

3-Phase IGBT/MOS Gate Driver IC

ECN33500FP Product Specifications

Rev.0

1. Product Description

1.1 Features

- (1) A motor is driven by three input signals (UI, VI, WI)
- (2) Dead time and six control signals from three input signals are generated
- (3) Maximum Ratings: 620V, suitable for the system from 200VAC to 240VAC
- (4) Drives a motor using a high voltage DC power supply and a low voltage DC power supply (15V)

1.2 Functions

- (1) Three input type
- (2) Built-in dead-time generating function (Top and bottom arm short-circuit protection)
- (3) All off signal input pin
- (4) Fault output pin
- (5) Built-in bootstrap diode
- (6) 5V power supply
- (7) Over-current protection
- (8) 15V_VCC low-voltage detection
- (9) Top arm low-voltage detection

1.3 Block Diagram

The ECN33500 is shown inside the bold line.

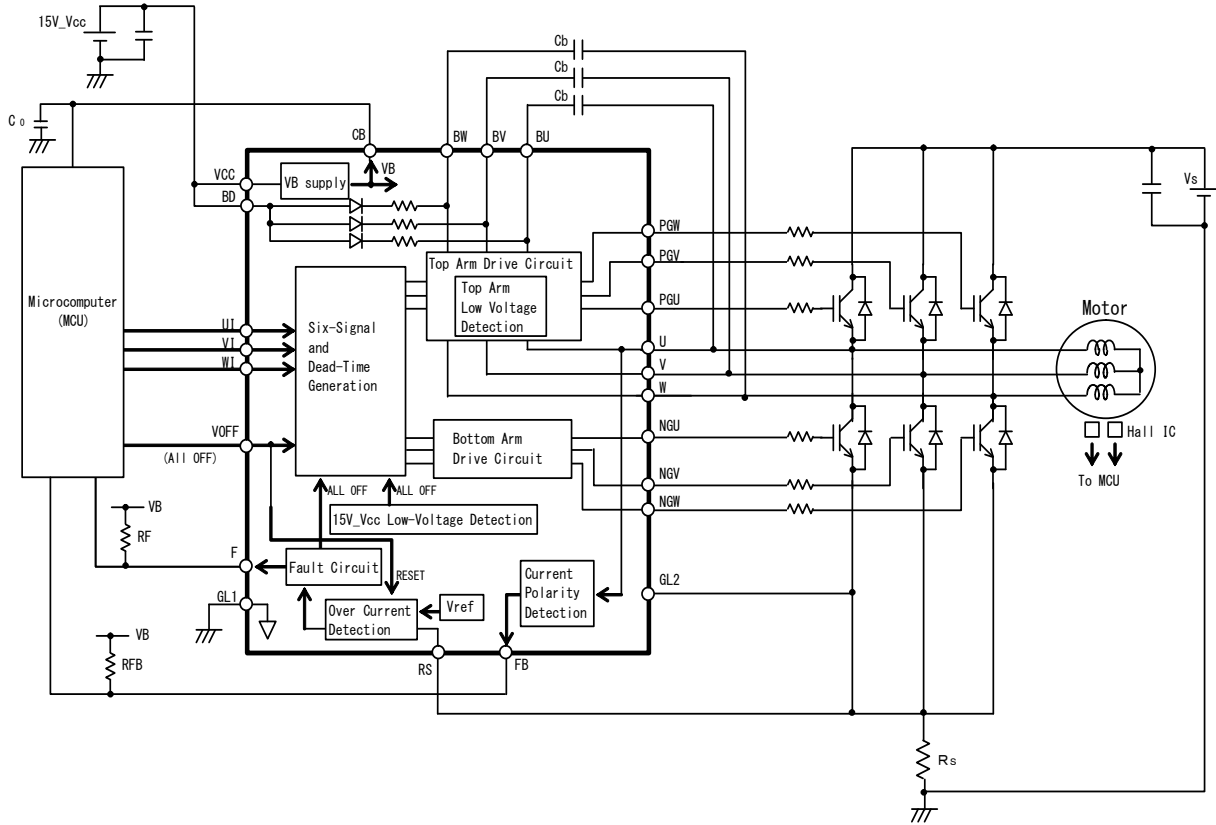
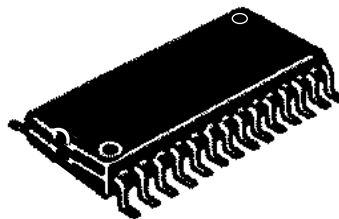


FIGURE 1.3.1 Block Diagram

1.4 Package



ECN33500FP
(Package: SOP-28)

FIGURE 1.4.1 Package of ECN33500FP

2. Specification

2.1 Maximum ratings

TABLE 2.1.1 Maximum ratings

Condition: Ta=25°C

No.	Item	Symbol	Pin	Rating	Unit	Condition
1	High voltage device breakdown voltage	VBV	BU,BV,BW	620	V	
2	GL2 pin voltage	VGL2	GL2	-5 to VCC	V	
3	U, V, W pin voltage	VU,VV,VW	U,V,W	-5 to 600	V	
4	Voltage between BU-BD, BV-BD, BW-BD	VBUD VBVD VBWD	BU,BV,BW, BD	-5 to 600	V	
5	VCC power supply voltage	15V_VCC	VCC	20	V	
6	Voltage between BU-U, BV-V, BW-W	VBSU VBSV VBSW	BU,U BV,V BW,W	20	V	
7	Voltage between VCC-GL2	VCCGL2	VCC,GL2	23	V	$-5V \leq VGL2 \leq -3V$
8	Input voltage	VIN	UI,VI,WI VOFF,RS	-0.5 to VB+0.5	V	
9	Fault pin voltage	Vflt	F	-0.5 to VB+0.5	V	
10	FU, FV pin voltage	Vfu,Vfv	FU,FV	-0.5 to VB+0.5	V	
11	VB supply output current	IBMAX	CB	50	mA	
12	Operating junction temperature	Tjop	—	-40 to +125	°C	
13	Storage temperature	Tstg	—	-40 to +150	°C	

Note 1: Thermal resistance

Between junction and air (Mounted PCB*) : 96°C/W [Reference value]

(Material of PCB : Glass epoxy, PCB size : 40mm × 40mm × 1.6mm, Wiring density : 10%)

*PCB: Printed Circuit Board

2.2 Electrical Characteristics

TABLE 2.2.1 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	Is1	VCC	—	3	10	mA	VCC=15V, GL2=0V VOFF=0V, IB=0A		
		Is2	BU, BV, BW	—	15	30	μA	Between BU-U, BV-V, BW-W=15V		
2	Output source current	Io+	PGU, PGV, PGW NGU, NGV, NGW	0.20	0.25	—	A	VCC=15V, Pulse width ≤ 10μs Between BU-PGU, BV-PGV, BW-PGW, VCC-NGU, NGV, NGW=15V		
3	Output sink current	Io-	PGU, PGV, PGW NGU, NGV, NGW	0.30	0.40	—	A	VCC=15V, Pulse width ≤ 10μs Between PGU-U, PGV-V, PGW-W NGU, NGV, NGW-GL2=15V		
4	High level output voltage	VOH	PGU, PGV, PGW NGU, NGV, NGW	—	—	100	mV	VCC=15V, Io+=0A Between BU-PGU, BV-PGV, BW-PGW Between VCC-NGU, NGV, NGW		
5	Low level output voltage	VOL	PGU, PGV, PGW NGU, NGV, NGW	—	—	100	mV	VCC=15V, Io-=0A Between PGU-U, PGV-V, PGW-W Between NGU, NGV, NGW-GL2		
6	Output delay time	Turn ON	TdONT	PGU, PGV, PGW	—	1.7	3.0	μs	VCC=15V, CL=1000pF	
7			TdONB	NGU, NGV, NGW	—	1.7	3.0	μs		
8		Turn OFF	TdOFFT	PGU, PGV, PGW	—	0.4	1.0	μs		
9			TdOFFB	NGU, NGV, NGW	—	0.4	1.0	μs		
10	Dead-time	Top arm ON	TDT	PGU, PGV, PGW	0.7	1.3	1.9	μs	VCC=15V, CL=1000pF NOTE 1	
11		Bottom arm ON	TDB	NGU, NGV, NGW	0.7	1.3	1.9	μs		
12	Leakage current at high voltage pin	IL	BU, BV, BW, U, V, W	—	—	10	μA	BU, BV, BW=U, V, W=450V		
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	—	2.0	4.0	μs	VCC=15V, CL=1000pF		
15	UI, VI, WI, VOFF inputs	Voltage	VIH	UI, VI, WI,	2.5	—	—	V	VCC=15V	
16			VIL	VOFF	—	—	1.0	V		
17		Current	IIL	UI, VI, WI,	-10	—	—	μA	Input=0V, VCC=15V	Pull-down resistor NOTE 2
18			IIH	VOFF	—	—	100	μA	Input=4.5V, VCC=15V	
19	RS input current	IILRS	RS	-100	—	—	μA	VCC=15V, 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		
22	LVSD	Operating voltage	LVSDON	VCC	9.5	11.0	12.5	V	NOTE 4	
23		Recovery voltage	LVSDOFF		10.0	11.5	13.0	V		
24	Top arm	Operating voltage	LVSDONT	BU, BV, BW	9.0	10.5	12.0	V		
25	LVSD	Recovery voltage	LVSDOFFT		9.5	11.0	12.5	V		
26	F, FB output resistance	RON	F, FB	—	0.4	0.8	kΩ	I= -1mA NOTE 5		
27	Fault reset delay time	tflrs	F	—	15	30	μs	VCC=15V		
28	All off delay time	taoff	VOFF	—	0.3	2.0	μs	VCC=15V, CL=1000pF		
29	Bootstrap diode forward voltage	VFDB	BU, BV, BW, BD	—	1.0	1.5	V	I=1mA, Between BD-BU, BV, BW Included series resistance		

Note 1: FIGURE 2.4.2.1 shows definition of the dead-time. The values shown in No.10 and No.11 are based on the actual measured values of the ECN33500. They don't correspond to the values calculated from the values shown in No.6 to No.9.

Note 2: Internal pull-down resistor is typically 200kΩ. The equivalent circuit is shown in FIGURE 2.2.1.

Note 3: Internal pull-up resistor is typically 200kΩ. The equivalent circuit is shown in FIGURE 2.2.2.

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

Note 5: The equivalent circuit is shown in FIGURE 2.2.3.

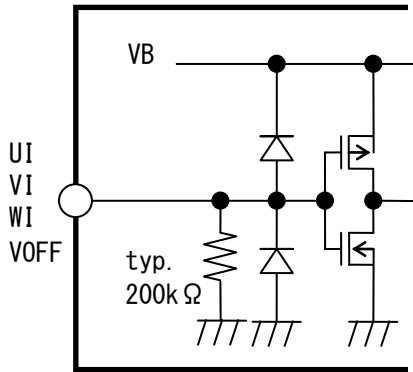


FIGURE 2.2.1 Equivalent Circuit around UI, VI, WI, VOFF Pins

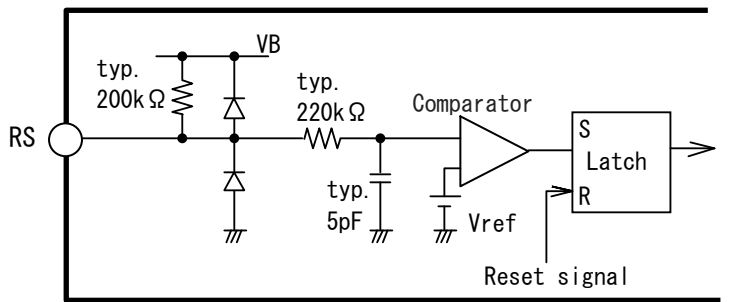


FIGURE 2.2.2 Equivalent Circuit around RS Pin

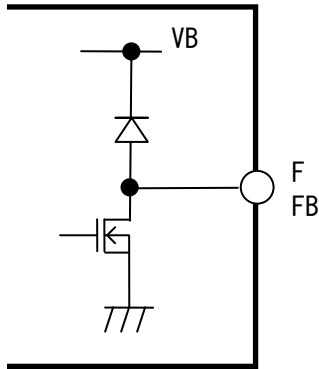


FIGURE 2.2.3 Equivalent Circuit around F, FB Pins

2.3 Operating Condition

TABLE 2.3.1 Operating Condition

Condition: Ta=25°C

No.	Item	Symbol	Pin	Min.	Typ.	Max.	Unit	Condition
1	U, V, W voltage	VUVWop	U, V, W	-3	-	450	V	VCC=15V Each voltage between BU-U, BV-V, BW-W: 15V
2	VCC voltage	VCCop	VCC	13.5	15.0	16.5	V	
3	Voltage between BU-U, BV-V, BW-W	VBSUop VBSVop VBSWop	BU, U BV, V BW, W	12.0	15.0	16.5	V	

2.4 Functions and Operations

2.4.1 Truth Table

TABLE 2.4.1.1 Truth Table

Pin	Input	Top arm output	Bottom arm output
UI, VI, WI	L	OFF	ON
	H	ON	OFF
VOFF	L	ALL OFF	
	H	Based on UI, VI, WI input	

2.4.2 Dead-time

The ECN33500 generates six output signals with dead time from three input signals (UI, VI, WI).

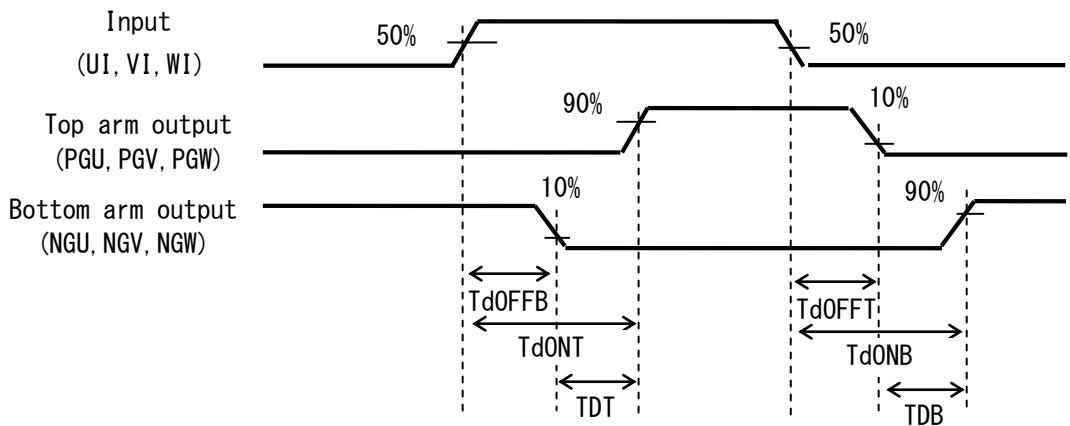


FIGURE 2.4.2.1 Definition of Dead time (Capacitive Load)

2.4.3 All Output Shutoff Function

When the “L” signal is input to the VOFF pin, the outputs of the top and bottom arms become all “L”.

When the “H” signal is input to the VOFF pin, the ECN33500 outputs the signals in accordance with

TABLE 2.4.1.1.

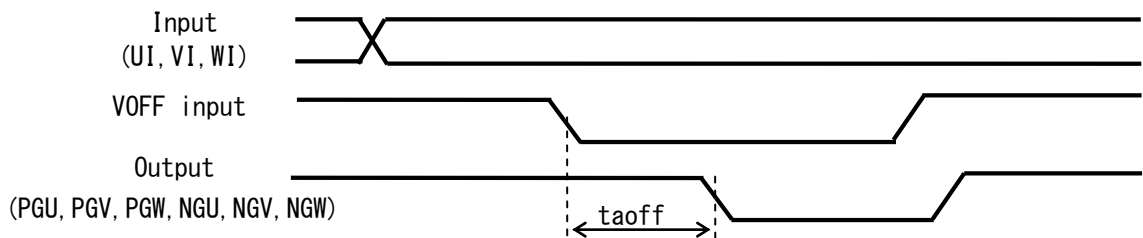


FIGURE 2.4.3.1 Definition of taoff

2.4.4 Over Current Protection

The ECN33500 monitors the current through the shunt resistance R_s . When the voltage at the RS pin exceeds the V_{ref} (Typ. 0.5V) of the internal detection circuit, the outputs of the top and bottom arms become all “L” and the F pin outputs “L”. Input “L” at the VOFF pin to reset this “All-Off” state. The F pin outputs “H” by inputting “L” after a lapse of the fault reset delay time (t_{flrs}). Lengthen the period of the VOFF “L” for the fault reset delay time or more.

Just after the VCC power supply is turned on, the over current protection may operate. In this case, reset the “All-Off” state.

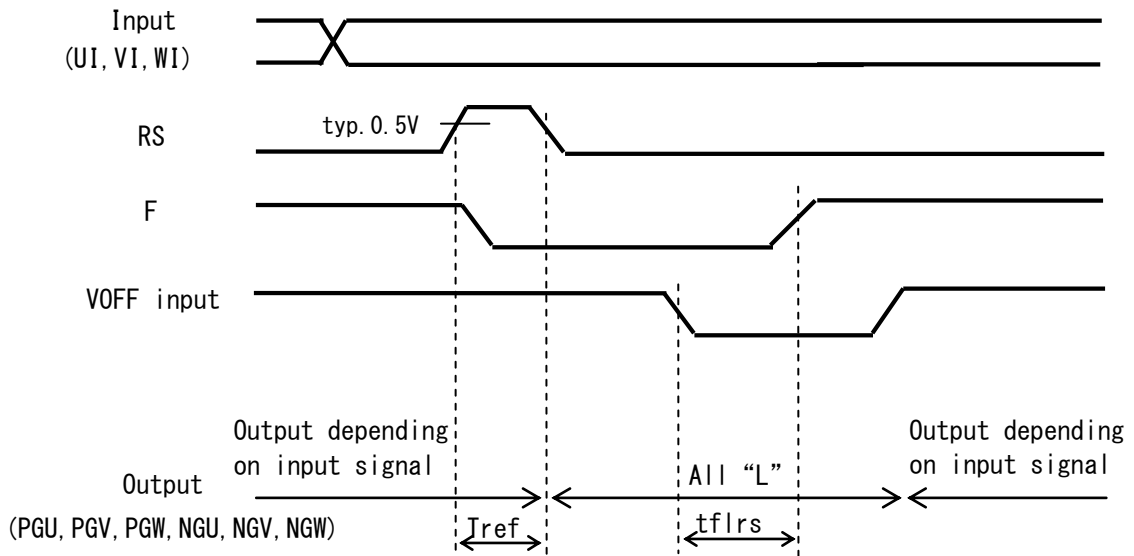


FIGURE 2.4.4.1 Definition of T_{ref} and t_{flrs}

2.4.5 15V_VCC Low-voltage Detection

When the 15V_VCC voltage goes below the LVSD operating voltage (LVSDON), the outputs of the top and bottom arms become all “L”. When the 15V_VCC voltage goes up, this all “L” state is reset at the LVSD recovery voltage (LVSDOFF).

2.4.6 Top Arm Low-voltage Detection

When the voltage between BU and U (BV and V, or BW and W) goes below the top arm low-voltage detection operating voltage (LVSDONT), the top arm output of the corresponding phase becomes “L”. The “L” output state is reset when the “H” signal is input to the top arm after the voltage between BU and U (BV and V, or BW and W) goes up to the top arm low-voltage detection recovery voltage (LVSDOFFT).

3. Standard Applications

3.1 External Components

TABLE 3.1.1 External Components

Component	Standard value	Usage	Remark
C0	1.0μF ± 20%	Smooths the internal power supply (VB)	Voltage stress is VB (=5.5V)
Cb	3.3μF ± 20%	For bootstrap	Voltage stress is 15V_VCC
Rs	Note 1	Sets over-current protection	
RF, RFB	10kΩ ± 5%	Pull-up resistor	

Note 1. The over-current detection setting IO is calculated as follows.

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

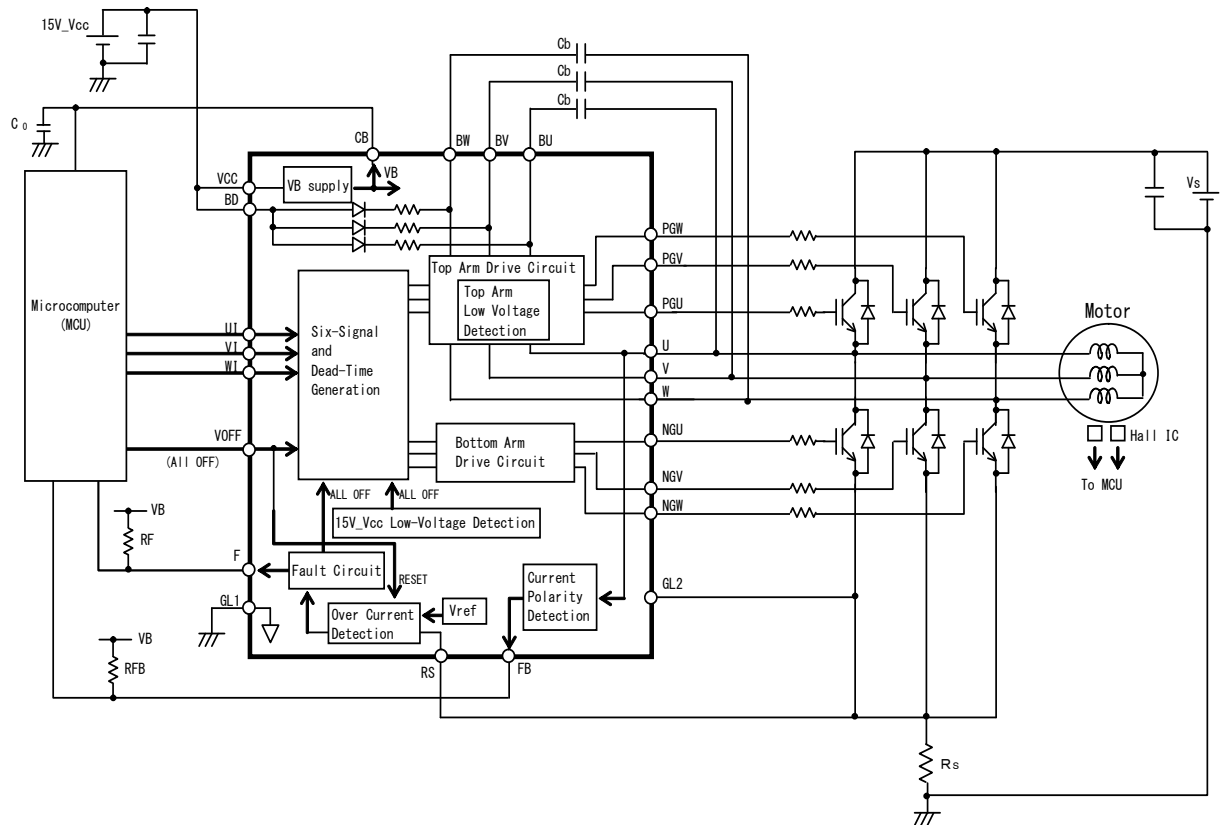


FIGURE 3.1.1 Block Diagram (ECN33500 is shown inside the bold line.)

3.2 Input Pins (UI, VI, WI, VOFF)

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)
0.01μF ± 20% ceramic capacitor close to the input pin (VOFF)

4. Pin Locations

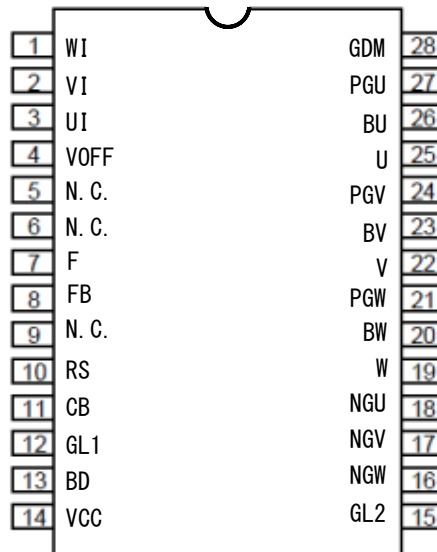


FIGURE 4.1 Pin Locations (Top view)

5. Explanations of Pins

TABLE 5.1 Explanations of Pins

Pin No.	Symbol	Explanation	Remark
1	WI	W-phase control signal input	
2	VI	V-phase control signal input	
3	UI	U-phase control signal input	
4	VOFF	All off signal input	
5	N.C.	No connection	* 2
6	N.C.	No connection	* 2
7	F	Fault signal output	
8	FB	Feedback signal (current polarity signal) output	* 3
9	N.C.	No connection	* 2
10	RS	Rs voltage input for over-current detection	
11	CB	VB power supply output	
12	GL1	Control system GND	
13	BD	For bootstrap diode	
14	VCC	15V control power supply	
15	GL2	Reference pin of bottom arm outputs (connected to a current detection resistor)	
16	NGW	W-phase bottom arm gate drive signal output	
17	NGV	V-phase bottom arm gate drive signal output	
18	NGU	U-phase bottom arm gate drive signal output	
19	W	Reference pin of W-phase top arm output	* 1
20	BW	W-phase top arm driving circuit power supply	* 1
21	PGW	W-phase top arm gate drive signal output	* 1
22	V	Reference pin of V-phase top arm output	* 1
23	BV	V-phase top arm driving circuit power supply	* 1
24	PGV	V-phase top arm gate drive signal output	* 1
25	U	Reference pin of U-phase top arm output	* 1
26	BU	U-phase top arm driving circuit power supply	* 1
27	PGU	U-phase top arm gate drive signal output	* 1
28	GDM	Non-usable pin (GND potential. Do not connect anything to this pin.)	

*1. High voltage pin

*2. Not connected to the internal IC chip

*3. It's used for motor control using the ECN39500 set with a microcomputer and the ECN33500

6. Inspection

Hundred percent inspections shall be conducted on electric characteristics at room temperature ($T_a=25\pm 5^\circ\text{C}$).

7. Cautions

7.1 Countermeasures against Electrical Static Discharge (ESD)

- (a) IC needs to be dealt with caution to protect from damage by ESD. Material of container or any device to carry semiconductor devices should be free from ESD, which may be caused by vibration while transportation. To use electrically conductive container or aluminum sheet is recommended as an effective countermeasure.
- (b) What touches semiconductor devices such as work platform, machine and measuring and test equipment should be grounded.
- (c) Workers should be grounded connecting with high impedance around $100\text{k}\Omega$ to $1\text{M}\Omega$ while dealing with semiconductor to avoid damaging IC by electric static discharge.
- (d) Friction with other materials such as a high polymer should not be caused.
- (e) Attention is necessary so that electric potential will be kept on the same level by short circuit pins when PC board with mounted IC is carried and that vibration or friction might 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.

7.2 Maximum Ratings

Regardless of changes in external conditions during use, "maximum ratings" should never be exceeded in designing electronic circuits that employ products. In a case maximum ratings are exceeded, products may be damaged or destroyed. In no event shall Hitachi Power Semiconductor Device, Ltd. be liable for any failure in products or any secondary damage resulting from use at a value exceeding the maximum ratings.

7.3 Derating Design

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 maximum ratings, to ensure reliability.

7.4 Safe Design

Products 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.

7.5 Usage

Products are not designed, manufactured, or warranted to be suitable for use where extremely high reliability is required (such as use in nuclear power control, aerospace and aviation, automobile, traffic equipment, life-support-related medical equipment, fuel control equipment and various kinds of safety equipment). Inclusion of products in such application shall be fully at the risk of customers.

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7.6 Soldering

This power semiconductor product is lead-free. The recommended reflow soldering condition is shown in FIGURE 7.1.

7.7 Others

See “Precautions for Use of Hitachi High-Voltage Monolithic ICs” for other precautions and instructions on how to deal with these kinds of products.

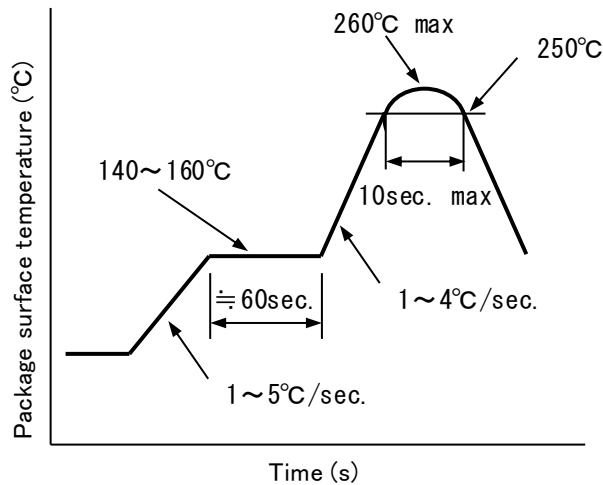


FIGURE 7.1 Recommended Conditions for Infrared Reflow or Air Reflow

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- (4) Hitachi Power Semiconductor Device, Ltd. reserves the right to make changes in this specification document and to discontinue mass production of the relevant products without notice. Customers are advised before purchasing to confirm specifications of the product of inquiry is the latest version and that the relevant product is on mass production status in such a case purchasing is suspended for one year or more.
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◆Appendix - Supplementary Data

1. Dimensions

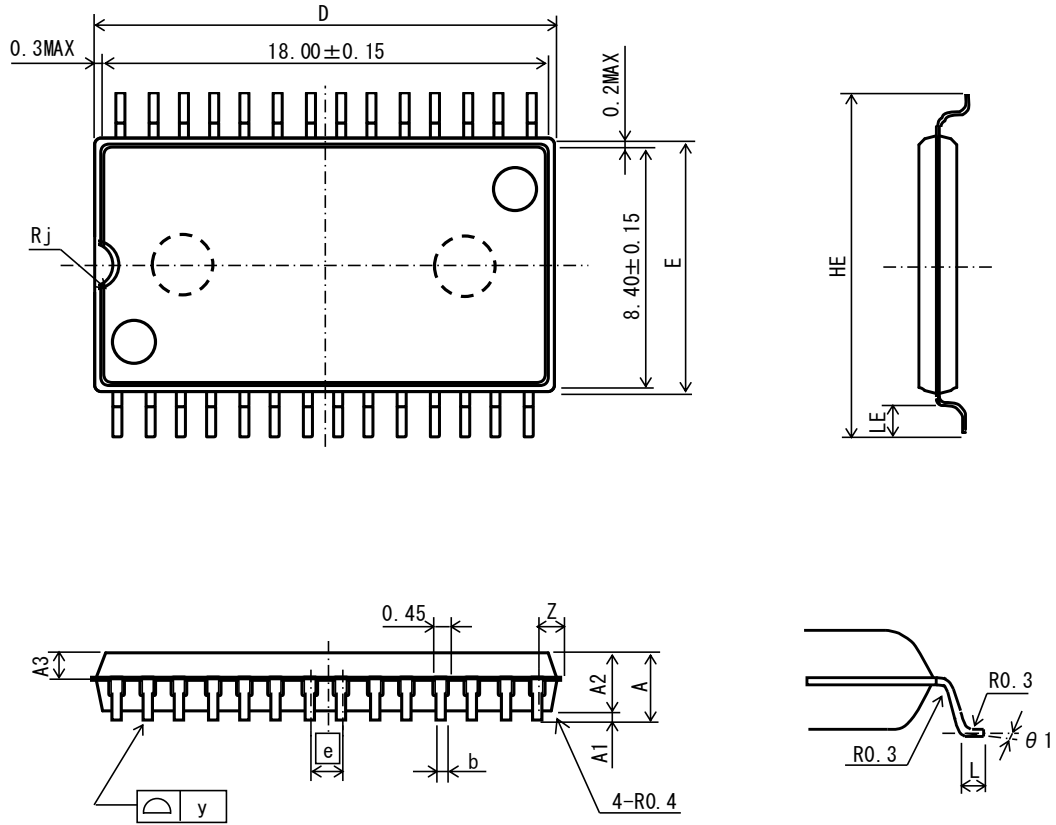


FIGURE 1.1 Dimensions

TABLE 1.1 Dimensions

	MIN	TYP	MAX
A	—	—	2.40
A1	0.10	—	—
A2	—	2.00	2.10
A3	0.75	0.85	0.95
b	0.32	0.40	0.48
D	—	—	18.75
E	—	8.60	8.80
e	1.17	1.27	1.37
HE	11.50	11.80	12.10
L	0.80	1.00	1.20
LE	—	1.70	—
Rj	—	0.60	—
Z	—	—	1.12
$\theta 1$	0°	—	8°
y	—	—	0.15

Precautions for Safe Use and Notices

If semiconductor devices are handled in inappropriate manner, failures may result. For this reason, be sure to read the latest version of "Instructions for Use of Hitachi High-Voltage Monolithic ICs" 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 exceeded 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 Data Sheet 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 Data Sheet 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 Data Sheet and specifications.
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