

**TENTATIVE**

TOSHIBA Bi-CMOS Integrated Circuit Silicon Monolithic

# TB6598FN/FNG

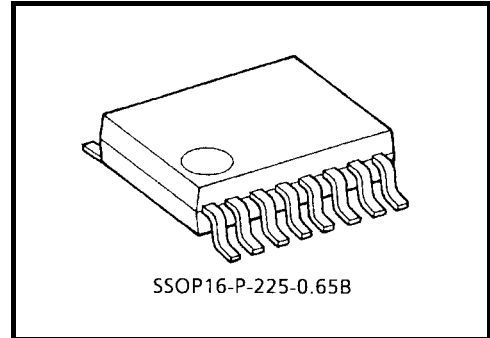
## Dual Full-Bridge Driver for Stepping Motors

The TB6598FN/FNG is a 2-phase bipolar stepping motor driver employing an LDMOS structure with low ON-resistance for output drive transistors. By applying four input signals (EN1, EN2, IN1, IN2), it is possible to control the rotation direction (forward/reverse) of 2-phase/1-2-phase stepper motor.

It is also possible to achieve constant-current drive (PWM chopper drive).

### Features

- Motor supply voltage:  $V_M \leq 15$  V (max)
- Control supply voltage:  $V_{CC} = 2.7$  V to 6 V
- Output current:  $I_{out} \leq 0.8$  A (max)
- Low ON-resistance:  $1.5 \Omega$  (upper side + lower side typ. @  $V_M = 5$  V)
- Constant-current control (PWM chopper drive)
- Standby (power-saving) mode
- On-chip thermal shutdown circuit (TSD)
- Compact package: SSOP-16



SSOP16-P-225-0.65B

Weight: 0.07 g (typ.)

#### TB6598FNG:

TB6598FNG is a Pb-free product.

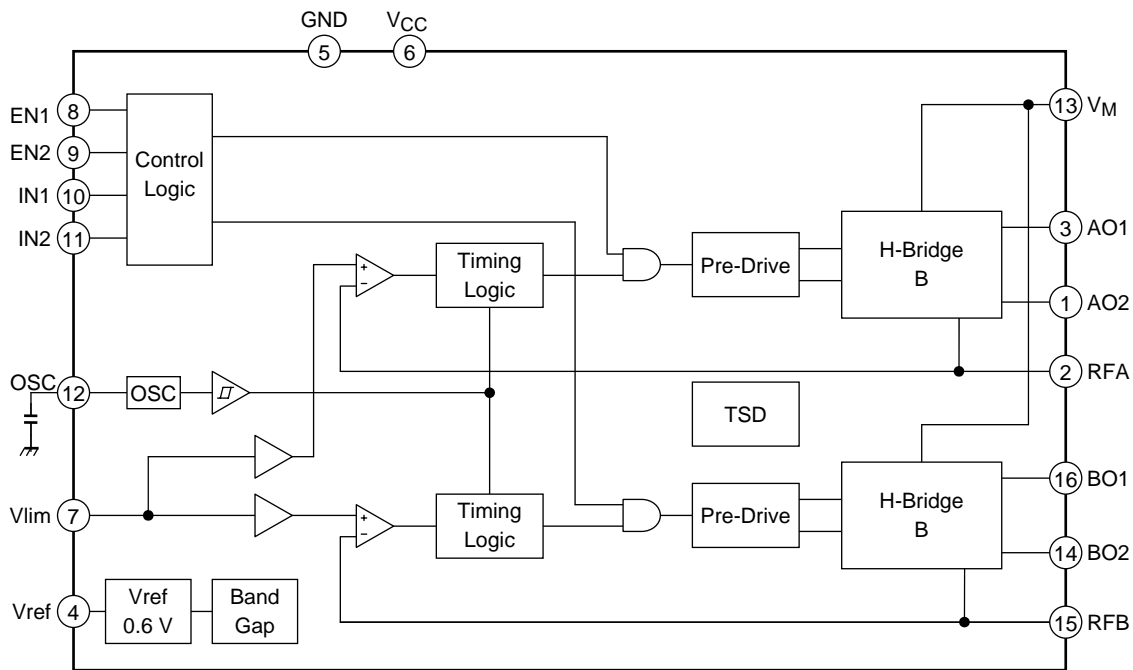
The following conditions apply to solderability:

##### \*Solderability

1. Use of Sn-37Pb solder bath
  - \*solder bath temperature = 230°C
  - \*dipping time = 5 seconds
  - \*number of times = once
  - \*use of R-type flux
2. Use of Sn-3.0Ag-0.5Cu solder bath
  - \*solder bath temperature=245°C
  - \*dipping time = 5 seconds
  - \*the number of times = once
  - \*use of R-type flux

- This product has a MOS structure and is sensitive to electrostatic discharge. When handling the product, ensure that the environment is protected against electrostatic discharge by using an earth strap, a conductive mat and an ionizer. Ensure also that the ambient temperature and relative humidity are maintained at reasonable levels.
- Install the product correctly. Otherwise, breakdown, damage and/or degradation in the product or equipment may result.

**Block Diagram**



Some functional blocks, circuits, or constants may be omitted or simplified in the block diagram for explanatory purposes.

**Pin Functions**

Pin Name	Pin No.	Functional Description	Remarks
AO2	1	Output 2 (Ch. A)	Ch. A motor winding connection pin
RFA	2	Winding current detection pin (Ch. A)	
AO1	3	Output 1 (Ch. A)	Ch. A motor winding connection pin
Vref	4	Internal reference voltage	+0.6 V (typ.)
GND	5	Ground pin	
VCC	6	Small-signal power supply pin	$V_{CC(ope)} = 2.7\text{ V to }5.5\text{ V}$
Vlim	7	Winding current setting pin	$I_{coil(A)} = V_{limit(V)}/\text{external RF}(\Omega)$
EN1	8	Enable input 1	
EN2	9	Enable input 2	
IN1	10	Control input 1	
IN2	11	Control input 2	
OSC	12	Internal oscillation frequency setting pin	Connect an oscillator capacitor externally
VM	13	Motor power supply pin	$V_{M(ope)} = 4.5\text{ V to }13.5\text{ V}$
BO2	14	Output 2 (Ch. B)	Ch. B motor winding connection pin
RFB	15	Winding current detection pin (Ch. B)	
BO1	16	Output 1 (Ch. B)	Ch. B motor winding connection pin

### Truth Table 1

EN1 (EN2)	IN1 (IN2)	AO1 (BO1)	AO2 (BO2)	Mode
L	*	OFF	OFF	ALL OFF
H	H	L	H	Reverse
	L	H	L	Forward

\*" indicates "don't care."

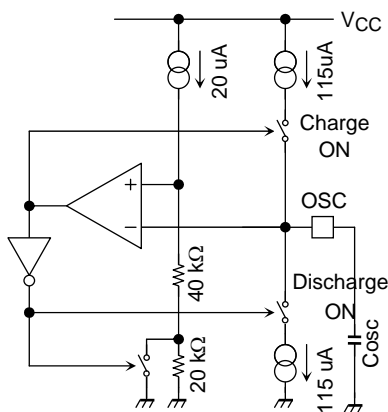
### Truth Table 2

EN1	EN2	Mode
L (Note)	L (Note)	Standby
L	H	Operation
H	L	
H	H	

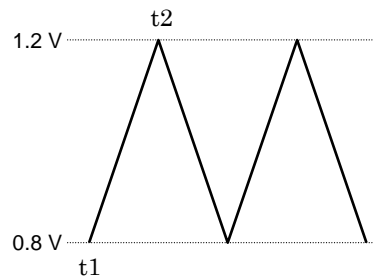
Note: VINL (EN1 = EN2) ≤ 0.5 V.

## Operating Description

The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.



**Oscillator circuit**



**Vosc waveform**

- The internal oscillation frequency is determined by charging and discharging an external capacitor (Cosc).

$$V_{osc} = \frac{1}{C_{osc}} \int i dt,$$

$$\Delta V_{osc} = I \times (t1 - t2) / C_{osc},$$

$$\frac{1}{t1 - t2} = \frac{I}{\Delta V_{osc} \cdot C_{osc}},$$

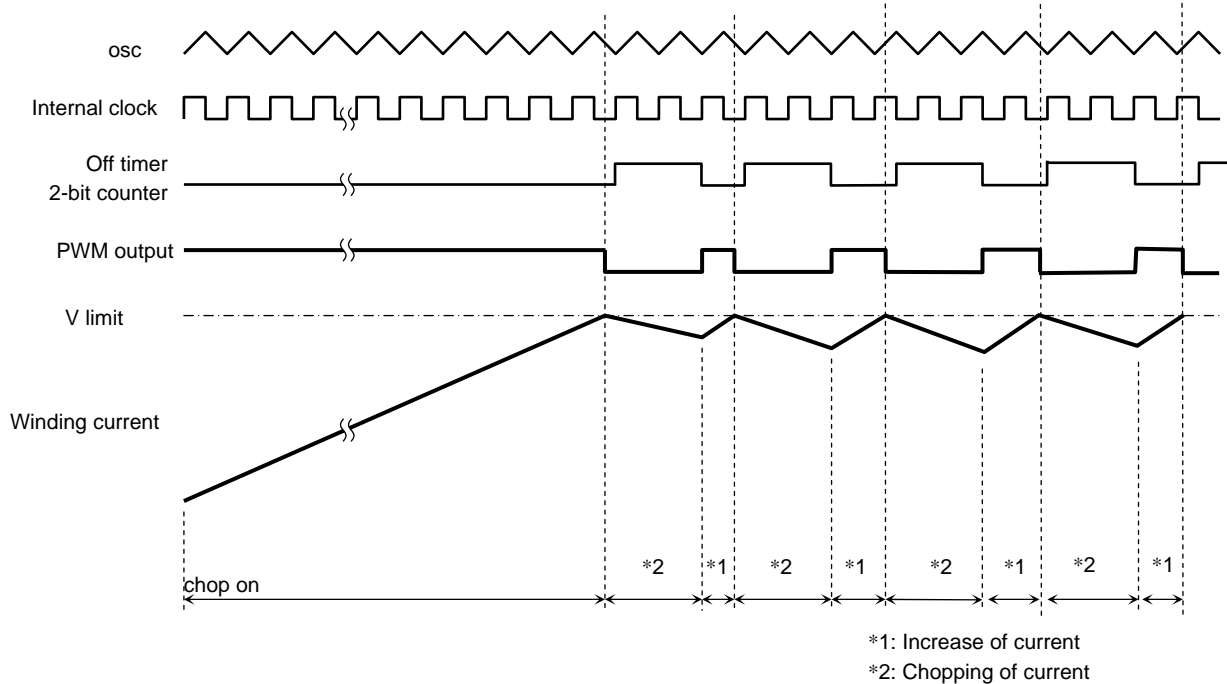
$$f_{osc} = \frac{1}{2(t1 - t2)} = \frac{I}{2 \cdot \Delta V_{osc} \cdot C_{osc}},$$

$$= \frac{1}{2 \times 0.4 / 115 \mu A \times C_{osc}} = \frac{1}{6.957 \times 10^3 \times C_{osc}} \text{ (theoretical formula) .}$$

- Chopper control

The winding current flows while the output drive transistor is On. When the  $V_{RF}$  reaches the limit voltage level ( $V_{limit}$ ), the comparator detects it and turns off the output drive transistor.

The oscillator output is squared to generate an internal clock. The off timer starts on the edge of the internal clock and is active for two internal clocks. When the off timer stops, the PWM goes high.



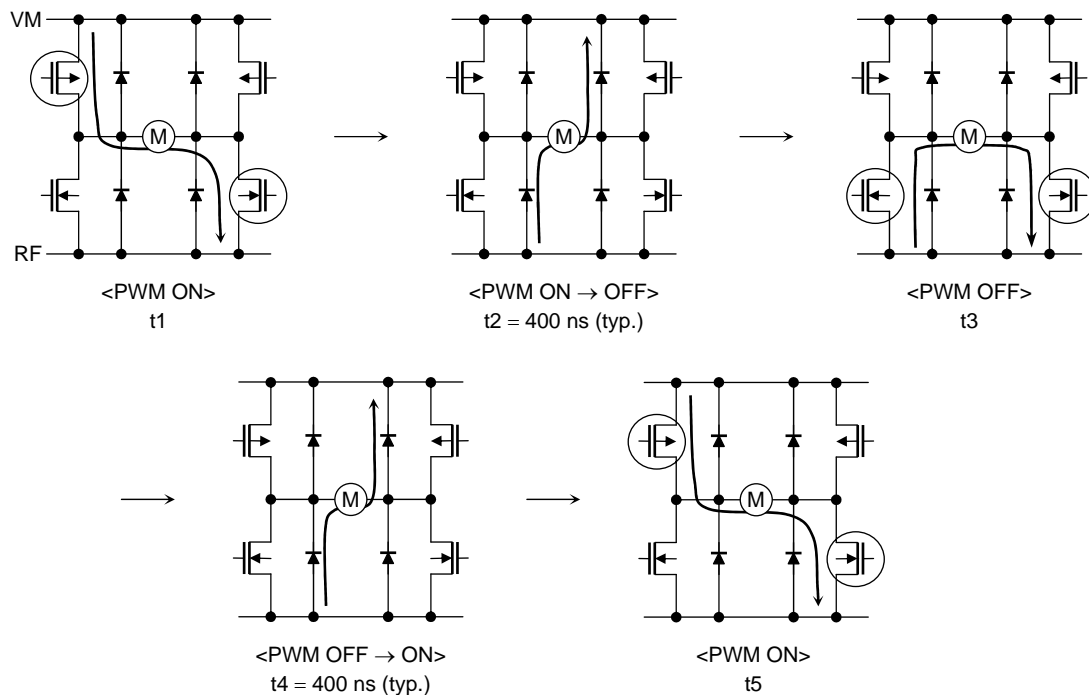
The PWM control limits the winding current to a level determined by the current value ( $I_0$ ) as expressed in the equation below:

$$I_0 = V_{limit}/R_{NF}$$

- PWM control function

When PWM control is provided, normal operation and short brake operation are repeated.

To prevent penetrating current, dead time  $t_2$  and  $t_4$  are provided in the IC.



## Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit	Remarks
Power supply voltage	V <sub>M</sub>	15	V	
	V <sub>CC</sub>	6		
Input voltage	V <sub>IN</sub>	-0.2 to 6	V	IN1, IN2, EN1 and EN2 pins
Output current	I <sub>OUT</sub>	0.8	A	
Power dissipation	P <sub>D</sub>	0.78 (Note 1)	W	
Operating temperature	T <sub>opr</sub>	-20 to 85	°C	
Storage temperature	T <sub>stg</sub>	-55 to 150	°C	

Note 1: When mounted on a glass-epoxy PCB (50 mm × 30 mm × 1.6 mm, Cu area: 40%)

The absolute maximum ratings of a semiconductor device are a set of specified parameter values that must not be exceeded during operation, even for an instant.

If any of these ratings are exceeded during operation, the electrical characteristics of the device may be irreparably altered, in which case the reliability and lifetime of the device can no longer be guaranteed.

Moreover, any exceeding of the ratings during operation may cause breakdown, damage and/or degradation in other equipment. Applications using the device should be designed so that no maximum rating will ever be exceeded under any operating conditions.

Before using, creating and/or producing designs, refer to and comply with the precautions and conditions set forth in this document.

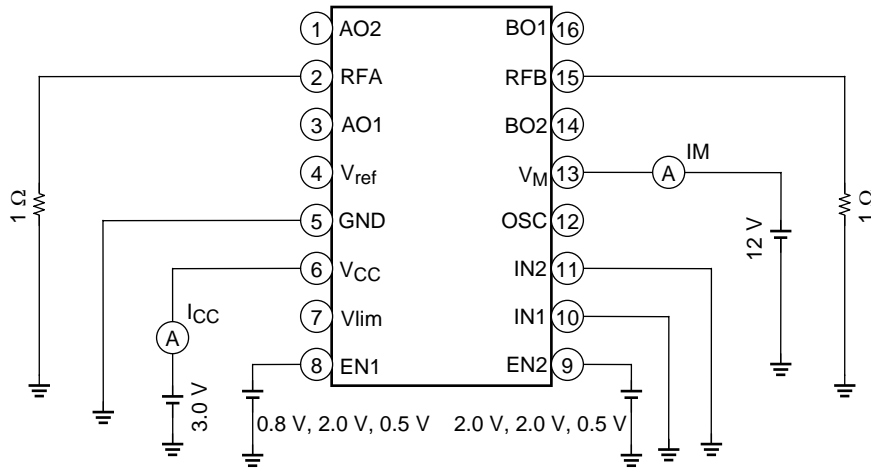
## Operating Range (Ta = -20 to 85°C)

Characteristics	Symbol	Min	Typ.	Max	Unit
Power supply voltage (V <sub>CC</sub> )	V <sub>CC</sub>	2.7	3	5.5	V
Power supply voltage (V <sub>M</sub> )	V <sub>M</sub>	2.5	5	13.5	V
Output current	I <sub>OUT</sub>	—	—	0.6	A
Limit voltage	V <sub>limit</sub>	GND	—	V <sub>ref</sub>	V
OSC frequency	f <sub>osc</sub>	—	—	1	MHz
Chopping frequency	f <sub>chop</sub>	20	—	250	kHz

## Electrical Characteristics (unless otherwise specified, $V_{CC} = 3\text{ V}$ , $V_M = 12\text{ V}$ , $T_a = 25^\circ\text{C}$ )

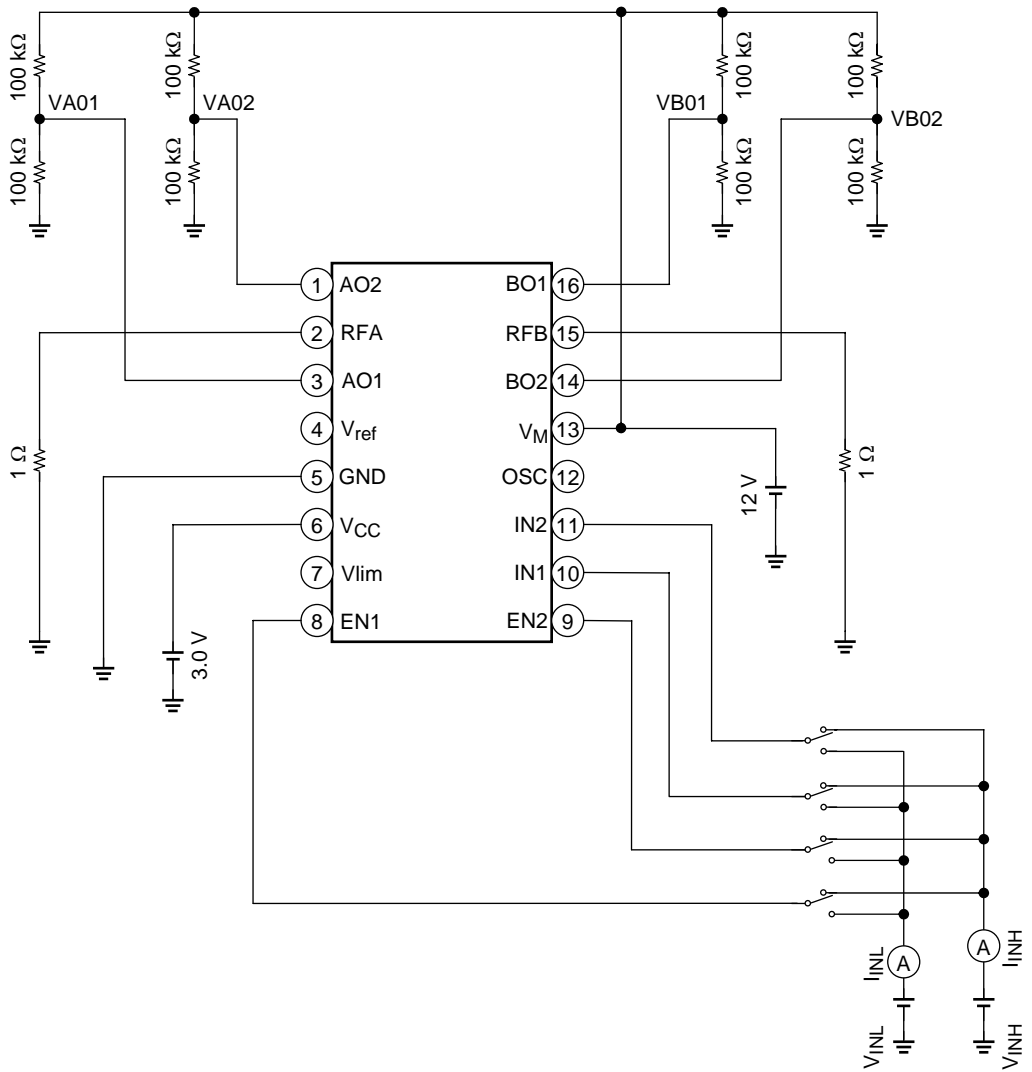
Characteristics		Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit	
Supply current		$I_{CC1}$	1	1ch ON $EN1 = 0.8\text{ V}$ , $EN2 = 2.0\text{ V}$	—	1.4	3	mA	
		$I_{CC2}$	1	2ch ON $EN1 = EN2 = 2.0\text{ V}$	—	1.4	3	mA	
		$I_{CC3}$	1	Standby mode $EN1 = EN2 = 0.5\text{ V}$	—	7	15	$\mu\text{A}$	
		$I_{M1}$	1	1ch ON, Output open $EN1 = 0.8\text{ V}$ , $EN2 = 2.0\text{ V}$	—	1.9	3.0	mA	
		$I_{M2}$	1	2ch ON, Output open $EN1 = EN2 = 2.0\text{ V}$	—	1.9	3.0		
			$I_{M3}$	1	Standby mode $EN1 = EN2 = 0.5\text{ V}$	—	—	1	$\mu\text{A}$
Control circuit		Input voltage	$V_{INH}$	2		2	—	$V_{CC} + 0.2$	V
			$V_{INL1}$	2		-0.2	—	0.8	
			$V_{INL2}$	2	Standby mode	-0.2	—	0.5	
		Hysteresis voltage	$V_{IN}(\text{HIS})$	—	(Design target value)	—	0.2	—	
		Input current	$I_{INH}$	2	$V_{IN} = 3\text{ V}$	5	15	30	$\mu\text{A}$
			$I_{INL}$	2	$V_{IN} = \text{GND}$	—	—	1	$\mu\text{A}$
Output saturating voltage		$V_{\text{sat}}(\text{U} + \text{L})$	3	$I_O = 0.2\text{ A}$	—	0.3	0.4	V	
				$I_O = 0.6\text{ A}$	—	0.9	1.2		
Output constant-current detection level		$V_{RF}$	4	$R_{RF} = 0.1\ \Omega$ , $V_{\text{ref}} = 0.6\text{ V}$	0.565	0.6	0.635	V	
Reference voltage		$V_{\text{ref}}$	5	No load	0.57	0.6	0.63	V	
Reference voltage current capacity		$I_{\text{ref}}$	5	Source ( $\Delta V_{\text{ref}} = 50\text{ mV}$ )	—	—	100	$\mu\text{A}$	
Input current at winding current setting pin		$I_{IN}(\text{limit})$	6	$V_{\text{limit}} = \text{GND}$	—	—	1	$\mu\text{A}$	
Output leakage current		$I_L(\text{U})$	7	$V_M = 15\text{ V}$	—	—	1	$\mu\text{A}$	
		$I_L(\text{L})$	7		—	—	1		
Diode forward voltage		$V_F(\text{U})$	8	$I_O = 0.6\text{ A}$	—	1	1.2	V	
		$V_F(\text{L})$	9	$I_O = 0.6\text{ A}$	—	1	1.2		
Oscillation frequency		$f_{\text{osc}}$	10	$C_{\text{osc}} = 220\text{ pF}$	430	530	630	kHz	
Capacitor charge current		$I_{C1}$	11	$V_{\text{osc}} = 0\text{ V}$	—	115	—	$\mu\text{A}$	
Capacitor discharge current		$I_{C2}$	11	$V_{\text{osc}} = 2\text{ V}$	—	115	—	$\mu\text{A}$	
Thermal shutdown circuit operating temperature		$T_{SD}$	—	(Design target value)	—	170	—	$^\circ\text{C}$	
Thermal shutdown hysteresis		$\Delta T_{SD}$	—		—	20	—	$^\circ\text{C}$	

**Test Circuit 1:  $I_{CC1}$ ,  $I_{CC2}$ ,  $I_{CC3}$ ,  $I_{M1}$ ,  $I_{M2}$ ,  $I_{M3}$**



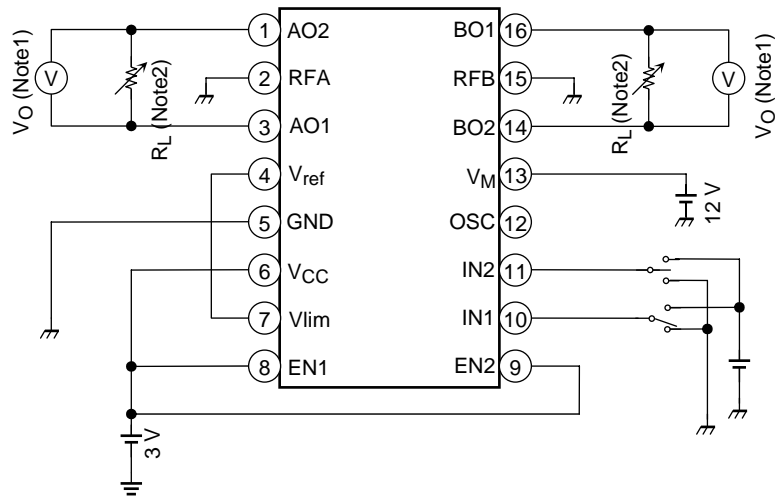
$I_{CC1}$ ,  $I_{M1}$ : EN1 = 0.8 V, EN2 = 2.0 V  
 $I_{CC2}$ ,  $I_{M2}$ : EN1 = 2.0 V, EN2 = 2.0 V  
 $I_{CC3}$ ,  $I_{M3}$ : EN1 = 0.5 V, EN2 = 0.5 V

**Test Circuit 2:  $V_{INH}$ ,  $V_{INL1}$ ,  $V_{INL2}$ ,  $I_{INH}$ ,  $I_{INL}$**





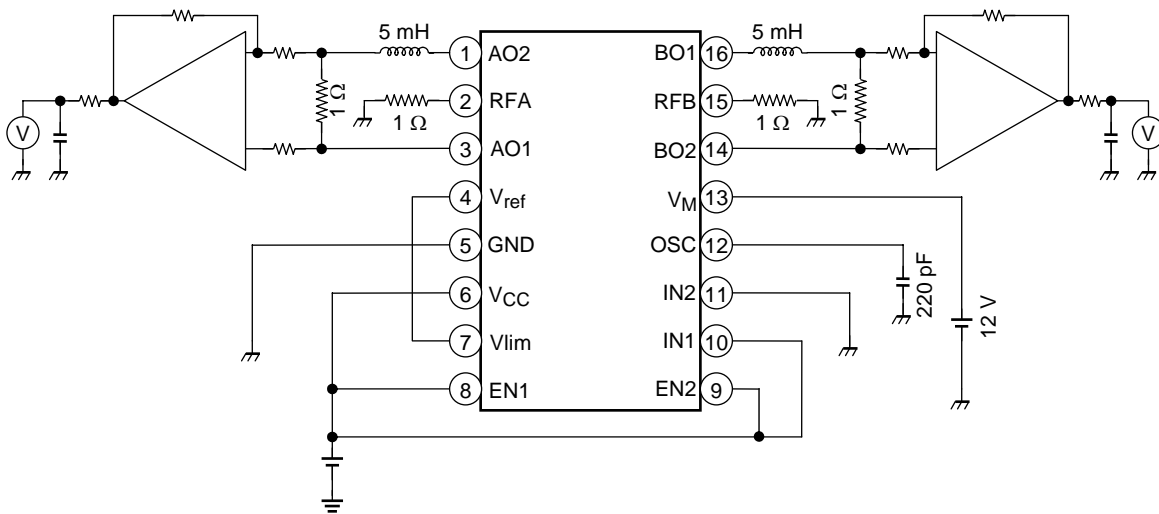
**Test Circuit 3:  $V_{SAT} (U + L)$**



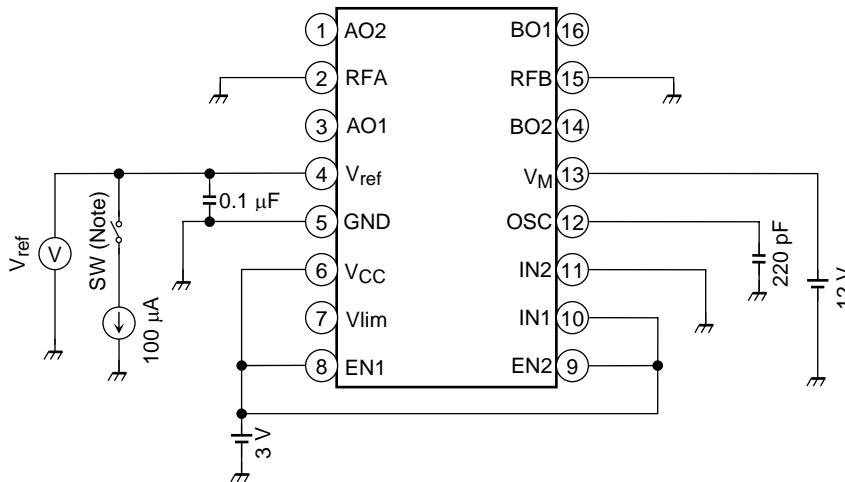
Note1:  $V_{SAT} (U + L) = 12 - V_O$

Note2: Calibrate  $I_O$  to 0.2 A / 0.6 A by  $R_L$ .

**Test Circuit 4:  $V_{RF}$**



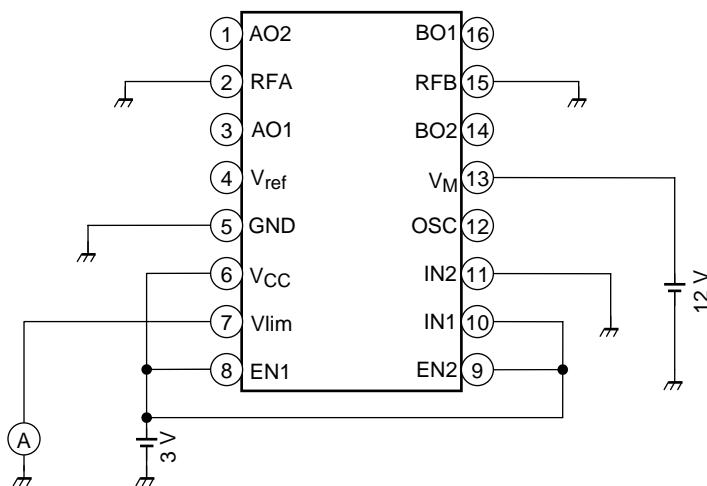
**Test Circuit 5:  $V_{ref}$ ,  $I_{ref}$**



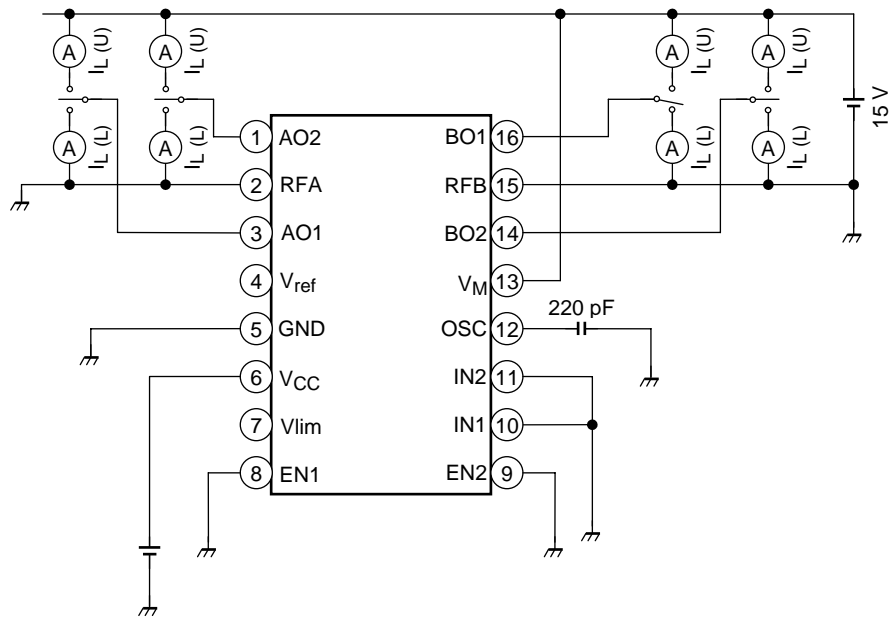
Note: 1.  $V_{ref}$ : SW = OFF

2.  $I_{ref}$ : The  $V_{ref}$  voltage descent at the time of SW = ON checks below 50 mV.

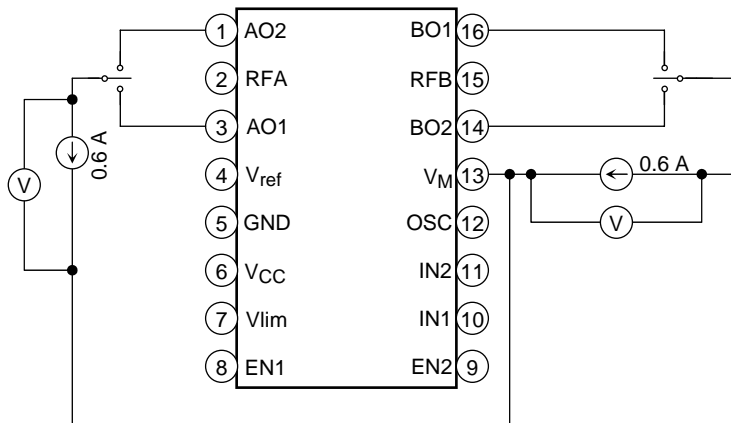
**Test Circuit 6:  $I_{IN}$  (limit)**



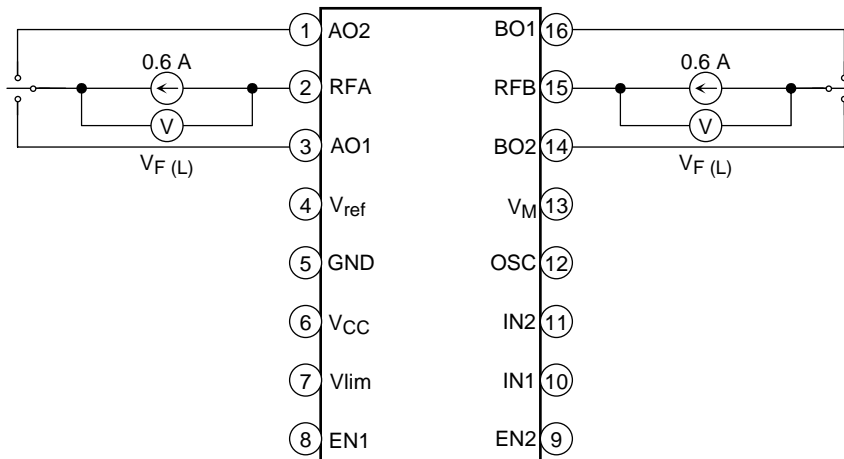
**Test Circuit 7:  $I_L$  (U),  $I_L$  (L)**



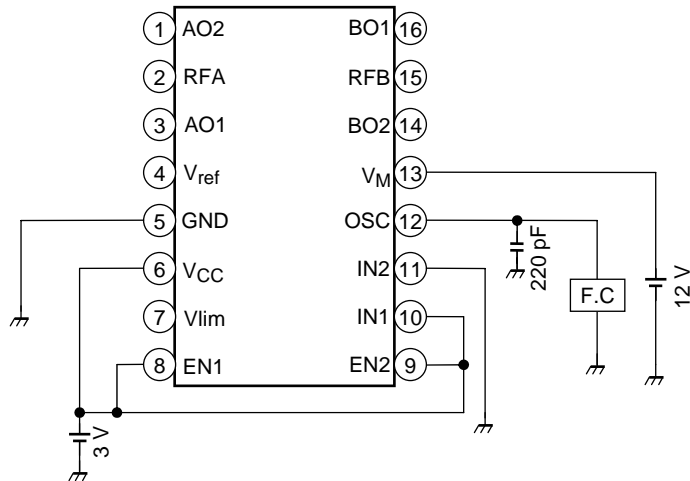
**Test Circuit 8:  $V_F$  (U)**



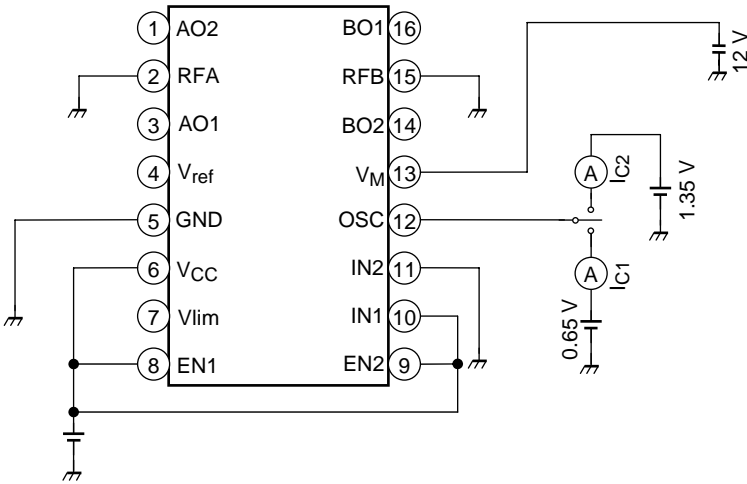
**Test Circuit 9:  $V_F$  (L)**



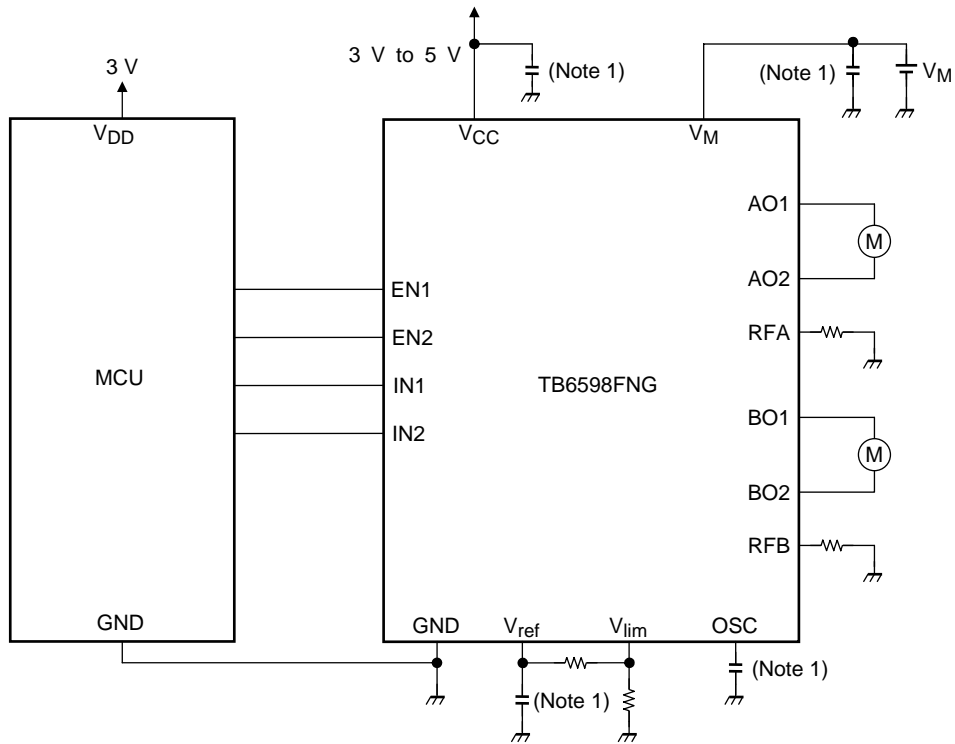
**Test Circuit 10:  $f_{osc}$**



Test Circuit 11:  $I_{c1}$ ,  $I_{c2}$



**Application Circuit Example**

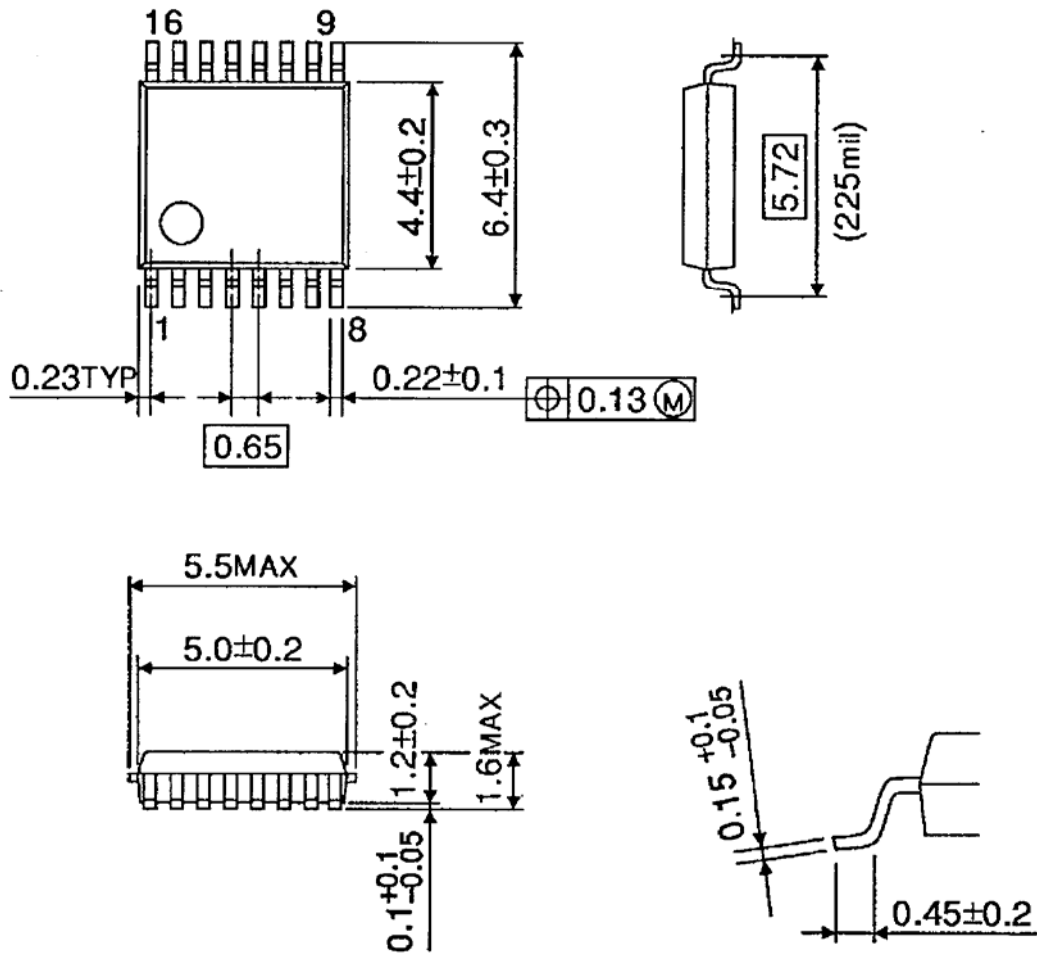


- Note 1: Noise suppression capacitors and oscillator capacitors should be connected as close as possible to the IC.
- Note 2: Utmost care is necessary in the design of the output, V<sub>CC</sub>, V<sub>M</sub>, and GND lines since the IC may be destroyed by short-circuiting between outputs, air contamination faults, or faults due to improper grounding, or by short-circuiting between contiguous pins.

## Package Dimensions

SSOP16-P-225-0.65B

Unit : mm



Weight: 0.07 g (typ.)

## Notes on Contents

### 1. Block Diagrams

Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

### 2. Equivalent Circuits

The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

### 3. Timing Charts

Timing charts may be simplified for explanatory purposes.

### 4. Application Circuits

The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass production design stage.

Toshiba does not grant any license to any industrial property rights by providing these examples of application circuits.

### 5. Test Circuits

Components in the test circuits are used only to obtain and confirm the device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure from occurring in the application equipment.

## IC Usage Considerations

### Notes on handling of ICs

- [1] The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.  
Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.
- [2] Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.
- [3] If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. IC breakdown may cause injury, smoke or ignition.  
Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.
- [4] Do not insert devices in the wrong orientation or incorrectly.  
Make sure that the positive and negative terminals of power supplies are connected properly.  
Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.  
In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.



**Points to remember on handling of ICs****(1) Thermal Shutdown Circuit**

Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately.

Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.

**(2) Heat Radiation Design**

In using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature ( $T_J$ ) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into consideration the effect of IC heat radiation with peripheral components.

**(3) Back-EMF**

When a motor rotates in the reverse direction, stops or slows down abruptly, a current flow back to the motor's power supply due to the effect of back-EMF. If the current sink capability of the power supply is small, the device's motor power supply and output pins might be exposed to conditions beyond maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

**RESTRICTIONS ON PRODUCT USE**

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In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc. 021023\_A
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