3-phase Motor Driver IC

ECN33201 Product Specification Rev. 0

1. Product Description

1.1 Description

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

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

(3) Applicable to three shunt motor control method because emitter pins are set for U, V, W of bottom arm IGBTs (Insulated Gate Bipolar Transistors).

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

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

1.2 Functions and Features

(1) Three input type.

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

(3) Three shunt method applicable.

(4) IGBT all off signal input pin.

(5) Fault output pin.

(6) Built-in charge pump circuit.

(7) Built-in 5V power supply circuit.

(8) Built-in over-current protection.

(9) Built-in 15V_VCC under-voltage detection.

1.3 Block Diagram

ECN33201 is shown inside the bold line in Fig. 1.1.

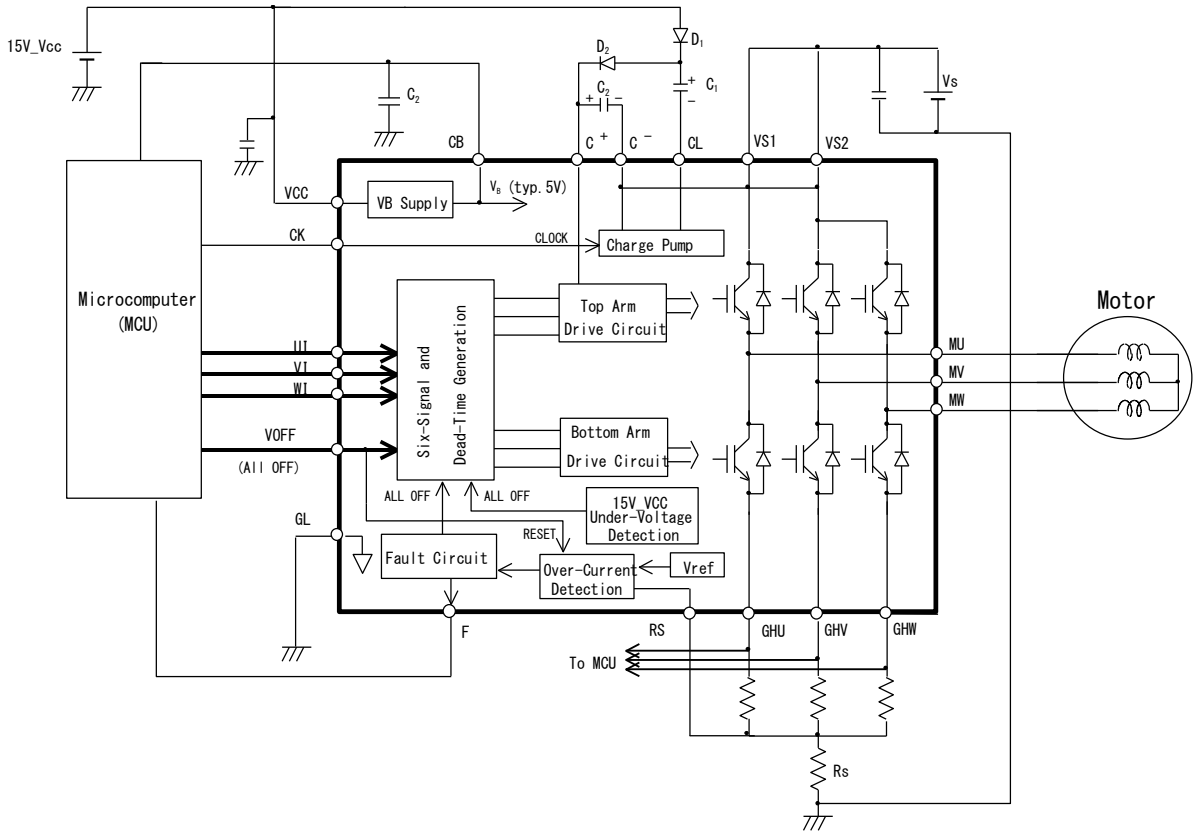
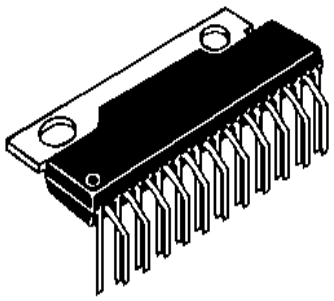
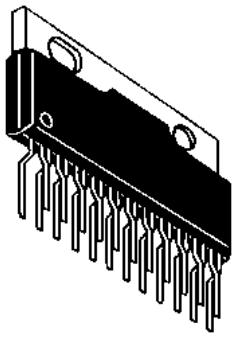


Fig.1.1 Block Diagram

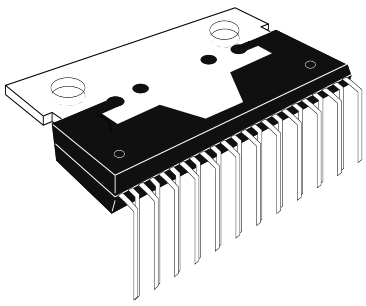
1.4 Types and Packages



ECN33201SP
(Package Type:SP-23TA)



ECN33201SPV
(Package Type:SP-23TB)



ECN33201SPR
(Package Type:SP-23TR)

Fig. 1.2 Types and Packages of ECN33201

2. Specifications

2.1 Absolute Maximum Ratings

Table 2.1 Absolute Maximum Ratings Condition: Ta=25℃

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	℃	Note 2
9	Storage temperature		Tstg	−	−40 to +150	℃	

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

Note 2: Thermal resistance

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

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

2.2 Electrical Characteristics

Table 2.2 Electrical Characteristics Suffix (T: Top arm, B: Bottom arm) Condition: Ta=25℃

No.	Item		Symbol	Pin	Min.	Typ.	Max.	Unit	Condition
1	Standby current		ISH	VS1, VS2	—	0.15	1.0	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	0.5	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	UI, VI, WI, VOFF, CK	-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 output resistance		ROP	F	—	2.0	4.0	kΩ	I=1mA,VCC=15V Note 5
25			RON	F	—	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. 2.4. 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. 2.1 is the equivalent circuit.

Note 3: Internal pull-up resistance is typically 200kΩ. Fig. 2.2 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. 2.3.

2.3 Operating Condition

Table 2.3 Operating Condition

No.	Item	Symbol	Pin	Min.	Typ.	Max.	Unit	Condition
1	Supply voltage	VSop	VS1, VS2	15	—	450	V	
2		VCCop	VCC	13.5	15	16.5	V	
3	Clock input frequency	Fck	CK	12	—	22	kHz	
4	PWM input frequency	Fpwm	UI, VI, WI	12	—	22	kHz	
5	GH voltage	Vgh	GHU, GHV, GHW	−1.0	—	1.0	V	Based on GL

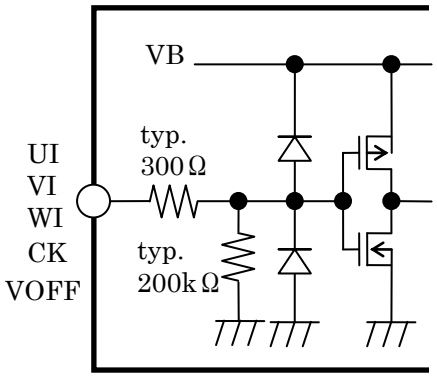


Fig. 2.1
Equivalent Circuit Around UI, VI, WI, CK, VOFF Pins

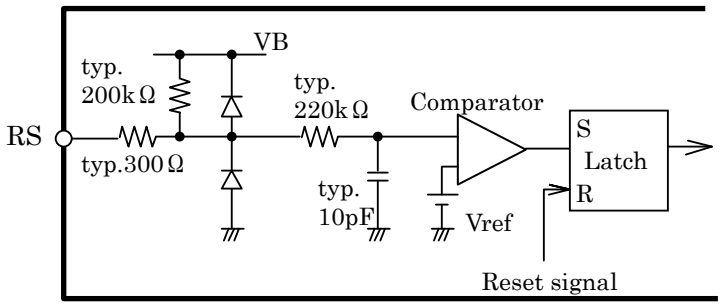


Fig. 2.2
Equivalent Circuit Around RS Pin

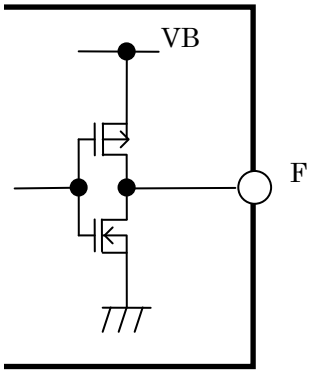


Fig. 2.3
Equivalent Circuit Around F Pin

2.4 Functions and Operations

2.4.1 Truth Table

Table 2.4 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	

2.4.2 Dead Time

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

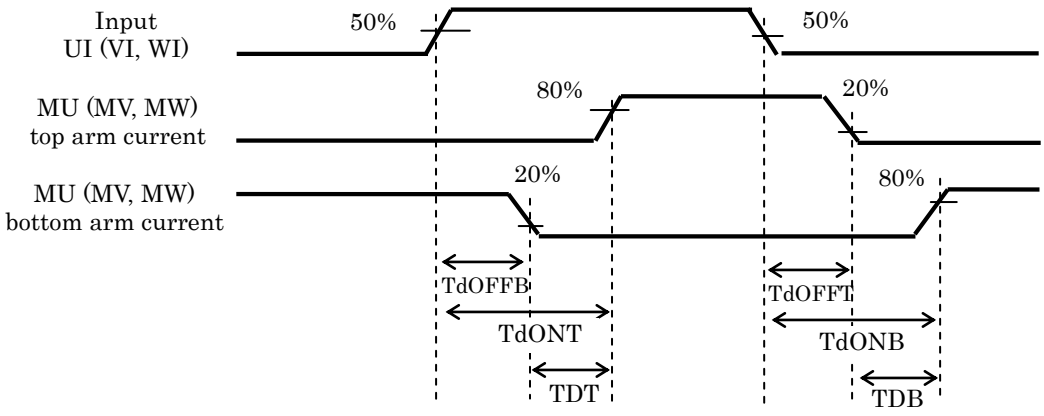


Fig. 2.4 Definition of Dead Time (Resistive Load)

2.4.3 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.

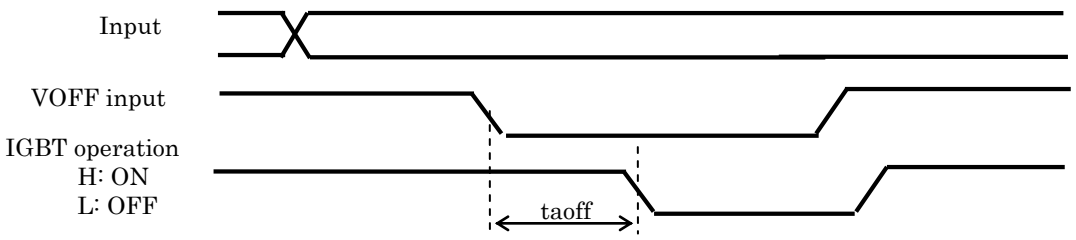


Fig. 2.5 Definition of taoff

2.4.4 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".

Input "L" at VOFF pin to reset this all off state. The F pin outputs "H" by inputting "L" after a lapse of fault reset delay time (tflrs). Lengthen the period of VOFF "L" for the fault reset delay time or more.

Input "H" at VOFF pin to restart.

Just after the 15V_VCC is input, the over current protection may operate. In this case, reset the all off state.

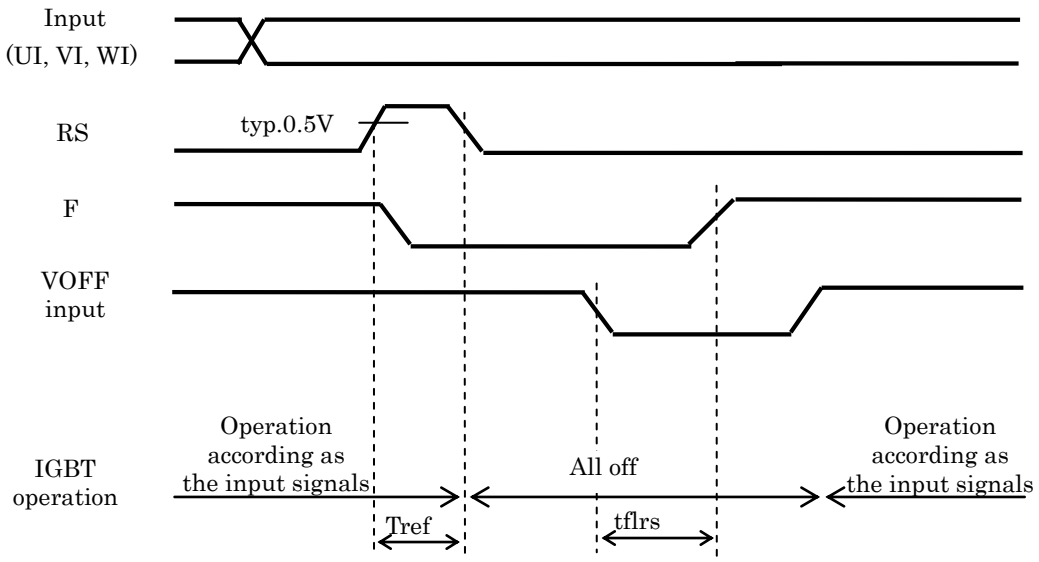


Fig. 2.6 Definition of Tref, tflrs

2.4.5 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).

2.4.6 Input Signals at Standby Condition

Input "L" at VOFF and CK pins at standby condition.

2.4.7 Clock Signal

Input the clock signal specified as follows into CK pin.

・H level = VB, L level = 0V, Duty = 50%

3. Specifications

3.1 External Parts

Table 3.1 External Parts

Part	Standard Value	Usage	Remarks
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 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 4.

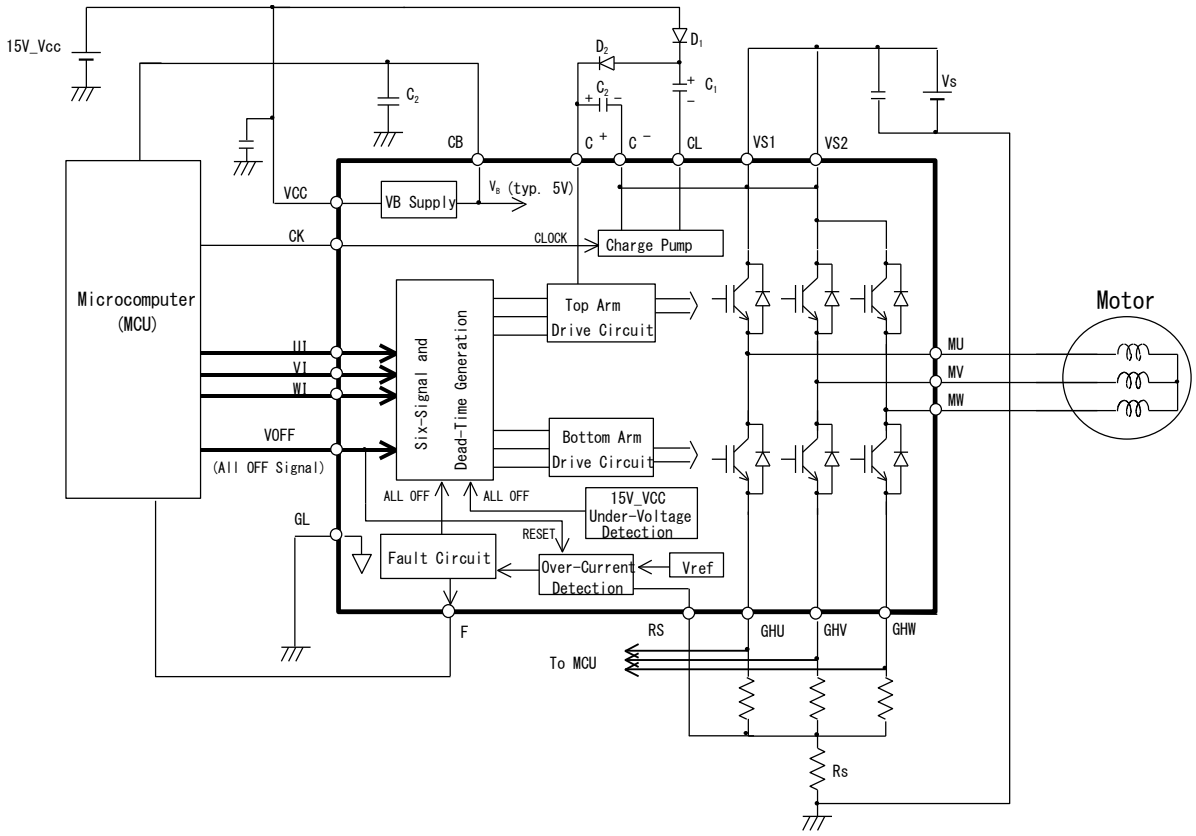


Fig. 3.1 Block Diagram (ECN33201 is shown inside the bold line.)

3.2 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).

4. Pin Locations

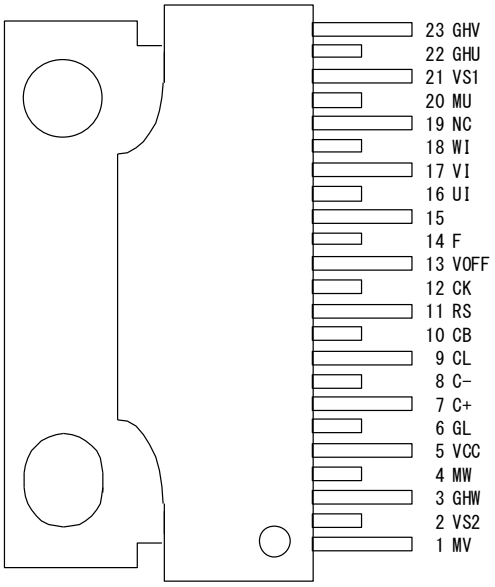


Fig. 4.1 Pin Locations

5. Explanations of Pins

Table 5.1 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	−	Feedback signal output for kit product (ECN39300 series) Open the pin.	
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.

6. Inspection

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

7. Warnings and Usage Precautions

7.1 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.

7.2 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.

7.3 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

7.4 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.

7.5 Absolute Maximum Ratings

Regardless of changes in external conditions during use, “absolute maximum ratings” should never be exceeded in designing electronic circuits that employ the ECN33201. If absolute maximum ratings are exceeded, the ECN33201 may be damaged or destroyed. In no event shall Hitachi be liable for any failure in the ECN33201 or any secondary damage resulting from use at a value exceeding the absolute maximum ratings.

7.6 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 absolute maximum ratings, to ensure reliability.

7.7 Safe Design

The ECN33201 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.

7.8 Use

The ECN33201 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 ECN33201 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.)

7.9 Soldering

The peak temperature of flow soldering* must be less than 260°C, and the dip time must be less than 10 seconds. High stress by mounting, such as long time thermal stress by preheating, mechanical stress, etc, can lead to degradation or destruction. Make sure that your mounting method does not cause problem as a system.

* Flow soldering: Only pins enter a solder bath, while the resin or tab does not.

7.10 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.

8. Operation

(1) Hitachi warrants performance of the ECN33201 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.

(2) If the performance of the ECN33201 does not meet this specification within one month after the delivery, all of the appropriate lot will be tested and delivered again. However, the ECN33201 delivered more than one month ago is excluded.

(3) Hitachi assumes no obligation for compensation for any fault in customer's goods using the ECN33201 in the marketplace. However, if Hitachi clearly has a responsibility and the ECN33201 does not meet this specification, and a customer demands for compensation within one year after the delivery of the ECN33201, the customer will be compensated by substitutions or amount of money up to worth of them.

(4) Hitachi reserves the right to make changes in this specification and to discontinue mass production of the ECN33201 without notice. Customers are advised before purchasing to confirm that this specification of the ECN33201 is the latest version and that the ECN33201 is on mass-production status if purchasing has been suspended for one year or more.

(5) 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.

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

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

(8) For the ECN33201 (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 ECN33201 (technologies), the necessary procedures are to be taken in accordance with related laws and regulations.

◆Supplementary Reference Data

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

1. Safe Operation Area (SOA)

It is important that the ECN33201 be used within the SOA shown in Fig. 1.1, where the current and voltage are at the MU, MV, and MW pins (motor coils).

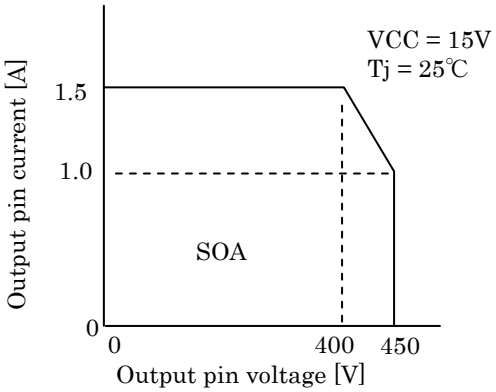


Fig. 1.1 SOA

2. Output Pin Current Derating for 15V_VCC

The output pin current derating for 15V_VCC is shown in Fig. 2.1. Use the ECN33201 below the derating curve.

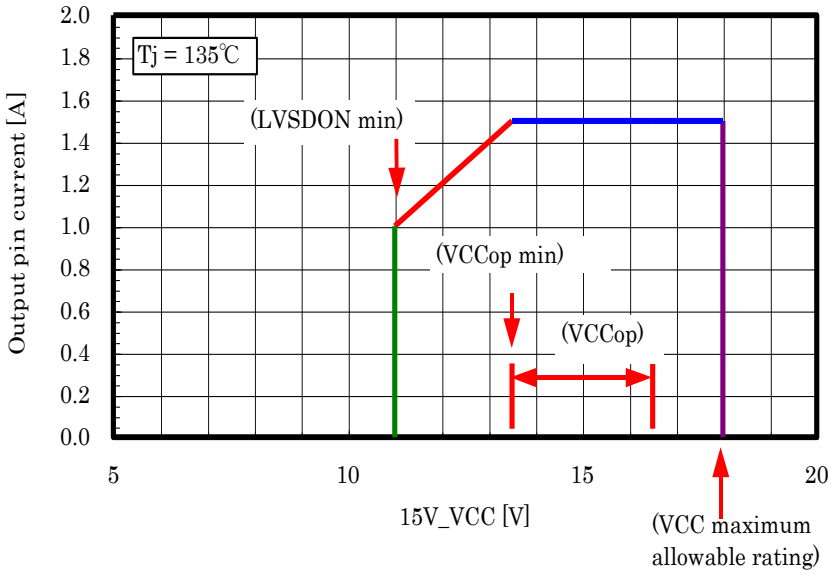


Fig. 2.1 Output Pin Current Derating for 15V_VCC

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. 3.1.

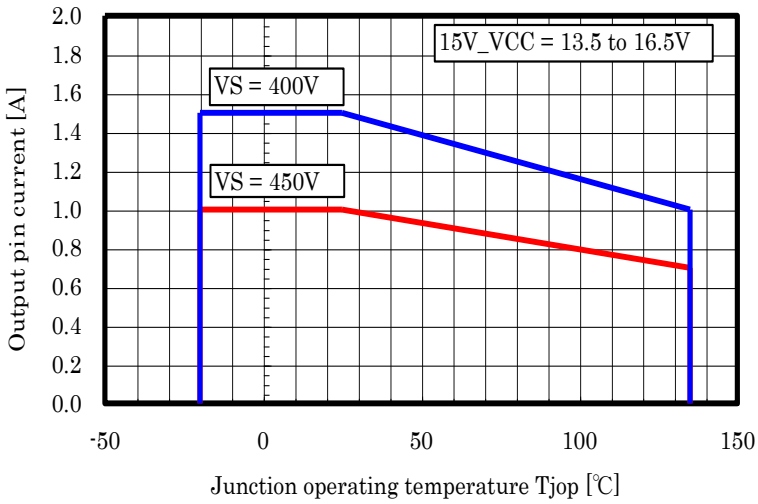


Fig. 3.1 Output Pin Current Derating for Junction Operating Temperature

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. 2.1 and 3.1.

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.

6. Power Supply Sequence

Follow the power supply sequence below.

・At the time of power on ; Power on VCC → Power on VS → Input clock to CK pin → Input "H" at VOFF pin
・At the time of power off ; Input "L" at VOFF pin → Stop inputting clock to CK pin → Power off VS → Power off VCC

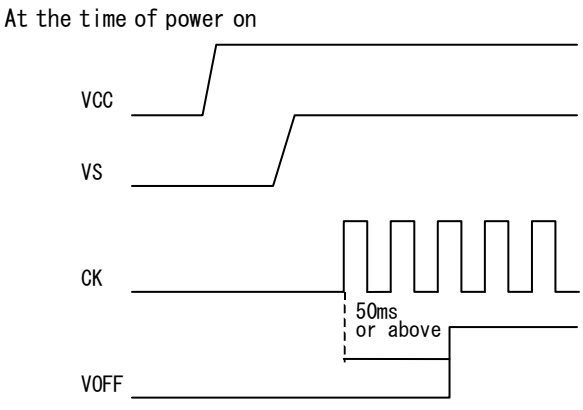


Fig. 6.1 Power Supply Sequence at Time of Power On

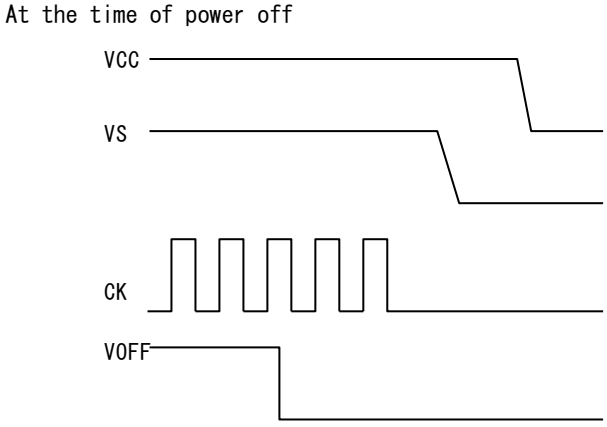


Fig. 6.2 Power Supply Sequence at Time of Power Off

7. Dimensions (mm)

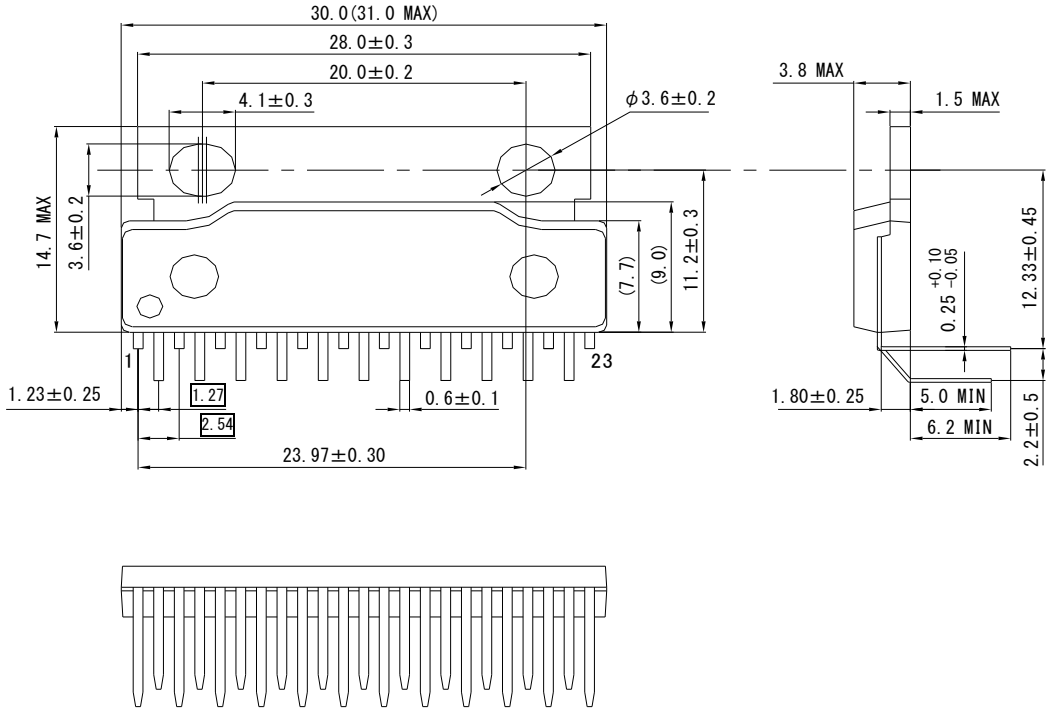
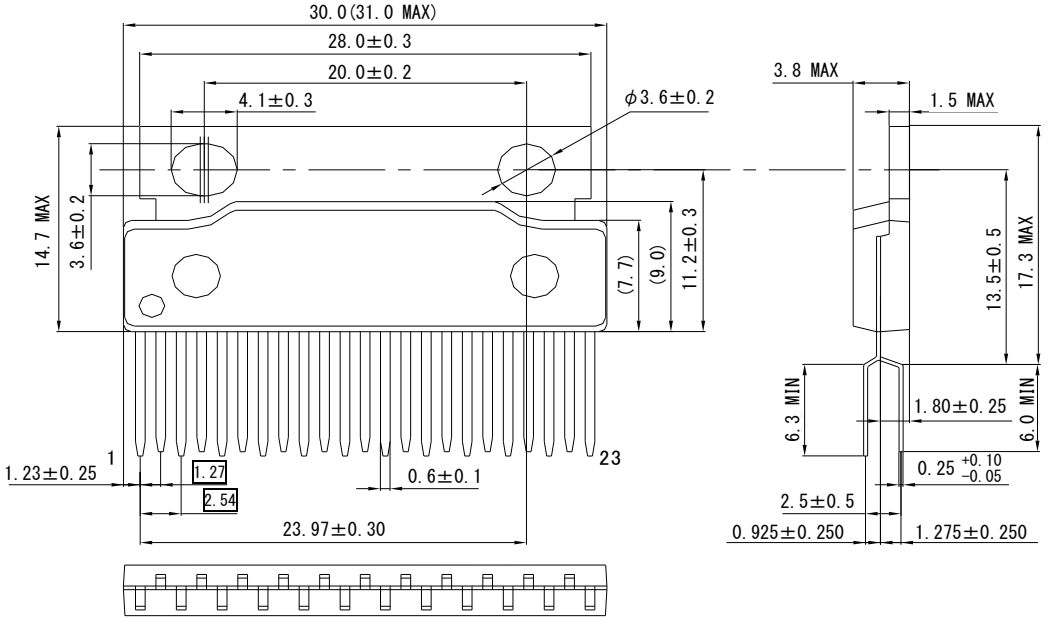
Package	Dimensions
SP (SP-23TA)	
SPV (SP-23TB)	

Fig. 7.1 Dimensions (SP, SPV) (mm)

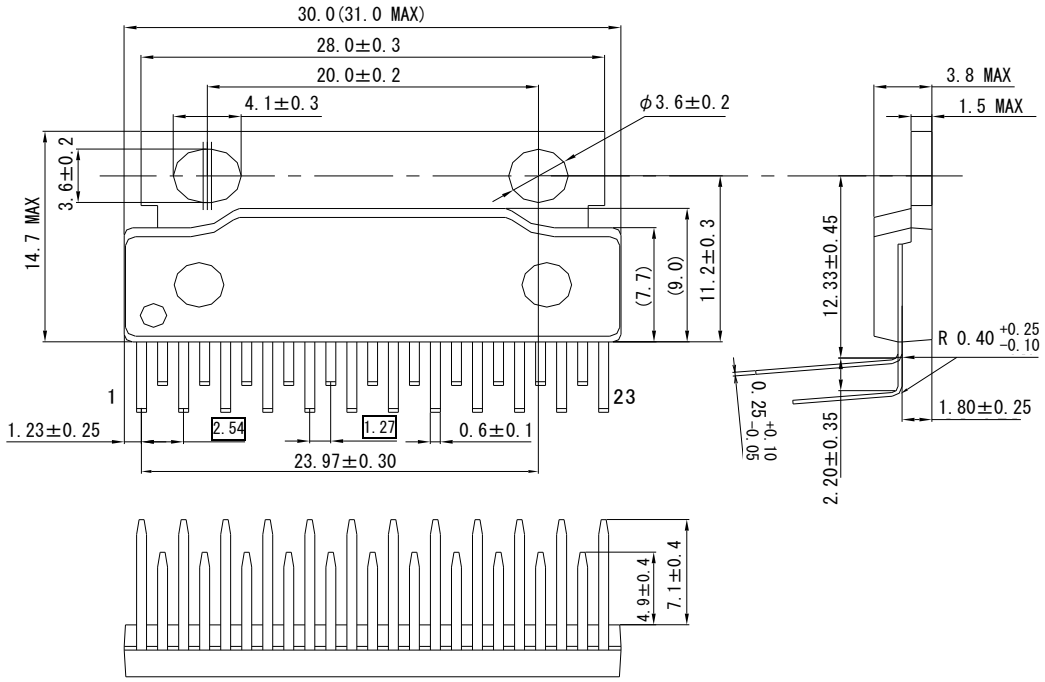
Package	Dimensions
SPR (SP-23TR)	

Fig. 7.2 Dimensions (SPR) (mm)

Precautions for Safe Use and Notices

If semiconductor devices are handled in an 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 requiring caution.

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 of semiconductor devices, the “maximum ratings” and “safe operating area(SOA)” should never be exceeded when designing electronic circuits that employ semiconductor devices.

(2) Semiconductor devices may fail due to accidents or unexpected surge voltages. Accordingly, adopt safe design features, such as redundancy and measures to prevent misuse, in order to avoid extensive damage in the event of a failure.

(3) If semiconductor devices are applied to uses where high reliability is required, obtain the document of permission from HPSD in advance (Automobile, Train, Vessel, etc.). Do not apply semiconductor devices to uses where extremely high reliability is required (Nuclear power control system, Aerospace instrument, Life-support-related medical equipment, etc.).

(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.)

NOTICES

1. This Data Sheet contains the specifications, characteristics, etc. concerning power semiconductor products (hereinafter called “products”).
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