1.Absolute Maximum Ratings(Ta=25℃)

Symbol	Terms	Values 222W	Values 222WA	Units
V_S	Supply voltage primary	+16		V
V_{in}	Input PWM level(HIGH) V_{in}A; V_{in}B	V_S+0.3		V
V_{iH}	Input signal voltage(HIGH) (mode select; external error signal)	V_S+0.3		V
I_{OC}	Output signal voltage(HIGH) (error signal output current)	±10		mA
$Iout_{PEAK}$	Output peak current	±10	±15	A
$Iout_{AV}$	Output average current	±50		mA
V_{CES}	Collector-emitter voltage sense	1700		V
$V_{isol\ IO}$	Isolation test voltage IN-OUT(1 min,ac)	4000		V_{ac}
$R_{G\ min}$	Minimal gate resistance	3	2	Ω
$Q_{out/pulse}$	Charge per pulse	±10	≥10 [1]	μC
dv/dt	Rate of rise and fall of voltage	50		kV/μs
$f_{SW\ max.}$	Maximum operating frequency	50		kHz
$I_{DC\ max.}$	Maximum DC/DC current primary	280		mA
$t_{TD\ min}$	Top-bottom interlock dead-time adjusted from factory	10		μs
T_{op}	Operating temperature	-40 ... +85		°C
$T_{stg.}$	Storage temperature	-40 ... +85		°C

POWER-SEM

Thick-film Dual IGBT Driver

PSHI 222W
PSHI 222WA

Features

- Thick-film dual IGBT driver
- Drive all series IGBTs with V_{CE} up to 1200V & 1700V
- Half-bridge or two independent single drives mode selected
- Short circuit protection by V_{CEsat} monitoring
- Soft short circuit turn-off
- Isolation due to ferrite transformer
- Supply undervoltage protection <13.5V
- Error memory
- Driver interlock top/bottom in half-bridge mode
- Internal isolated DC/DC power supply
- High peak output current
- ±15V IGBT gate driving voltage
- Short signal transition time
- Short-pulse control function (<500ns restrained)

2.Electrial Characteristics(Ta=25℃)

Symbol	Terms	Min.	Typ.	Max.	Rec.	Units
V_S	Supply voltage primary	+14	+15	+16	+15	V
I_{DC}	Supply current primary	100	---	300		mA
V_{IT}	Input threshold voltage		8			V
R_{in}	Input resistance		10			kΩ
$V_{G(on)}$	Turn-on output gate voltage		+15			V
$V_{G(off)}$	Turn-off output gate voltage		-15			V
$t_{d(on)IO}$	Input-output turn-on propagation time		1			μs
$t_{d(off)IO}$	Input-output turn-off propagation time		1			μs
$t_{d(err)}$	Error input-output propagation time		650			ns
t_{md}	Narrow pulse restrain		500			ns
V_{CEstat}	Reference voltage for V_{CE} monitoring	2	5.2	6.3	6.3 [2]	V
t_{BK}	Both low reset when: input signal V_{in}A / V_{in}B both low		1			ms
C_{PS}	Primary to secondary capacitance		16			pF

Typical Applications

- Single and bridge circuit
- Inverter
- Welding machine
- Induction heating
- Converter
- High power UPS
- High frequency SMPS

1, PSHI 222WA can increase this value by adjusting Pins group 19,21,37 & 29, 31,38, which depending on the capacitance of external capacitors.
2, 6.3V suit for 1700V IGBT, adjusted from factory; 5.2V suit for 600V &1200V IGBT.

Max. switching frequency:

$$f_{SW\ max.} = \frac{I_{outAV}(mA)}{Q_G(\mu C)}$$

$f_{sw\ max.}$: maximum switching frequency
Q_G : maximum IGBT gate charge at ΔV_{GE}
I_{outAV} : average cont. output current per channel

System structure of PSHI 222W /PSHI 222WA

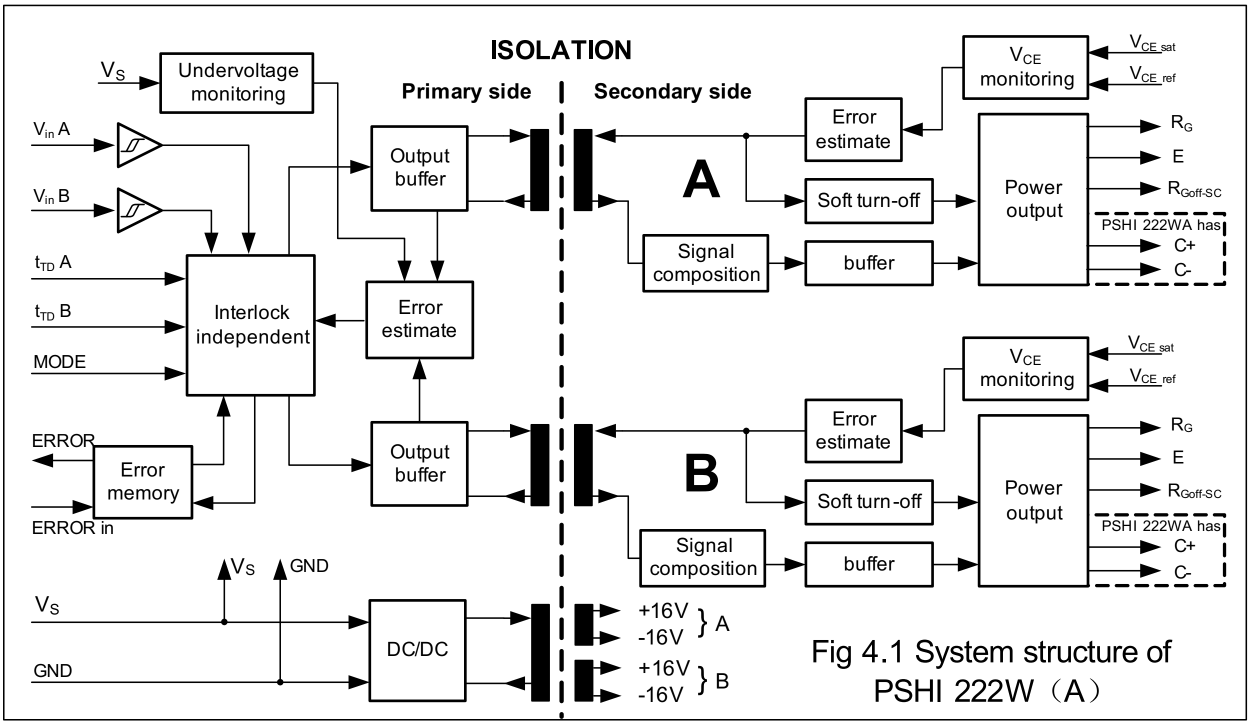

Fig 4.1 System structure of PSHI 222W（A）

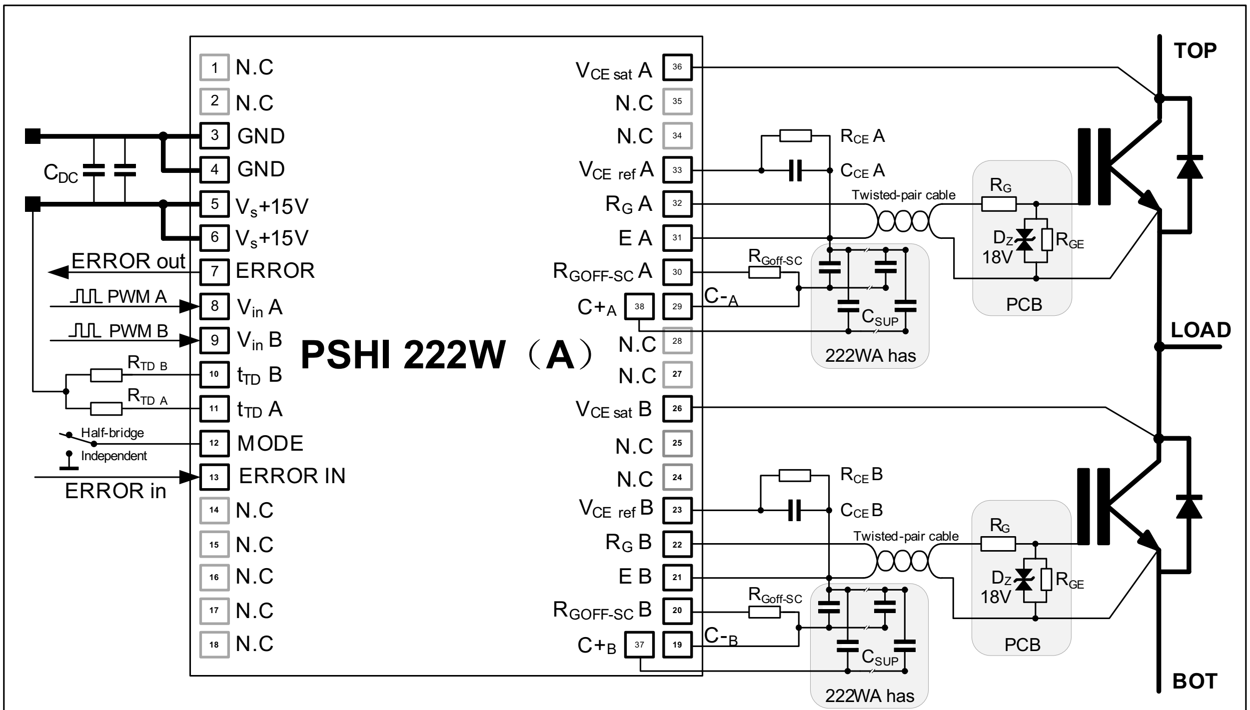

Fig 4.2 Pins array and designation

3. Product Overview

PSHI 222W is a standard IGBT driver for all power IGBTs in the market which drives all IGBTs with V_{CE} up to 1200V and 1700V. To protect the driver against moisture,dust and salt fog, it adopts module filling package.The adaption of the drivers to the application has been improved by using pins to change several parameters and functions. It can drive different IGBTs by adjusting their gate resistance R_G and "soft turn-off" resistor $R_{GOFF-SC}$ simply.

It can drive two IGBTs under half-bridge mode or independent mode. In order to improve driver's anti-jamming ability, it chooses 15V level as control signal, as well as whole logic process. Integrated transformer is devided into three parts: 2 pulse transformers and dual DC/DC switch mode power supply. All of these design can make it supply minimum coupling capacitance and high insolated voltage.

Short turn-off function is provided to protect IGBT from damage by high voltage spike. In case of short circuit, it automatically increases the IGBT turn-off time and hence reduces the V_{CE} voltage overshoot to improve the IGBT's reliability which make it can be used in higher DC voltage application.

Integrated DC/DC power supply with high galvanic isolation(4 kV/1 minute) ensures that the user is protected from the high voltage(secondary side). The power supply for the driver may be the same as used in the control board(+15V) without the requirement of isolation. All information that is transmitted between input and output uses ferrite transformers, resulting in high dv/dt immunity(50 kV/μs) which has high anti-jamming ability.

4. Block diagram PSHI 222W

System structure and performance features: (see fig. 4.1)

4.1 Signal level

The maximum value of PSHI 222W input level is V_S+0.3V,the reverse short peak current with the same value will not damage input stage. The driver's signal input resistance is 10kΩ, internal Schmitt trigger upset threshold on input stage is 8V(to GND).

Active-logic control whatever under independent mode or half-bridge mode, that is: high level IGBT switch on, while low level IGBT switch off.

Internal narrow pulse restrain circuit, make sure that the narrow pulse <500ns will be restrained.

When connecting PSHI 222W to control board using short connecting lead, otherwise, shielded cable or external interference suppression nets is needed.

4.2 Logic level and error reset

Logic level:

"Logic level" includes: error input/output, mode select and error reset.

The max.value of Input signal level(error output & mode select) is V_S+0.3V, upset threshold is 8V. So 15V is very suitable as logic signal.

Mode select see: fig. 4.2

Error reset: After faults detecting, the driver can be activated to reset by adjusting 2 PWM signals--V_{in} A / V_{in} B. If install both of PWM signals LOW at the same time for more than 1ms, error reset automatically. See fig. 4.3

Logic output:

PSHI 222W can monitor short-circuit, over-current and undervoltage of IGBT by direct measurement of V_{CEsat}. It blocks IGBT's driving signals and "soft turn-off" the IGBT in case of faults occurs and sends a error signal to primary side."Error memory" circuit blocks all pulse output and keeps reset only be possible when both PWM signals are low level for more than 1ms. The low level error signal is fed to terminal by Pin 7. The error output of Pin 7 is open-collector output with internal 10kΩ pull-up resistor,and the maximum input current is 20mA. The IGBT drivers can use common error output line, no need to connect with pull-up resistor.(See fig.4.3)

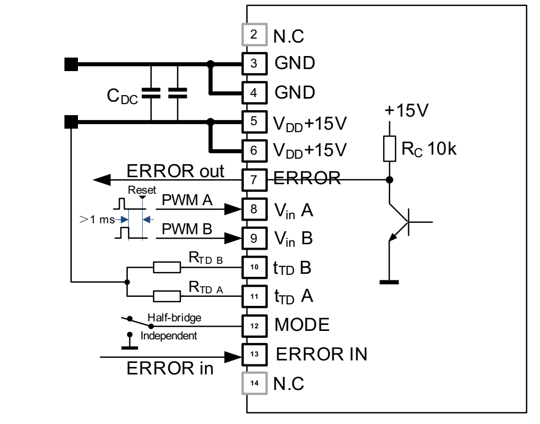

Fig 4.3 Error reset and open -collector output

Additionally, PSHI 222W has another function of external error input. It blocks all IGBT's driving signals output when Pin 13 receiving external input low level error signals.The external error input will not activate "error memory", and blocks will be relieved after it disappearing.Pin 7 & pin 13 of more drivers can be connected together to realize synchronous failure.

4.3 Working mode select

PSHI 222W has two methods to drive IGBT, including:direct independent mode & half-bridge interlock mode.

Direct independent mode: Under such mode, there is no electrical connection between two channels of PSHI 222W. Channel A & B can work independently, and can be switched on simultaneously.Direct mode can be activated by connecting Pin 12 "mode select" to GND(eg.connect to Pin 3/4). Then t_{TDA}(Pin 11) & t_{TDB}(Pin 10) not connected.

Half-bridge interlock mode: It can interlock two channels of PSHI 222W to prevent the top & bottom

IGBTs from being in the on-state simultaneously, which cause aninterlock time. The dead time can be set by adjusting external resistor of $t_{TD\ A}$(Pin 11) and $t_{TD\ B}$(Pin 10). Half-bridge interlock mode can be activated by Pin 12 "mode select" not bridged or connecting with V_s(Pin 5/6). Dead time to see fig. 4.4

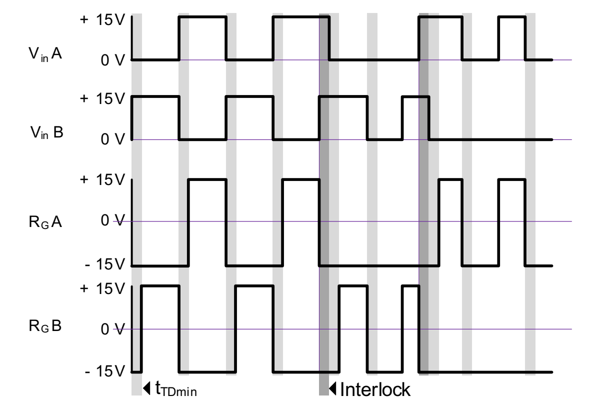

Fig 4.4 Dead time

Interlock dead time; Under half-bridge mode, there is a minimum inner interlock dead time between 2 channels of PSHI 222W,which adjusted from factory is 10μs.It can be reduced by paralling external resistor to V_s at $t_{TD\ A}$(Pin 11) & $t_{TD\ B}$(Pin 10) and inner capacitor. Table 4.5 shows the corresponding relationship between R_{TD} and dead time:

R_{TD}	Dead time t_{TD}	R_{TD}	Dead time t_{TD}
10kΩ	0.9μs	68kΩ	4μs
22kΩ	1.8μs	100kΩ	5μs
33kΩ	2.5μs	330kΩ	7.7μs
47kΩ	3.2μs	not connected	10μs

Tab 4.5 Corresponding relationship between t_{TD} and R_{TD}

The dead time error is decided by external capacitance, so it's better to choose resistors with less error.

4.5 Power supply

With internal DC/DC isolation power supply, PSHI 222W can create ±16V voltage on secondary side. Therefore, PSHI 222W only needs a +15V external power supply. In order to work under stable +15V (±1V) power voltage, an additional constant voltage capacitor C_{DC}(see fig.4.2) with min. capacitance of 20μF is required.

PSHI 222W has a function to monitor under-voltage of primary side. If power voltage of primary side below +13.5V, an error signal can be created to turn-off the driver and sends a low level error signal to outside by Pin 7.

4.6 Connecting IGBT

PSHI 222W can drive two single IGBTs by two independent channels, also can drive an IGBT's half-bridge by half-bridge mode. The size of PSHI 222WA(auxiliary board) is depending on IGBT's input capacitance and switching frequency.

When considering gate current, please note that it's not only determined by external gate resistance, but also need to take the internal gate resistance of IGBT into consideration. That is because most of high power IGBTs already have an integrated gate resistor inside(refer to relevant IGBT datasheets). Additionally, PSHI 222W has low output resistance. So it's not practical to calculate gate current only by external gate resistor. The approximate value of driving power and peak current can be calculated with:

Driver power $P_G = f_{SW} \times \Delta V_{GE}^2 \times C_{ies} \times 4$

$P = P_G + P_S$

Max. driver current $I_{G\,MAX} = \frac{\Delta V_{GE}}{I_{G\,min}}$

f_{sw} = switching frequency

C_{ies} = input capacity (datasheet)

P_S = driver dissipation

ΔV = 30V @ ± 15V

$R_{G\,min} = R_{G\,extern} + R_{G\,intern}$

Connecting gate:

IGBT gate is connected with R_G A or R_G B of the driver by external gate resistor R_G. Connect the auxiliary emitter of IGBT with E A or E B output of PSHI 222W directly. The gate output voltage of the driver V_G is ±15V, and the selection for external gate resistor R_G is according to the relevant IGBT (refer to the datasheets). Apart from gate resistor R_G, a gate-emitter resistor R_{GE} and gate clamp are also needed. Better to keep R_{GE} ≤10kΩ, and gate clamping can be reliazed by zener diode or TVS diode.Both the diodes should keep breakthrough voltage≤18V, which can protect gate voltage from rising up severely because of paratistics effect (eg. Miller Effect). When connecting PSHI 222W to IGBT gate, flat cable with pairs of conductors twisted is highly recommended and shoud be kept as short as possible(usually shorter than 20cm). Also, please fix gate resistor R_G, voltage clamp diode D_Z and gate-emitter resistor R_{GE} onto a small PCB. The gate PCB must be installed closed to IGBT.

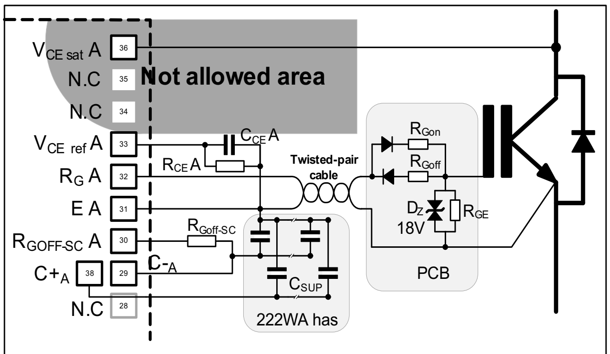

Fig 4.6 gate-collector connecting

As a general rule, we only need 1 gate resistor R_G to drive IGBT. If control di/dt or dv/dt of IGBT turn-on and turn-off by rising and dropping gate driving signals, please seperate gate driving signals. See fig.4.6.

Connecting collector:

$V_{CE\ sat}$ monitoring,

"$V_{CE\ sat}$ monitoring circuit" is responsible for short-circuit sensing. Due to the direct measurement of V_{CEstat} on the IGBT's collector, it blocks the output buffer (through the soft turn-off circuit) in case of short-circuit and sends a signal to the ERROR memory on the primary side.

Attention: Due to the connection to high voltage with V_{CEsat} monitor terminal of Pin 26&36, there must be no any other components or wirings over the 6mm radius area enclosed by V_{CEsat} monitor pins on auxiliary board and connecting leads in order to avoid creepage. See fig. 4.6.

4.7 IGBT short-circuit and "soft turn-off"

In case of short-circuit, a "soft turn-off" circuit turns-off the IGBT at a lower speed by increasing the turn-off resistance. The IGBT will be turned-off after time t_{SC}.This produces a smaller voltage spike above the DC link by reducing di/dt value.Because in short-circuit conditions, the Homogeneous IGBT's peak current increases up to 6-8 times the IGBT's rated current, and some stray inductance is always present in power loop circuits, it must fall to zero in a longer time than at normal operation to avoid damage IGBT by high voltage spike.

The internal resistor used for soft turn-off is 22Ω,this "soft turn-off " time can be reduced by paralleling resistor $R_{goff-SC}$ on Pin 19,20 & 29,30, with internal resistor of PSHI 222W.

4.8 Reference voltage V_{CEref}

The reference voltage V_{CEref} adjusted dynamically according to IGBT switch characteristics, and reset when IGBT turn-off. The V_{CEref} is not static but a dynamic reference which has an exponential shape starting at about 15 V and decreases to V_{CEstat} (determinated by R_{CE}), with a time constant T(controlled by C_{CE})(see Fig.4.7).

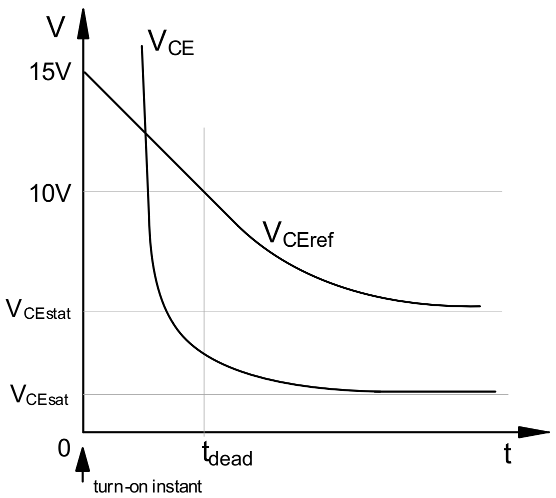

Fig.4.7, V_{CE} monitor waveform V_{CEref} & V_{CE} waveform when IGBT just starts to conduct

V_{CEsat} threshold is a static value of V_{CEref} which is controlled by resistor R_{CE}. It can be adjusted by resistor R_{CE} to reach the maximum value as per IGBT's demand. V_{CEstat} >V_{CEsat} under nomal conditions, but will not exceed 10V.The decay time of V_{CEref} is determined by capacitor C_{CE} and resistor R_{CE} (see Fig.4.7). It controls the dead time t_{dead} when IGBT just starts to conduct till V_{CEsat} monitoring starts. To avoid a false failure indication when the IGBT just starts to conduct (V_{CE}>V_{CEref}), some decay time t_{dead} must be provided for the V_{CEref}.As the V_{CE} signal is internally limited at 10V, "V_{CE} monitoring circuit" will be trigger and cut off IGBT by "soft turn-off circuit". when V_{CEref} drops to 10V(ie.leave monitoring dead area t_{dead}) and V_{CE} voltage rises above the reference voltage at any time(V_{CE}>V_{CEref}). The various different operating conditions are depicted in fig.4.8.

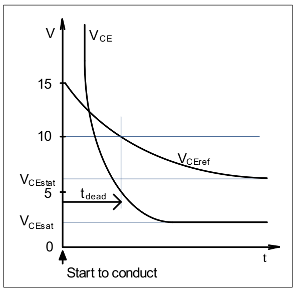

Fig 4.8a,Usual case

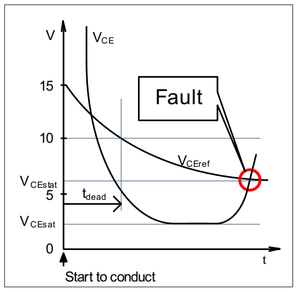

Fig 4.8b,Short circuit during operation

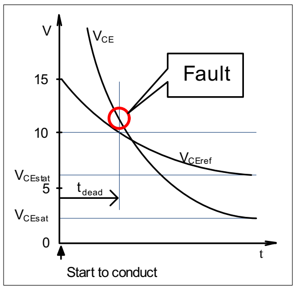

Fig 4.8c,IGBT turns on too slowly or dead time is too short

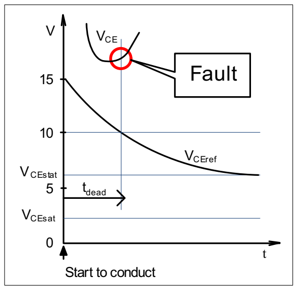

Fig 4.8d,Short circuit during turn-on

The monitor sensitivity of "V_{CE} monitoring circuit" is adjusted by changing dead time t_{dead}.This can be realized by extending or reducing monitoring dead area via adusting C_{CE}.Please make sure the tatal time from IGBT conduct(start from short circuit) to IGBT totally turn-off by soft turn-off circuit must shorter than IGBT safe soft circuit time(usually 10us or 6us, details pls refer to IGBT supplier). The total time includes t_{dead}, $t_{d(err)}$, t_{SC}, IGBT turn-off trailing time and safety time.

The internal V_{CEref} of PSHI 222W(adjusted from factory) is R_{CE}=36kΩ, C_{CE}=330pF,then V_{CEstat} = 6.3V, t_{dead} = 3.3μs. In real application, suitable value can be adjusted by paralleling external R_{CE},C_{CE} between V_{CEref} (Pin 23,33) & E (Pin 21,31) with internal resistors and capacitors.See fig.4.6.

1200V IGBT suggest to be connected with a 36kΩ resistor, then V_{CEstat} = 5.2V; t_{dead} = 3.3μs.
1700V IGBT suggest to be connected with a 140pF capacitor, then V_{CEstat} = 6.3V; t_{dead} = 4.4μs.

4.9 Additional isolation power supply output and snubber capacitor (PSHI 222WA)
In order to avoid voltage fluctuation by high current,PSHI 222WA has +16V power supply C+pins access. User can also get ±16V isolation power supply between C+/C- and E by using internal DC/DC isolation power supply on secondary side. Above-mentioned E is simulated as GND to IGBT emitter.
To avoid voltage sag because of high current,PSHI 222WA must increase an external snubber capacitor C_{SUP} between C+/C- and E in real application. Snubber capacitor C_{SUP} should be closed to driver's pins. Due to DC/DC working at freqency of 500kHz,high-frequency low-loss MLCC(multilayer ceramic capacitor) with high ripple current must be used as snubber capacitor. The capacitance is depending on output current, each channel needs 20μF at least in general.
Snubber capacitor C_{SUP} is recommended to be fixed onto the under parts of driver's inner side in order to avoid reducing isolation grade for routing reason. See fig.4.9

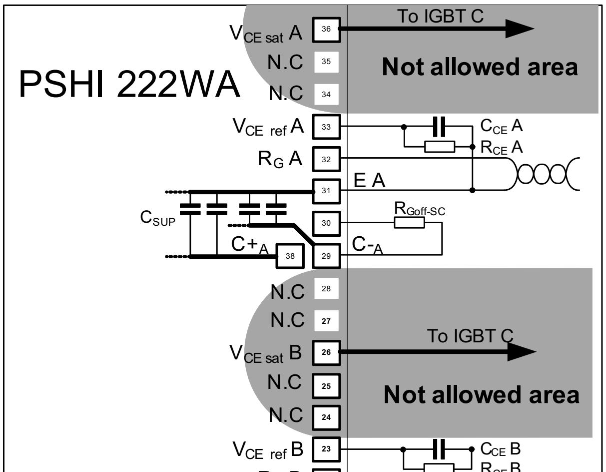

Fig 4.9 C_{SUP} position

5. Pins function and description

5.1 Pins array and designation refer to fig.4.2

5.2 PSHI 222W, PSHI 222WA pins function

PIN NO.	Designation	Function	PIN NO.	Designation	Function
1	N.C	Physically non existent	19	C- B	BOT -16V isolation power supply, connect with cathode for snubber capacitor
2	N.C	Physically non existent	20	$R_{GOFF-SC}$ B	BOT "soft turn-off" resistor
3	GND	ground	21	E B	BOT supply-ground & signal-ground, connect with IGBT auxiliary emitter
4	GND	ground	22	R_G B	BOT gate driving signal output, connect with IGBT gate by external gate resistor
5	V_S+15V	supply voltage, +15V	23	$V_{CE\ ref}$ B	BOT R; C net, set V_{CEref} curve
6	V_S+15V	supply voltage, +15V	24	N.C	Physically non existent
7	ERROR	error signal, open-collector output, low level active	25	N.C	Physically non existent
8	V_{in} A	TOP PWM input + 15V level	26	$V_{CE\ sat}$ B	BOT $V_{CE\ sat}$ monitoring input, connect with IGBT collector
9	V_{in} B	BOT PWM input + 15V level	27	N.C	Physically non existent
10	t_{TD} B	BOT interlock dead time setting (half-bridge mode active)	28	N.C	Physically non existent
11	t_{TD} A	TOP interlock dead time setting (half-bridge mode active)	29	C- A	TOP-16V isolation power supply, connect with cathod for snubber capacitor
12	MODE	working mode select, GND: independen; Not bridged: half-bridge	30	$R_{GOFF-SC}$ A	TOP "soft turn-off" resistor
13	ERROR in	External error input, low level active	31	E A	TOP supply-ground & signal-ground, connect with IGBT auxiliary emitter
14	N.C	Physically non existent	32	R_G A	TOP gate driving signal output, connect with IGBT gate by external gate resistor
15	N.C	Physically non existent	33	$V_{CE\ ref}$ A	TOP R; C net, set V_{CEref} curve
16	N.C	Physically non existent	34	N.C	Physically non existent
17	N.C	Physically non existent	35	N.C	Physically non existent
18	N.C	Physically non existent	36	$V_{CE\ sat}$ A	TOP $V_{CE\ sat}$ monitoring input,connect with IGBT collector
			37	C+ B (22WA)	BOT +16V isolation power, connect with anode for snubber capacitor
			38	C+ A (22WA)	TOP +16V isolation power, connect with anode for snubber capacitor

6.Mounting dimensions

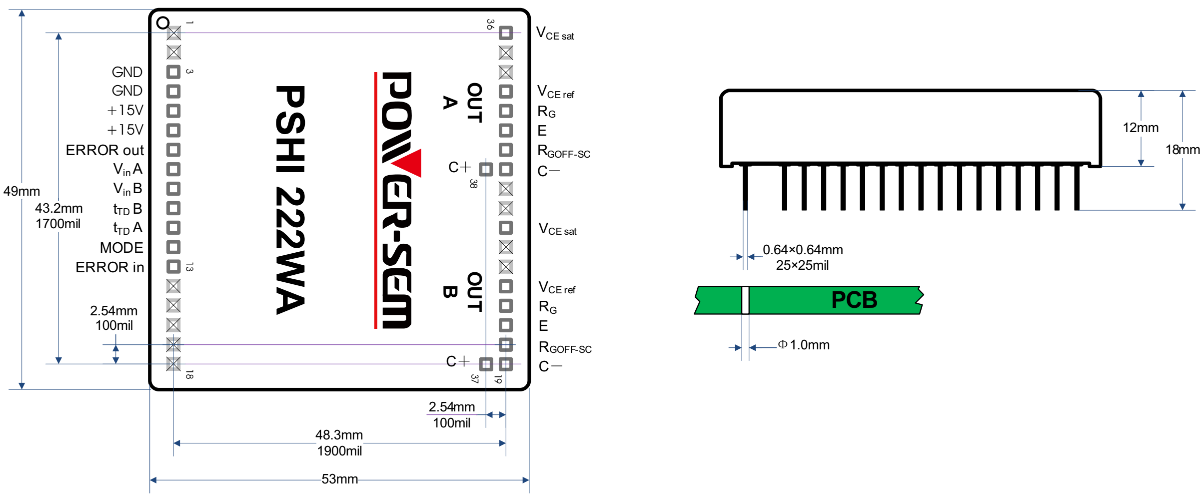

Fig 6 PSHI 222W（A）installation dimensions