

TOSHIBA Bipolar Linear IC Multichip

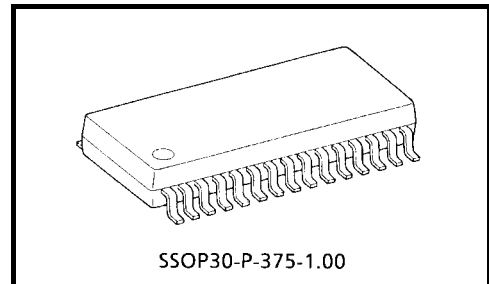
TA84006FG

Three-Phase Full Wave Motor Driver IC

The TA84006FG is a three-phase full-wave motor driver IC. Used with a three-phase sensorless controller (TB6548FG or TB6537PG), the TA84006FG can provide PWM sensorless drive for three-phase brushless motors.

Features

- Built-in voltage detector
- Overcurrent detector incorporated
- Overheating protector incorporated
- Multichip (MCP) structure
 - Uses P-ch-MOS for the upper output power transistor
- Rated at 25 V/1.0 A
- Package: SSOP30-P-375-1.00



Weight: 0.63 g (typ.)

Note 1: This product has a multichip (MCP) structure utilizing P-ch-MOS technology. The Pch-MOS structure is sensitive to electrostatic discharge and should therefore be handled with care.

The following conditions apply to solderability:

About solderability, following conditions were confirmed

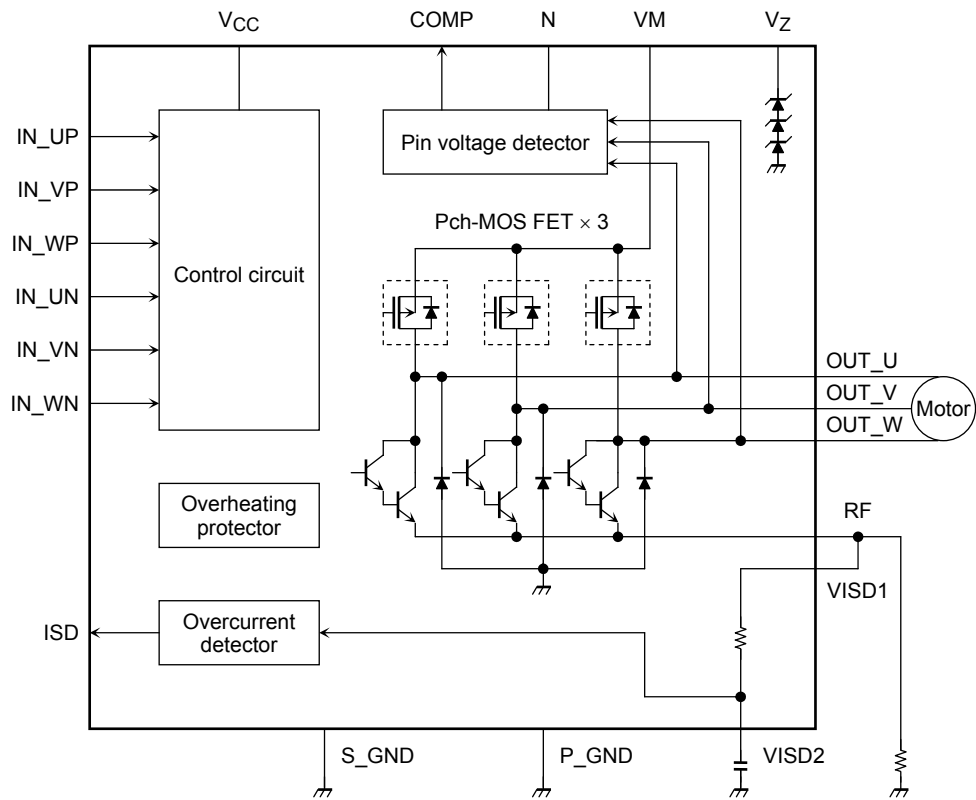
(1) Use of Sn-37Pb solder Bath

·solder bath temperature: 230°C·dipping time: 5 seconds·the number of times: once·use of R-type flux

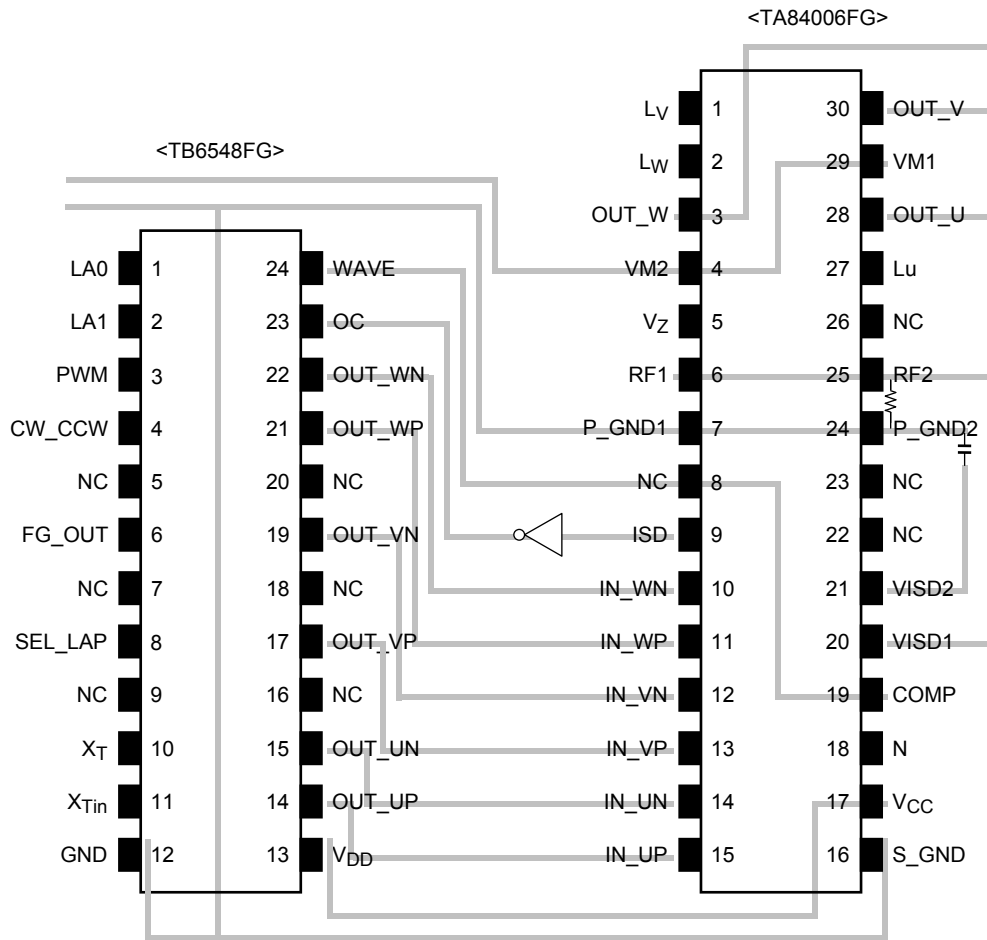
(2) Use of Sn-3.0Ag-0.5Cu solder Bath

·solder bath temperature: 245°C·dipping time: 5 seconds·the number of times: once·use of R-type flux

Block Diagram



Pin Assignment



Pin Description

Pin No.	Pin Symbol	Pin Function	Remarks
1	L _V	V-phase output upper P-ch gate pin	Leave open.
2	L _W	W-phase output upper P-ch gate pin	Leave open.
3	OUT_W	W-phase output pin	Connects motor.
4	VM2	Motor drive power supply pin	Externally connects to VM1.
5	V _Z	Reference voltage pin	Used for the VM drop circuit reference voltage when VM (max) ≥ 22 V. Left open when VM (max) ≤ 22 V.
6	RF1	Output current detection pin	Externally connected to RF2. (Connect a detection resistor between this pin and GND.)
7	P_GND1	Power GND pin	Externally connects to P_GND2.
8	NC	Not connected	—
9	ISD	Overcurrent detection output pin	Inputs the inversion of the ISD pin output to the OC pin of the TB6548FG (or TB6537PG/FG).
10	IN_WN	W-phase upper drive input pin	Connects to the OUT_WN pin of the TB6548FG (or TB6537PG/FG); incorporates pull-down resistor.
11	IN_WP	W-phase lower drive input pin	Connects to the OUT_WP pin of the TB6548FG (or TB6537PG/FG); incorporates pull-up resistor.
12	IN_VN	V-phase upper drive input pin	Connects to the OUT_VN pin of the TB6548FG (or TB6537PG/FG); incorporates pull-down resistor.
13	IN_VP	V-phase lower drive input pin	Connects to the OUT_VP pin of the TB6548FG (or TB6537PG/FG); incorporates pull-up resistor.
14	IN_UN	U-phase upper drive input pin	Connects to the OUT_UN pin of the TB6548FG (or TB6537PG/FG); incorporates pull-down resistor.
15	IN_UP	U-phase lower drive input pin	Connects to the OUT_UP pin of the TB6548FG (or TB6537PG/FG); incorporates pull-up resistor.
16	S_GND	Signal GND pin	—
17	V _{CC}	Control power supply pin	V _{CC (opr)} = 4.5 to 5.5 V
18	N	Mid-point pin	Mid-point potential confirmation pin; left open
19	COMP	Location detection signal output pin	Connects to the WAVE pin of the TB6548FG (or TB6537PG/FG).
20	VISD1	Overcurrent detection input pin 1	Externally connects to the RF2 pin.
21	VISD2	Overcurrent detection input pin 2	Connect a capacitor between this pin and GND. Internal resistor and capacitor used to reduce noise.
22	NC	Not connected	—
23	NC	Not connected	—
24	P_GND2	Power GND pin	Externally connects to the P_GND1 pin.
25	RF2	Output current detection pin	Externally connects to the RF1 pin. Connect a detection resistor between this pin and GND.
26	NC	Not connected	—
27	Lu	U-phase upper output P-ch gate pin	Leave open.
28	OUT_U	U-phase output pin	Connects motor.
29	VM1	Motor drive power supply pin	Externally connects to the VM2 pin.
30	OUT_V	V-phase output pin	Connects the motor.

Absolute Maximum Ratings ($T_a = 25^\circ\text{C}$)

Characteristic	Symbol	Rating	Unit
Motor power supply voltage	VM	25	V
Control power supply voltage	V _{CC}	7	V
Output current	I _O	1.0	A/phase
Input voltage	V _{IN}	GND - 0.3 to V _{CC} + 0.3 V	V
Power dissipation	P _D	1.1 (Note 2)	W
		1.4 (Note 3)	
Operating temperature	T _{opr}	-30 to 85	°C
Storage temperature	T _{stg}	-55 to 150	°C

Note 2: Standalone

Note 3: When mounted on a PCB (50 mm × 50 mm × 1.6 mm; Cu area, 30%)

Operating Ranges ($T_a = -30$ to 85°C)

Characteristic	Symbol	Test Circuit	Test Conditions	Min	Typ.	Max	Unit
Control power supply voltage	V _{CC}	—	—	4.5	5.0	5.5	V
Motor power supply voltage	VM	—	—	10	20	22	V
Output current	I _O	—	—	—	—	0.5	A
Input voltage	V _{IN}	—	—	GND	—	V _{CC}	V
Chopping frequency	f _{chop}	—	—	15	20	50	kHz
V _Z current	I _Z	—	—	—	—	1.0	mA

Electrical Characteristics (T_a = 25°C, V_{CC} = 5 V, V_M = 20 V)

Characteristic	Symbol	Test Circuit	Test Conditions	Min	Typ.	Max	Unit
Input voltage	V _{IN (H)}	1	IN_UP, IN_VP, IV_WP IN_UN, IN_VN, IN_WN	2.5	—	5.0	V
	V _{IN (L)}	1	—	GND	—	0.8	
Input current	I _{IN1 (H)}	2	V _{IN} = 5 V, IN_UP, IN_VP, IN_WP	—	—	20	μA
	I _{IN2 (H)}	2	V _{IN} = 5V, IN_UN, IN_VN, IN_WN	300	450	600	
	I _{IN1 (L)}	2	V _{IN} = GND, IN_UN, IN_VN, IN_WN	—	—	1	
	I _{IN2 (L)}	2	V _{IN} = GND, IN_UP, IN_VP, IN_WP	300	450	600	
Power supply current	I _{CC1}	3	Upper phase 1 ON, lower phase 1 ON, output open	—	8.0	13.0	mA
	I _{CC2}	3	Upper phase 2 ON, synchronous regeneration mode, output open	—	7.0	12.0	
	I _{CC3}	3	All phases OFF, output open	—	6.0	11.0	
	I _{M1}	3	Upper phase 1 ON, lower phase 1 ON, output open	—	2.0	3.5	
	I _{M2}	3	Upper phase 2 ON, synchronous regeneration mode, output open	—	2.0	3.5	
	I _{M3}	3	All phases OFF, output open	—	1.8	3.2	
Lower output saturation voltage	V _{sat}	4	I _O = 0.5 A	—	1.0	1.5	V
Upper output ON-resistance	R _{on}	5	I _O = ±0.5 A, bi-directional	—	0.65	1.0	Ω
Lower diode forward voltage	V _{F (L)}	6	I _F = 0.5 A	—	1.2	1.6	V
Upper diode forward voltage	V _{F (H)}	7	I _F = 0.5 A	—	0.9	1.4	V
Mid-point voltage	V _N	8	V _M = 20 V V _{RF} = 0 V	9.88	10.4	10.92	V
Pin voltage detection level	V _{CMP}	9	V _M = 20 V V _{RF} = 0 V	9.88	10.4	10.92	V
Pin voltage detection output voltage	V _{OL (CMP)}	9	I _{OL} = 1 mA	GND	—	0.5	V
	R _{OH (CMP)}	9	—	7	10	13	kΩ
Overcurrent detection level	V _{RF}	10	—	0.45	0.5	0.55	V
Overcurrent detection output voltage	V _{OH (ISD)}	10	I _{OH} = 0.1 mA	4.5	—	5.0	V
	V _{OL (ISD)}	10	I _{OL} = 0.1 mA	GND	—	0.5	V
Reference voltage	V _Z	11	I _Z = 0.5 mA, T _j = 25°C	20.9	22.0	23.1	V
TSD temperature	TSD	—	T _j	—	165	—	°C
TSD hysteresis width	ΔT	—	—	—	30	—	°C
Output leakage current	I _{L (H)}	12	Pch-MOS	—	0	100	μA
	I _{L (L)}	13	—	—	0	50	

Functions

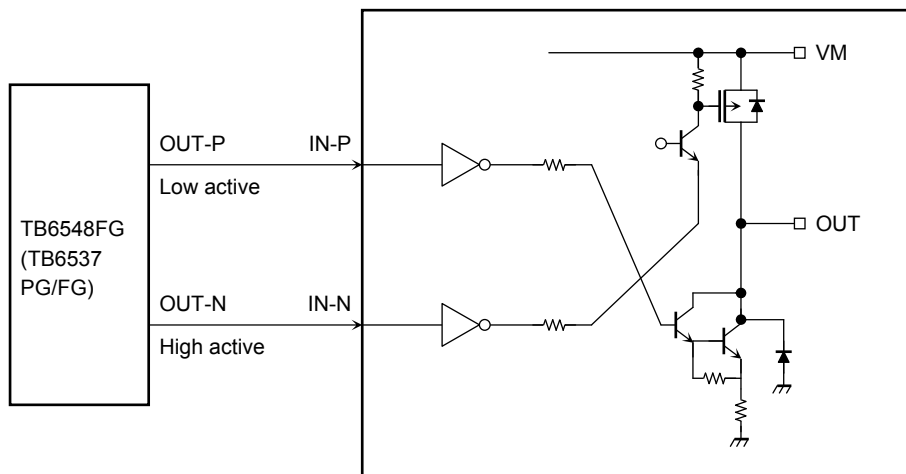
Input		Output		
IN-P	IN-N	Upper Power Transistor	Lower Power Transistor	
High	High	ON	OFF	High
Low	High	ON	ON	Prohibit mode (Note 4)
High	Low	OFF	OFF	High impedance
Low	Low	OFF	ON	Low

Connecting the TB6548FG (or TB6537PG/FG) to the TA84006FG allows electric motors to be controlled by PWM.

Note 4: In Prohibit Mode, the output power transistor goes into vertical ON mode and through current may damage the circuit. Do not use the TA84006FG in this mode.

This mode is not actuated when the TA84006FG is connected to the TB6548FG or TB6537PG/FG, but can be triggered by input noise during standalone testing.

<Schematic>

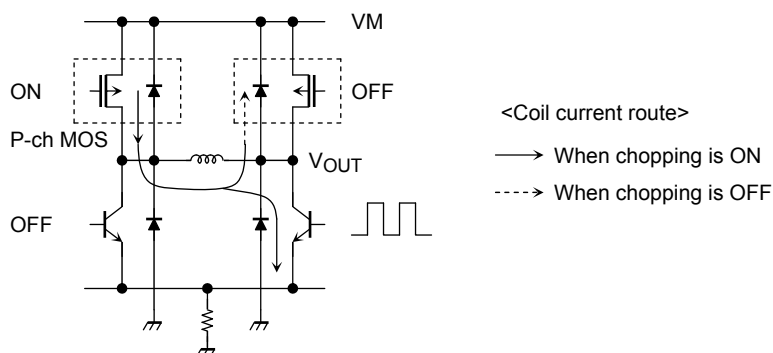


<Lower PWM>

Connecting the TA84006FG to the TB6537PG/FG controls the lower PWM.

At chopping ON, the diagonally output power transistors are ON.

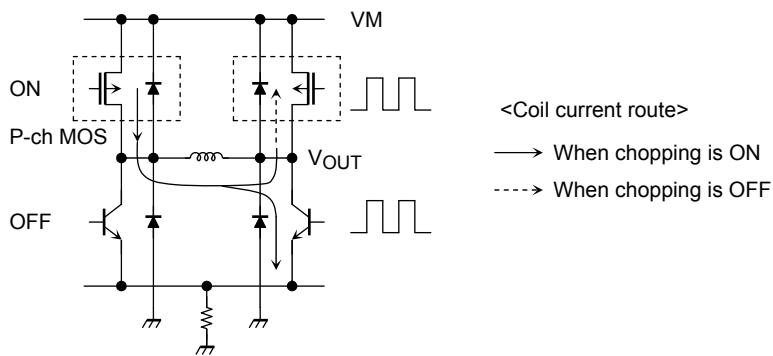
At chopping OFF, the lower transistor is OFF, regenerating the motor current via the upper diode (incorporating the P-ch MOS).



<Synchronous rectification PWM>

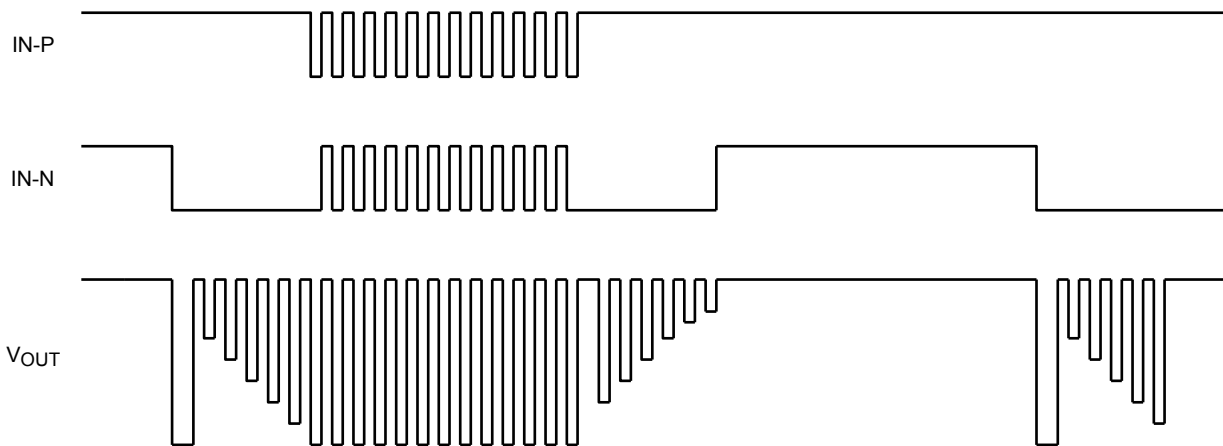
Connecting the TA84006FG to the TB6548FG controls the synchronous rectification PWM.

At chopping OFF, power dissipation is reduced by operating the P-ch MOS in reverse and regenerating the motor's current.



<Timing Chart>

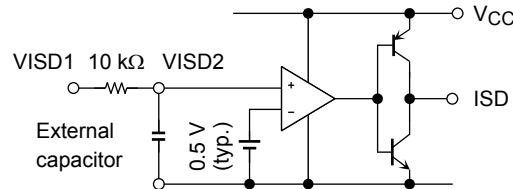
When controlling synchronous rectification PWM



Equivalent Circuit

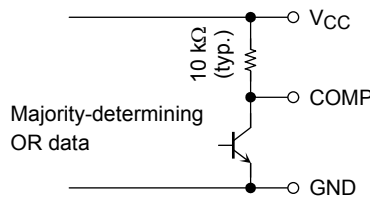
<Overcurrent detector (RF, VISD, ISD) >

- Input to the VISD1 pin the voltage generated at the overcurrent detection resistor RF connected to the RF pin.
- At chopping ON, voltage spikes at the RF pin as a result of the P-ch-MOS output capacitance. To cancel the spike, externally connect a capacitor to the VISD2 pin. (10 kΩ resistor built-in)
- If the VISD2 pin voltage exceeds the internal reference voltage (VRF = 0.5 V), the overcurrent detection output ISD pin goes Low.
Inputting the inversion of the ISD pin output to the TB6537PG/FG or TB6548FG OC pin limits the PWM ON time and the current at the ISD output rising edge.



<Pin voltage detector (COMP) >

- The pin voltage detector outputs the result of OR-ing the output pin voltages and the virtual mid-point N voltage to determine the majority.
(If at least two phases of the three-phase output are greater than the mid-point potential, the detector outputs “Low”. Conversely, if at least two phases are smaller than the mid-point potential, the circuit outputs “High”.)



- With the virtual mid-point potential VN used as the reference for the pin voltage detection circuit considered as half the voltage applied to the motor, then

$$VN = [(VM - Ron (upper) * IO) - (V_{sat} (lower) + V_{RF})] / 2 + V_{sat} + V_{RF}$$

$$= [VM - V_{RF} + V_{sat} (lower) - Ron (upper) * IO] / 2 + V_{RF}$$
 Here, assuming that: $V_{sat} (lower) - Ron (upper) * IO \approx V_F$,
 we have set the following: $VN = [VM - V_{RF} + V_F] / 2 + V_{RF}$

<Overheating protector>

- Automatic restoration TSD (ON) = 165°C TSD (OFF) = 135°C
- Temperature hysteresis supported TSD (HYS) = 30°C

<Example of 24 V support>

- Incorporate a Zener diode and make the external connections shown in the diagram below. Design the device so that the voltage applied to the VM is clamped to a voltage not higher than the maximum operating voltage of 22 V.
- A capacitor is needed to control the effect of the counter-electromotive force. Verification is particularly necessary when the motor current is large at startup or at shutdown (output OFF).

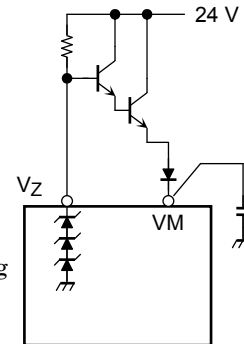
V_Z pin fluctuation width
20.9 V to 23.1 V

Due to the temperature characteristics (3.5 × 3 mV/°C), the following applies at an ambient temperature of 85°C:

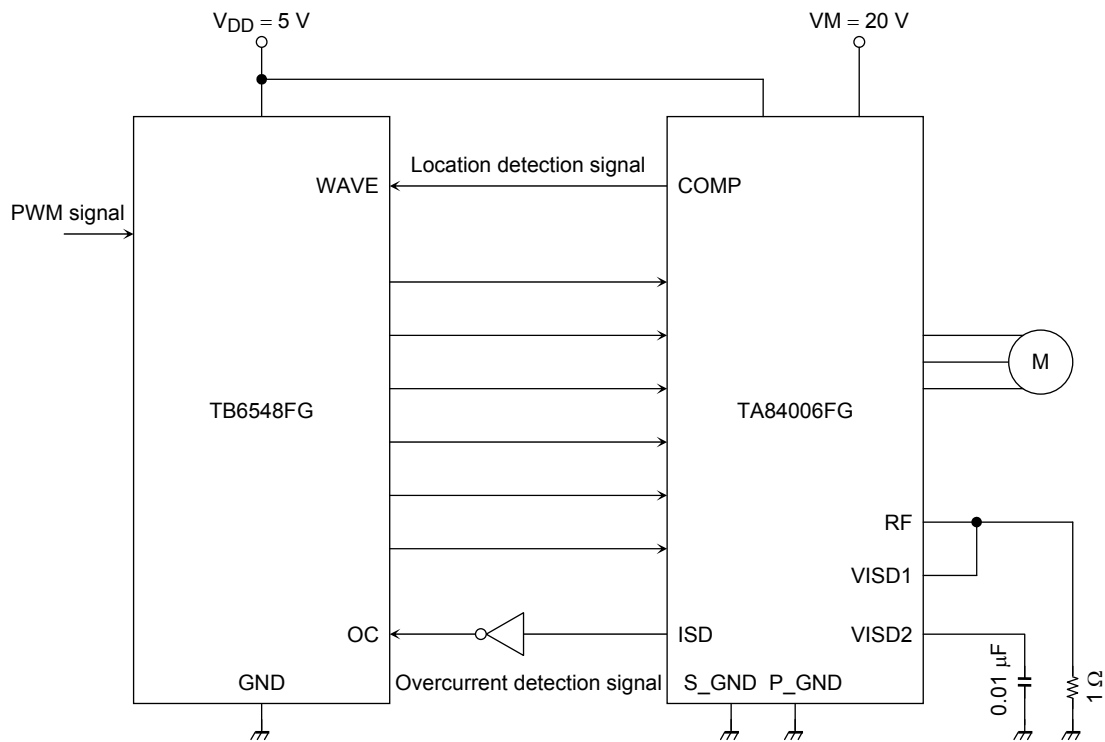
$$V_Z (\text{max}) = 23.1 + (85 - 25) \times 3.5 \times 3 \text{ mV} = 23.73 \text{ V}$$

By taking the measures shown in the diagram on the right to bring the voltage down to 22 V, the following becomes the case:

$$V_Z (\text{max}) = 23.73 - (0.7 - 2 \text{ mV} \times (85 - 25)) \times 3 = 21.99 \text{ V}$$

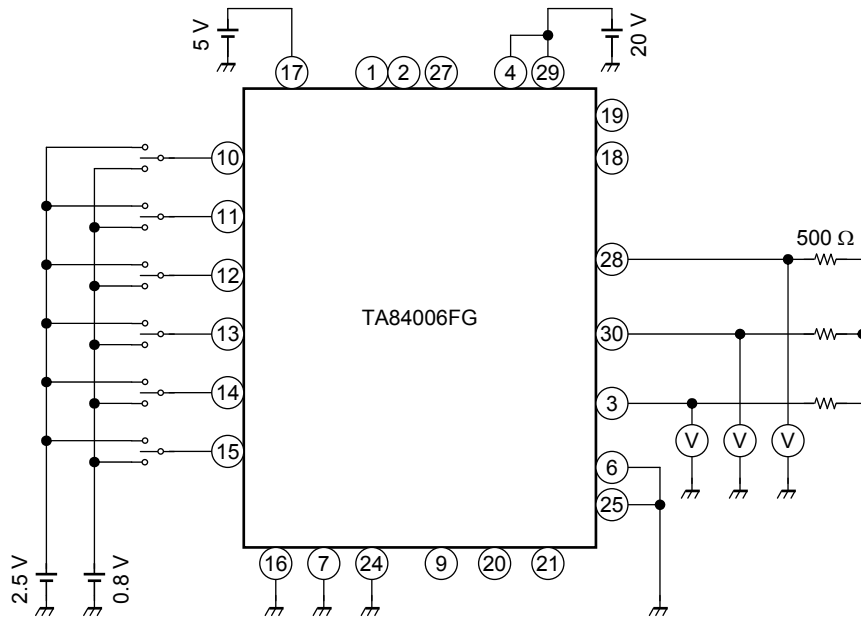


Example of Application Circuit



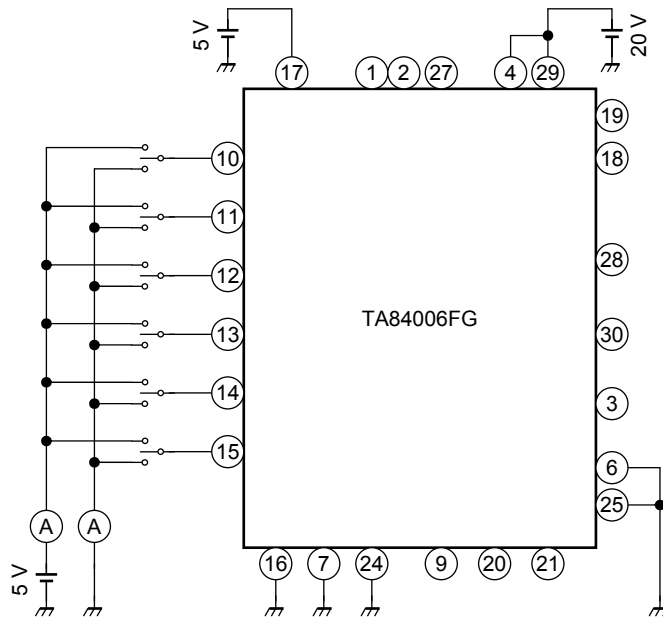
Note 5: Utmost care is necessary in the design of the output, V_{CC} , V_M , and GND lines since the IC may be destroyed by short-circuiting between outputs, air contamination faults, or faults due to improper grounding, or by short-circuiting between contiguous pins.

Test Circuit 1: V_{IN} (H), V_{IN} (L)

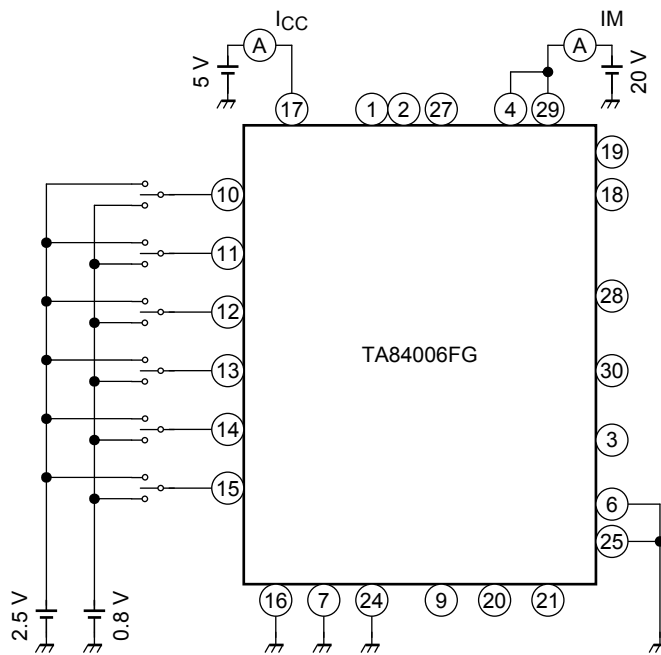


Input $V_{IN} = 0.8\text{ V}/2.5\text{ V}$, measure the output voltage, and test the function.

Test Circuit 2: I_{IN} (H), I_{IN} (L)

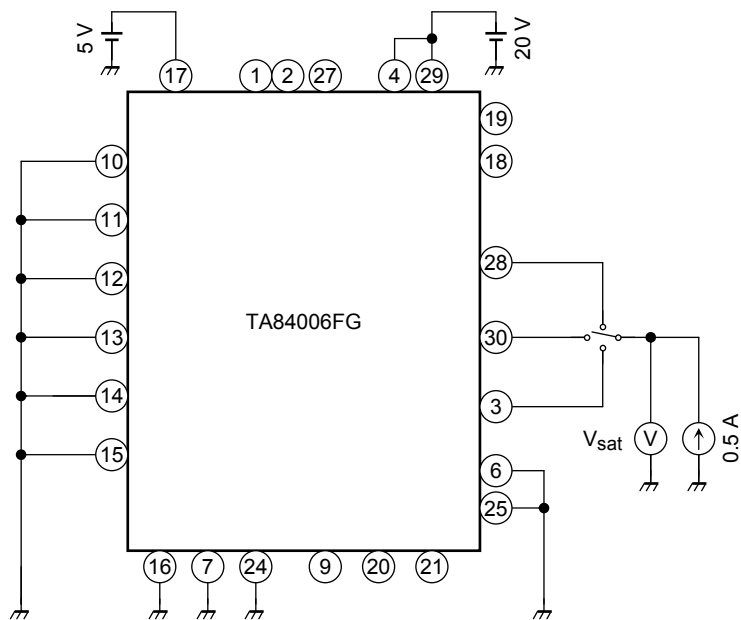


Test Circuit 3: I_{CC1}, I_{CC2}, I_{CC3}, I_{M1}, I_{M2}, I_{M3}

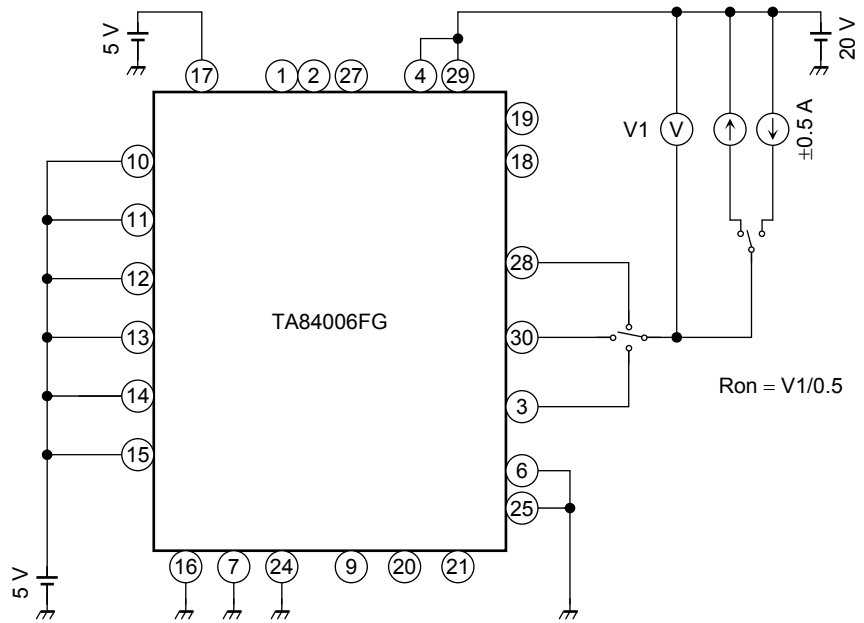


- I_{CC1}, I_{M1}: upper phase 1 ON, lower phase 1 ON (e.g., U-phase: H; V-phase: L; W-phase: Z)
- I_{CC2}, I_{M2}: upper phase 1 ON, synchronous regeneration mode (e.g., U-phase: H; V-phase: H; W-phase: Z)
- I_{CC3}, I_{M3}: all phases OFF

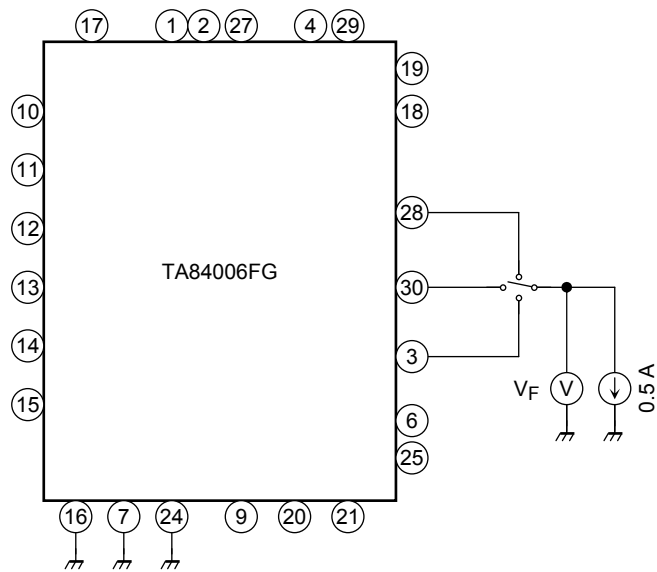
Test Circuit 4: V_{sat}



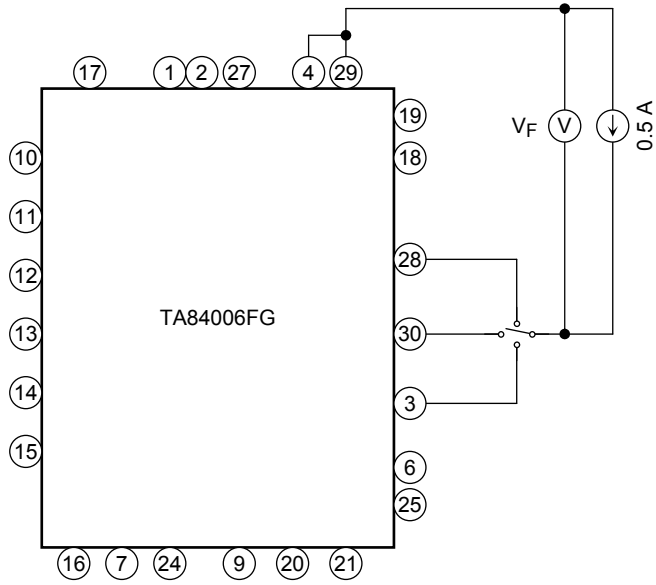
Test Circuit 5: Ron



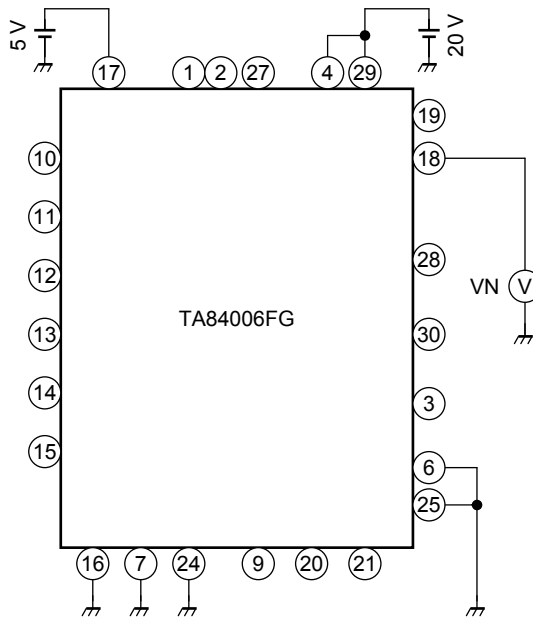
Test Circuit 6: V_F (L)



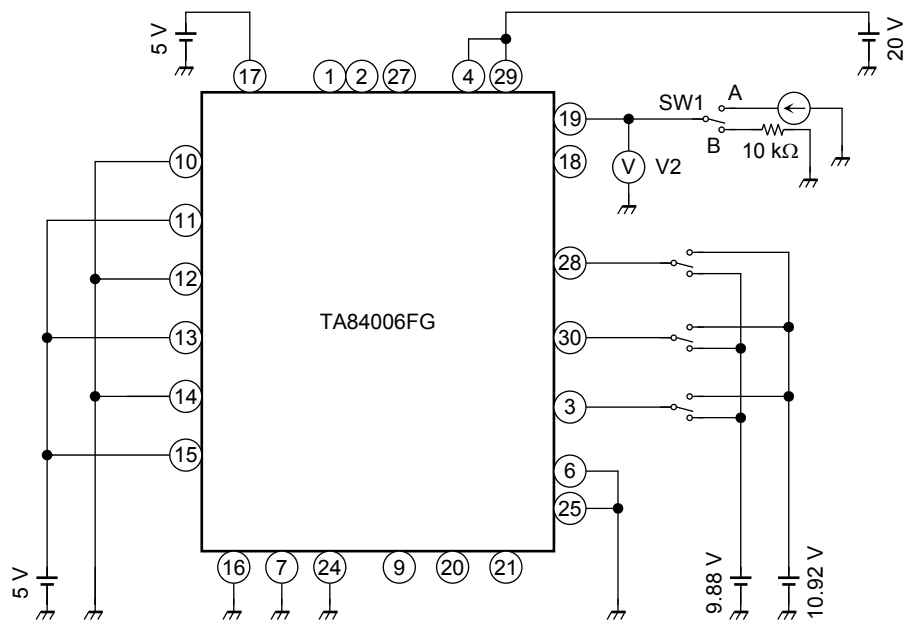
Test Circuit 7: V_F (H)



Test Circuit 8: V_N

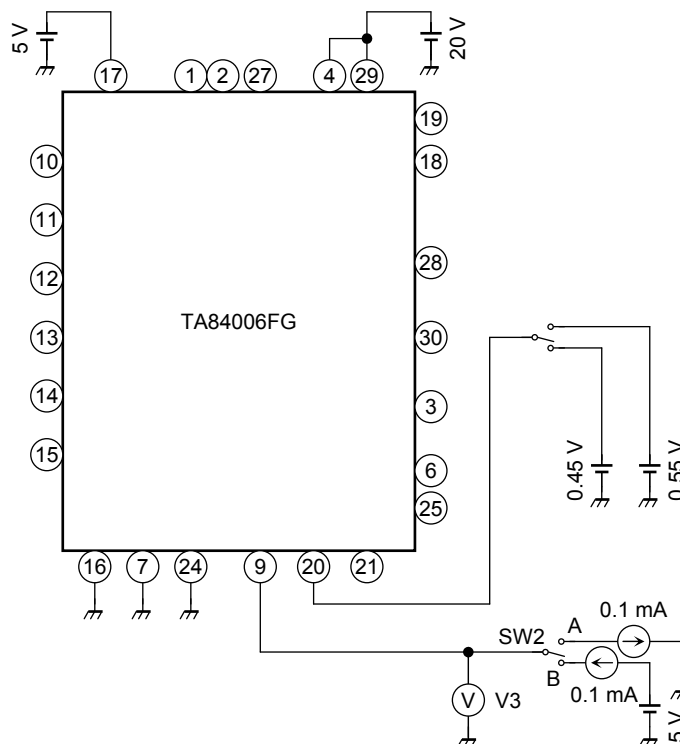


Test Circuit 9: VCMP, VOL (CMP), ROH (CMP)



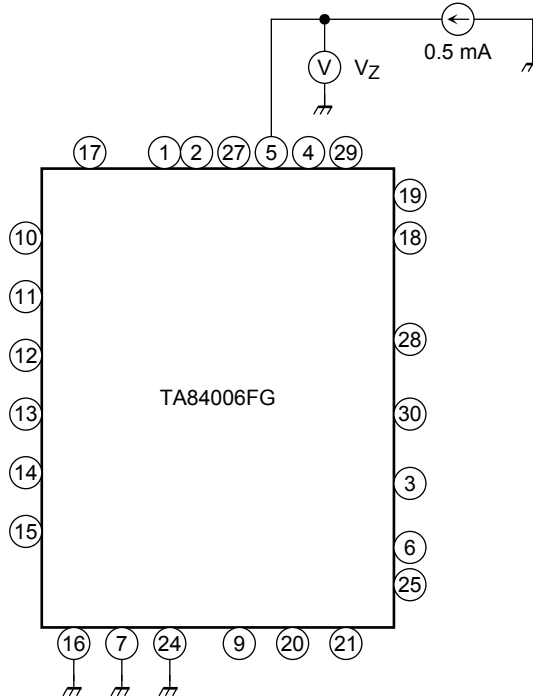
- (1) Where outputs of two phases are High (10.92 V) and an output of the other phase is Low (= 9.88 V), set SW1 = A and measure V2 = VOL (CMP).
- (2) Where an output of one phase is High (10.92 V) and outputs of the other two phases are Low (= 9.88 V), set SW1 = B and confirm that $5\text{ V} \times 10\text{ k}\Omega / (10\text{ k}\Omega + 13\text{ k}\Omega) < V2 < 5\text{ V} \times 10\text{ k}\Omega / (10\text{ k}\Omega + 7\text{ k}\Omega)$.

Test Circuit 10: VRF, VOH (ISD), VOL (ISD)

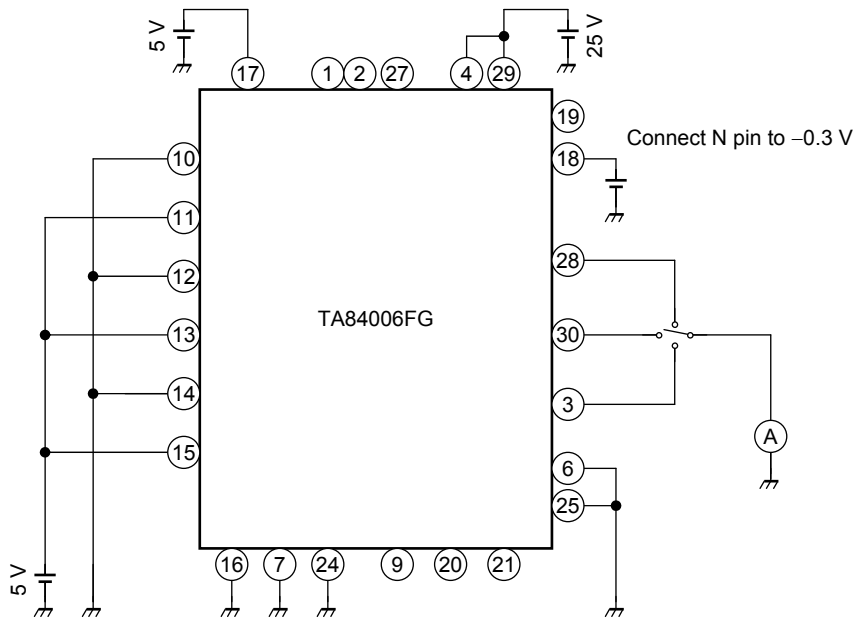


- (1) Where VISD = 0.55 V, set SW2 = A and measure V3 = VOH (ISD).
- (2) Where VISD = 0.45 V, set SW2 = B and measure V3 = VOL (ISD).

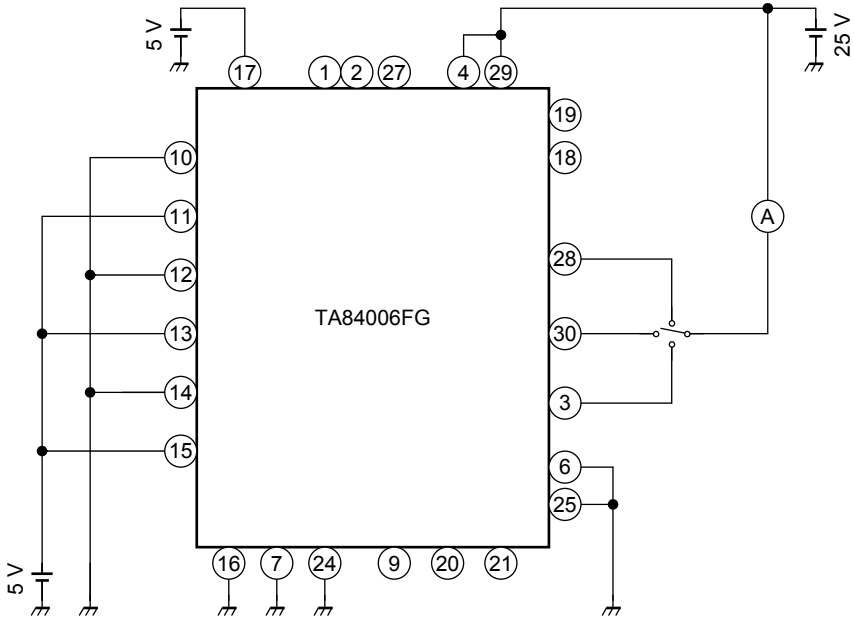
Test Circuit 11: V_Z



Test Circuit 12: $I_L (H)$



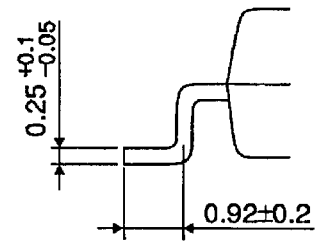
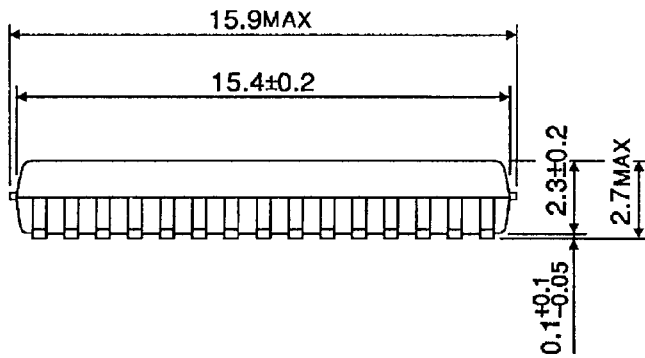
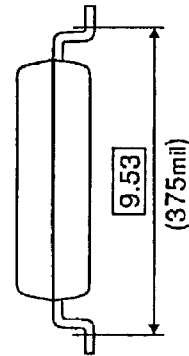
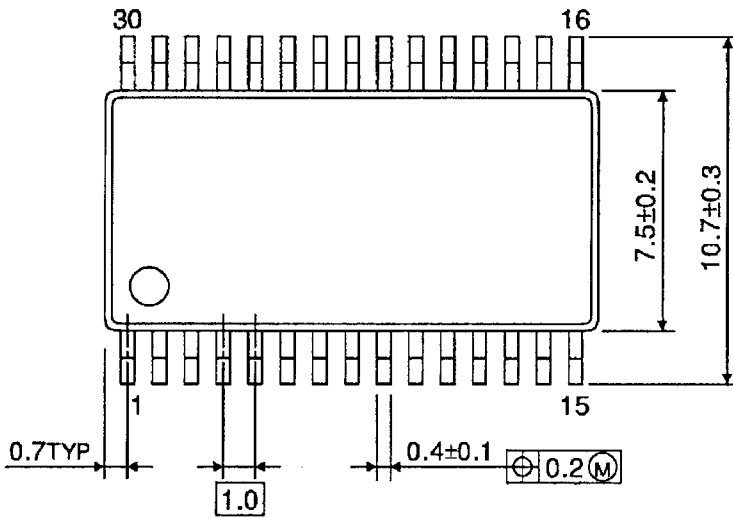
Test Circuit Test Circuit 13: I_L (L)



Package Dimensions

SSOP30-P-375-1.00

Unit : mm



Weight: 0.63 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.

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