SEMIKRON
innovation + service

SEMIKUBE®

USER MANUAL

VERSION 00

DATE: 12 / 2015

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Table of contents

1 BEFORE USING THE PRODUCT

1.1 SAFETY PRECAUTIONS

In order to avoid mistakes and injuries when processing the SEMIKUBE®, SEMIKRON may use 3 levels of warning messages within this document:

DANGER!

Attract the attention of the user on a potentially hazardous situation which, if not avoided, **will** result in death or serious injury.

WARNING!

Attract the attention of the user on a potentially hazardous situation which, if not avoided, **may** result in death or serious injury.

CAUTION!

Attract the attention of the user on a potentially hazardous situation which, if not avoided, **may** result in minor injury or property damage.

1.2 PURPOSE OF THE USER MANUAL

This manual deals with procedures for unpacking, handling, installing, operating and maintaining SEMIKUBE® power electronics assemblies.

The SEMIKUBE® platform is a range of power electronics assemblies that can be adapted in accordance to a customer specification. The basic power stack is called a KUBE.

The present manual summarizes procedures for standard power electronics assemblies supplied by SEMIKRON Solution Centers. This includes:

08800900	IGD-8-426-E1F12-BH-FA	088001003	IGDD6-4-426-D3816-E1F12-BL-FA
08800930	IGD-8-326-E1F12-BH-FA	088001004	IGDD6-1-326-D1616-E1N6-DL-FA
08800980	IGDD6-2-326-D1616-E1F12-DH-FA	088000445	IGD-1-424-P1N4-DL-FA
08800991	IGDD6-2-426-D1616-E1F12-DH-FA	088000446	IGD-2-424-P1N6-DH-FA
088001001	IGDD6-1-426-D1616-E1N6-DL-FA	088000447	IGD-4-424-P1F7-BL-FA
088001002	IGDD6-4-326-D3816-E1F12-BL-FA	088000448	IGD-8-424-P1F9-BH-FA

It does not take into account all converter configurations. Further user manuals are available for other customer specific SEMIKUBE® power electronics assemblies. Please contact your local Solution Center Application Engineer for further information.

Article numbers above are generic references of SEMIKUBE®. Due to continuous improvement of the product two letters are added to the article number to denote the revision of SEMIKUBE®.

Article number	
08800447	AA
Item number	2 digit evolution recognition

Please ask Solution Centers for the latest version of your selected item.

1.3 QUALIFIED PERSONS ONLY

Only appropriately trained persons who are familiar with and understand the contents of this manual are authorized to work on and with this product. In addition, these persons must have received safety training to recognize and avoid hazards. These persons must have sufficient technical training, knowledge and experience, and be able to foresee and detect potential hazards that may be caused by using the product, by changing the mechanical, electrical and electronic equipment of the entire system in which the product is used.

All persons working on and with the product must be familiar with all applicable standards, directives, and accident prevention regulations when performing such work.

1.4 SAFETY INSTRUCTIONS

DANGER!

High voltage present

Many sections of the SEMIKUBE® are directly connected to the mains power supply, in particular AC and DC bus bars, the capacitors bank, the SEMIKUBE® driver, the SEMITRANS® 3 power IGBT modules and IGBT Gate Bus Board. Voltages up to 1000 V_{DC} can be present AND accessible on the assembly.

So please ensure the following recommendations are followed :

- SEMIKUBE® shall be mounted into a closed cabinet where only authorized and qualified personal can access.
- Before performing maintenance on the SEMIKUBE®:
  - Switch off all power sources upstream of SEMIKUBE® power converter
  - Switch off all IGBT power switches
  - Ensure that no dangerous voltage is present inside the cabinet
  - Ensure that capacitor bank is discharged (< $24V_{DC}$)
  - Ensure that fans are switched-off
  - Disconnect all power connections from the Mains and the DC Bus
  - Lock out all power switches

The system integrator has the responsibility to provide the physical protection against direct or indirect contact with live parts, and ingress of external contaminants.

Failure to observe this instruction may result in death or serious injury

DANGER!

Stored Energy

SEMIKUBE® has a DC Bus capacitor bank which may store high energy for a long period.

Please ensure that the DC bus capacitors are completely discharged and that there is no residual voltage left across the capacitors before any intervention.

As an indication for standard versions,

- 460VAC 3-phase converter with electrolytic capacitors

IGD-8-•26-E1F12-BH-FA	$t_{d5\%} = 5\ min$
IGDD6-4-•26-E1F12-BL-FA	$t_{d5\%} = 5\ min$
IGDD6-2-•26-E1F12-DH-FA	$t_{d5\%} = 5\ min$
IGDD6-1-•26-E1N6-DL-FA	$t_{d5\%} = 5\ min$

- 460VAC 3-phase inverter with polypropylene capacitors

IGD-8-424-P1F9-BH-FA	$t_{d5\%} = 9\ min$
IGD-4-424-P1F7-BL-FA	$t_{d5\%} = 7\ min$
IGD-2-424-P1N6-DH-FA	$t_{d5\%} = 6\ min$
IGD-1-424-P1N4-DL-FA	$t_{d5\%} = 5\ min$

The system integrator has the responsibility to check the discharge of their own configuration of capacitor bank. It is mandatory to draw attention to servicing technicians and all people likely to perform work on the product, by a clear label that states that the discharge time of capacitors may be longer than 5s, and to indicate the minimum down time before intervention. A discharge system could be integrated inside the cabinet, please refer to SEMIKRON for validation.

Failure to observe this instruction may result in death or serious injury

WARNING!

Heavy parts handling

Assembling SEMIKUBE® requires handling heavy parts and assemblies. Always wear safety shoes or boots during mechanical assembly and follow local regulations for handling heavy materials.

Failure to observe this instruction may result in death or serious injury

CAUTION!

ESD protection

The driver of the SEMIKUBE® is subject to damage from electrostatic discharge. Each driver connector is equipped with an ESD foam cover. To avoid any electrostatic discharge do not remove the foam before the SEMIKUBE® is completely installed and ready to be connected.

Before working on the SEMIKUBE®, SEMIKRON recommends using conductive flooring, anti-ESD shoes or grounded armbands as explained in IEC 61340-5-1.

Failure to observe this instruction may result in semiconductor damage.

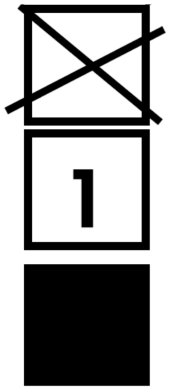
2 UNPACKING

2.1 HANDLING PRECAUTIONS

Poor handling of the SEMIKUBE® can contribute to premature failure of the product. Precautions must be observed when unpacking and handling the assemblies to minimize the possibility of premature failure, especially concerning the driver board.

The products are delivered in cardboard boxes mounted on pallets as defined in the above table. Use a forklift or a pallet truck to move pallets. Do not stack up more than 2 pallets of SEMIKUBE® together.

	Specifications
Pallet type	EUROPALLET NIMP 15
Packaging footprint	800mm x 1,200mm
Packaging height	630mm (pallet and carton box included)
Stacking capability	1 max (1 over 1)



1 Stacking precaution

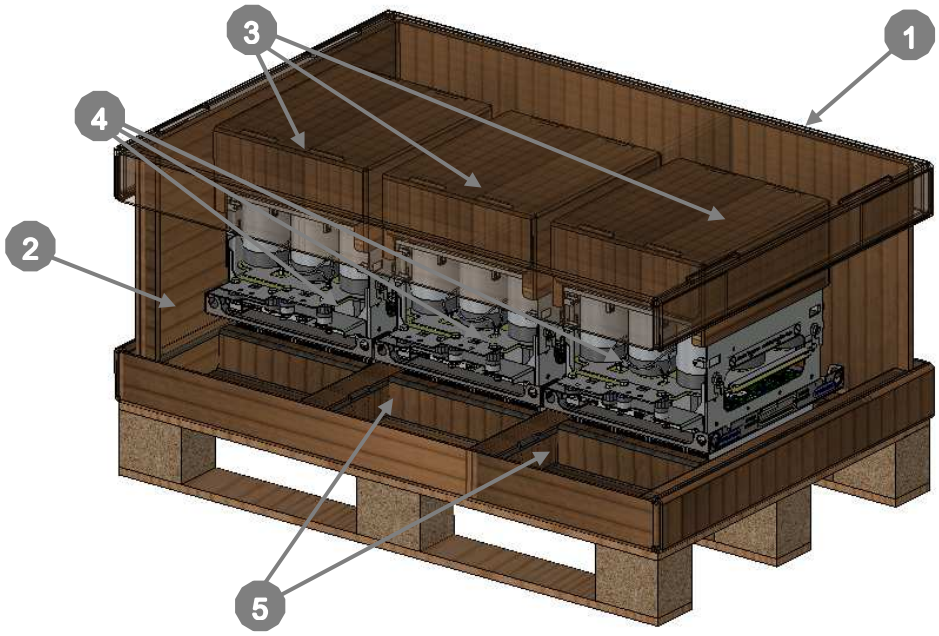
2.2 PACKAGING LIST AND BILL OF MATERIAL

The SEMIKUBE® and its options are delivered in several assemblies: the KUBEs, DC clamps and heatsink fan option. The table below describes the bill of material:

Packaging bill of material						
SEMIKUBE®	KUBE		DC Clamps		Heatsink fan option(*)	
Item #	Qty	Item #	Qty	Item #	Qty	Item #
08800445	1	08800437	-	none	1	08801320
08800446	1	08800574	-	none	1	08801320
08800447	1 1	08800597 08800598	3	08800312 or 08800320	2	08801320
08800448	3	08800594	8	08800312 or 08800320	3	08801320
08800900	3	08800581	8	08800312 or 08800320	-	none
08800930	3	08800931	8	08800312 or 08800320	-	none
08800980	1	08800603	-	none	-	none
08800991	1	08810064	-	none	-	none
08801001	1	08800595	-	none	-	none
08801002	1 1	08801005 08801006	3	08800312 or 08800320	-	none
08801003	1 1	08801007 08801008	3	08800312 or 08800320	-	none
08801004	1	08800602	-	none	-	none

(*) Heatsink fan option is a assembly including fan SKF 16P-230-01 with an air chamber.

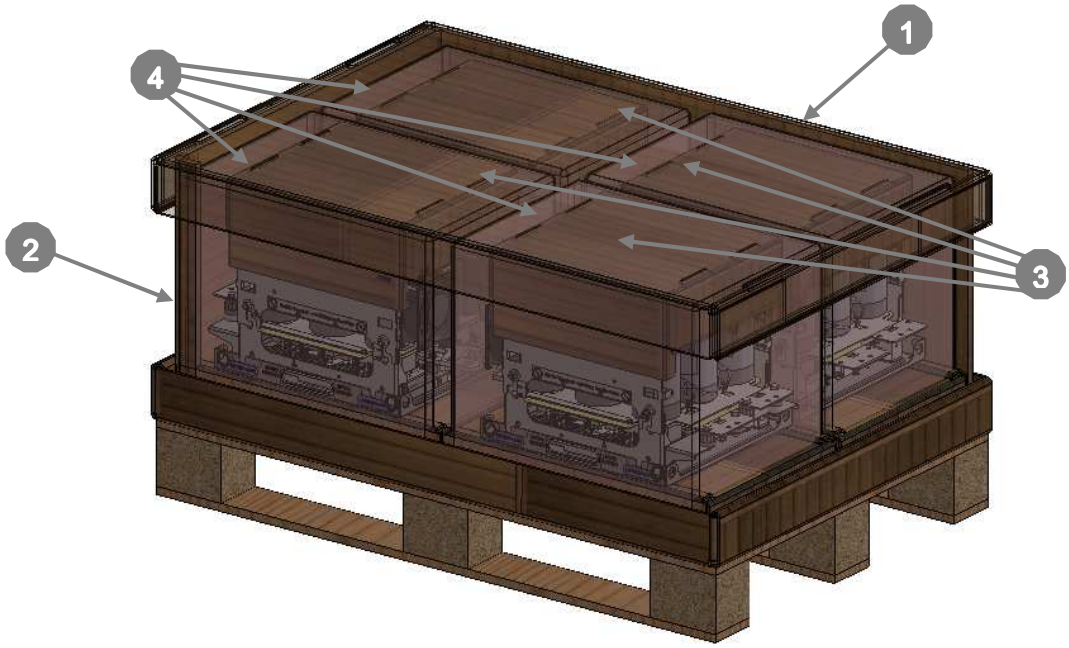
For SEMIKUBE® size T3, three identical KUBEs are aligned on 1 x pallet and the DC clamps options are packed inside the lower compartments of the packing crate.



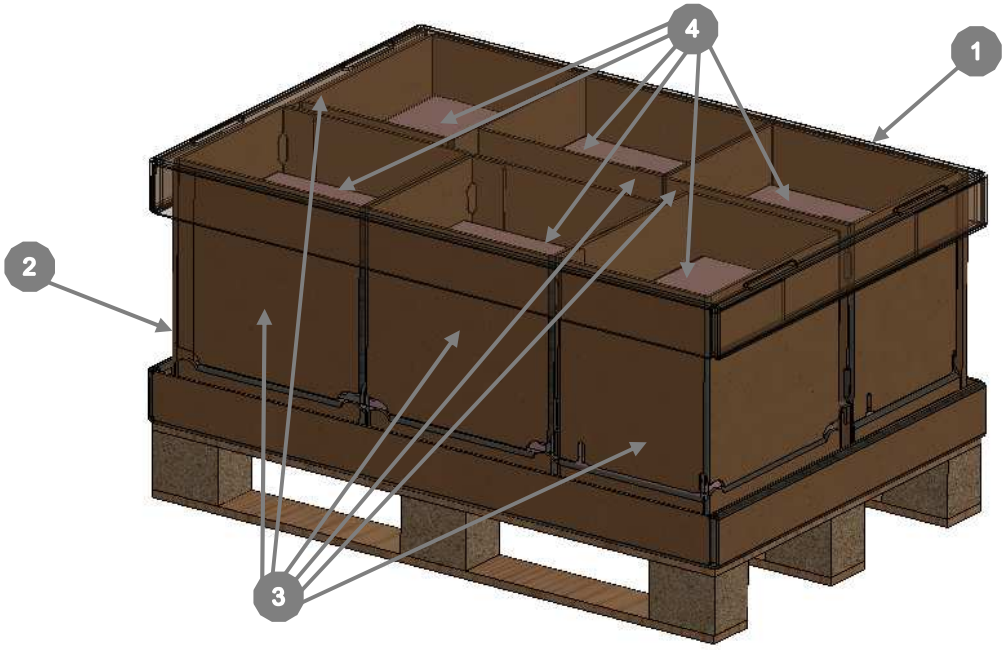
For SEMIKUBE® size T2, 2 x KUBEs with 2 AC phases (“GB” type) and 2 x KUBEs with 1 AC phase (“GH” type) are placed on the pallet.

For SEMIKUBE® size T1, 4 x KUBEs, are placed on the pallet.

For both configurations the DC Clamps options are placed inside the packing crate.



For SEMIKUBE® size T0.5, 6 x KUBEs are placed on the pallet.



For SEMIKUBE® items 08800445, 08800446, 08800447 and 08800448, each heatsink fan is delivered in a separately packed carton.

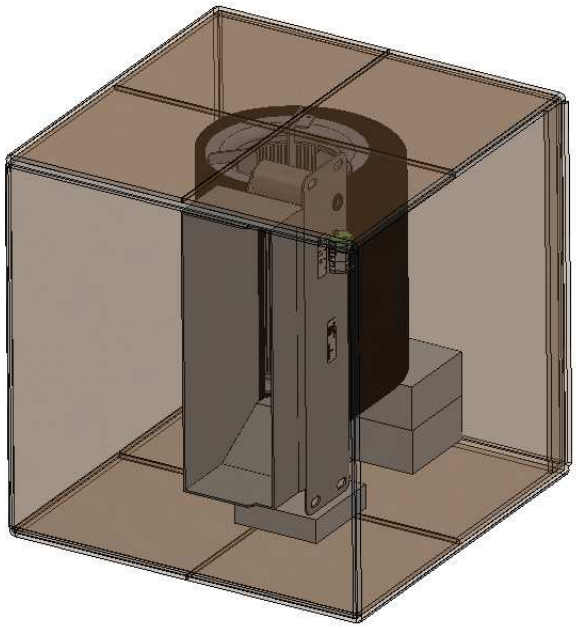


Figure 2 : Heatsink fan option packaging

2.3 SEMIKUBE® UNPACKING PROCEDURE

2.3.1 Size T0.5

Step1	Cut and remove plastic straps
Step2	Open the top side of the box (Part N°1)
Step3	Remove the cardboard belt (Part N°2)
Step4	Remove the unitary cardboard protection of the kube (Part N°3)
Step5	Place at least 2 hooks in the opposite corners of the main frame and lift the KUBE vertically by careful placement of the slings in order to avoid touching any part. (Remove ESD bag during lifting)

2.3.2 Sizes T1, T2 & T3

Step1 Cut and remove plastic straps

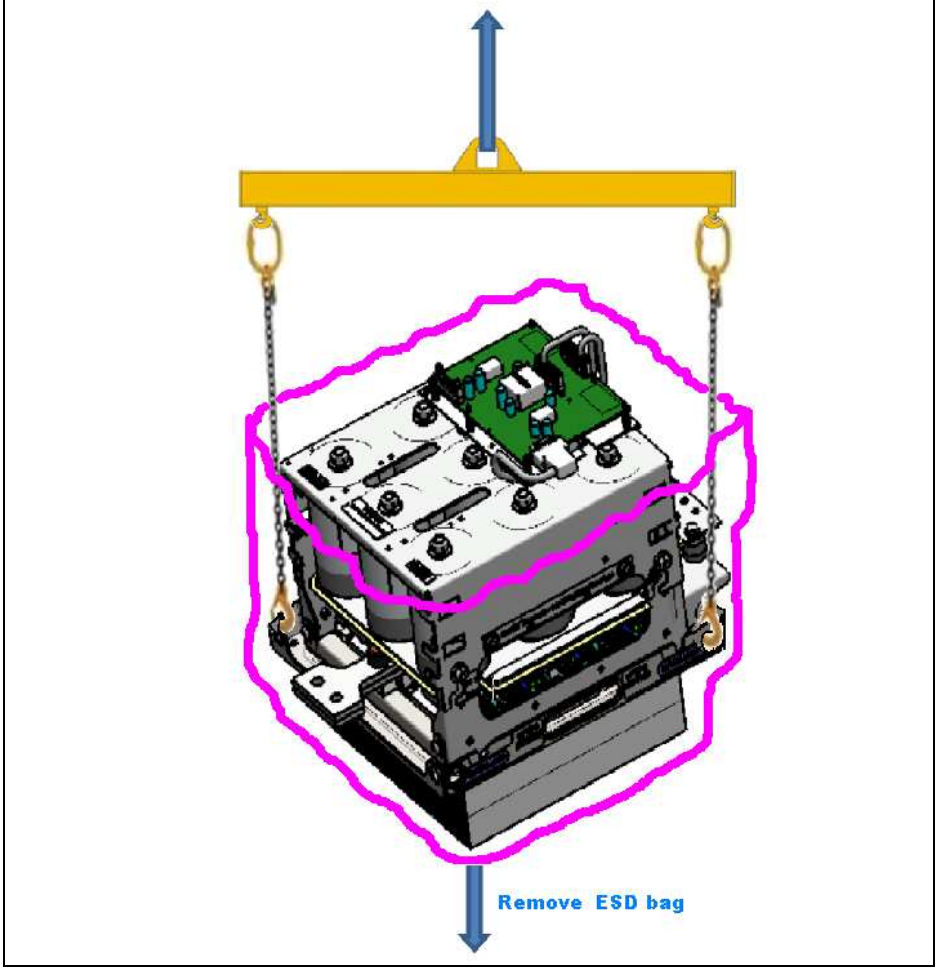
Step2 Open the top side of the box (Part N°1)

Step3 Remove the cardboard belt (Part N°2)

Step4 Open the ESD bag (Part N°4)

Place at least 2 hooks in the opposite corners of the main frame and lift the KUBE vertically by careful placement of the slings in order to avoid touching any part. Remove ESD bag during lifting.

Removing SEMIKUBE® from the packaging



Step5 Carefully place the KUBE on a flat surface free of any pollution and remove the cardboard driver protection (part N°3).

3 INSTALLATION

3.1 GENERAL PRECAUTIONS DURING INSTALLATION OF THE SEMIKUBE®

	**DANGER!**
	Clean installing area
Protect the SEMIKUBE® against ingress of conductive particles during assembly. In particular, never drill cut or saw any metallic part near the SEMIKUBE®. SEMIKUBE® power assembly is IP00: the presence of a metal particle on the assembly may cause arcing and product failure. **Failure to observe this instruction may result in death or serious injury**	

1. Never lift or hold the assembly at locations other than those designated for that purpose. Ideally at the time of installation of the SEMIKUBE® the ambient temperature shall be between 5℃ and 30℃.
2. At least 2 handling points must be used on top for lifting.
3. Protect all external electrical power contacts with contact treatment grease (Electrolube ref: CG53A).
4. The installer shall ensure connections, cables and busbars do not apply any mechanical effort or stress on the SEMIKUBE® electrical terminals.
5. Follow all recommendations regarding ESD protection
    - Always use grounded wrist bands when connecting or disconnecting the controller (including installing and removing the protective foam).
    - After having disconnected the controller, immediately re-fit the protective foam before dismounting the SEMIKUBE®.

The installer is responsible for insulation coordination in the cabinet and shall meet applicable local standards and regulations. Standard EN50178 for a pollution degree 2 requires a minimum distance between main circuit and its environment to be more than 8mm (Basic insulation) for a rated insulation voltage of 1,400kV_{DC}.

3.2 MOUNTING SEMIKUBE® IN A CABINET

3.2.1 Before mounting the KUBEs

Each KUBE has an aluminum DC bus bar. During transport or storage dust may accumulate on the DC bus bars. Therefore it is necessary to clean the DC bus bars before connecting user bus bars or SEMIKRON DC clamps.

Suggested material for cleaning DC bus bars
• Cleaning rag or tissue which does not leave any remnants • Solvent Loctite 7063

1. Thoroughly clean each bus bar using a clean rag soaked in solvent, for a period of 10s.

2. Let the bus bar dry for approximately 30s.

WARNING!

DC clamp mounting non-repeatability

The clamp integrates lamellas which ensure a correct DC connection between DC bus bars of each KUBE when tightening. Those lamellas have a limited spring capability and therefore it is allowed to mount and dismount **twice** the DC clamps on the DC bus bars of the KUBE. Over this value, it is strongly recommended to use new DC clamps.

Failure to observe this instruction may result in product destruction.

3.2.2 Sizes T1 & T0.5

Step 1

Prepare the rails in the cabinet in order to match the attachment points of the main frame of the central KUBE (n°1 on Figure 3: Sizes T0.5 & T1 mounting process)

Secure the KUBE metal chassis on the rails using 4 screws M8 class 8.8 and contact washers. Max Torque: 18 Nm.

Step 2

Valid for SEMIKUBE® items **08800445** & **08800446**

When the fan option is provided, place the metal frame on the two rails and slide the fan assembly in contact with the heatsink of the KUBE.

Secure the heatsink fan assembly using 4 screws M8 class 8.8 and contact washers. Max Torque: 18 Nm.

Figure 3: Sizes T0.5 & T1 mounting process

3.2.3 Size T2

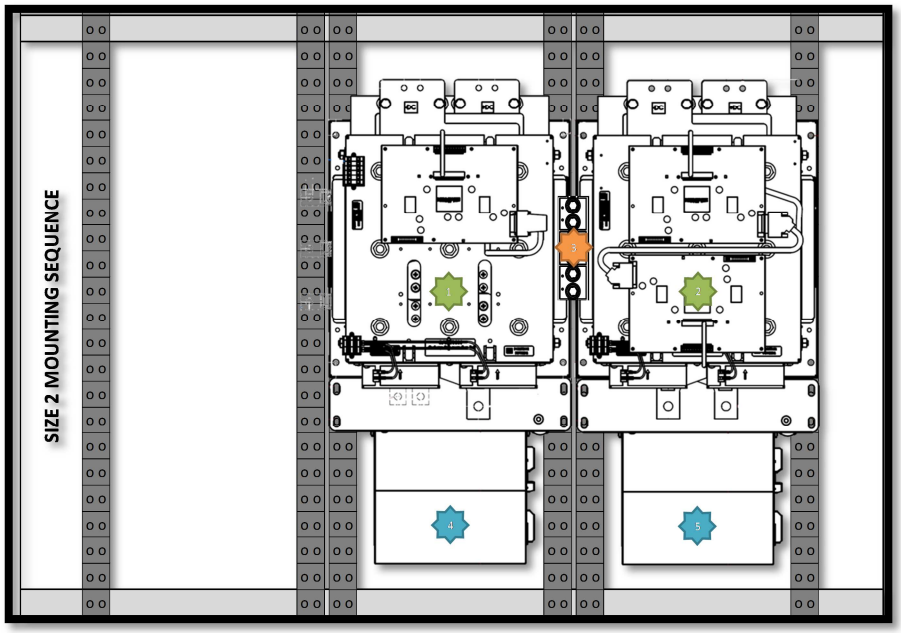


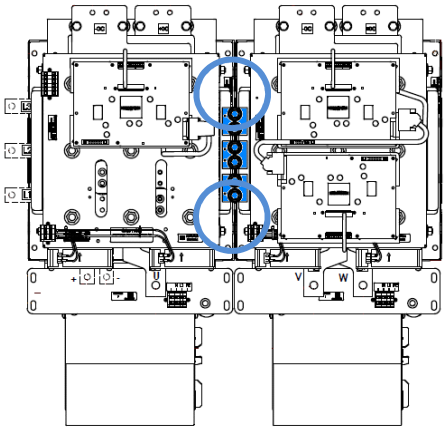
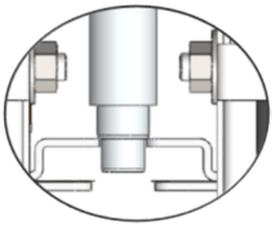
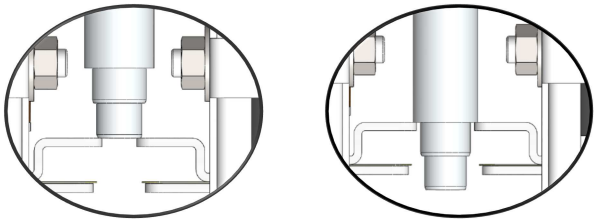
Figure 4: size T2 mounting process

Step 1

Prepare the rails in the cabinet in order to match the attachment points of the main frame of the central KUBE (n°1 on Figure 4: size T2 mount ing process)

Secure the KUBE metal chassis on the rails using 4 screws M8 class 8.8 and contact washers. Max Torque: 18 Nm.

Step 2 Prepare the rails of the right side KUBE (n°2 on Figure 4: size T2 mounting process) in accordance with the correct distance between KUBEs:

<table>
<tr><th colspan="2">Distance between KUBEs</th></tr>
<tr><td>  </td><td>Position the right side KUBE in relation to the central KUBE, respecting the distance between the DC bus bar connections using the jig tool 15751351:
  </td></tr>
<tr><td> 
Valid positioning</td><td> 
Non valid positioning</td></tr>
</table>

Secure the KUBE metal chassis on the rails using 4 screws M8 class 8.8 and contact washers. Max Torque: 18 Nm.

Step 3 Assemble the 3 bipolar DC Clamps according to DC Clamp mounting instruction

Step 4 Valid for SEMIKUBE® items **08800447**

When fan option is provided, place the metal frame on the two rails and slide each fan assembly in contact with the heatsink of each KUBE.

Secure each heatsink fan assembly using 4 screws M8 class 8.8 and contact washers. Max Torque: 18 Nm.

3.2.4 Size T3

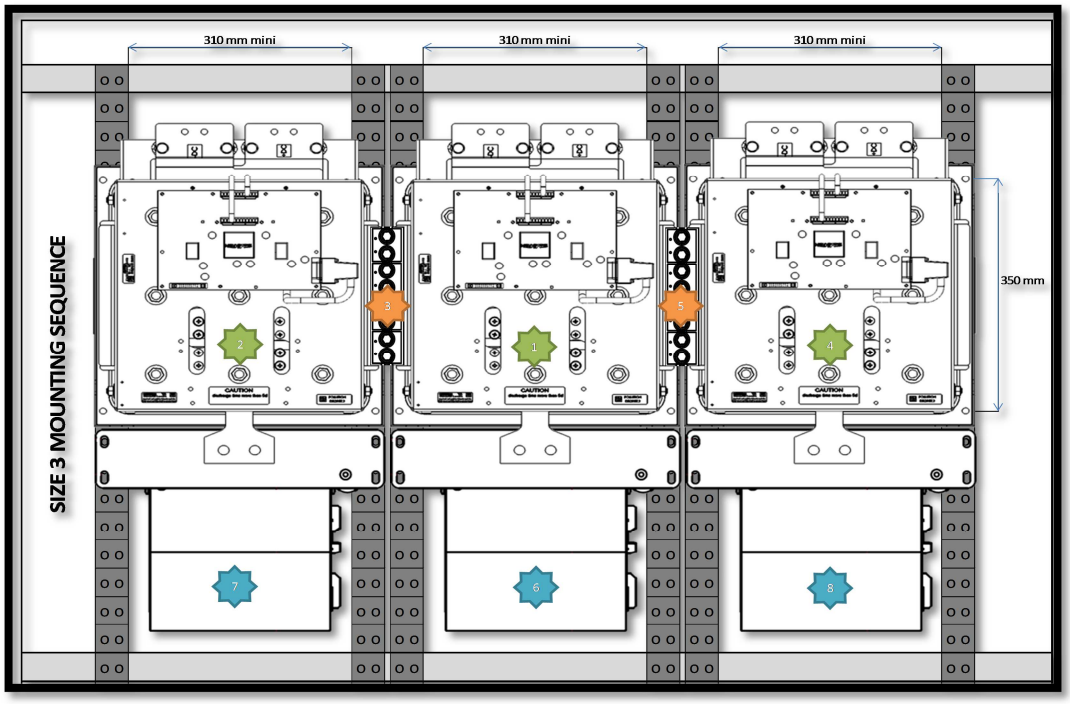
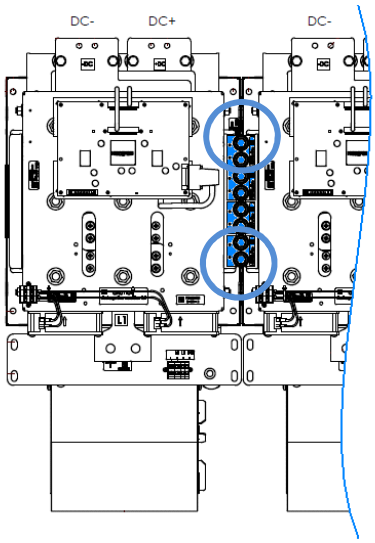
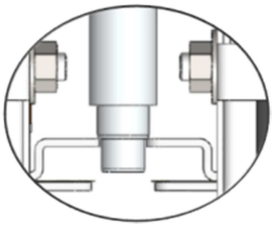
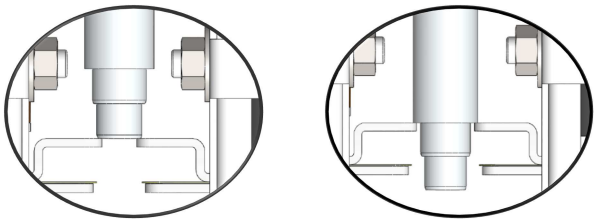


Figure 5: Size T3 mounting process

Step 1 — Prepare the rails in the cabinet in order to match the attachment points of the main frame of the central KUBE (n°1 on Figure 5: Size T3 mount ing process)

Secure the KUBE metal chassis on the rails using 4 screws M8 class 8.8 and contact washers. Max Torque: 18 Nm.

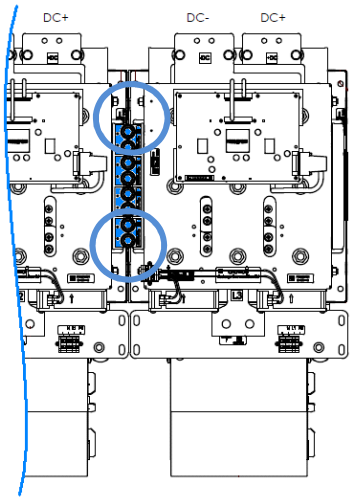
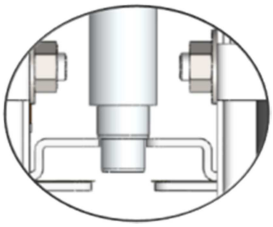
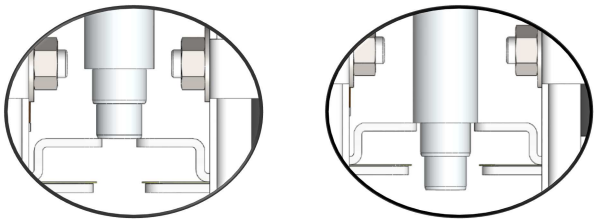
Step 2 — Prepare the rails of the left side KUBE (n°2 on Figure 5: Size T3 mounting process) in relation to the distance between KUBEs:

Distance between KUBEs	
	Position the left side KUBE in relation to the central KUBE, respecting the distance between the DC bus bar connections using the jig tool 15751351: 
 **Valid** positioning	 **Non valid** positioning

Secure the KUBE metal chassis on the rails using 4 screws M8 class 8.8 and contact washers. Max Torque: 18 Nm.

Step 3 Assemble the 4 bipolar DC Clamps according to DC Clamp mounting instruction

Step 4 Prepare the rails of the right-side KUBE (N°3 on Figure 5: Size T3 mounting process) in relation to the distance between KUBEs:

Distance between KUBEs	
	Position the right side KUBE in relation to the central KUBE, respecting the distance between the DC bus bar connections using the jig tool 15751351: 
 **Valid** positioning	 **Non valid** positioning

Secure the KUBE metal chassis on the rails using 4 screws M8 class 8.8 and contact washers. Max Torque: 18 Nm.

Step 5 Assemble the 4 bipolar DC Clamps according to DC Clamp mounting instruction

Step 6 Valid for SEMIKUBE® items 08800448

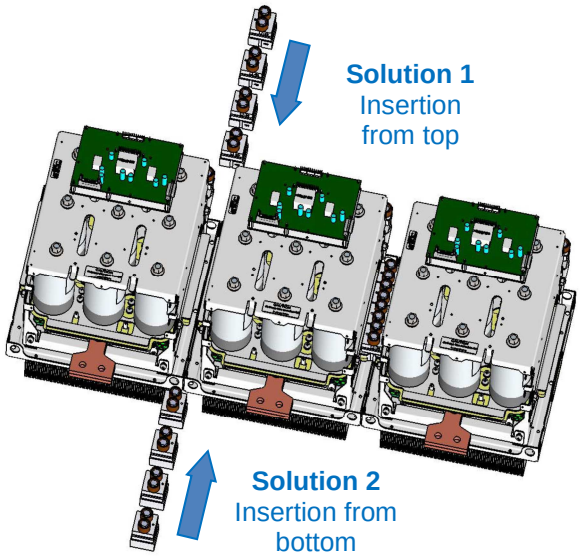
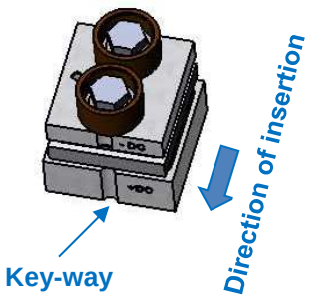
When fan option is provided, place the metal frame on the two rails and slide each fan assembly in contact with the heatsink of each KUBE.

Secure each heatsink fan assembly using 4 screws M8 class 8.8 and contact washers. Max Torque: 18 Nm.

3.2.5 DC Clamp mounting instruction

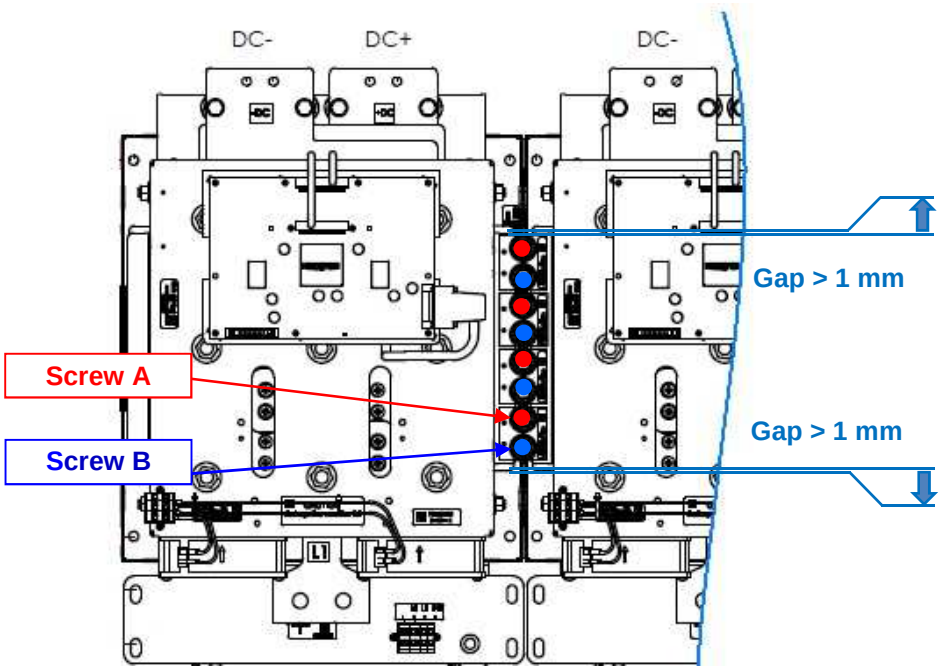
Use the DC clamps provided in the packing list Packaging list and Bill of material.

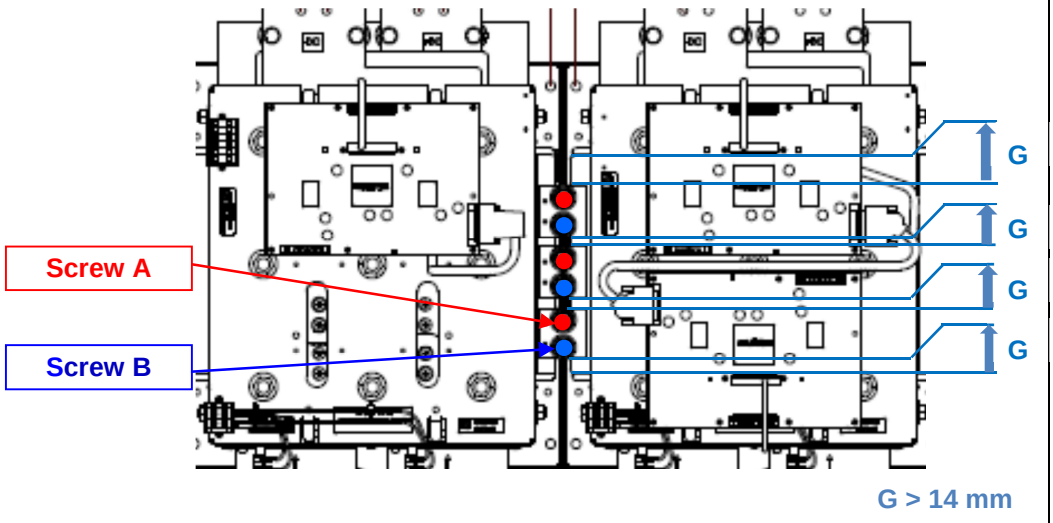
Insert the DC clamps one by one paying close attention to the clamp key-way relative to the direction of mounting.

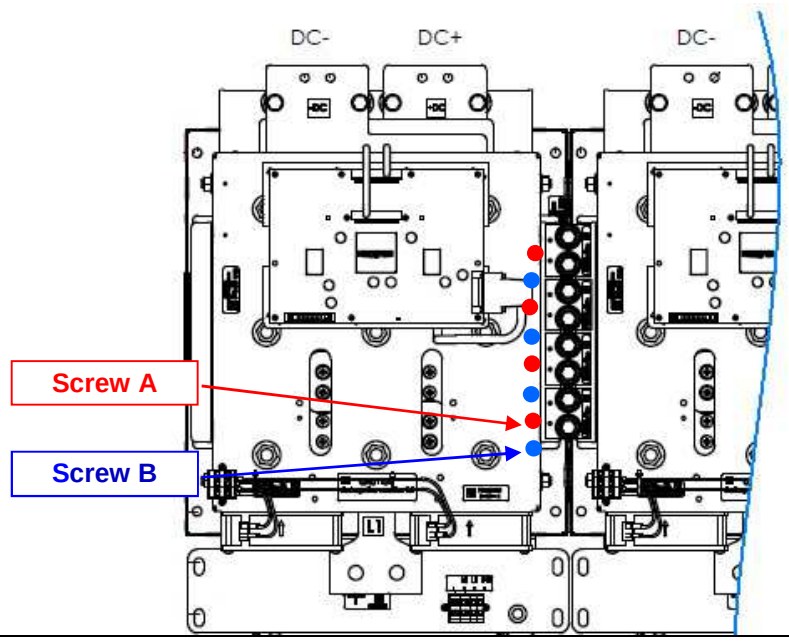
DC Clamps insertion	
	
DC Clamps can be inserted from both the **top** or **bottom** direction, respecting the DC clamp key-way mark.	

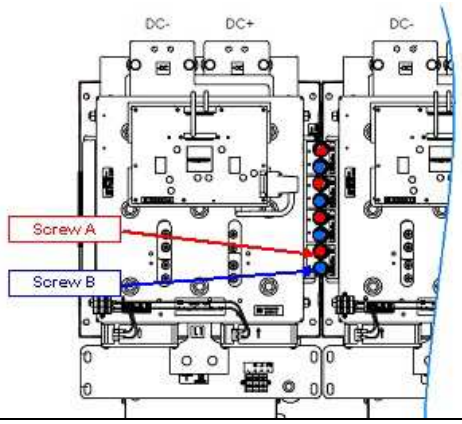
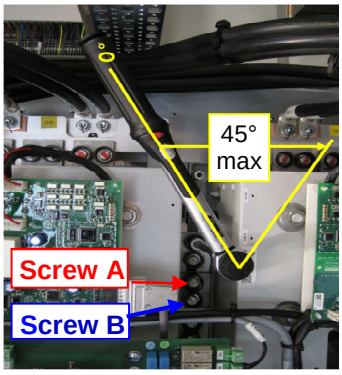
	WARNING!
	Respect DC Clamps insertion direction
The insertion direction of the DC Clamps must be respected by checking the key way position. **Failure to observe this instruction may result in death or serious injury**	

Position the clamps equidistantly along the DC bus bar connection.

Size T3 DC Clamps positioning and screw preparation

Ensure that the upper and lower aluminum DC Clamps are at least at 1 mm from the border of the busbars Put the screws A & B (x4) in by hand and turn until they are tight.

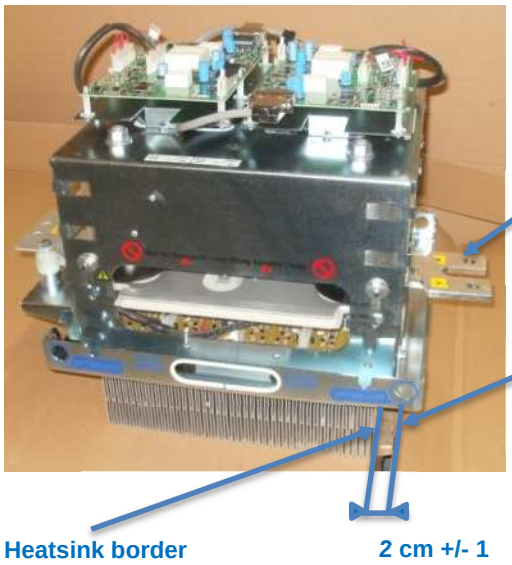
Size T2 DC Clamps positioning and screw preparation

Respect a minimum distance of 14mm between DC Clamps and/or busbars borders Put the screws A & B (x3) in by hand and turn until they are tight.

Size T2 & T3 DC Clamps screw pre tightening sequence

Tighten using a standard wrench to 10 N.m max torque following the sequence screw A and then screw B for each DC Clamp. Repeat the operation for each clamp.

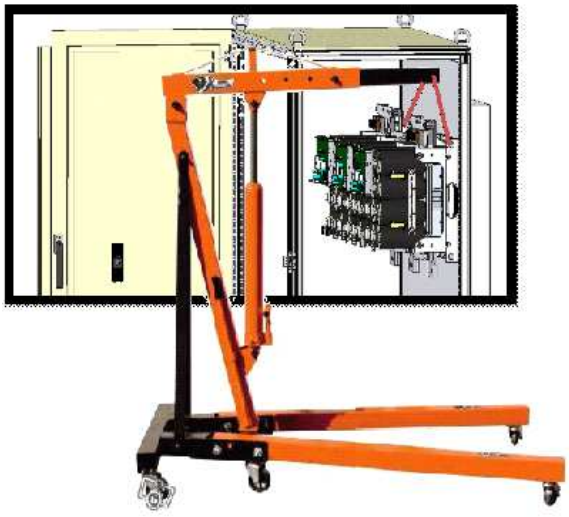
Size T3 & T2 DC Clamps final tightening sequence
   
Only use a torque wrench with a precision of +/- 7% max, set at torque 26N.m max 1/ Tighten the screw B by 45° 2/ Tighten the screw A by 45° 3/ Repeat respectively operation 1 and 2 until reaching the validation signal of the torque wrench on the first screw (A or B) 4/ Tighten the other screw until the validation signal of the torque wrench 5/ Re-tighten the first screw until the validation signal of the torque wrench

3.2.6 KUBE handling device

⚠	**WARNING!**
	Do not damage any part of the SEMIKUBE®
Always observe precautions during handling of the SEMIKUBE®. It's important to ensure that no external part can mechanically or electrically damage the SEMIKUBE® during installation or maintenance. **Failure to observe this instruction may result in death or serious injury**	

Size T3, T2 and T1 handling	
	Place the KUBE at 2 cm from the border of the pallet and place the AC output outside the pallet

	Place 2 hooks in the lifting lugs and slowly lift the KUBE using a mobile crane. Size each hook in order to carry a 35kg static weight. Manually direct the main metal frame in the lifting phase to avoid shocks on the AC output bus bars.
	Move the crane in front of the cabinet and place the KUBE heatsink between the two fixation rails. Place at least 2 screws in the two lower fixation holes and remove the hooks to place the other two fixing screws.

Example of handling system


3.3 AIR COOLING

3.3.1 SEMIKUBE® requirements

The SEMIKUBE® must be integrated INSIDE a cabinet. In order to ensure the SEMIKUBE® operates within its specified temperature range a cooling air flow is required.

In order to reach the heatsink performance, the bottom side of the heatsink must be closed with a seal plate.

During product qualification, SEMIKUBE® ratings have been tested using the standard fan SKF 16P-230-01, ErP2015, with built in speed control input (PWM) and tachymeter output running at $230V_{AC}$, 50Hz/60Hz.

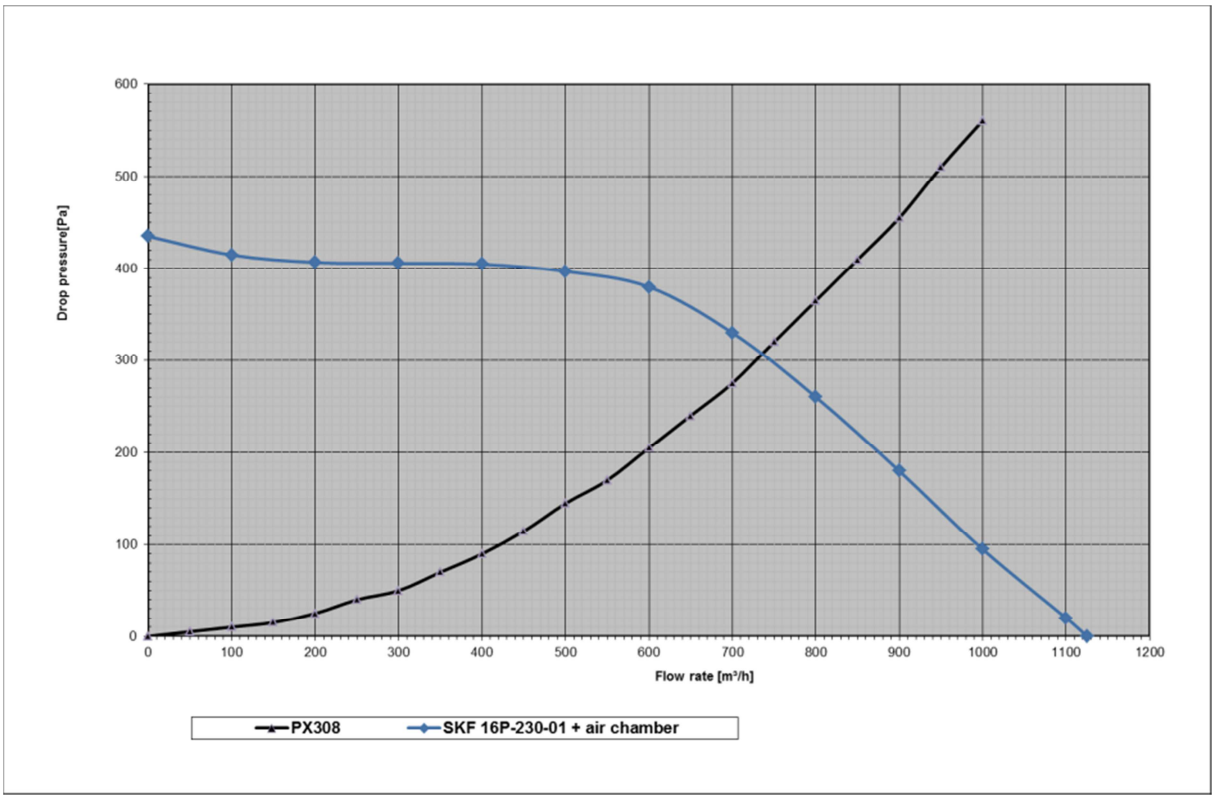
Another fan may be used, providing it supplies both sufficient cooling airflow and min back pressure, please, refer to explanations below.

For this purpose, one should compare the curves of the fan with the given characteristics of SKF 16P-230-01. The intersection of the fan curve and the SEMIKUBE® heat sink pressure drop shall occur at an equal or higher air volume than the one given by the chart.

The design of the cabinet shall be made in order to minimize the additional pressure drop of the complete air channel. In the case that an SKF 16P-230-01 is used, the additional pressure drop must be limited to no more that 10% of the overall value, otherwise a derating of the SEMIKUBE® maximum current must be applied.

For this purpose, it is recommended to leave free space at the air outlet of about 1 meter on top of the cabinet to ensure obstruction free airflow, and to choose the filter which creates the lowest pressure drop.

SEMIKUBE® pressure drop vs. air flow



3.3.2 Filtering of the cooling air

If accumulation of dust occurs on the heatsink fins, thermal efficiency may be reduced. In this case, it is advised to add an air filter to prevent the dust accumulation.

It is also strongly recommended that the fan operation is checked regularly. For example a recurring stop due to over-temperature may be a symptom of an obstructed filter, or dusty fins. Please follow maintenance planning.

The air filter should be chosen with the lowest pressure drop possible. A high pressure drop induced by the filter could lead to a derating of the stack performances.

3.3.3 Airflow in the cabinet

In order to avoid hot spot inside the cabinet, an air flow is necessary according overall component arrangement inside the enclosure. Cabinet ventilation efficiency depends on all equipment installed in the cabinet as well as fans, air-inlets and filters. The design and the validation of this ventilation are not within SEMIKRON's scope of supply.

Temperature stabilization time may take up to 5 hours.

3.3.4 Hotspot acceptance criteria

The temperature of the SEMIKUBE® components shall not exceed the values listed below :

Temperature limits		
Item	Max surface temperature not to be exceeded	Max recommended surface operating temperature
Film capacitors 420µF 1100V	78℃	67℃ (1)
Electrolytic capacitors 4700µF 400V	t.b.d.	t.b.d.
Snubbers	100℃	100℃
AC and DC-busbars	100℃	100℃
DC clamp and connected busbars	Refer to DC clamp datasheet	Refer to DC clamp datasheet

(1) Capacitor lifetime is reduced if operating between 67℃ and 78℃ for long periods

3.3.5 Hints for ventilation design

The air flow should be exhausted at the top of the cabinet to provide a vertical upwards airflow over the SEMIKUBE® components.

SEMIKRON recommend to use a cooling system that provides an airflow >1 m/s over all snubbers. If the air speed is lower than 1 m/s, there's high risk to exceed max operating temperature.

Final internal air cooling system validation is done by measuring hotspots as described above.

3.4 CONDENSATION PREVENTION

DANGER!

Condensation

According to EN50178, pollution degree 2, no condensation is allowed during operation. Ambient air humidity around SEMIKUBE® must be controlled at all times to avoid condensation on any parts, live or not.

Failure to observe this instruction may result in death or serious injury

Condensation may be present on some parts of the SEMIKUBE® and the rest of the system, before the system has been started for the first time or during periods of non-operation. In this case it is necessary to dry all parts by heating the cabinet. This operation may take several hours before all condensation has disappeared and the system has returned to acceptable humidity and temperature levels.

4 ELECTRICAL CONNECTIONS

4.1 POWER CONNECTION

Characteristic of connection terminals					
	Function	Type of connection and tightening torque **T0,5**	Type of connection and tightening torque **T1**	Type of connection and tightening torque **T2**	Type of connection and tightening torque **T3**
U, V, W(1)	AC output (motor or mains)	M8 – 18Nm	M8 – 18Nm	M12 – 60Nm	2xM12 – 60Nm
DC+, DC- (1)	DC input	M8 – 18Nm Per polarity	2xM8 – 18Nm Per polarity	4xM8 – 18Nm Per polarity	6xM8 – 18Nm Per polarity
Fan	DC link cooling	Cage clamp 5pin	Cage clamp 5pin	2xCage clamp 5pin	3xCage clamp 5pin
Fan	Main fan supply&control	Cage clamp 7pin	Cage clamp 7pin	2xCage clamp 7pin	3xCage clamp 7pin
Control	Inverter PWM signal, analog measurement, driver supply	HE10-34pin	HE10-34pin	3xHE10-20pin	3xHE10-20pin

(1) : Protect all external electrical power contacts with contact treatment grease (Electrolube ref: CG53A).

DANGER!

Dimensioning of AC connections

Links between the SEMIKUBE®'s terminals and the integrator's interfaces must be designed for worst case operating conditions.

Heating of connected elements shall not increase any bus bars' temperature above 100℃.

It is the integrator's responsibility to insure that clearance and creepage distances required by applicable standards and regulations are met.

It is the integrator's responsibility to verify and ensure the quality of power connections of the SEMIKUBE® is made according to their own specifications and local regulations.

Failure to observe these instructions may result in electrical shock or fire.

DANGER!

Electrical circuit protection

Fuses shall be inserted between the SEMIKUBE® and the mains.

These fuses shall be suitable for the power of the application, and the maximum i^2t of the input bridge or transformer.

A circuit breaker is also recommended.

Varistors on the AC connections may also be used.

Local standards and regulations may override SEMIKRON's recommendations and require more demanding protections.

Failure to observe these instructions may result in electrical shock or fire.

DANGER!

Cable connection on AC bars

Mounting of AC cables must be done carefully to minimize the stress applied onto the AC terminals.

Failure to observe this instruction may result in death or serious injury

4.2 DC CONNECTION

DANGER!

Choice of cables and lugs

The assembly recommended for the DC busbars is similar to the recommended assembly for the AC bars.

Cables shall be connected so that clearance and creepage distances required by applicable standards are met.

However local standards and regulations may override SEMIKRON's recommendations and demand bars or cables of a bigger section.

It is the integrator's responsibility to verify and ensure the quality of power connections of the SEMIKUBE® is done according to their own specifications and local regulations.

Failure to observe these instructions may result in electrical shock or fire.

CAUTION!

Electro-galvanic compatibility

The DC connections of SEMIKUBE® are made of aluminium bars and the AC connections of SEMIKUBE® are made of tinned copper bars. The connection of the SEMIKUBE® with the load should be made with an electro-galvanic compatible metal to prevent corrosion. Use appropriate mounting method to prevent over heating of bars.

In particular, tin plated copper is compatible with bare copper, tin and nickel plated copper, and bare aluminum.

Use of zinc plated metal should be avoided.

Failure to observe this instruction may result in corrosion of electrical contact

4.3 GROUNDING

DANGER!

Bonding and grounding recommendations

According to standard IEC 60439-1, exposed conductive parts must be connected to their protection circuit using the appropriate connections.

The metal frame of each KUBE shall be bonded to the metal frame of the cabinet and grounded.

After assembling the SEMIKUBE in the cabinet, the installer shall check and measure the electrical resistance between ground and all accessible non-live metallic parts. Electrical resistance shall be less than 3mΩ.

The metal frame of the SEMIKUBE shall not be used as a PEN (Protective Earth – Neutral) conductor.

Failure to observe these instructions may result in electrical shock or fire.

DANGER!

Bonding and grounding: installer responsibilities

Other local standards and regulations may demand more strict installation rules that may override SEMIKRON recommendations. Apply whichever is more strict and provides the highest level of safety.

It is the integrator's responsibility to verify and ensure the quality of grounding for the SEMIKUBE according to their own specifications and local regulations.

Failure to observe these instructions may result in electrical shock or fire.

DANGER!

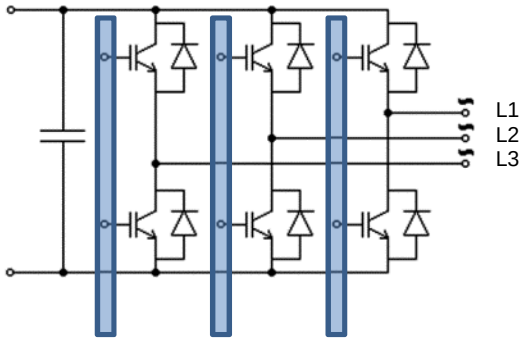
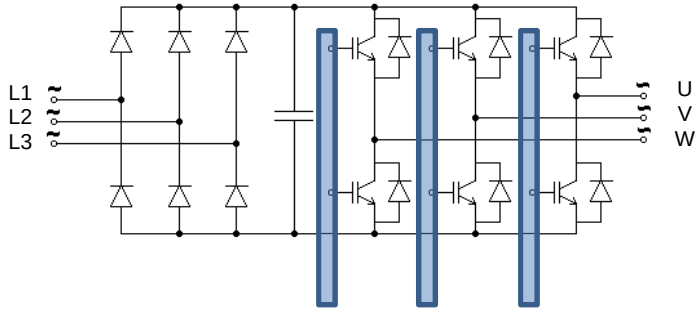
EMC recommendations and safety requirements

The recommendations given in this paragraph are rules to limit EMC problems. In case of contradiction between EMC recommendations and safety requirements, safety requirements always override EMC recommendations.

Failure to observe these instructions may result in electrical shock or fire.

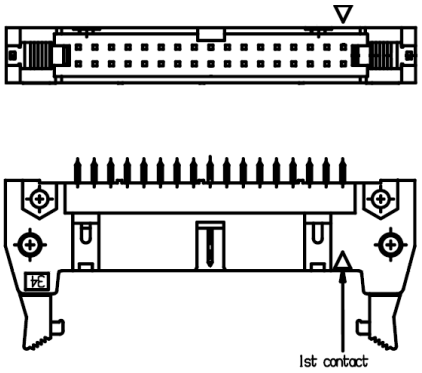
4.5 CONNECTING INTERFACES

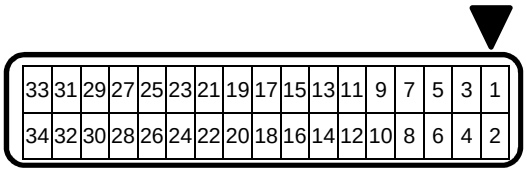
4.5.1 Sizes T0.5 & T1

Interface identification on SEMIKUBE® T0.5 & T1 functional view
Inverter topology    Driver connector X1
Rectifier & inverter topology    Driver connector X1

The table describes interface connector pin assignment.

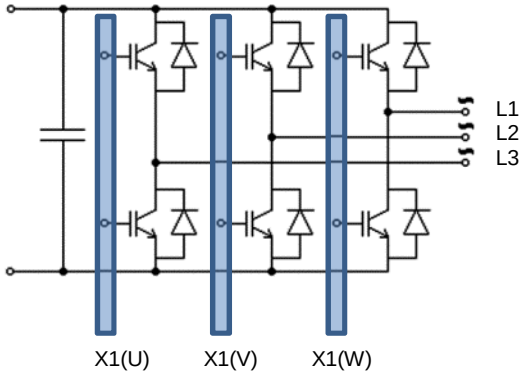
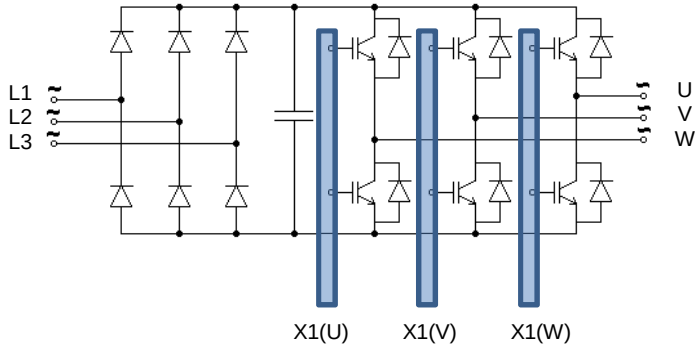
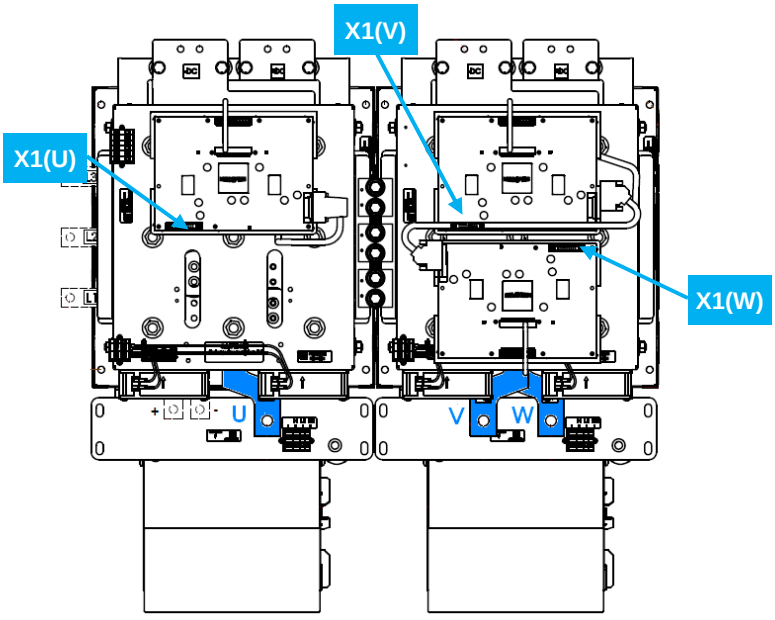
Connector X1				
Connector type HE10 DIN 41651, 34 contacts	Pin	Signal	Name	Type
	1,3,5	V_S IN	IF_PWR_VP	-
	2,4,6	GND	IF_PWR_GND	-
	7	[Reserved]	IF_CMN_rsrvd	[1]
	8	GND (Signal Status)	IF_CMN_GND	-
	9	Signal Status BIDIRECTIONAL	IF_CMN_nHALT	[1]
	10	[Reserved]	IF_CMN_rsrvd	[1]
	11	Temperature Analogue OUT	IF_CMN_ANLG0	[2]
	12	GND (Temperature Analogue)	IF_CMN_AGND0	-
	13	U_{DC} Analogue OUT	IF_CMN_ANLG1	[2]
	14	GND (U_{DC} Analogue)	IF_CMN_AGND1	-
	15	TOP phase U Switching Signal IN	IF_HB1_TOP	[3]
Pin arrangement	16	BOT Phase U Switching Signal IN	IF_HB1_BOT	[3]
	17	[Reserved]	IF_HB1_rsrvd	[1]
	18	GND (TOP & BOT phase U)	IF_HB1_GND	-
	19	I phase U Analogue OUT	IF_HB1_ANLG	[2]
	20	GND (I Analogue phase U)	IF_HB1_AGND	-
	21	TOP phase V Switching Signal IN	IF_HB2_TOP	[3]
	22	BOT Phase V Switching Signal IN	IF_HB2_BOT	[3]
	23	[Reserved]	IF_HB2_rsrvd	[1]
	24	GND (TOP & BOT phase V)	IF_HB2_GND	-
	25	I phase V Analogue OUT	IF_HB2_ANLG	[2]
	26	GND (I Analogue phase V)	IF_HB2_AGND	-
	27	TOP phase W Switching Signal IN	IF_HB3_TOP	[3]
	28	BOT phase W Switching Signal IN	IF_HB3_BOT	[3]
	29	[Reserved]	IF_HB3_rsrvd	[1]
	30	GND (TOP & BOT phase W)	IF_HB3_GND	-
Suitable female connector Harting P/N 09 18 534 7904	31	I phase W Analogue OUT	IF_HB3_ANLG	[2]
	32	GND (I Analogue phase W)	IF_HB3_AGND	-
	33	[Reserved]	IF_rsrvd	-
	34	[Reserved]	IF_GND_rsrvd	-



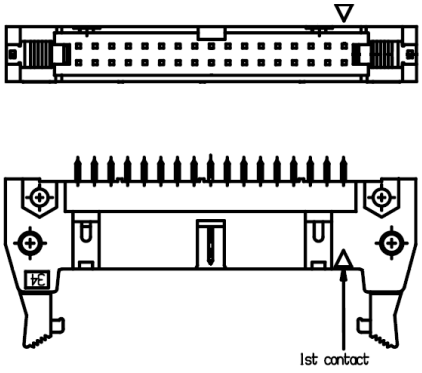
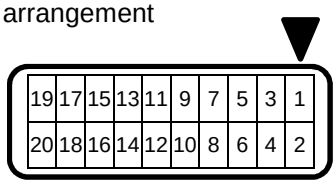


[1]: dominant/recessive
[2]: analogue
[3]: push/pull

4.5.2 Size T2

Interface identification on SEMIKUBE® T2 functional view
Inverter topology 
Rectifier & inverter topology 


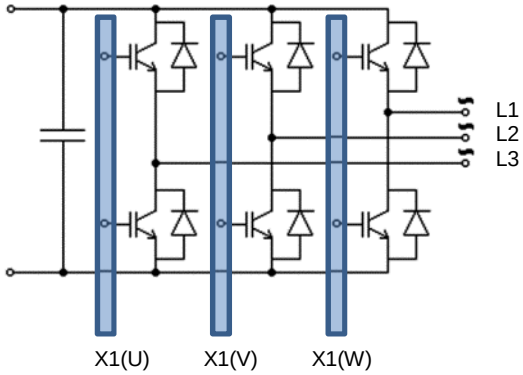
The table describes interface connector pin assignment.

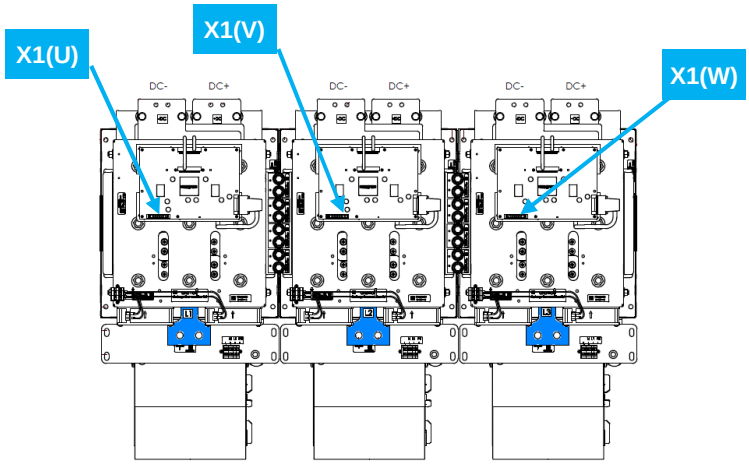
Connector X1(•)				
Connector type HE10 DIN 41651, 20 contacts	Pin	Signal	Name	Type
	1,3,5	V_S IN	IF_PWR_VP	-
	2,4,6	GND	IF_PWR_GND	-
	7	[Reserved]	IF_CMN_rsrvd	[1]
	8	GND for Signal Status OUT	IF_CMN_GND	-
	9	Signal Status BIDIRECTIONAL	IF_CMN_nHALT	[1]
	10	General purpose IO	IF_CMN_GPIO	[1]
	11	X1(U) & X1(V): Temperature Analogue OUT X1(W): not available	IF_CMN_ANLG0	[2]
Pin arrangement 	12	GND for Temperature Analogue OUT	IF_CMN_AGND0	-
	13	U_{DC} Analogue OUT	IF_CMN_ANLG1	[2]
	14	GND for U_{DC} Analogue OUT	IF_CMN_AGND1	-
	15	TOP Switching Signal IN	IF_HB1_TOP	[3]
	16	BOT Switching Signal IN	IF_HB1_BOT	[3]
Suitable female connector Harting P/N 09 18 520 7813	17	[Reserved]	IF_HB1_rsrvd	[1]
	18	GND for TOP & BOT IN	IF_HB1_GND	-
	19	I Analogue OUT	IF_HB1_ANLG	[3]
	20	GND for I Analogue OUT	IF_HB1_AGND	-

[1]: dominant/recessive
[2]: analogue
[3]: push/pull

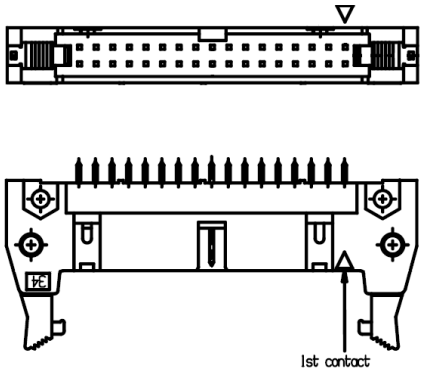
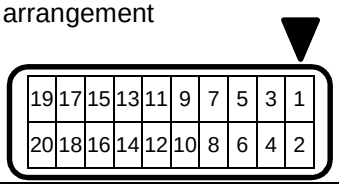
4.5.3 Size T3

Interface identification on SEMIKUBE® T3 functional view





The table describes interface connector pin assignment.

Connector X1(•)				
Connector type HE10 DIN 41651, 20 contacts	Pin	Signal	Name	Type
	1,3,5	V_S IN	IF_PWR_VP	-
	2,4,6	GND	IF_PWR_GND	-
	7	[Reserved]	IF_CMN_rsrvd	[1]
	8	GND for Signal Status OUT	IF_CMN_GND	-
	9	Signal Status BIDIRECTIONAL	IF_CMN_nHALT	[1]
	10	General purpose IO	IF_CMN_GPIO	[1]
	11	Temperature Analogue OUT	IF_CMN_ANLG0	[2]
	12	GND for Temperature Analogue OUT	IF_CMN_AGND0	-
	13	U_{DC} Analogue OUT	IF_CMN_ANLG1	[2]
Pin arrangement 	14	GND for U_{DC} Analogue OUT	IF_CMN_AGND1	-
	15	TOP Switching Signal IN	IF_HB1_TOP	[3]
	16	BOT Switching Signal IN	IF_HB1_BOT	[3]
	17	[Reserved]	IF_HB1_rsrvd	[1]
Suitable female connector Harting P/N 09 18 520 7813	18	GND for TOP & BOT IN	IF_HB1_GND	-
	19	I Analogue OUT	IF_HB1_ANLG	[3]
	20	GND for I Analogue OUT	IF_HB1_AGND	-

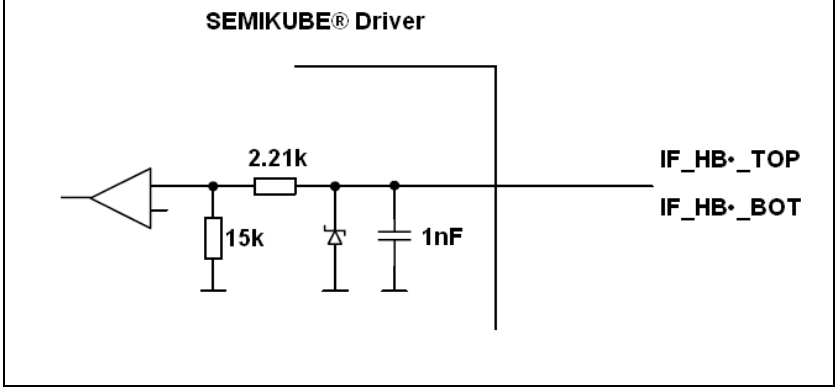
[1]: dominant/recessive
[2]: analogue
[3]: push/pull

4.6 INTERFACE TYPES

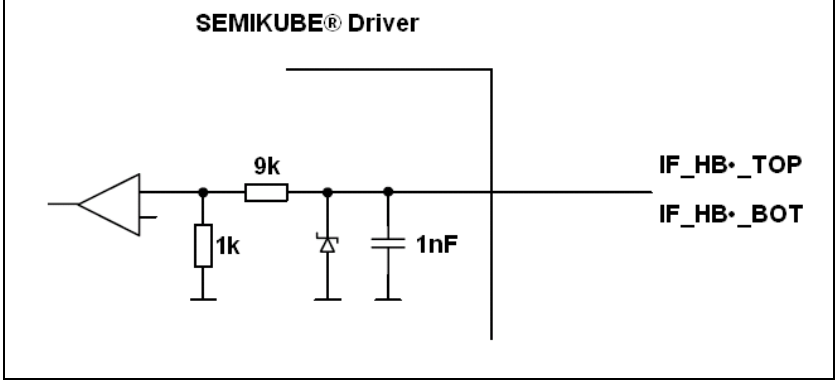
4.6.1 TOP/BOT inputs

It is mandatory to use circuits which switch active to V_S and 0V. Pull up and open collector output stages must not be used for TOP / BOT control signals. It is recommended choosing the line drivers according to the demanded length of the signal wires.

Size T0.5 & T1 internal TOP/BOT input diagram



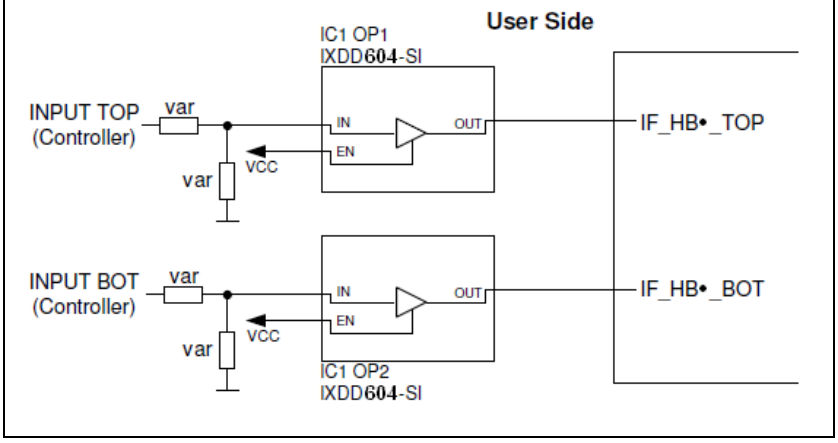
Size T2 & T3 internal TOP/BOT input diagram



A capacitor is connected to the input to obtain high noise immunity. This capacitor can cause for current limited line drivers a little delay of few ns, which can be neglected.

It is not permitted to apply switching pulses shorter than 1µs. A non-connected input will be considered as a LOW signal.

User interface TOP/BOT example



The circuit is based on a Dual Low-Side Ultrafast MOSFET Driver IXDD604SI.

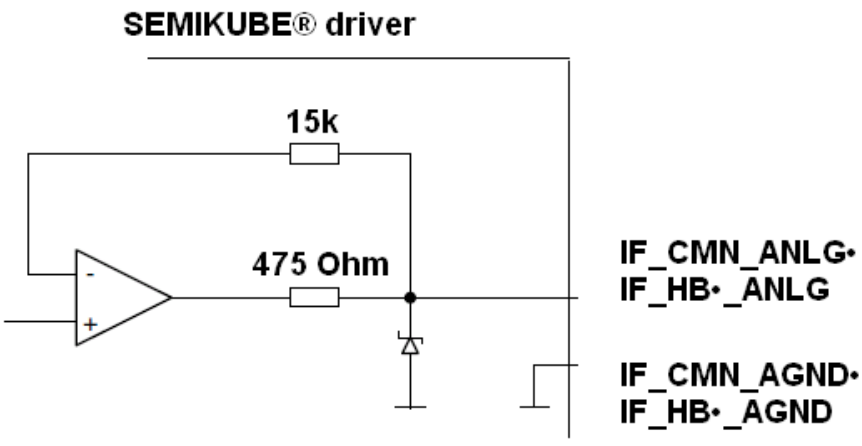
Please read the data sheet of the MOSFET Driver before using the component in your application.

Control signals from the controller (e.g. 3.3V, 5V) are shifted to Digital IF_PWR_VP logic

4.6.2 Analogue outputs

The following schematic shows the analog output lines of the driver board.

Analogue Outputs

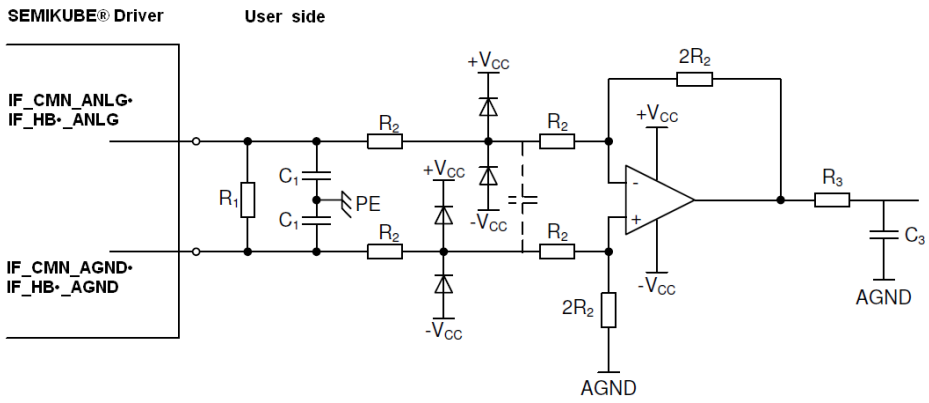


The 475 Ω resistor in series with the voltage follower does avoid potential damage caused by a temporary short circuit at user side. Please ensure that the maximum driven current by the output operational amplifier does not exceed 5 mA.

For trouble-free interaction of the driver board and user side control it is necessary to adapt the user input to the driver board outputs. For that reason the corresponding

analog signal ground (IF_CMN_AGND• and IF_HB•_AGND) shall be used when analog signals are measured. The analog signal ground is on the driver board on the same potential as the ground of the power supply (IF_PWR_GND). The difference is that the analog signal ground line is not used for supply currents and for that reason no voltage drop due to supply current will be caused.

User interface analogue output example



The circuit is a symmetrical wired differential amplifier.

- At the input is a 10kΩ resistor (R_1). The interference sensitivity of the overall circuit (user control, driver) is reduced by a continuous current flow through this resistor ;

- C1 suppresses differential and common mode high-frequency interference currents. This capacitor should not be larger than 100pF to ensure that there is no additional time delay in the system.

- The symmetrical wiring of the amplifier is as follows. Please note that no capacitor is in parallel to the feedback resistor and also to the resistor of the non-inverting input to ground ($2R_2$). These capacitors have often higher tolerances, so the common-mode rejection of the circuitry is reduced by this effect.

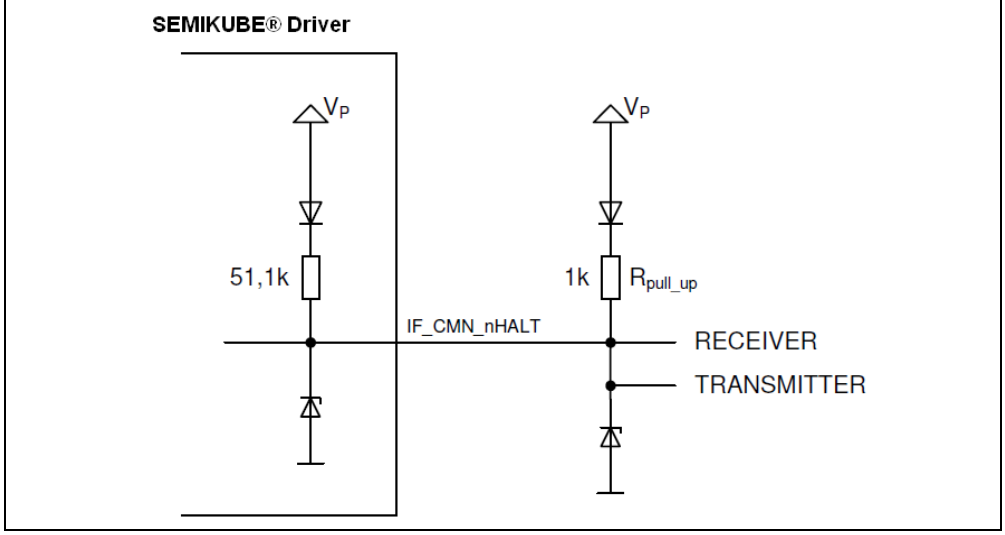
- The input resistor should be split up and installed between the clamping-diodes. The current in the diodes is limited by this resistor. A diode with a low reverse current should be selected e.g. 1N4148.

- If low pass filtering shall be implemented in the input circuit, this should be done with a capacitor between the input resistors (see dotted lines). In most cases this capacitor is not necessary and the smoothing can be realized by a simple RC network (R_3, C_3) at the end of the operational amplifier.

4.6.3 HALT bidirectional signal

The HALT logic signal IF_CMN_nHALT is a bidirectional signal with dominant recessive behavior. On size T0.5 and T1, HALT signal is for the 3-phase inverter while Sizes T2 & T3 have a HALT signal per inverter phase.

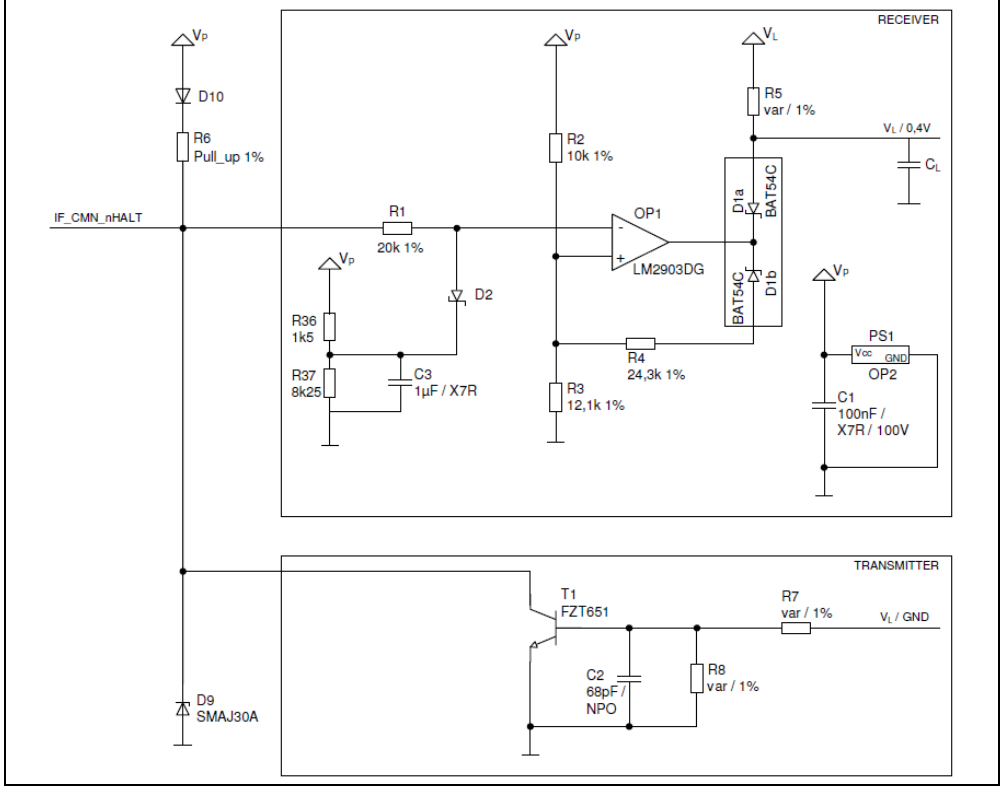
Halt pin connection



An external pull-up resistor of 1kΩ and a diode is required.

IF_CMN_nHALT must operate with IF_PWR_VP logic. The receiver and transmitter circuit have to be high impedance to assure a recessive logic level higher than 0,9*V_P, independent of the number of connected circuits. Therefore, a circuit which uses direct pull-down resistor connected to IF_CMN_nHALT, does not fit to the specification. See the following application example for possible solution.

User interface with HALT signal example



- The output of the stage is inverted.
- Propagation delay for on / off depends on C_L and R_5. Due to the open collector output of the LM2903, the propagation delay time of the rising edge is smaller than the propagation delay time of the falling edge of the HALT signal.
- The current through the open collector of the comparator is limited by the resistor R_5 and should not exceed 5mA in order to limit the voltage drop and the losses.
- The resistors R_{36} and R_{37} clamp the voltage for the input of the comparator. By this, the inverting input stays in the permissible common mode range.
- D_2 should be a Schottky diode with low voltage drop.
- The resistors R_7 and R_8 have to be selected according to the used logic level to drive the transistor T_1. A base current of about 1mA is recommended.

On SEMIKUBE® size T0.5 and T1, there is an additional I/O reflecting the status of Halt signal. IF_CMN_GPIO (pin 7) returns the inverted value of IF_CMN_nHALT.

	CAUTION!
	No short circuit protection

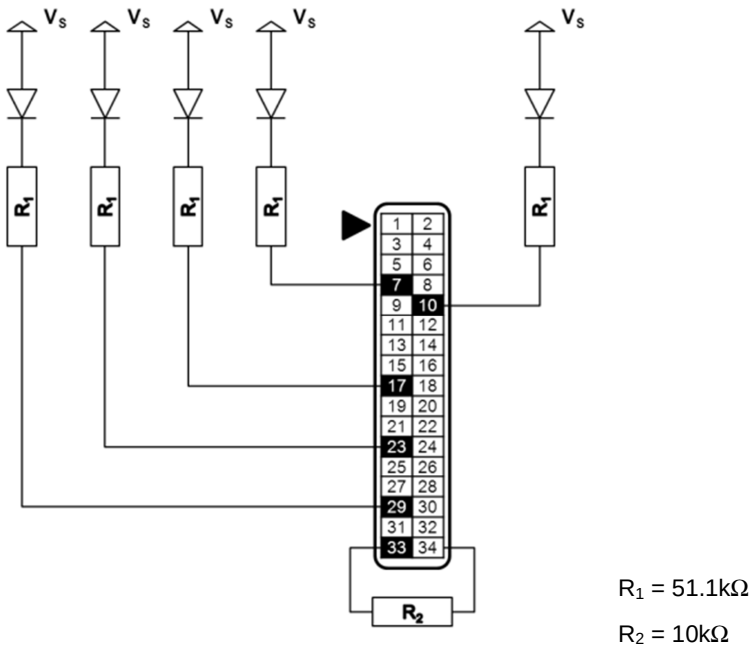
SEMIKRON attract the attention that HALT input/output is not short circuit protected. It is the responsibility of the user to provide necessary protection to avoid overcurrent and over voltage.

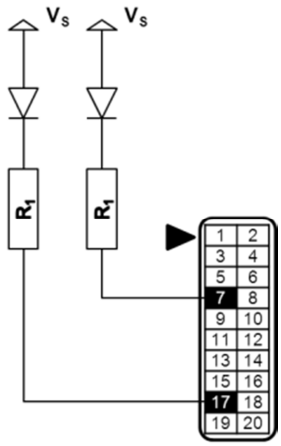
Failure to observe this instruction may result in HALT input/output damage.

4.6.4 Reserved signals

Signals of the interface which are specified as reserved must be connected as shown in the following table.

Size T0.5 & T1 reserved signals



Size T2 & T3 reserved signals
 R_1 = 51.1kΩ

4.6.5 Unused signals

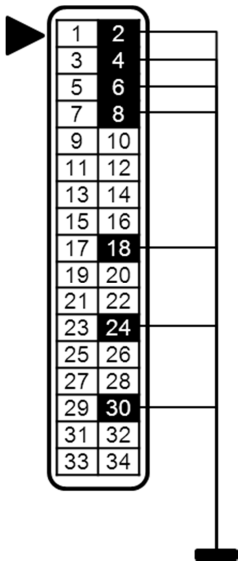
Signal type	Connection required on user side
Dominant recessive	Pull up resistor (50kΩ) to IF_PWR_VP
Analog	Pull down direct to GND (IF_PWR_GND)
Push pull	Pull down resistor (10kΩ) to analog ground of user

4.6.6 I/O grounding

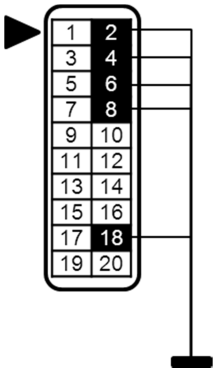
The ground potentials on the driver board are equal and all physically connected with each other on the printed circuit board. Because of the voltage drop on the power supply cable, the potential of power supply ground at the user side is different to the ground potential on the driver board. If the potential of the analog signals are only referred to the user ground potential, the measurement is failing. To eliminate this failure different signal for ground potential are used. The analog ground signal can be used to sense the ground potential of the driver board for a differential measurement.

It is mandatory on the user side to differ between analog ground (IF_CMN_AGND• & IF_HB•_AGND) and IF_PWR_GND to avoid faulty analog values. It is allowed to short-circuit the IF_PWR_GND, the IF_CMN_GND and the ground pin of the half bridge (IF_HB•_GND) on the user side. But all analog signals have to be measured differential referred to the corresponding ground signal at the user interface. It is not allowed to short-circuit the analog ground signal with the IF_PWR_GND signal on user side.

I/O grounding on X1



Sizes T0.5 & T1



Sizes T2 & T3

4.7 AUXILIARY SUPPLIES

4.7.1 Drivers DC supply

The SEMIKUBE® platform drivers need to be supplied with a $24V_{DC}$ power supply.

It is recommended to avoid the paralleling of several customer side power supply units. Their different set current limitations may lead to dips in the supply voltage.

$24V_{DC}$ power supply per driver					
Features		Unit	Min.	Rated	Max.
V_S V_P	Supply voltage	[V_{DC}]	21.6	24	26.4
I_{S0}	Sizes T0.5 & T1 Supply current primary (no load)	[A_{DC}]		270	
	Sizes T2 & T3 Supply current primary (no load)	[A_{DC}]	360		
	Supply current primary (max.)	[A_{DC}]			1.5
	Maximum rise time	[ms]			50
	Power on reset completed after	[ms]		700	

V_S voltage supply shall be applied between IF_PWR_VP & IF_PWR_GND.

The driver board is ready for operation typically 700ms after turning on the supply voltage.

CAUTION

UPS recommended

It is recommended to provide a UPS for the power supply of the SEMIKUBE Drivers to keep control of the SEMIKUBE® in case of power outage and to turn it off safely.

Failure to provide a UPS may cause overvoltage on DC-link and result in SEMIKUBE® damage.

4.7.2 AC fan power

The SEMIKUBE® platform integrates 2 types of fans:

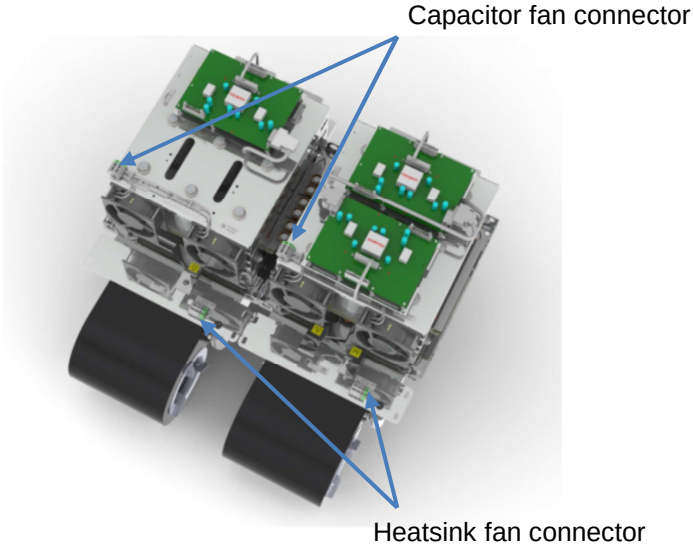
- Centrifugal fans to cool down the heatsinks
- Axial fans to cool down the capacitor banks

The table below defines types of fans and number per SEMIKUBE® type:

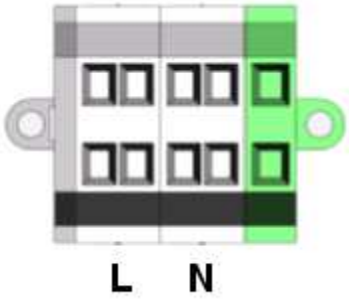
SEMIKUBE®	SKF 3-230-01	SKF 16P-230-01
08800900	6	Defined in chapter Packaging list and Bill of material
08800930	6	
08800980	2	
08800991	2	
08801001	0	
08801002	4	
08801003	4	
08801004	0	
08800445	0	
08800446	0	
08800447	4	
08800448	6	

For SEMIKUBE® equipped with fans, each KUBE has a separate connection area for the capacitor fan and the heatsink fan.

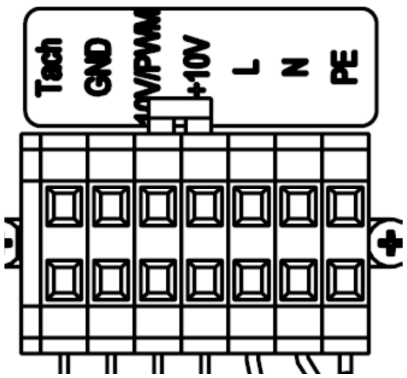
Example of fan connector location on size T2



Two fans SKF 3-230-01 are connected in parallel to a WAGO terminal as described below:

Capacitor fan option connectors		
	Connector type	
	Spring terminal block Wago item # 261-331 12A max. per single terminal 24A max. per dual terminals	
	Suitable cable	
	Cross section cable 0.08 to 2.5mm² Cable gauge AWG 28 – 14	
	Fan electrical requirement	
	V_{L1-N}	$230V_{AC}$ -10/+10%
	f_{IN}	47..52Hz
	Max input current	0.24 A per KUBE

Each SKF 16O-230-02 fan heatsink assembly includes a WAGO terminal:

Heatsink fan option F1 and F2 connectors		
	Connector type	
	Spring terminal block Wago item # 261-331 12A max. per single terminal 24A max. per dual terminals	
	Suitable cable	
	Cross section cable 0.08 to 2.5mm² Cable gauge AWG 28 – 14	
	Fan electrical requirement	
	V_{L1-N}	$230V_{AC}$ -10/+10%
	f_{IN}	45..65Hz
	Nom input current	1.2 A per assembly

4.8 GROUNDING

DANGER!

Bonding and grounding recommendations

According to standard IEC 60439-1, exposed conductive parts must be connected to their protection circuit using the appropriate connections.

The metal frame of each KUBE shall be bonded to the metal frame of the cabinet and grounded.

After assembling the SEMIKUBE® in the cabinet, the installer shall check and measure the electrical resistance between ground and all accessible non-live metallic parts. Electrical resistance shall be less than 3mΩ.

The metal frame of the SEMIKUBE® shall not be used as a PEN (Protective Earth – Neutral) conductor.

Failure to observe these instructions may result in electrical shock or fire.

DANGER!

Bonding and grounding: installer responsibilities

Other local standards and regulations may demand more strict installation rules that may override SEMIKRON recommendations. Apply whichever is more strict and provides the highest level of safety.

It is the integrator's responsibility to verify and ensure the quality of grounding for the SEMIKUBE® according to their own specifications and local regulations.

Failure to observe these instructions may result in electrical shock or fire.

DANGER!

EMC recommendations and safety requirements

The recommendations given in this paragraph are rules to limit EMC problems. In case of contradiction between EMC recommendations and safety requirements, safety requirements always override EMC recommendations.

Failure to observe these instructions may result in electrical shock or fire.

Bonding KUBE frames and cabinet frames at several points is recommended to improve immunity to EMC perturbations. The 0V of the DC power supplies shall also be connected to chassis ground. Analog grounds shall not be connected to chassis ground.

In order to avoid uneven potentials in chassis ground, all non-live metallic parts should be bonded by a low impedance connection.

5 OPERATION

5.1 FIRST START PROCEDURE

DANGER!

Risk of SEMIKUBE® damage

Before starting, SEMIKRON recommends checking the storage period before applying voltage to electrolytic DC link capacitor. Storage of more than one year without voltage required a reforming procedure. Please contact SEMIKRON.

Failure to observe this instruction may result in SEMIKUBE® damage and death or serious injury.

DANGER!

High voltage present!

The purpose of the first start procedure is to supply electrical power to the SEMIKUBE® converter in order for the user to operate their complete system.

All installing and connecting operations must be performed and checked by skilled technical people. Refer to paragraph Safety instructions.

Labeling and identification:

- AC connections
- DC connections
- Driver interface connections
- PE (Earth) terminal on SEMIKUBE®

…shall be identified before starting.

Failure to observe this instruction may result in death or serious injury.

The first start procedure shall be followed step by step:

Step1 Ensure all electrical power switches are disabled and locked out.
Ensure drivers are not supplied, DC bus voltage is not connected or separated, load is disconnected, and fans are not supplied.

Step2 Connect fan power supply (Refer to fan electrical ratings specification AC fan power) Ensure that the air cooling system is operational.

Step3 Connect the power inputs and outputs using the appropriate cables and lugs section (refer to AC connection and DC connection). Tightening torque shall respect SEMIKRON requirements.

Step4 Connect SEMIKUBE® driver I/O to the controller circuit using appropriate flat cable.

Step5 Power on SEMIKUBE® drivers and ensure that no LEDs are blinking red (in case of error please refer to Diagnostics). If all LED indicators are green then no connection faults are present, your SEMIKUBE® system is ready to operate.

Step6 Ensure controller signals are set up so that current and voltage remain at zero when power is unlocked.

Step6 Unlock switches and turn on AC and DC power circuits.

Step7 Progressively increase voltage and current and regularly check operation.

Step8 Ensure PWM signals, current level and waveforms, voltage level and waveforms, current and voltage frequency and sensor signals are satisfactory before reaching nominal operating point.

5.2 TOP/BOT COMMANDS

DANGER!

Risk of SEMIKUBE® damage

Before starting, SEMIKRON recommends checking PWM signals, current level and waveforms, voltage level and waveforms, current and voltage frequency and sensor signals. It is the customer responsibility to monitor these parameters and all other necessary ones.

Do not increase voltage or current if all signals are not satisfactory at each step.

Failure to observe this instruction may result in SEMIKUBE® damage and death or serious injury.

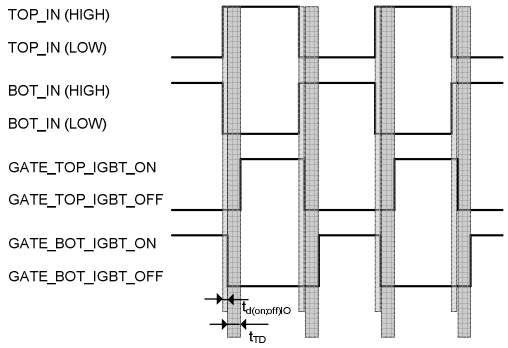
The two input signals for the TOP and BOT signals of each phase have a digital positive / active high logic (input HIGH = IGBT on; input LOW = IGBT off).

A non-connected input will be considered like a LOW signal.

5.2.1 Dead time generation (Interlock TOP / BOT)

The DT circuit prevents, that TOP and BOT IGBT of one half bridge are switched on at the same time (shoot through). The dead time is not added to a dead time given by the controller. Thus the total dead time is the maximum of "built in dead time" and "controller dead time". It is possible to control the driver with one switching signal and its inverted signal.

Pulse pattern – DT



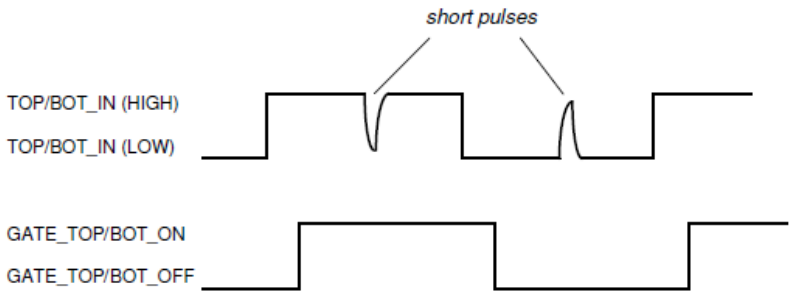
- The total propagation delay of the driver is the sum of interlock dead time (t_{TD}) and driver input output signal propagation delay ($t_{d(on;off)IO}$) as shown in the pulse pattern. Moreover the switching time of the IGBT chip has to be taken into account (not shown in the pulse pattern).
- In case both channel inputs (TOP_IN and BOT_IN) are at high level, the IGBTs will be turned off.
- If only one channel is switching, there will be no interlock dead time.

Please note:
No error message will be generated when overlap of switching signals occurs.

5.2.2 Short pulse suppression

The SEMIKUBE® drivers suppress short turn-on and off-pulses of incoming signals. This way the IGBTs are protected against spurious noise as they can occur due to bursts on the signal lines. Pulses shorter than 620ns (typ.) are suppressed.

TOP/BOT pattern



5.3 HALT MANAGEMENT

It shows and controls the drive board status.

The Halt Logic Signal IF_CMN_nHALT is a bidirectional signal with dominant recessive behaviour. It shows and controls the drive board status. When IF_CMN_nHALT is HIGH (recessive), the driver core is ready to operate. When IF_CMN_nHALT is LOW (dominant), the driver core is disabled / not ready to operate / HALT mode because of e. g. detected failure or system start of the driver board. With a LOW signal at IF_CMN_nHALT or IF_HALT_EXT the driver board can be hold in a safe state (e.g. during a start up of a system or gathered failure signal of other hardware) or a synchronous release of paralleled driver can be generated.

Please note:
IF_CMN_nHALT is not short circuit proof.

5.4 VOLTAGE RATINGS

Supply voltage variation of the mains should not be more than 10% of the nominal voltage. In other case, please ask SEMIKRON recommendation.

400 Vac version (1200V IGBTs with electrolytic capacitors)
INPUT Please refer to the product datasheet
OUTPUT Please refer to the product datasheet **Please note** : very low fundamental frequency (less than 2 Hz) may require a derating of the current.

Please note : Maximum ratings

Maximum ratings mentioned in the data-sheets should on no occasion be exceeded, at the risk of a physical destruction failure. Among others, we particularly bring your attention to :

- maximum current
- maximum DC voltage
- maximum switching frequency
- maximum coolant and internal temperature
- maximum heatsink temperature
- maximum power supply voltage of the driver board

5.5 PHASE CURRENT MONITORING

The analogue current signal provides the normalized current value of the related phase to the customer connector. The driver has an internal over current protection to switch off safely over current without overstress of the IGBTs. In the case of over current the HALT signal indicates an error and the IGBTs will be switched off.

5.5.1 Current measurement

General parameters of current measurement are given in product data sheet. The “I analog out” signal provide instantaneous phase current value normalized according datasheet parameters.

Fundamental frequency: DC to 1 kHz.

Open loop current sensors are included in the SEMIKUBE® to return the instantaneous value of current to the controller.

Compliance of this current sensor to the application should be carefully examined, for example when very fast feedback is required. Though experience has proven that the sensors used in SEMIKUBE® are effective enough for most applications, open loop sensors induce a small delay in the measuring loop.

When extreme speed and/or accuracy is required, please insert adequate external current sensors in the circuit.

5.5.2 Over current protection

Over Current Protection (OCP) is activated when the instant value of the phase current exceed the Itrip value. When Itrip is exceeded the IGBT are switched off , and the HALT signal is set to the Error state.

Itrip levels are provided in the product datasheet.

5.6 DC VOLTAGE MONITORING

With the DC-link-voltage sensing feature, a normalized, analog voltage signal of the actual DC-link-voltage level is available at the connector of the driver board. The measurement is realized by a high impedance differential amplifier. The circuit is designed, manufactured and tested according to standard EN50178 (VDE0160).General parameters of DC voltage measurement are given in product data sheet.

Please note:
The DC voltage values given in datasheet show the maximum values that the driver board can read. It must not be understood as maximum acceptable DC voltage value for the SEMIKUBE.
The controller should protect the system in case the DC voltage goes beyond the maximal values.

5.7 HEATSINK TEMPERATURE MONITORING

The heatsink temperature is constantly monitored through a NTC thermistor. This measure is physically isolated from the power – located on the heatsink.

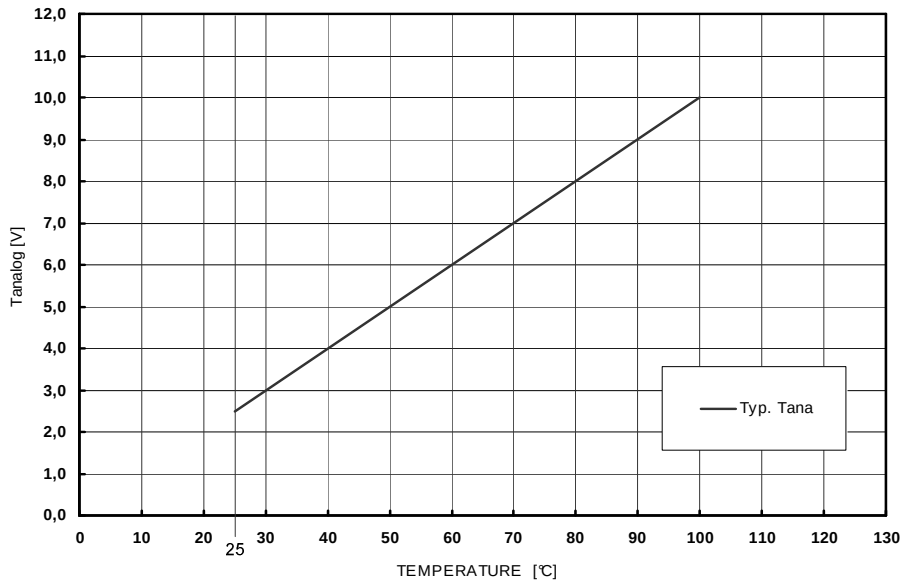
The driver board provides a normalized, analog voltage signal of the received temperature information, at the connector of the driver board.

As a standard, SEMIKUBE driver boards protect the system by tripping when the heatsink temperature goes beyond 100℃ +/-4℃. The error is can be reset when heatsink temperature goes below 70℃

In any case, the controller should include protection to stop the application when the heatsink reaches a dangerous temperature, which depends strongly on the usage of the product. For more information, please contact SEMIKRON.

Signal Characteristics	
Over temperature trip level	100℃
Accuracy of the over temperature trip level	±4℃
Threshold level for reset after failure event	70℃
Minimum measurable temperature	25℃

Analog Temperature Signal with Temperature Sensor A1004AS20T1



5.8 DIAGNOSTICS

5.8.1 SIZE T0,5 & T1, System Diagnostic Indication by LED

The following informations are relative to the SEMIKUBE T0,5 & T1 (GD driver)

The system status during system power on, normal operation or failure event are illuminated by three tri-colours LEDs (LED 0 (V1) on primary side, LED 2 (V151) on secondary side TOP, LED 3 (V128) on secondary side BOT) on the driver board. The LEDs indicate the following conditions.

Diagnostic Code – System Start

LED 0 (V1)	Description
green, flashes	System is starting and checking supply voltages.
red, flashes	Supply voltage < V_s min.
yellow, flashes	Failure during system start. Automatic restart after 10 seconds and V_s > threshold level for reset.

LED 1 (V8)	Description
green, steady on	Start or last restart of system by applying supply voltage.
red, steady on	Last restart of system was generated by controller on board, because of unknown failure.
yellow, steady on	Last system restart was generated by controller on board, because the supply voltage has fallen below UVP trip level.

Diagnostic Code – Normal Operation

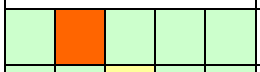
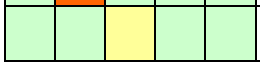
LED 0 (V1)	Description
green, steady on	System is working. No system failures occur since last system start.
yellow, steady on	System is working, but failure occurred during system operation. Failure occurred minimum three hours ago and type of error in not indicated anymore.

LED 1 (V8)	Description
green, steady on	Start or last restart of system by applying supply voltage.
red, steady on	Last restart of system was generated by controller on board, because of unknown failure.
yellow, steady on	Last system restart was generated by controller on board, because the supply voltage has fallen below UVP trip level.

Diagnostic Code – Failure Type Indication after Failure Event

LED 0 (V1) or / and LED 1 (V8) is illuminating five flashes with a frequency of 1Hz. After no illumination for three seconds, the flashing
sequence is repeated. The failure indication is illuminated for three hours. After three hours, the flashing sequence is stopped and

LED 0 (V1) is steady on yellow (see normal operation).

Examples for LED 0 (V1):	
Flashing sequence	Description
	Failure caused by under voltage protection or dynamic short circuit protection at SKYPER 32PRO phase V is present.
	Failure caused by under voltage protection or dynamic short circuit protection at SKYPER 32PRO phase W happened, but is not present anymore.

LED 0 (V1)				
flash 1	flash 2	flash 3	flash 4	flash 5
status SKYPER 32PRO phase U	status SKYPER 32PRO phase V	status SKYPER 32PRO phase W	status internal generated +15V	status internal generated -15V

LED 1 (V8)				
flash 1	flash 2	flash 3	flash 4	flash 5
status over current Phase U	status over current Phase V	status over current Phase W	status over temperature	status HALT signal

LED 0 (V1), LED 1 (V8) (colour of the flash)	**Description**
green	OK. No failure.
yellow	Failure was occurred, but failure is not present anymore.
red	Failure is present.

5.8.2 SIZE T2 & T3, System Diagnostic Indication by LED

The system status during system power on, normal operation or failure event are illuminated by three tri-colours LEDs (LED 0 (V1) on primary side, LED 2 (V151) on secondary side TOP, LED 3 (V128) on secondary side BOT) on the driver board. The LEDs indicate the following conditions.

Diagnostic Code – System Start

LED 0 (V1)	Description
green, flashes	System is starting and checking supply voltages.
red, flashes	Supply voltage < V_s min.
yellow, flashes	Failure during system start. Automatic restart after 10 seconds and V_s > threshold level for reset.

LED 2 (V151), LED 3 (V128)	Description
yellow, flashes	System is starting and waiting for configuration of secondary side.

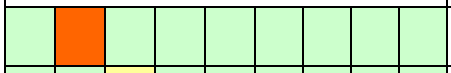
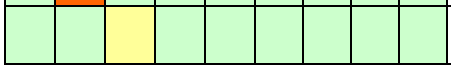
Diagnostic Code – Normal Operation

LED 0 (V1)	Description
green, steady on	System is working. No system failures occur since last system start.

LED 2 (V151), LED 3 (V128)	Description
green, steady on	System is working. No system failures occur since last system start.

Diagnostic Code – Failure Type Indication after Failure Event on Primary Side

LED 0 (V1) is illuminating ten flashes with a frequency of 1Hz. After no illumination for three seconds, the flashing sequence is repeated. The failure indication is illuminated until the driver is rebooted (turn-off of internal power supply).

Examples for LED 0 (V1):	
Flashing sequence	Description
	Failure caused by over current at CT is present.
	Failure caused by over current at CT happened, but is not present anymore.

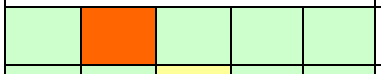
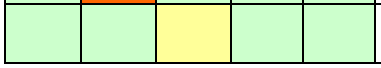
LED 0 (V1)				
flash 1	flash 2	flash 3	flash 4	flash 5
status over current CT	status over current CT	status over current CT	status over current CT	status over temperature
flash 6	flash 7	flash 8	flash 9	flash 10
status failure secondary side	status under voltage	status input signal error [1)]	status internal error	status HALT signal

LED 0 (V1) (colour of the flash)	**Description**
green	OK. No failure.
yellow	Failure was occurred, but failure is not present anymore.
red	Failure is present.

[1)] Input signal oscillation > 55kHz

Diagnostic Code – Failure Type Indication after Failure Event on Secondary Side

LED 2 (V151) and LED 3 (V128) are illuminating five flashes with a frequency of 2Hz. After no illumination for three seconds, the flashing sequence is repeated. The failure indication is illuminated until reconfiguration of the secondary side (turn-off of internal power supply).

Examples for LED 2 (V151), LED 3 (V128):	
Flashing sequence	Description
	Failure caused by under voltage +15V is present.
	Failure caused by under voltage -15V happened, but is not present anymore.

LED 2 (V151), LED 3 (V128)				
flash 1	flash 2	flash 3	flash 4	flash 5
status short circuit protection	status under voltage +15V	status under voltage -15V	status over temperature of power output stage	status internal error

LED 2 (V151), LED 3 (V128) (colour of the flash)	**Description**
green	OK. No failure.
yellow	Failure was occurred, but failure is not present anymore.
red	Failure is present.

6 DATA

6.1 STANDARDS APPLIANCE

SEMIKUBE® was designed according to the following standard recommendations for insulation coordination:

- EN 50178
- UL (600V)

For each user application, SEMIKUBE® configuration conformity should be checked by relevant qualification.

6.2 CERTIFICATIONS

SEMIKUBE® was designed according to the following standard recommendations for insulation coordination:

- UL 508C File : E242581

UL certification is applied for SEMIKRON factories :

UL certified	
France SEMIKRON SA 130 route de Cormeilles FR-78501 Sartrouville cedex	**United States** SEMIKRON Inc. 11 Executive Drive NH 03051 Hudson

SEMIKUBE® UL certified are marked by corresponding designation starting with character “I”. Further information are described on next chapter.

6.3 SEMIKUBE® DESIGNATION

SEMIKUBE® designation describes an electrical converter with accessories.

One SEMIKUBE® ordering number always includes an electrical converter and its accessories.

Please contact Solutions to define a correct designation for the assembly and the accessory before ordering

SEMIKUBE® converter designations are defined according to following rules:

SEMIKUBE® converter designation

S K U B I G D D 6 - 4 - 4 2 6 - D 3 8 1 6 - E 1 F 1 2 - B L - F A

SEMIKUBE®

UL Certification
_ : UL certified
I : Not UL-certified

IGBT electrical function
GB : 1 inverter phase
GH : 2 inverter phases
GD : 3 inverter phases

Rectifier electrical function
Dn : n-Diodes
Tn : n-Thyristors
Hn : n/2 Thyristors and n/2 Diodes
D6 : 3 phase rectifier with 6 diodes

Number of IGBT in parallel
4 : 4 modules in parallel

IGBT nominal current
4 : IGBT Ic/100

IGBT voltage class
2 : 1200V

IGBT Chip generation
4 : Trench 4 (E4) chip
6 : Trench 3 chip

Rectifier modules (refer to SEMIKRON module type and voltage ratings)
D3816 : SKKD 280/16

Capacitor technology and type
E1 : Electrolytic, 4 700µF / 400V
E2 : Electrolytic, 3 300µF / 450V
P1 : Polypropylene, 420µF / 1 100V

Capacitor cooling mode
F : Forced air cooling
N : Natural convection

Number of capacitors
12 : 12 capacitors

KUBE description (SEMIKRON internal purpose)
_ : SEMIKUBE designation
1 : KUBE n°1 description
2 : KUBE n°2 description
3 : KUBE n°3 description

Driver type
D : GD11 (3-channel driver)
B : GB11 (1-phase driver)

Driver threshold
L : Low
H : High

Heatsink cooling methode
F : Px308

AC phase alignment
A : aligned with air flow
X : crossed with air flow

SEMIKUBE® accessory designations are defined according to following rules:

SEMIKUBE® accessory designation

2 C 2 N 2 P K-1 P N X-2 F 1

n * Bipolar clamps
Sum of Bipolar clamps between cubes and clamps connected to bipolar external DC connection
2C : 2 Bipolar clamps

n * Negative clamps
Clamps connected to negative external DC connection
2N : 2 negative clamps

n * Positive clamps
Clamps connected to positive external DC connection
2P : 2 positive clamps

External DC connections
0X : no external DC connection
nEX : n extended DC bus bars
nNX : n Negative connections only
nPX : n Positive connections only
nPNX : both negative and positive DC connections
nBX : n Bipolar connections
1P1NX : 1 negative and 1 positive DC connection

n * Fan
G : no fan
nF1 : n fans type SKF 16O (position high)
nF2 : n fans type SKF 16O (position low)
nF3 : n fans type SKF 2J (position high)
nF4 : n fans type SKF 2J (position low)
2F1 : 2 fans SKF 16O (position high)

6.4 ACCESSORIES

Available accessories on SEMIKUBE® platform		
Designation	**Ordering number**	**Unit**
SKF 3-230-01	30031061	1
SKF 16P-230-01	15801062	1
SEMIKUBE Fan option F1&F3	08801319	1
SEMIKUBE Fan option F2&F4	08801320	1
Bipolar DC clamp (UL) RYTON	08800320	1
Negative DC clamp RYTON	08800323	1
Positive DC clamp RYTON	08800326	1
Bipolar DC clamp (UL) DIC	08800312	1
Negative DC clamp DIC	08800313	1
Positive DC clamp DIC	08800314	1
Bipolar DC Clamp Tool Kit	08750834	1
Unipolar DC Clamp Tool kit	08750835	1
Control Tool between Kubes	15751351	1

6.5 ENVIRONMENTAL CONDITIONS

6.5.1 Protection degree

Relative to standard IEC 60529, SEMIKUBE® power assemblies are:

Protection Level			
Protection degree	IEC 60529	-	IP00

6.5.2 Pollution degree

Relative to standard EN 50178, SEMIKUBE® power assemblies are:

Pollution Degree			
Pollution degree	EN 50178	-	2

6.5.3 Shock and vibration

Shock and vibration qualification tests have been performed on SEMIKUBE® KUBEs only. It is the responsibility of the end user to qualify the complete system in accordance with applicable standards for shock and vibration conditions.

- Transportation, Storage

Relative to standard IEC 60721-3-2, the KUBE comply with:

Shock and vibration in storage and transportation			
Transportation class	IEC 60721-3-2:2002	-	2M1

- Operation

Relative to standard IEC 60721-3-3, the KUBE comply with:

Shock and vibration in operation			
Operation class	IEC 60721-3-3:2002	-	3M3

6.5.4 Climatic conditions

Climatic qualification tests have been performed on KUBEs only. It is the responsibility of the end user to qualify the complete system in accordance to applicable standards for climatic conditions.

- Transportation, Storage

Relative to standard IEC 60721-3-1 and IEC 60721-3-2, the KUBEs comply with:

Climatic condition in storage and transportation			
Storage class	IEC 60721-3-1:2002	-	1K4
Ambiant temperature range		[℃]	-25 to +70
Humidity rate range		[%]	5 to 85

- Operation

Relative to standard IEC 60721-3-3, the KUBEs comply with:

Climatic condition in operation			
Operation class	IEC 60721-3-3:2002	-	3K3[(1)]
Ambiant temperature range		[℃]	-25 to +55
Air coolant temperature range		[℃]	-20 to +50
Humidity rate range		[%]	5 to 85 No condensation, no icing

[(1)] Expanded temperature range -25 to +55℃

6.5.5 Biological conditions

Relative to standard IEC 60721-3-3, the SEMIKUBE® complies with:

Biological conditions in operation			
Biological condition	IEC 60721-3-3:2002	-	3B1

6.5.6 Mechanically and chemically active substance conditions

Relative to standard IEC 60721-3-3, the SEMIKUBE® complies with:

Active substance conditions in operation			
Mechanical active substance	IEC 60721-3-3:2002	-	3S1
Chemically active substance	IEC 60721-3-3:2002	-	3C1

6.5.7 Altitude

The SEMIKUBE® can be stored or operated:

Altitude		
Max. storage or transportation altitude	[m]	4 000
Maximum operating altitude	[m]	1 000

6.6 ENVIRONMENTAL COMPLIANCE

SEMIKUBE® power assemblies comply with European Directives relative to Environment protection:

- RoHS: European directive 2002/95/EC (Restriction of the use of Hazardous Substances in electrical and electronic equipment)
- REACH (Registration, Evaluation, Authorization and Restriction of Chemicals)
- Wood pallets for SEMIKUBE® transport and storage comply with International Standards For Phytosanitary Measures No. 15 (ISPM 15).

Separate certification documents are available on request.

7 MAINTENANCE

7.1 WARRANTY

SEMIKUBE® power assemblies have a 2-year warranty, running from the day of SEMIKRON Solution Center factory shipment.

This warranty is applicable to SEMIKUBE® configuration described in chapter Purpose of the user manual

7.2 LIFE TIME

Lifetimes given below are estimations. These indicative values are based on suppliers' datasheets and are given for information only.

Lifetime are based on datasheet operating points :

- for polypropylene capacitors. Calculated lifetime is 100,000h at 40℃ ambient;
- the electrolytic capacitors. Calculated lifetime is 60,000h at 40℃ ambient;
- the fan SKF 3-230-01. L_{10} lifetime is 45,000h at 40℃ ambient;
- the fan SKF16O-230-02. L_{10} lifetime is 40,000h at 40℃ inlet ambient when operating at 50Hz;
- SEMITRANS® 3 thermal cycles. This is application dependent. For this matter, please contact an application engineer.

For more information, please refer to Preventive maintenance calendar section.

7.3 IDENTIFICATION, TRACEABILITY

Traceability label	Product ID
Date: 1218 SEMIKRON P/N: 08800415BA S/N: FR12345678 The traceability number (ID) is identified by a data matrix code and plain text label, and refers to : • Date code YYWW • Product number and version • Serial number	The product serial number is given in matrix code mode as well as explicit form. The traceability of the product within SEMIKRON is based on the serial number. The serial number should be mentioned in every communication. Ex : in this label, the serial number is FR12345678

SEMIKRON internal database keeps track of the following fields for each individual S/N:

- KUBE: date code, part number, production tracking number, line identifier;
- Components: date code, supplier;
- Operators;
- Test results (already individually stored in a separate database);

7.4 MAINTENANCE

7.4.1 Security precautions before any intervention on the SEMIKUBE®

WARNING!

Safety!

Before starting any work on SEMIKUBE® converters,

- Read chapter 1.4 carefully
- Carefully ensure no high voltage is still present on the power stack
- Turn off power supply of the driver after high voltage shut down
- Do not remove cables from the driver before shutting down all power sources

Failure to observe this instruction may result in death or serious injury.

7.4.2 Preventive maintenance calendar

Assuming Year 0 is the installation date of the SEMIKUBE®, here is a proposed schedule for:

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	next
Date														
Cleaning														
Capacitor bank			●	●	●	●	●	●	●	●	●	●	●	●
Capacitor bank fan			●	●	●	●	●	●	●	●	●	●	●	●
Heatsink fan			●	●	●	●	●	●	●	●	●	●	●	●
Heatsink fins			●	●	●	●	●	●	●	●	●	●	●	●
Replacing														
Electrolytic capacitor bank (*)								●						Every 60,000h
Polypropylene capacitor bank (**)											●			Every 100,000h
Capacitor bank fans						●					●			Every 45,000h
Heatsink fans					●				●				●	Every 40,000h

(*) Electrolytic capacitor bank is sized to have a lifetime over than 60,000 hours at 40℃. Depending on the cycle of the application, it could be slightly longer.

(**) Electrolytic capacitor bank is sized to have a lifetime over than 100,000 hours at 40℃. Depending on the cycle of the application, it could be slightly longer.

In any case, please contact SEMIKRON application team to get a simulation.

7.4.3 Cleaning recommendations

- Capacitor bank

It is advised to dismount the KUBE from the power electronic cabinet. Once the KUBE is dismounted, the technician should transport the KUBE to an appropriate area where the capacitor bank can be dismounted from the KUBE. The technician can then blow down the capacitor bank to remove any contaminants.

Blowing down the capacitor bank directly either mounted in the power electronics cabinet or attached to the SEMIKUBE® may spread contaminants into the electronics circuits which may cause short circuit.

- Fans

Similar recommendation for the heatsink fans and the capacitor fans. They shall be dismounted from the SEMIKUBE® and blown down in a separate area. Before re-mounting the fan, connect a $230V_{AC}$ power supply to visually check there is no damage.

- Heatsink fins

The KUBE shall be dismounted from the power electronics cabinet and transported to an appropriate area for cleaning. Enclose the capacitor bank, driver and IGBT area into an electrostatic plastic bag, then blow down the fins.

7.4.4 Procedure in case of failure

In case of SEMIKUBE identified failure :
Before commencing any work on a SEMIKUBE check that:

- all electrical power is switched off to the cabinet and any interlocked circuits from other sources which feed into that cabinet - wait at least 5 minutes after isolating supplies
- the cooling fan has been switched off

Then :

- Proceed to a visual check of the failed SEMIKUBE
- If no visual damage observe, check LED status on the driver (refer to Diagnostics)
- Proceed to reset if possible
- Then try to restart the system
- If visual damage is observed, proceed to a driver diagnostic, record all information given by the driver and replace the SEMIKUBE

In case of explosion, very high currents may cause internal invisible damage to IGBT modules and capacitors or cause electrical stress that may affect SEMIKUBE reliability. It may not possible to detect all the effects of electrical stress on apparently undamaged and functional components. Functional tests may pass and may not show any electrical damages due to the explosion but the reliability may be reduced and further failure may occur later as a result of the explosion.
Therefore, in case of explosion, it is highly recommended to change all IGBT modules and all capacitors. Moreover, parts damaged by arcing or mechanical deformation shall be replaced.
When any equipment is being returned for servicing it is important that all the details available about the conditions under which the equipment failed are provided, using the SEMIKRON document and procedure, with the returned equipment.

7.4.5 Recommended Procedure for SEMIKUBE replacement

Remove all electrical wiring from the SEMIKUBE in the following sequence:

- disconnect all power cables, a.c. and d.c., noting their connection positions
- disconnect all control wiring from terminal boards and/or ribbon connections
- before handling, ensure that the SEMIKUBE is cooled down
- The modules are delicate and vulnerable to damage - handle carefully.
- Only lift or move them by use of the lifting point.
- Place the SEMIKUBE on a flat surface with heatsink on bottom.

The removal of a SEMIKUBE module from a cabinet requires use of the crane and the presence of two people.

- disconnect the air duct system from the heatsink of the SEMIKUBE
- release the module from its frame by undoing the fixing screws
- attach the crane shackle to the lifting hole in the top of the module
- take up the weight of the module on the crane and carefully withdraw the module from its frame.
- with the crane taking the weight of the module, completely withdraw the module from its frame
- with the module hanging on the crane

7.4.6 Transporting a SEMIKUBE

Preparation of the SEMIKUBE for Shipping

- check that the ‘end caps’ have been fitted to all couplings
- use the original packing material

8 APPENDIX

8.1 RELATED DOCUMENTS

Document	Entity	Author	Revision	Date
SEMIKUBE Board GD 11 Technical explanation	SEMIKRON Germany	Markus Hermwille	05	01/10/2007

