3-Phase BLDC Motor Driver IC

ECN30214 Product Specification Rev. 4

1. Product Description

1.1 Features

(1) Maximum Ratings: 600VDC/1.5A, suitable for the system from 200VAC to 240VAC

(2) Drives a motor using high voltage PWM (Pulse Width Modulation) control, increasing efficiency

(3) Variable speed control by an analog speed command signal (VSP signal)

(4) Six IGBTs, six FWDs (Free-Wheeling Diodes), drivers for IGBTs, protection circuits, etc. integrated into a single chip, resulting in space reduction

(5) Drives a motor using a high voltage DC power supply and a low voltage DC power supply (15V)

1.2 Functions

(1) Hall elements applicable (Hall amplifiers are embedded)

(2) Power on/off sequence-free (condition: output pin current is less than 1A)

(3) Charge pump circuit (built-in high voltage diodes for charge pump)

(4) FG (Frequency Generator) signal outputs for motor rotational speed monitor

(5) All IGBT shutoff function

(6) Current limit (detects at 0.5V)

(7) Vcc low-voltage detection

(8) Over temperature protection

(9) PWM circuit (enable 20kHz PWM operation)

(10) Three-phase distributor circuit

1.3 Block Diagram

The ECN30214 is shown inside the bold line.

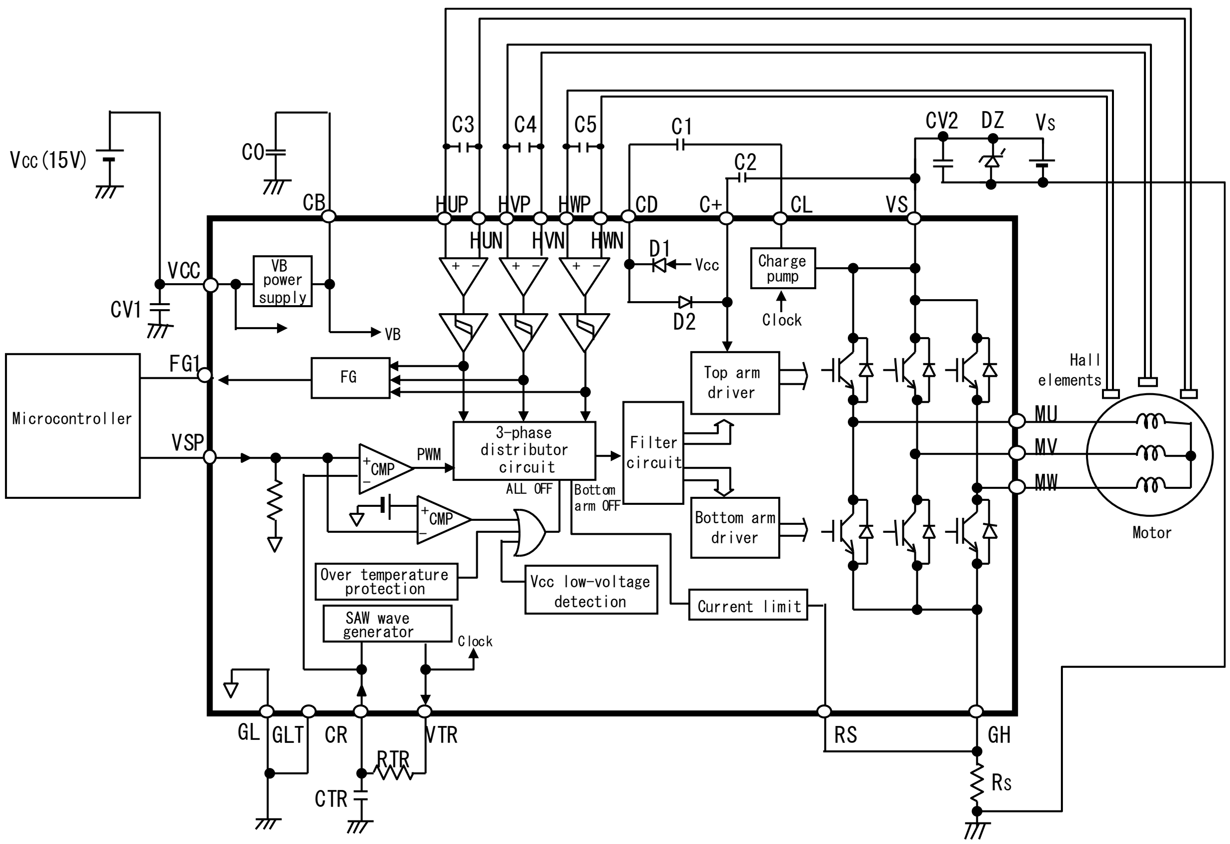
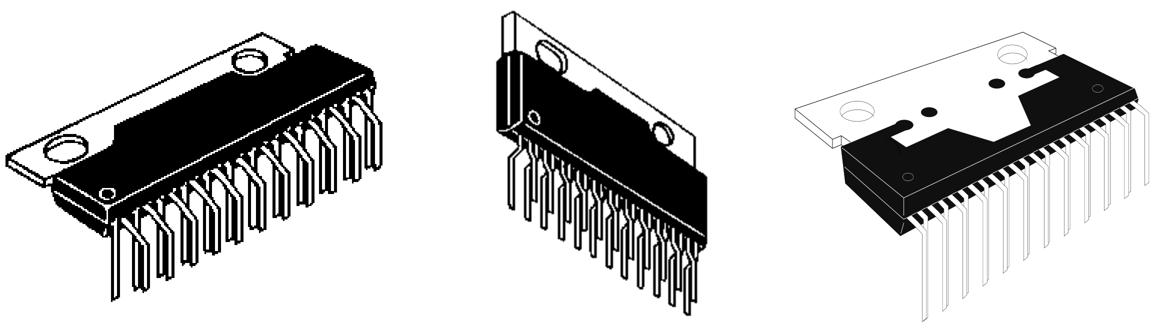


FIGURE 1.3.1 Block Diagram

1.4 Packages



ECN30214SP ECN30214SPV ECN30214SPR

FIGURE 1.4.1 Packages of ECN30214

2. Specification

2.1 Maximum Ratings

TABLE 2.1.1 Maximum Ratings Condition: Ta=25℃

No.	Item		Symbol	Pin	Rating	Unit	Condition
1	Output device withstand voltage		VSM	VS, CL, CD, MU, MV, MW	600	V	
2	Vcc power supply voltage		VCC	VCC	18	V	
3	Voltage between C+ and VS		VCPM	C+, VS	18	V	
4	Input voltage		VIN	VSP, RS, HUP, HUN, HVP, HVN, HWP, HWN	−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	―	−40 to +135	℃	Note 2
9	Storage temperature		Tstg	―	−40 to +150	℃	

Note 1: Output IGBTs can handle this peak current.
Note 2: Thermal resistance
Between junction and case: Rjc = 4℃/W (Reference value)

2.2 Electrical Characteristics

TABLE 2.2.1 Electrical Characteristics (1/2) Suffix (T: Top arm, B: Bottom arm) Condition: Ta=25℃

No.	Item		Symbol	Pin	Min.	Typ.	Max.	Unit	Condition
1	Standby current		ISH	VS	—	0.1	0.4	mA	VSP=0V, VS=325V, VCC=15V
2			ICC	VCC	—	4	10	mA	VSP=0V, 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		—	2.0	3.0	V	
5	Free-wheeling diode forward voltage		VFDT		—	1.6	2.8	V	I=0.35A
6			VFDB		—	1.6	2.8	V	
7	VTR output resistance		RVTR	VTR	—	200	400	Ω	IVTR=±1mA, VCC=15V
8	SAW wave	High/Low level	VSAWH	CR	4.9	5.4	5.9	V	VCC=15V
9			VSAWL		1.7	2.1	2.4	V	
10		Amplitude	VSAWW		2.8	3.3	3.8	V	VCC=15V Note 1
11	Current limit	Reference voltage	Vref1	RS	0.45	0.50	0.55	V	VCC=15V
12		Delay time	Tref1		1.2	2.0	4.5	μs	
13	RS input current		IILRS	RS	−100	—	—	μA	VCC=15V, RS=0V Note 5
14	Hall signal input	Minimum differential voltage	VHOS	HUP, HUN, HVP, HVN, HWP, HWN	60	—	—	mVp-p	VCC=15V Note 2
15		Current	IH		—	—	2	μA	
16		Common mode voltage range	VHCM		3	—	6	V	
17		Hysteresis	VHHYS		20	40	60	mV	
18		Voltage L→H	VHLH		−5	20	45	mV	
19		Voltage H→L	VHHL		−45	−20	5	mV	
20	VSP input	Current	IVSPH	VSP	5	—	100	μA	VSP=5.0V, VCC=15V Pull-down resistor Note 3
21		Offset voltage	SPCOMOF		−40	60	160	mV	VCC=15V Voltage from CR pin
22		All off operating voltage	Voff		0.85	1.23	1.60	V	VCC=15V
23	VB supply output	Voltage	VB	CB	6.8	7.5	8.2	V	VCC=15V, IB=0A
24		Current	IB		—	—	45	mA	VCC=15V
25	FG1 output resistance		RFGP	FG1	—	0.9	3.0	kΩ	IFG=1mA, VCC=15V Note 4
26			RFGN		—	0.4	1.5	kΩ	IFG=−1mA, VCC=15V Note 4
27	Vcc low-voltage detection	Operating voltage	LVSDON	VCC, MU, MV, MW	11.0	12.0	12.9	V	
28		Recovery voltage	LVSDOFF		11.1	12.5	13.0	V	
29	Minimum pulse width (bottom arms)		TMINB	MU, MV, MW	0.8	—	—	μs	VCC=15V Note 6
30	Charge pump diode forward voltage		VFDCP	VCC, CD, C+	—	0.8	1.4	V	I=1mA

TABLE 2.2.1 Electrical Characteristics (2/2) Suffix (T: Top arm, B: Bottom arm) Condition: Ta=25℃

No.	Item		Symbol	Pin	Min.	Typ.	Max.	Unit	Condition
31	Over temperature protection	Operating temperature	TSDON	MU, MV, MW	140	170	195	℃	VCC=15V
32		Recovery temperature	TSDOFF		115	145	170	℃	

Note 1: The amplitude of SAW wave (i.e., VSAWW) is determined by the following equation.

VSAWW = VSAWH − VSAWL (V)

Note 2: The equivalent circuit is shown in FIGURE 2.2.1.

Note 3: Internal pull-down resistor is typically 240kΩ. The equivalent circuit is shown in FIGURE 2.2.2.

Note 4: The equivalent circuit is shown in FIGURE 2.2.3.

Note 5: Internal pull-up resistor is typically 200kΩ. The equivalent circuit is shown in FIGURE 2.2.4.

Note 6: The minimum pulse width to pass the filter circuit.

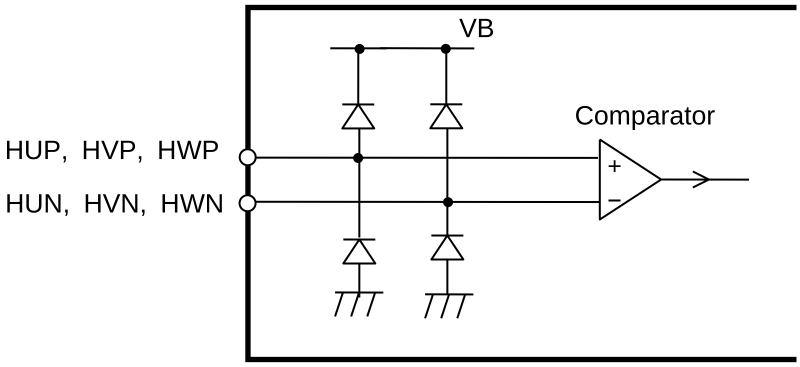


FIGURE 2.2.1 Equivalent Circuit Around Hall Signal Pins

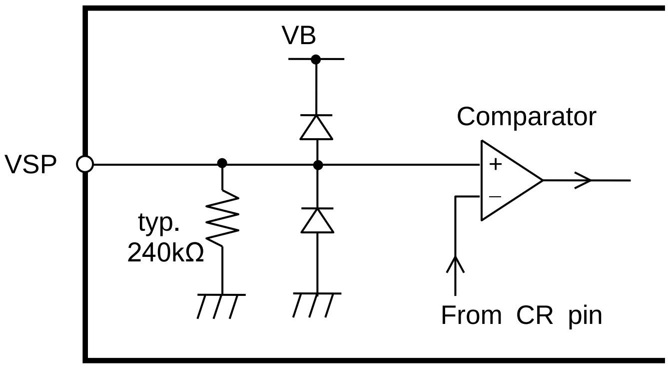


FIGURE 2.2.2 Equivalent Circuit Around VSP Pin

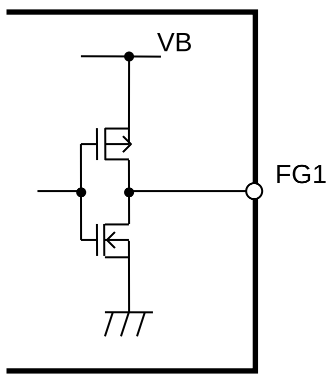


FIGURE 2.2.3 Equivalent Circuit Around FG1 Pin

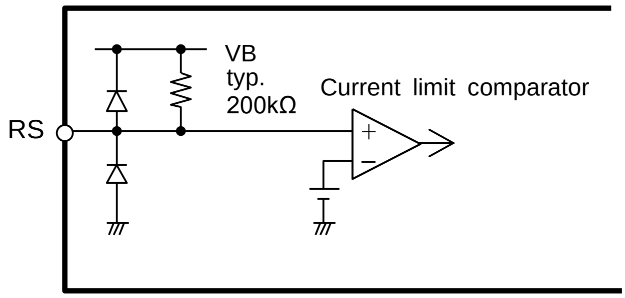


FIGURE 2.2.4 Equivalent Circuit Around RS Pin

2.3 Operating Condition

TABLE 2.3.1 Operating Condition

No.	Item	Symbol	Pin	Min.	Typ.	Max.	Unit
1	Supply voltage	VSop	VS	15	325	450	V
2		VCCop	VCC	13.5	15.0	16.5	V

2.4 Functions and Operations

2.4.1 Truth Table

TABLE 2.4.1.1 Truth Table

Mode	Hall signal input			Phase-U		Phase-V		Phase-W		FG1 output
	HU	HV	HW	Top arm	Bottom arm	Top arm	Bottom arm	Top arm	Bottom arm	
(1)	H	L	H	OFF	ON	ON	OFF	OFF	OFF	H
(2)	H	L	L	OFF	ON	OFF	OFF	ON	OFF	L
(3)	H	H	L	OFF	OFF	OFF	ON	ON	OFF	H
(4)	L	H	L	ON	OFF	OFF	ON	OFF	OFF	L
(5)	L	H	H	ON	OFF	OFF	OFF	OFF	ON	H
(6)	L	L	H	OFF	OFF	ON	OFF	OFF	ON	L
―	L	L	L	OFF	OFF	OFF	OFF	OFF	OFF	L
―	H	H	H	OFF	OFF	OFF	OFF	OFF	OFF	H

Note: Inputs H: Input voltage between H*P and H*N＞VHLH
Inputs L: Input voltage between H*P and H*N＜VHHL

2.4.2 Timing Chart

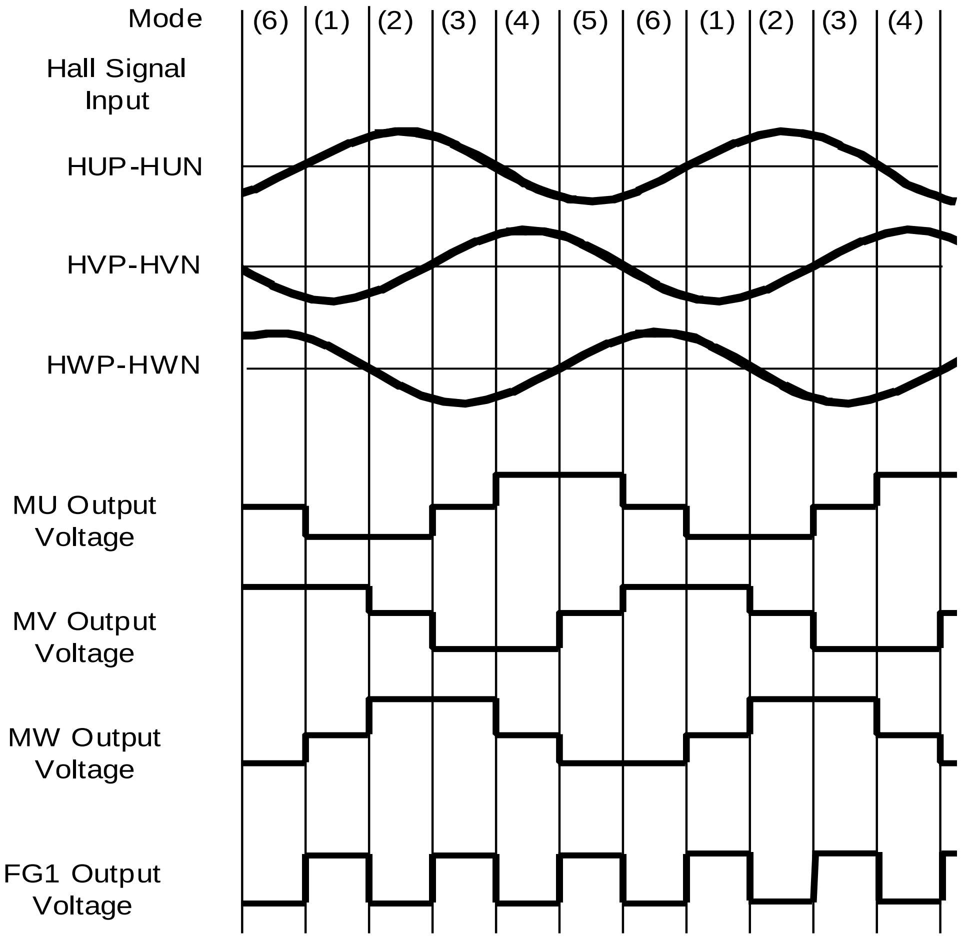


FIGURE 2.4.2.1 Timing Chart

2.4.3 PWM Operation

The PWM signal is generated by comparing the input voltage at the VSP pin with an internal SAW wave voltage (available at the CR pin). The relation between VSP input voltage and PWM duty is shown in FIGURE 2.4.3.1. The PWM duty represents the duty of IGBT gate drive signals. The voltages at output pins (MU, MV, MW) may be different from the figure depending on conditions. The PWM is operated by bottom arms.

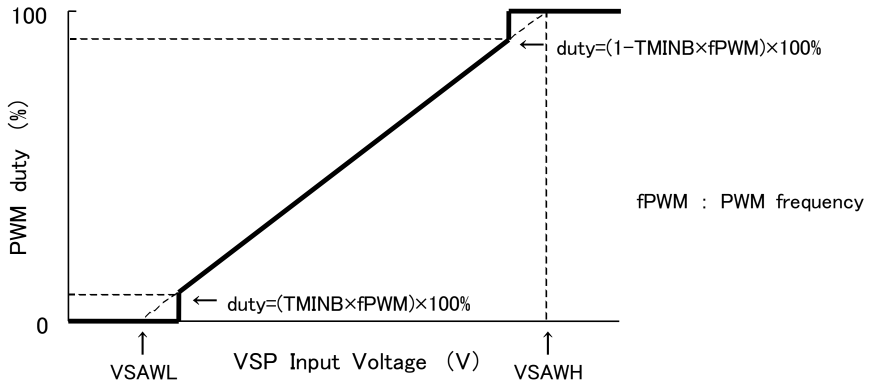


FIGURE 2.4.3.1 Relation between VSP Input Voltage and PWM Duty

2.4.4 Current Limit

This IC detects current using an external shunt resistor Rs. When the voltage at the shunt resistor Rs exceeds the current limit reference voltage (Vref1, typ. 0.5V), all bottom arm IGBTs are turned off. This off state is automatically reset once per internal CLOCK period (available at VTR pin).

2.4.5 Vcc Low-voltage Detection

When Vcc voltage drops below the operating voltage of the Vcc low-voltage detection (LVSDON), all IGBTs (top and bottom arms) are turned off. When Vcc voltage goes up above the recovery voltage of the Vcc low-voltage detection (LVSDOFF), the IC returns to the state in which the IGBTs operate depending on input signals.

When the IGBTs of the top and bottom arms are all turned off by operation of this function or other function during motor driving, the power supply voltage may rise as a result of a regenerative current flow. The power supply voltage must not exceed the maximum rating (600V).

2.4.6 All IGBT Shutoff Function

When the input voltage at the VSP pin drops below VSAWL (typ. 2.1V), the IC stops the motor drive. When the input voltage at the VSP pin drops further from VSAWL and becomes below Voff (typ. 1.23V), the IGBTs (top and bottom arms) are all shut off to reduce current consumption within the IC. The state of the output IGBTs with regard to the VSP input voltage is shown in TABLE 2.4.6.1.

TABLE 2.4.6.1 IGBT Operation to VSP Input Voltage

VSP input voltage	Motor drive state	Top arm IGBTs	Bottom arm IGBTs
0V≦VSP＜Voff	Stop	All OFF	All OFF
Voff≦VSP＜VSAWL		Based on TABLE 2.4.1.1	All OFF
VSAWL≦VSP	Drive	Based on TABLE 2.4.1.1	Based on TABLE 2.4.1.1

2.4.7 Over Temperature Protection

When IC temperature exceeds the operating temperature of over temperature protection (TSDON), all IGBTs (top and bottom arms) are turned off. When IC temperature goes below the recovery temperature of over temperature protection (TSDOFF), the IC returns to the state in which the IGBTs operate depending on input signals.

2.4.8 Power On/Off Sequence-free

When the current at the output pins is below 1A, IGBT current saturation does not occur regardless of power on/off sequence of the Vcc power supply, Vs power supply and VSP input voltage.

3. Standard Applications

3.1 External Components

TABLE 3.1.1 External Components

Component	Standard value	Usage	Remark
C0	1.0μF±10%, 25V	Smooths the internal power supply (VB)	
CV1	1.0μF±10%, 25V	Smooths the Vcc power supply	Note 1
CV2	33nF±10%, 630V	Smooths the Vs power supply	Note 1
DZ	5W	Absorbs Vs line surge voltage	
C1, C2	0.22μF±10%, 25V	For charge pump	
C3, C4, C5	1000pF±10%, 25V	Eliminates Hall signal noise	Note 2
Rs	1Ω±1%, 1W	Sets current limit	Note 3
CTR	2200pF±5%, 25V	Sets PWM frequency	Note 4
RTR	11kΩ±5%		

Note 1: As necessary, increase the capacitance and add a zener diode in consideration of noise immunity.
Note 2: Optimize the capacitance corresponding to conditions.
Note 3: The current limit set value can be calculated as follows.

$$I = Vref1 / Rs \text{ (A)}$$

To determine the shunt resistor Rs, see TABLE 3.1.1 and Section 4.

Note 4: The PWM frequency is approximated by the following equation.

$$fPWM \fallingdotseq 0.494 / (CTR \times RTR) \text{ (Hz)}$$

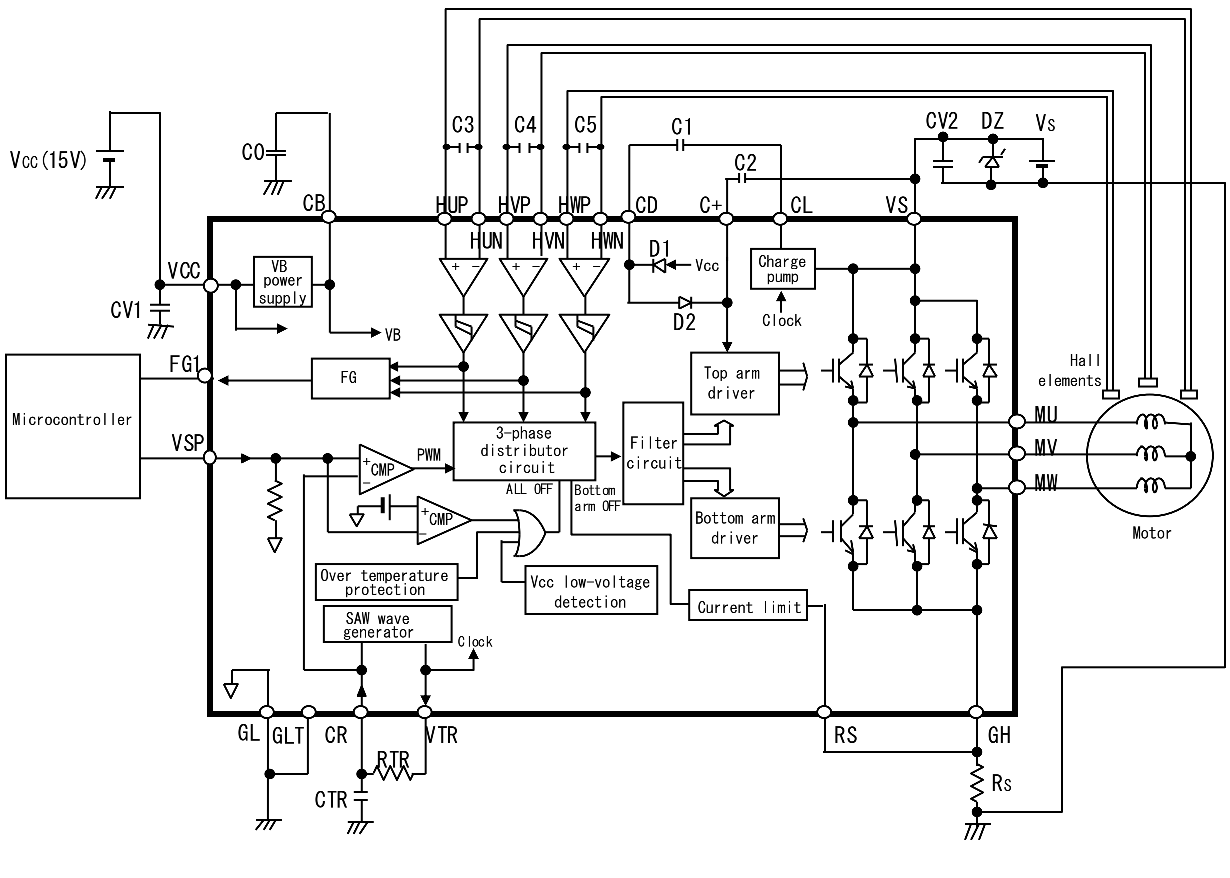


FIGURE 3.1.1 Block Diagram (ECN30214 is shown inside the bold line.)

4. Safe Operation Area (SOA) and Derating

4.1 Safe Operation Area (SOA)

The current and voltage at output pins must not be outside the SOA shown in FIGURE 4.1.1.

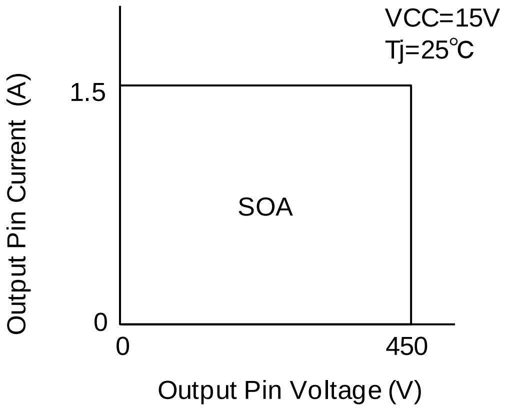


FIGURE 4.1.1 SOA

4.2 Power On/Off Sequence and Current Derating for VCC Pin Voltage

The current derating for VCC pin voltage is shown in FIGURE 4.2.1. Use the output pin current below the derating curve. When the output pin current is less than 1A, power on/off sequence is free.

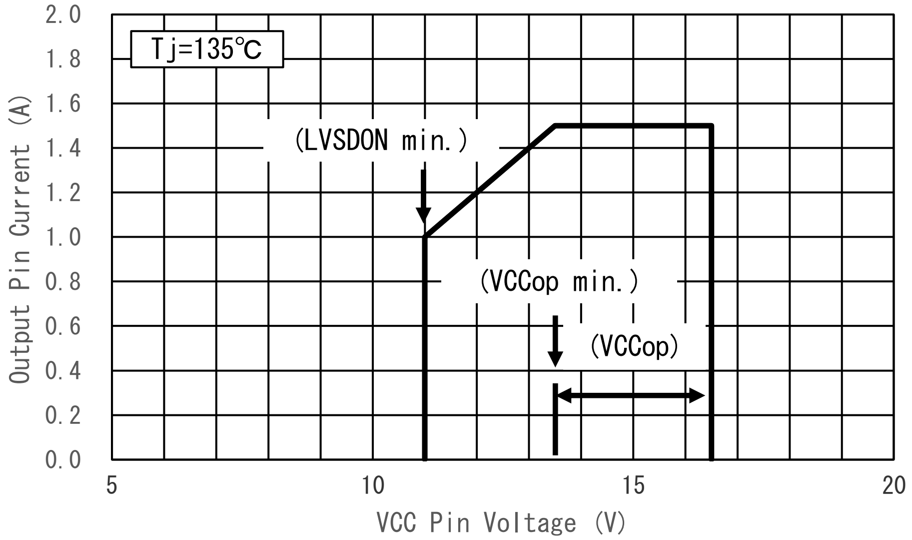


FIGURE 4.2.1 Current Derating for VCC Pin Voltage

4.3 Current Derating for Junction Operating Temperature

The current derating for junction operating temperature is shown in FIGURE 4.3.1. Use the output pin current below the derating curve.

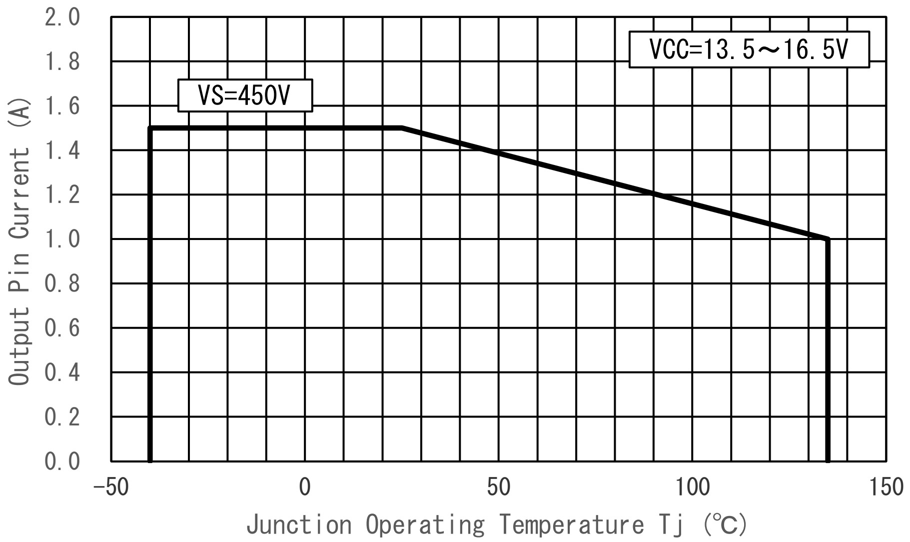


FIGURE 4.3.1 Current Derating for Junction Operating Temperature

4.4 Shunt Resistor Setting

When setting the current limit, consider the variability of the reference voltage (Vref1), the variability of shunt resistor (Rs) and the delay time.

The current must be below the derating curves of FIGURE 4.2.1 and FIGURE 4.3.1.

4.5 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.

Junction operating temperature depends on various parameters such as power supply voltages, ambient temperature, load, heat dissipation routes. Test it sufficiently by using actual systems.

5. Pin Locations

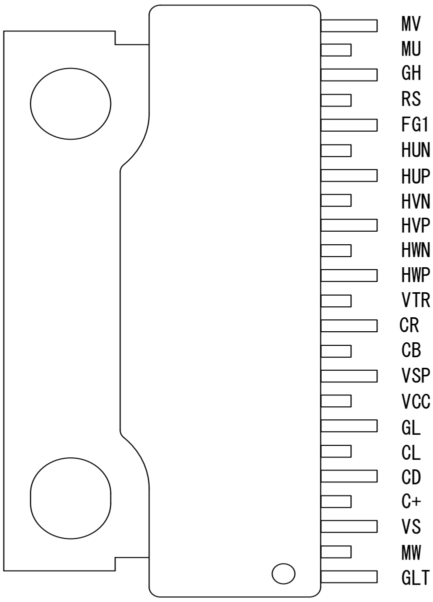


FIGURE 5.1 Pin Locations (Resin surface side)

6. Explanations of Pins

TABLE 6.1 Explanations of Pins

Pin No.	Symbol	Explanation	Remark
1	GLT	To be set to ground potential	Note 2, Note 3
2	MW	W phase output	Note 1
3	VS	High voltage power supply	Note 1
4	C+	For the charge pump circuit	Note 1
5	CD	For the charge pump circuit	Note 1
6	CL	For the charge pump circuit	Note 1
7	GL	Ground	Note 2
8	VCC	15V power supply	
9	VSP	Analog speed command signal input	
10	CB	VB power supply output	
11	CR	Connect a resistor and a capacitor to set the PWM frequency	
12	VTR	Connect a resistor to set the PWM frequency	
13	HWP	W phase Hall signal plus input	
14	HWN	W phase Hall signal minus input	
15	HVP	V phase Hall signal plus input	
16	HVN	V phase Hall signal minus input	
17	HUP	U phase Hall signal plus input	
18	HUN	U phase Hall signal minus input	
19	FG1	Output for motor rotational speed monitor	
20	RS	Current limit input	
21	GH	Emitters of bottom arm IGBTs and anodes of bottom arm FWDs (Connected to a shunt resistor)	
22	MU	U phase output	Note 1
23	MV	V phase output	Note 1

Note 1: High voltage pin. The voltage between CD and CL and the voltage between C+ and VS are low.
Note 2: Connect GLT to GL externally.
Note 3: The potential of tab (IC heat sink) is the same as that of the GLT pin. Set the tab potential to open or the same as that of GL pin.

7. Inspection

Hundred percent inspection shall be conducted on electric characteristics at room temperature. For the operating temperature and recovery temperature of the over temperature protection, equivalent inspections are conducted at room temperature.

8. Precautions for Use

8.1 Attachment

To attach a heat sink to the IC, tightening torque should be 0.39 to 0.78 N·m. Tab should not be soldered.

8.2 Countermeasures against Electrostatic Discharge (ESD)

(a) Customers need to take precautions to protect ICs from electrostatic discharge (ESD). The material of the container or any other device used to carry ICs 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 ICs, such as the work platform, machine, measuring equipment, and test equipment, should be grounded.
(c) Workers should be high-impedance grounded (100kΩ to 1MΩ) while working with ICs, to avoid damaging the ICs by ESD.
(d) Friction with other materials, such as high polymers, should be avoided.
(e) When carrying a PCB with a mounted IC, ensure that the electric potential is maintained at a constant level using the short-circuit terminals and that there is no vibration or friction.
(f) The humidity at an assembly line where ICs are mounted on circuit boards should be kept around 45 to 75 percent using humidifiers or such. If the humidity cannot be controlled effectively, using ionized air blowers (ionizers) is effective.

8.3 High Voltage Pin Insulation

Apply resin coating to the pins that high voltage is impressed to or encapsulate the PCB by resin molding.

8.4 Output Short-circuit Protection

Our IC could break by a short circuit (ex. load short). Therefore, external protection is needed.

8.5 Maximum Ratings

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

8.6 Derating Design

Continuous high-load operation (high temperatures, high voltages, large currents) should be avoided and derating design should be applied, even within the ranges of the maximum ratings, to ensure reliability.

8.7 Safe Design

Our IC 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.

8.8 Application

If our IC is applied to the following uses where high reliability is required, obtain the document of permission from our company in advance.

・Automobile, Train, Vessel, etc.

Do not apply our IC to the following uses where extremely high reliability is required.

・Nuclear power control system, Aerospace instrument, Life-support-related medical equipment, etc.

8.9 Soldering

The peak temperature of flow soldering* must be less than 260ºC, 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.

8.10 Others

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

9. Usage

(1) Our company warrants that our products have the specified performance according to the respective specifications at the time of its sale. Testing and other quality control techniques of our products by our company are utilized to the extent we need to meet the specifications described in this document. Not every device of our products is specifically tested on all parameters, except those mandated by relevant laws and/or regulations.

(2) Following any claim regarding the failure of a product to meet the performance described in this document made within one month of product delivery, all the products in relevant lot(s) shall be re-tested and re-delivered. Our products delivered more than one month before such a claim shall not be counted for such response.

(3) Our company assumes no obligation nor makes any promise of compensation for any fault which should be found in a customer’s goods incorporating the products in the market. If a product failure occurs for reasons obviously attributable to our company and a claim is made within six months of product delivery, our company shall offer free replacement or payment of compensation. The maximum compensation shall be the amount paid for the products, and our company shall not assume responsibility for any other compensation.

(4) Our company reserves the right to make changes in this document and to discontinue mass production of the relevant products without notice. Customers are advised to confirm specification of the product of inquiry before purchasing of the products that the customer desired. Customers are further advised to confirm before purchasing of such above products that the product of inquiry is the latest version and that the relevant product is in mass production status if the purchasing of the products by the customer is suspended for one year or more.

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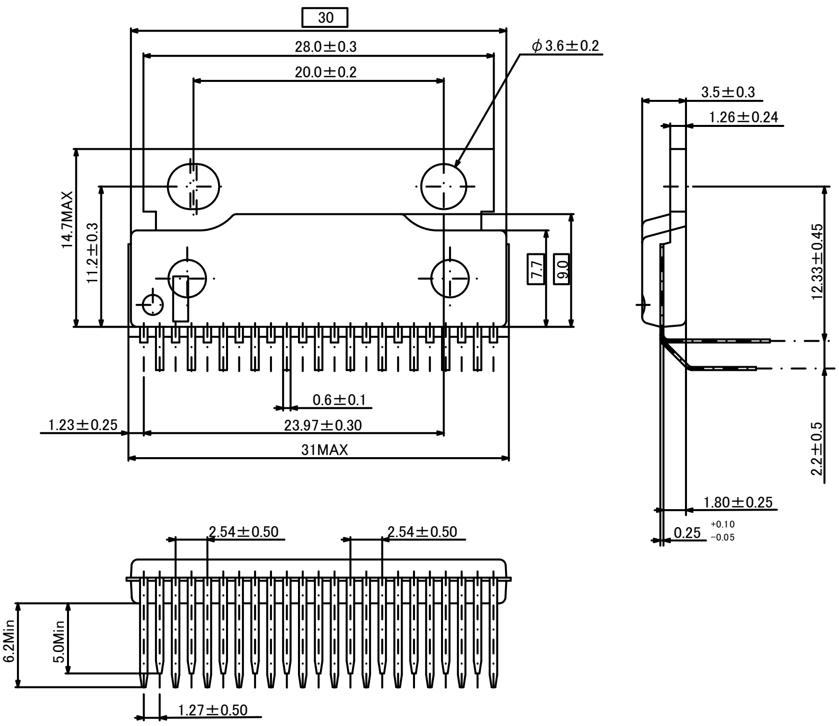
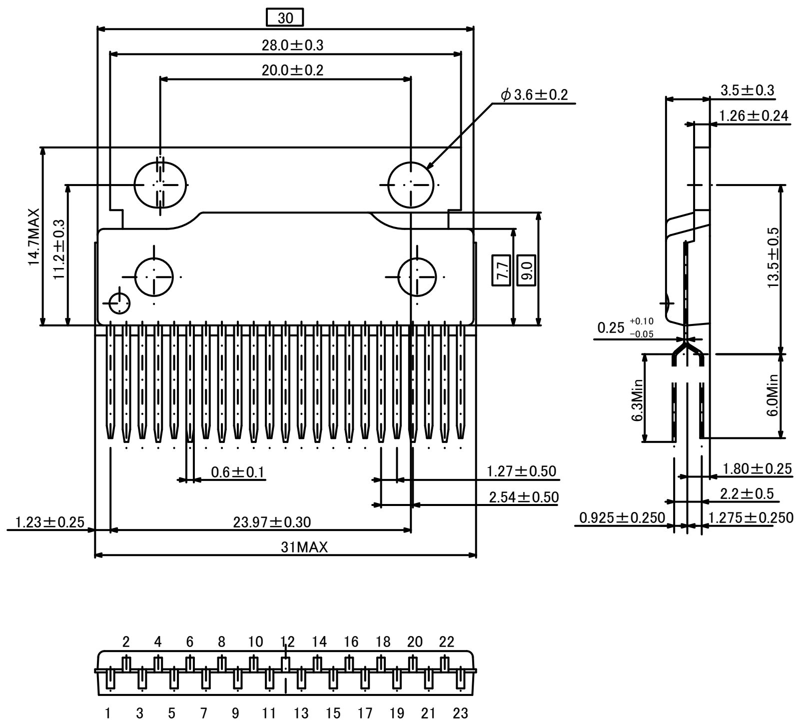
◆Appendix - Supplementary Data

1. Dimensions



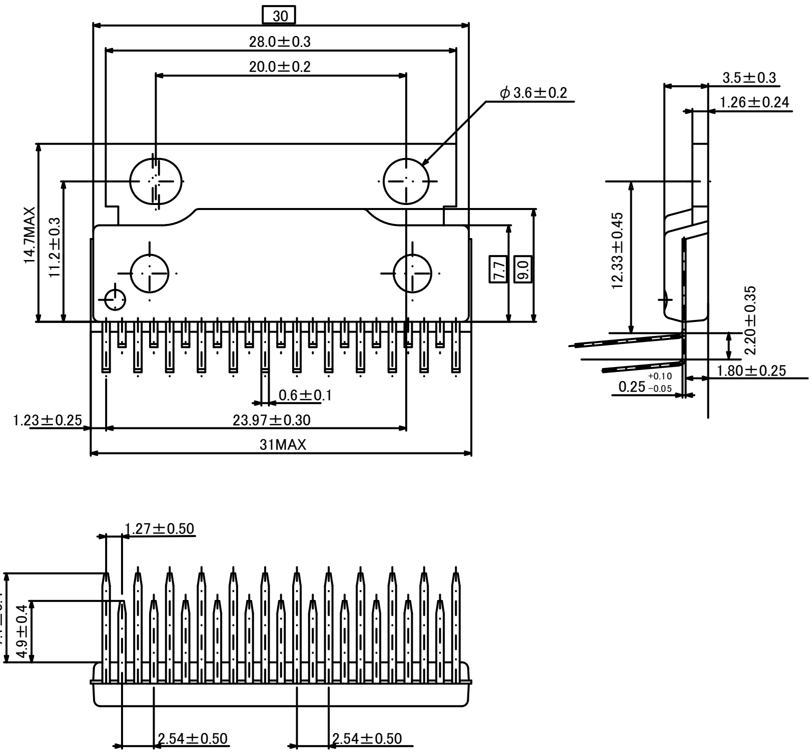
Unit: mm

FIGURE A: Dimensions of SP



Unit: mm

FIGURE B: Dimensions of SPV



Unit: mm

FIGURE C: Dimensions of SPR

2. External Packaging

FIGURE D shows the external packaging.

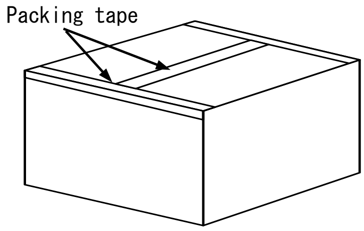
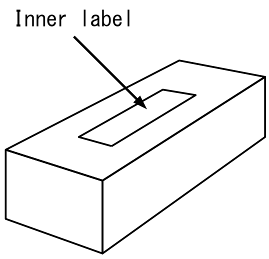
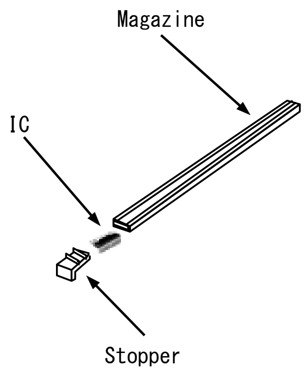
	Inverter IC
Outer box	
Inner box	
Magazine	 The number of ICs; 15 pcs/magazine

FIGURE D: External Packaging

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 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 MPSD 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

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