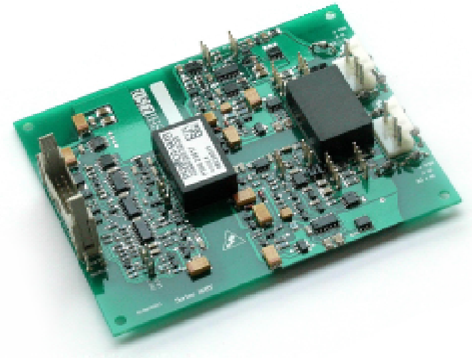
1. Absolute Maximum Ratings(Ta=25℃)

Symbol	Terms	Values	Units
V_S	Supply voltage primary	18	V
V_{iH}	Input signal voltage(HIGH)	V_S+0.3	V
$I_{outPEAK}$	Output peak current	±8	A
I_{outAV}	Output average current	±50	mA
V_{CE}	Collector-emitter voltage sense	1200/1700	V
dv/dt	Rate of rise and fall of voltage	75	kV/μs
$V_{isol\ IO}$	Isolation test volt.IN-OUT(1min.AC)	4000	V
$R_{Gon\ min}$	Minimal R_{Gon}	3	Ω
$R_{Goff\ min}$	Minimal R_{Goff}	3	Ω
$Q_{out/pulse}$	Charge per pulse	4.8	μC
T_{op}	Operating temperature	-25~85	℃
T_{stg}	Storage temperature	-25~85	℃

2. Electrical Characteristics

Symbol	Terms	Values			Unit
		min	typ	max	
V_S	Supply voltage primary	14.4	15	15.6	V
I_S	Supply current(max.)		0.32[1)]		A
I_{SO}[2)]	Supply current primary side(standby)		0.12		A
$V_{IT}+$	Input threshold voltage(HIGH)min For 15V input level	12.5			V
$V_{IT}-$	Input threshold voltage(LOW)max For 15V input level			3.6	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		-8		V
f	Maximum operating frequency		see Fig.1		
$t_{d(on)IO}$	Input-output turn-on propagation time		1.4		μs
$t_{d(off)IO}$	Input-output turn-off propagation time		1.4		μs
$t_{d(err)}$	Error input-output propagation time		1[3)]		μs
V_{CEstat}	Reference voltage for V_{CE} monitoring		5.6[4)]/6.3[5)]		V
C_{PS}	Primary to secondary capacitance		12		Pf

1) This current value is a function of the output load condition
2) Operating fsw=0Hz
3) This value is not considerred by t_{on} and t_{dead} of IGBT,but adjusted by R_{CE} and C_{CE}
4) With R_{CE}=18k Ω,C_{CE}=330pF(PSHI23S12 used for 1200V IGBT)
5) With R_{CE}=36k Ω,C_{CE}=470pF(PSHI23S17 used for 1700V IGBT)



POWER-SEM
PCB IGBT Driver
PSHI 23S12
PSHI 23S17

High Power Double Series IGBT Driver

Features

- PSHI 23S12 drives all series IGBTs with V_{CES} up to 1200V(V_{CE} -monitoring adjusted from factory for 1200V IGBT)
- PSHI 23S17 drives all series IGBTs with V_{CES} up to 1700V(V_{CE} -monitoring adjusted from factory for 1700V IGBT)
- CMOS/TTL(HCMOS) compatible input buffers
- Short circuit protection by V_{CE} monitoring
- Soft short circuit turn-off
- Isolation due to transformers(no opto couplers)
- Supply undervoltage protection(<13V)
- Error memory/output signal (LOW OR HIGH LOGIC)
- Internal isolated power supply
- Short-pulse control function(<500ns restrained)
- Forced synchronization of TOP & BOT IGBTs gate signal

Typical Applications

- 2400V/3400V high-voltage application
- Single and bridge circuit
- Mid-voltage inverter
- induction heating
- High power UPS
- High frequency SMPS

3. Product Overview

The new intelligent double series IGBT driver, PSHI23S12 respectively PSHI23S17 is a standard driver for dual IGBTs in series in the market which drives all IGBT's with V_{CE} up to 1200V and 1700V.
To protect the driver against moisture,dust and salt fog, it is coated with three-proof protective agents. Different types of IGBT can be droved easily by adjusting R_{Gon}, R_{Goff},and $R_{Goff-SC}$ value.The output buffers have been improved to make it possible to switch up to 400A IGBT modules at frequencies up to 20kHz.High power output can be achieved by paralleling more IGBTs.The driver has powerful function to correct the discrepancy for gate signal of TOP & BOT IGBT's, especially make sure the consistency of gate signal during soft turn-off process. With additional"single-driver over-voltage turn-on" function, the driver guarantee IGBT's safe and reliable in series use.

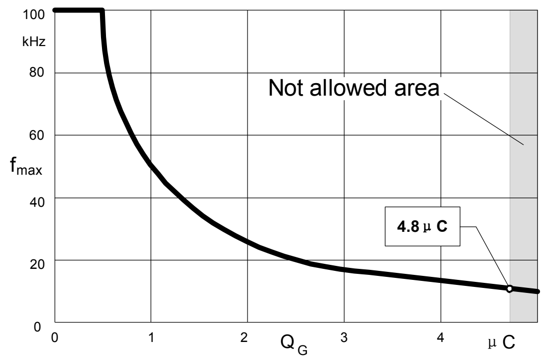


Fig.1 Relationship between maximum operating frequency and charge per pulse

A new function has been added to the short circuit protection circuit(Soft Turn Off), this automatically increases the IGBT turn off time and hence reduces the DC voltage overshoot enabling the use of higher DC-bus voltages.
With the function of forced synchronization of TOP & BOT IGBTs' gate signal, the driver can supply the signal synchronization with error < 20ns (the error is limited by the precision error of R_G) no matter when usual case or soft turn-off.
Integrated DC/DC converters with high galvanic isolation (4kV/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(0/+15V) without the requirement of isolation. All information that is transmitted between input and output uses ferrite transformers, resulting in high dv/dt immunity(75kV/ μ s).

4. Block diagram PSHI 23S

System structure features(see Fig 2).

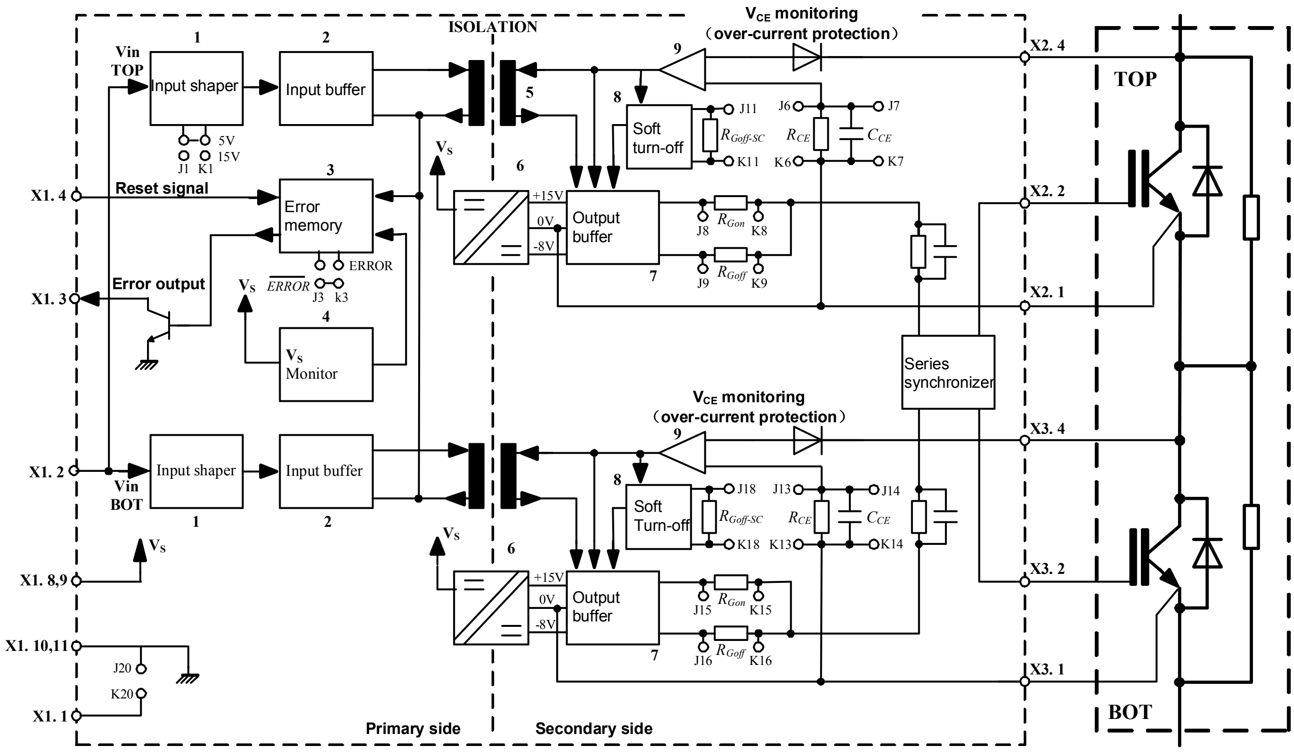
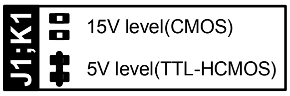


Fig.2 System structure of PSHI 23S

Systerm structure and performance features:

- "INPUT LEVEL SELECTOR" circuit can choose 5V (TTL,HCMOS) or 15V (CMOS) signal. By comparing a signal with a level, it fix input signals and enhance improve driver's anti-jamming ability. COMS is adjusted from factory for 15V, but can be changed by the user to 5V HCMOS level by solder bridging between J1 and K1. The standard level is +15V (factory adjusted) intended for noisy environments or when long connections (L>50cm) between the external control circuit and PSHI 23S are used, where noise immunity must be considerate.For lower power, and short connections between control board and driver, the TTL-HCMOS level (+5V) can be selected by solder bridging between J1and K1.

  When connecting PSHI23S to control board using short connecting lead, no special attention needs to be taken.Otherwise, if the length is 50cm or more (we suggest to limit the cable length to about 1 meter), some care must be taken.The TTL (5V) level should be avoided and CMOS(15V) is to be used instead; flat cable must have the pairs of conductors twisted or be shielded cable is used, it can be connected to pins J20 & K20 and x1.1 coupled to ground through a capacitor, resistor or jumper.



  5V level is not commended to be used for long input cable because of exsisting interference.

  An internal pull-down resistor of driver signal inputs keeps the IGBT in OFF state in case V_{in} connection is interrupted or left non connected.

  The following overview is showing the input threshold voltages:

V_{IT}+ (High)	min	typ	max
15 V	9.5 V	11.0 V	12.5 V
5 V	1.8 V	2.0 V	2.4 V

V_{IT}- (Low)	min	typ	max
15 V	3.6 V	4.2 V	4.8 V
5 V	0.50 V	0.65 V	0.80 V

- "INPUT BUFFER" circuit converts input signals in order to make them meet the needs of ferrite transformers and avoid other false signals being transmitted to output side.
- The "ERROR MEMORY" blocks the transmission of all turn-on signals to the IGBT and output error signal by a OC transistor if either over-current or under-voltage is detected. Default error signal output is high level active (high level fault).
- The "V_S MONITOR" ensures that V_S actual is not below 13V.Once V_S below 13V, system will blocks the transmission of all input signals to the IGBT.
- With a "FERRITE TRANSFORMER" the information between primary and secondary may flow in both directions and high levels of dv/dt and high isolation voltage.At the same time, it can also restrain the short-pulse signals below 500ns.
- A high frequency "DC/DC power supply" used in "power output circuit" to supply isolation power supply with output voltage:+15V/-8V. Power supply use full-bridge circuit,filtering and stablization, which make the driver get enough gate voltage without external isolation power supply. The drivers and controlled system can use same power supply(+15V), even if we are using more than one PSHI23S(+15V).
- In case of short-circuit, a further circuit (SOFT TURN-OFF) can realize the IGBT over-current protection by " over-current monitor". This produces a smaller voltage spike above the DC link by reducing the di/dt value to avoid damage IGBT by high voltage spike.The default resistor used for soft turn-off is 22 Ω, this "soft turn-off time" can be reduced by connecting a parallel resistor $R_{Goff-SC}$ on J11,K11 & J18,K18 to reduce "soft turn-off time".
- " V_{CE} 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.

  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 τ (controlled by C_{CE})(see Fig.3).

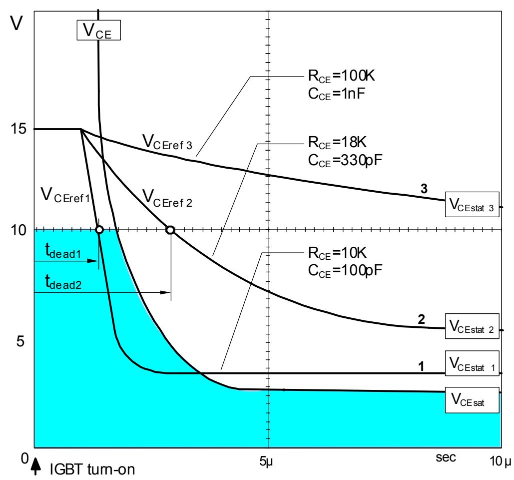


Fig.3 V_{CEref} Protection waveform with parameters R_{CE} & C_{CE}

V_{CEsat} threshold is a static value of V_{CEref} which is controlled by resistor R_{CE}(see Fig.4a).It can be adjusted by resistor R_{CE} (J6,K6;J13,K13) 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.4b) it controls the dead time t_{dead} when IGBT just starts to conduct till V_{CEsat} monitoring starts.

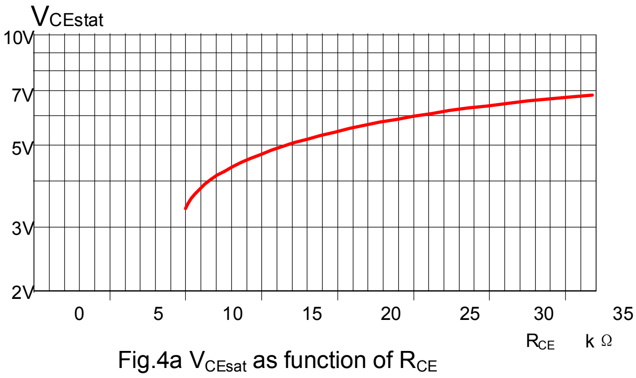


Fig.4a V_{CEsat} as function of R_{CE}

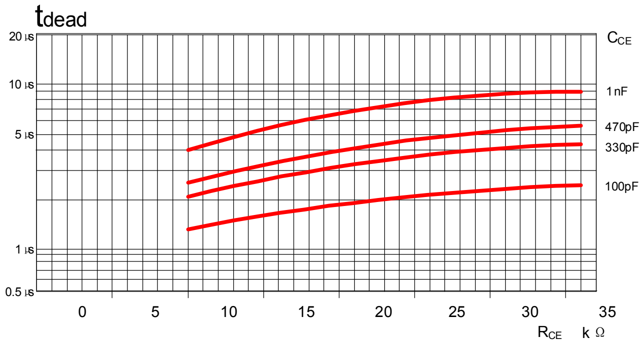


Fig.4b t_{dead} as function of R_{CE} & C_{CE}

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 monitor 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.5.

The monitor sensitivity of "V_{CE} monitoring circuit" is adjusted by changing dead time t_{dead}.

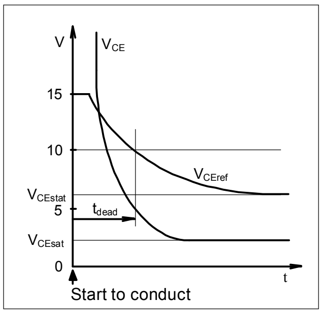


Fig.5a Usual case

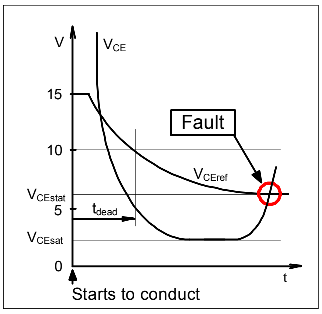


Fig.5b Short circuit during operation

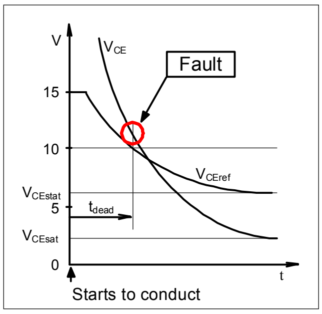


Fig.5c IGBT turns on too slowly or dead time is too short

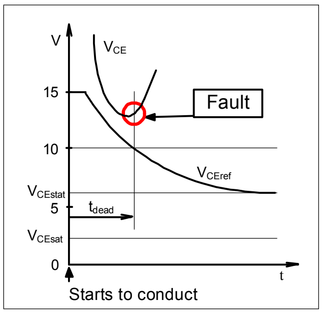


Fig.5d Short circuit during turn-on

PSHI 23S12 driver with R_{CE} =18k Ω, C_{CE}=330pF adjusted from factory.

PSHI 23S17 driver with R_{CE} =36k Ω, C_{CE}=470pF adjusted from factory.

(see Fig.3 curve 2)

Attention:If this function is not used, for example during the experimental phase(not connect to IGBT), the V_{CE} MONITORING(X2.5;X3.5) must be connected with the EMITTER output(X2.1;X3.1) to avoid possible fault indication and consequent gate signal blocking.

- "The POWER OUTPUT" is responsible for providing enough current to IGBT for turn-on and turn-off.If these signals do not have sufficient power, the IGBT will not switch properly, and additional losses or even the destruction of the IGBT may occur. According to the application (switching frequency and gate charge of the IGBT),different R_{Gon} and R_{Goff} must be selected. The internal R_{Gon} of the driver is 22 Ω, R_{Goff} is 22 Ω. Need R_{Gon} can be gained by paralleling relevant resistor on pins J8K8 and J15K15;need R_{Goff} can be gained by paralleling relevant resistor on J9K9 and J16K16.

Please make sure that the total value of R_{Gon} & R_{Goff} not below 2.7 Ω in order to avoid damaging driver.

- "Series Synchronization circuit" make sure the gate signal of two IGBTs in series synchro operation.The circuit can supply the signal synchronization with error < 20ns(the error is limited by the precision error of R_G) no matter when usual case or soft turn-off. It also has the function of single IGBT over-voltage turn-on which guarantee the series IGBTs safe and reliable(see Fig.9b).

5. Input Interface Criterion

1). Input Signal Level

Input PWM signals can be CMOS/TTL(HCMOS) level, active-logic control(high level IGBT switch on),controlled signal is connected with Pin X1.2.

2).Error Output

When over-current occurs, driver can cut off the series two IGBT TOP & BOT automatically. Fault signals output X1.3 can demand high level active(high level is fault), or output low level active.When high level active, Pin X1.3 is required to be connected through a pull-up resistor.While low level active,Pin X1.3 need not to connnected with pull-up resistor. The voltage of pull-up circuit should below 24V, and external power supply should below 6mA (see Fig 6).

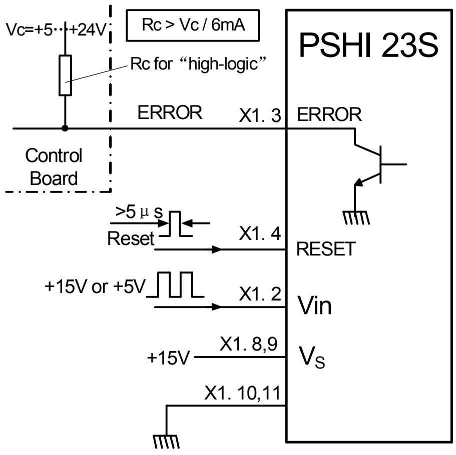


Fig.6 Driver status information ERROR and RESET

3).Error Reset

Install X1.4 HIGH for more than 5 us,error reset automatically.

4).Connecting leads between Driver and Control Board.

The length between driver and control board should be kept short. If the length is below 50cm, connect with common flat cable is OK (see Fig 7a) .If the length is 50-100cm,only CMOS level can be used for signal transmission,flat cable must have the pairs of conductors twisted or be shielded. If a shielded cable is used, it can be connected to pin X1.1 and solder bridged J20 with K20. The connecting leads between driver and control board is not allowed to more than 1meter (see Fig 7b).

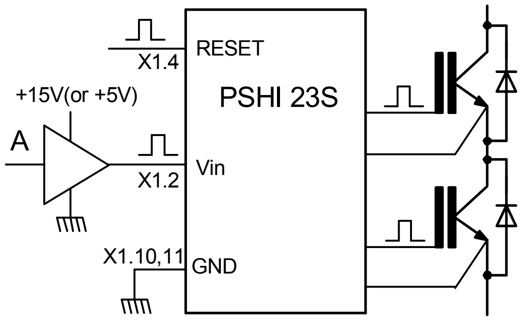


Fig.7a Connecting PSHI23S with short cables(<50cm)

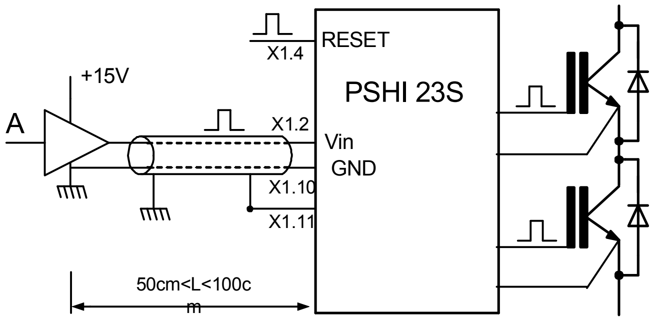


Fig.7b Connecting PSHI23S with short cables(50-100cm)

6. Dimensions and connections of The PSHI 23S

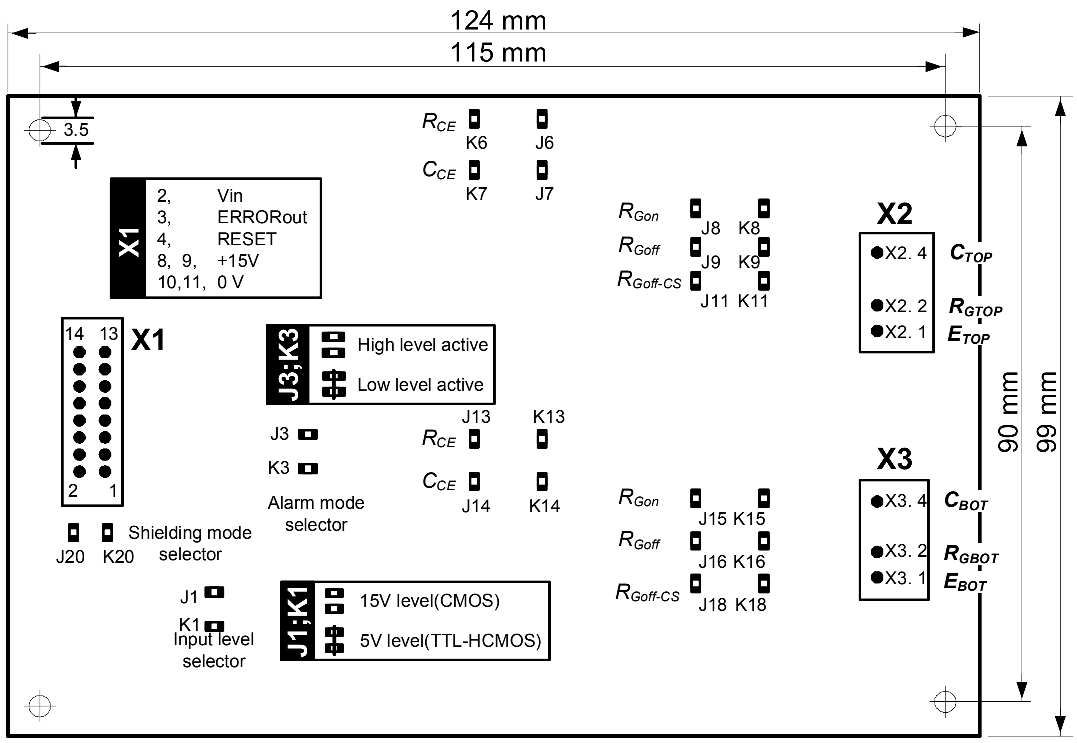


Fig.8 Installation dimensions and pins place instruction

Tab.2 Pins place instruction from J1,K1 to J20,K20

Function	Pin description	Adjustment by factory	Possibilities of functions
Input level selector	J1、K1	not bridged：15V CMOS	soldering bridged：5V HCMOS
Error-logic	J3、K3	not bridged：High level active	solering bridged：Low level active
R_{CE} TOP	J6、K6	not bridged： PSHI23S12,18kΩ PSHI23S17,36kΩ	adjustment according Fig.4
C_{CE} TOP	J7、K7	not bridged： PSHI23S12,330pf PSHI23S17,470pf	adjustment according Fig.4
R_{Gon} TOP	J8、K8	not bridged：22Ω	adjustment automatically
R_{Goff} TOP	J9、K9	not bridged：22Ω	adjustment automatically
$R_{goff\text{-}SC}$ TOP	J11、K11	not bridged：22Ω	adjustment automatically
R_{CE} BOT	J13、K13	not bridged： PSHI23S12,18kΩ PSHI23S17,36kΩ	adjustment according Fig.4
C_{CE} BOT	J14、K14	not bridged： PSHI23S12,330pf PSHI23S17,470pf	adjustment according Fig.4
R_{Gon} BOT	J15、K15	not bridged：22Ω	adjustment automatically
R_{Goff} BOT	J16、K16	not bridged：22Ω	adjustment automatically
$R_{goff\text{-}SC}$ BOT	J18、K18	not bridged：22Ω	adjustment automatically
Shield	J20、K20	not bridged：not connect with GND	soldering bridged：screening to GND

Tab.2 Pins function instruction

7. Application/Handling

1).The CMOS inputs of the driver are extremely sensitive to overvoltage. Voltages higher than (V_S +0.3V) or under-0.3V may destroy drivers. Therefore, the signal of control board must be observed for above mentioned demand,and not-used pins should be soldering bridged with GND in order to avoid un-equipped pins. Pay more attention to electrostatic breakdown.

2).The connecting leads between the driver and the power module must be as short as possible, and should be twisted.

3).Any parasitic inductance should be minimized, turn-off over-voltage can be decreased by differenet snubber circuit.

4).It is important to feed any ERROR back to the control circuit to switch the equipment off immediately in such events. Repeated turn-on of the IGBT into a short circuit, with a frequency of several kHz, may destroy the device.

Waveform comparision when soft turn-off

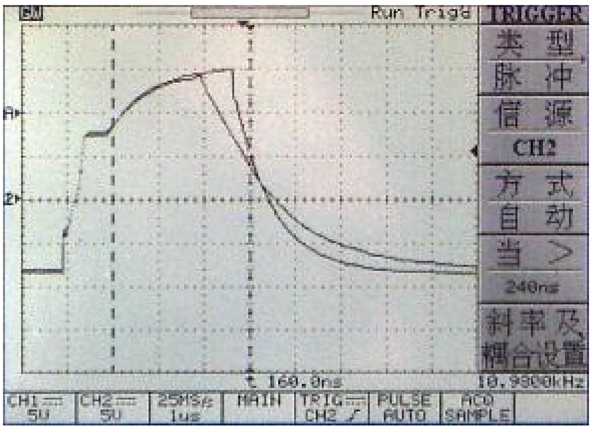


Fig.9a Soft turn-off waveform of PSHI23 without synchronization circuit

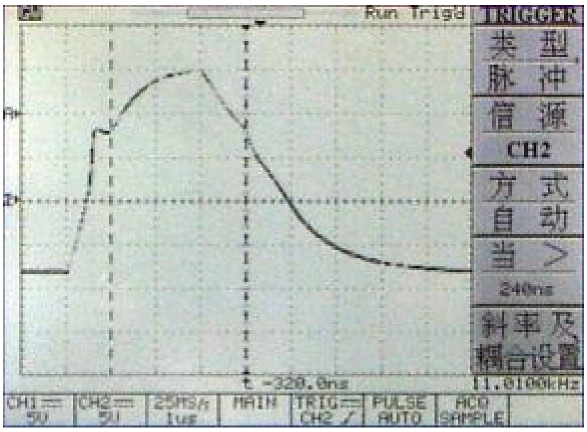


Fig.9b Soft turn-off waveform of PSHI23S with synchronization circuit