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PDE-39300-0
Ref. No.: IC-SP-10016 R0

Datasheet

# Sine Wave Solution Kit

# ECN39300

Power Device Division
Power & Industrial Systems Division
Power Systems Company
**Hitachi, Ltd.**

# ECN39300

－Contents－

# ECN39300

## 0. Applicable Scope

This specification is applicable to the kit product consisting of the inverter IC (hereinafter called "ECN33201") and the microcomputer (hereinafter called "MCU") described in the table below. See Sine Wave Solution Kit Application Notes (document No. IC–SP–10018) regarding directions for use.

**Table 0.1 Configuration of Sine Wave Solution Kit (Type: ECN39300)**

| Name | Components | |
|---|---|---|
| | Inverter IC (Individual specifications: Section 3) | Microcomputer (Individual specifications: Section 4) |
| ECN39300SP | ECN33201SP | R5F21334CN505FP (including control software) |
| ECN39300SR | ECN33201SPR | |
| ECN39300SV | ECN33201SPV | |

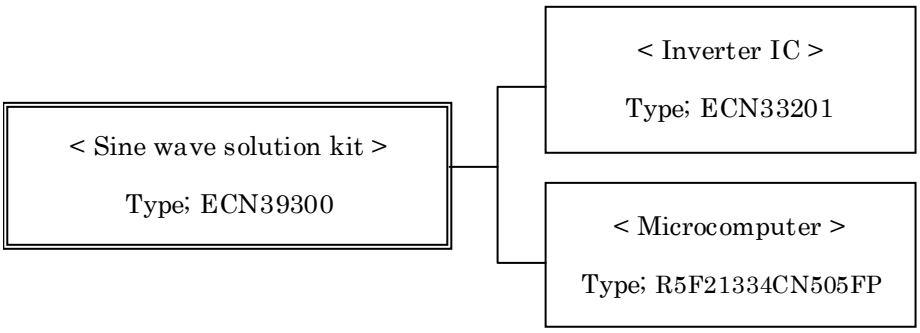



**Fig. 0.1 Configuration of Sine Wave Solution Kit (Type: ECN39300)**

# ECN39300

## 1. Conditions of Sale

1.1 Operation

(1) The ECN39300 is sold in kit form, with the ECN33201 and MCU. However, if either of them is unavailable due to production line failures or market failures, please contact Hitachi's sales office.

(2) Hitachi receives orders of more than 2000 in units of 1000. If you need fewer than 2000, please contact a Hitachi sales office.

(3) Lead time (the period of time between receipt of an order and delivery of the product) of at least 3 months is generally necessary. Please contact a Hitachi sales office for detailed delivery dates.

(4) Shipping inspections are individually conducted on the ECN33201 and MCU according to the specifications of each.

(5) Hitachi warrants performance of the ECN39300 to the specifications applicable at the time of sale in accordance with this specification. Testing and other quality control techniques are utilized to the extent Hitachi needs to meet specifications described in this document. Specific testing of all parameters of each device is not necessarily performed, except those mandated by related laws and/or regulations.

(6) Hitachi assumes no obligation for compensation for any fault in customer's goods using the ECN39300 in the marketplace.

(7) Hitachi reserves the right to make changes in this specification and to discontinue mass production of the ECN39300. Customers are advised before purchasing to confirm that this specification of the ECN39300 is the latest version and that the ECN39300 is on mass-production status if purchasing has been suspended for one year or more.

(8) In no event shall Hitachi be liable for any damage that may result from an accident or any other cause during operation of the user's units according to this specification. Hitachi assumes no responsibility for any intellectual property claims or any other problems that may result from applications of information, products or circuits described in this specification.

(9) No license is granted by this specification under any patents or other rights of any third party or Hitachi.

(10) This specification should not be reproduced or duplicated, in any form, in whole or in part, without the expressed written permission of Hitachi.

(11) For the ECN39300 (technologies) described in this specification, the followings are prohibited.

(a) To provide to any party whose purpose in their application will hinder maintenance of international peace and safety.

(b) To be applied to the above-described purpose by direct purchasers or any third party.

When exporting the ECN39300 (technologies), the necessary procedures are to be taken in accordance with related laws and regulations.

# ECN39300

1.2 Warnings and Disclaimers

(1) Regardless of changes in external conditions during use, “absolute maximum ratings” should never be exceeded in designing electronic circuits that employ the ECN39300. If absolute maximum ratings are exceeded, the ECN39300 may be damaged or destroyed. In no event shall Hitachi be liable for any failure in the ECN39300 or any secondary damage resulting from use at a value exceeding the absolute maximum ratings.

(2) Continuous high-loaded (high temperature, high voltage, large current) operation should be avoided and derating design should be applied, even within the ranges of the absolute maximum ratings, to ensure reliability.

(3) The ECN39300 may experience failures due to accident or unexpected surge voltages. Accordingly, adopt safe design features, such as redundancy or prevention of erroneous action, to avoid extensive damage in the event of a failure.

(4) The ECN39300 is not manufactured to be suitable for use where extremely high reliability is required (such as use in nuclear power control, aerospace and aviation, traffic equipment, life–support–related medical equipment, fuel control equipment and various kinds of safety equipment). Inclusion of the ECN39300 in such application shall be fully at the risk of the customer. Hitachi assumes no liability for applications assistance, customer product design, or performance. In such cases customers are advised to ensure circuit and/or product safety by using semiconductor devices that assures high reliability or by user’s fail–safe precautions or other arrangements. (If a semiconductor device fails, there may be cases in which the semiconductor device, wiring or wiring pattern will emit smoke or cause a fire or in which the semiconductor device will burst.)

# ECN39300

## 2. External Packaging

2.1 External Packaging

Fig. 2.1.1 shows the external packaging of the ECN39300. The ECN33201 is put into a magazine, the MCU is in a reel, and the two are individually packed in inner boxes. The two inner boxes are packed into an outer box.

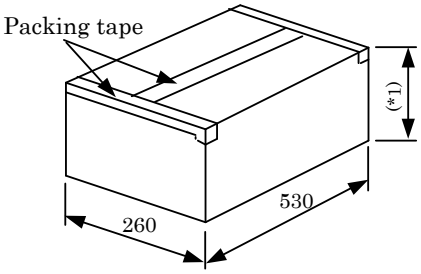
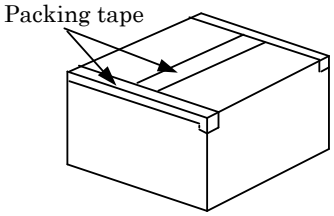
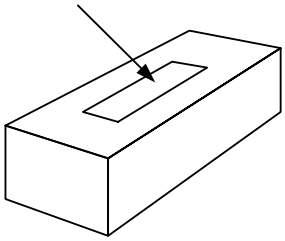
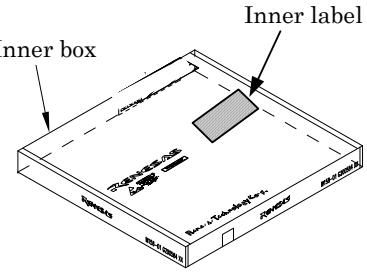
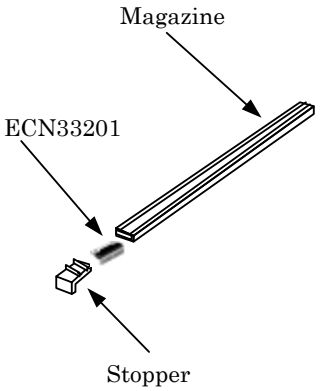
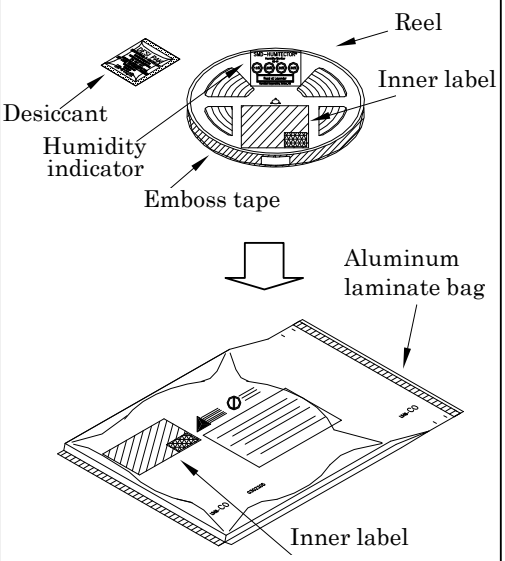
| | ECN33201 | MCU |
|---|---|---|
| Outer box (Unit: mm) |  <br>(*1) 120mm or 165mm<br>Depends on the number of packages.<br><br>(1) Dimensions are approximate (referential).<br>Actual dimensions may differ slightly. |  |
| Inner box |  |  |
| Magazine<br><br>Reel |  <br>The number of ICs; 15 / magazine |  <br>The number of MCUs; 1000 / reel |

**Fig. 2.1.1 External Packaging**

# ECN39300

2.2 Emboss Taping

Fig. 2.2.1 shows MCU insertion direction and tape pull-out direction from reel. Fig. 2.2.2 shows shape and dimensions of tape. MCU mark side looks top cover.

The emboss taping complies with EIA–481 and JIS C 0806.

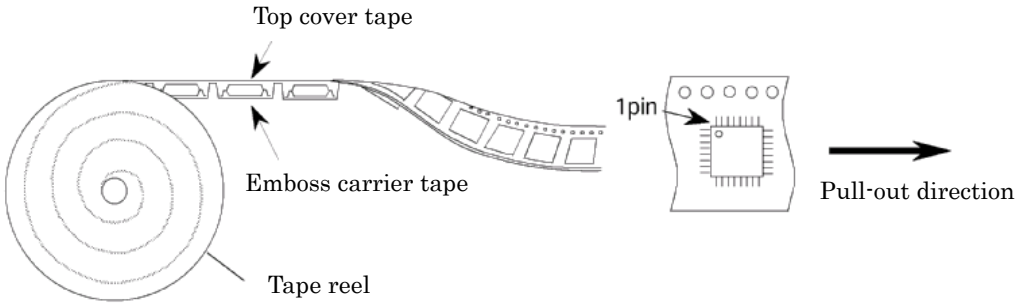



**Fig. 2.2.1 MCU Insertion Direction and Tape Pull-out Direction**

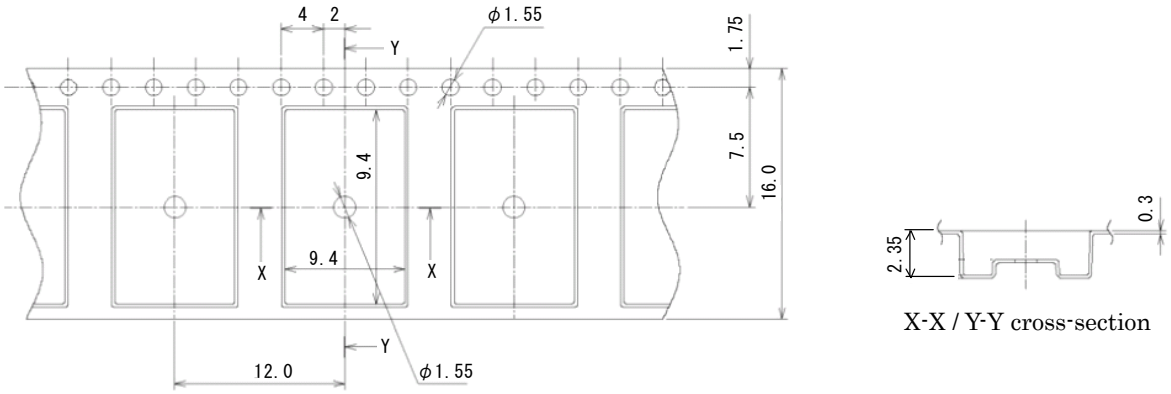
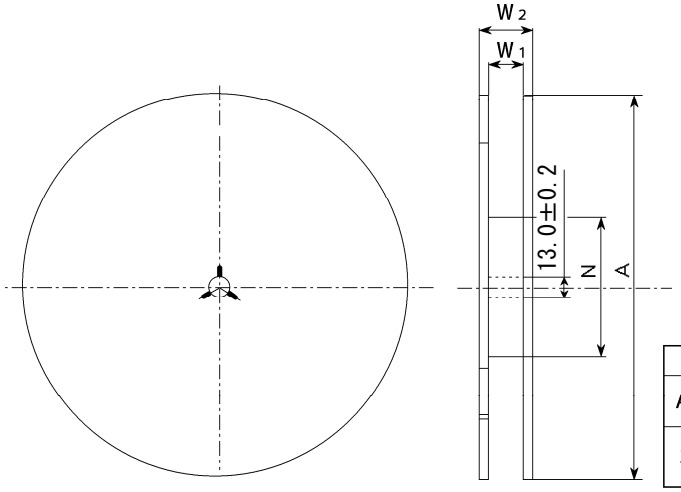



**Fig. 2.2.2 Tape Dimensions (Unit: mm)**

2.3 Reel Specification

Fig. 2.3.1 shows reel dimensions.




| Dimensions (mm) | | | |
|---|---|---|---|
| A ±2 | N +2 0 | W1 +2 0 | W2 MAX |
| 254 | 80 or 100 | 16.4 | 22.4 |

**Fig. 2.3.1 Reel Dimensions (Unit: mm)**

# ECN39300

### 3. Inverter IC (ECN33201) Specifications

3.1 Description

(1) Combined with the MCU as described in Section 0, offers a sine wave solution for a three-phase motor, for low noise levels and high efficiency.

(2) A motor is driven by three input signals (U, V, W) to ECN33201.

(3) Dead time and six control signals from three input signals are generated in ECN33201.

(4) Acceptable for incoming power of AC 200V to 230V. Maximum rating: 500VDC/1.5A. (Condition: Tj=25°C)

(5) Latch-up free monolithic IC built with high voltage Dielectric Isolation (DI) technology.

(6) Available to drive a motor using a high voltage DC power supply and a low voltage (15V) DC power supply.

3.2 Functions and Features

(1) Three input type.

(2) Built–in dead time generation. (Top and bottom arm short–circuit protection)

(3) Built–in charge pump circuit.

(4) Built–in 5V power supply circuit.

(5) Built–in over-current protection.

(6) Built–in 15V_VCC under-voltage detection.

(7) Fault output pin.

(8) FB–signal output pin for phase control.

(9) IGBT all off signal input pin.

# ECN39300

3.3 Block Diagram

ECN33201 is shown inside the bold line in Fig. 3.3.1.

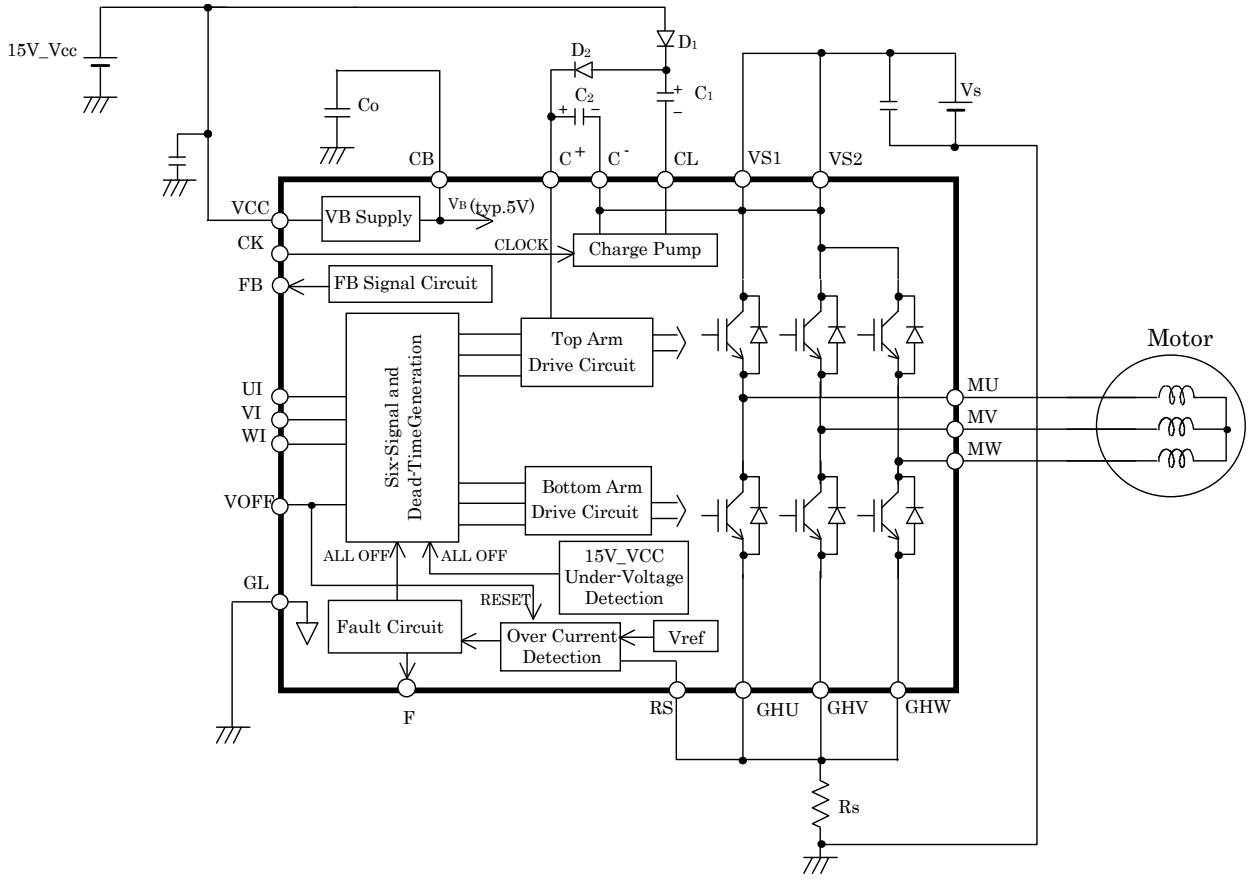
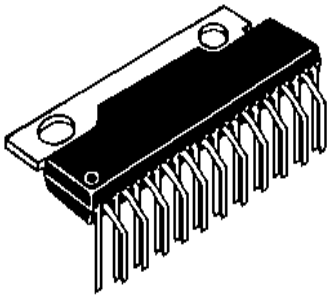
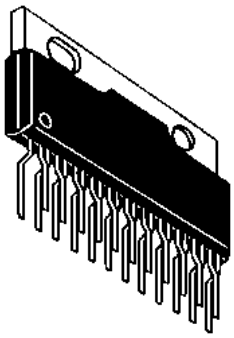



**Fig. 3.3.1 Block Diagram**

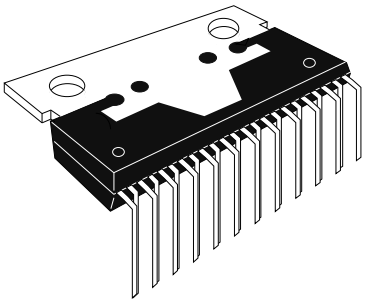
3.4 Types and Packages



ECN33201SP
(Package Type: SP-23TA)



ECN33201SPV
(Package Type: SP-23TB)



ECN33201SPR
(Package Type: SP-23TR)

**Fig. 3.4.1 Types and Packages of ECN33201**

# ECN39300

3.5 Absolute Maximum Ratings

**Table 3.5.1 Absolute Maximum Ratings** Condition: Ta=25°C

| No. | Item | | Symbol | Pin | Rating | Unit | Condition |
|---|---|---|---|---|---|---|---|
| 1 | Output device breakdown voltage | | VSM | VS1, VS2 MU, MV, MW | 500 | V | |
| 2 | VCC power supply voltage | | 15V_VCC | VCC | 18 | V | |
| 3 | Voltage between C+ and C– | | VCPM | C+, C– | 18 | V | |
| 4 | Input voltage | | VIN | UI, VI, WI CK, RS, VOFF | –0.5 to VB +0.5 | V | |
| 5 | Output current | Pulse | IP | MU, MV, MW | 1.5 | A | Note 1 |
| 6 | | DC | IDC | | 0.7 | | |
| 7 | VB supply output current | | IBMAX | CB | 50 | mA | |
| 8 | Junction operating temperature | | Tjop | – | –20 to +135 | °C | Note 2 |
| 9 | Storage temperature | | Tstg | – | –40 to +150 | °C | |

Note 1: Output IGBTs can handle this peak current at 25°C junction operating temperature.

Note 2: Thermal resistance

(1) Between junction and ECN33201 case (tab): Rjc=4°C/W

(2) Between junction and air: Rja=40 °C/W

# ECN39300

3.6 Electrical Characteristics

**Table 3.6.1 Electrical Characteristics** Suffix (T: Top arm, B: Bottom arm) Condition: Ta=25°C

| No. | Item | | Symbol | Pin | Min. | Typ. | Max. | Unit | Condition |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Standby current | | ISH | VS1, VS2 | – | 0.15 | 1.00 | mA | VOFF=0V, CK=0V |
| 2 | | | ICC | VCC | – | 3 | 10 | mA | VS=325V, VCC=15V, IB=0A |
| 3 | IGBT collector-emitter saturation voltage | | VONT | MU, MV, MW | – | 2.0 | 3.0 | V | I=0.35A, VCC=15V |
| 4 | | | VONB | MU, MV, MW | – | 2.0 | 3.0 | V | I=0.35A, VCC=15V |
| 5 | Output delay time | Turn on | TdONT | MU, MV, MW | – | 3.5 | 5.0 | µs | VS=325V, VCC=15V I=0.35A Resistive load |
| 6 | | | TdONB | MU, MV, MW | – | 3.5 | 5.0 | µs | |
| 7 | | Turn off | TdOFFT | MU, MV, MW | – | 2.5 | 4.0 | µs | |
| 8 | | | TdOFFB | MU, MV, MW | – | 2.5 | 4.0 | µs | |
| 9 | Dead time | Top arm on | TDT | MU, MV, MW | 0.3 | 1.0 | 1.8 | µs | VS=325V, VCC=15V, I=0.35A Resistive load Note 1 |
| 10 | | Bottom arm on | TDB | MU, MV, MW | 0.3 | 1.0 | 1.8 | µs | |
| 11 | Free-wheeling diode forward voltage | | VFDT | MU, MV, MW | – | 1.6 | 2.8 | V | I=0.35A |
| 12 | | | VFDB | MU, MV, MW | – | 1.6 | 2.8 | V | |
| 13 | Over current protection reference voltage | | Vref | RS | 0.45 | 0.50 | 0.55 | V | VCC=15V |
| 14 | Over current protection delay time | | Tref | RS | – | 5.0 | 7.0 | µs | VCC=15V |
| 15 | UI, VI, WI, VOFF, CK inputs | Voltage | VIH | UI, VI, WI, VOFF, CK | 2.5 | – | – | V | VCC=15V |
| 16 | | | VIL | | – | – | 1.0 | V | |
| 17 | | Current | IIL | | –10 | – | – | µA | Input=0V VCC=15V Pull-down resistor Note 2 |
| 18 | | | IIH | | – | – | 100 | µA | Input=4.5V VCC=15V |
| 19 | RS input current | | IILRS | RS | –100 | – | – | µA | RS=0V Pull-up resistor Note 3 |
| 20 | VB supply output | Voltage | VB | CB | 4.5 | 5.0 | 5.5 | V | VCC=15V, IB=0A |
| 21 | | Current | IB | CB | – | – | 45 | mA | VCC=15V |
| 22 | LVSD | Operating voltage | LVSDON | VCC, MU, MV, MW | 11.0 | 11.7 | 12.5 | V | Note 4 |
| 23 | | Recovery voltage | LVSDOFF | | 11.5 | 12.2 | 13.0 | V | |
| 24 | F, FB output resistance | | ROP | F, FB | – | 2.0 | 4.0 | kΩ | I=1mA,VCC=15V Note 5 |
| 25 | | | RON | F, FB | – | 0.7 | 1.5 | kΩ | I=–1mA,VCC=15V Note 5 |
| 26 | Fault reset delay time | | tflrs | F | – | 15 | 30 | µs | VCC=15V |
| 27 | All off delay time | | taoff | VOFF | – | 2.5 | 4.0 | µs | VCC=15V |

Note 1: The definition of dead time is shown in Fig. 3.8.2.1. The values of No.9 and No.10 are based on actual measurement values. Therefore, not all values of No.9 and No.10 are the same as the values calculated from the values of No.5 to No.8.

Note 2: Internal pull-down resistances are typically 200kΩ. Fig. 3.6.1 is the equivalent circuit.

Note 3: Internal pull-up resistances are typically 200kΩ. Fig. 3.6.2 is the equivalent circuit.

Note 4: The LVSD function detects and shuts down at low VCC.

Note 5: The equivalent circuit is shown in Fig. 3.6.3.

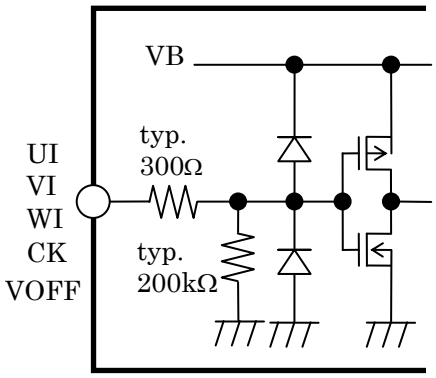



**Fig. 3.6.1 Equivalent Circuit around UI, VI, WI, CK, VOFF Pins**

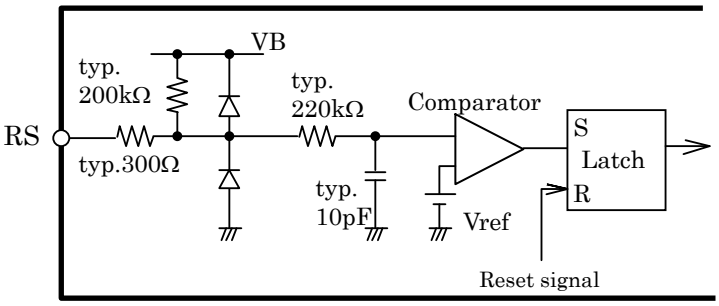



**Fig. 3.6.2 Equivalent Circuit around RS Pin**

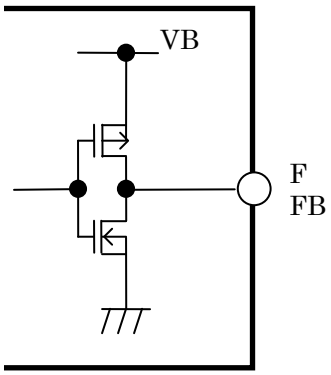



**Fig. 3.6.3 Equivalent Circuit around F, FB Pins**

3.7 Operating Condition

**Table 3.7.1 Operating Condition**

| No. | Item | Symbol | Pin | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| 1 | Supply voltage | VSop | VS1, VS2 | 15 | – | 450 | V |
| 2 | | VCCop | VCC | 13.5 | 15.0 | 16.5 | V |

3.8 Functions and Operations

3.8.1 Truth Table

**Table 3.8.1.1 Truth Table**

| Pin | Input | Top arm | Bottom arm |
|---|---|---|---|
| UI, VI, WI | L | OFF | ON |
| | H | ON | OFF |
| VOFF | L | ALL OFF | |
| | H | Based on UI, VI, WI inputs | |

3.8.2 Dead Time

The ECN33201 generates six signals with dead time from three input signals, and the six signals control top and bottom arm IGBTs.

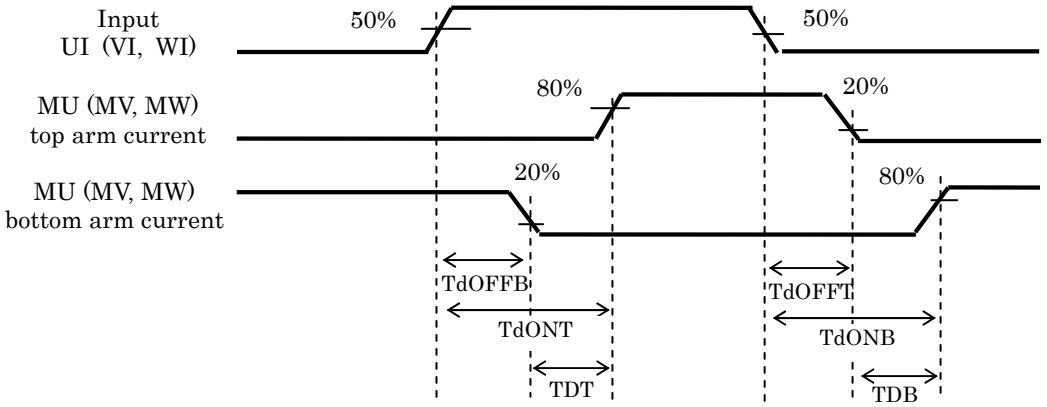



**Fig. 3.8.2.1 Definition of Dead Time (Resistive load)**

3.8.3 All Output IGBT Shutoff Function

When "L" is input to VOFF pin, all IGBTs are turned off. When "H" is input to VOFF pin, IGBTs operate based on UI, VI, WI, and RS input signals.

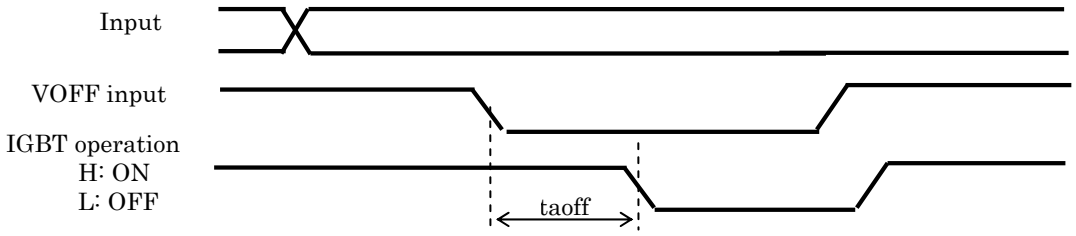



**Fig. 3.8.3.1 Definition of taoff**

3.8.4 Over Current Protection

The ECN33201 monitors the current through the shunt resistance Rs. When the voltage at the RS pin exceeds the Vref (Vref is typically 0.5V) of the internal detection circuit, all IGBTs are turned off and the F pin outputs "L".

After VOFF pin are at "L" for more than the fault reset delay time (tflrs), this all off state is reset. Just after the 15V_VCC is input, the over current protection may operate. Also in this case, the all off state is reset by the above method.

3.8.5 Definition of Tref, tflrs

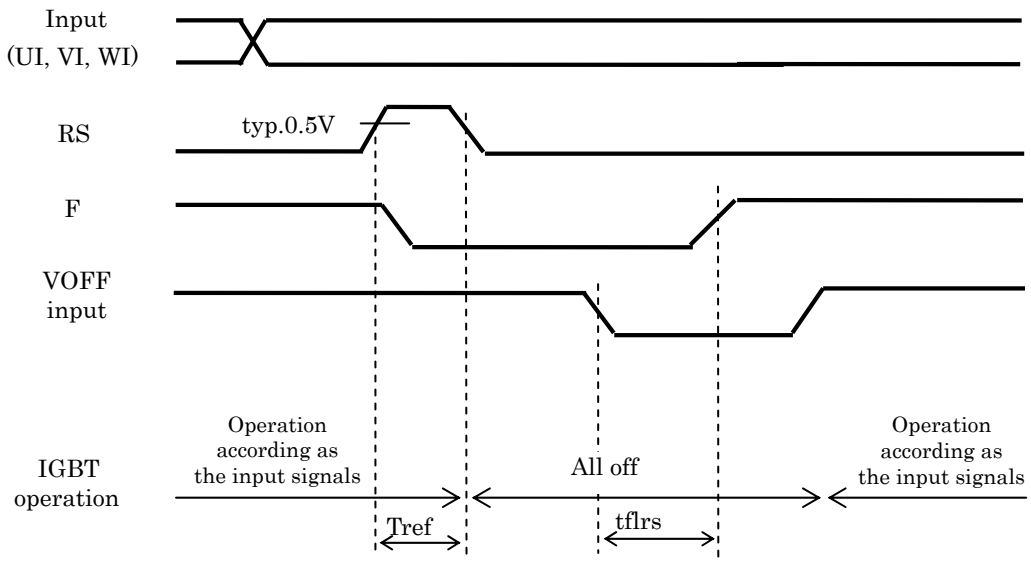



**Fig. 3.8.5.1 Definition of Tref, tflrs**

3.8.6 15V_VCC Under–Voltage Detection

When the 15V_VCC voltage goes below the LVSD operating voltage (LVSDON), all IGBTs are turned off. When the 15V_VCC voltage goes up, this all off state is reset at the LVSD recovery voltage (LVSDOFF).

3.9 Standard Application

3.9.1 External Parts

**Table 3.9.1.1 External Parts**

| Part | Standard Value | Usage | Remark |
|---|---|---|---|
| C0 | 1.0μF ± 20% | Filters the internal power supply (VB) | Stress voltage is VB (=5.5V) |
| C1, C2 | 1.0μF ± 20% | For charge pump | Stress voltage is 15V_VCC |
| D1, D2 | 600V, 1.0A<br>trr ≤ 100ns | For charge pump | |
| Rs | Note 1 | Sets over current limit | |

Note 1: The over current protection setting IO is calculated as follows.

$$IO = Vref / Rs \quad (A)$$

To determine the shunt resistance Rs for over-current protection, refer to the above IO and the Supplementary reference data in Section 3.15.4.

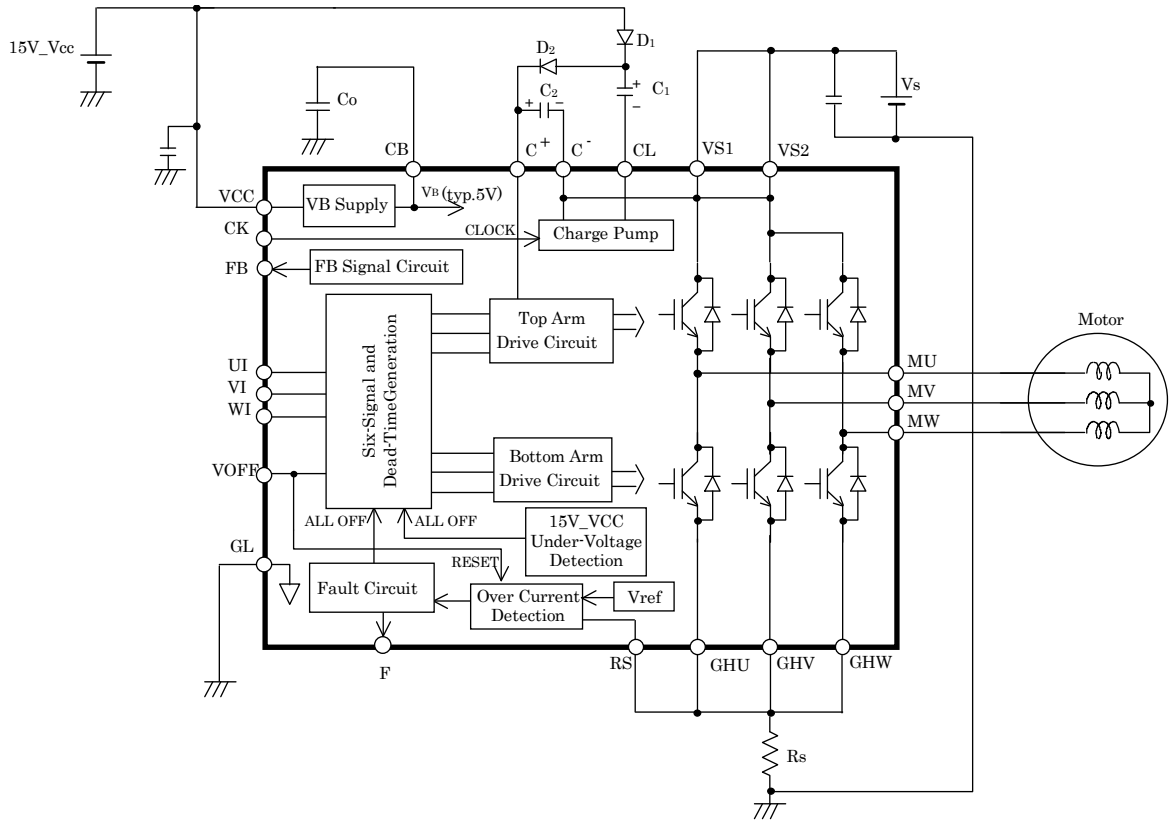



**Fig. 3.9.1.1 Block Diagram** (ECN33201 is shown inside the bold line.)

3.9.2 Input Pins (UI, VI, WI, VOFF, CK)

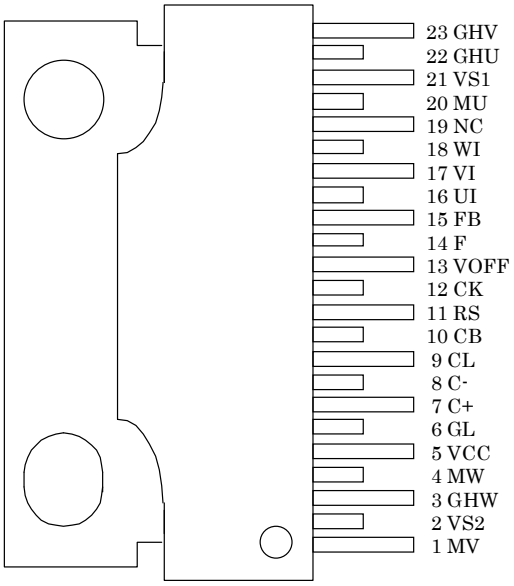
In some applications, input pins may be sensitive to noise due to high impedance.

If noise is detected at an input pin, the following resistor and /or capacitor should be added.

- Resistor : 5.6kΩ ±5% pull-down resistor between the GL pin and input pins.
- Capacitor : 470pF ±20% ceramic capacitor close to the input pins (UI, VI, WI, CK).
  : 0.01μF ±20% ceramic capacitor close to the input pin (VOFF).

# ECN39300

3.10 Pin Locations




(Resin side)

**Fig. 3.10.1 Pin Locations**

3.11 Explanations of Pins

**Table 3.11.1 Explanations of Pins**

| No | Symbol | Definition | Remarks |
|---|---|---|---|
| 1 | MV | V phase output | Note 1 |
| 2 | VS2 | Power supply for top arm IGBTs of V and W phases | Note 1, Note 2 |
| 3 | GHW | Emitter of W phase bottom arm IGBT and anode of W phase bottom arm FWD | |
| 4 | MW | W phase output | Note 1 |
| 5 | VCC | 15V control power supply | |
| 6 | GL | Control system GND | |
| 7 | C+ | For the charge pump circuit, power supply for top arm drive circuits | Note 1 |
| 8 | C- | For the charge pump circuit | Note 1, Note 2 |
| 9 | CL | For the charge pump circuit | Note 1 |
| 10 | CB | 5V power supply output | |
| 11 | RS | RS voltage input for over current protection | |
| 12 | CK | Clock input | |
| 13 | VOFF | All off input | |
| 14 | F | Fault signal output | |
| 15 | FB | Feedback signal (current polarity signal) output | |
| 16 | UI | Input control signal for U phase | |
| 17 | VI | Input control signal for V phase | |
| 18 | WI | Input control signal for W phase | |
| 19 | NC | No connection | Note 3 |
| 20 | MU | U phase output | Note 1 |
| 21 | VS1 | Power supply for top arm IGBT of U phase | Note 1, Note 2 |
| 22 | GHU | Emitter of U phase bottom arm IGBT and anode of U phase bottom arm FWD | |
| 23 | GHV | Emitter of V phase bottom arm IGBT and anode of V phase bottom arm FWD | |

Note 1: High voltage pin.

Note 2: The VS1, VS2 and C– pins are connected within the ECN33201 but VS1 and VS2 must also be connected by external wiring.

Note 3: Not connected to the internal chip.

3.12 Identification Markings

3.12.1 SP (SP–23TA), SPV (SP–23TB) type

Marking is on the front (resin) side of ECN33201.

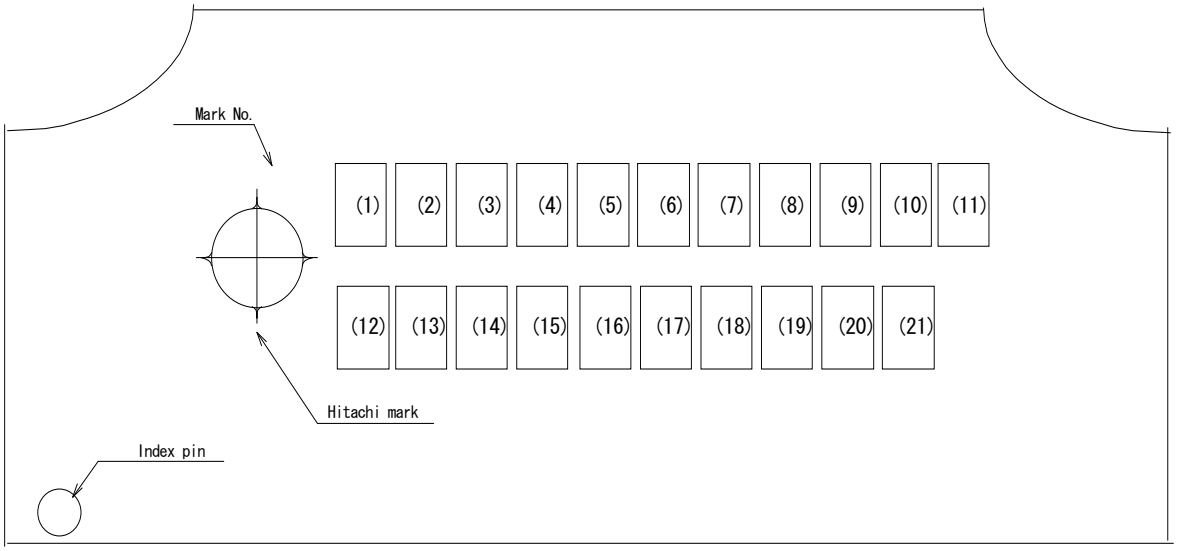



**Fig. 3.12.1.1 Marking Layout**

a) Mark No. (1) to (11): Model name

b) Mark No. (12) to (16): Assembly location (Japan)

c) Mark No. (17) to (21): Lot number

No. (17): Last one-digit of the year of assembly

No. (18): Month of assembly:

January: A, February: B, March: C April: D, May: E, June: K,

July: L, August: M, September: N, October: X, November: Y, December: Z

No. (19), (20), (21): Quality control number (one or three digits)

Represented with letters from “A” to “Z” except “I” and”O”, numbers from “1” to “9”, or blank.

d) Marking method: Laser marking

# ECN39300

3.12.2 SPR (SP–23TR) Type

Marking is on the back (tab) side of ECN33201.

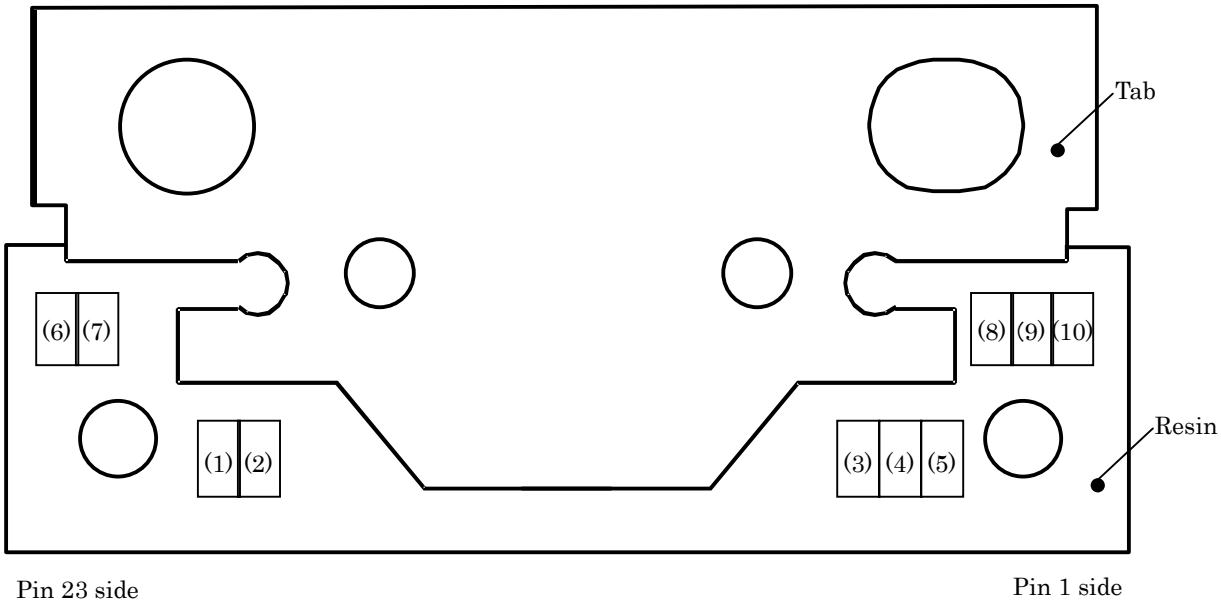



**Fig. 3.12.2.1 Marking Layout**

a) Mark No. (1) to (5): Digit portion of model name
(Example) The ECN33201SPR is represented as “33201”.

b) Mark No. (6) to (10): Lot number
No. (6): Last digit of the year of assembly

No. (7): Month of assembly:
January: A, February: B, March: C, April: D, May: E, June: K,
July: L, August: M, September: N, October: X, November: Y, December: Z

No. (8), (9), (10): Quality control number (one or three digits)
Represented with letters from “A” to “Z” except “I” and”O”, numbers from “1” to “9”, or blank.

c) Marking method: Laser marking

3.13 Inspection

Hundred percent inspection is conducted on electric characteristics at Ta = 25 ±5°C.

3.14 Warnings and Usage Precautions

3.14.1 Assembling

When assembling the device on the heat sink, tightening torque range should be 0.39 to 0.78N·m

Tab should not be soldered.

3.14.2 Countermeasure Against Electrical Static Discharge (ESD)

(a) The ECN33201 must be handled carefully to protect it from ESD. The material of containers or any other device used to carry semiconductor devices should be free from ESD, which can be caused by vibration during transportation. Use of electrically conductive containers is recommended as an effective countermeasure.

(b) Everything that touches semiconductor devices, such as the work platform, machine, measuring equipment, and test equipment should be grounded.

(c) Workers should be high-impedance grounded (around 100kΩ to 1MΩ) while working with the semiconductor, to avoid damaging the ECN33201 by ESD.

(d) Friction with other materials, such as high polymers, should be avoided.

(e) When a PCB with a mounted ECN33201 is carried, ensure that electric potential is kept on the same level by the short-circuit terminals and that vibration or friction does not occur.

(f) The humidity at assembly line to mount IC on circuit boards should be kept around 45 to 75 percents using humidifiers or such. If the humidity cannot be controlled sufficiently, using neutralization apparatus such as ionizers are effective.

3.14.3 Note Regarding Insulation between Pins

High voltages are applied between the pin numbers specified below. Hitachi advises the application of coating resin or molding treatment.

Between pin numbers: 1 - 2, 2 – 3, 3 – 4, 4 - 5, 6 - 7, 8 - 9, 9 - 10, 18 – 20, 20 – 21, 21 – 22

3.14.4 Output Short-Circuit Protection

ECN33201 has no protection function against output short-circuit (load short–circuit, earth fault, etc.). If output is short-circuited, there is a possibility that the ECN33201 will be destroyed. Thus, be sure to protect it externally.

In the case of an output short-circuit mode in which over-current protection operates repeatedly, such as load short-circuits or short-circuits between the top and bottom arms, ECN39300 extends the reset time. Extension of reset time protects the ECN33201 against rising temperature and destruction. However, this operation cannot always prevent the ECN33201 from being destroyed.

3.14.5 Other

See “Instructions for Use of Hitachi High–Voltage Monolithic ICs” (No. IC–HI–002) for other precautions and instructions on how to deal with these kinds of products.

# ECN39300

3.15 Supplementary Reference Data

Refer to the derating information below when designing with the ECN33201.

3.15.1 Safe Operation Area (SOA)

It is important that the ECN33201 be used within the SOA shown in Fig. 3.15.1.1, where the current and voltage are at the MU, MV, and MW pins (motor coils).

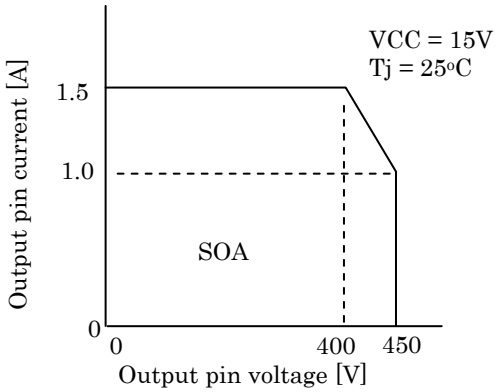



**Fig. 3.15.1.1 SOA**

3.15.2 Output Pin Current Derating for 15V_VCC

The output pin current derating for 15V_VCC is shown in Fig. 3.15.2.1. Use the ECN33201 below the derating curve.

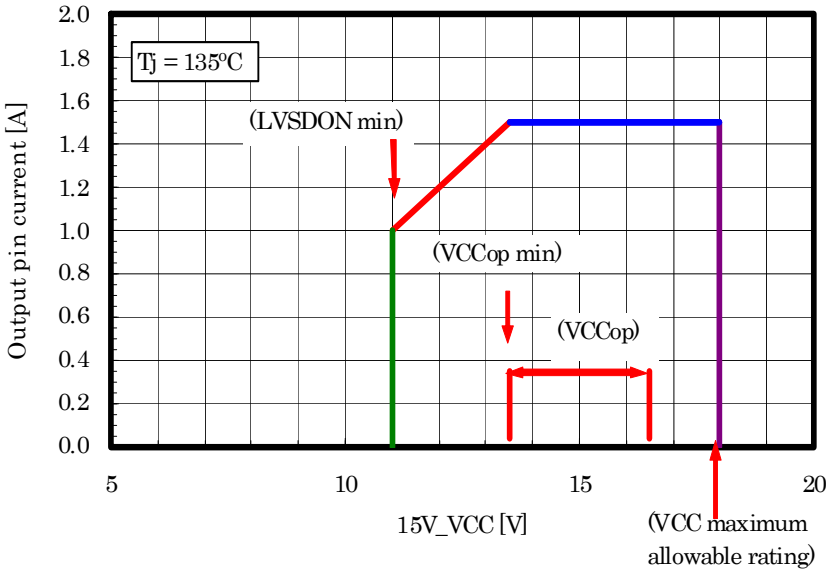



**Fig. 3.15.2.1 Output Pin Current Derating for 15V_VCC**

3.15.3 Output Pin Current Derating for Junction Operating Temperature

The SOA is dependent upon junction operating temperature (Tjop) and VS power supply voltage. The output pin current derating for junction operating temperature is shown in Fig. 3.15.3.1.

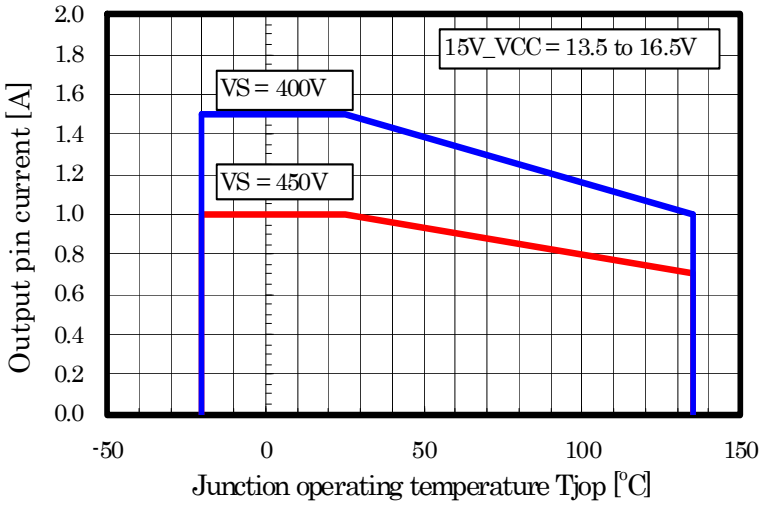



**Fig. 3.15.3.1 Output Pin Current Derating for Junction Operating Temperature**

3.15.4 Determination of Over-Current Protection Resistance

When determining the over-current protection resistance (Rs), consider the variabilities of the over-current protection reference voltage (Vref) and the Rs. The current must be less than the derating curves shown in Figs. 3.15.2.1 and 3.15.3.1.

3.15.5 General Design Derating Standards

(a) Temperature: Junction operating temperature must be kept under 110°C.

(b) Supply voltage: VS power supply voltage must be kept under 450V.

# ECN39300

3.15.6 Dimensions (Unit: mm)

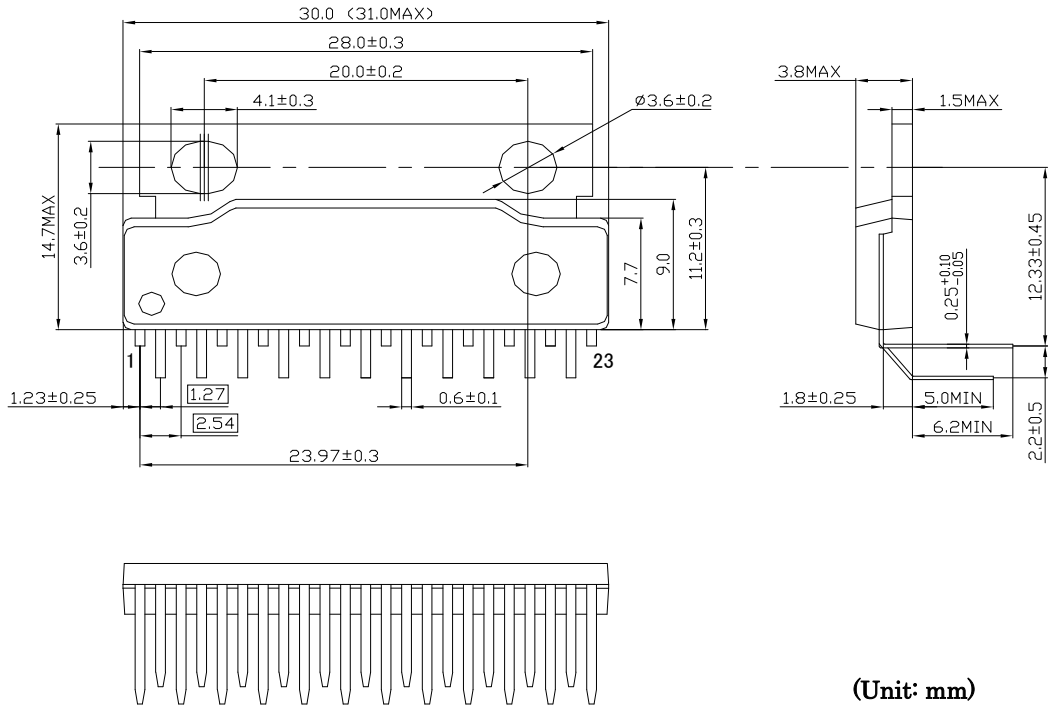
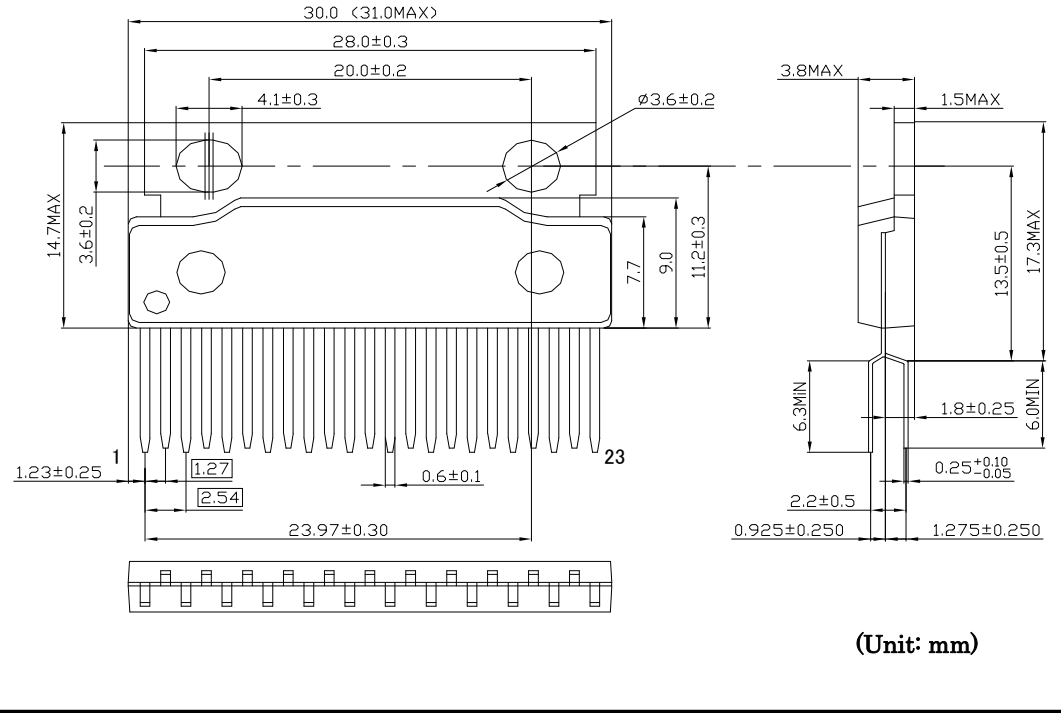
| Package | Dimensions |
|---|---|
| SP<br>(SP-23TA) |  <br>(Unit: mm) |
| SPV<br>(SP-23TB) |  <br>(Unit: mm) |

Fig. 3.15.6.1 Dimensions (SP, SPV)

# ECN39300

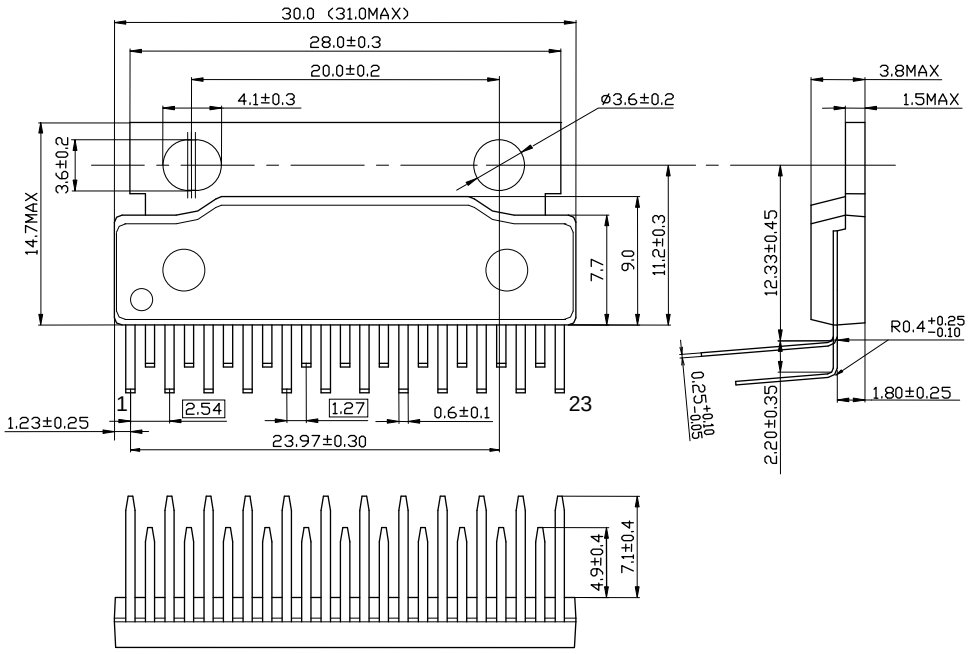
| Package | Dimensions |
|---|---|
| SPR<br>(SP-23TR) |  |



Fig. 3.15.6.2 Dimensions (SPR)

## 4. Microcomputer (R5F21334CN505FP) Specifications

4.1 MCU Performance Overview

The kit product of the MCU and the ECN33201 offers a sine wave solution for a three-phase BLDC motor. Table 4.1.1 outlines the specifications of the MCU.

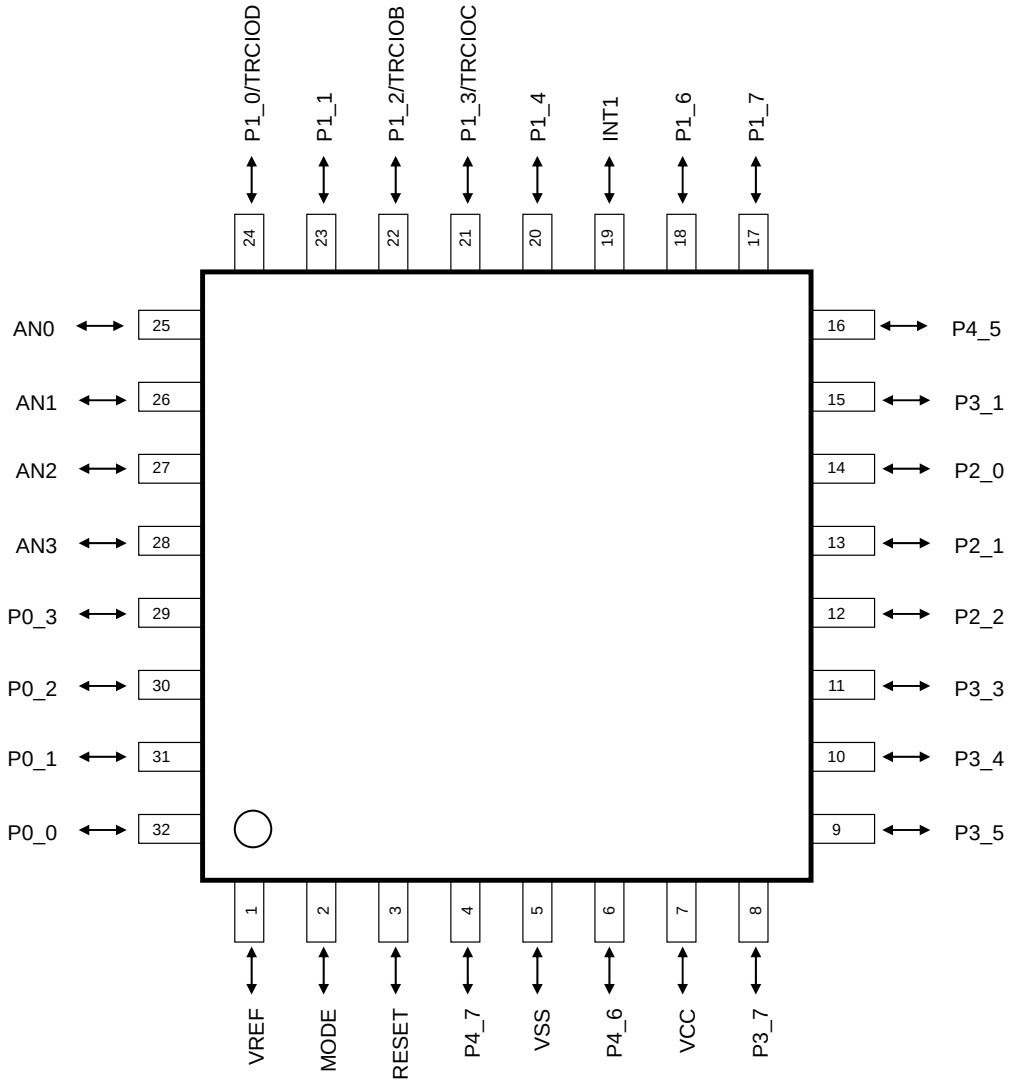
**Table 4.1.1 MCU Performance Overview**

| No. | Item | | Specification |
|---|---|---|---|
| 1 | CPU | Minimum instruction execution time | 50ns(f (XIN) = 20MHz, 5V_Vcc = 3.55 to 5.50V) |
| 2 | Peripheral functions | Ports | I/O ports: 27 pins<br>Input port: 1 pin |
| | | Clock generation circuit | On–chip oscillator (high speed, low speed) |
| | | Voltage detection circuit | On–chip |
| | | Power-on reset circuit | On–chip |
| 3 | Electrical characteristics | Supply voltage | 5V_Vcc = 3.0 to 5.5V(f (XIN) = 20MHz) |
| | | Current consumption | Typ. 6.5mA (5V_Vcc = 5V, f (XIN) = 20MHz) |
| 4 | Operating ambient temperature | | –20 to 85°C |
| 5 | Package | | 32-pin LQFP |

# ECN39300

4.2 Pin Assignments

Fig. 4.2.1 shows MCU pin assignments (top view).



# ECN39300

4.3 Pin Locations

Table 4.3.1 shows MCU pin locations.

**Table 4.3.1 MCU Pin Locations (1/2)**

| Pin | Symbol | Type | Remarks |
|---|---|---|---|
| 1 | VREF | 5V_Vcc connection pin | Connection pin for the 5V_Vcc. Mount a bypass capacitor (0.047μF) close to this pin. |
| 2 | MODE | MODE pin | MODE pin. Pull up the pin (4.7kΩ ±5%). |
| 3 | RESET | RESET pin | RESET pin. Pull up the pin (4.7kΩ ±5%) and mount a bypass capacitor (0.01μF). |
| 4 | P4_7 | Selection pin for acceleration and deceleration rate | Selection pin for acceleration and deceleration rate. See Section 4.7.3.1 for pin setting. |
| 5 | VSS | GND pin | GND pin. Connect this pin to GND. |
| 6 | P4_6 | Selection pin for rotation direction | Setting pin for forward or reverse rotation. See Section 4.7.3.2 for pin setting. |
| 7 | VCC | 5V_Vcc pin | 5V_Vcc pin. Connect this pin to CB pin (Pin 10) of ECN33201. |
| 8 | P3_7 | Selection pin for VSP input voltage | Setting pin for VSP input voltage. See Section 4.7.3.6 for pin setting. |
| 9 | P3_5 | No-connection pin | Unused pin. Open the pin. |
| 10 | P3_4 | No-connection pin | Unused pin. Open the pin. |
| 11 | P3_3 | No-connection pin | Unused pin. Open the pin. |
| 12 | P2_2 | Modulation method setting | Setting pin for modulation method. See Section 4.7.3.3 for pin setting. |
| 13 | P2_1 | Motor selection pin 1 | Selection pin for motor. Select a motor with Pin 14 of the MCU (Motor selection pin 2). See Section 4.7.3.4 for pin setting. |
| 14 | P2_0 | Motor selection pin 2 | Selection pin for motor. Select a motor with Pin 13 of the MCU (Motor selection pin 1). See Section 4.7.3.4 for pin setting. |
| 15 | P3_1 | No-connection pin | Unused pin. Open the pin. |
| 16 | P4_5 | No-connection pin | Unused pin. Open the pin. |
| 17 | P1_7 | Clock signal output pin | Clock output pin for a charge pump of ECN33201. Connect this pin to CK pin (Pin 12) of ECN33201. |
| 18 | P1_6 | VALL_OFF pin | Control signal output pin to turn off the six IGBTs. Connect this pin to VOFF pin (Pin 13) of ECN33201. Mount a capacitor for noise absorption (0.01μF) very close to this pin. *1 |
| 19 | INT1 | Fault signal input pin | Input pin for Fault signal. Connect this pin to F pin (Pin 19) of ECN33201. Mount a capacitor for noise absorption (0.01μF) very close to this pin. *1 |
| 20 | P1_4 | FB-signal input pin | Input pin for FB-signal. Connect this pin to FB pin (Pin 15) of ECN33201. Mount a capacitor for noise absorption (0.01μF) very close to this pin. |

*1 Pay close attention to the wiring of this line so that switching noise (IGBT switching surge, etc.) is not coupled on this line.

Table 4.3.1 MCU Pin Locations (2/2)

| Pin | Symbol | Type | Remarks |
|---|---|---|---|
| 21 | P1_3/TRCIOC | U-phase drive signal output pin | Drive signal output pin of U-phase top arm. Connect this pin to UI pin (Pin 16) of ECN33201. *1 |
| 22 | P1_2/TRCIOB | V-phase drive signal output pin | Drive signal output pin of V-phase top arm. Connect this pin to VI pin (Pin 17) of ECN33201. *1 |
| 23 | P1_1 | No-connection pin | Unused pin. Open the pin. |
| 24 | P1_0/TRCIOD | W-phase drive signal output pin | Drive signal output pin of W-phase top arm. Connect this pin to WI pin (Pin 18) of ECN33201. *1 |
| 25 | AN0 | VS voltage detecting pin | Analog input pin for VS power supply voltage detection. See Section 4.7.2.1 for the relation between VS voltage and AN0 input voltage. |
| 26 | AN1 | VSP (speed command) detecting pin | Analog input pin for VSP (speed command) detection. See Section 4.7.2.2 for the relation between VSP and AN1 input voltage. |
| 27 | AN2 | Temperature detecting pin | Analog input pin for temperature detection. Operation of the protection or the restriction function is based on input voltage. |
| 28 | AN3 | Phase setting pin | Analog input pin for phase setting. See Section 4.7.2.4 for setting details. |
| 29 | P0_3 | No-connection pin | Unused pin. Open the pin. |
| 30 | P0_2 | FG output pin | Outputs the signal of the 60-degree cycle. If speed information for the 60-degree cycle is needed, connect the FG-signal line to this pin. Open the pin if it is not connected to the FG-signal line. |
| 31 | P0_1 | V-phase position sensor signal pin | The V-phase position sensor signal input pin. Mount a capacitor (1000pF) for noise absorption very close to this pin. *2 |
| 32 | P0_0 | U-phase position sensor signal pin | The U-phase position sensor signal input pin. Mount a capacitor (1000pF) for noise absorption very close to this pin. *2 |

*1 MCU operating ambient temperature must be −20°C to +85°C. Locate MCU close to ECN33201 within an area where ambient temperature is less than +85 °C and make the connection as short as possible.

*2 Pay close attention to the wiring of this line so that switching noise (IGBT switching surge, etc.) is not coupled on this line.

# ECN39300

4.4 Electrical Characteristics

In Section 4.4 "Vcc" means "5V_Vcc".

**Table 4.4.1 Absolute Maximum Ratings**

| Symbol | Item | Condition | Rated value | Unit |
|---|---|---|---|---|
| Vcc/AVcc | Supply voltage | | –0.3 to 6.5 | V |
| VI | Input voltage | | –0.3 to VCC + 0.3 | V |
| Vo | Output voltage | | –0.3 to VCC + 0.3 | V |
| Pd | Power dissipation | –20 °C ≤ Topr ≤ 85 °C | 500 | mW |
| Topr | Operating ambient temperature | | –20 to 85 | °C |
| Tstg | Storage temperature | | –65 to 150 | °C |

**Table 4.4.2 Recommended Operating Conditions**

| Symbol | Item | | Condition | Standard | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| Vcc/AVcc | Supply voltage | | | 1.8 | – | 5.5 | V |
| Vss/AVss | Supply voltage | | | – | 0 | – | V |
| VIH | Input "H" voltage | | 4.0V ≤ VCC ≤ 5.5V | 0.65VCC | – | VCC | V |
| VIL | Input "L" voltage | | 4.0V ≤ VCC ≤ 5.5V | 0 | – | 0.4VCC | V |
| IOH (sum) | Peak sum output "H" current | Sum of all pins IOH (peak) | | – | – | –160 | mA |
| | Average sum output "H" current | Sum of all pins IOH (avg) | | – | – | –80 | mA |
| IOH (peak) | Peak output "H" current | Drive capacity LOW | | – | – | –10 | mA |
| | | Drive capacity HIGH | | – | – | –40 | mA |
| IOH (avg) | Avge outputera "H" current | Drive capacity LOW | | – | – | –5 | mA |
| | | Drive capacity HIGH | | – | – | –20 | mA |
| IOL (sum) | Peak sum output "L" current | Sum of all pins IOL (peak) | | – | – | 160 | mA |
| | Average sum output "L" current | Sum of all pins IOL (avg) | | – | – | 80 | mA |
| IOL (peak) | Peak output "L" current | Drive capacity LOW | | – | – | 10 | mA |
| | | Drive capacity HIGH | | – | – | 40 | mA |
| IOL (avg) | Average output "L" current | Drive capacity LOW | | – | – | 5 | mA |
| | | Drive capacity HIGH | | – | – | 20 | mA |
| – | System clock | | 3.6V ≤ VCC ≤ 5.5V | – | – | 20 | MHz |

NOTES:

1. Vcc = 1.8V to 5.5V at Topr = – 20 to 85 °C, unless otherwise specified.
2. The average output currents are shown in 100ms average.

**Table 4.4.3 A/D Converter Characteristics**

| Symbol | Item | Condition | Standard | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| – | Resolution | Vref = AVcc | – | – | 10 | Bit |
| – | Absolute accuracy | Vref = AVcc = 5.0V | – | – | ±3 | LSB |
| Vref | Reference voltage | | 2.2 | – | AVcc | V |
| VIA | Analog input voltage * | | 0 | – | Vref | V |

* When the analog input voltage is over the reference voltage, the A/D conversion result will be 3FFh in 10-bit mode.

**Table 4.4.4 Voltage Detection 0 Circuit Electrical Characteristics**

| Symbol | Item | Condition | Standard | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Vdet0 | Voltage detection level | | 1.80 | 1.90 | 2.05 | V |
| – | Voltage detection circuit response time ** | At the time of lowering VCC from 5V to (Vdet0−0.1V) | – | 6 | 150 | μs |

* The measurement condition is Vcc = 1.8V to 5.5V and Topr = −20 to 85 °C.
** Time until voltage monitor 0 reset is generated after the voltage passes Vdet0.

**Table 4.4.5 Voltage Detection 1 Circuit Electrical Characteristics**

| Symbol | Item | Condition | Standard | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Vdet1 | Voltage detection level | | 3.30 | 3.55 | 3.85 | V |
| – | Voltage detection 1 circuit response time ** | At the time of lowering VCC from 5V to (Vdet1−0.1V) | – | 60 | 150 | μs |

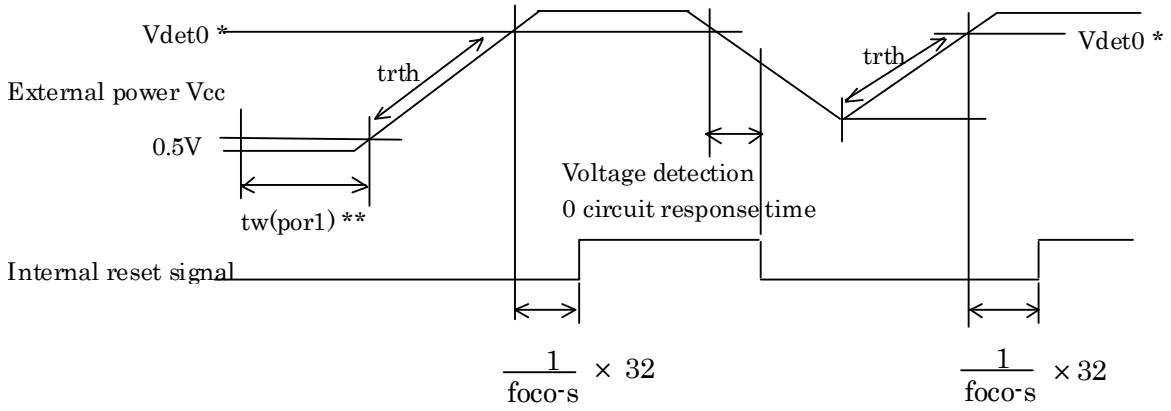
* The measurement condition is Vcc = 1.8V to 5.5V and Topr = −20 to 85 °C.
** Time until the voltage monitor 1 interrupt request is generated after the voltage passes Vdet1.

# ECN39300

**Table 4.4.6 Power-on Reset Circuit Electrical Characteristics**

| Symbol | Item | Condition | Standard | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| trth | External power Vcc rise gradient | | 0 | – | 50000 | mV/ms |

* The measurement condition is Topr = −20 to 85 °C.




NOTES:
* Vdet0 means voltage detection level of voltage detection 0 circuit.
** tw(por) indicates the duration that the external power Vcc must be held below the effective voltage (0.5V) to enable a power-on reset. When turning on the power after turning off with voltage monitor 0 reset ineffective, maintain tw (por) for 1 millisecond or more.

**Fig. 4.4.1 Power-on Reset Circuit Electrical Characteristics**

**Table 4.4.7 High-Speed On-Chip Oscillator Circuit Electrical Characteristics**

| Symbol | Item | Condition | Standard | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| – | High-speed on-chip oscillator frequency after reset | 1.8V ≤ VCC ≤ 5.5V, -20 °C ≤ Topr ≤ 85 °C | 38.4 | 40 | 41.6 | MHz |
| – | Oscillation stability time | VCC = 5.0V, Topr = 25 °C | – | 0.5 | 3 | ms |
| – | Self power consumption at oscillation | VCC = 5.0V, Topr = 25 °C | – | 400 | – | μA |

**Table 4.4.8 Low-Speed On-Chip Oscillator Circuit Electrical Characteristics**

| Symbol | Item | Condition | Standard | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| fOCO-S | Low-speed on-chip oscillator frequency | | 60 | 125 | 250 | kHz |
| – | Oscillation stability time | VCC = 5.0V, Topr = 25 °C | – | 30 | 100 | μs |
| – | Self power consumption at oscillation | VCC = 5.0V, Topr = 25 °C | – | 2 | – | μA |

* Vcc = 1.8V to 5.5V, Topr = −20 to 85 °C, unless otherwise specified.

**Table 4.4.9 Power Supply Circuit Timing Characteristics**

| Symbol | Item | Condition | Standard | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Td (P-R) | Time for internal power supply stabilization during power-on** | | – | – | 2000 | μs |

* The measurement condition is Vcc = 1.8V to 5.5V and Topr = 25 °C.

** Waiting time until the internal power supply generation circuit stabilizes during power-on.

**Table 4.4.10 Electrical Characteristics**

| Symbol | Item | | Condition | | Standard | | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | | | | Min. | Typ. | Max. | |
| VOH | Output "H" voltage | | Drive capacity HIGH VCC=5V | IOH = –20mA | VCC–2.0 | – | VCC | V |
| | | | Drive capacity LOW VCC=5V | IOH = –5mA | VCC–2.0 | – | VCC | V |
| VOL | Output "L"voltage | | Drive capacity HIGH VCC=5V | IOL=20mA | – | – | 2.0 | V |
| | | | Drive capacity LOW VCC=5V | IOL=5mA | – | – | 2.0 | V |
| VT+–VT– | Hysteresis | INT0 | | | 0.1 | 1.2 | – | V |
| | | RESET | | | 0.1 | 1.2 | – | V |
| IIH | Input "H" current | | VI = 5V, Vcc = 5V | | – | – | 5.0 | μA |
| IIL | Input "L" current | | VI = 0V, Vcc = 5V | | – | – | –5.0 | μA |
| RPULLUP | Pull-up resistance | | VI = 0V, Vcc = 5V | | 25 | 50 | 100 | kΩ |
| Icc | Power supply current (Vcc = 3.3V to 5.5V) Single-chip mode, output pins are open, other pins are Vss. | | High-speed on-chip oscillator on fOCO = 20MHz. Low-speed on-chip oscillator on = 125kHz. No division | | – | 7.0 | 15 | mA |
| | | | High-speed on-chip oscillator on fOCO = Stop. Low-speed on-chip oscillator on = 125kHz. Divide-by-8 | | – | 90 | 400 | μA |

* Vcc = 4.2V to 5.5V at Topr = –20 to 85 °C, unless otherwise specified.

**Table 4.4.11 External Interrupt INT0 Input**

| Symbol | Item | Condition | Standard | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Tw (INL) | INT0 input "L" width | | 250 | – | – | ns |

# ECN39300

4.5 Identification Markings
Markings are on the top surface of the package.

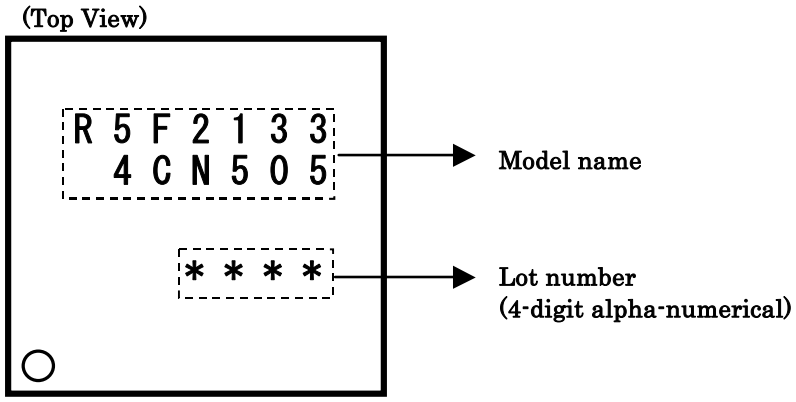



Fig. 4.5.1 Marking Layout

# ECN39300

4.6 Notices and Usage Precautions

1) Electrical characteristics shall be within the limits defined herein, and the mechanical shape shall meet the dimensional limits defined by the outline drawing.
2) In case of failure of delivered parts, examination shall be conducted by both parties and where we are deemed to be responsible for the failure after deliberation by both parties, serviceable parts shall be delivered to substitute for the faulty parts.
3) Issues not specified by these applicable specifications shall be deliberated by both parties.

Observe the following precautions when handling the MCU.

(1) Keep voltage and current to each terminal below the maximum ratings.
   (a) The recommended ranges of operating conditions provide adequate safety margins. Operating within these limits will assure maximum equipment performance and quality.
   (b) Do not apply forward bias to any terminal. Excessive current may cause thermal destruction.
   (c) Do not connect output terminals directly to the power supply. Short-circuiting of a terminal to a power supply having low impedance may cause burn-out of the internal leads or thermal destruction due to excessive current.

(2) Keep all terminals at the same potential during transport and storage. When MCUs are not in use, both input and output terminals can be in a very high impedance state, making them easily susceptible to electrostatic induction from AC fields of the surrounding space or from charged objects in their vicinity. MCUs must be protected from electrostatic charges during transport and storage by conductive rubber foam, aluminum foil, shielded boxes, or other protective precautions.

(3) Keep electrical equipment, worktables, and operating personnel at the same potential.
   (a) Work tables should be covered with an electrical conduction mat made of copper or aluminum, and grounded. One way to ground personnel, after making sure that there is no potential difference with electrical equipment, is to use a wristwatch metallic ring, etc. attached around the wrist and grounded in series with a 1MΩ resistor. Be sure that the grounding meets national regulations for personnel safety.
   (b) Prevent current leakage from electrical equipment at all times, not only for personnel safety, but also to avert the destruction of MCUs, as described above. Items such as testers, curve-tracers and synchro-scopes must be checked for current leakage before being grounded. Soldering guns require the same attention.

(4) Notes on composition of equipment
   (a) The printed wiring lines to the input and output terminals of the MCU should not be close to or parallel to high-voltage or high-power signal lines. Turning power on while the device is short-circuited, either by a solder bridge made during assembly or by a probe during adjusting and testing, may cause maximum ratings to be exceeded, which could result in the destruction of the device.
   (b) When the input/output terminals of MCU are connected under open-circuit we must consider the possibility of current leakage and take precautions similar to those in (2) above. To reduce such undesirable occurances, it is recommended that an interface circuit be inserted at the input or output terminal, or a resistance which does not exceed the output driving capability of the MCU be inserted between the power supply and the ground.
   (c) A filter circuit should be inserted in the AC power supply line to absorb surges, which frequently can be strong enough to destroy a MCU.
   (d) Ungrounded metal plates should not be placed near the input or output terminals of any MCU, since their insulation can be destroyed if they become electrostatically charged.
   (e) Equipment cases should provide shielding from electrostatic charges for more reliable operation. When a plastic case is used, it is desirable to coat the inside of the case with conductive paint and to ground it. This is necessary even for battery-operated equipment.

# ECN39300

4.7 Supplementary Reference Data

4.7.1 MCU Block Diagram

Fig. 4.7.1.1 shows MCU block diagram.

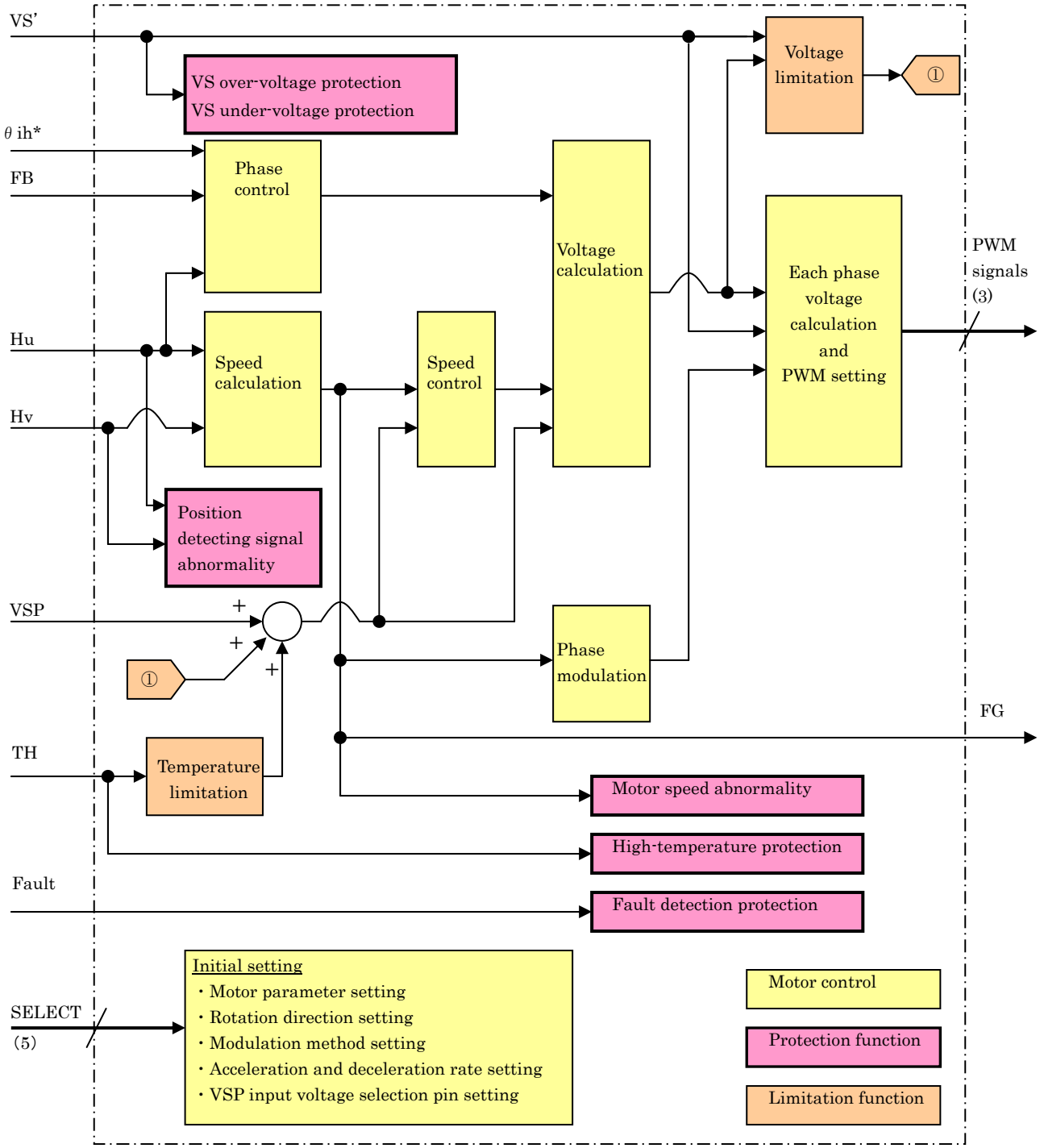



**Fig. 4.7.1.1 MCU Block Diagram**

※Explanation of the corresponding MCU pins and their abbreviations:

VS' : High voltage detection value [Pin 25], θ ih* : Phase setting [Pin 28], FB : Current polarity signal [Pin 20], Hu : U-phase position sensor signal [Pin 32], Hv : V-phase position sensor signal [Pin 31], VSP : Speed command [Pin 26], TH : Temperature detection value [Pin 27], Fault : Fault signal [Pin 19], FG : Detected speed signal [Pin 30]

4.7.2 Analog Inputs to MCU

There are four analog inputs to MCU, as shown below. This section describes the analog inputs.

**Table 4.7.2.1 Analog Inputs**

| MCU pin No. | Pin name | Pin function |
|---|---|---|
| 25 | AN0 | VS voltage detecting pin |
| 26 | AN1 | VSP detecting pin |
| 27 | AN2 | Temperature detecting pin |
| 28 | AN3 | Phase setting pin |

4.7.2.1 VS Voltage Detection

Fig. 4.7.2.1.1 shows the relation between VS voltage and AN0 input voltage for the recommended VS voltage detection circuit shown in Fig. 4.7.2.1.2. Input the VS voltage to the MCU such that the VS voltage is divided by the ratio shown in Fig. 4.7.2.1.1. (Typical values are shown in Fig. 4.7.2.1.1.)

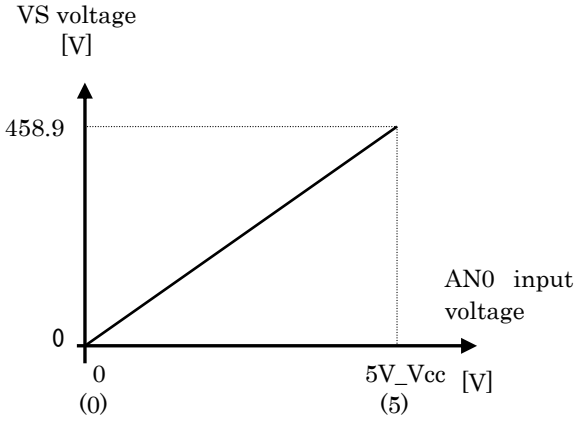



**Fig. 4.7.2.1.1 Relation Between VS Voltage and AN0 Input Voltage**

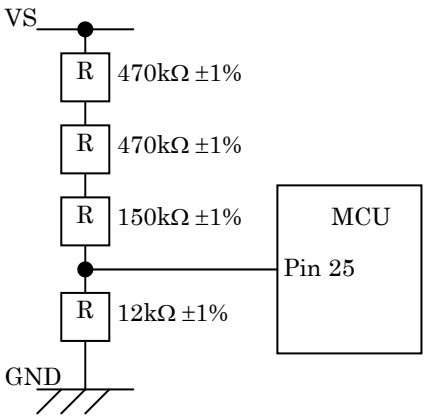



**Fig. 4.7.2.1.2 VS Voltage Detection Circuit (Recommended circuit)**

4.7.2.2 VSP Detection

Fig.4.7.2.2.1 and Fig.4.7.2.2.2 show the relation between electric angular frequency*1 and AN1 input voltage. (Typical values are shown.)

○ MCU Pin 8 setting : "H"

0.00 [V] ≤ AN1 input voltage ≤ 1.86 [V] : 0Hz

1.86 [V] < AN1 input voltage ≤ 4.85 [V] : (AN1 input voltage – 1.86 [V]) ÷ 2.99 [V] × 146.67Hz

4.85 [V] < AN1 input voltage ≤ 5.00 [V] : 146.67Hz

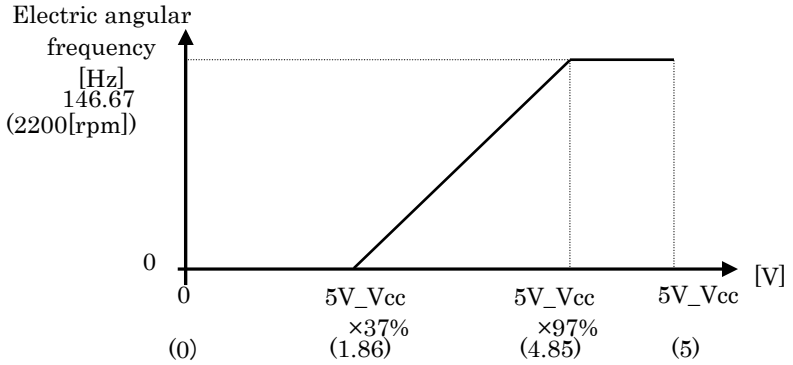



**Fig. 4.7.2.2.1 Relation between Electric Angular Frequency and AN1 Input Voltage**

○ MCU Pin 8 setting : "L"

0.00 [V] ≤ AN1 input voltage ≤ 0.82 [V] : 0Hz

0.82 [V] < AN1 input voltage ≤ 4.85 [V] : ( AN1 input voltage – 0.82 [V]) ÷ 4.03[V] × 146.67Hz

4.85 [V] < AN1 input voltage ≤ 5.00 [V] : 146.67Hz

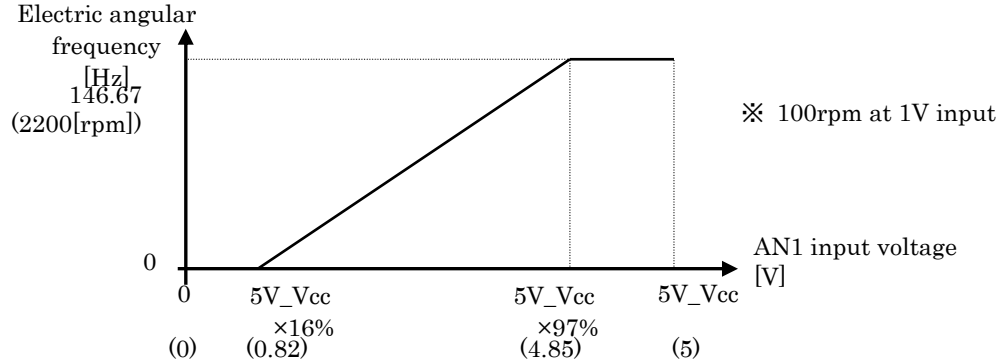



**Fig. 4.7.2.2.2 Relation between Electric Angular Frequency and AN1 Input Voltage**

*1 The formula for the relation between motor speed and electric angular frequency is as follows. (For example, motor pole is 8, frequency is 4Hz, and motor speed is 60rpm.)

Electric angular frequency = (Motor speed ÷ 60) × (Motor pole ÷ 2)

*2 See Section 4.7.3.6 Selection pin for VSP input voltage.

4.7.2.3 Temperature Detection

AN2 input voltage is used for high-temperature protection and temperature restriction. See Section 4.7.4 regarding high-temperature protection. See Section 4.7.6 regarding temperature restriction operation. Select a thermistor and a resistance such that the protection and the restriction operation are coordinated.

4.7.2.4 Phase Setting

Phase setting is defined as the phase difference between a rising edge of the current polarity signal (FB-signal) and a falling edge of the U-phase position sensor signal. See Fig. 4.7.2.4.1. Fig. 4.7.2.4.3 and Table 4.7.2.4.1 show the relation between phase setting values and AN3 input voltage. Set AN3 input voltage to the medium voltage level of the desired phase setting with an external circuit. (Example: In the case of forward rotation and 36-degree phase setting, design an external circuit so that AN3 input voltage is 1.945V. See Fig. 4.7.2.4.2.) AN3 input voltage is not detected constantly. The voltage is detected and the phase is set only when the MCU is reset.

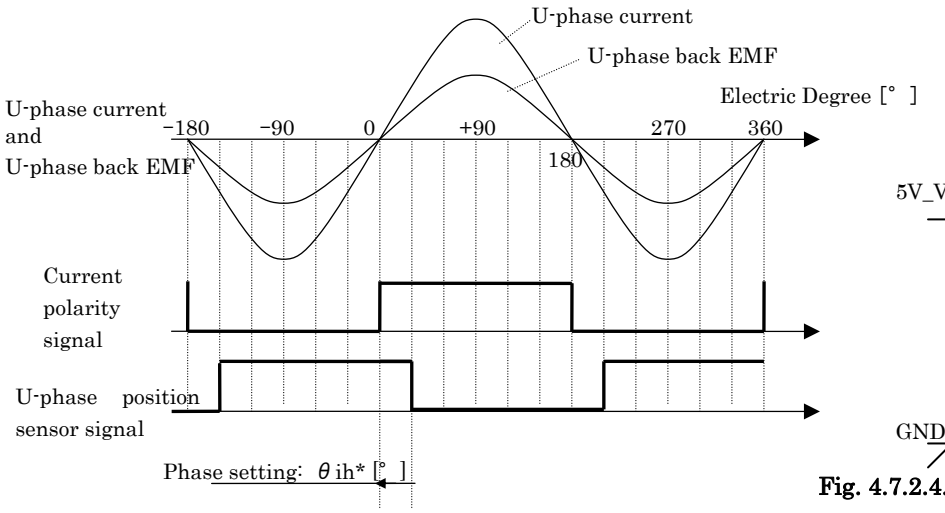



Fig. 4.7.2.4.1 Descriptive Diagram of Phase Definition Setting

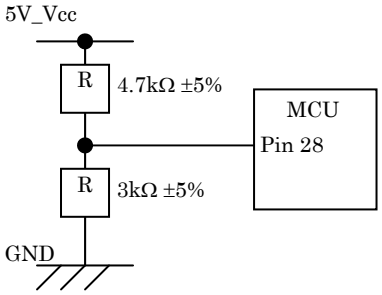



Fig. 4.7.2.4.2 Example of 36-Degree Phase Setting Case

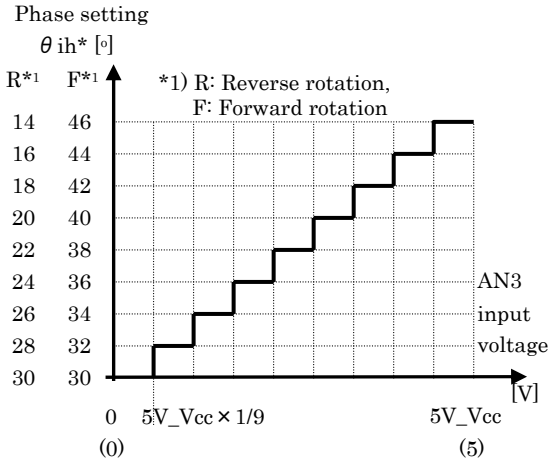



Fig. 4.7.2.4.3 Relation Between the Phase Setting Value and AN3 Input Voltage

Table 4.7.2.4.1 Relation Between Phase Setting and AN Input Voltage

| AN3 [V] | | Phase setting θ ih* [°] | |
|---|---|---|---|
| Theoretical formula | (5V_Vcc = 5V) | F*1 | R*1 |
| 0 ≤ AN3 < 5V_Vcc×1/9 | 0 ≤ AN3 < 0.56 | 30 | 30 |
| 5V_Vcc×1/9 ≤ AN3 < 5V_Vcc×2/9 | 0.56 ≤ AN3 < 1.11 | 32 | 28 |
| 5V_Vcc×2/9 ≤ AN3 < 5V_Vcc×3/9 | 1.11 ≤ AN3 < 1.67 | 34 | 26 |
| 5V_Vcc×3/9 ≤ AN3 < 5V_Vcc×4/9 | 1.67 ≤ AN3 < 2.22 | 36 | 24 |
| 5V_Vcc×4/9 ≤ AN3 < 5V_Vcc×5/9 | 2.22 ≤ AN3 < 2.78 | 38 | 22 |
| 5V_Vcc×5/9 ≤ AN3 < 5V_Vcc×6/9 | 2.78 ≤ AN3 < 3.33 | 40 | 20 |
| 5V_Vcc×6/9 ≤ N3 < 5V_Vcc×7/9 | 3.33 ≤ AN3 < 3.89 | 42 | 18 |
| 5V_Vcc×7/9 ≤ AN < 5V_Vcc×8/9 | 3.89 ≤ AN3 < 4.44 | 44 | 16 |
| 5V_Vcc×8/9 ≤ AN3 | 4.44 ≤ AN3 | 46 | 14 |

*1) R: Reverse rotation, F: Forward rotation

4.7.3 How to Set Selection Pins

This section describes the selection and setting pins as shown in Table 4.7.3.1. The selection pins in the table are detected only when the MCU is reset. They are not detected constantly.

**Table 4.7.3.1 Selection Pin List**

| MCU pin No. | Pin name | Pin function |
|---|---|---|
| 4 | P4_7 | Acceleration and deceleration rate selection pin |
| 6 | P4_6 | Selection pin for rotation direction (forward or reverse) |
| 8 | P3_7 | Selection pin for VSP input voltage |
| 12 | P2_2 | Modulation method selection pin |
| 13, 14 | P2_0, P2_1 | Motor selection pin |
| 28 | AN3 | Analog pin for phase setting |

4.7.3.1 Acceleration and Deceleration Rate Selection Pin

Acceleration and deceleration rates comply with this pin setting (except for the restriction operation described in Section 4.7.6). Set to "H" for ±200rpm/s and "L" for ±100rpm/s. See Table 4.7.3.1.1. This pin is used to set acceleration and deceleration rates within the MCU. Thus, motors may not always accelerate and decelerate at the set rate, depending on the inertia of the motor or its load, such as a fan.

**Table 4.7.3.1.1 Acceleration and Deceleration Rate Setting**

| Pin 4 | Setting |
|---|---|
| H | ±200rpm/s |
| L | ±100rpm/s |

4.7.3.2 Selection Pin for Rotation Direction

This pin is used for the motor rotation direction. Set to "H" for forward rotation and "L" for reverse rotation. See Table 4.7.3.2.1.

**Table 4.7.3.2.1 Motor Rotation Direction Selection**

| Pin 6 | Setting |
|---|---|
| H | Forward |
| L | Reverse |

4.7.3.3 Modulation Method Selection Pin

The modulation method is changed based on motor speed. The changing frequency is set with this pin. When the frequency is lower than the changing frequency, the modulation method becomes the HIP modulation method (Fig. 4.7.3.3.1). When the changing frequency is equal to or exceeds the changing frequency, the modulation method becomes a two-phase modulation method (Fig. 4.7.3.3.2). To give priority to efficiency, "H" is well suited. To give priority to low-noise level, "L" is well suited. See Table 4.7.3.3.1.

**Table 4.7.3.3.1 Modulation Method Selection Pin Setting**

| Pin 12 | Setting |
|---|---|
| H | 30Hz – 36Hz |
| L | 47Hz – 55Hz |

* Frequency means electrical angular frequency.

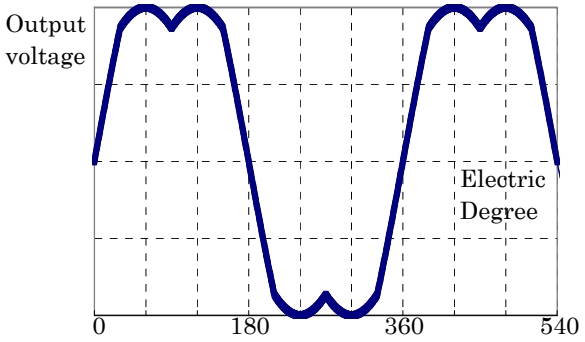



**Fig. 4.7.3.3.1 Example of HIP Modulation Method**

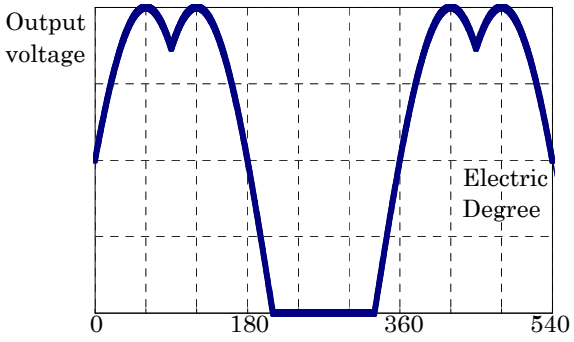



**Fig. 4.7.3.3.2 Example of Two-Phase Modulation Method**

4.7.3.4 Motor Selection Pin

This pin is used to set a motor driven by the kit product to the MCU. Measure a phase resistance value before setting. Then set Pin 13 and Pin 14 in accordance with the phase resistance value in Table 4.7.3.4.1. Basically, the kit product is independent of motor parameters. Thus, set only the following information. If phase resistance is outside the values in Table 4.7.3.4.1, contact the Hitachi sales office or your distributor.

**Table 4.7.3.4.1 Motor Selection Pin Setting**

| Selection pin | | Setting *1 |
|---|---|---|
| Pin 13 | Pin 14 | |
| L | L | 17.0Ω – 30.0Ω |
| H | L | 30.0Ω – 48.0Ω |
| L | H | 48.0Ω – 60.0Ω |
| H | H | 60.0Ω – 80.0Ω |

*1 Each phase resistance is the value measured at 25℃.

4.7.3.5 Phase Setting Pin
See Section 4.7.2.4.

4.7.3.6 Selection Pin for VSP Input Voltage
This pin is used to set VSP input voltage of a motor driven by the kit product. Set to "H" for operation at 2V and "L" for operation at 1V.

**Table 4.7.3.6.1 VSP Input Voltage Selection Pin Setting**

| Pin 8 | Setting |
|---|---|
| H | 100rpm at 2V VSP input voltage. (See Fig. 4.7.2.2.1) |
| L | 100rpm at 1V VSP input voltage. (See Fig. 4.7.2.2.2) |

4.7.4 Protection Functions

The kit product has the protection functions described in Table 4.7.4.1 below. When a protection function is operational, the output IGBTs of the top and bottom arms are all turned off. Once a protection function operates, the kit product is reset automatically after a lapse of 20 milliseconds and satisfaction of the protection reset conditions. (The number of resets is unlimited.)

Detailed specifications for the various protection functions are provided in Tables 4.7.4.2 – 4.7.4.8.

**Table 4.7.4.1 Protection Function List**

| Protection item | Outline | Specification |
|---|---|---|
| Over-current | Against a detected current of shunt resistance (Rs) in ECN33201 in excess of the rated value. | Table 4.7.4.2 |
| 15V_VCC under–voltage | Against a drop of the 15V_VCC. | Table 4.7.4.3 |
| Temperature rise | Against a temperature around the thermistor used for temperature protection in excess of the rated value. | Table 4.7.4.4 |
| VS over–voltage | Against a rise in VS voltage in excess of the rated value. | Table 4.7.4.5 |
| VS under–voltage | Against a drop in VS voltage to below the rated value. | Table 4.7.4.6 |
| Position detecting signal abnormality | Against detected abnormalities in the position detecting signals. | Table 4.7.4.7 |
| Motor speed abnormality | Against a detected motor speed, as calculated from position detecting signals, in excess of the rated value. | Table 4.7.4.8 |

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**Table 4.7.4.2 Specification of Over-Current Protection**

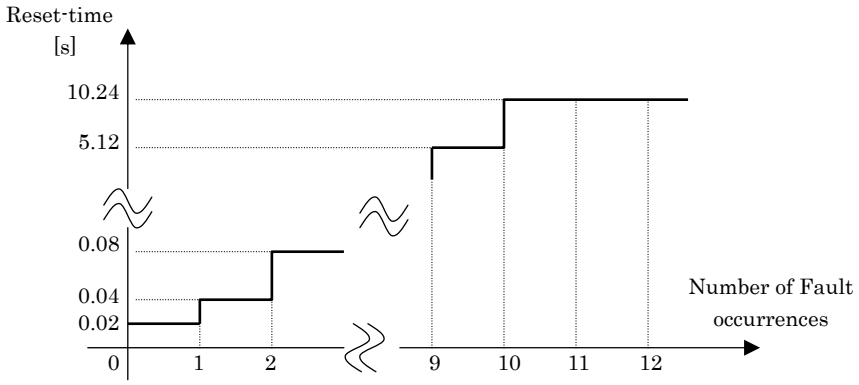
| Protection item | Over-current protection |
|---|---|
| Detection part | ECN33201 |
| Detection cycle of protection | At all times |
| Protection condition | Against the RS pin voltage of ECN33201 in excess of the Vref of the internal detecting circuit. *1 |
| Performance after satisfaction of protection condition | 1) ECN33201 stops. (The output IGBTs of the top and bottom arms are all turned off.)<br>2) Transition to the protection state. |
| Detection cycle of reset | 20ms cycle |
| Reset condition | The RS pin voltage of ECN33201 falls below the Vref of the internal detecting circuit, and the protection reset time passes. (See Fig. 4.7.4.1 to confirm the protection reset time.) |
| Performance after satisfaction of the reset condition | Transition to the usual stop state. |
| Remarks | ・The MCU has a function which enables it to set the protection reset time (hereinafter called, "Reset-time") when detecting a fall in the Fault signal from ECN33201. (See Fig. 4.7.4.1.)<br>・That function focuses on restraining against secondary failure under abnormal conditions in which the protection operates continuously.<br>・Initial value of the Reset-time is 20ms. Whenever Faults occur, MCU sets double the previous Reset-time (to a maximum 10.24s).<br>・If no Fault protection is detected for over a minute, MCU sets the Reset-time back to its initial value.<br>  |

**Fig.4.7.4.1 Relation between Number of Fault Occurrences and Reset-Time (When the Reset-time is deinitialized.)**

*1 RS pin : Input for over–current protection of ECN33201 (Pin 11 in ECN33201), Vref : Reference voltage for over-current protection of ECN33201.

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**Table. 4.7.4.3 Specification of 15V_VCC Under-Voltage Protection**

| Protection item | 15V_VCC under-voltage |
|---|---|
| Detection part | ECN33201 |
| Detection cycle of protection | At all times |
| Protection condition | 15V_VCC ≤ LVSDON *1 |
| Performance after satisfaction of the protection condition | 1) The ECN33201 stops. (The output IGBTs of the top and bottom arms are all turned off.)<br>2) Transition to the protection state. |
| Detection cycle of reset | At all times |
| Reset condition | 15V_VCC ≥ LVSDOFF *1 |
| Performance after satisfaction of the reset condition | – |
| Remarks | – |

*1 15V_VCC : Control power supply voltage for ECN33201 (Pin 5 in ECN33201), LVSDON : LVSD operating voltage for ECN33201, LVSDOFF : LVSD recovery voltage for ECN33201

**Table. 4.7.4.4 Specification of Temperature Rise Protection**

| Protection item | Temperature rise protection |
|---|---|
| Detection part | MCU |
| Detection cycle of protection | 20ms cycle |
| Protection condition | AN2 input voltage > 5V_Vcc × 0.8 *1 |
| Performance after satisfaction of the protection condition | 1) ECN33201 stops. (The output IGBTs of the top and bottom arms are all turned off.)<br>2) Transition to the protection state. |
| Detection cycle of reset | 20ms cycle |
| Reset condition | AN2 input voltage ≤ 5V_Vcc × 0.75 |
| Performance after satisfaction of the reset condition | Transition to the usual stop state. |
| Remarks | – |

*1 AN2 input voltage : Temperature detection (Pin 27), 5V_Vcc : Control power supply voltage for MCU (Pin 7)

Table. 4.7.4.5 Specification of VS Over-Voltage Protection

| Protection item | VS over-voltage protection |
|---|---|
| Detection part | MCU |
| Detection cycle of protection | 20ms cycle |
| Protection condition | AN0 input voltage > 5V_Vcc × 0.959　(VS=440V Typ.)　*1 |
| Performance after satisfaction of the protection condition | 1) ECN33201 stops. (The output IGBTs of the top and bottom arms are all turned off.)<br>2) Transition to the protection state. |
| Detection cycle of reset | 20ms cycle |
| Reset condition | AN0 input voltage ≤ 5V_Vcc × 0.937　(VS=430V Typ.) |
| Performance after satisfaction of the reset condition | Transition to the usual stop state. |
| Remarks | – |

*1　AN0 input voltage : AN0 input voltage for VS voltage detection (Pin 25), VS : High voltage power supply

Table 4.7.4.6 Specification of VS Under-Voltage Protection

| Protection item | VS under-voltage protection |
|---|---|
| Detection part | MCU |
| Detection cycle of protection | 20ms cycle |
| Protection condition | AN0 input voltage < 5V_Vcc × 0.109　(VS = 50V Typ.) *1 |
| Performance after satisfaction of the protection condition | 1) The ECN33201 stops. (The output IGBTs of the top and bottom arms are all turned off.)<br>2) Transition to the protection state. |
| Detection cycle of reset | 20ms cycle |
| Reset condition | AN0 input voltage ≥ 5V_Vcc × 0.109　(VS = 50V Typ.) |
| Performance after satisfaction of the reset condition | Transition to the usual stop state. |
| Remarks | – |

*1　AN0 input voltage : AN0 input voltage for VS voltage detection (Pin 25), 5V_Vcc : Control power supply voltage for MCU (Pin 7), VS : High voltage power supply

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**Table. 4.7.4.7 Specification of Position Detecting Signal Abnormality Protection**

| Protection item | Abnormality protection of position detecting signals |
|---|---|
| Detection part | MCU |
| Detection cycle of protection | 25μs cycle |
| Protection condition | At the time either of the following conditions is satisfied.<br>1) False detection of position sensor signals.<br>2) Discontinuous pattern of position sensor signals. |
| Performance after satisfaction of the protection condition | 1) ECN33201 stops. (The output IGBTs of the top and bottom arms are all turned off.)<br>2) Transition to the protection state. |
| Detection cycle of reset | 20ms cycle |
| Reset condition | At the time both of the following conditions are satisfied.<br>1) Normal detection of position sensor signals.<br>2) Continuous pattern of position sensor signals. |
| Performance after satisfaction of the reset condition | Transition to the usual stop state. |
| Remarks | ・The following (A) describes the detection process of position sensor signals.<br>(A) The kit product detects position sensor signals of U-phase and V-phase three times in every PWM carrier cycle.<br>・False detection of position sensor signals means that the three patterns described above in (A) are all different (see Example 1).<br>(Example 1: In the case of the following position sensor signals, position sensor signals are judged as false detection. The first, second, and third readings are not the same.<br>First: Hu = H Hv = H, Second: Hu = H Hv = L, Third: Hu = L Hv = L)<br>・Discontinuous pattern of position sensor signals means signal patterns of the position sensor information detected this time and the previous time are discontinuous (See Fig. 4.7.4.2).<br>(Example 2: This time: Hu = L, Hv = L. Previous time: Hu = H, Hv = H. These patterns are considered to be discontinuous.) |

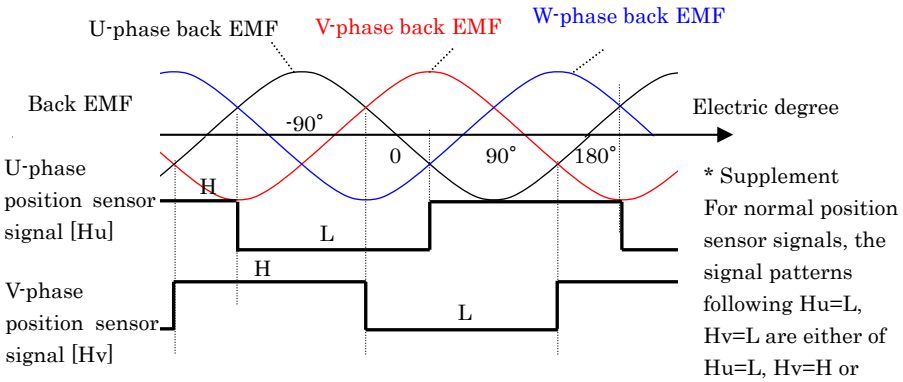


**Fig. 4.7.4.2 Logic of Position Sensor Signals and Back EMFs**

**Table. 4.7.4.8 Specification of Motor Speed Abnormality Protection**

| Protection items | Motor speed abnormality protection |
|---|---|
| Detection part | MCU |
| Detection cycle of protection | 20ms cycle |
| Protection condition | At the time either of the following conditions is satisfied.<br>(1) Fr > 176Hz, (2) Fr < –176Hz (Typ.) |
| Performance after satisfaction of the protection condition | 1) ECN33201 stops. (The output IGBTs of the top and bottom arms are all turned off.)<br>2) Transition to the protection state. |
| Detection cycle of reset | 20ms cycle |
| Reset condition | – 146.6Hz ≤ Fr ≤ 146.6Hz (Typ.) |
| Performance after satisfaction of the reset condition | Transition to the usual stop state. |
| Remarks | – |

* Fr : Detected motor frequency (Electric angular frequency calculated based on position sensor signals)

4.7.5 MCU Monitoring Functions

The monitoring functions of MCU are described in Table 4.7.5.1. When a monitoring function operates, MCU transits to the reset state. Then MCU is restarted. (The number of restarts after MCU monitoring operations is unlimited.)

Specifications for the various monitoring functions are provided in Tables 4.7.5.2 – 4.7.5.5.

**Table 4.7.5.1 MCU Monitoring Function List**

| MCU monitoring items | Outline | Specifications |
|---|---|---|
| 5V_Vcc monitoring | Monitors the control power supply (5V_Vcc). A value below the rated value causes transition to the reset state. | Table 4.7.5.2 |
| Watchdog timer monitoring | Monitors MCU operation. Overrunning of MCU causes transition to the reset state. | Table 4.7.5.3 |
| RAM check | Monitors RAM built into the MCU. When RAM cannot be read or written, MCU transits to the reset state. | Table 4.7.5.4 |
| ROM check | Monitors ROM built into the MCU. When the sum of ROM is abnormal, MCU transits to the reset state. | Table 4.7.5.5 |

**Table 4.7.5.2 Specification of 5V_Vcc Monitoring**

| MCU monitoring items | 5V_Vcc monitoring |
|---|---|
| Detection part | MCU |
| Detection cycle of monitoring | At all times |
| Monitoring condition | 5V_Vcc < 3.55V (Typ.) *1 |
| Performance after satisfaction of the monitoring condition | Transition to MCU reset. |
| Detection cycle of reset | At all times |
| Reset condition | 5V_Vcc ≥ 3.55V (Typ.) |
| Performance after satisfaction of the reset condition | Initial setting is done. Then, the MCU transits to the usual stop state. |
| Remarks | – |

*1 5V_Vcc: Control power supply voltage for MCU (Pin 7)

**Table 4.7.5.3 Specification of Watchdog Timer Monitoring**

| MCU monitoring items | Watchdog timer monitoring |
|---|---|
| Detection part | MCU |
| Detection cycle of monitoring | At all times |
| Monitoring condition | The watchdog timer built into the MCU cannot be cleared within the specified time. |
| Performance after satisfaction of monitoring condition | Transition to MCU reset. |
| Detection cycle of reset | – |
| Reset condition | – |
| Performance after satisfaction of the reset condition | – |
| Remarks | When this monitor operates, MCU must transit to the reset state. Then, initial setting is done. Monitoring with MCU hardware. |

Table 4.7.5.4 Specification of RAM Check

| MCU monitoring items | RAM check |
|---|---|
| Detection part | MCU |
| Detection cycle of check | Once every reset of MCU |
| Check condition | RAM built into the MCU cannot be read or written. |
| Performance after satisfaction of the check condition | Transition to MCU reset state. |
| Detection cycle of reset | – |
| Reset condition | – |
| Performance after satisfaction of the reset condition | – |
| Remarks | When this monitor operates, MCU must transit to the reset state. Then, initial setting is done. |

Table 4.7.5.5 Specification of ROM Check

| MCU monitoring items | ROM check |
|---|---|
| Detection part | MCU |
| Detection cycle of check | Once every reset of MCU |
| Check condition | The sum of ROM built into the MCU does not match the sum setting. |
| Performance after satisfaction of the check condition | Transition to MCU reset state. |
| Detection cycle of reset | – |
| Reset condition | – |
| Performance after satisfaction of the reset condition | – |
| Remarks | When this monitor operates, MCU must transit to the reset state. Then, initial setting is done. |

* Sum setting is stored in fixed address.

4.7.6 Limited Drive Functions

The kit product has the limited drive functions described in Table 4.7.6.1. Once the limited drive function operates, the motor speed is decreased without complying with the VSP voltage until the reset condition is satisfied. When no reset condition of limited drive is satisfied, the limit is the lowest frequency (4Hz). Detailed specifications for the limited drive functions are provided in Tables 4.7.6.2 and 4.7.6.3.

**Table 4.7.6.1 Limited Drive Function List**

| Limited drive item | Outline |
|---|---|
| Limited temperature drive | When the temperature around the thermistor used for temperature protection exceeds the rated value, the motor speed is decreased. |
| Limited output voltage drive | When the output voltage for VS voltage exceeds the rated value, the speed is decreased. |

**Table 4.7.6.2 Specification of Temperature Limited Drive**

| Limited drive item | Limited temperature drive |
|---|---|
| Detection part | MCU |
| Detection cycle of operation | 20ms cycle |
| Operation condition | AN2 input voltage > 5V_Vcc × 0.75 *1 |
| Performance after satisfaction of the operation condition | Decelerates at the usual deceleration rate without complying with VSP values. (Limit : The lowest frequency, 4Hz) |
| Detection cycle of reset | 20ms cycle |
| Reset condition | AN2 input voltage ≤ 5V_Vcc × 0.75 |
| Performance after satisfaction of the reset condition | Accelerates at one-fourth of the usual rate until reaching the VSP value. |
| Remarks | − |

*1 AN2 input voltage : Temperature detection (Pin 27), 5V_Vcc : Control power supply voltage for MCU (Pin 7)

**Table 4.7.6.3 Specification of Output Voltage Limited Drive**

| Limited drive item | Limited output voltage drive |
|---|---|
| Detection part | MCU |
| Detection cycle of operation | Cycle of position sensor variation (maximum 20ms). |
| Operation condition | Kh ≥ 1.05 *1 |
| Performance after satisfaction of the operation condition | Decelerates at a rate corresponding to the rate at which Kh exceeds the standard value of 1.05. (Limit : The lowest frequency, 4Hz) |
| Detection cycle of reset | Cycle of position sensor variation (maximum 20ms). |
| Reset condition | Kh < 1.05 |
| Performance after satisfaction of the reset condition | Accelerates at the usual rate until the VSP value is reached. |
| Remarks | − |

*1 Kh : Percent modulation (Percent modulation = Inverter phase voltage peak / (VS voltage / 2))

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4.7.7 Control Specification

Table 4.7.7.1 shows the carrier frequency.

**Table 4.7.7.1 Carrier Frequency Range**

| No. | Item | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| 1 | Carrier frequency | 16.0 | 16.7 | 17.4 | kHz |

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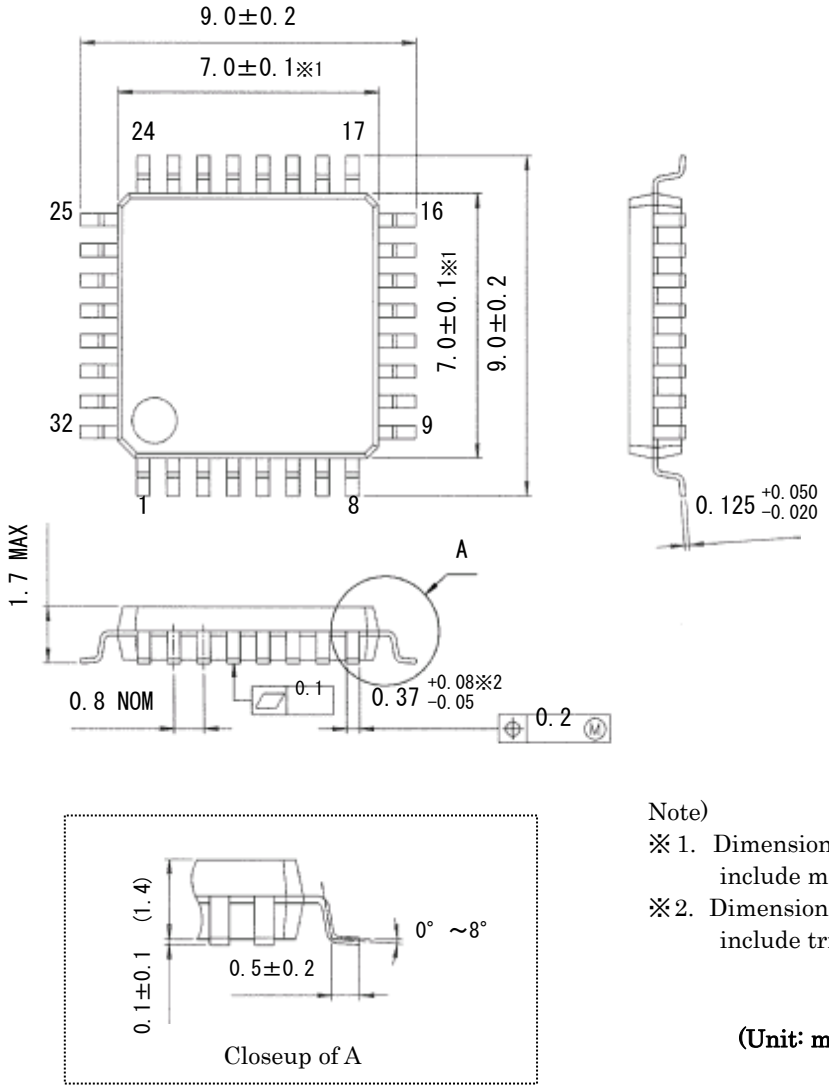
4.7.8 Dimensions (Unit: mm)
The dimensional outline drawing is shown in Fig. 4.7.8.1.




Note)
※1. Dimensions ※1 do not include mold flash.
※2. Dimension ※2 does not include trim offset.

**(Unit: mm)**

**Fig. 4.7.8.1 Dimensions**

# Precautions for Safe Use and Notices

If semiconductor devices are handled inappropriate manner, failures may result. For this reason, be sure to read “Precaution for Use” before use.

| | |
|---|---|
| ⚠ | This mark indicates an item about which caution is required. |
| ⚠ **CAUTION** | This mark indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury and damage to property. |

## ⚠ CAUTION

(1) Regardless of changes in external conditions during use “absolute maximum ratings” should never be exceed in designing electronic circuits that employ semiconductors.
In the case of pulse use, furthermore,″safe operating area (SOA)”precautions should be observed.

(2) Semiconductor devices may experience failures due to accident or unexpected surge voltages. Accordingly, adopt safe design features, such as redundancy or prevention of erroneous action, to avoid extensive damage in the event of a failure.

(3) In cases where extremely high reliability is required (such as use in nuclear power control, aerospace and aviation, traffic equipment, life-support-related medical equipment, fuel control equipment and various kinds of safety equipment), safety should be ensured by using semiconductor devices that feature assured safety or by means of user’s fail-safe precautions or other arrangement. Or consult Hitachi’s sales department staff.

(If a semiconductor devices fails, there may be cases in which the semiconductor device, wiring or wiring pattern will emit smoke or cause a fire or in which the semiconductor device will burst)

## NOTICES

1. This Datasheet contains the specifications, characteristics (in figures and tables), dimensions and handling notes concerning power semiconductor products (hereinafter called “products”) to aid in the selection of suitable products.
2. The specifications and dimensions, etc. stated in this Datasheet are subject to change without prior notice to improve products characteristics. Before ordering, purchasers are advised to contact Hitachi’s sales department for the latest version of this Datasheet and specifications.
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