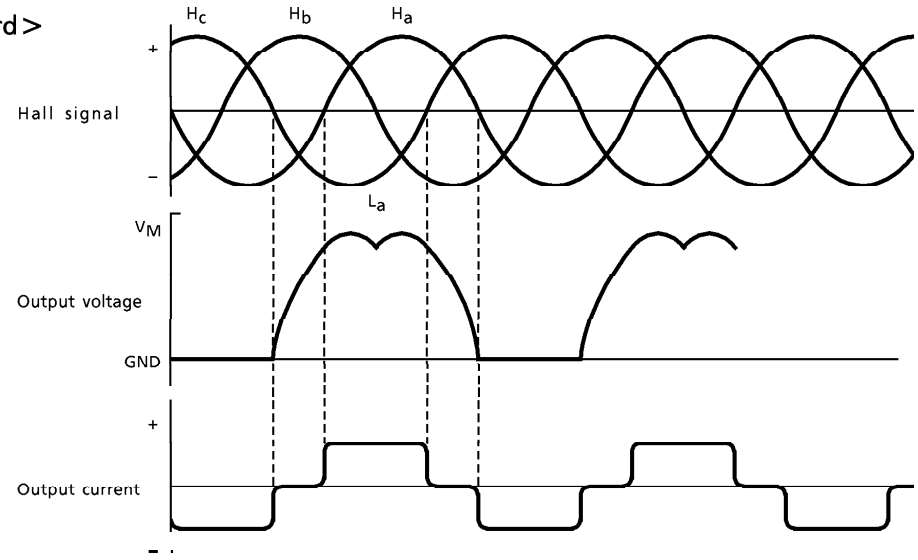
			FORWARD			REVERSE		
H_a	H_b	H_c	L_a	L_b	L_c	L_a	L_b	L_c
H	L	L	H	L	M	L	H	M
H	H	L	H	M	L	L	M	H
L	H	L	M	H	L	M	L	H
L	H	H	L	H	M	H	L	M
L	L	H	L	M	H	H	M	L
H	L	H	M	L	H	M	H	L

<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

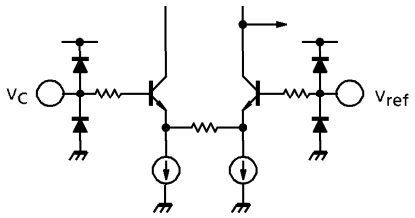
<Forward>



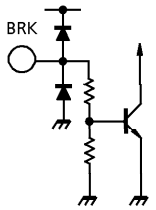
FUNCTIONAL DESCRIPTION

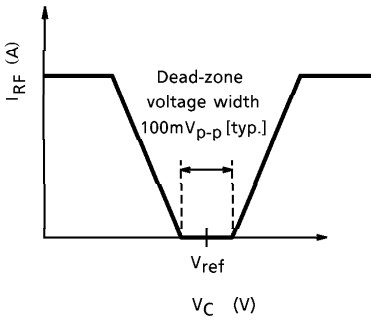
This IC is a 3-phase, full-wave brushless DC motor driver of the current-control / current-drive type. It contains in its upper stage a PNP discrete power transistor, which, because of the Multi-Chip Package (MCP) structures provides high torque and thermal efficiency.
In addition, when combined with a switching regulator, its efficiency can be increased still further.

- Control amp input circuit



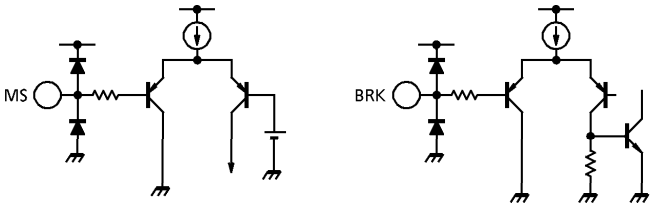
The Common mode input voltage ranges for both V_C and V_{ref} are 1.0 to 4.0V.
The control input-to-drive output gain is 1.0A / V (typ.), whose characteristic is shown below.
The input is provided with a dead-zone area whose voltage width is 100mV (typ.).





$$g_m = \frac{\Delta I_{RF}}{\Delta V_C} = 1.0\ [A/V]\ (typ.)\quad (at\ R_F = 0.3\Omega)$$

- 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

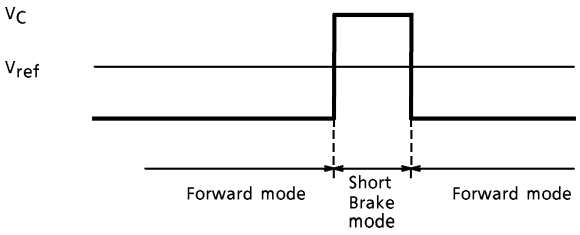
$V_C > V_{ref}$

		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)

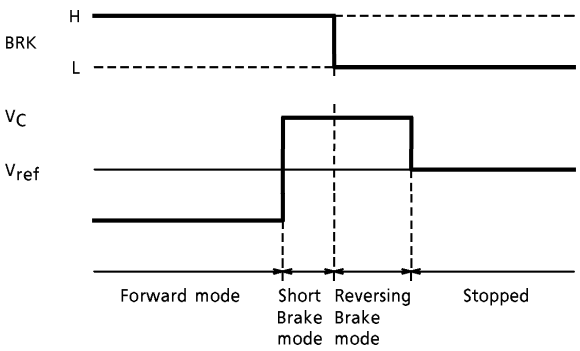
MS : H or L, BRK : H



(Reversing brake)

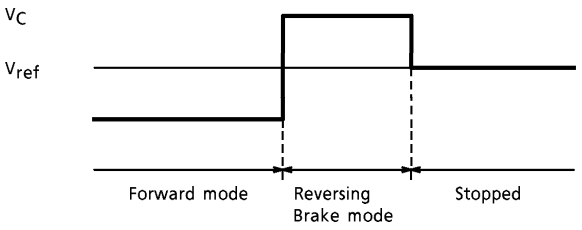
① When stopping the motor by applying a reversing brake after a short brake

MS : L



② When stopping the motor using Reversing Brake mode

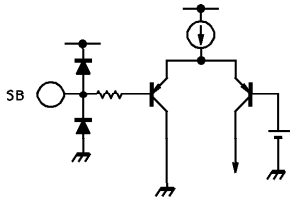
MS : L, BRK : L



(*) 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.

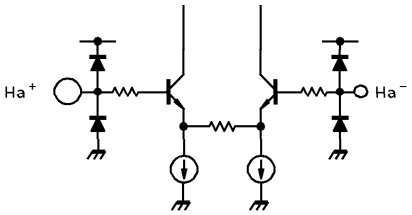
- Run / stop control circuit



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

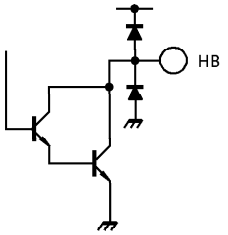
H : start
L : standby

- Hall amp circuit



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

- Hall element bias circuit

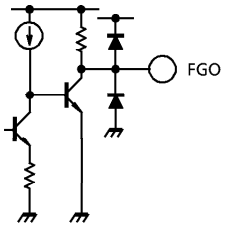


The hall element bias current is turned off when the driver IC is in standby state.
Make sure that the negative hall bias line is connected to the HB pin.
The remaining voltage is as follows :

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

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



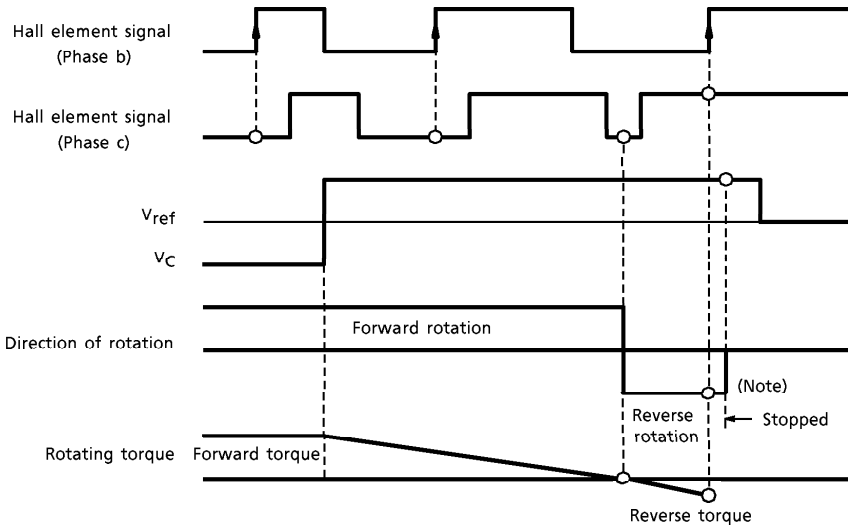
This circuit uses a hall element signal which is output to FGO after a Schmitt stage.
The FG amp has a hysteresis of 20 [mV_{p-p}] (typ.) and its output voltages are

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

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

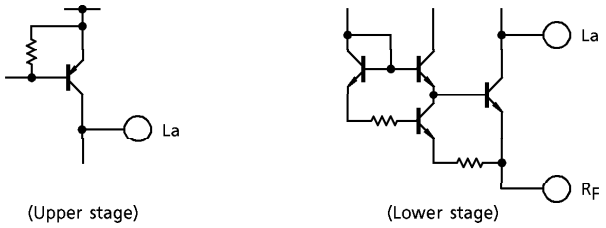
- Reverse rotation detection circuit

  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 power transistor's base current to regulate the circuit's output current. The upper-stage power transistor consists of a PNP discrete transistor (RN6006), which gives high torque efficiency.

- Current limiter circuit

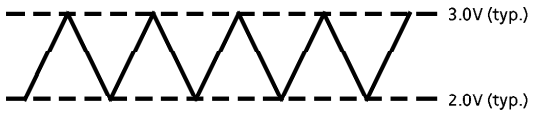
  The current limit value is determined by the equation below.

$$I_{LIM} \fallingdotseq \frac{0.24}{R_F + 0.1} \text{ [A] (typ.)}$$

- Triangular wave oscillator circuit

  Triangular waves are generated by connecting a capacitor between the OSC pin and GND. The charging / discharging currents are $\pm 50\mu A$, and the oscillation frequency is as follows :

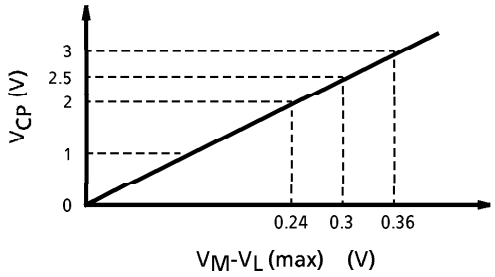
$$f_{OSC} = \frac{100\ (\mu A)}{2 \times C\ (pF)}\ [Hz]$$



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

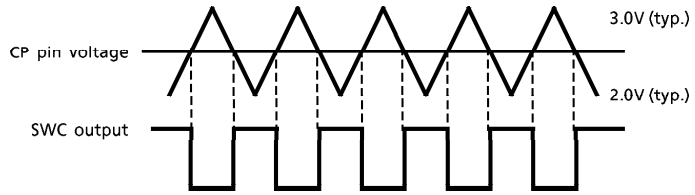
- V_M output voltage (3-phase maximum) detection circuit

  This circuit selects the highest voltage from the three phases of output voltages and then outputs the voltage difference between the selected voltage and V_M as a voltage referenced to GND (V_{CE} for the upper output stage).
  This voltage is filtered by a capacitor at the CP pin and compared with the triangular wave before being output on the SWC pin.
  When using a switching regulator, the driver IC operates in a closed loop with a V_{CE} of 0.3V (typ.) for the upper output stage.



- Switching regulator control signal output circuit

  This circuit outputs the result of comparison between V_{CE} for the upper stage and the triangular wave from one of the open-collector output terminals. By controlling an external PNP transistor in this way, the circuit controls V_M.
  The output function is as follows :



- Thermal shut down circuit

  This circuit turns off output when $T_j = 175°C$ (typ.) (according to design specification).

EXTERNAL PARTS

TERMINAL No.	FUNCTION	RECOMMENDED VALUE	REMARKS
C_1	Control system phase correction	0.01μF	Note 1
C_2	Triangular wave oscillation	250pF	See Page 12.
C_3	Power supply line oscillation prevention	0.22μF	—
C_4	Filter	1μF (Electrolytic capacitor)	Note 2
C_5	Forward / reverse changeover gain adjustment	0.01μF	Note 3
C_6	For switching regulator	100μF (Electrolytic capacitor)	—
R_1	Hall element bias	—	Note 4
R_2	Control amp reference voltage	—	Note 5
R_3	Output current detection	0.3Ω	See Page 11.
R_4	Base current control for switching regulator PNP transistor	1kΩ	Note 6
R_5	Leakage absorption of switching regulator PNP transistor	10kΩ	Note 7
L_1	For switching regulator	68μH	—

Note 1: Check carefully to see that there is no output oscillation.

Note 2: This is used to filter the output of the difference between the three-phase output voltage and V_M.

Note 3: This is used to adjust the rotation direction changeover gain.
The capacitance valve and the gain are in inverse.
This capacitance is to prevent from output through current.

Note 4: 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 characteristics.

Note 5: This voltage must be set to fall within the Common mode input voltage range of the control amp. Toshiba recommends setting it to $V_{CC/2}$.
Also, consider the Vref pin's input current: 1.3μA (typ.) (when $V_C \ll V_{ref}$) when setting the resistance value.

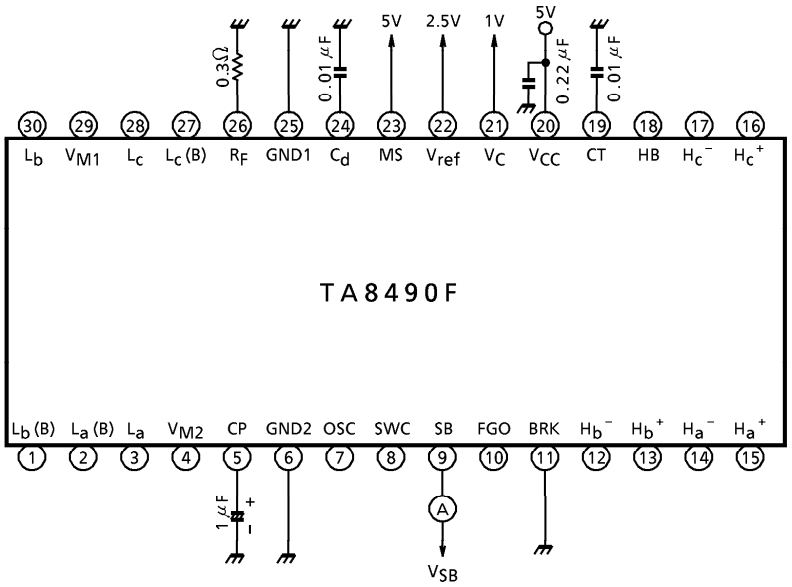
Note 6: The SWC pin is an open-collector, so that when the internal transistor saturates, its switching characteristic is degraded. Toshiba recommends that when SWC is low, its pin voltage should be 2V or above.

Note 7: The external PNP transistor used for the switching regulator has its offset voltage determined by this resistance. Use a resistance of between several kΩ and 10kΩ according to the switching characteristics.

(*) Tr.1 : 2SA1241
D1 : U1GWJ44

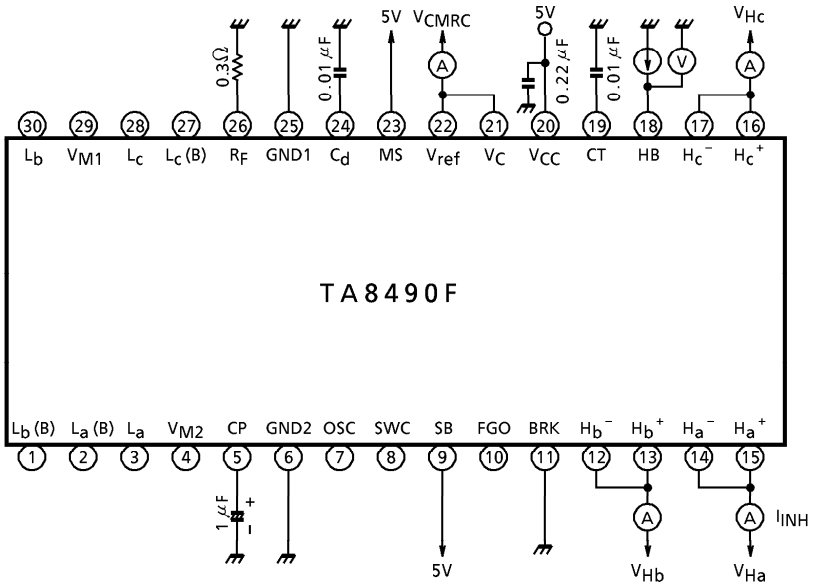
TEST CIRCUIT

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



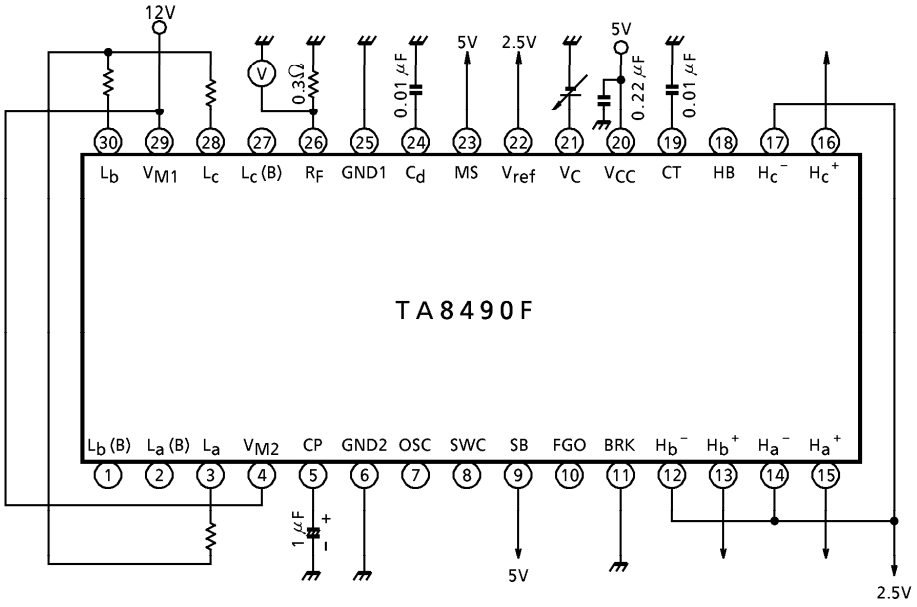
- I_{CC1} : $V_{SB} = 3.0V$
- I_{CC2} : $V_{SB} = 0.5V$
- $V_{INS\,(H)}$, $V_{INS\,(L)}$: Jndged by the gap between I_{CC1} and I_{CC2}
- V_{INS} : $V_{INS} = 0V$

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



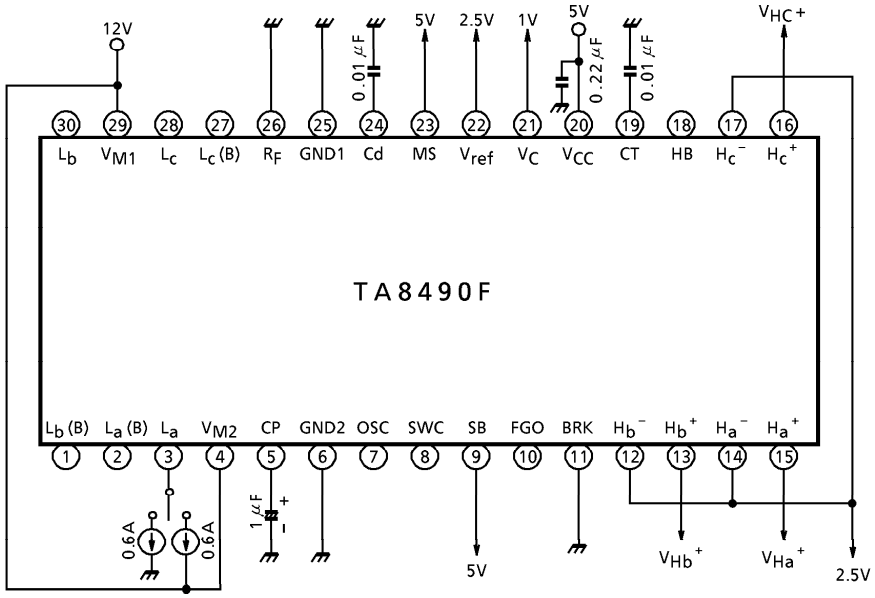
- I_{INH} : Total of a phase negative and positive input current.
  $V_{Ha} = V_{Hb} = V_{Hc} = 2.5V$
- V_{CMRH} : Measure the I_{INH} gap between $V_{Ha} = 1.5V$ and $V_{Ha} = 4.0V$.
  b and c phase are measured the same method.
- V_{HB} : $I_{HB} = 10mA$
- V_{INC} : Total of V_C and V_{ref} input current. At $V_{CMRC} = 2.5V$.
- V_{CMRC} : Measure the I_{INC} gap between $V_{CMRC} = 1.0V$ and $V_{CMRC} = 4.0V$.

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



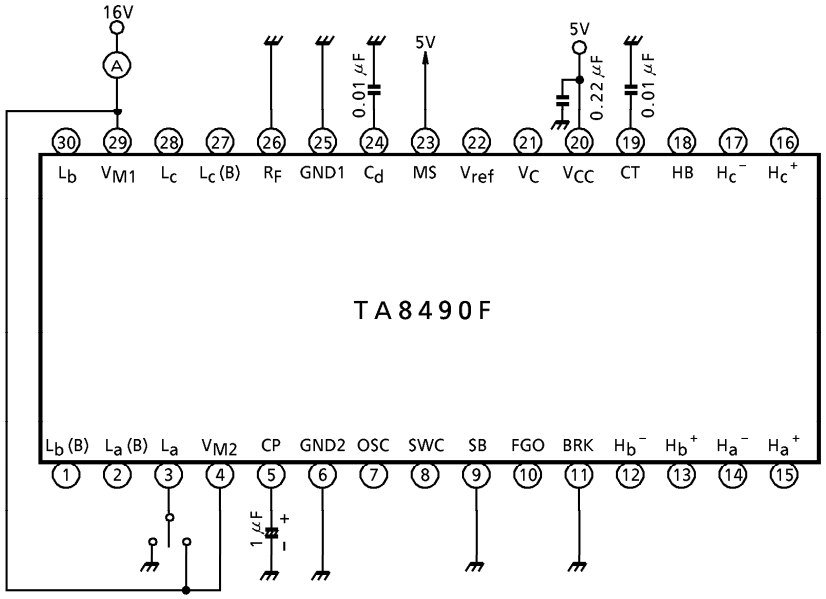
- $\Delta V_{OFF\,(F)}$: Measure V_{RF} at V_C = 2.48V / 2.35V.
- $\Delta V_{OFF\,(R)}$: Measure V_{RF} at V_C = 2.52V / 2.65V.
- I_{LIM} : Change to current value after measuring V_{RF} at V_C = 1.0V

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



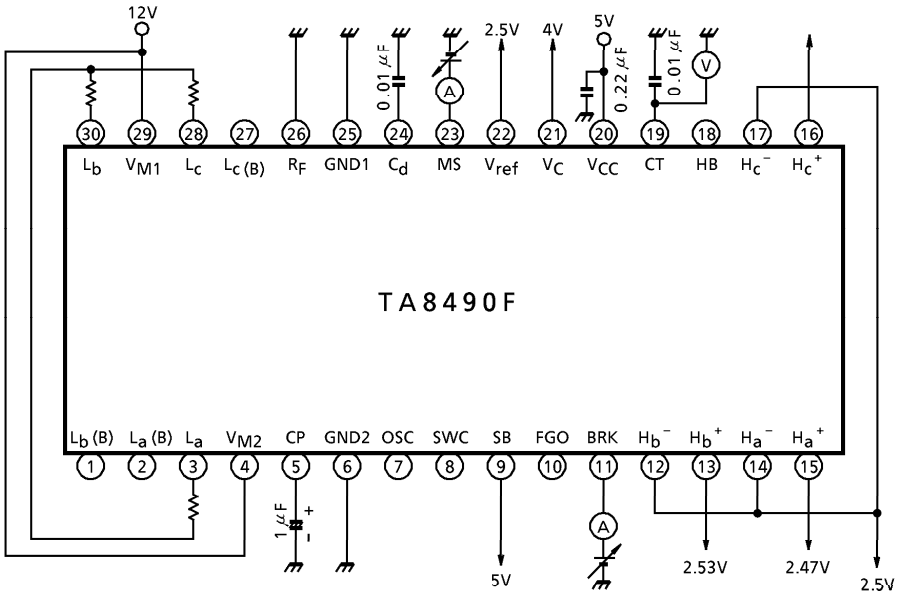
- $V_{sat\,(U)}$: Determined output function by $V_{Ha}{}^+$, $V_{Hb}{}^+$, $V_{Hc}{}^+$ (2.4V / 2.6V). Measure voltage value between V_M and L_a. b phase and c phase are measured the same method.
- $V_{sat\,(L)}$: Determined output function by $V_{Ha}{}^+$, $V_{Hb}{}^+$, $V_{Hc}{}^+$ (2.4V / 2.6V). Measure voltage value between L_a and GND. b phase and c phase are measured the same method.

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



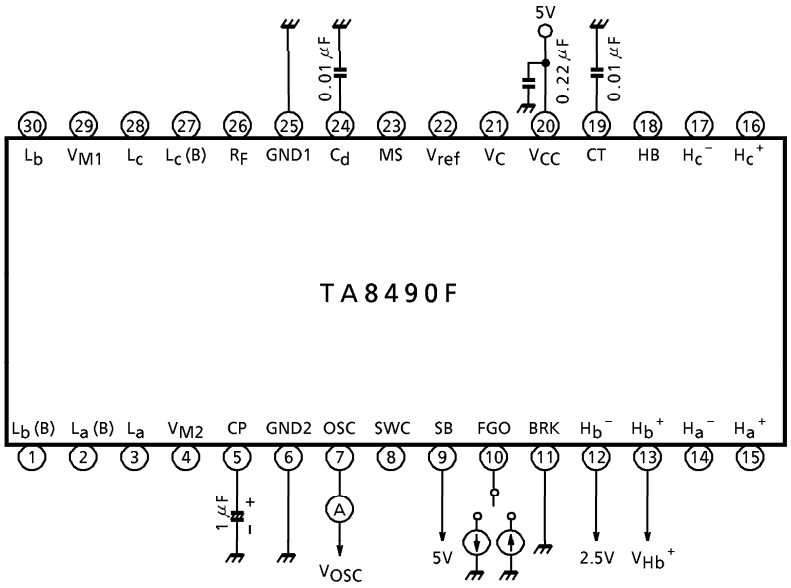
- $I_{L\,(U)}$: Measure I_M when L_a and GND are shortted. b phase and c phase are measured the same method.
- $I_{L\,(L)}$: Measure I_M when V_M and L_a are shortted. b phase and c phase are measured the same method.

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



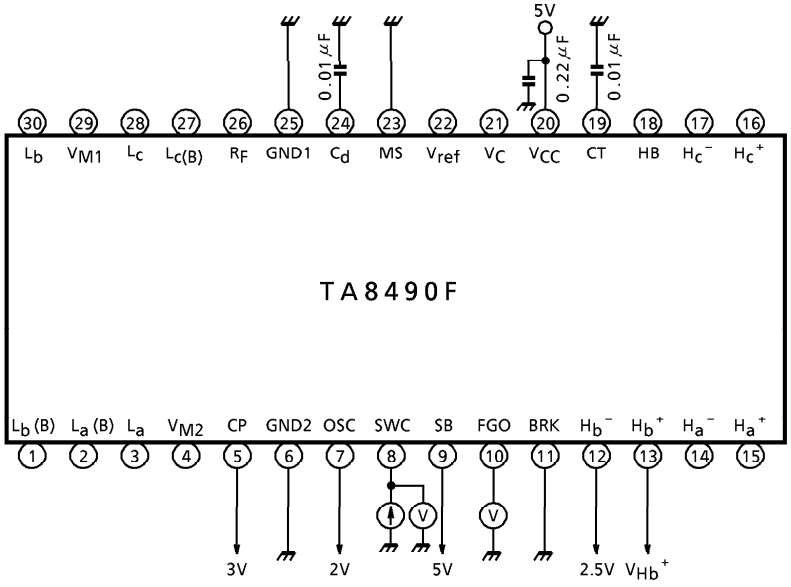
- $V_{MS\,(H)}$: $V_{MS} = 3.0V$, $V_{BRK} = 0V$, verify that output function is reverse mode.
- $V_{MS\,(L)}$: $V_{MS} = 0.5V$, $V_{BRK} = 0V$, verify that $V_{CT} \fallingdotseq 0V$
- $I_{MS\,(L)}$: $V_{MS} = 0V$, $V_{BRK} = 0V$
- $V_{BRK\,(H)}$: $V_{MS} = 5V$, $V_{BRK} = 3.0V$, verify that $L_a = L_b = L_c$: H
- $V_{BRK\,(L)}$: $V_{MS} = 5V$, $V_{BRK} = 0.5V$, verify that output function is reverse mode.

7. $V_{OFG\ (H)}$, $V_{OFG\ (L)}$, I_{OSC}^{+}, I_{OSC}^{-}



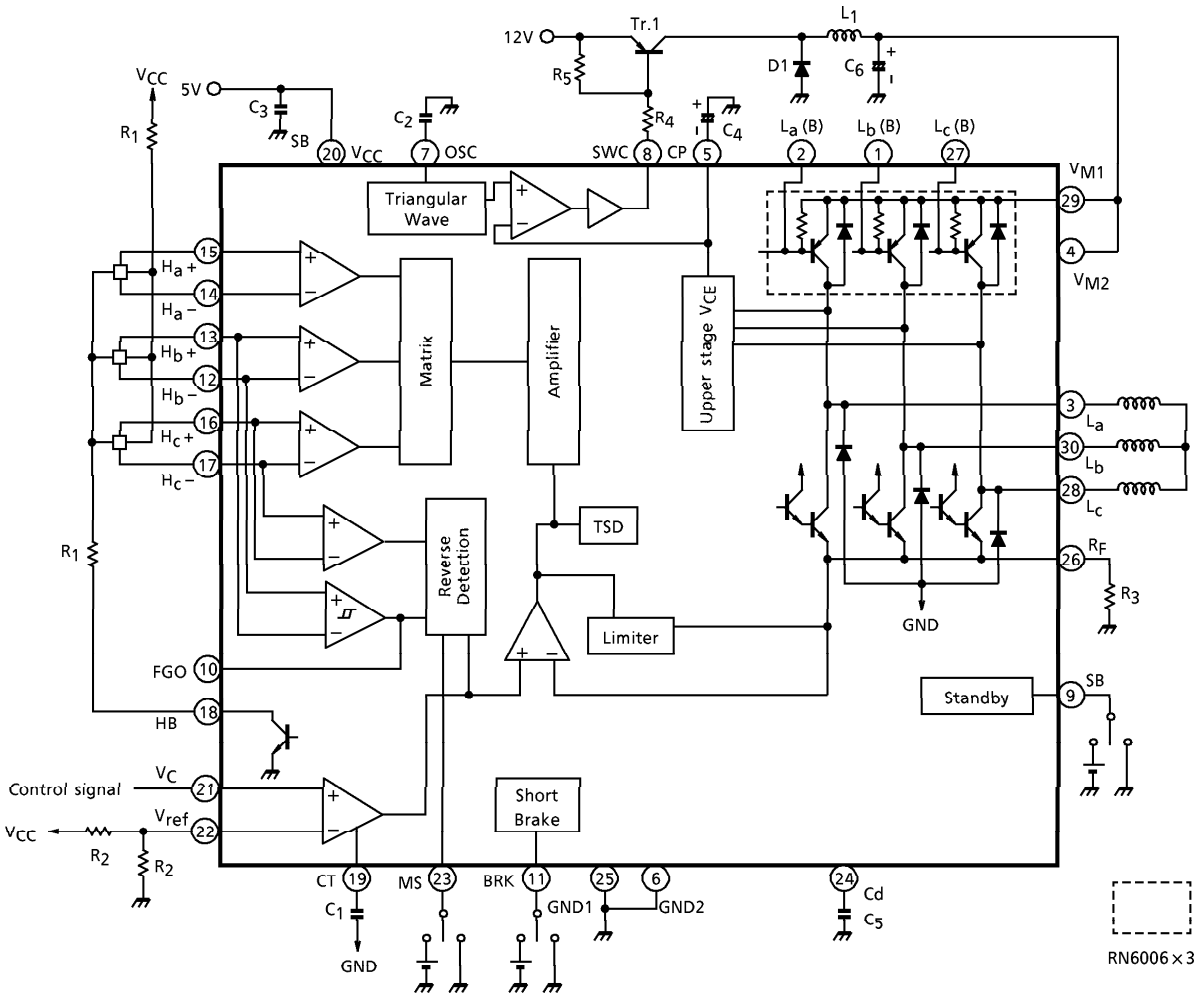
- $V_{OFG\ (H)}$: $V_{Hb}^{+} = 2.53V$, $I_{FGO} = 10\mu A$ (source)
- $V_{OFG\ (L)}$: $V_{Hb}^{+} = 2.47V$, $I_{FGO} = 10\mu A$ (sink)
- I_{OSC}^{+} : $V_{OSC} = 2V$
- I_{OSC}^{-} : $V_{OSC} = 3V$

8. $V_{sat\text{-}sw}$, V_{HYS}



- $V_{sat\text{-}sw}$: $I_{swc} = 20mA$
- 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.

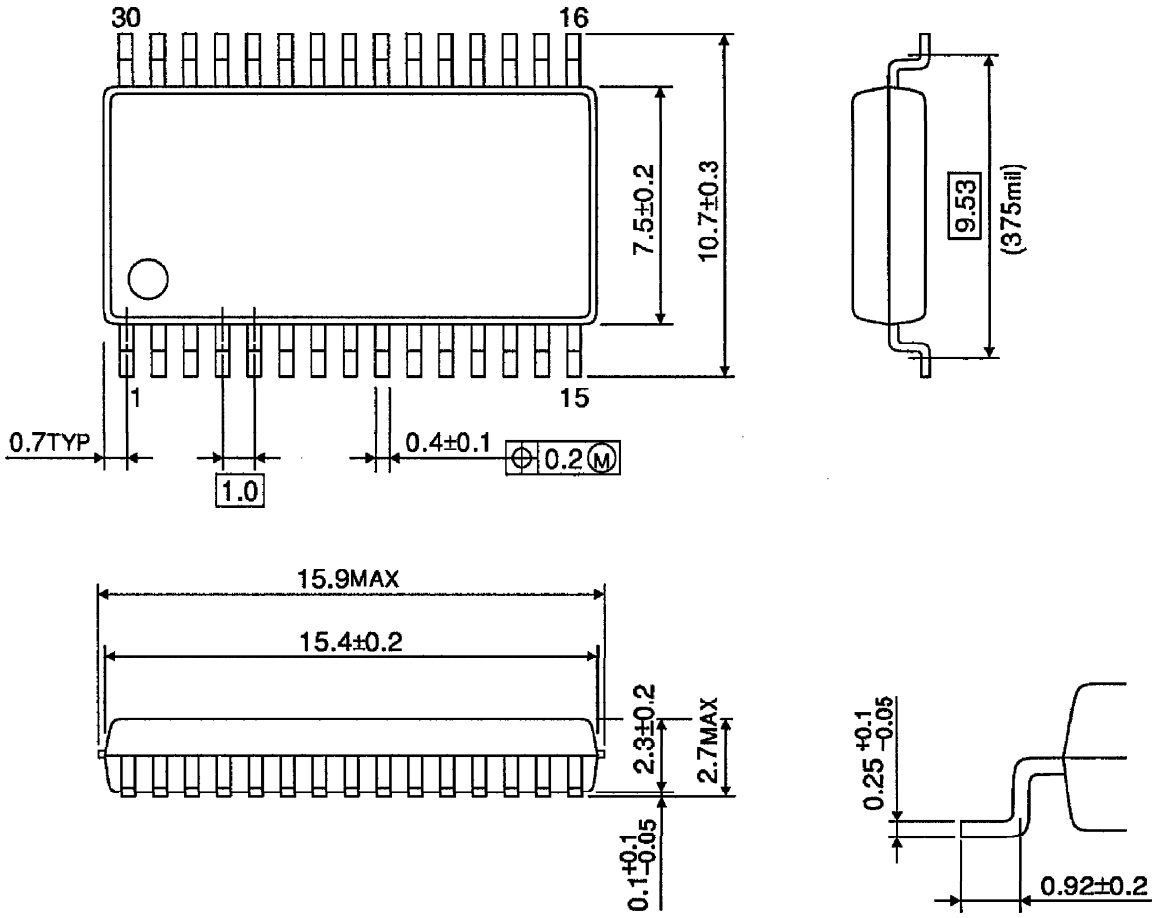
APPLICATION CIRCUIT



OUTLINE DRAWING

SSOP30-P-375-1.00

Unit : mm



Weight : 0.63g (Typ.)