

TOSHIBA BIPOLAR LINEAR INTEGRATED CIRCUIT MULTI-CHIP

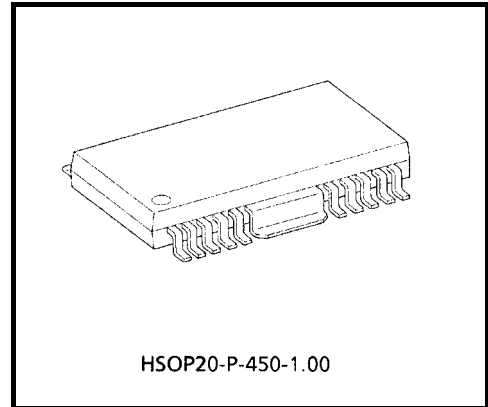
# TA84002F/FG

## PWM CHOPPER-TYPE 2-PHASE BIPOLAR STEPPING MOTOR DRIVER

The TA84002F/FG is designed to drive both windings of a two-phase bipolar stepping motor.

### FEATURES

- Internal PWM current control
- Wide range of operating supply voltages  
V<sub>M</sub> (motor) : 10 V to 30 V  
V<sub>CC</sub> (control) : 4.5 V to 5.5 V
- Output current : 1.0 A (peak)
- Multichip IC consisting of four P-channel MOSFETs and one main chip
- Full-step and half-step are available
- Internal thermal-shutdown circuit
- Package : HSOP20-P-450-1.00



Weight: 0.79 g (typ.)

Note 1: This product has a multichip (MCP) structure utilizing Pch MOS technology, which is sensitive to electrostatic discharge. Handle with care.

#### TA84002FG:

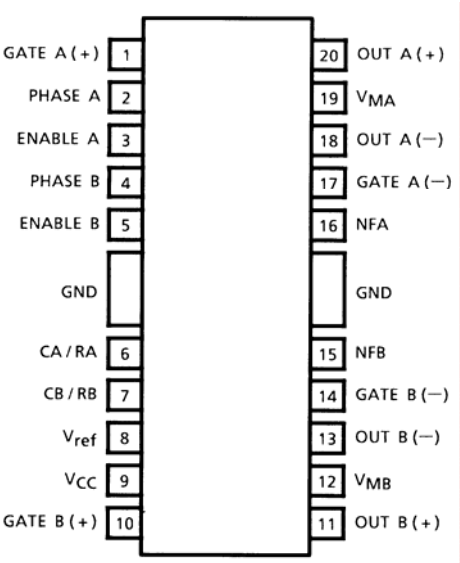
The TA84002FG is a Pb-free product.

The following conditions apply to solderability:

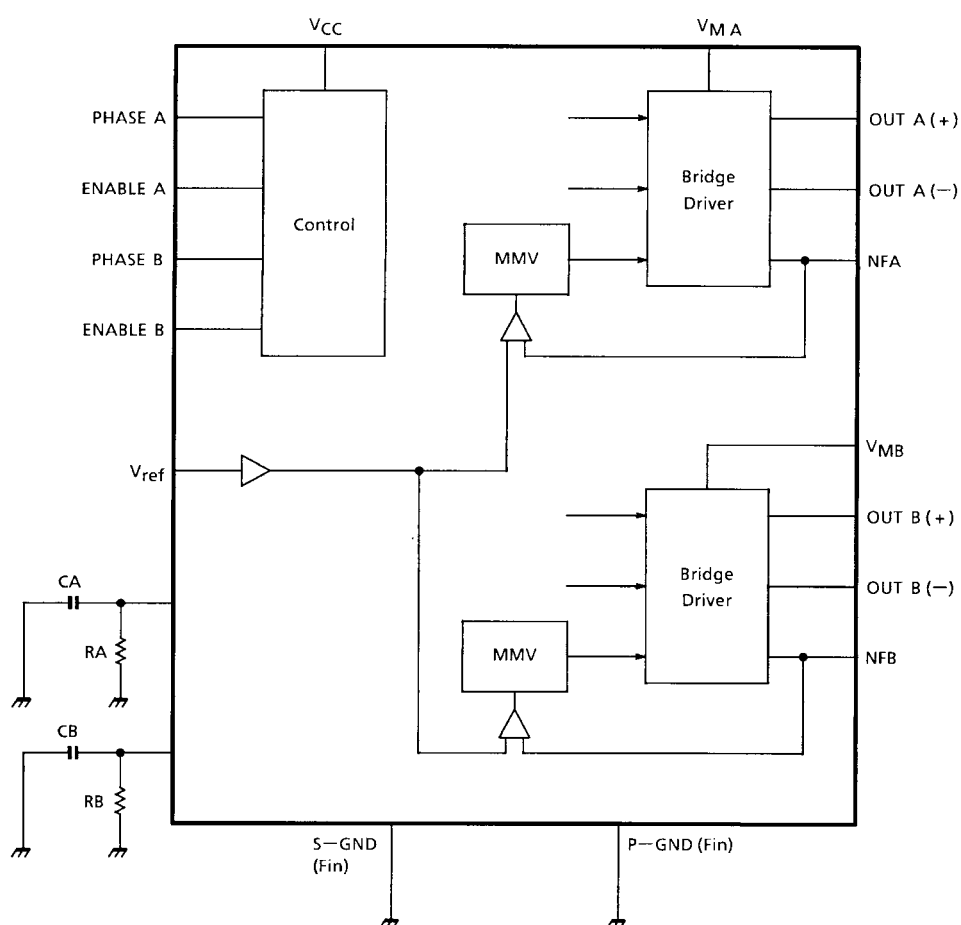
##### \*Solderability

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  
\*number of times = once  
\*use of R-type flux

PIN ASSIGNMENT



## BLOCK DIAGRAM



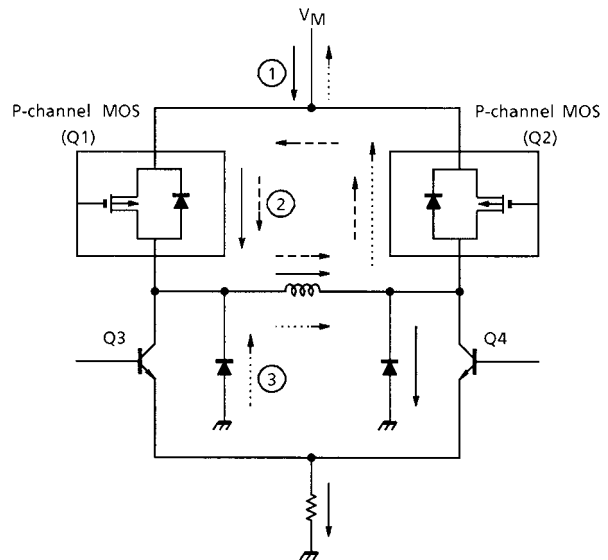
## TRUTH TABLE

| PHASE | ENABLE | OUT (+) | OUT (-) |
|-------|--------|---------|---------|
| X     | H      | OFF     | OFF     |
| H     | L      | H       | L       |
| L     | L      | L       | H       |

X: Don't care

## OUTPUT STAGE

- The TA84002F/FG is a multichip IC consisting of four P-channel MOSFETs and one main chip.
- The four P-channel MOSFETs are used as upper-side power transistors.
- The output current is controlled by a switching lower-side transistor.
- During CHOP ON, the current flows through the P-channel MOS, motor winding, sink transistor and sense resistor.
- During CHOP OFF, the current circulates the motor winding, P-channel MOS and the diode of the P-channel MOS.
- Power dissipation is divided between the five chips.



—→ : (1) CHOP ON

(Drive Mode)

Q1: ON, Q2: OFF

Q3: OFF, Q4: ON

- - -→ : (2) CHOP OFF

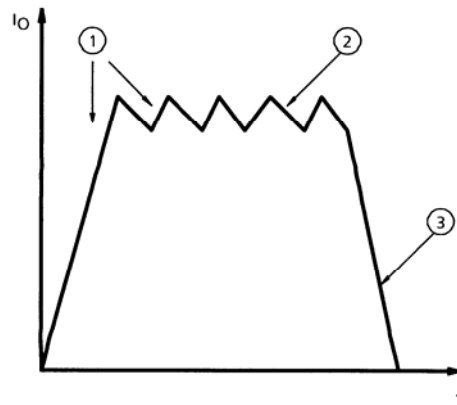
(Slow Decay)

Q1: ON, Q2: OFF

Q3: OFF, Q4: OFF

.....→ : (3) ALL OFF

(Fast Decay)



## PWM CURRENT CONTROL

The output current is sensed and controlled independently in each bridge by an external sense resistor ( $R_{FN}$ ), internal comparator, and mono-stable multi-vibrator.

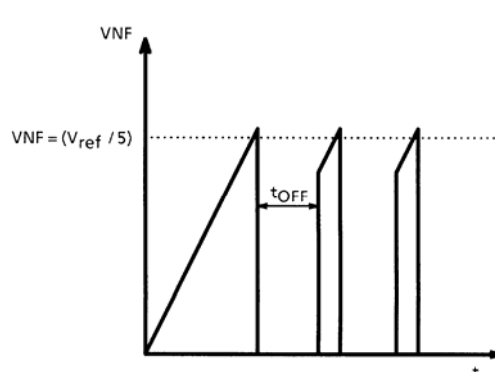
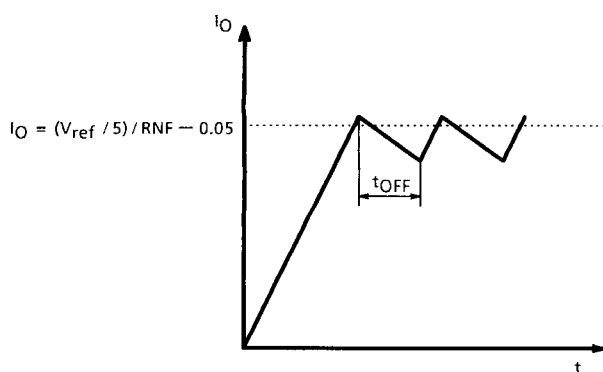
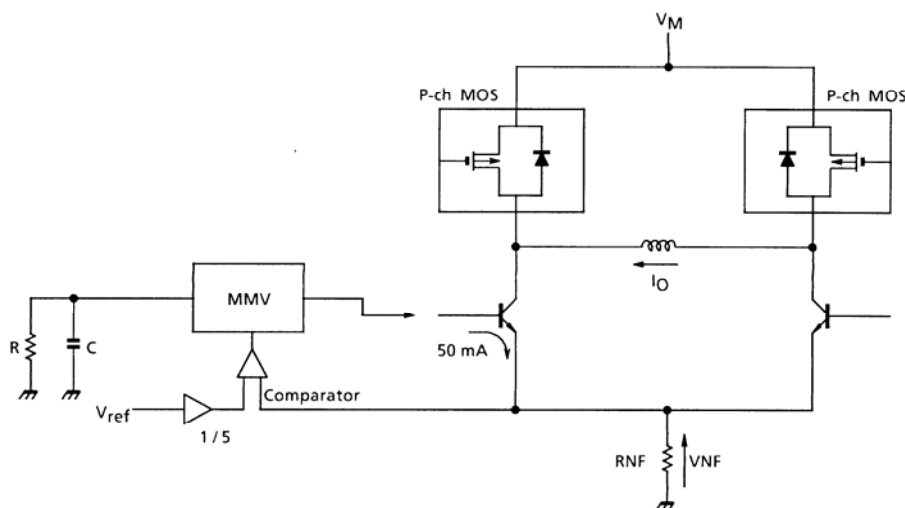
When the bridge is turned ON, the current increases in the motor winding and flows through the external sense resistor until the sense voltage ( $V_{NF}$ ) reaches the level set at the comparator input:  $V_{ref} / 5$ . The comparator then triggers the mono-stable multivibrator, which turns OFF the lower transistor of the bridge.

The OFF time is determined by the external RC timing components of the monostable multivibrator:

$$t_{OFF} \approx 1.1 CR.$$

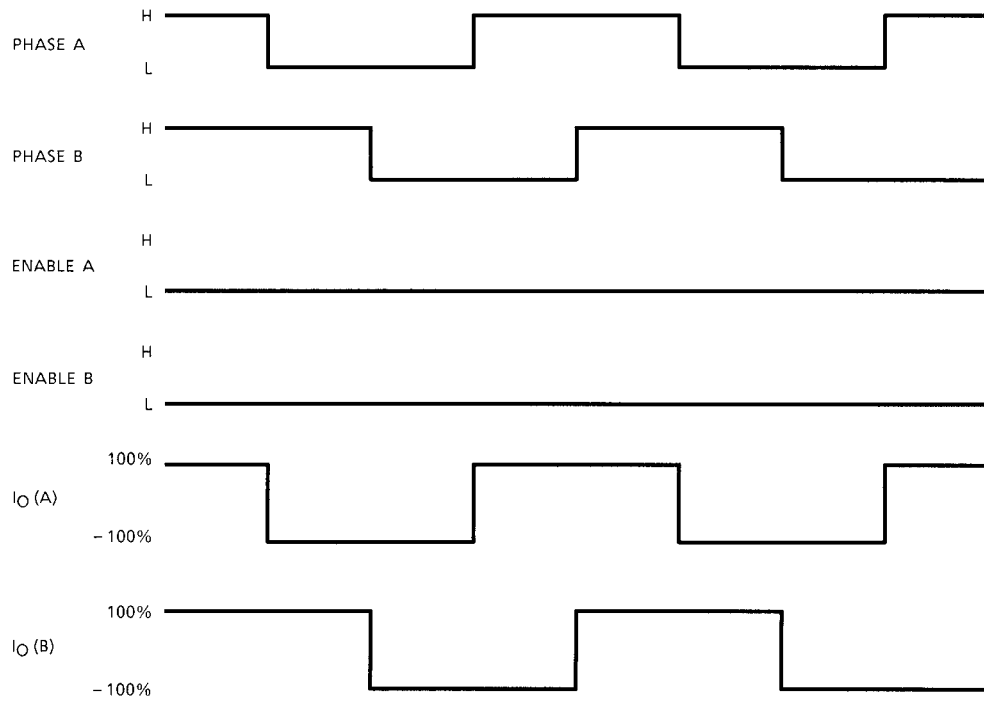
The approximate value of the current limiting ( $I_O$ ) is given by the following:

$$I_O = (V_{ref} / 5) / R_{NF} - 0.05.$$

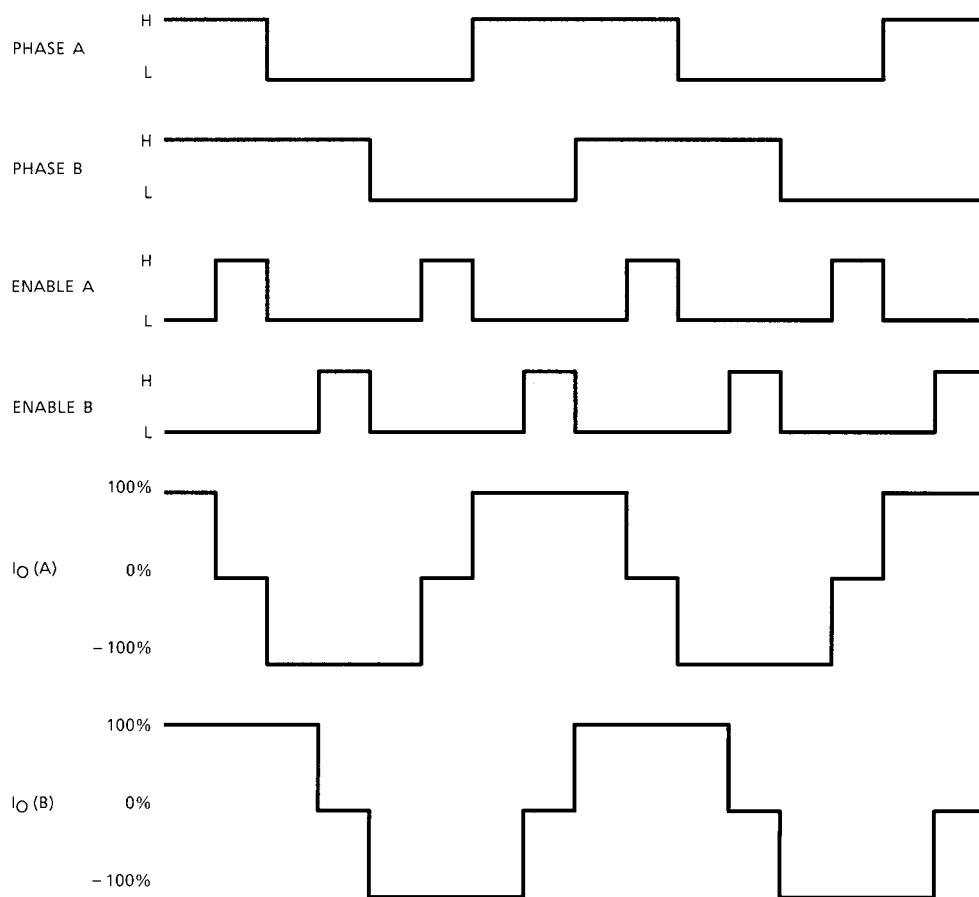


## TIMING CHART

(1) Full Step



## (2) Half Step



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

| CHARACTERISTIC           | SYMBOL           | RATING                               | UNIT   |
|--------------------------|------------------|--------------------------------------|--------|
| Supply Voltage (Motor)   | V <sub>M</sub>   | 35                                   | V      |
| Supply Voltage (Control) | V <sub>CC</sub>  | 7                                    | V      |
| Output Current           | I <sub>O</sub>   | 1.0                                  | A / ch |
| Input Voltage            | V <sub>IN</sub>  | GND – 0.4 to V <sub>CC</sub> + 0.4 V | V      |
| Power Dissipation        | P <sub>D</sub>   | 2.5 (Note)                           | W      |
| Operating Temperature    | T <sub>opr</sub> | –30 to 85                            | °C     |
| Storage Temperature      | T <sub>stg</sub> | –55 to 150                           | °C     |

Note: This rating is obtained when the product is mounted on a 50 × 50 × 1.6 mm PCB 60% or more of which is occupied by copper.

## RECOMMENDED OPERATION CONDITION (Ta = –30 to 85°C)

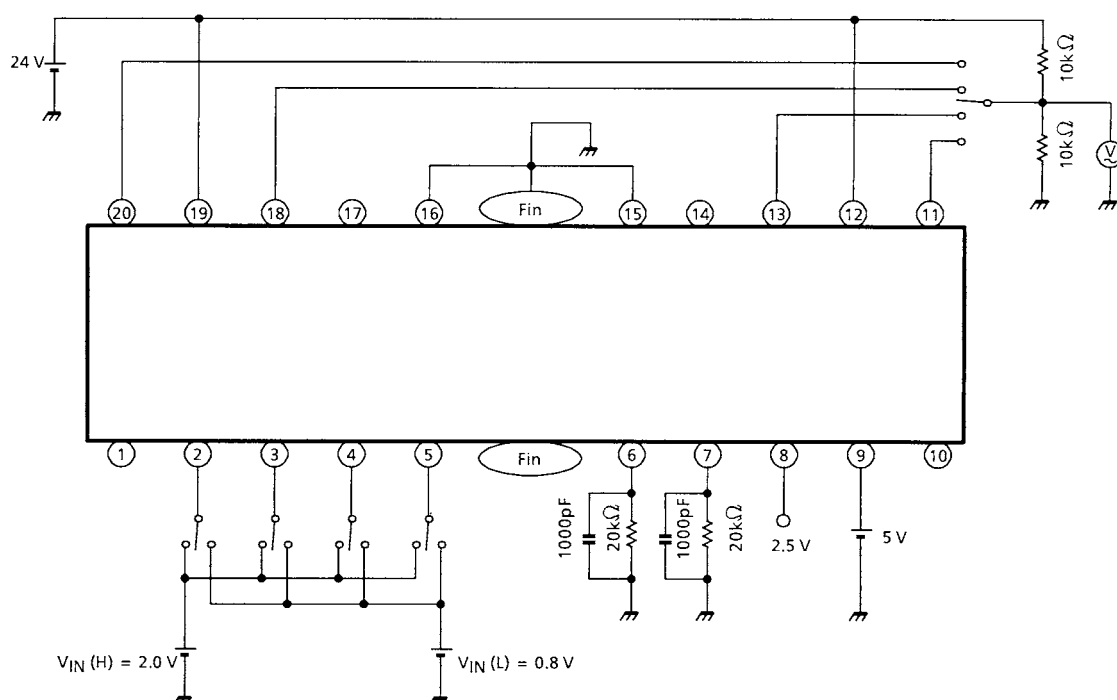
| CHARACTERISTIC           | SYMBOL           | TEST CIR-CUIT | TEST CONDITION | MIN | TYP. | MAX                   | UNIT   |
|--------------------------|------------------|---------------|----------------|-----|------|-----------------------|--------|
| Supply Voltage (Control) | V <sub>CC</sub>  | —             |                | 4.5 | 5.0  | 5.5                   | V      |
| Supply Voltage (Motor)   | V <sub>M</sub>   | —             |                | 10  | 24   | 30                    | V      |
| Output Current           | I <sub>O</sub>   | —             |                | —   | —    | 0.8                   | A / ch |
| Input Voltage            | V <sub>IN</sub>  | —             | PHASE, ENABLE  | GND | —    | V <sub>CC</sub>       | V      |
| Reference Voltage        | V <sub>ref</sub> | —             |                | 1.2 | 2.5  | V <sub>CC</sub> – 0.5 | V      |
| PWM Frequency            | f <sub>PWM</sub> | —             |                | 15  | 30   | 50                    | kHz    |

**ELECTRICAL CHARACTERISTICS (Ta = 25°C, V<sub>CC</sub> = 5 V, V<sub>M</sub> = 24 V)**

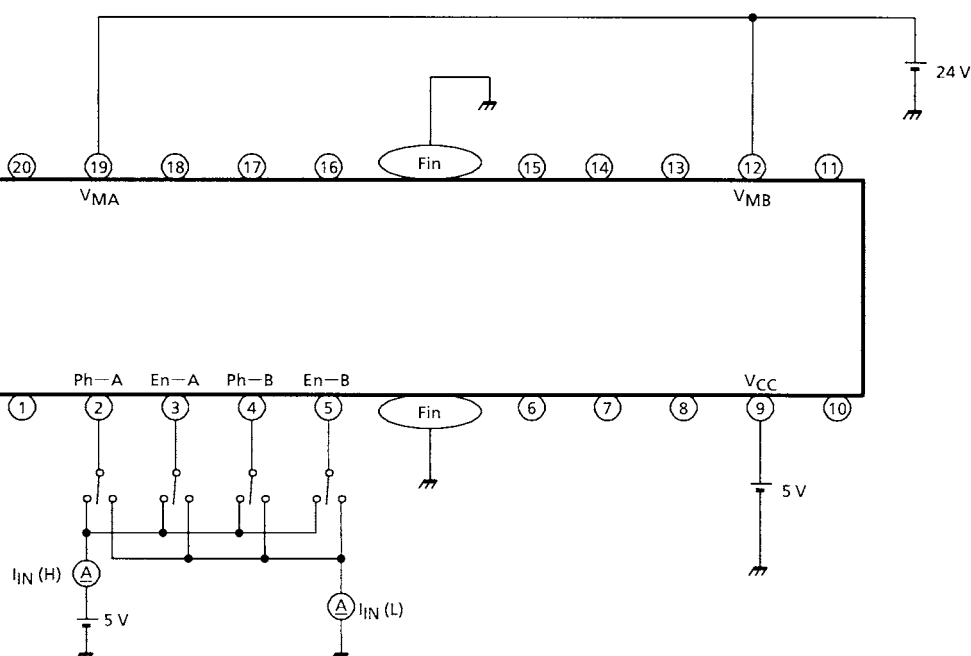
| CHARACTERISTIC                            | SYMBOL             | TEST CIR-CUIT | TEST CONDITION                                  | MIN         | TYP. | MAX                     | UNIT |
|-------------------------------------------|--------------------|---------------|-------------------------------------------------|-------------|------|-------------------------|------|
| Input Voltage                             | V <sub>IN(H)</sub> | 1             | PHASE, ENABLE                                   | 2.0         | —    | V <sub>CC</sub> + 0.3 V | V    |
|                                           | V <sub>IN(L)</sub> |               |                                                 | GND - 0.3 V | —    | 0.8                     |      |
| Input Current                             | I <sub>IN(H)</sub> | 2             | PHASE, ENABLE, V <sub>IN</sub> = 5 V            | —           | 2    | 20                      | μA   |
|                                           | I <sub>IN(L)</sub> |               | PHASE, V <sub>IN</sub> = GND                    | —           | 0    | 1                       |      |
|                                           | I <sub>IN(L)</sub> |               | ENABLE, V <sub>IN</sub> = GND                   | —           | 50   | 100                     |      |
| Supply Current                            | I <sub>CC1</sub>   | 3             | ENABLE A / B = Low<br>2-Phase 100% ON           | —           | 110  | 180                     | mA   |
|                                           | I <sub>CC2</sub>   | 4             | ENABLE A / B = Low<br>2-Phase 100% OFF          | —           | 6    | 14                      |      |
|                                           | I <sub>CC3</sub>   | 3             | ENABLE A = Low,<br>B = High<br>1-Phase 100% ON  | —           | 55   | 90                      |      |
|                                           | I <sub>CC4</sub>   | 4             | ENABLE A = Low,<br>B = High<br>1-Phase 100% OFF | —           | 6    | 14                      |      |
|                                           | I <sub>CC5</sub>   | 3             | ENABLE A / B = High<br>2-Phase OFF              | —           | 6    | 14                      |      |
|                                           | I <sub>M1</sub>    | 5             | ENABLE A / B = Low<br>2-Phase ON                | —           | 5    | 13                      |      |
|                                           | I <sub>M2</sub>    |               | ENABLE A = Low,<br>B = High<br>1-Phase ON       | —           | 4.5  | 11                      |      |
|                                           | I <sub>M3</sub>    |               | ENABLE A / B = High<br>2-Phase OFF              | —           | 4    | 9                       |      |
| Output Saturation Voltage<br>(Lower-side) | V <sub>SAT1</sub>  | 6             | I <sub>O</sub> = 0.5 A                          | —           | 0.35 | 0.8                     | V    |
|                                           | V <sub>SAT2</sub>  |               | I <sub>O</sub> = 1.0 A                          | —           | 0.65 | 2.0                     |      |
| ON Resistor (Upper-side)                  | R <sub>on1</sub>   | 7             | I <sub>O</sub> = 0.5 A                          | —           | 0.6  | 1.0                     | Ω    |
| Diode Forward Voltage (Lower-side)        | V <sub>F(L)</sub>  | 8             | I <sub>F</sub> = 1.0 A                          | —           | 1.4  | 2.0                     | V    |
| Diode Forward Voltage (Upper-side)        | V <sub>F(H)</sub>  | 9             | I <sub>F</sub> = 1.0 A                          | —           | 0.95 | 1.8                     | V    |
| Reference Voltage Range                   | V <sub>ref</sub>   | —             |                                                 | 1.0         | 2.5  | V <sub>CC</sub> - 0.5   | V    |
| Reference Current                         | I <sub>ref</sub>   | 10            | V <sub>ref</sub> = 2.5 V                        | —           | 0.2  | 5                       | μA   |
| Reference Divider Ratio                   | GAIN               | 11            | V <sub>NF</sub> / V <sub>ref</sub>              | 0.17        | 0.2  | 0.23                    |      |
| Setting Current                           | I <sub>set</sub>   | —             | V <sub>ref</sub> = 2.5 V, R <sub>NF</sub> = 1 Ω | 0.35        | 0.45 | 0.55                    | A    |
| Thermal Shutdown Temperature              | TSD                | —             | T <sub>j</sub>                                  | —           | 165  | —                       | °C   |
| Thermal Shutdown Hysteresis               | ΔT                 | —             |                                                 | —           | 15   | —                       | °C   |
| Output Leakage Current                    | I <sub>L (H)</sub> | 12            | P-Channel MOS                                   | —           | 0    | 100                     | μA   |
|                                           | I <sub>L (L)</sub> |               |                                                 | —           | 0    | 50                      |      |
| Pch MOS Drive Current                     | I <sub>G</sub>     | 13            |                                                 | 330         | 530  | 730                     | μA   |

## TEST CIRCUIT

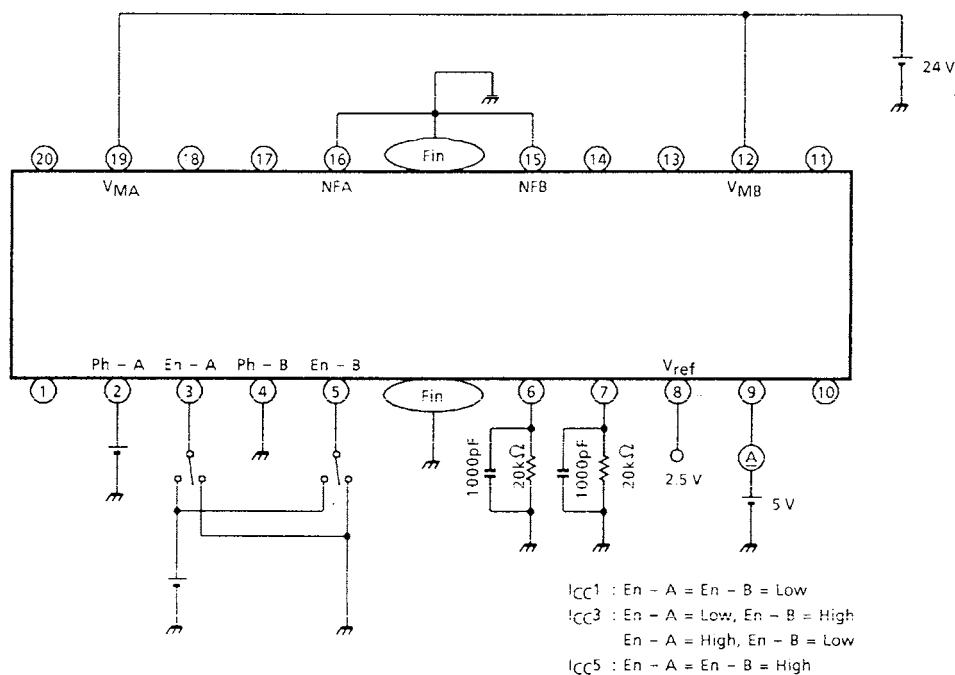
### 1. $V_{IN}$ (H), $V_{IN}$ (L)



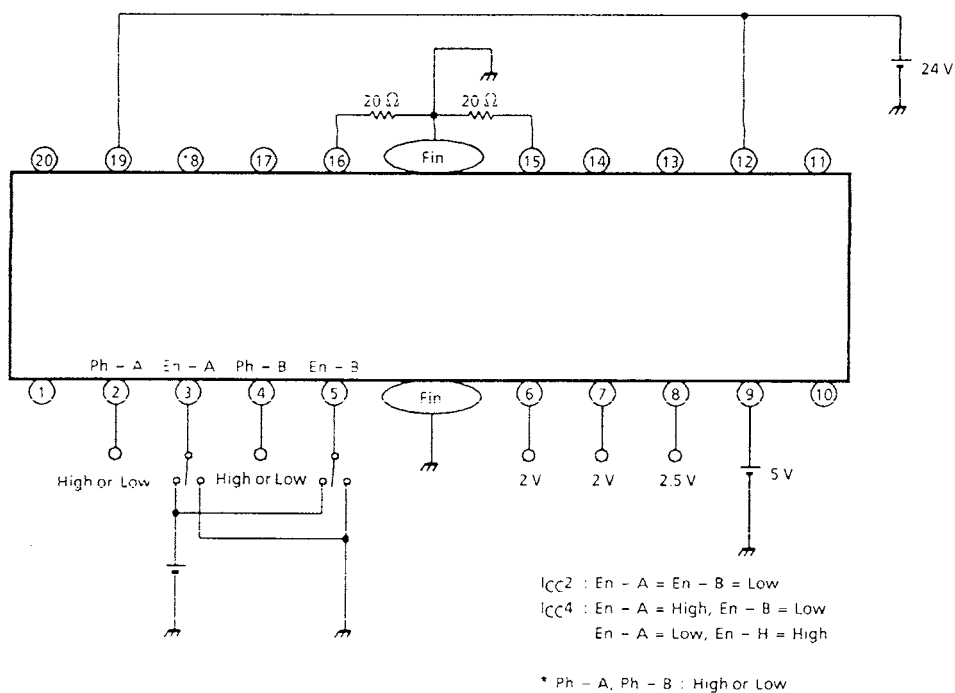
### 2. $I_{IN}$ (H), $I_{IN}$ (L)



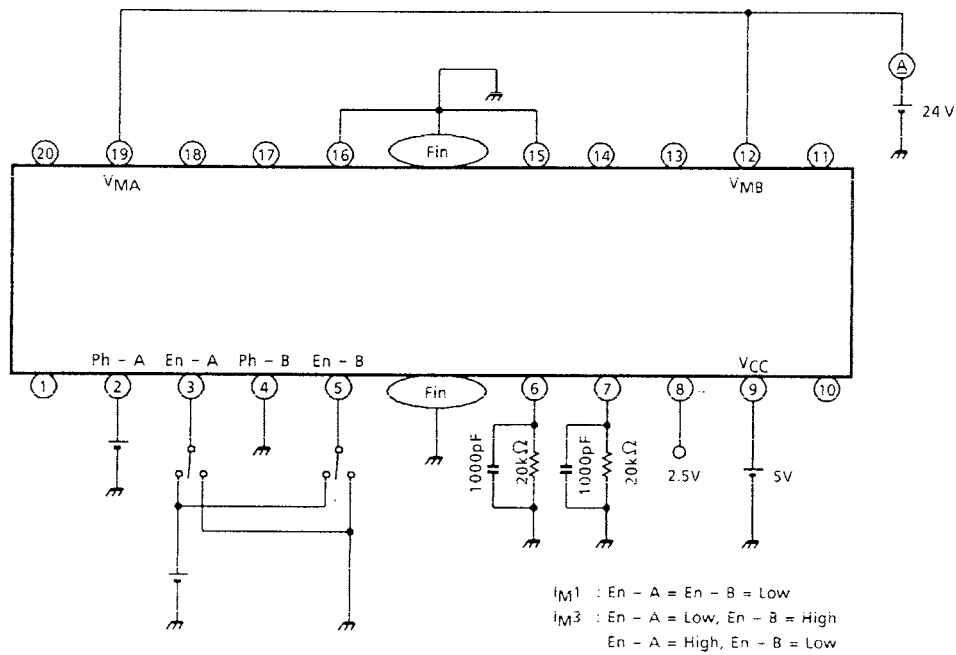
## 3. Icc1, Icc3, Icc5



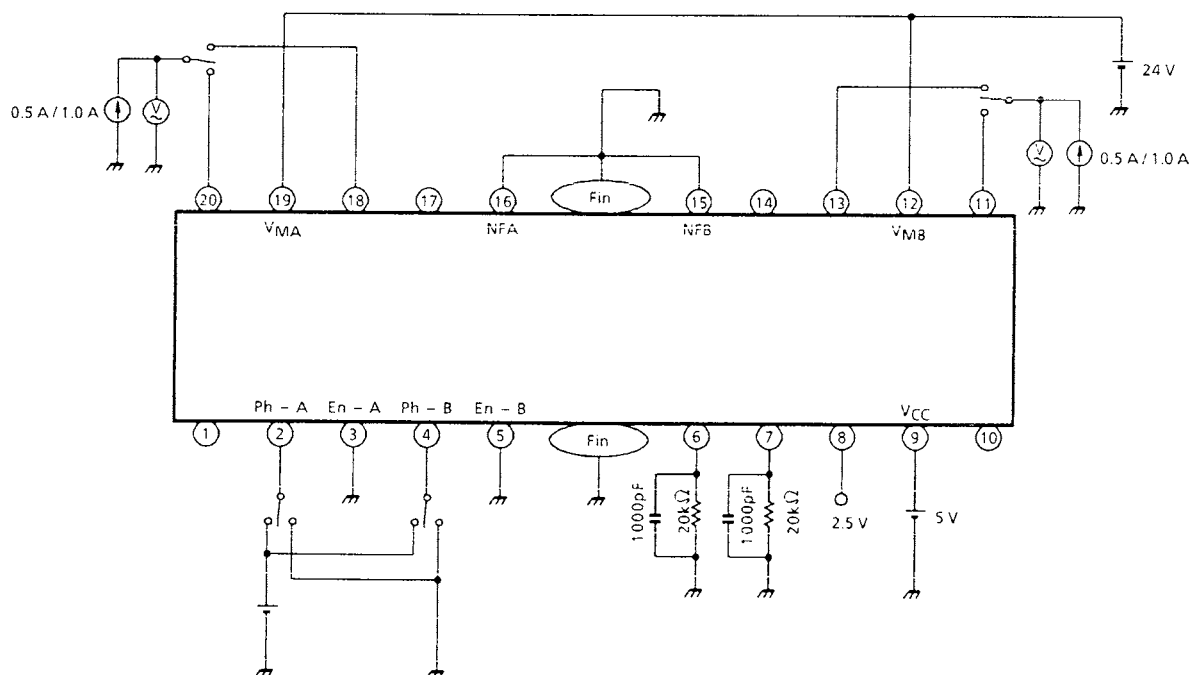
## 4. Icc2, Icc4



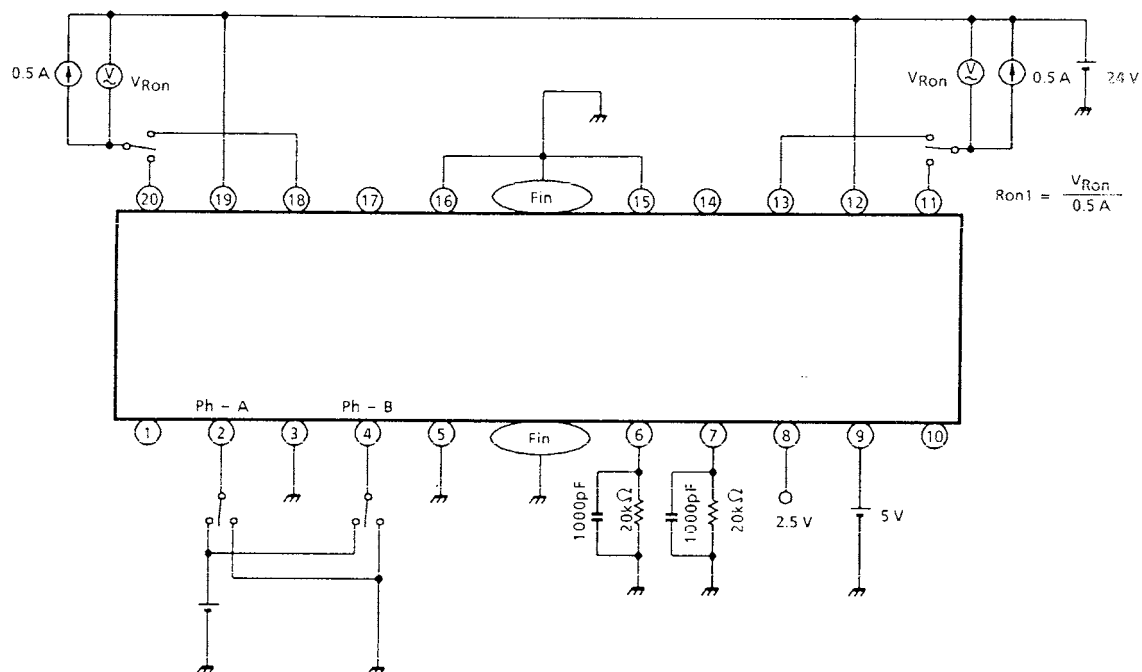
## 5. $I_{M1}$ , $I_{M2}$ , $I_{M3}$



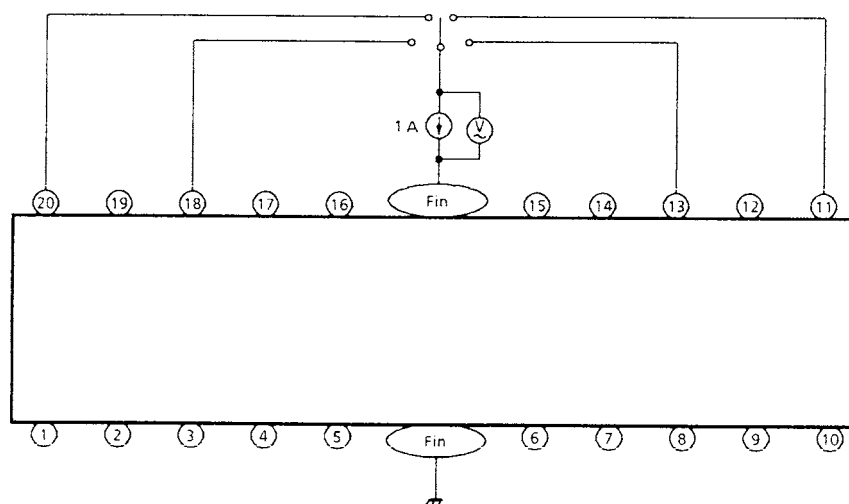
## 6. $V_{SAT1}$ , $V_{SAT2}$



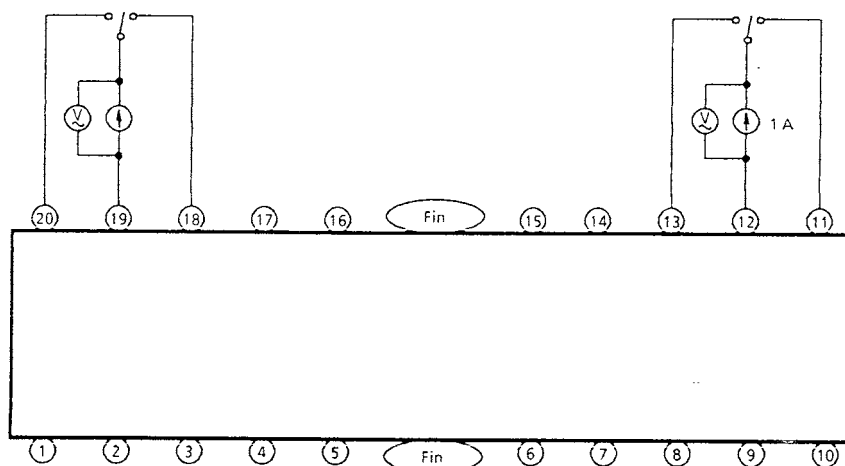
7.  $R_{on1}$



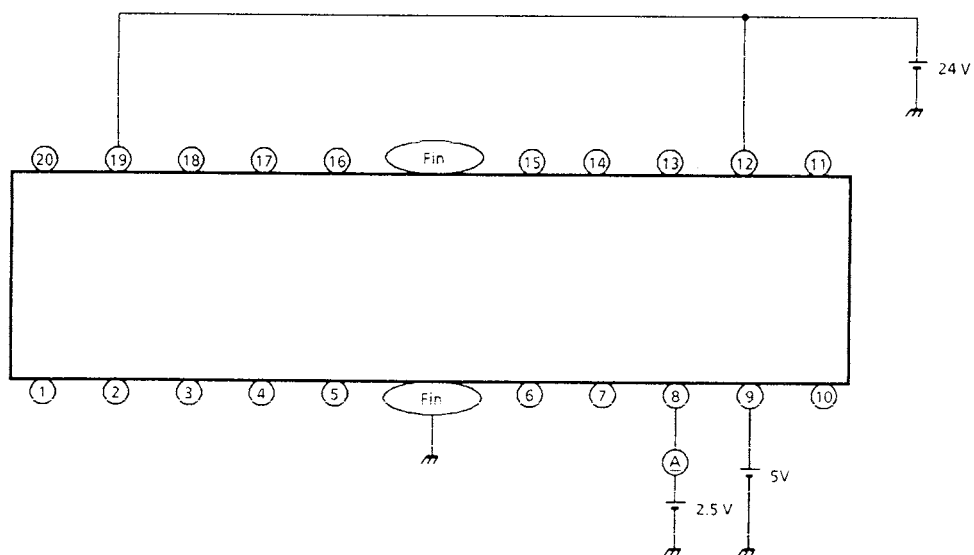
8.  $V_F (L)$



## 9. VF (H)



## 10. I<sub>ref</sub>



The diagram shows a 20-pin microcontroller package with the following connections:

- Pin 1:** Connected to a voltage source  $V$  and ground.
- Pin 2:** Connected to a voltage source  $V$  and ground.
- Pin 3:** Connected to ground.
- Pin 4:** Connected to a voltage source  $V$  and ground.
- Pin 5:** Connected to ground.
- Pin 6:** Connected to a voltage source  $V$  and ground.
- Pin 7:** Connected to a voltage source  $V$  and ground.
- Pin 8:** Connected to a voltage source  $V$  and ground.
- Pin 9:** Connected to a voltage source  $V$  and ground.
- Pin 10:** Connected to a voltage source  $V$  and ground.
- Pin 11:** Connected to a voltage source  $V$  and ground.
- Pin 12:** Connected to a voltage source  $V$  and ground.
- Pin 13:** Connected to a voltage source  $V$  and ground.
- Pin 14:** Connected to a voltage source  $V$  and ground.
- Pin 15:** Connected to a voltage source  $V$  and ground.
- Pin 16:** Connected to a voltage source  $V$  and ground.
- Pin 17:** Connected to a voltage source  $V$  and ground.
- Pin 18:** Connected to a voltage source  $V$  and ground.
- Pin 19:** Connected to a voltage source  $V$  and ground.
- Pin 20:** Connected to a voltage source  $V$  and ground.

The circuit includes several components:

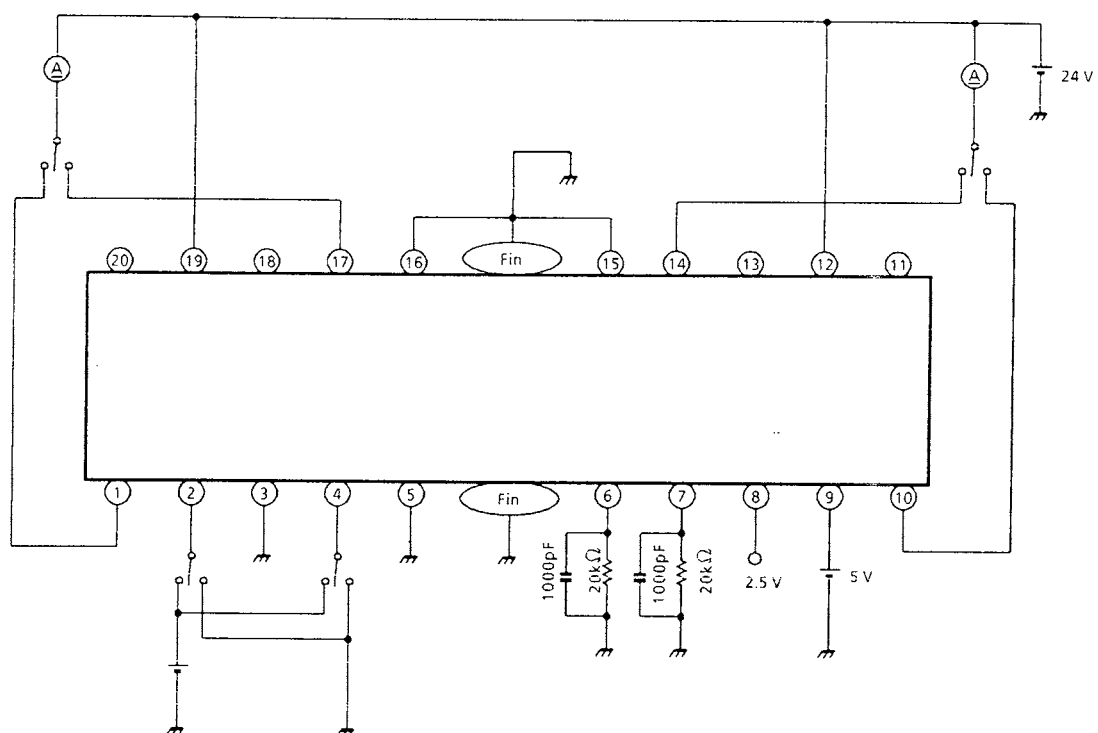
- A voltage source  $V$  connected to pins 1, 2, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20.
- A voltage source  $V_{set}$  connected to pin 11.
- A voltage source  $V_{set}$  connected to pin 12.
- A voltage source  $V_{set}$  connected to pin 13.
- A voltage source  $V_{set}$  connected to pin 14.
- A voltage source  $V_{set}$  connected to pin 15.
- A voltage source  $V_{set}$  connected to pin 16.
- A voltage source  $V_{set}$  connected to pin 17.
- A voltage source  $V_{set}$  connected to pin 18.
- A voltage source  $V_{set}$  connected to pin 19.
- A voltage source  $V_{set}$  connected to pin 20.
- A voltage source  $V_{set}$  connected to pin 11.
- A voltage source  $V_{set}$  connected to pin 12.
- A voltage source  $V_{set}$  connected to pin 13.
- A voltage source  $V_{set}$  connected to pin 14.
- A voltage source  $V_{set}$  connected to pin 15.
- A voltage source  $V_{set}$  connected to pin 16.
- A voltage source  $V_{set}$  connected to pin 17.
- A voltage source  $V_{set}$  connected to pin 18.
- A voltage source  $V_{set}$  connected to pin 19.
- A voltage source  $V_{set}$  connected to pin 20.

The formula for the set current is given as:

$$I_{set} = \frac{V_{set}}{I_O \times A}$$

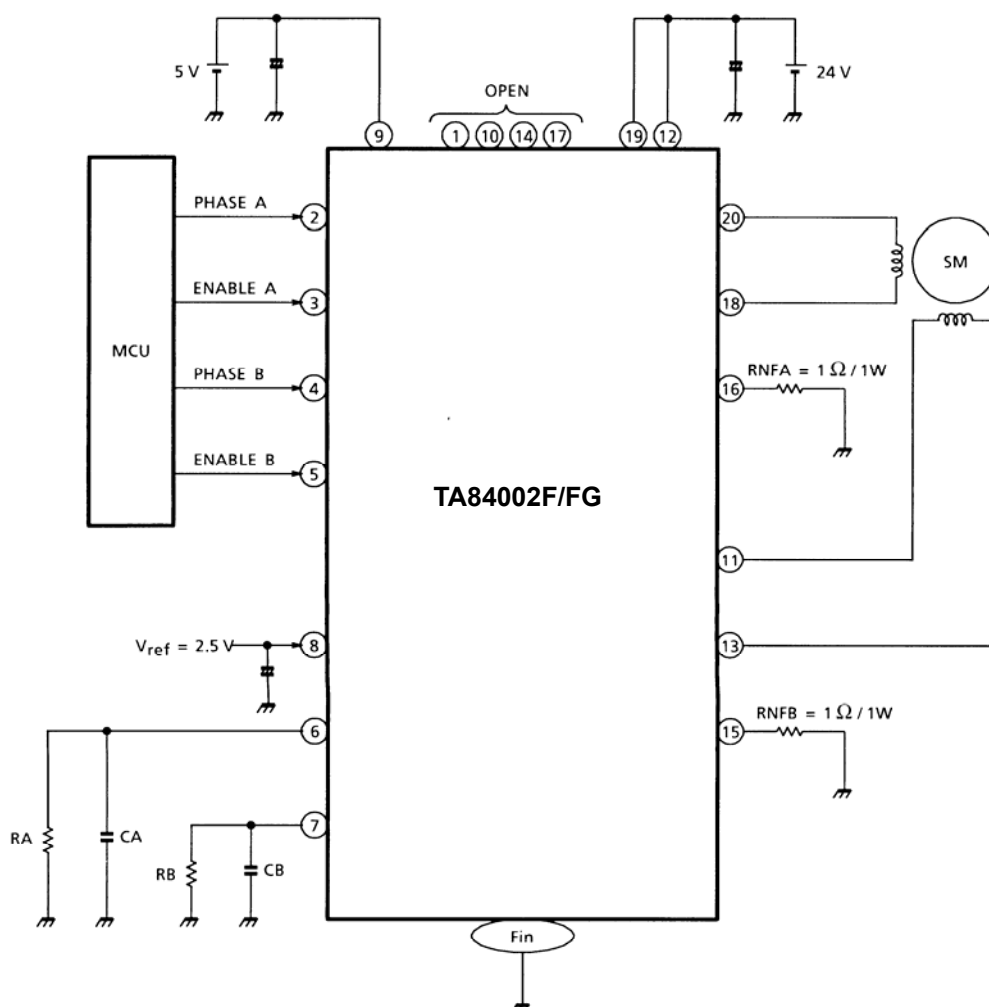
$$I_{set} = \frac{V_{set}}{I_0 \times A}$$

The schematic diagram shows a test circuit with two main power supplies: a 24V source at the top and a 5V source at the bottom. The circuit is organized into two horizontal rows of components, separated by a central horizontal line. The top row includes a 24V source connected to a network of resistors, switches, and ammeters. The bottom row includes a 5V source connected to a network of resistors, capacitors, and switches. A central component labeled 'Fin' is connected to both sections. The circuit is labeled with pin numbers 1 through 20. The top row has pins 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20. The bottom row has pins 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The 'Fin' component is connected to pins 15 and 6. The 24V source is connected to pins 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20. The 5V source is connected to pins 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. The circuit includes several resistors (20kΩ, 100kΩ, 100pF, 1000pF), capacitors (100pF, 1000pF), and switches. Ammeters are connected in series with the resistors in the top section.

13. I<sub>G</sub>

## APPLICATION CIRCUIT

In case of  $I_{OUT} = 0.5\text{ A}$



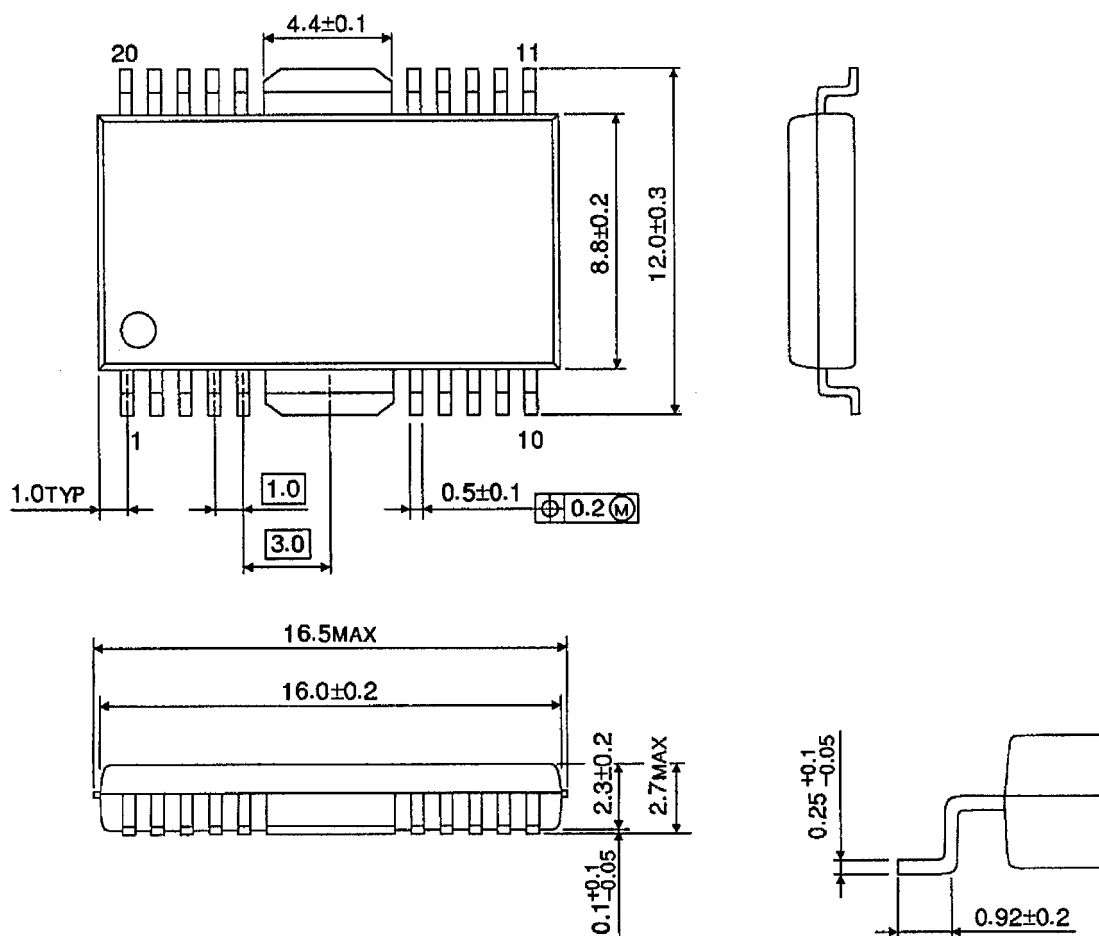
Note 1: A capacitor for noise suppression should be connected between the power supply ( $V_{CC}$ ,  $V_M$ ,  $V_{ref}$ ) and GND to stabilize operation.

Note 2: 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.

## PACKAGE DIMENSIONS

HSOP20-P-450-1.00

Unit: mm



Weight: 0.79 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 flows 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**

060116EBA

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