3-Phase Motor Driver IC

ECN30626 Product Specification Rev. 2

1. Product Description

1.1 Features

(1) Maximum Ratings: 600VDC/3.0A, suitable for the system from 200VAC to 240VAC

(2) PWM control of top and bottom arm IGBTs is possible with six control signals

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

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

(5) A capacitor for top arm power supply is built in, so external capacitor is not required

(6) Lineup of three packages, DIP26, SOP26, and SOP26R ensuring insulation distance for high voltage pins

1.2 Functions

(1) Prevention function against simultaneous ON of top and bottom arm IGBTs

(2) Over-current protection (detects at 0.8V, automatic recovery)

(3) Over temperature protection (automatic recovery)

(4) Fault function (Over-current protection, Over temperature protection, Vcc low-voltage detection)

(5) Vcc low-voltage detection (automatic recovery)

(6) 5V power supply circuit

1.3 Block Diagram of IC
FIGURE 1.3.1 shows block diagram.

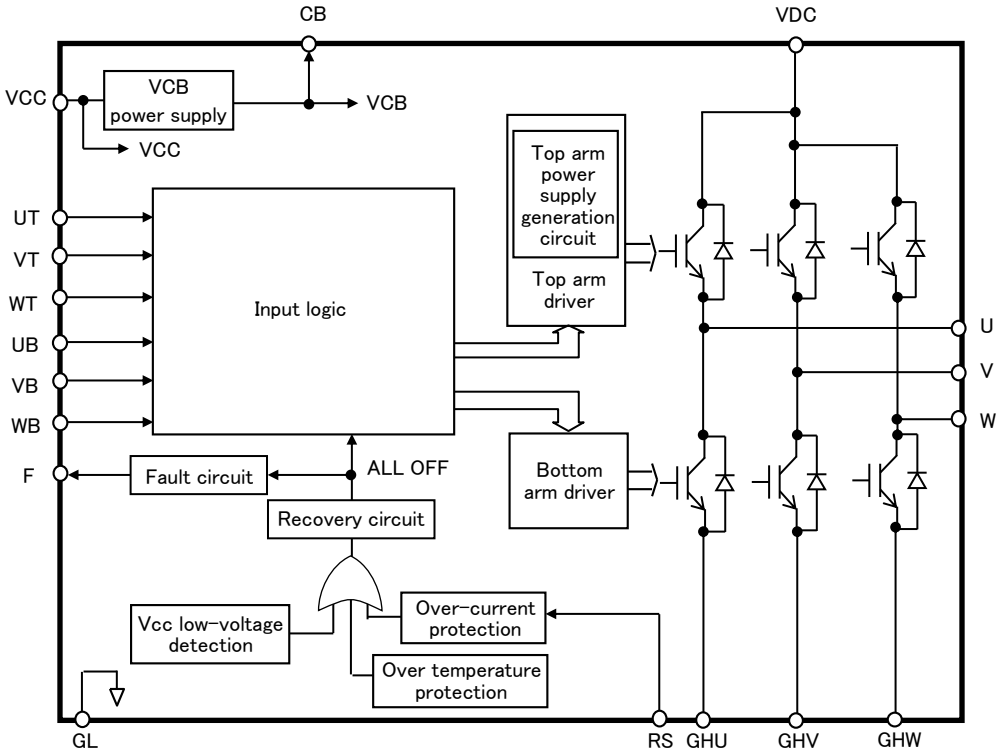
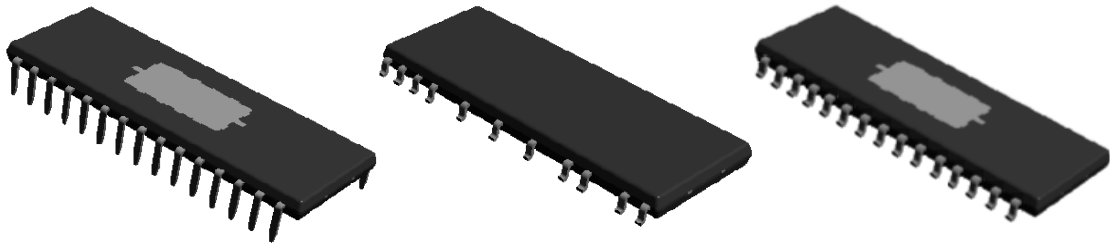


FIGURE 1.3.1 Block Diagram of IC

1.4 Package



ECN30626P
(Package: DIP26)

ECN30626F
(Package: SOP26)

ECN30626R
(Package: SOP26R)

FIGURE 1.4.1 Package of ECN30626

2. Specification

2.1 Maximum Ratings

TABLE 2.1.1 Maximum Ratings Condition: Ta=25°C

No.	Item		Symbol	Pin	Rating	Unit	Remarks
1	Output device withstand voltage		VDCM	VDC U, V, W	600	V	
2	Vcc power supply voltage		VCC	VCC	18	V	
3	Input voltage		VIN	UT, VT, WT, UB, VB, WB, RS	−0.5 to VCB+0.5	V	
4	Output current	Pulse	IP	U, V, W	3.0	A	Note 1
5		DC	IDC		2.0		
6	Fault output voltage		Vflt	F	−0.5 to Vcc+0.5	V	
7	VCB supply output current		ICBMAX	CB	50	mA	
8	Junction operating temperature		Tjop	—	−40 to +135	°C	Note 2
9	Junction temperature		Tj	—	+150	°C	
10	Storage temperature		Tstg	—	−40 to +150	°C	

Note 1: Output IGBTs can handle this peak current.
Note 2: Thermal resistance
Between junction and case: Rjc = 3°C/W (Reference value)

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		IDCH	VDC	—	0	0.1	mA	UT,VT,WT,UB,VB,WB=0V
2			ICC	VCC	—	5	10	mA	VDC=325V, VCC=15V, ICB=0A
3	IGBT collector-emitter saturation voltage		VONT	U, V, W	—	2.0	3.0	V	I=0.7A, VCC=15V
4			VONB		—	2.0	3.0	V	
5	Free-wheeling diode forward voltage		VFDT	U, V, W	—	1.6	2.8	V	I=0.7A
6			VFDB		—	1.6	2.8	V	
7	Output delay time	Turn ON	TdONT	U, V, W	—	0.7	1.1	μs	VDC=325V, VCC=15V I=0.7A, Resistance load
8			TdONB		—	0.7	1.1	μs	
9		Turn OFF	TdOFFT		—	0.7	1.1	μs	
10			TdOFFB		—	0.7	1.1	μs	
11	Minimum pulse width		TMIN	U, V, W	0.5	—	—	μs	VCC=15V Note 1
12	RS input current		IILRS	RS	−100	—	—	μA	VCC=15V, RS=0V Note 2
13	UT,VT,WT, UB,VB,WB, inputs	Voltage	VIH	UT, VT, WT, UB, VB, WB	2.5	—	—	V	VCC=15V
14			VIL		—	—	1.0	V	
15		Current	IIH		—	—	100	μA	Input =4.5V VCC=15V Pull-down resistor
16			IIL		−10	—	—	μA	Input =0V VCC=15V Note 3
17	VCB supply output	Voltage	VCB	CB	4.5	5.0	5.5	V	VCC=15V, ICB=0A
18		Current	ICB		—	—	45	mA	VCC=15V
19	F output resistance		RONF	F	—	0.9	1.8	kΩ	IF=1mA, VCC=15V Note 4
20	Over-current protection	Reference voltage	Vref	RS, F	0.72	0.80	0.88	V	VCC=15V
21		Delay time	Tref		—	1.7	3.0	μs	
22	Over temperature protection	Operating temperature	TSDON	U, V, W, F	135	160	185	°C	VCC=15V
23		Hysteresis	TSDHYS		—	25	—	°C	
24	Vcc low-voltage detection	Operating voltage	LVSDON	VCC, U, V, W, F	11.0	12.0	12.9	V	
25		Recovery voltage	LVSDOFF		11.1	12.5	13.0	V	
26	Protection recovery time		Trs	F	20	—	—	μs	

Note 1: The minimum pulse width to be able to turn on and off top and bottom arms.
Note 2: Internal pull-up resistor is typically 200kΩ. The equivalent circuit is shown in FIGURE 2.2.1.
Note 3: Internal pull-down resistor is typically 200kΩ. The equivalent circuit is shown in FIGURE 2.2.2.
Note 4: The equivalent circuit is shown in FIGURE 2.2.3.

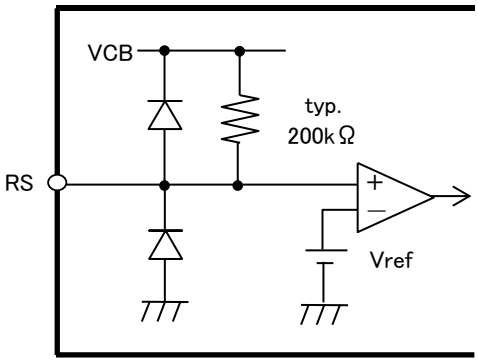


FIGURE 2.2.1 Equivalent Circuit Around RS Pin

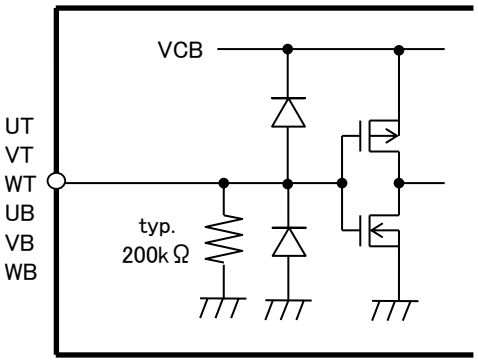


FIGURE 2.2.2 Equivalent Circuit Around UT, VT, WT, UB, VB, WB Pins

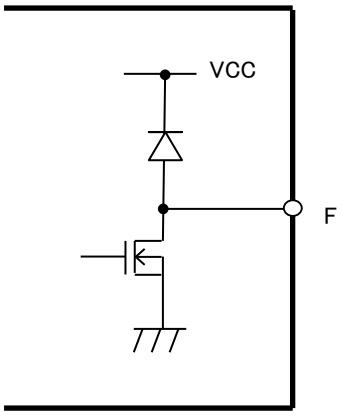


FIGURE 2.2.3 Equivalent Circuit Around F Pin

2.3 Operating Condition

TABLE 2.3.1 Operating Condition

No.	Item	Symbol	Pin	Min.	Typ.	Max.	Unit	Condition
1	Supply voltage	VDCop	VDC	100	325	450	V	
2		VCCop	VCC	13.5	15.0	16.5	V	
3	GH voltage	Vgh	GHU, GHV, GHW	−1.2	―	1.2	V	Based on GL pin
4	Dead time	Tdt	UT, VT, WT, UB, VB, WB	1.0	―	―	μs	
5	PWM frequency	fPWM	UT, VT, WT, UB, VB, WB	14	―	30	kHz	Note 1

Note 1. Depending on the usage conditions, this frequency may go in an audible band, generating noise.

2.4 Functions and Operations

2.4.1 Truth Table

TABLE 2.4.1.1 Truth Table

Input UT, VT, WT UB, VB, WB	IGBT operation
L	OFF
H Note 1	ON

Note 1: When the top input and bottom input in the same phase are “H” simultaneously, the top and bottom arm IGBTs in this phase are both off.

2.4.2 Over-current Protection

When the voltage at the RS pin reaches the over-current protection reference voltage (Vref, typ. 0.80V), the F output is “L”, and all IGBTs (top and bottom arms) are turned off. When the voltage at the RS pin drops below the over-current protection reference voltage (Vref, typ. 0.80V) and the over-current protection recovery time passes, the F output is “H”, and the IC automatically returns to a state in which the IGBTs operate depending on input signals. The protection recovery time is fixed at Trs.

FIGURE 2.4.2.1 shows the timing chart for the over-current protection operation.

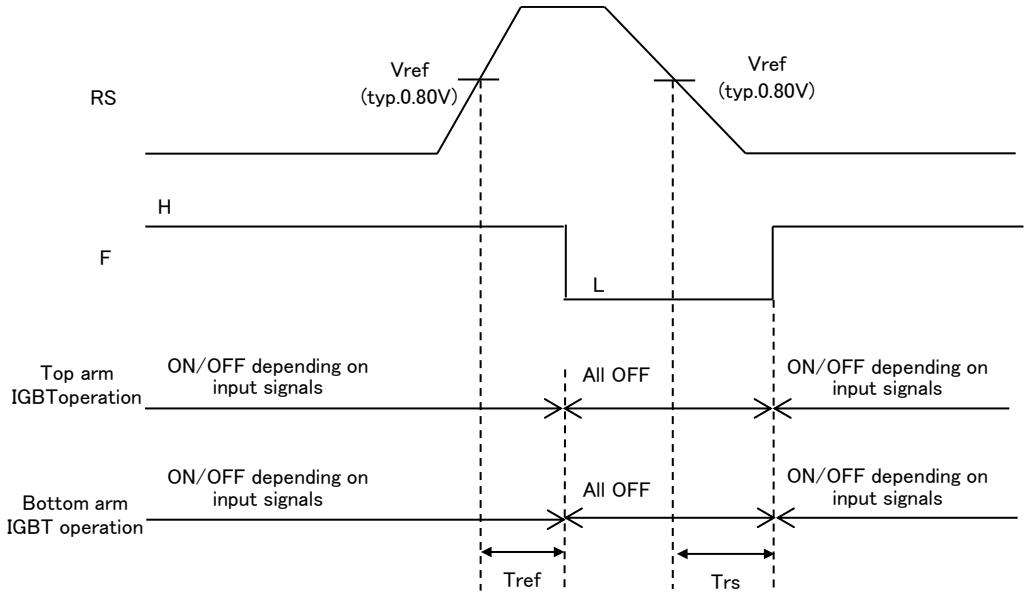


FIGURE 2.4.2.1 Timing Chart for Over-current Protection Operation

2.4.3 Vcc Low-voltage Detection

We call the Vcc low-voltage detection “LVSD”. When the Vcc voltage drops below the LVSD operating voltage (LVSDON, typ.12.0V), the F output is “L”, and all IGBTs (top and bottom arms) are turned off. When the Vcc voltage goes up to a level equal to or exceeding the LVSD recovery voltage (LVSDOFF, (typ. 12.5V) and the protection recovery time (Trs) passes, the F output is “H”, and the IC automatically returns to a state in which the IGBTs operate depending on input signals. The protection recovery time is fixed at Trs.

FIGURE 2.4.3.1 shows the timing chart for the Vcc low-voltage detection operation.

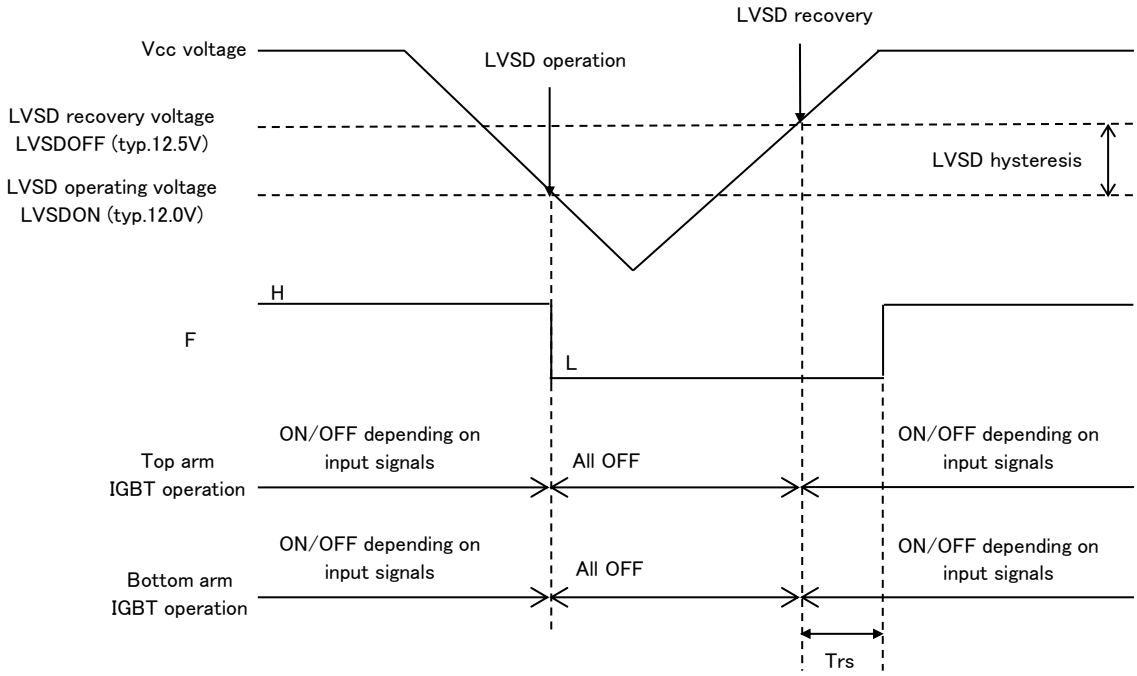


FIGURE 2.4.3.1 Timing Chart for Vcc Low-voltage Detection Operation

2.4.4 Over Temperature Protection

We call the Over temperature protection “TSD”. When the IC temperature exceeds the TSD operating temperature (TSDON, typ. 160˚C), the F output is “L”, and all IGBTs (top and bottom arms) are turned off. When the IC temperature goes down the hysteresis (TSDHYS, typ. 25˚C) from the TSD operating temperature (TSDON, typ. 160˚C) and protection recovery time passes, the F output is “H”, and the IC automatically returns to a state in which the IGBTs operate depending on input signals. The protection recovery time is fixed at Trs.

FIGURE 2.4.4.1 shows the timing chart for the over temperature protection operation.

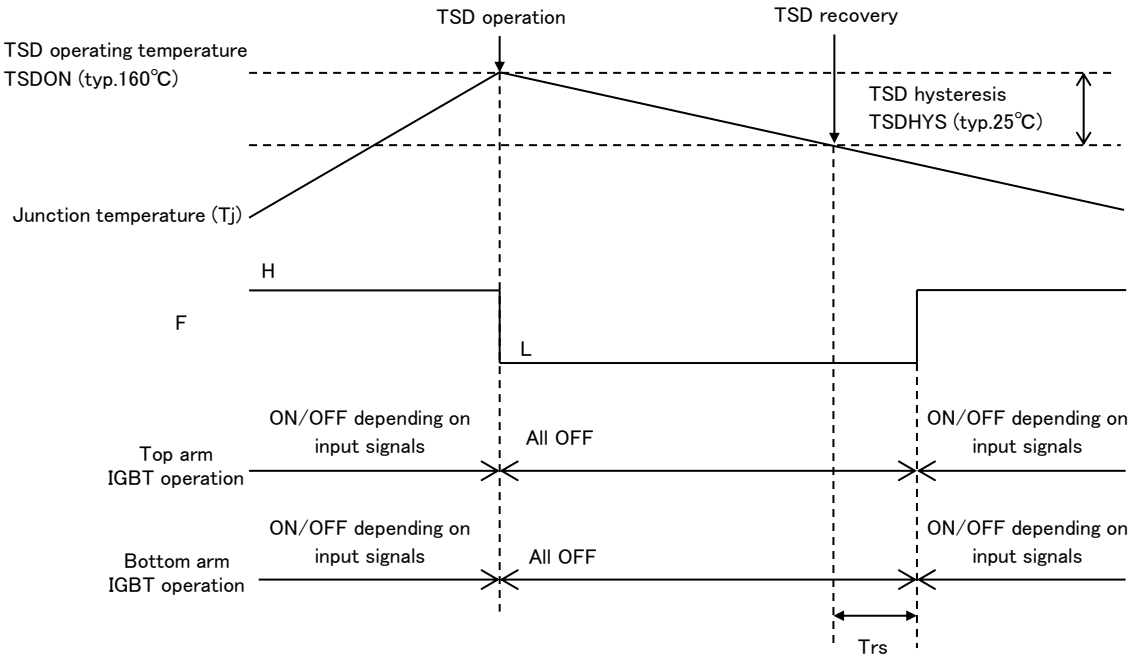


FIGURE 2.4.4.1 Timing Chart for Over Temperature Protection Operation

3. Standard Applications

3.1 External Components

TABLE 3.1.1 External Components

Component	Standard value	Usage	Remarks
C0	1μF±10%, 25V	Smooths the internal power supply (VCB)	
CV1	1μF±10%, 25V	Smooths the Vcc power supply	Note 1
CV2	33nF±10%, 630V	Smooths the Vdc power supply	Note 1
Rs	1Ω±1%, 1W	Sets over-current protection	Note 2 for how to set Rs.
CF	0.01μF±10%, 25V	Eliminates output noise of Fault signal	
RF	10kΩ±10%	For pull up	

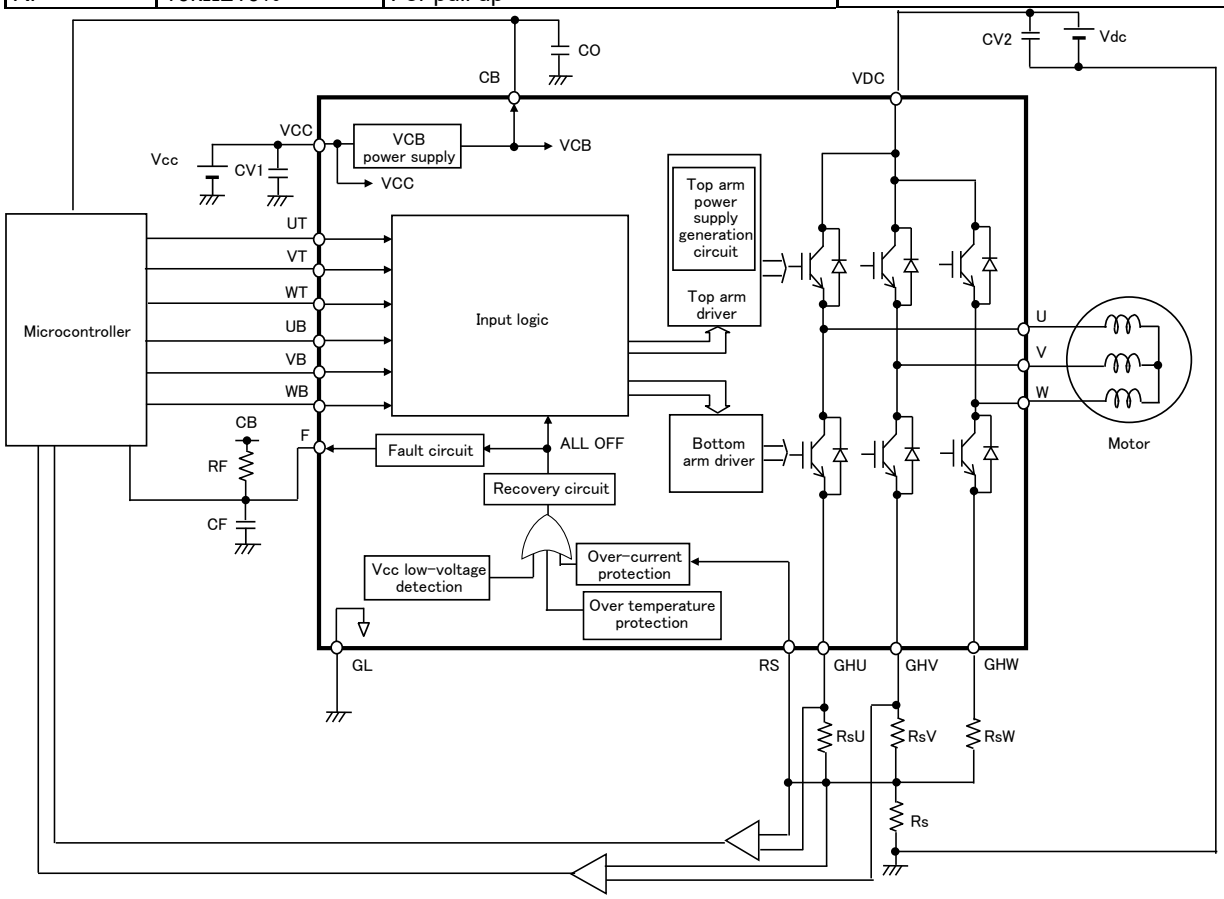


FIGURE 3.1.1 Block Diagram and External Components of IC

Note 1. Caution for smoothing capacitor

As necessary, increase the capacitance and add a zener diode in consideration of noise immunity. Mount each of the components close to the pins of the IC.

Note 2. Caution for Rs resistance setting

The over-current protection set value (IO) can be calculated as follows.

IO = Vref/Rs

Vref : Over-current protection reference voltage

Rs : Shunt resistance value

Delay time to turn output IGBT off (Tref) and variability of Vref, Rs need to be considered. Observe the output currents of the IC (the coil currents of the motor) and confirm a design margin.

Set the shunt resistance so that voltages of the GHU, GHV, and GHW pins are within the specified voltage range of GH pin (Vgh) shown in TABLE 2.3.1.

3.2 Input Pins (UT, VT, WT, UB, VB, WB)

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 pin

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.

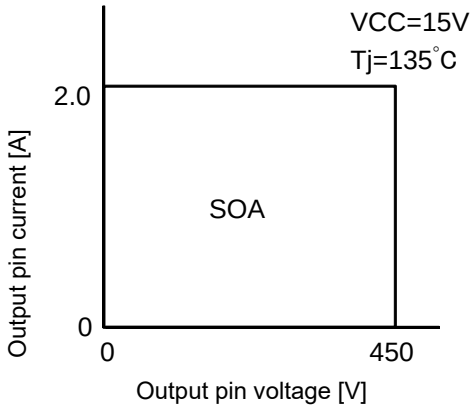


FIGURE 4.1.1 SOA

4.2 Shunt Resistor (Rs) Setting

Delay time to turn output IGBT off (Tref) and variability of Vref, Rs need to be considered, and the current must be below the curve of FIGURE 4.1.1.

4.3 General Design Derating Standards

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

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

5. Pin Locations

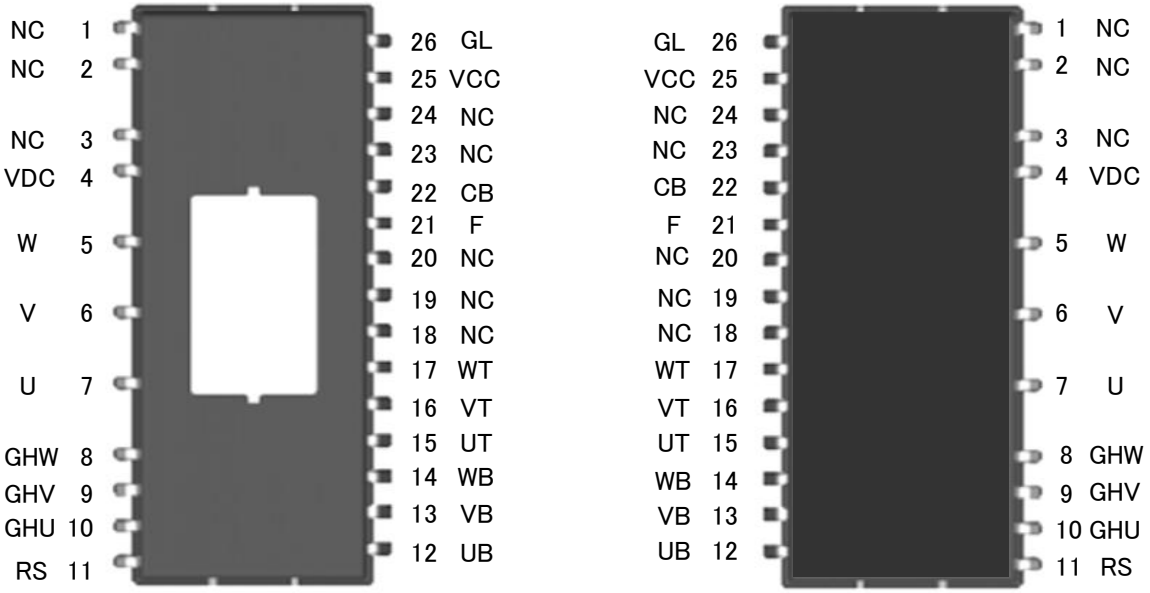


FIGURE 5.1 Pin Locations

6. Pin Assignments

TABLE 6.1 Pin Assignments

Pin No.	Symbol	Pin functions	Remarks
1, 2, 3, 18, 19, 20, 23, 24	NC	No connection	Note 1
4	VDC	High voltage power supply	Note 2
5	W	W-phase output	Note 2
6	V	V-phase output	Note 2
7	U	U-phase output	Note 2
8	GHW	Emitter of W-phase bottom arm IGBT and anode of W-phase bottom arm FWD	
9	GHV	Emitter of V-phase bottom arm IGBT and anode of V-phase bottom arm FWD	
10	GHU	Emitter of U-phase bottom arm IGBT and anode of U-phase bottom arm FWD	
11	RS	Input for over-current protection	
12	UB	Input control signal for U-phase bottom arm	
13	VB	Input control signal for V-phase bottom arm	
14	WB	Input control signal for W-phase bottom arm	
15	UT	Input control signal for U-phase top arm	
16	VT	Input control signal for V-phase top arm	
17	WT	Input control signal for W-phase top arm	
21	F	Fault signal output	
22	CB	VCB power supply output	
25	VCC	Control power supply	
26	GL	Ground	

Note 1. Not connected to the chip in the IC.

Note 2. High voltage pin.

Note 3. The tab potential is the same as that of the GL pin. Set the tab potential to open or the same as that of GND. If the tab is mounted on the external cabinet of the motor for heat radiation purposes, the IC will not be able to withstand an insulation withstand voltage test in which a high voltage is applied between the external cabinet and the GND. Please insert an insulation sheet or something similar between the IC tab and the external cabinet.

7. Inspection

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

8. Precautions for Use

In this document, “MPSD” stands for Minebea Power Semiconductor Device Inc.

8.1 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.

8.2 Output Short-circuit Protection

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

8.3 Maximum Ratings

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

8.4 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.

8.5 Safe Design

The MPSD 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.

8.6 Application

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

・Automobile, Train, Vessel, etc.

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

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

8.7 Soldering

(1) DIP26 Soldering condition

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.

(2) SOP26, SOP26R Soldering condition

This power semiconductor product is lead-free. The recommended reflow soldering condition is shown in FIGURE 8.7.1. 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.

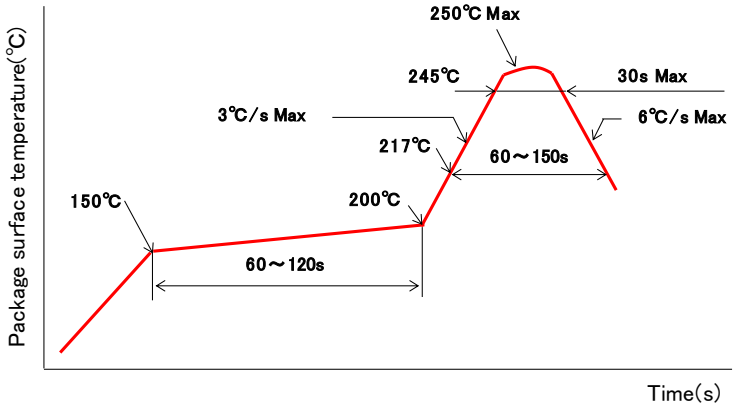


FIGURE 8.7.1 Recommended Conditions for Infrared Reflow or Air Reflow

(3) Reliability of solder connection

The reliability of solder connection depends on soldering condition, materials of circuit boards, footprint, etc. Test it sufficiently by heat cycle test, heat shock test, and so on after mounting ICs on circuit boards.

8.8 Storage Conditions

The following conditions are applied to ECN30626F/R (SOP26, SOP26R).

(1) Before opening the moisture prevention bag (aluminum laminate bag)

Temperature: less than 40˚C
Humidity: less than 90%RH
Period: less than 12 months

(2) After opening the moisture prevention bag (aluminum laminate bag)

Temperature: 5˚C to 30˚C
Humidity: less than 60%RH
Period: less than 168 hours

※ When the period of (1) and (2) is likely to expire, store the ECN30626F/R (SOP26, SOP26R) in a drying furnace (10%RH or lower) at ordinary temperature.

(3) Baking process

When the period of (1) and (2) has expired, the ECN30626F/R (SOP26, SOP26R) should be baked in accordance with the following conditions. (However, when the ECN30626F/R (SOP26, SOP26R) is stored in a drying furnace (10%RH or lower) at ordinary temperature, there is no need to bake.) Do not bake the tape and the reel of the taping package because they are not heat resistant. Transfer the ECN30626F/R (SOP26, SOP26R) to a heat resistant container prior to baking.

Temperature: 125˚C to 135˚C
Period: more than 48 hours

8.9 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) MPSD warrants that the MPSD products have the specified performance according to the respective specifications at the time of its sale. Testing and other quality control techniques of the MPSD products by MPSD are utilized to the extent MPSD needs to meet the specifications described in this document. Not every device of the MPSD 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. The MPSD products delivered more than one month before such a claim shall not be counted for such response.

(3) MPSD 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 MPSD and a claim is made within six months of product delivery, MPSD shall offer free replacement or payment of compensation. The maximum compensation shall be the amount paid for the products, and MPSD shall not assume responsibility for any other compensation.

(4) MPSD 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.

(5) When you dispose of MPSD products and/or packing materials, comply with the laws and regulations of each country and/or local government. Conduct careful preliminary studies about environmental laws applying to your products such as RoHS, REACH. MPSD shall not assume responsibility for compensation due to contravention of laws and/or regulations.

(6) MPSD shall not be held liable in any way for damages and infringement of patent rights, copyright or other intellectual property rights arising from or related to the use of the information, products, and circuits in this document.

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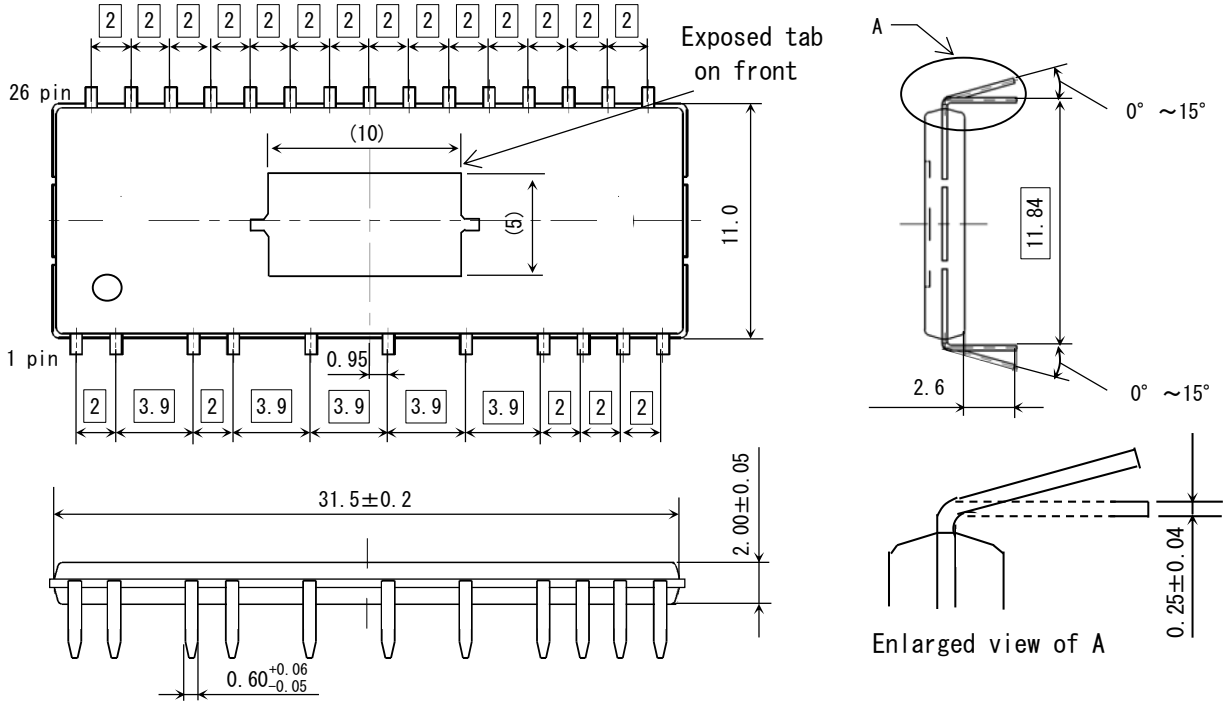
(8) This document may not be reprinted, reproduced or duplicated, in any form, in whole or in part without the express written permission of MPSD.

(9) You shall not use the MPSD products (technologies) described in this document and any other products (technologies) manufactured or developed by using them (hereinafter called "END Products") or supply the MPSD products (technologies) and END Products for the purpose of disturbing international peace and safety, including (ⅰ) the design, development, production, stockpiling or any use of weapons of mass destruction such as nuclear, chemical or biological weapons or missiles, (ⅱ) the other military activities, or (ⅲ) any use supporting these activities. You shall not sell, export, dispose of, license, rent, transfer, disclose or otherwise provide the MPSD products (technologies) and END Products to any third party whether directly or indirectly with knowledge or reason to know that the third party or any other party will engage in the activities described above.

When exporting, re-export transshipping or otherwise transferring the MPSD products (technologies) and END Products, all necessary procedures are to be taken in accordance with Foreign Exchange and Foreign Trade Act (Foreign Exchange Act) of Japan, Export Administration Regulations (EAR) of US, and any other applicable export control laws and regulations promulgated and administered by the governments of the countries asserting jurisdictions over the parties or transaction.

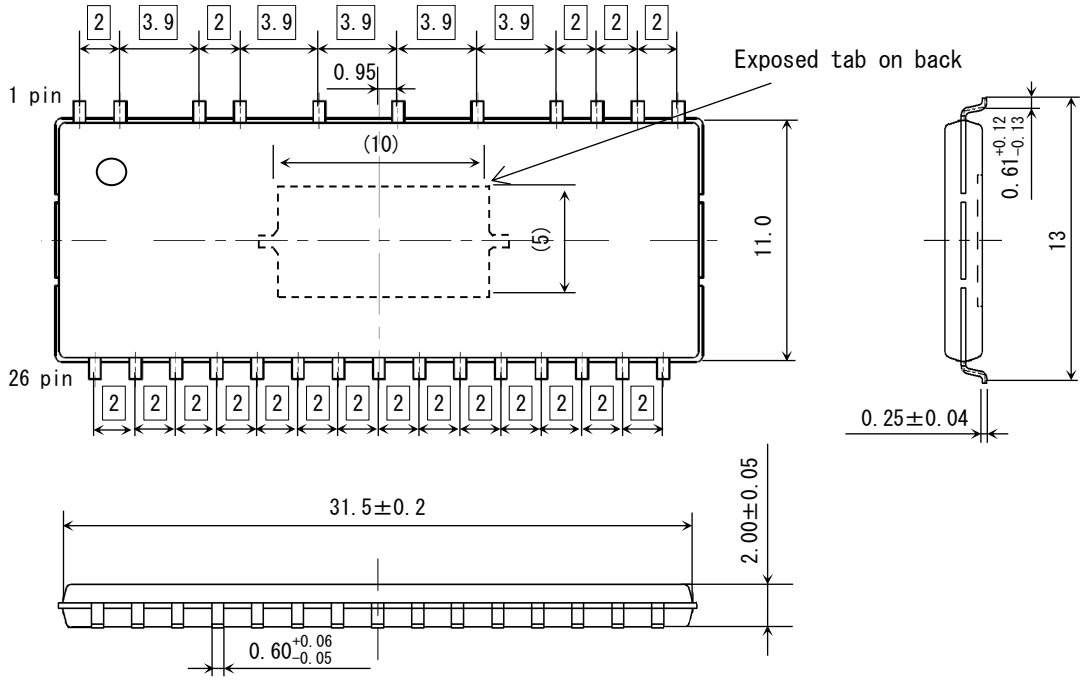
◆Appendix - Supplementary Data

1. Dimensions



Unit: mm

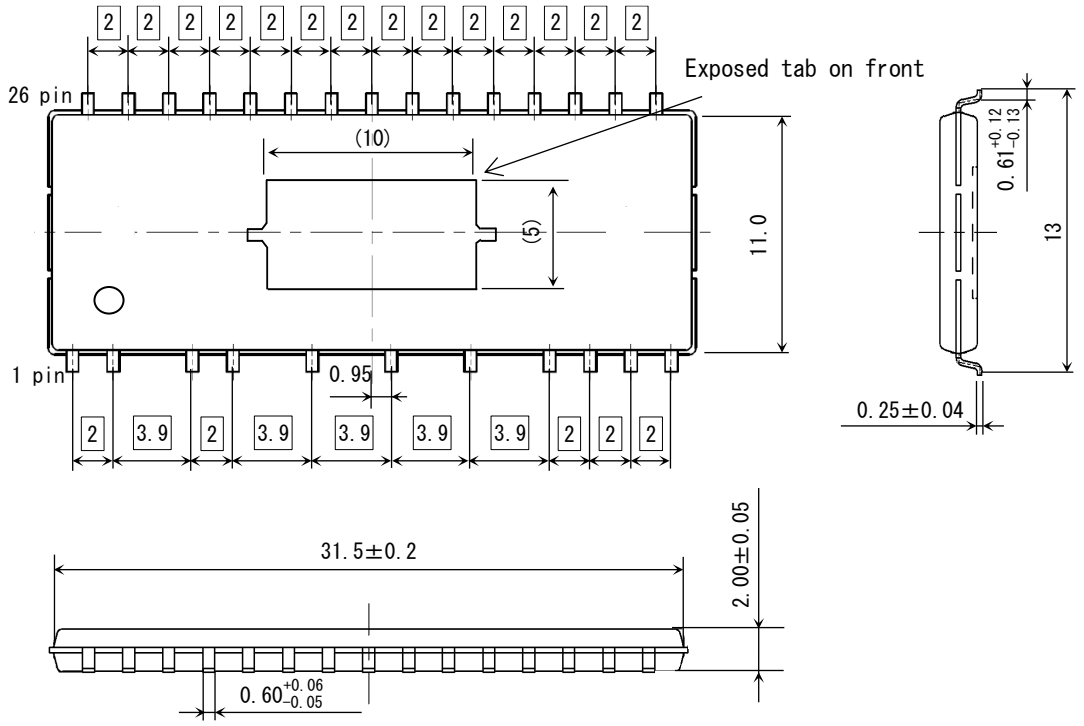
FIGURE A: Dimensions of DIP26



Unit: mm

FIGURE B: Dimensions of SOP26

Note: Unless otherwise specified, the tolerance is ±0.1.



Unit: mm

FIGURE C: Dimensions of SOP26R

Note: Unless otherwise specified, the tolerance is ±0.1.

2. External Packaging

FIGURE D shows the external packaging. The order quantity is basically the following.

- ECN30626P : 2,430 pcs or its multiple
- ECN30626F : 3,500 pcs or its multiple
- ECN30626R : 3,500 pcs or its multiple

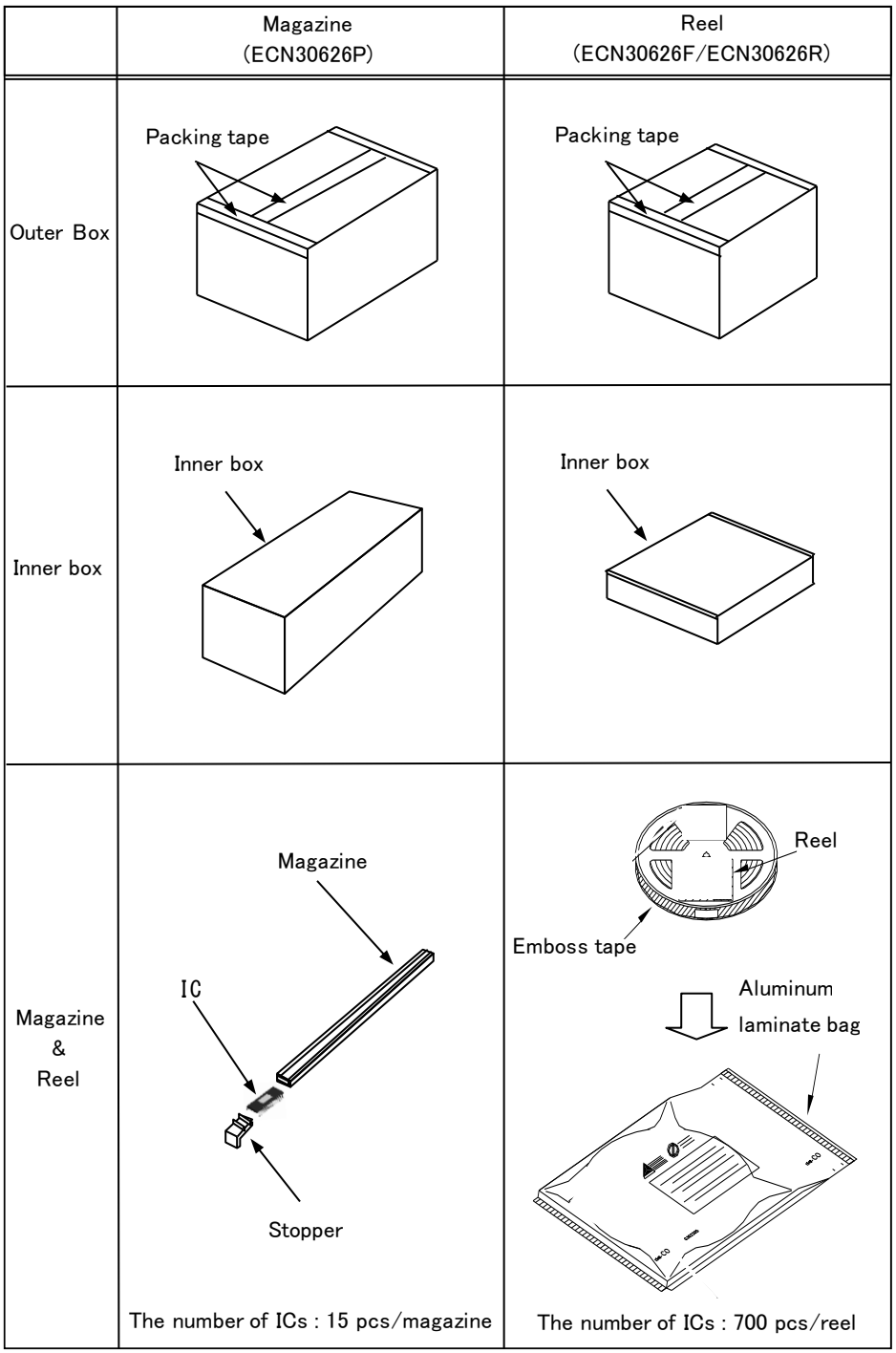


FIGURE D: External Packaging