Fe Fuji Electric
Innovating Energy Technology

Fuji 7th Generation IGBT-IPM
X Series

X series 7G

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.

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					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.

2.1 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°C, T_{vj}=175°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)

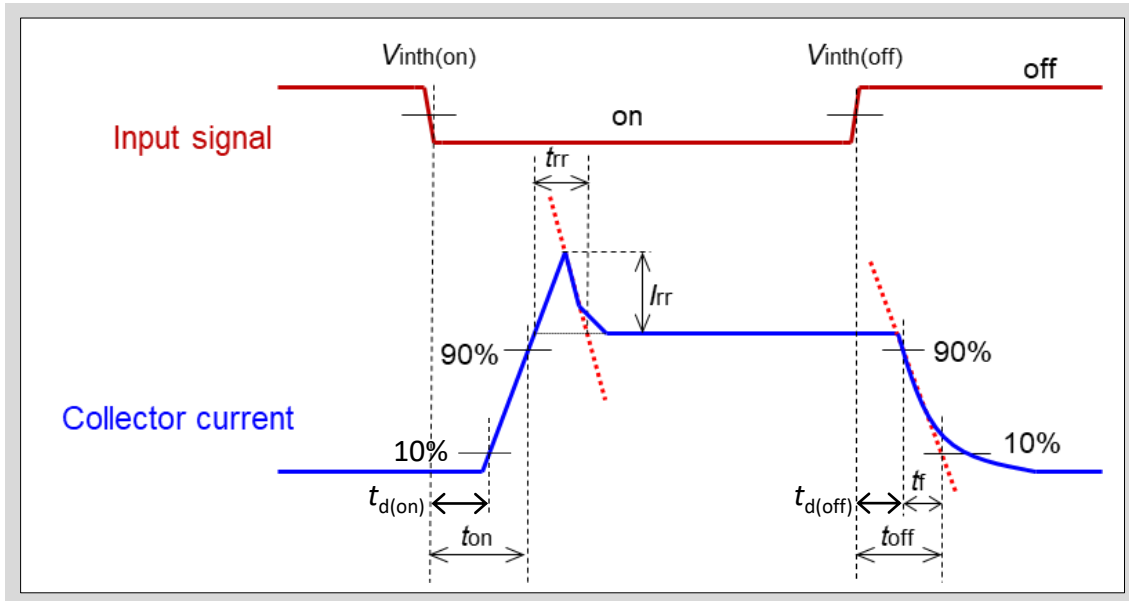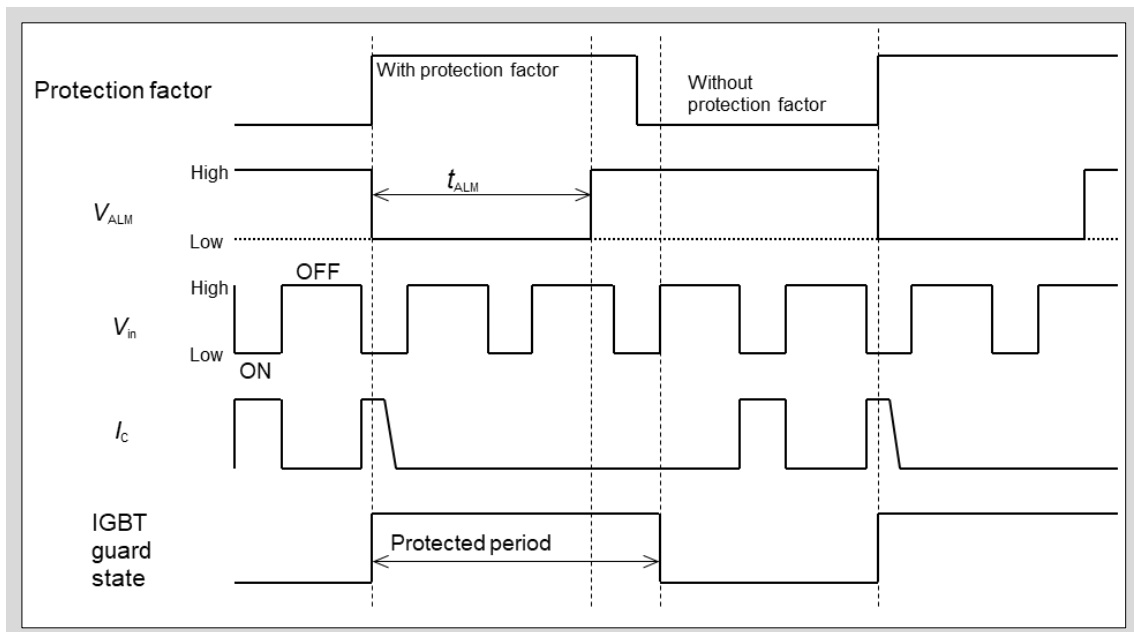## 2.6 Operation explanatory diagram

Fig.2-1 Switching times

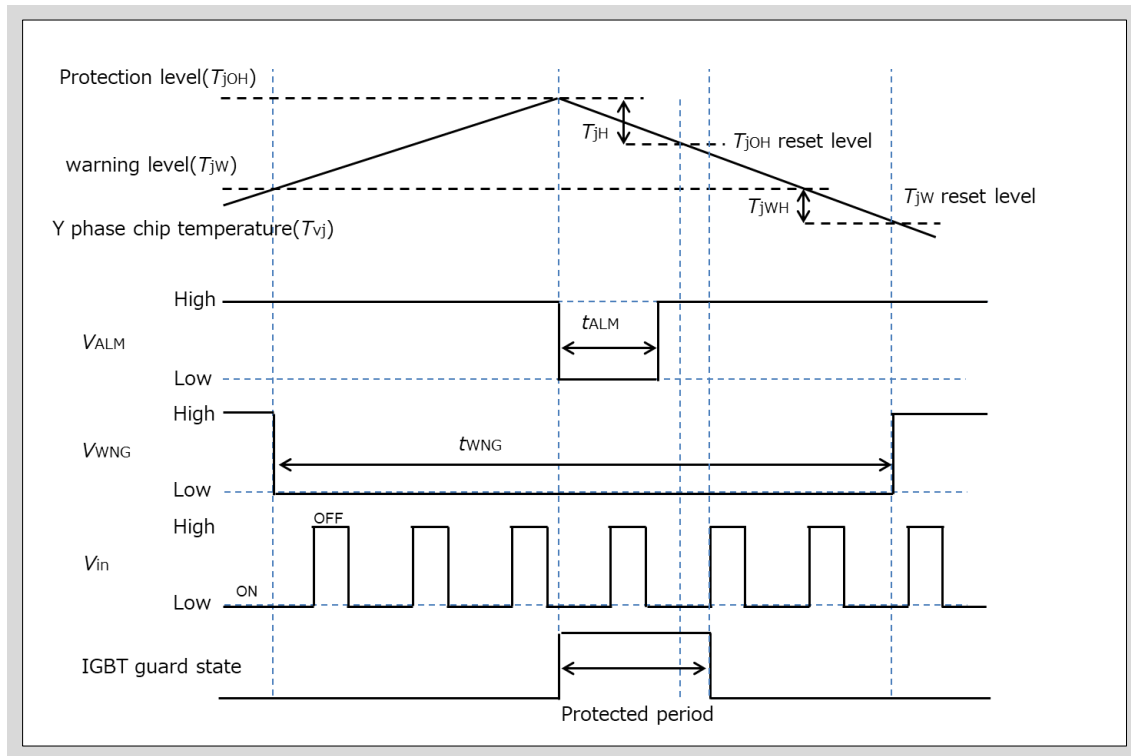Fig.2-2 Alarm signal output hold time(t_{ALM})
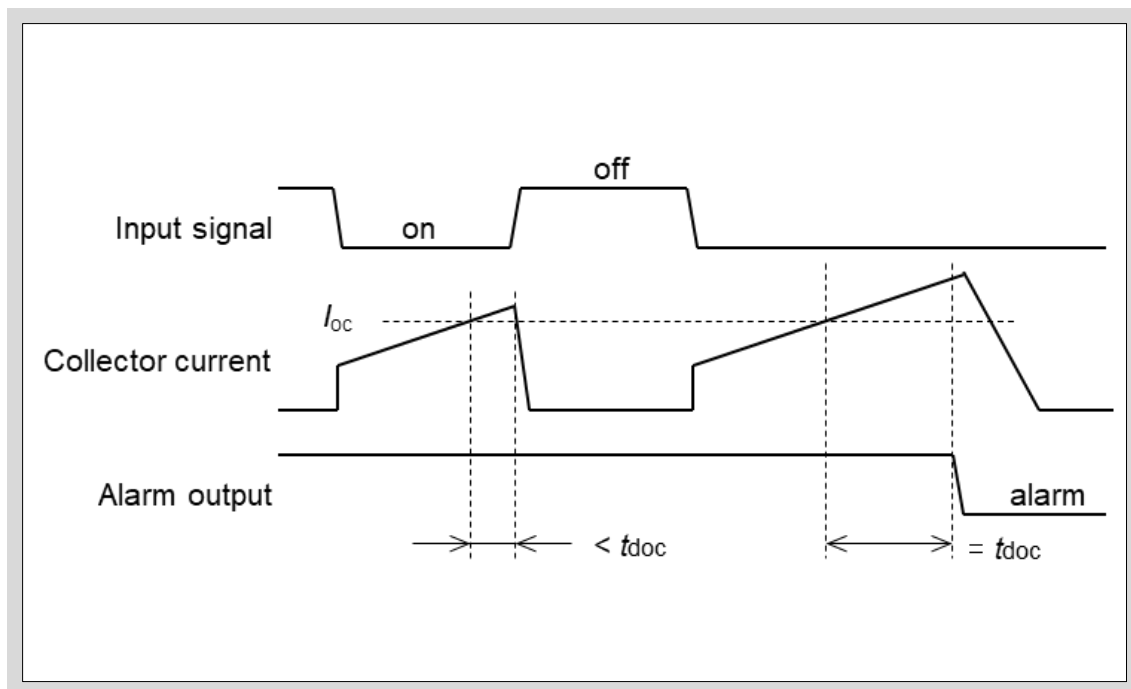
Fig.2-3 Warning Timing Diagram

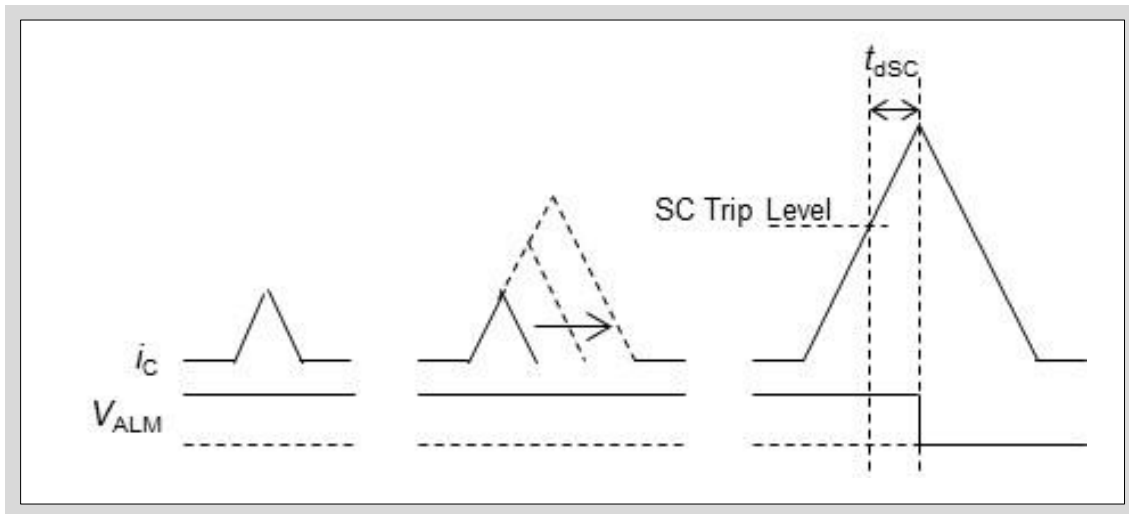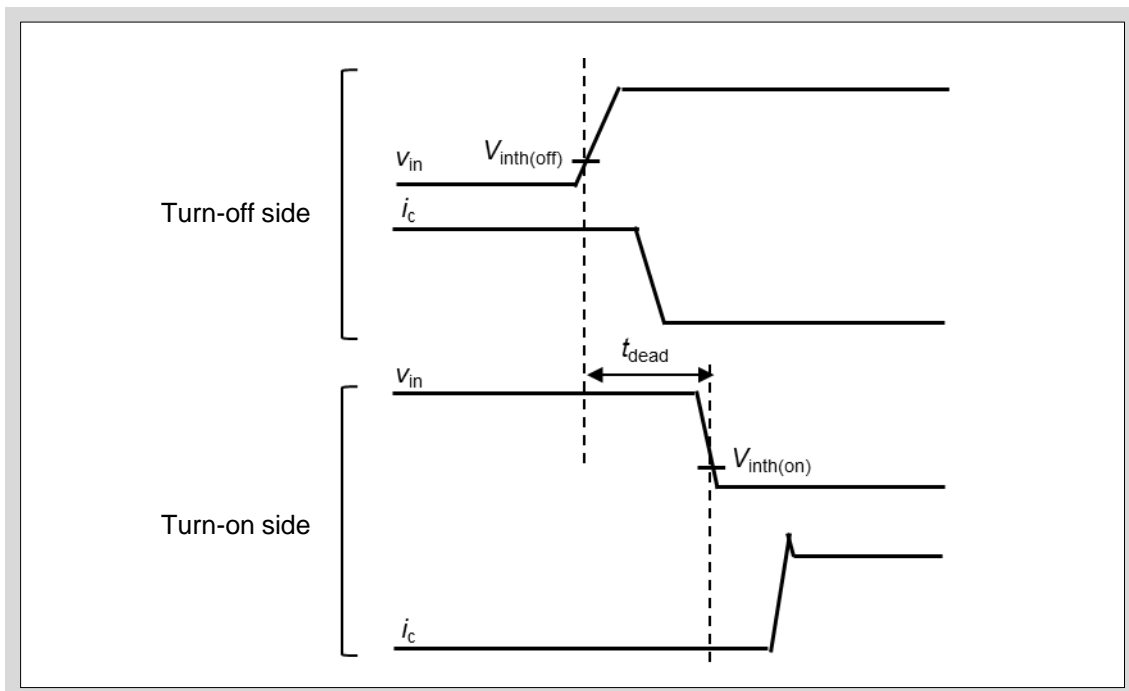Fig.2-4 Overcurrent protection delay time(t_{dOC})

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

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