

## Fuji 7<sup>th</sup> Generation IGBT-IPM X Series



# Application Manual

## Warning:

This manual contains the product specifications, characteristics, data, materials, and structures as of October 2021.

The contents are subject to change without notice for specification changes or other reasons. When using a product listed in this manual, be sure to obtain the latest specifications.

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## Cautions

### (1) During transportation and storage

Keep locating the shipping carton boxes to suitable side up. Otherwise, unexpected stress might affect to the boxes. For example, bend the terminal pins, deform the inner resin case, and so on.

When you throw or drop the product, it gives the product damage.

If the product is wet with water, that it may be broken or malfunctions, please subjected to sufficient measures to rain or condensation.

Temperature and humidity of an environment during transportation are described in the specification sheet. There conditions shall be kept under the specification.

### (2) Assembly environment

Since this power module device is very weak against electro static discharge, the ESD countermeasure in the assembly environment shall be suitable within the specification described in specification sheet. Especially, when the conducting pad is removed from control pins, the product is most likely to get electrical damage.

### (3) Operating environment

If the product had been used in the environment with acid, organic matter, and corrosive gas (hydrogen sulfide, sulfurous acid gas), the product's performance and appearance can not be ensured easily.

## Chapter 2 Description of terminal marking and terms

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This chapter describes the terminal marking and terms of the X series IPM.

## 1. Description of terminal marking

### 1.1 Main terminals

Terminal name	Description
P (P1, P2) N (N1, N2)	$V_{DC}$ input terminals after smoothing capacitor P: + side, N: - side
B	Collector terminal of the Brake IGBT. Connect a brake resistor for dissipating regenerative energy
U V W	3-phase output terminals

\* P1, P2, N1 and N2 terminals are available in P631 package only.

### 1.2 Control terminals

Terminal name	P639 P629	P626,P644 P630, P636,P638	P631	Description
GND U	①	①	①	Ground reference for the U-arm control power supply
$V_{CC}$ U	③	④	③	U-arm control power supply positive terminal
$V_{in}$ U	②	③	②	U-arm control signal input
ALM U	—	②	④	U-arm alarm signal output
GND V	④	⑤	⑤	Ground reference for the V-phase control power supply
$V_{CC}$ V	⑥	⑧	⑦	V-arm control power supply positive terminal
$V_{in}$ V	⑤	⑦	⑥	V-arm control signal input
ALM V	—	⑥	⑧	V-arm alarm signal output
GND W	⑦	⑨	⑨	Ground reference for the W-phase control power supply
$V_{CC}$ W	⑨	⑫	⑪	W-arm control power supply positive terminal
$V_{in}$ W	⑧	⑪	⑩	W-arm control signal input
ALM W	—	⑩	⑫	W-arm alarm signal output
GND	⑩	⑬	⑬	Ground reference for the lower arms control power supply
$V_{CC}$	⑪	⑭	⑭	Control power supply positive terminal for the lower arms
$V_{in}$ X	⑫	⑯	⑯	X-arm control signal input
$V_{in}$ Y	⑬	⑰	⑰	Y-arm control signal input
$V_{in}$ Z	⑭	⑱	⑱	Z-arm control signal input
$V_{in}$ DB	—	⑮	⑮	DB-arm control signal input
WNG	—	⑮	⑮	$T_{vj}$ warning signal output for IGBT (Y)
ALM	⑮	⑲	⑲	Lower-arm alarm signal output

\* Pin (15) of P626 and P638 is WNG.

\* Pin (15) of P636(6in1), P630(6in1) and P631(6in1) is WNG.

## 2. Description of terms

### 2.1 Absolute maximum rating

Term	Symbol	Description	
DC power supply voltage	$V_{DC}$	Maximum DC bus voltage between the P and N terminal	
DC power supply voltage at short circuit	$V_{SC}$	Maximum DC bus voltage between the P and N terminal during short-circuit protection and over current protection	
Collector-Emitter voltage	$V_{CES}$	Maximum voltage between the collector and emitter terminal of the built-in IGBT, and peak inverse voltage of the FWD.	
Collector current	$I_C$	Maximum DC collector current for each IGBT	
	$I_{CP}$	Maximum peak collector current for each IGBT	
	$-I_C$	Maximum DC forward current for each FWD	
Diode forward current for DB	$I_F$	Maximum DC forward current for FWD in brake circuit	
Total power dissipation	$P_{tot}$	Maximum power dissipation for each IGBT at $T_c=25^\circ\text{C}$ , $T_{vj}=175^\circ\text{C}$	
Supply voltage of pre-driver	$V_{CC}$	Maximum voltage between the $V_{CC}$ and GND terminal	
Input signal voltage	$V_{in}$	Maximum voltage between the $V_{in}$ and GND terminal	
Alarm signal voltage	$V_{ALM}$	Maximum voltage between the ALM and GND terminal	
Alarm signal current	$I_{ALM}$	Maximum current between the ALM and GND terminal	
$T_{vj}$ warning signal voltage	$V_{WNG}$	Maximum voltage between the WNG and GND terminal	
$T_{vj}$ warning signal current	$I_{WNG}$	Maximum current between the WNG and GND terminal	
Virtual junction temperature	$T_{vj}$	Junction temperature of IGBT and FWD	
Operating virtual junction temperature	$T_{vjop}$	Junction temperature at which IGBT and FWD can operate continuously	
Operating case temperature	$T_{cop}$	Allowable case temperature during switching operation (measured point of the case temperature $T_c$ is shown in Figure 5-4)	
Storage temperature	$T_{stg}$	Allowable ambient temperature during storage without being subject to electrical load.	
Solder temperature	$T_{sol}$	Maximum temperature for soldering the terminals to a PCB	
Isolation voltage	$V_{isol}$	Maximum RMS sinusoidal voltage between all the terminals and heat sink (all terminals are shorted)	
Screw torque	Terminal	$M_t$	Maximum screw torque when connecting the main terminal and external wiring with specified screw
	Mounting	$M_s$	Maximum screw torque when mounting the IPM on heat sink with specified screw

## 2.2 Electrical characteristics

### 2.2.1 Main circuit

Term	Symbol	Description
Collector Current at off signal input	$I_{CES}$	Leakage current when specified voltage is applied between the collector and emitter and all input signals are "H" (=all IGBTs are turned-off).
Collector-Emitter saturation voltage	$V_{CE(sat)}$	Voltage drop between the collector and emitter when gate input signal is "L" (=IGBT is turned-on).
Forward voltage of FWD	$V_F$	Voltage drop across the FWD at defined forward current at input signal is "H" (=IGBT is turned of).
Turn-on time	$t_{on}$	The time from when the input signal drop below the input threshold value $V_{inth(on)}$ until the collector current of IGBT become above 90% of predetermined current. Refer to Figure 2-1.(page 2-7)
	$t_{d(on)}$	The time from when the input signal drop below the input threshold value $V_{inth(on)}$ until the collector current of IGBT become above 10% of predetermined current. Refer to Figure 2-1.
Turn-off time	$t_{off}$	The time from when the input signal rise above the input threshold value $V_{inth(off)}$ until the collector current of IGBT become 10% of predetermined current. Refer to Figure 2-1.
	$t_{d(off)}$	The time from when the input signal rise above the input threshold value $V_{inth(off)}$ until the collector current of IGBT become 90% of predetermined current. Refer to Figure 2-1.
Fall time	$t_f$	The time for the collector current to decrease from 90% to 10% of the load current. Refer to Figure 2-1.
Reverse recovery time	$t_{rr}$	The time required for the reverse recovery current of the FWD to disappear on the tangent line where it decreases. Refer to Figure 2-1.
Dead time	$t_{dead}$	On-off timing delay between upper and lower arm. Refer to Figure 2-6.

### 2.2.2 Control circuit

Term	Symbol	Description
Supply current of pre-driver	$I_{ccp}$	Current flows between $V_{CC}$ terminal and GND of upper arm control power supply
	$I_{ccn}$	Current flows between $V_{CC}$ terminal and GND of lower arm control power supply
Input signal threshold voltage	$V_{inth(on)}$	Input voltage which IPM can detect as ON signal.
	$V_{inth(off)}$	Input voltage which IPM can detect as OFF signal.

### 2.2.3 Protection circuit

Term	Symbol	Description
Over current protection level	$I_{OC}$	Threshold current for overcurrent protection
Over current protection delay time	$t_{dOC}$	Delay time from exceeding the over current protection trip level until the protection starts. Refer to Figure 2-4.
Short circuit protection operating current	$I_{SC}$	Threshold current for short-circuit protection
Short circuit protection delay time	$t_{dSC}$	Delay time from exceeding the short-circuit protection trip level until the protection starts. Refer to Figure 2-5.
IGBT chips over heating protection temperature level	$T_{jOH}$	Threshold junction temperature for over heating protection.
Over heating protection hysteresis	$T_{jH}$	Temperature drop required for over heating protection to reset.
IGBT chips warning temperature level	$T_{jW}$	IGBT chips temperature at which chips warning temperature signal is output.
Warning hysteresis	$T_{jWH}$	Temperature drop required for chips warning temperature operation to reset.
Under voltage protection level	$V_{UV}$	Threshold voltage for under voltage protection.
Under voltage protection hysteresis	$V_H$	Voltage that must exceed for under voltage protection to reset.
Alarm signal hold time	$t_{ALM(OC)}$	Alarm signal pulse width for overcurrent protection (OC)
	$t_{ALM(UV)}$	Alarm signal pulse width for under voltage protection (UV)
	$t_{ALM(TjOH)}$	Alarm signal pulse width for IGBT chips over heating protection ( $T_{jOH}$ )
Warning signal hold time	$t_{WNG}$	Warning signal output time during chip temperature warning operation
Alarm signal voltage	$V_{ALMH}$	Alarm terminal voltage when protection is not operating
Warning signal Voltage	$V_{WNGH}$	Warning terminal voltage when chip temperature warning is not operating.
Alarm output resistance	$R_{ALM}$	Value of the built-in resistance that is connected in series to alarm terminals. It limits the primary side forward current of optocoupler.
Warning output resistance	$R_{WNG}$	Value of the built-in resistance that is connected in series to warning terminals. It limits the primary side forward current of optocoupler.



### 2.3 Thermal characteristics

Term	Symbol	Description
Thermal resistance between junction and case	$R_{th(j-c)Q}$	Thermal resistance between the case and IGBT junction.
	$R_{th(j-c)D}$	Thermal resistance between the case and FWD junction.
Thermal resistance between case and heat sink	$R_{th(c-s)}$	Thermal resistance between the case and the heat sink, when the IPM is mounted on a heat sink with the specified torque and thermal compound.
Case temperature	$T_c$	IPM case temperature (Temperature of the copper base surface directly under the chip)

### 2.4 Noise tolerance

Term	Symbol	Description
Common mode rectangular noise	—	Common mode noise tolerance in our test circuit

### 2.5 Others

Term	Symbol	Description
Weight	$W_t$	Weight of the IPM
Switching frequency	$f_{sw}$	Switching frequency that can be input to the control signals input terminals.
Reverse recovery current	$I_{rr}$	Peak value of the reverse recovery current. Refer to Figure 2-1.
Reverse bias safe operating area	RBSOA	The area of voltage and current which the IPM can operate safely during turn-off. If used outside this area, the IPM may be destroyed.
Switching loss	$E_{on}$	Dissipated switching energy of the IGBT during turn-on
	$E_{off}$	Dissipated switching energy of the IGBT during turn-off
	$E_{rr}$	Dissipated switching energy of the FWD during reverse recovery
Input current	$I_{in}$	Maximum current into the $V_{in}$ terminals
Soft shutdown	—	Turn-off operation when protective operation is activated. (Softer turn-off than normal)

2.6 Operation explanatory diagram

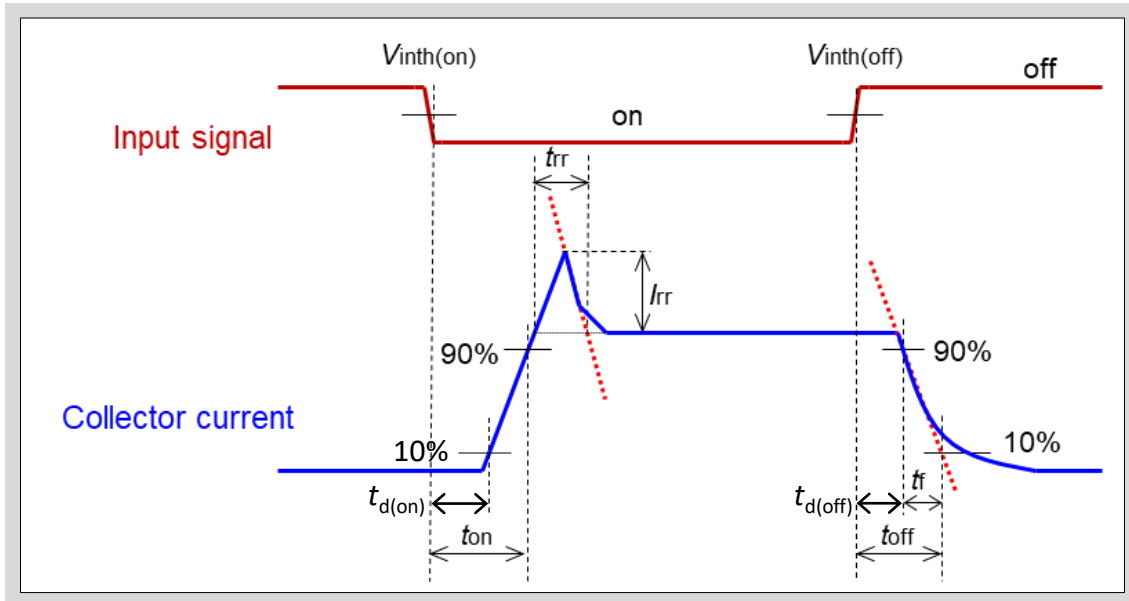


Fig.2-1 Switching times

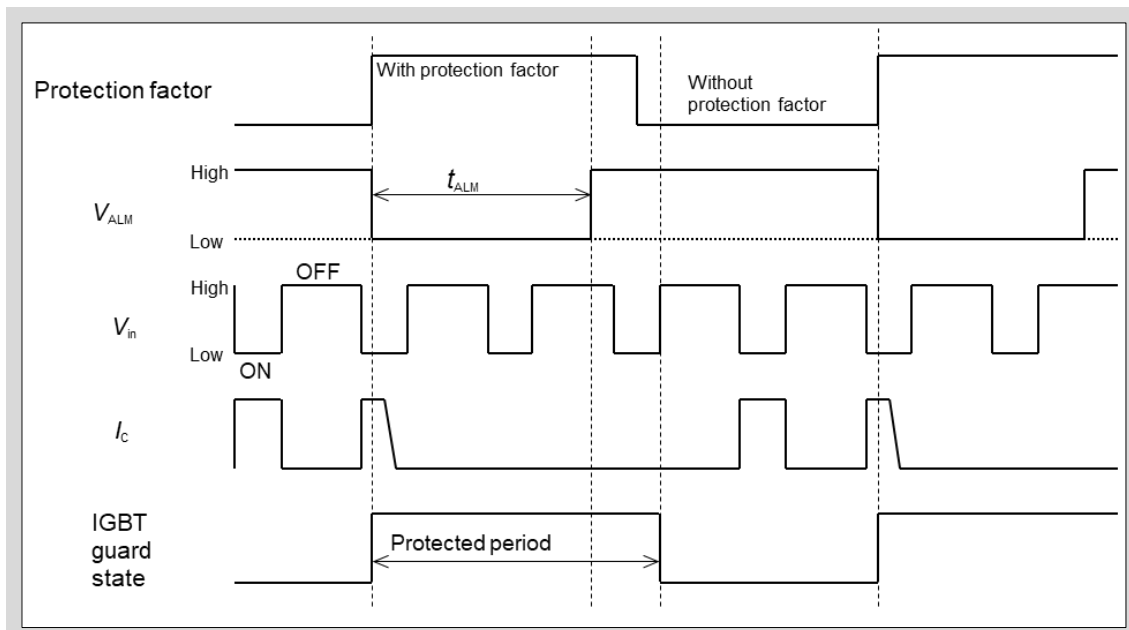


Fig.2-2 Alarm signal output hold time ( $t_{ALM}$ )

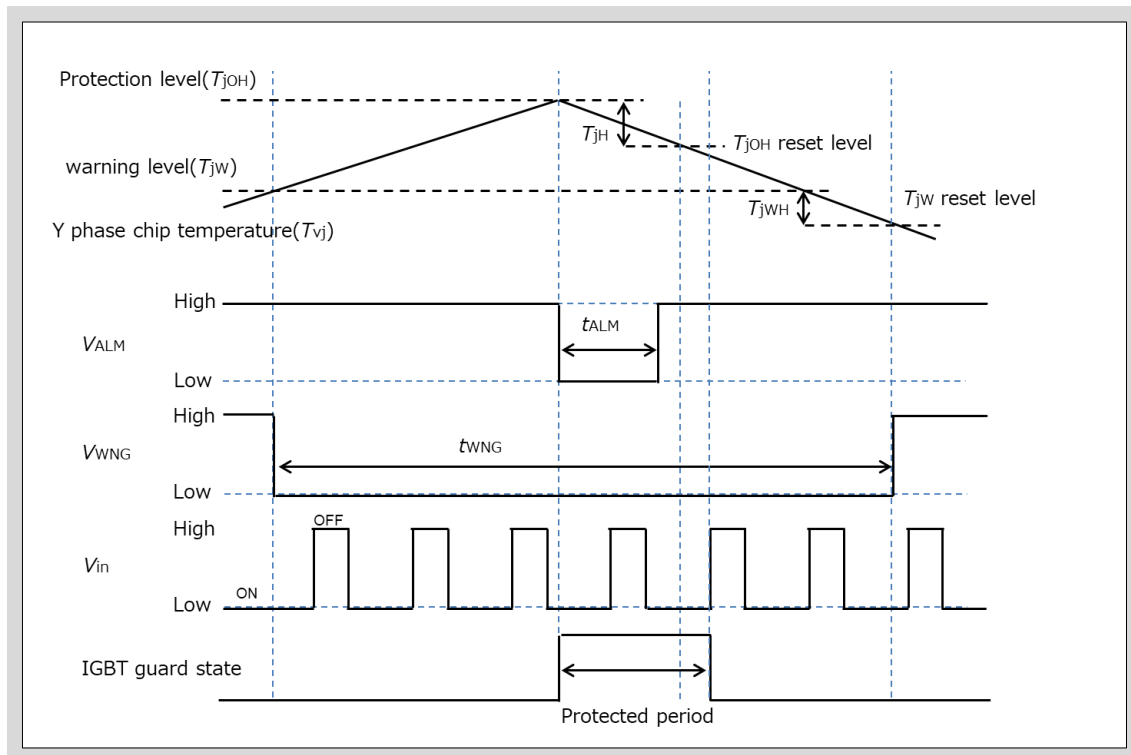


Fig.2-3 Warning Timing Diagram

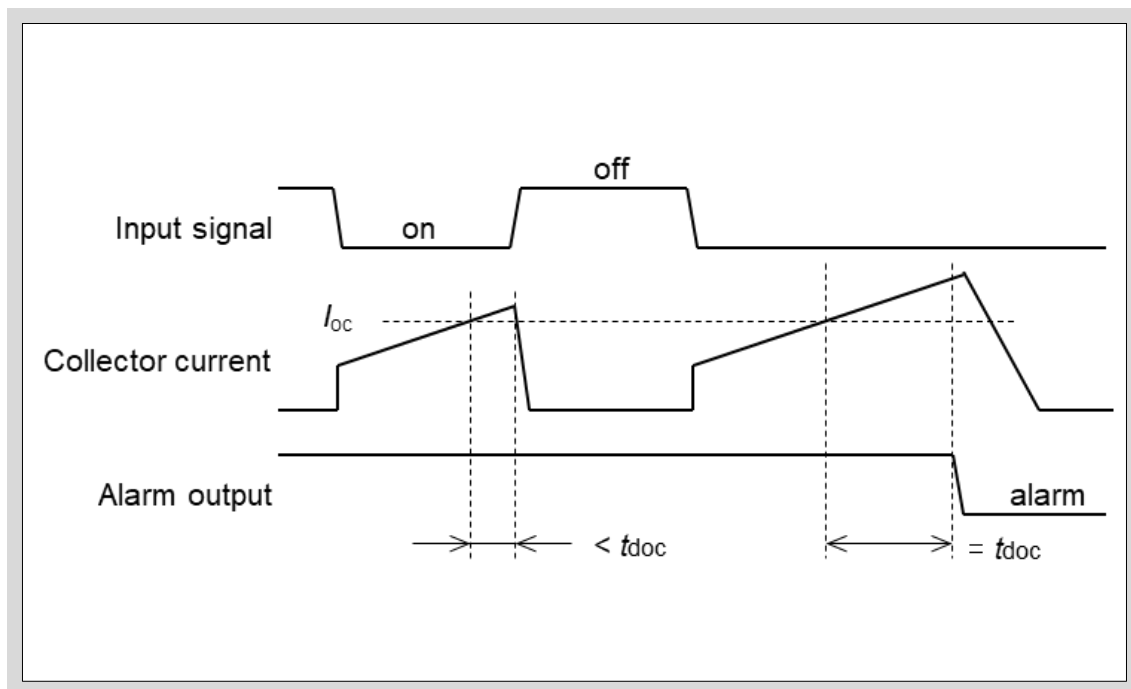


Fig.2-4 Overcurrent protection delay time( $t_{doc}$ )

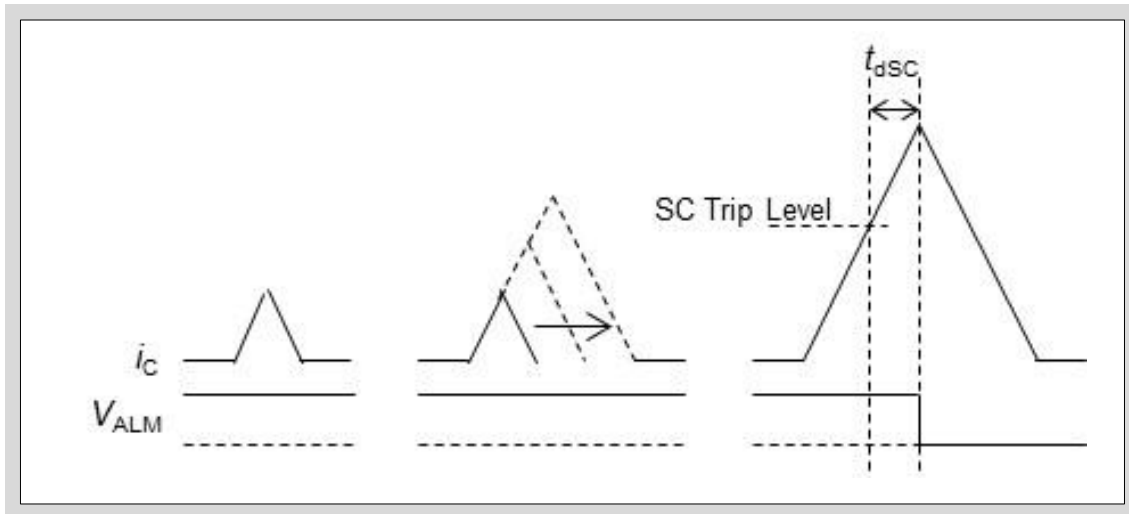


Fig.2-5 Short circuit protection delay time( $t_{dSC}$ )

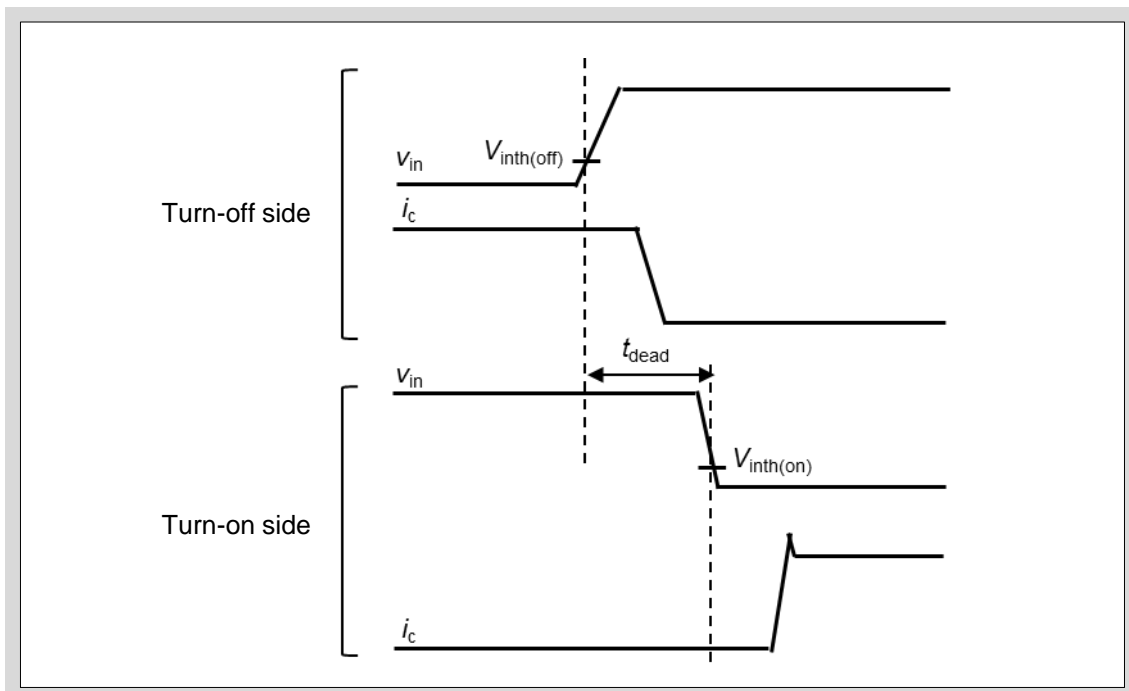


Fig.2-6 Dead time( $t_{dead}$ )