3-Phase Motor Driver IC

ECN30625S Product Specification Rev. 2

1. Product Description

1.1 Features

(1) Maximum Ratings: 600VDC/2.0A, 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) Motor under free run condition detected by built-in back electromotive force (hereinafter called "back EMF") detection circuit

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

1.2 Functions

(1) Back EMF detection (Two phases)

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

(3) Over-current protection (detects at 0.8V)

(4) Over temperature protection

(5) Fault function (Over-current protection, over temperature protection, Vcc low-voltage detection, shutdown function)

(6) Protection recovery time adjusting function (automatic recovery)

(7) Vcc low-voltage detection

(8) 5V power supply circuit

(9) Shutdown function

1.3 Block Diagram of IC

FIGURE 1.3.1 shows block diagram.

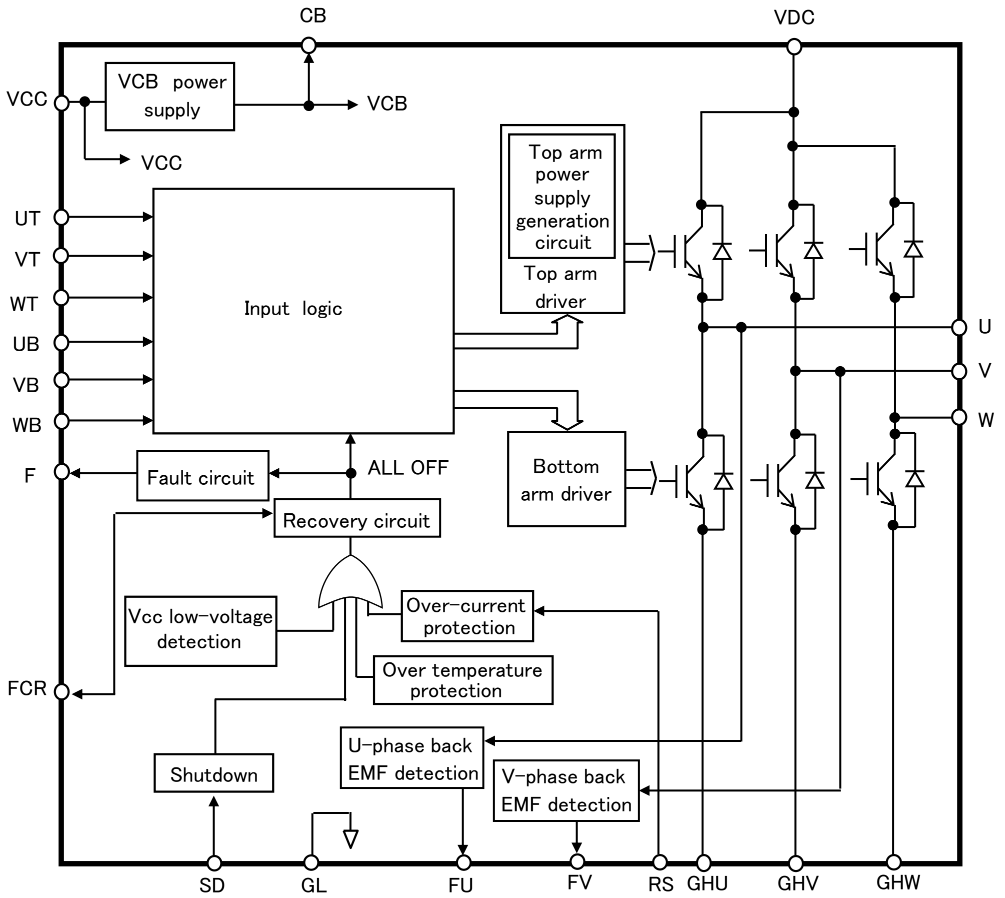
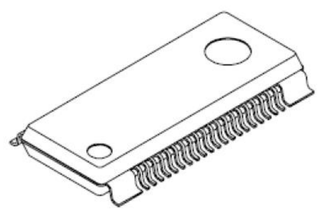


FIGURE 1.3.1 Block Diagram of IC

1.4 Package



ECN30625S
(Package: HSOP-37N)

FIGURE 1.4.1 Package of ECN30625S

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, SD, FCR	−0.5 to VCB+0.5	V	
4	Output current	Pulse	IP	U, V, W	2.0	A	Note 1
5		DC	IDC		1.0		
6	Fault output voltage		Vflt	F	−0.5 to Vcc+0.5	V	
7	FU, FV output voltage		VFU, VFV	FU, FV	−0.5 to VCB+0.5	V	
8	VCB supply output current		ICBMAX	CB	50	mA	
9	Junction operating temperature		Tjop	—	−40 to +135	˚C	Note 2
10	Junction temperature		Tj	—	+150	˚C	
11	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 (1/2) 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 VDC=325V, VCC=15V, ICB=0A
2			ICC	VCC	—	5	10	mA	
3	IGBT collector-emitter saturation voltage		VONT	U, V, W	—	2.0	3.0	V	I=0.35A, 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=0.35A
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=0.35A, 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	FU, FV output resistance		RONFU, RONFV	FU, FV	—	0.4	0.8	kΩ	IFU, IFV=1mA, VCC=15V Note 4
20	Back EMF detection level		VIHE	U, V	5.5	—	—	V	VCC=15V, UT,VT,WT,UB,VB,WB=0V
21			VILE		—	—	2.5	V	
22	F output resistance		RONF	F	—	0.9	1.8	kΩ	IF=1mA, VCC=15V Note 5
23	Over-current protection	Reference voltage	Vref1	RS, F, FCR	0.72	0.80	0.88	V	VCC=15V
24		Delay time	Tref1		—	1.7	3.0	μs	
25	Over temperature protection	Operating temperature	TSDON	U, V, W, F, FCR	135	160	185	°C	VCC=15V
26		Hysteresis	TSDHYS		—	25	—	°C	
27	Vcc low-voltage detection	Operating voltage	LVSDON	VCC, U, V, W, F	11.0	12.0	12.9	V	
28		Recovery voltage	LVSDOFF		11.1	12.5	13.0	V	

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

No.	Item		Symbol	Pin	Min.	Typ.	Max.	Unit	Condition
29	Shutdown function	Operating voltage	Vref2	SD, F, FCR	1.15	1.23	1.31	V	VCC=15V
30		Recovery voltage	Vref3		1.10	1.18	1.26	V	
31		Delay time	Tref2		—	2.5	5.0	μs	
32	SD pin input current		IIHSD	SD	—	—	2	μA	VCC=15V, SD=4.5V Note 6
33			IILSD		−2	—	—	μA	VCC=15V, SD=0V Note 6
34	FCR output resistance		RONFCR	FCR	—	0.4	0.8	kΩ	IFCR=1mA, VCC=15V Note 7
35	Protection recovery time		Trs1	FCR	—	1.0	2.0	ms	When VCC=15V, CFCR=1000pF is connected to GL, and RFCR=1MΩ is connected to CB Note 8
36			Trs2		20	-	-	μs	When VCC=15V, and RFCR=10kΩ is connected to CB Note 9

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.
Note 5: The equivalent circuit is shown in FIGURE 2.2.4.
Note 6: The equivalent circuit is shown in FIGURE 2.2.5.
Note 7: The equivalent circuit is shown in FIGURE 2.2.6.
Note 8: Typical value when the protection recovery time adjusting function is enabled. Details are shown in Section 2.4.6.
Note 9: Typical value when the protection recovery time adjusting function is disabled. Details are shown in Section 2.4.6.

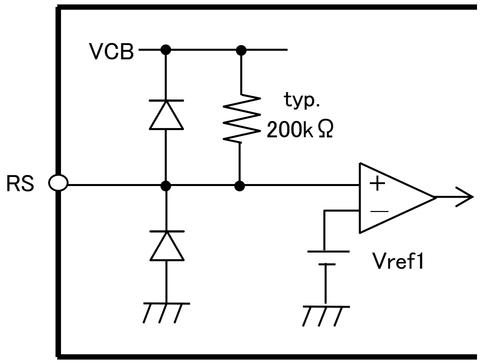


FIGURE 2.2.1 Equivalent Circuit Around RS Pin

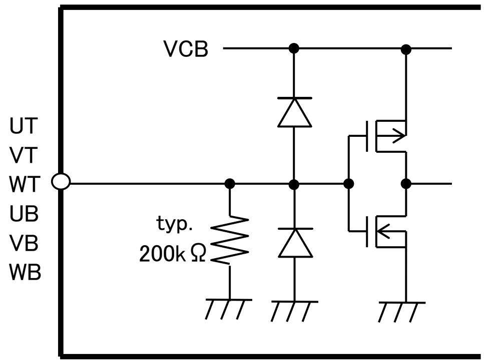


FIGURE 2.2.2 Equivalent Circuit Around UT, VT, WT, UB, VB, WB Pins

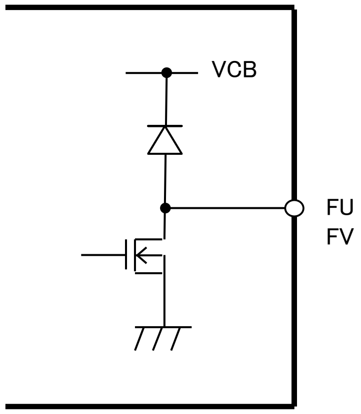


FIGURE 2.2.3 Equivalent Circuit Around FU, FV Pins

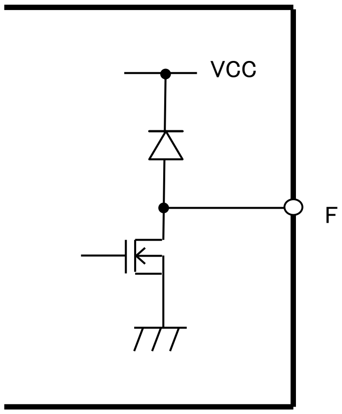


FIGURE 2.2.4 Equivalent Circuit Around F Pin

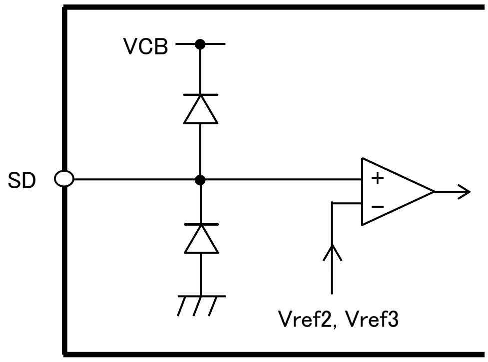


FIGURE 2.2.5 Equivalent Circuit Around SD Pin

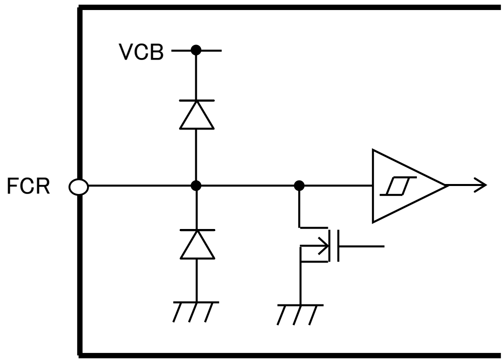


FIGURE 2.2.6 Equivalent Circuit Around FCR Pin

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 (Vref1, 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 (Vref1, 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 adjustable using FCR pin, and the adjustment method is shown in Section 2.4.6.

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

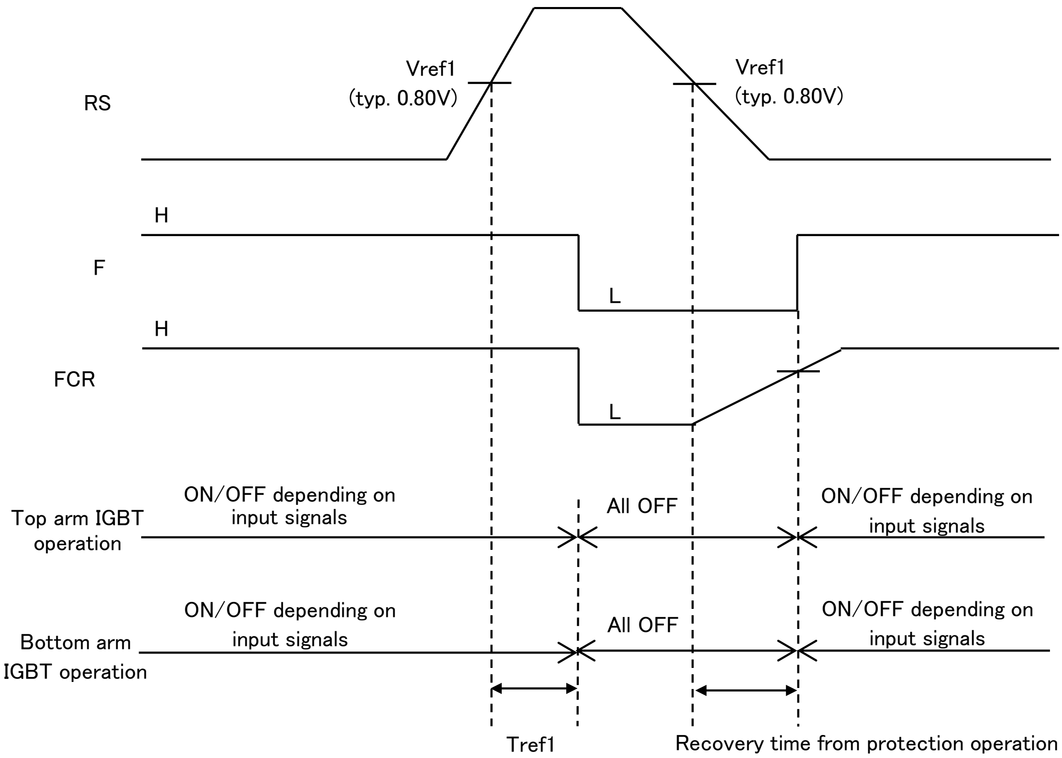


FIGURE 2.4.2.1 Timing Chart for Over-current Protection Operation

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 (Trs2) 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 Trs2.

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

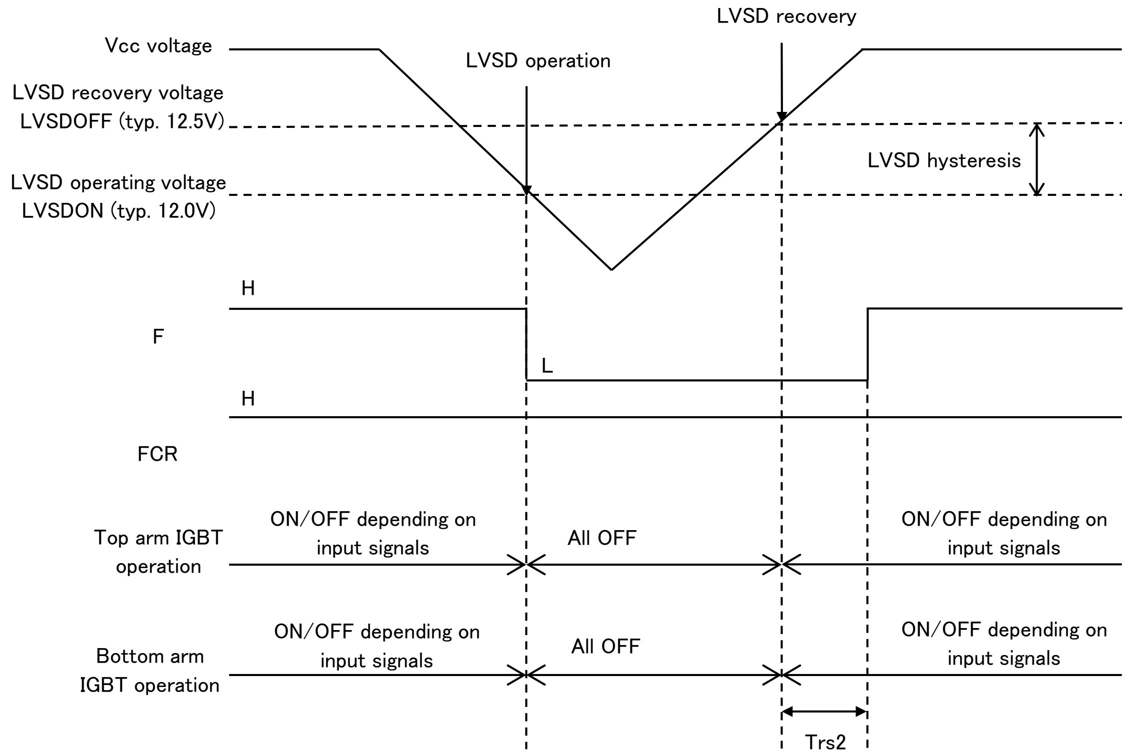


FIGURE 2.4.3.1 Timing Chart for Vcc Low-voltage Detection Operation

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 adjustable using FCR pin, and the adjustment method is shown in Section 2.4.6.

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

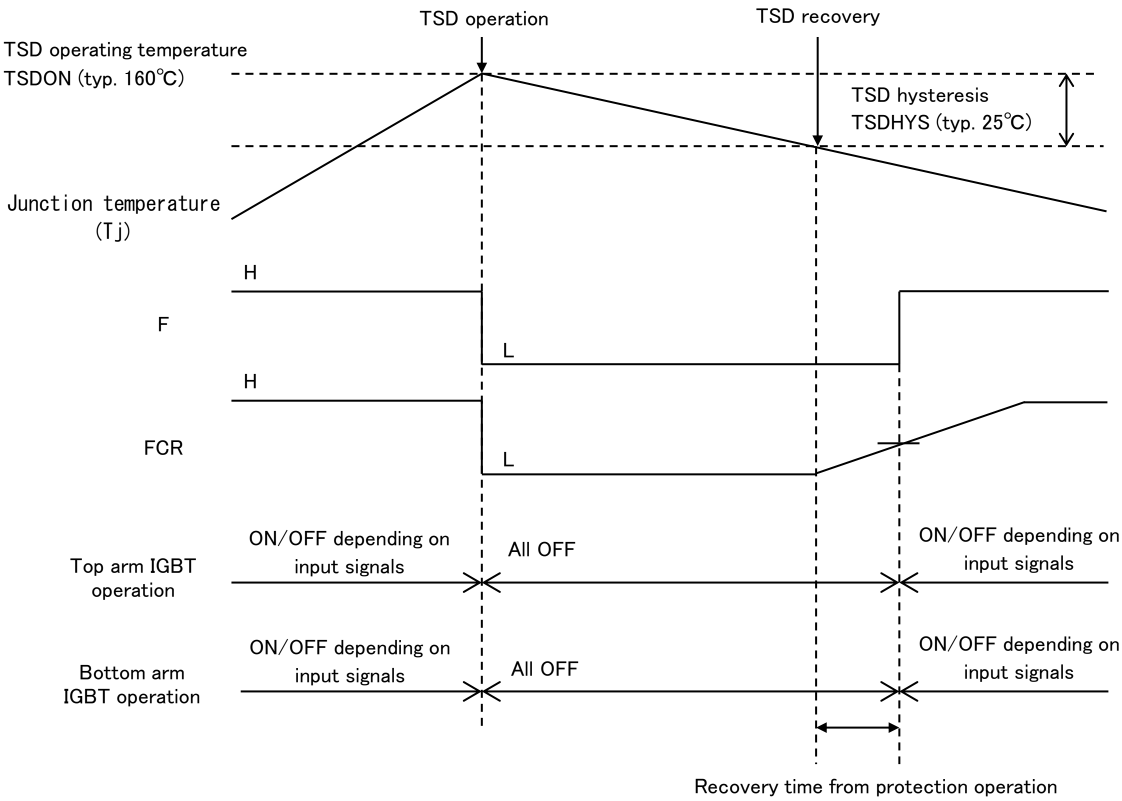


FIGURE 2.4.4.1 Timing Chart for Over Temperature Protection Operation

2.4.5 Shutdown Function

When the voltage at the SD pin reaches the shutdown operating voltage (Vref2, typ. 1.23V), the F output is "L", and all IGBTs (top and bottom arms) are turned off. After that, when the voltage at the SD pin falls below the shutdown recovery voltage (Vref3, typ. 1.18V) 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 adjustable using the FCR pin, and the adjustment method is shown in Section 2.4.6.

This function can be used as an over-voltage protection when over-voltage is applied on the VDC pin. The operating voltage and recovery voltage of the over-voltage protection are adjustable by the resistance values of external resistors ROVP1 and ROVP2 which are connected between the VDC pin and GL pin. These voltages can be calculated using the following equations:

Over-voltage protection operating voltage: $$\mathrm{OVPON(V)} = \frac{\mathrm{ROVP1}(\Omega) + \mathrm{ROVP2}(\Omega)}{\mathrm{ROVP2}(\Omega)} \times \mathrm{Vref2(V)}$$

Over-voltage protection recovery voltage: $$\mathrm{OVPOFF(V)} = \frac{\mathrm{ROVP1}(\Omega) + \mathrm{ROVP2}(\Omega)}{\mathrm{ROVP2}(\Omega)} \times \mathrm{Vref3(V)}$$

When this function is not used, connect the SD pin to the GL pin. FIGURE 2.4.5.1 shows the timing chart for shutdown operation.

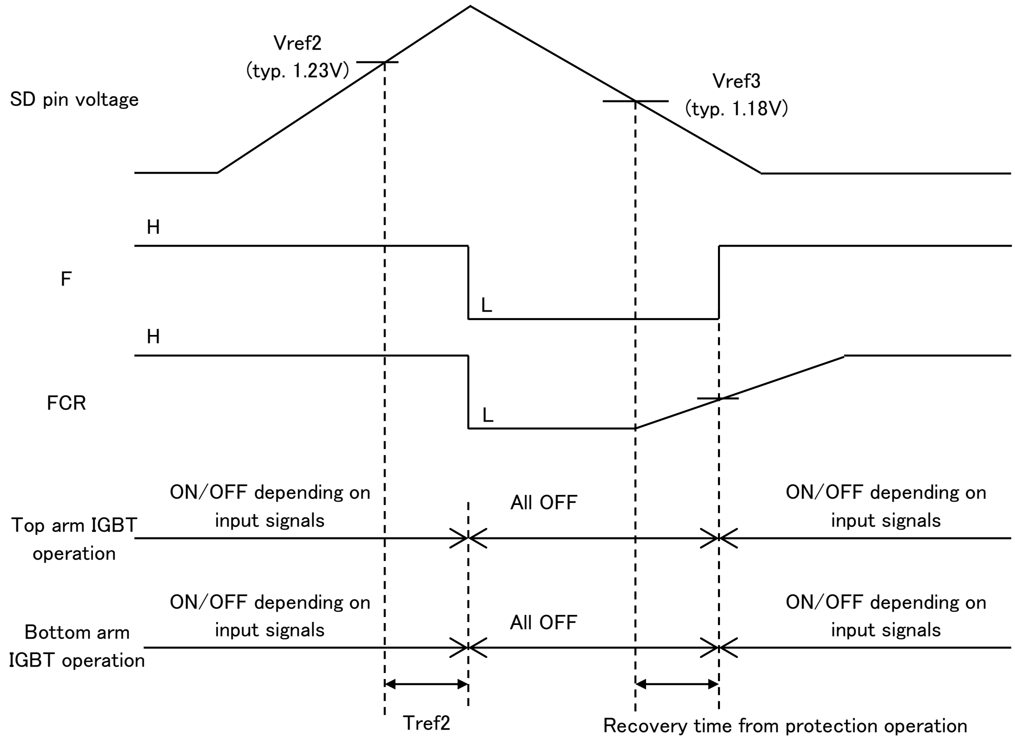


FIGURE 2.4.5.1 Timing Chart for Shutdown Operation

2.4.6 Protection Recovery Time Adjusting Function

The FCR pin is used for adjusting the protection recovery time. Connect the RFCR and CFCR between the CB pin and GL pin. Then, connect the midpoint of the CB pin and GL pin to the FCR pin. See the connection example in FIGURE3.1.1. When any of the protection functions (over-current, over temperature, or shutdown function) operates, the voltage at the FCR pin is “L”. After that, when the protection recovery conditions are satisfied and protection recovery time (Trs) determined by RFCR and CFCR passes, the F output is “H”, and the IC returns to a state in which the IGBTs operate depending on input signals. On the other hand, when RFCR=10kΩ is connected between the CB pin and FCR pin with the CFCR unconnected, after the protection recovery conditions are satisfied and protection recovery time (Trs2) determined by the internal circuit passes, the F output is “H”, and the IC returns to a state in which the IGBTs operate depending on input signals. When the Vcc low-voltage detection operates, the protection recovery time is Trs2 regardless of RFCR and CFCR values.

Trs can be calculated as follows.

$$\text{Trs (ms)} = \text{Trs1 (ms)}^{*} \times \frac{\text{RFCR}(\text{M}\Omega) \times \text{CFCR}(\text{pF})}{1(\text{M}\Omega) \times 1000(\text{pF})}$$

* Trs1 (typ. 1ms)

Please set RFCR to 500kΩ to 2MΩ and CFCR to 1000pF to 5000pF as a guide.
TABLE 2.4.6 shows the relationship between each protection function and protection recovery time.
FIGURE 2.4.6.1 shows the timing chart in case of FCR pin connected to RFCR and CFCR. FIGURE 2.4.6.2 shows the timing chart in case of RFCR=10kΩ connected to FCR pin with CFCR unconnected.

TABLE 2.4.6 Relationship Between Protection and Protection Recovery Time

Protection function	Protection recovery time	
	When protection recovery time adjusting function is enabled (When RFCR, CFCR are connected to FCR pin)	When protection recovery time adjusting function is disabled (When RFCR=10kΩ is connected to FCR pin with CFCR unconnected)
Vcc low-voltage detection	Trs2	Trs2
Over-current protection	Trs	
Over temperature protection		
Shutdown function		

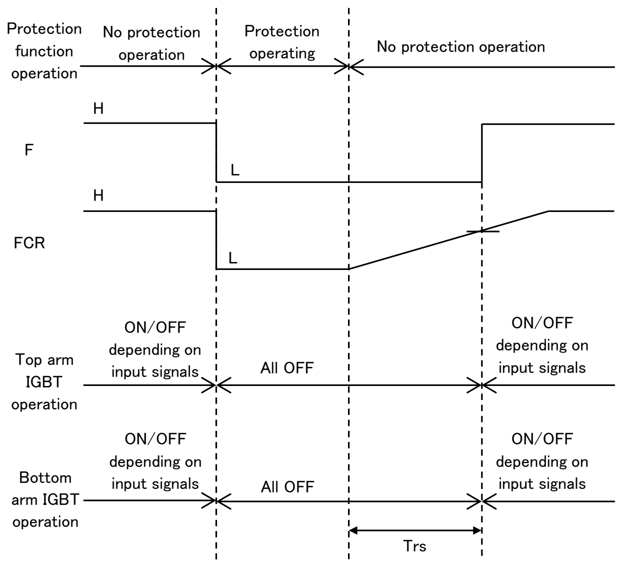


FIGURE 2.4.6.1
Timing Chart in Case of Protection Recovery Time Adjusting Function Enabled (Except for Vcc low-voltage detection)

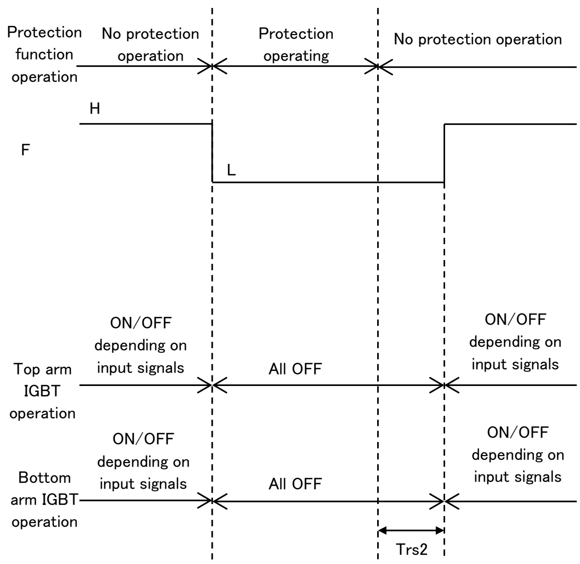


FIGURE 2.4.6.2
Timing Chart in Case of Protection Recovery Time Adjusting Function Disabled

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.
RFU, RFV	10kΩ±5%	For pull up	
CF	0.01μF±10%, 25V	Eliminates output noise of Fault signal	
RF	10kΩ±10%	For pull up	
CFCR	1000pF±10%, 25V	Sets protection recovery time	When the protection recovery time adjusting function is enabled, connect RFCR and CFCR to FCR pin.
RFCR	1MΩ±10%		
CFCR	–	–	When the protection recovery time adjusting function is disabled, connect RFCR to FCR pin and do not connect CFCR to FCR pin.
RFCR	10kΩ±10%	For pull up	
ROVP1	–	Sets over-voltage protection operating voltage/recovery voltage	Note 3 for how to set ROVP1.
ROVP2	–	Sets over-voltage protection operating voltage/recovery voltage	Note 3 for how to set ROVP2.
COVP	0.1μF±10%, 25V	Eliminates input noise of SD signal	Note 4

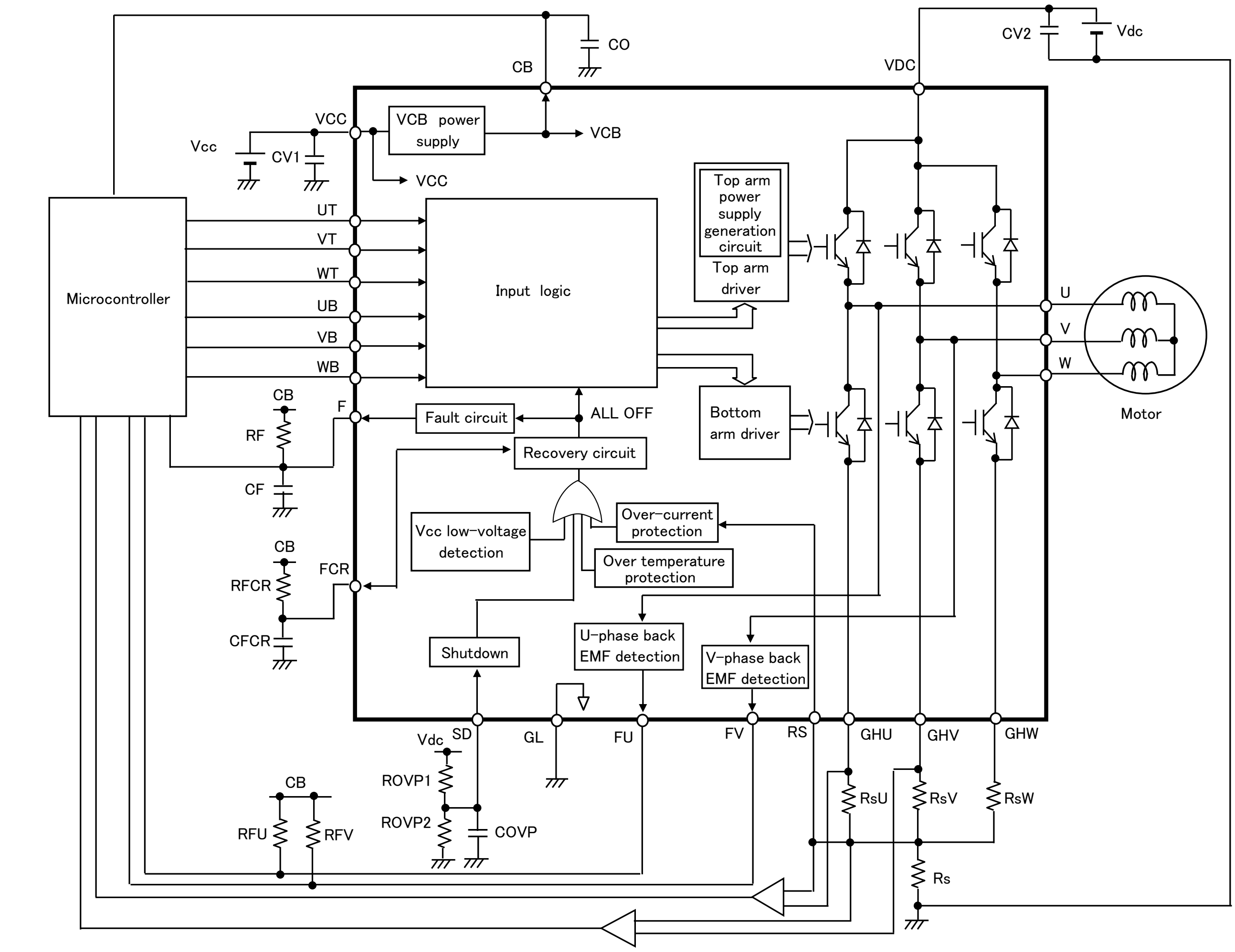


FIGURE 3.1.1 Block Diagram and External Components of IC

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 = Vref1/Rs

Vref1: Over current protection reference voltage

Rs: Shunt resistance value

Delay time to turn output IGBT off (Tref1) and variability of Vref1, 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.

Note 3. Section 2.4.5 shows how to set the resistance values.

Note 4. When influence of noise or others is large, adjust the capacitance of the capacitor as necessary.

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.

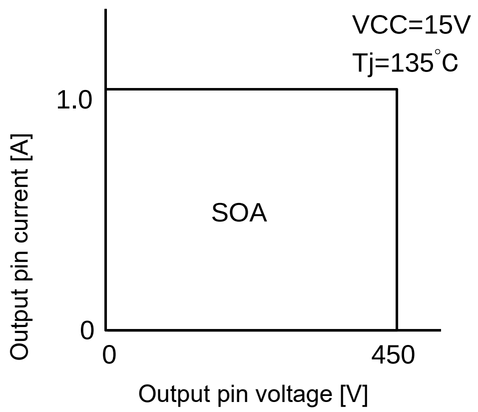


FIGURE 4.1.1 SOA

4.2 Shunt Resistor (Rs) Setting

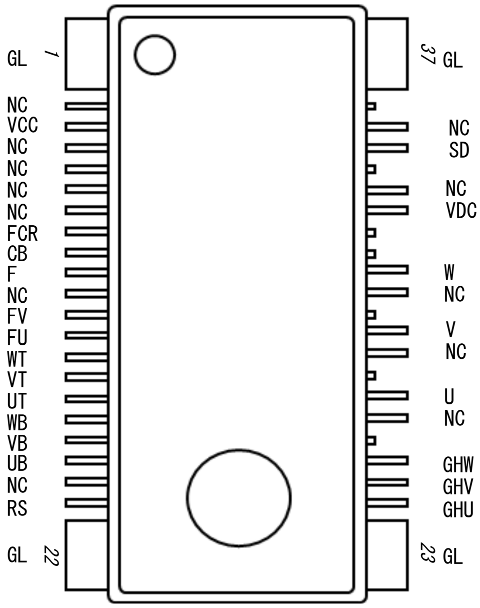
Delay time to turn output IGBT off (Tref1) and variability of Vref1, Rs need to be considered, and the current must be below the curve of FIGURE 4.1.1.

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



(Top View)

FIGURE 5.1 Pin Locations

6. Pin Assignments

TABLE 6.1 Pin Assignments

Pin No.	Symbol	Pin functions	Remarks
2, 4, 5, 6, 7 11,20,27,29, 31, 34, 36	NC	No connection	Note 1
1,22,23,37	GL	Ground	
3	VCC	Control power supply	
8	FCR	For adjusting protection recovery time	
9	CB	VCB power supply output	
10	F	Fault signal output	
12	FV	V-phase back EMF signal output	
13	FU	U-phase back EMF signal output	
14	WT	Input control signal for W-phase top arm	
15	VT	Input control signal for V-phase top arm	
16	UT	Input control signal for U-phase top arm	
17	WB	Input control signal for W-phase bottom arm	
18	VB	Input control signal for V-phase bottom arm	
19	UB	Input control signal for U-phase bottom arm	
21	RS	Input for over-current protection	
24	GHU	Emitter of U-phase bottom arm IGBT and anode of U-phase bottom arm FWD	
25	GHV	Emitter of V-phase bottom arm IGBT and anode of V-phase bottom arm FWD	
26	GHW	Emitter of W-phase bottom arm IGBT and anode of W-phase bottom arm FWD	
28	U	U-phase output	Note 2
30	V	V-phase output	Note 2
32	W	W-phase output	Note 2
33	VDC	High voltage power supply	Note 2
35	SD	For shutdown function	

Note 1. Not connected to the chip in the IC.
Note 2. High voltage pin.

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

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

Our 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 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.

8.4 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

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.

8.6 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.

8.7 Soldering

(1) Soldering Condition

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.

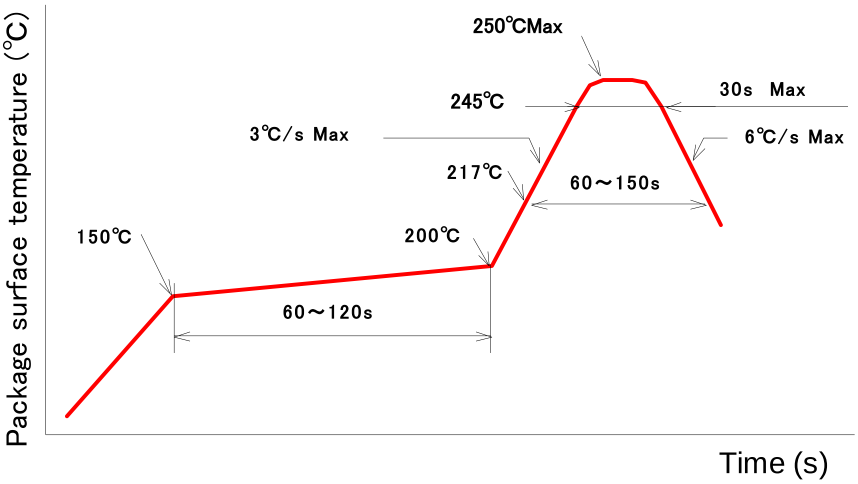


FIGURE 8.7.1 Recommended Conditions for Infrared Reflow or Air Reflow

(2) 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

(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 IC in a drying furnace (10%RH or lower) at ordinary temperature.

(3) Baking process

When the period of (1) and (2) has expired, the IC should be baked in accordance with the following conditions. (However, when the IC 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 IC 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) 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.

(5) When you dispose of our 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. Our company shall not assume responsibility for compensation due to contravention of laws and/or regulations.

(6) Our company 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.

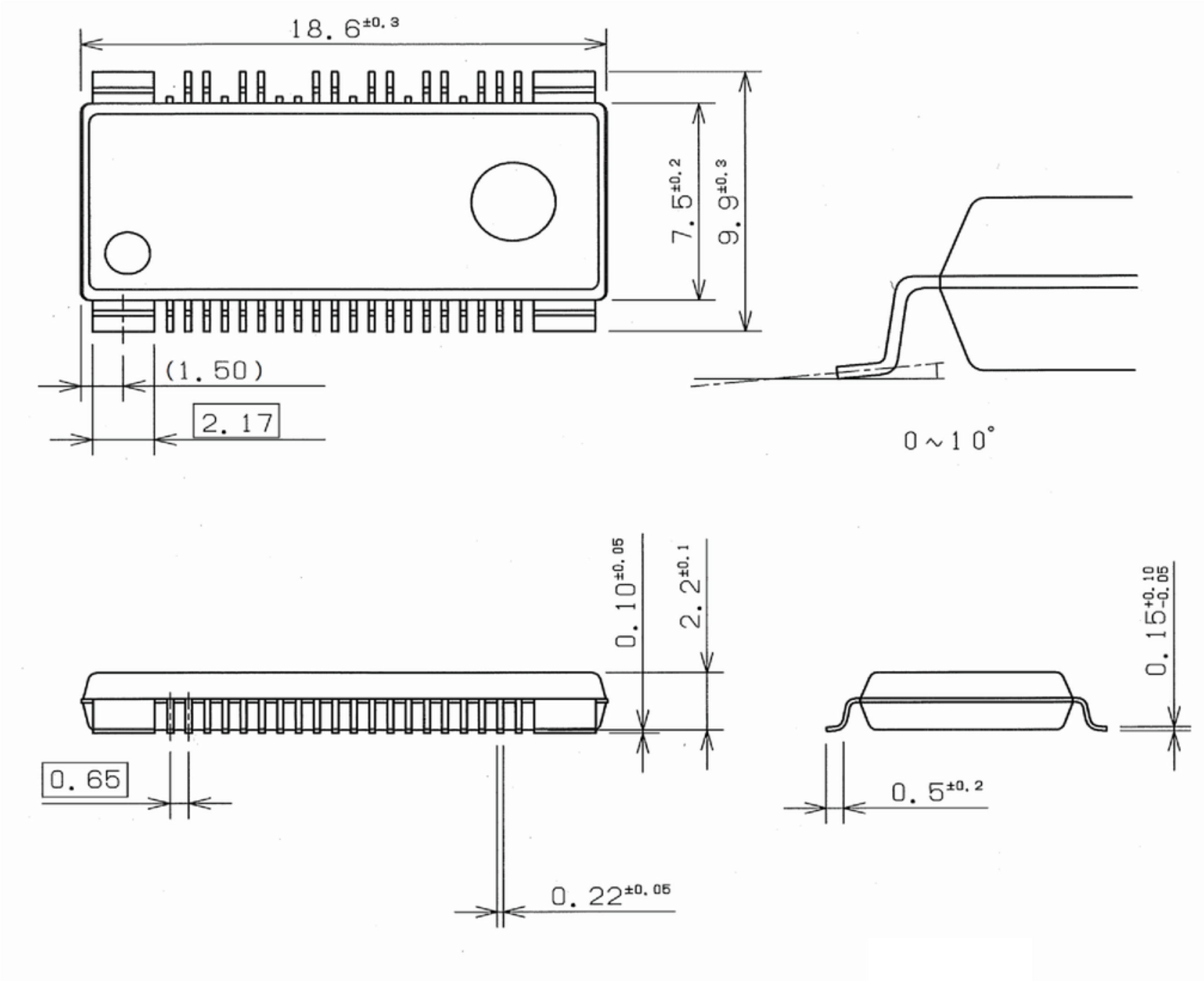
(7) No license is granted by this document of any patents, copyright or other intellectual property rights of any third party or of our company.

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

(9) You shall not use our products (technologies) described in this document and any other products (technologies) manufactured or developed by using them (hereinafter called "END Products") or supply our 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 our 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 our 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

2. External Packaging

FIGURE B shows the external packaging. Order quantities are basically multiples of 2000.

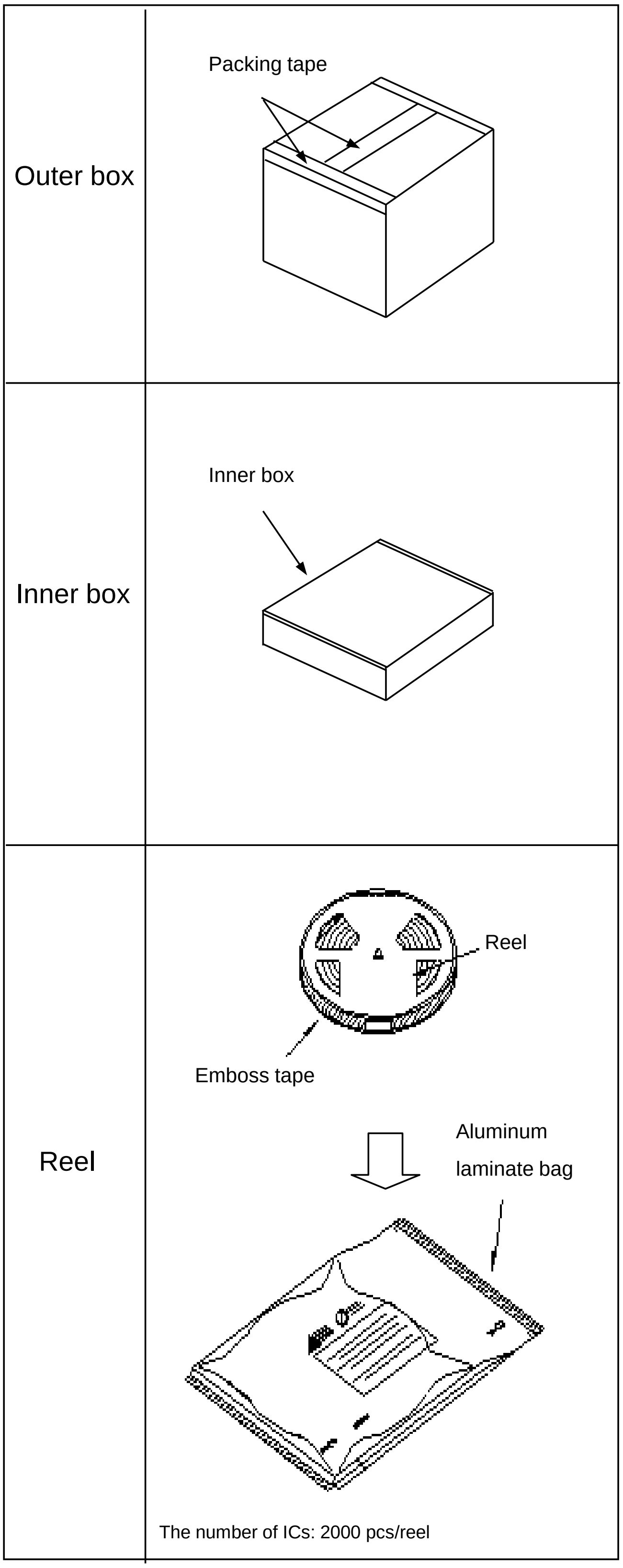


FIGURE B: External Packaging

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

1. This Data Sheet contains the specifications, characteristics, etc. concerning power semiconductor products (hereinafter called "products").
2. All information included in this document such as product data, diagrams, charts, algorithms, and application circuit examples, is current as of the date this document is issued. Such information, specifications of products, etc. are subject to change without prior notice. Before purchasing or using any of the MPSD products listed in this document, please confirm the latest product information with a MPSD sales office.
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7. In no event shall MPSD be liable for any failure in MPSD products or any secondary damage resulting from use at a value exceeding the maximum ratings.

Refer to the following website for the latest information. Contact a MPSD sales office if you have any questions.

https://www.minebea-psd.com/en