COMBIVERT

0.5...200 hp

POWER STAGE
INSTRUCTION MANUAL

00.F5.0UB-K001

STOP **Read this instruction manual completely before attempting to operate the unit!**

05/2003

This Instruction Manual describes the power circuit of the KEBCO COMBIVERT F5 Series Motor Control. It is only valid together with the Instruction Manual Control Stage. Both Instruction Manuals must be made available to the user. Prior to performing any work on the unit the user must familiarize himself with the unit. This includes especially the knowledge and observance of the **safety and warning information on page 5 of this book**. The pictographs used in this Instruction Manual have following meaning:

Danger
Warning
Caution

Attention,
observe at
all costs

Information
Help
Tip

Table of Contents

1. General

1.1 Product description

In selecting the COMBIVERT F5 series inverter, you have chosen a frequency inverter with the highest quality and dynamic performance.

It is exclusively designed for smooth speed regulation of a three phase motor.

The operation of other electrical loads is forbidden and can lead to destruction of the unit.

This manual describes the frequency inverter **COMBIVERT F5.**

- 1 hp...60 hp / 230V class
- 1 hp...200hp / 460V class

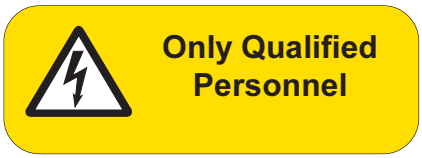
Note: 250hp to 450hp units, sizes 28 - 31 are described in a supplemental manual 00.F4.0UZ-KW01. For technical data and wiring connections of these sizes please consult this document.

The COMBIVERT F5 inverter has the following features:

- small mounting footprint
- IGBT power circuit gives low switching losses
- low motor noise with high carrier frequency
- extensive protection for over- current, voltage and temperature
- voltage and current monitoring in static and dynamic operation
- short circuit proof and ground-fault proof
- noise immunity in accordance with IEC1000
- hardware current regulation
- integrated cooling fan
- uniform mounting pattern
- can be mounted side by side with zero clearance
- CE compliant and UL listed

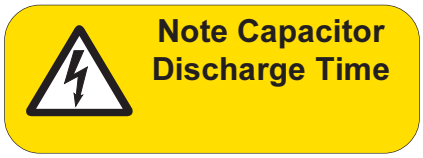
1.2 Safety Precautions

AC motor controls and servo drives contain dangerous voltages which can cause death or serious injury. During operation they can have live "energized" un-insulated parts, moving parts, as well as hot surfaces. Care should be taken to ensure correct and safe operation in order to minimize risk to personnel and equipment.



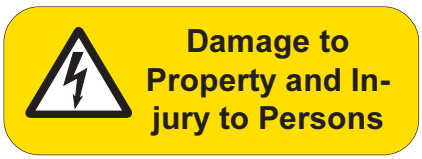
All work involving this product, installation, start up as well as maintenance may only be performed by qualified electrical technical personnel. According to this manual "qualified" means: those who are able to recognize and acknowledge the possible dangerous conditions based on their training and experience and those who are familiar with the relevant standards and installation codes as well as the field of power transmission.

AC motor controls and servo drives must be protected against physical damage during transport, installation, and use. Components or covers must not be bent or deformed as this may decrease insulation distances inside the unit resulting in an unsafe condition. On receipt of the unit visual damage should be reported immediately to the supplier. DO NOT ATTEMPT TO POWER UP A UNIT WITH VISIBLE PHYSICAL DAMAGE. This unit contains electrostatically sensitive components which can be destroyed by in correct handling. For that reason, disassembly of the unit or contact with the components should be avoided.



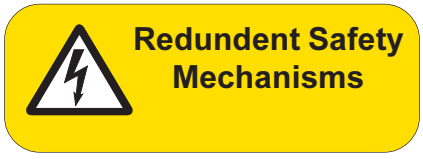
Before any installation and connection work can be done the supply voltage must be turned off and locked out. After turning off the supply voltage, dangerous voltages may still be present within the unit as the bus capacitors discharge. Therefore it is necessary to wait 5 minutes before working on the unit after turning off the supply voltage.

The low voltage control terminal strip and communication ports are securely isolated in accordance with EN50178. When connecting to other systems, it is necessary to verify the insulation ratings of these systems in order to ensure the EN requirements are still met. When connecting the unit to a grounded delta power system, the control circuit can no longer be classified as a "securely isolated circuit".



Before putting the motor control or servo system into operation be sure the connection terminals are tight and all covers removed for installation have been replaced.

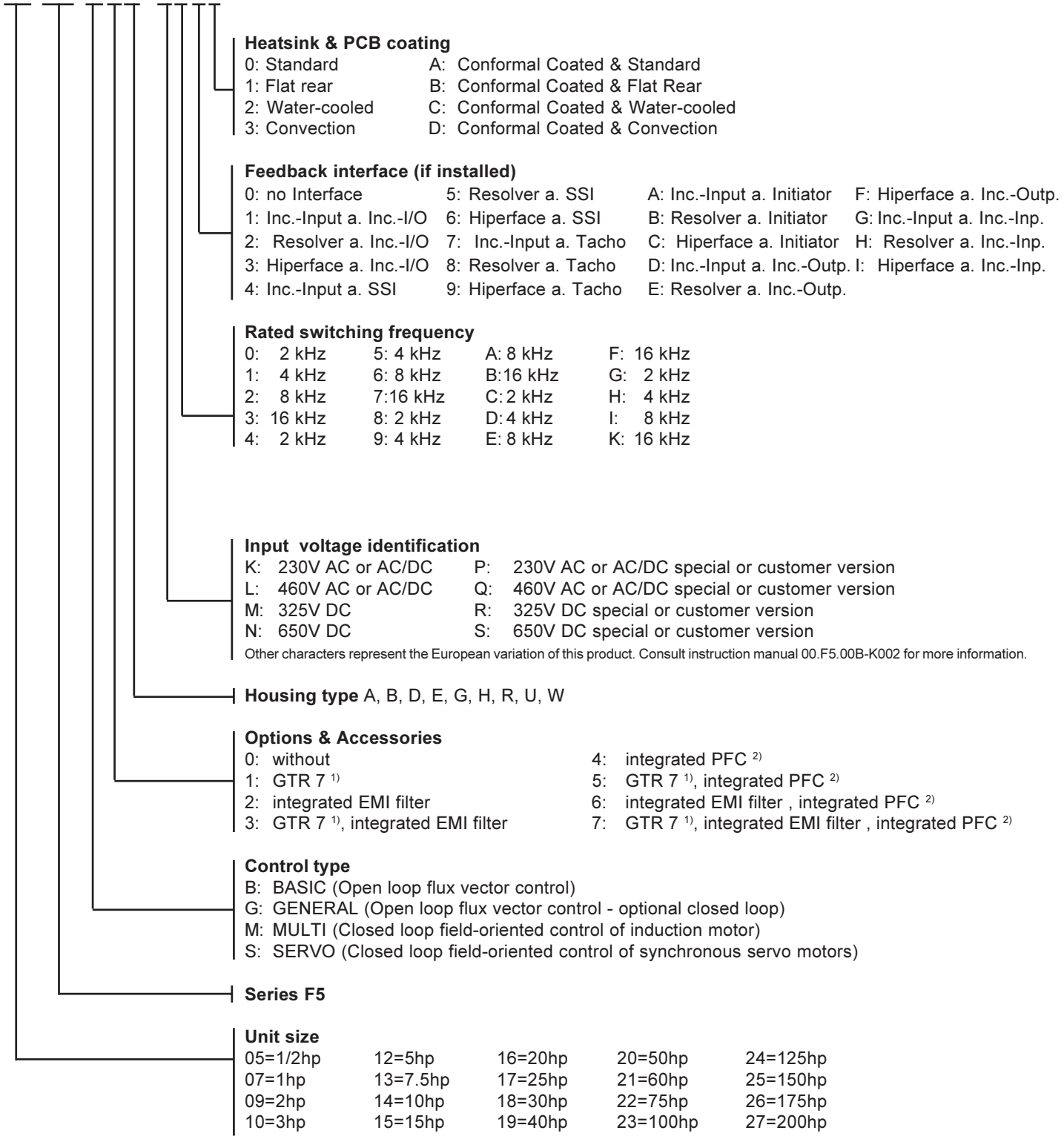
The AC motor control or servo system can be adjusted to self initiate an automatic restart in the even of a fault or error condition. The design of the system must take this into account, such that personnel are safe guarded against potentially dangerous circumstances.



Software functions in the AC motor control or servo system can be used to control or regulate external systems. However, in the event of failure of the motor control or servo system there is no guarantee these software function(s) will continue to provide the desired level of control. As a result, when operator or machine safety is at stake, external elements must be used to supplement or override the software function within the AC motor control or servo system.

1.3 Part number system

10.F5.G1B–3200



Heatsink & PCB coating

0: Standard	A: Conformal Coated & Standard
1: Flat rear	B: Conformal Coated & Flat Rear
2: Water-cooled	C: Conformal Coated & Water-cooled
3: Convection	D: Conformal Coated & Convection

Feedback interface (if installed)

0: no Interface	5: Resolver a. SSI	A: Inc.-Input a. Initiator	F: Hiperface a. Inc.-Outp.
1: Inc.-Input a. Inc.-I/O	6: Hiperface a. SSI	B: Resolver a. Initiator	G: Inc.-Input a. Inc.-Inp.
2: Resolver a. Inc.-I/O	7: Inc.-Input a. Tacho	C: Hiperface a. Initiator	H: Resolver a. Inc.-Inp.
3: Hiperface a. Inc.-I/O	8: Resolver a. Tacho	D: Inc.-Input a. Inc.-Outp.	I: Hiperface a. Inc.-Inp.
4: Inc.-Input a. SSI	9: Hiperface a. Tacho	E: Resolver a. Inc.-Outp.	

Rated switching frequency

0: 2 kHz	5: 4 kHz	A: 8 kHz	F: 16 kHz
1: 4 kHz	6: 8 kHz	B: 16 kHz	G: 2 kHz
2: 8 kHz	7: 16 kHz	C: 2 kHz	H: 4 kHz
3: 16 kHz	8: 2 kHz	D: 4 kHz	I: 8 kHz
4: 2 kHz	9: 4 kHz	E: 8 kHz	K: 16 kHz

Input voltage identification

K: 230V AC or AC/DC	P: 230V AC or AC/DC special or customer version
L: 460V AC or AC/DC	Q: 460V AC or AC/DC special or customer version
M: 325V DC	R: 325V DC special or customer version
N: 650V DC	S: 650V DC special or customer version

Other characters represent the European variation of this product. Consult instruction manual 00.F5.00B-K002 for more information.

Housing type A, B, D, E, G, H, R, U, W

Options & Accessories

0: without	4: integrated PFC [2]
1: GTR 7 [1]	5: GTR 7 [1], integrated PFC [2]
2: integrated EMI filter	6: integrated EMI filter , integrated PFC [2]
3: GTR 7 [1], integrated EMI filter	7: GTR 7 [1], integrated EMI filter , integrated PFC [2]

Control type

B: BASIC (Open loop flux vector control)
G: GENERAL (Open loop flux vector control - optional closed loop)
M: MULTI (Closed loop field-oriented control of induction motor)
S: SERVO (Closed loop field-oriented control of synchronous servo motors)

Series F5

Unit size

05=1/2hp	12=5hp	16=20hp	20=50hp	24=125hp
07=1hp	13=7.5hp	17=25hp	21=60hp	25=150hp
09=2hp	14=10hp	18=30hp	22=75hp	26=175hp
10=3hp	15=15hp	19=40hp	23=100hp	27=200hp

1) GTR 7: brake transistor
2) PFC: Power Factor Control

1.4 Mounting instructions

1.4.1 Classification

❑ **The COMBIVERT F5 is classified as an "Open Type" inverter with an IP20 rating and must be mounted inside of a control cabinet.**

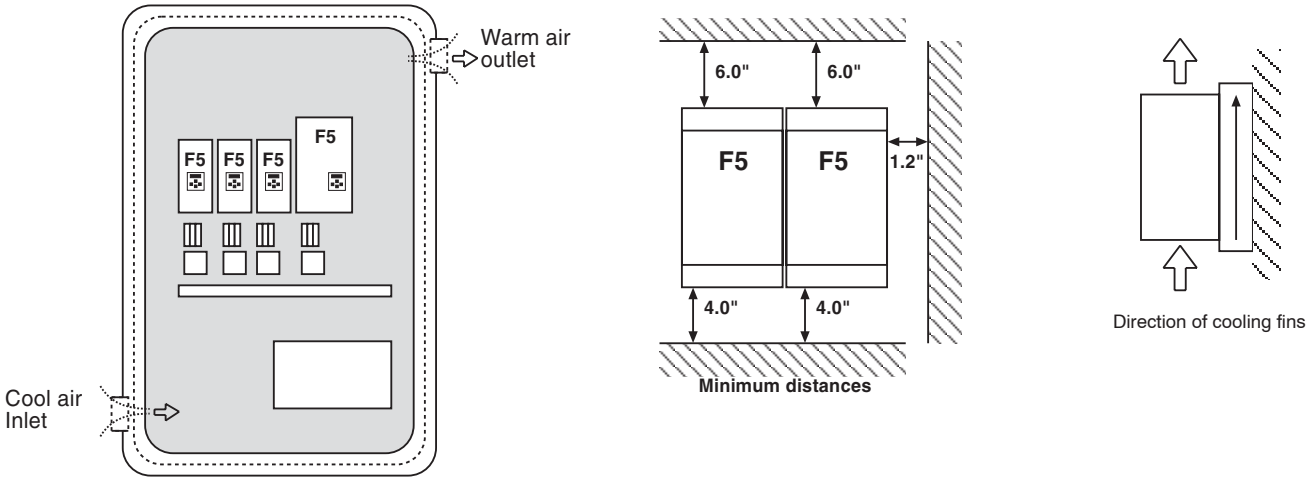
1.4.2 Physical Mounting

❑ Install the inverter in a stationary location offering a firm mounting point with low vibration.

❑ Installation of the inverter on moving system may require special earth ground connections to the inverter. Please consult KEBCO.

❑ For best high frequency grounding, install the inverter on a bare metal sub-panel, i.e. zinc plated steel or galvanized steel.

❑ Take into consideration the minimum clearance distances when positioning the inverter (see drawing below). The F5 series inverters are designed for vertical installation and can be aligned next to each other. Maintain a distance of at least 2 inches in front of the unit. Make sure cooling is sufficient.



1.4.3 Harsh Environments

❑ For extended life, prevent dust from getting into the inverter. Select units with conformal coating when the inside of the control cabinet may be occasionally subject dust, moisture, or other substances which could build up over time.

❑ When installing the unit inside a sealed enclosure, make sure the enclosure is sized correctly for proper heat dissipation or that a cooling system has been installed in the panel.

❑ **Protect the inverter against conductive and corrosive gases and liquids. Water or mist should not be allowed into the inverter.**

❑ **The COMBIVERT F5 inverter must be installed in an explosion-proof enclosure when operating in an explosion-proof environment.**

1.4.4 Ambient Conditions

- **The operating temperature range of the unit is -10°C to + 45°C. Operation outside of this temperature range can lead to shut down of the inverter.**
- The unit can be stored (power off) in the temperature range -25°C to 70°C. After prolonged storage, one half year or more, apply voltage to the inverter for 2 hours before operating the motor. This will allow the electrolytic bus capacitors to stabilize before use and result in longer lifetime of the unit.
- The power rating of the inverter must be derated for operation above 3,300 ft (1000 m). Reduce the rated power 1% for each additional 330 ft (100 m). The maximum elevation for operation is 6,560 ft (2000 m)
- The relative humidity should be limited to 95% without condensation.

1.3.5 Cooling systems

The KEB COMBIVERT F5 is available with different cooling systems:

- **Standard -** Standard design with heat sink and thermostatically controlled two speed fan.
- **Flat Back -** With this design the heat sink is omitted. The unit must be mounted onto an appropriate base (a machined surface) to ensure heat removal from the inverter. The dissipation of the heat must be guaranteed by the machine builder. Advantages include: low profile for intermittent duty controls, heatsink sharing, modular assembly.
- **Water-cooling -** This design is laid out for connection to an existing cooling system. The dissipation of the heat must be guaranteed by the machine builder. To avoid moisture condensation, the minimum inlet temperature of the coolant may not fall below the room temperature. The maximum inlet temperature shall not exceed 40°C. Measures must be taken to prevent contamination and calcifying buildup within the cooling system. The maximum pressure on the cooling system shall not exceed 4 bar (60 psi (special versions with higher pressures on request). The standard water pipe fitting is G1/2.
- **Convection (push through version) -** The heat sink is over sized and designed to push through the cabinet wall to the outside. The smaller units (<40hp) generally will operate without additional air flow through the heatsink. The larger units will require some type of forced airflow through the heatsink.

1.5 Electrical connections

1.5.1 Safety First

- **RISK OF ELECTRIC SHOCK! Always disconnect supply voltage before servicing the COMBIVERT F5.**
- **After disconnecting the supply voltage, always wait 5 minutes before attempting to change the wiring. The internal DC BUS capacitors must discharge.**

1.5.2 Voltage Supply

- The F5 series inverters are suitable for use on a circuit capable of delivering not more than 10kA rms symmetrical amperes, at the inverter's rated maximum voltage.
- Pay attention to the supply voltage and be sure the supply voltage matches that of the inverter. A 230V unit can be supplied with voltage in the range 180 to 260VAC +/-0%, for a 460V unit the range is 305 to 500VAC +/- 0%, 48Hz to 62 Hz.

- **Connection of the F5 series inverters to voltage systems configured as a corner grounded delta, center tap grounded delta, open delta, or ungrounded delta, may defeat the internal noise suppression of the inverter and the isolation of the control part is no longer classified as a "securely isolated circuit". Increased high frequency disturbance in the machine and on the line may be experienced. On such a system the maximum allowable phase to ground voltage is 500VACrms. A balanced, center grounded wye connection is always recommended. The three phase voltage imbalance must be less than 2% phase to phase. Greater imbalance can lead to damage of the inverter's power circuit.**

1.5.3 Disconnect Switch

- A disconnect switch or contactor should be provided as a means of turning off the supply voltage when the unit is not in use or when it must be serviced.
- Repetitive cycling on and off of the input supply voltage more than once every five minutes can lead to damage of the inverter. For shorter times contact KEBCO.

- **A disconnect or switch placed between the motor and inverter should be avoided if at all possible. However, if not, the following points should be considered. It is not allowed to actively switch the motor on a closed loop (Field Oriented Control induction or AC servo) system. The inverter must first be brought into NOP status by turning off the drive enable input on terminal X2.16. On openloop systems, switching off a motor running under load can cause the COMBIVERT F5's overcurrent protection to activate resulting in a fault shut down of the unit. When starting motors by closing the contact into an already running inverter, the inverter should be sized based on the starting current of the motor. Or to reduce the current demand, the "speed search" function of the inverter should be activated.**

1.5.4 Fusing

- **A circuit breaker or a disconnect switch with fuses must be provided as branch circuit protection in accordance with the National Electric Code (NEC) and all local codes.**
- **The F5 is to be connected to the supply voltage using Class J fuses (BUSSMANN type LPJ or equivalent) or using a magnetic trip circuit breaker with type D characteristic. Ratings for the short-circuit protection device are specified per unit size in the tables on pages 15-20.**
- The minimum voltage rating for protection devices used with 230V inverters shall be 250VAC. The minimum voltage rating for protection devices used with 460V inverters shall be 600VAC.
- Fuses should not be installed between the inverter and the motor. The output of the inverter is short circuit protected and ground fault protected with a maximum trip value (varies by housing size) of 250% of the rated output current. The tripping time is less than 1 mSec. Repeated short-circuits faults can cause premature failure of the output transistors. If the motor is operating in regenerative mode (2nd or 4th quadrant) and a short circuit occurs, the inverter may not be able to limit the current before failure occurs.

1.5.5 Line Chokes

- **A line choke with minimum 3% impedance is required for all 230 V inverters 40hp (size 19) and greater. A line choke with minimum 3% impedance is required for all 460V inverters 100hp (size 23) and greater.**
- Installing a line choke will considerably extend the lifetime of the DC bus capacitors especially on systems operating continuously at rated power.

- **A line choke with minimum 3% impedance should be installed when the power available at the nearest distribution point is significantly greater (more than 200 times) than the rated power of the inverter.**

  Example: 5 hp COMBIVERT F5 S_{rated} = 6.6kVA, S_{dist_xfrmr}=2,000 kVA.

  2,000kVA / 6.6 kVA = 303 > 200 -> install 3% choke

  Another method to determine whether a choke is required; if the line impedance is less than 0.5%, then a choke should be used.
- A line choke can be used to generally reduce conducted high frequency noise eliminating nuisance trips. See section 3.2.1 on page 33 for more information.

1.5.6 Motor Thermal Protection

❑ The F5 series inverters by default provide motor overload protection at 130% of the inverter's UL rated current.

❑ The F5 series inverters are classified as a UL approved solid state overload protection device. It is necessary to activate the function in the software of the inverter. The function meets the requirements set forth in VDE 0660 Part 104, UL508C section 42, and NEC 430 part C. See parameters dr.11, dr.12 and Pn.14 in the application mode for adjustment.

❑ Overload protection using a normally closed contact (min. rating 15V 6mA) or PTC type sensor is also available using terminals T1 and T2. This function also must be activated by the software of the inverter. See parameters CP.28 or Pn.10.

❑ **In general, overload protection through current sensing does not always provide protection against overheating at low speeds; reduced fan cooling. Therefore it is recommended that a motor winding sensor be used in applications requiring prolonged operation at low motor speeds.**

1.5.7 High Voltage Connections

❑ Always note inverter voltage, select appropriate over current protection devices, select disconnect device, and select proper wire size before beginning the wiring process. Wire the inverter according to NEC Class 1 requirements.

❑ The correct wire gauge for each size inverter can be selected from the charts on pages 15-20. Always use UL listed and CSA approved wire. The wire gauge is based on the recomended fuse rating for the inverter and a minimum of 75°C insulation rating. Use copper wire only. If a lower rated fuse is selected, then it may be possible to use a smaller gauge wire. Use 300V rated wire with 230V systems and 600V rated wire with 460V systems.

❑ The terminal tightening torque can be found for each unit in the same tables.

❑ To prevent coupling high frequency noise, the following wires must be spatially separated from each other a minimum distance of 8 inches (20 cm)when they are laid parallel to each other :

- AC supply power and motor lines not connected to inverters
- motor lines connected to inverters
- control and data lines (low-voltage level < 48 V)

❑ When using KEBCO EMI filters, use only the wire provided with the filter to connect the filter to the inverter. Do not add additional wire between the filter and the inverter as this will have a negative effect on the operation of the filter.

1.5.8 DC Supply Connections

When connecting the F4 series inverter from a DC supply or when connecting several F4 series inverters to a common DC bus the following points should be observed.

- ❑ Each inverter must be fused on both the + and - conductors. BUSSMANN DC fuse type FWP are recommended. The DC input current of the inverter can be calculated using the equations below.
- ❑ Connect the positive wire to the ++ terminal and the negative wire to the -- terminal. Terminals marked PA, PB, or - are not suited for DC voltage input. See page 24 for wiring example. All previously stated wiring conditions are still valid.
- ❑ The peak DC supply current can be calculated with the following formulas:

230V Supply

$$\frac{2.6 \times \text{rated motor voltage} \times \text{rated motor current} \times \text{motor PF}}{310V}$$

460V Supply

$$\frac{2.6 \times \text{rated motor voltage} \times \text{rated motor current} \times \text{motor PF}}{620V}$$

If the motor power factor (PF) is not known, use the value 0.78 as a default.

For additional information about DC supply of the inverter contact KEBCO Inc.

1.5.9 Ground Connections

- ❑ When working with high frequencies (> 1kHz) and power semiconductors it is recommended to make all ground connections with large exposed metal surfaces in order to minimize the ground resistance.
- ❑ The metal sub-plate the inverter is mounted on is regarded as the central ground point for the machine or the equipment. For best results use an unpainted, galvanized or plated sub-panel.

- ❑ **The AC motor control or servo system is designed for fixed installation. High frequency discharge currents in the ground circuit can exceed 3.5mA especially when using EMI filters. Therefore, an additional high frequency ground wire should be connected between the inverter and the sub-panel. Use a stranded wire (6 gauge) or a thick ground strap. This is in addition to the ground wire required by NEC.**
- ❑ All ground connections should be kept as short as possible and as close as possible to the ground system, sub-panels.
- ❑ If other components in the system exhibit problems due to high frequency disturbances, connect an additional high frequency ground wire between them and the sub-panel.
- ❑ The KEBCO EMI filter should be mounted to the inverter or as close as possible to the inverter and on the same sub-panel as the inverter. Good metallic surface contact to the sub-panel is required to provide adequate high frequency grounding of the filter.

1.5.10 High Frequency Shielding

- Use of shielded cable is recommended when high frequency emissions or easily disturbed signals are present. Examples are as follows:

  - motor wires connected to inverters: connect shield to ground at both the inverter and motor, NOTE the shield should never be used as the protective ground conductor required by NEC. Always use a separate conductor for this.

  - digital control wires: connect shield to ground at both ends.

  - analog control wires: connect shield to ground only at the inverter.

- The connection of meshed shields to the ground connection should not be done through a single strand of the shield, but with metallic clamps to provide 360° contact around the surface of the shield to the ground point. Connection with a single wire bundle from the braided shield reduces the effectiveness of the shield 70%. Metal conduit clamps work well for this. Be sure the fit is tight.

- Ridged metal conduit can be used as the shield of the motor wires. Always observe the following points :

  - remove all paint from the control cabinet and motor housing where the conduit is fastened

  - securely fasten all conduit fittings

  - run only the motor wires through the conduit, all other wires, high voltage AC and low voltage signal, should be pulled through a separate conduit.

  - connect the control panel to the Sub-panel with a heavy ground strap.

- If KEBCO CE filters are used, they should be mounted to the inverter or as close as possible to the inverter and on the same sub-panel as the inverter. Good metallic surface contact to the sub-panel is required to provide adequate high frequency grounding of the filter. Always use the shielding plate provided with the filter when connecting the filter to the inverter.

- Shielding of control wires:

  If digital signal wires are terminated on a terminal block in the control panel, the shields should be firmly connected to the sub-panel on both sides of the terminal block.

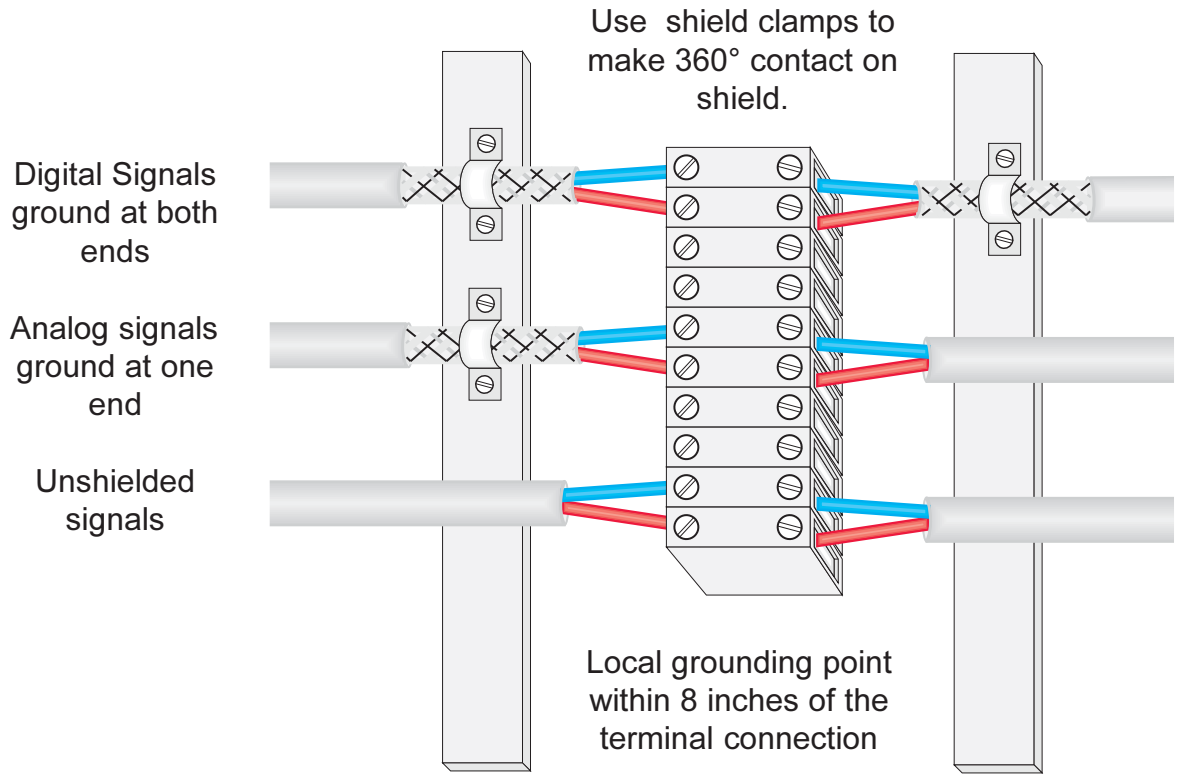
  The shields of digital signal wires originating outside the control cabinet which are not terminated on a terminal block, must be connected to the sub-panel at the point where the cable enters the control panel and at the inverter.

  If the shield is terminated to the sub-panel with in 8 inches (20cm) of the inverter, then the shield no longer needs to be connected to the inverter.

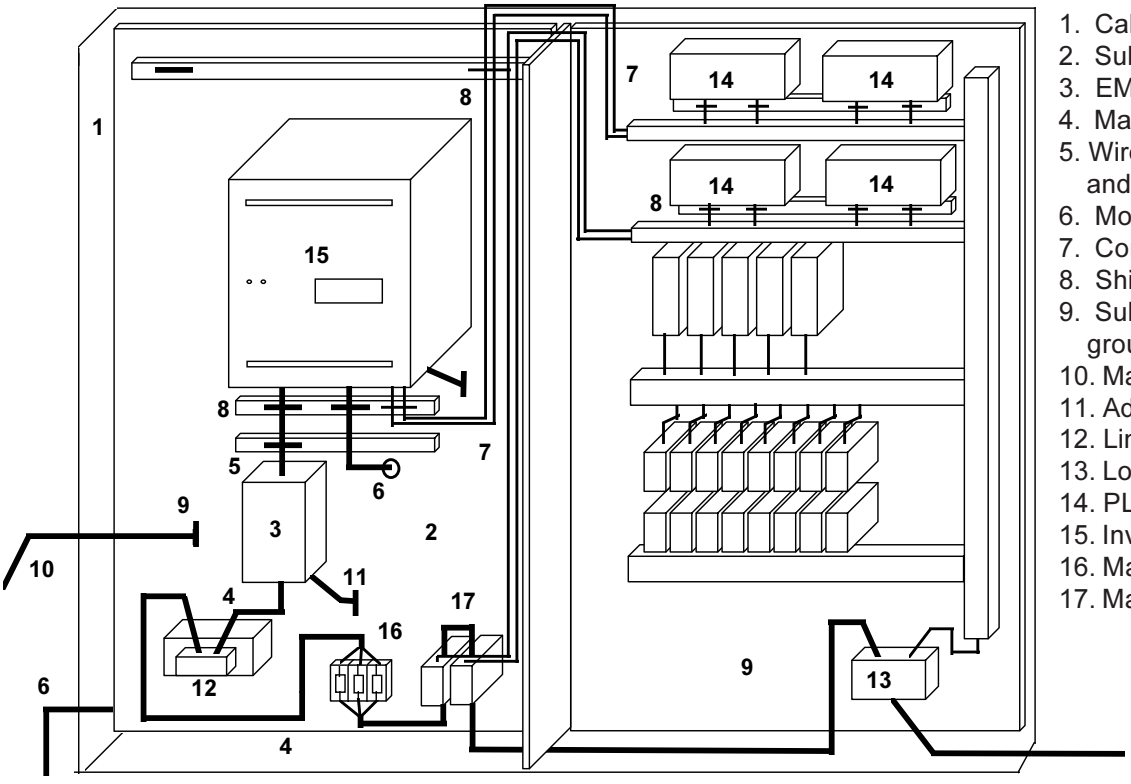
  When using un-shielded signal wires, they should always be installed as a twisted pair (signal and common).

  Low voltage signal wires should cross high voltage wires at right angles.

1.5.11 Example shield connections



1.5.12 Example control cabinet layout



1. Cabinet
2. Sub-panel
3. EMI filter
4. Main voltage supply
5. Wires between EMI filter and voltage supply
6. Motor wires
7. Control wires
8. Shield with clamps
9. Sub-panel is central ground point
10. Main ground connection
11. Additional HF ground wire
12. Line choke
13. Low voltage power supply
14. PLCs or PCs
15. Inverter
16. Main supply fuse
17. Main supply contactor

2. Technical Data

2.1 Technical Data 230V Class

Inverter Size	05			07			09				10				12	13	14	
Recommended Motor Power [hp]	1/2			1			2				3				5	7.5	10	
Housing size	A	B		A	B		B		D		B		D		D	E	E	G
Input Ratings																		
Supply voltage [V]	180…260 ±0 (230 V rated voltage)																	
Supply voltage frequency [Hz]	50 / 60 +/- 2																	
Input phases	1	1	3	1	1	3	1	3	1	3	1	3	1	3	3	3	3	
Rated input current [A]	4,0	4,0	2,8	8,0	8,0	5,6	14	9,5	14	9,5	19	13	19	13	21	29	36	
Rated input current [2] [A]	–	3,2	–	–	6,4	–	–				–				–	–	–	
Rated input "real" power [2] [kW]	–	0.85	–	–	1.5	–	–				–				–	–	–	
Recommended maximum input fuse [A]	15			15	15	15	20	15	20	15	25	20	25	20	25	35	50	
Recommended wire gauge[3] [awg]	14			14	14	14	12	14	12	14	10	12	10	12	10	10	8	
Output Ratings																		
Rated output power [kVA]	0,9			1.6			2.8				4.0				6.6	9.5	13	
Rated motor power [kW]	0.37			0.75			1,5				2,2				4.0	5.5	7.5	
Rated output current [A]	2.0			4.0			6.8				9.6				15.2	22	28	
Peak current (30 seconds)[1] [A]	4,1			7.2			12,6				18				29.7	36	49.5	
Over current fault (E.OC) trip level [A]	5.0			8.6			15,1				21,6				35.6	43	59	
Overload curve (see annex)	1																	
Output voltage [V]	3 x 0...V input (3 x 0…255V [2])																	
Output frequency [Hz]	Generally 0 to 1600Hz (limited by control board and carrier frequency)																	
Rated switching frequency [kHz]	8 [8]	16		8	16		16				8	16			8	8	4	16
Maximum switching frequency [kHz]	8	16		8	16		16				16	16			16	16	16	16
Power loss at rated operation[7] [W]	30	50		55	65		90	130			105	170			210	290	350	330
Power loss at rated operation [2] [W]	–	85	–	–	130	–	–				–				–	–	–	
Stall current at 4kHz [A]	2.3			4			7				10	10			16,5	24	33	33
Stall current at 8kHz [A]	2.3			4			7				10	10			16,5	24	24	33
Stall current at 16kHz [A]	–	2.3		–	4		7				8	10			10	16,8	16,8	33
Braking Circuit																		
Min. braking resistance [4] [Ohm]	100	56		100	56		47				33				27	16	16	13
Typ. braking resistance [4] [Ohm]	180	100		100			68				56				47	22	22	16
Max. braking current [A]	4.5	7.5		4.5	7.5		9.5				12				15	25	25	29
Installation Information																		
Max. shielded motor cable length at 4 kHz [5] [ft]	30	100		30	330		330	330										
Max. shielded motor cable length at 8 kHz [5] [ft]	30	65		30	165		330	330										
Max. shielded motor cable length at 16kHz[5] [ft]	–	30		–	65		130	330										
Tightening torque for terminal strip [in lb]	4.5															11		
Environmental																		
Max. heat sink temperature TOH [°C]	90°C / 194°F																	
Storage temperature [°C]	-25...70 °C / -13...158°F																	
Operating temperature [°C]	-10...45 °C / 14...113°F																	
Housing design / protection	Chassis / IP20																	
Relative humidity	max. 95% without condensation																	
Approvals																		
Tested in accordance with...	EN 61800-3 /UL508C																	
Standards for emitted interference	EN 55011 Class B / EN 55022 Class A																	
Standards for noise immunity	IEC 1000-4-2 / -3 / -4 / -5/ -6																	
Climatic category	3K3 in accordance with EN 50178																	

1) With the regulated systems F5-M as well as F5-S 5% must be subtracted as control reserve
2) This data is only valid for units with integrated PFC (see "unit identification")
3) The wire gauge is based on the maximum fuse rating, copper wire with minimum 75°C insulation rating, THHW or equivalent. If branch circuit protection is selected based on rated input current, the wire size could be reduced.
4) This data is only valid for units with internal brake transistor GTR 7 (see "unit identification")
5) With units with integrated EMI filter the distance is less:
   up to max. 5m line length and 4kHz operating frequency = Limit Value B (EN 55011)
   up to max. 10m line length and 16kHz operating frequency = Limit Value A (EN 55022)
7) Rated operation means rated input voltage, rated output current, and rated carrier frequency.
8) 8 kHz only with a mounting plate > 55 in² and a 1.6 inch minimum distance to other components.

Technical Data 230V Class Continued

Inverter Size	**15**		**16**	**17**	**18**	**19**	**20**	**21**
Recommended Motor Power [hp]	**15**		**20**	**25**	**30**	**40**	**50**	**60**
Housing size	**G**	**H**	**H**	**R**	**R**	**R**	**R**	**R**
Input Ratings								
Supply voltage [V]	180…260 ±0 (230 V rated voltage)							
Supply voltage frequency [Hz]	50 / 60 +/- 2							
Input phases	3		3	3	3	3	3	3
Rated input current [A]	46		59	75	88	114	143	169
Recommended maximum input fuse [A]	50	60	80	100	100	125	175	200
Recommended wire gauge[3] [awg]	8	6	4	3	3	1	2/O	3/O
Output Ratings								
Rated output power [kVA]	17		23	29	35	42	52	62
Rated motor power [kW]	11		15	18,5	22	30	37	45
Rated output current [A]	42		54	68	80	104	130	154
Peak current (30 seconds)[1] [A]	72		99	126	150	172	225	270
Over current fault (E.OC) trip level [A]	88		119	135	162	207	270	315
Overload curve (see annex)	1							
Output voltage [V]	3 x 0...V input (3 x 0...255V [2])							
Output frequency [Hz]	Generally 0 to 1600Hz (limited by control board and carrier frequency)							
Rated switching frequency [kHz]	4	16	16	8	8	8	8	8
Maximum switching frequency [kHz]	4	16	16	16	8	8	8	8
Power loss at rated operation[7] [W]	330	430	550	850	1020	1200	1400	1700
Stall current at 4kHz [A]	36	48	66	84	100	115	150	180
Stall current at 8kHz [A]	-	48	66	84	100	115	150	180
Stall current at 16kHz [A]	-	48	66	50	-	-	-	-
Braking Circuit								
Min. braking resistance [4] [Ohm]	13	5,6	5,6	4,7	4,7	3,3	2,5	2,5
Typ. braking resistance [4] [Ohm]	16	13,6	8,8	5,6	5,6	4,7	3,9	3,0
Max. braking current [A]	29	70	70	88	88	133	160	160
Installation Information								
Max. shielded motor cable length [5] [ft]	330			165				
Tightening torque for terminal strip [in lb]	11	22		53				
Environmental								
Max. heat sink temperature TOH [°C]	90°C / 194°F							
Storage temperature [°C]	-25…70 °C / -13…158°F							
Operating temperature [°C]	-10…45 °C / 14…113°F							
Housing design / protection	Chassis / IP20							
Relative humidity	max. 95% without condensation							
Approvals								
Tested in accordance with…	EN 61800-3 /UL508C							
Standards for emitted interference	EN 55011 Class B / EN 55022 Class A							
Standards for noise immunity	IEC 1000-4-2 / -3 / -4 / -5/ -6							
Climatic category	3K3 in accordance with EN 50178							

1) With the regulated systems F5-M as well as F5-S 5% must be subtracted as control reserve
3) The wire gauge is based on the maximum fuse rating, copper wire with minimum 75°C insulation rating, THHW or equivalent. If branch circuit protection is selected based on rated input current, the wire size could be reduced.
4) This data is only valid for units with internal brake transistor GTR 7 (see "unit identification")
5) The maximum cable length is the same for all carrier frequencies.
6) Contact KEBCO for this specifications.
7) Rated operation means, rated input voltage, rated output current, and rated carrier frequency.

2.2 Technical Data 460V Class

Inverter Size	05	07	09		10		12			13			14		
Recommended Motor Power [hp]	1/2	1	2		3		5			7,5			10		
Housing size	B	B	B	D	B	D	B	D	E	D	E	G	D	E	G
Input Ratings															
Supply voltage [V]	305...500 ±0 (460 V Nominal voltage [4])														
Supply voltage frequency [Hz]	50 / 60 +/- 2														
Input phases	3	3	3		3		3			3			3		
Rated input current [A]	1,4	2,5	4,8		6,7		11			15			20		
Recommended maximum input fuse [A]	15	15	15		15		20			20			25		
Recommended wire gauge[1] [awg]	14	14	14		14		12			12			10		
Output Ratings															
Rated output power [kVA]	0,9	1.8	2,8		4.0		6.6			8.3			11		
Rated motor power [kW]	0,37	0.75	1,5		2,2		4.0			5.5			7,5		
Rated output current [A]	1.0	1.8	3.4		4.8		7.6			11			14		
Peak current (30 seconds)[2] [A]	2.3	4.7	7.4		10.4		17			21.6		18	29,7		24,8
Over current fault (E.OC) trip level [A]	2.8	5.6	8.9		12.5		21			25.9		21.6	35,6		29,7
Overload curve (see annex)	1														
Output voltage [V]	3 x 0...V Line														
Output frequency [Hz]	Generally 1600Hz however it is limited by the switching frequency														
Rated switching frequency [kHz]	16	16	8	8	8	16	4	8	16	4	8	16	2	8	16
Maximum switching frequency [kHz]	16	16	16	16	16	16	4	16	16	16	16	16	4	16	16
Power loss at rated operation[3] [W]	60	90	80	105	120	170	150	185	300	185	250	200	185	320	260
Stall current at 4kHz [A]	1,3	2,6	4,1	4,1	5,8	5,8	7,6	9,5	9,5	12	12	12	14	16,5	16,5
Stall current at 8kHz [A]	1,3	2,6	4,1	4,1	5,8	5,8	–	9,5	9,5	9,5	12	12	-	16,5	16,5
Stall current at 16kHz [A]	1,3	2,6	3,5	3,5	4,9	5,8	–	5,8	9,5	5,8	12	12	-	10	12
Braking Circuit															
Min. braking resistance [4] [Ohm]	390	120	120		82		82			56	39	50	39		
Typ. braking resistance [4] [Ohm]	390	390	270		270		150			100			82		
Max. braking current [A]	2.2	7.5	7.5		10		10			15	21	15	21		
Installation Information															
Max. shielded motor cable length at 4 kHz [5] [f	30	30	330		330	330	165	330		300			300		
Max. shielded motor cable length at 8 kHz [5] [f	25	25	100		165	330	–	330		300			-	330	
Max. shielded motor cable length at 16kHz[5] [f	15	20	100		100	65	–	330		300			-	330	
Tightening torque for terminal strip [in lb]	4.5									4.5	4.5	11	4.5	4.5	11
Environmental															
Max. heat sink temperature TOH [°C]	90°C / 194°F														
Storage temperature [°C]	-25...70 °C / -13...158°F														
Operating temperature [°C]	-10...45 °C / 14...113°F														
Housing design / protection	Chassis / IP20														
Relative humidity	max. 95% without condensation														
Approvals															
Tested in accordance with...	EN 61800-3 /UL508C														
Standards for emitted interference	EN 55011 Class B / EN 55022 Class A														
Standards for noise immunity	IEC 1000-4-2 / -3 / -4 / -5/ -6														
Climatic category	3K3 in accordance with EN 50178														

1) The wire gauge is based on the maximum fuse rating, copper wire with minimum 75°C insulation rating, THHW or equivalent. If branch circuit protection is selected based on rated input current, the wire size could be reduced.
2) With the regulated systems F5-M as well as F5-S 5% must be subtracted as control reserve
3) Rated operation means, rated input voltage, rated output current, and rated carrier frequency.
4) This data is only valid for units with internal brake transistor GTR 7 (see "unit identification")
5) With units with integrated EMI filter the distance is less:
up to max. 5m line length and 4kHz operating frequency = Limit Value B (EN 55011)
up to max. 10m line length and 16kHz operating frequency = Limit Value A (EN 55022)

Technical Data 460V Class continued

Inverter Size	15			16		17		18		19	
Recommended Motor Power [hp]	15			20		25		30		40	
Housing size	E	G	H	G	H	G	H	H	R	H	R
Input Ratings											
Supply voltage [V]	305…500 ±0 (460 V Nominal voltage)										
Supply voltage frequency [Hz]	50 / 60 +/- 2										
Input phases	3										
Rated input current [A]	27			35		44		52		57	
Recommended maximum input fuse [A]	35			40		60		60		70	
Recommended wire gauge[1] [awg]	10			8		6		6		4	
Output Ratings											
Rated output power [kVA]	17			23		29		35		42	
Rated motor power [kW]	11			15		18,5		22		30	
Rated output current [A]	21			27		34		40		52	
Peak current (30 seconds)[2] [A]	36			49,5		63		75		90	
Over current fault (E.OC) trip level [A]	43,2			59,4		75,6		90		108	
Overload curve (see annex)	1										
Output voltage [V]	3 x 0…Vsupply										
Output frequency [Hz]	Generally 0 to 1600Hz (limited by control board and carrier frequency)										
Rated switching frequency [kHz]	4	8	16	8	16	4	8	8	16	4	8
Maximum switching frequency [kHz]	16	16	16	16	16	16	16	16	16	16	16
Power loss at rated operation[3] [W]	350	290	360	310	490	360	470	610	850	540	750
Stall current at 4kHz [A]	24	24	24	33	33	42	42	50	50	60	60
Stall current at 8kHz [A]	16	19	24	21.5	33	29,4	30	45	50	39	60
Stall current at 16kHz [A]	10	8.5	15	9.7	20	21	13.5	20	40	18	27
Braking Circuit											
Min. braking resistance [4] [Ohm]	39	39	22	25	22	25	22	13	9	13	9
Typ. braking resistance [4] [Ohm]	56			39		28		22		16	
Max. braking current [A]	21	21	37	30	37	30	37	63	88	63	88
Installation Information											
Max. shielded motor cable length [5] [ft]	330										
Tightening torque for terminal strip [in lb]	11		22	11	22	11	22		53	22	53
Environmental											
Max. heat sink temperature TOH [°C]	90°C / 194°F										
Storage temperature [°C]	-25…70 °C / -13…158°F										
Operating temperature [°C]	-10…45 °C / 14…113°F										
Housing design / protection	Chassis / IP20										
Relative humidity	max. 95% without condensation										
Approvals											
Tested in accordance with…	EN 61800-3 /UL508C										
Standards for emitted interference	EN 55011 Class B / EN 55022 Class A										
Standards for noise immunity	IEC 1000-4-2 / -3 / -4 / -5/ -6										
Climatic category	3K3 in accordance with EN 50178										

1) The wire gauge is based on the maximum fuse rating, copper wire with minimum 75°C insulation rating, THHW or equivalent. If branch circuit protection is selected based on rated input current, the wire size could be reduced.
2) With the regulated systems F5-M as well as F5-S 5% must be subtracted as control reserve
3) Rated operation means, rated input voltage, rated output current, and rated carrier frequency.
4) This data is only valid for units with internal brake transistor GTR 7 (see "unit identification")
5) The maximum cable length is the same for all carrier frequencies.

Technical Data 460V Class continued

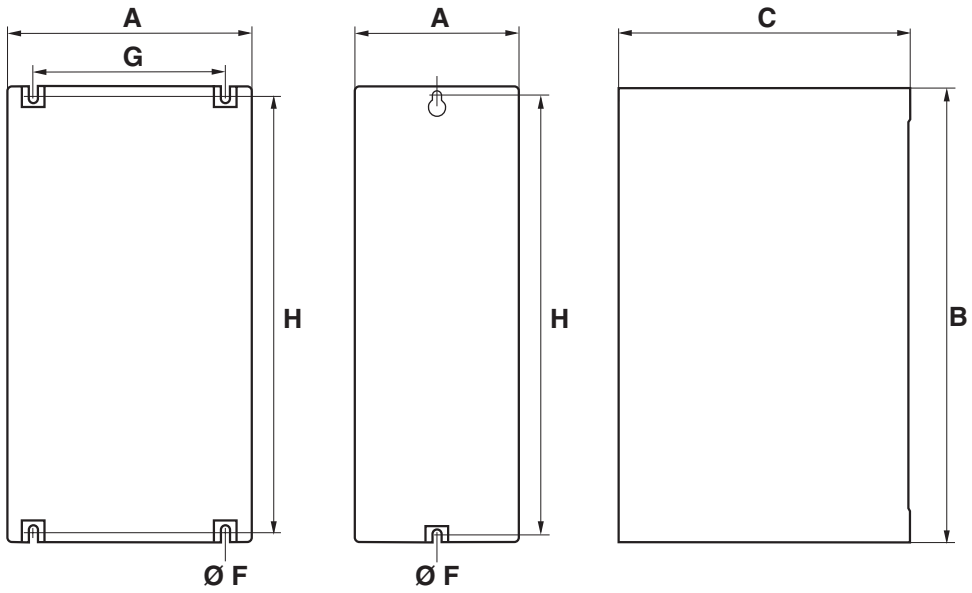
Inverter Size	20	21		22		23		24	
Recommended Motor Power [hp]	50	60		75		100		125	
Housing size	R	R	R	R	R	R	U	U	U
Input Ratings									
Supply voltage [V]	305...500 ±0 (460 V Nominal voltage)								
Supply voltage frequency [Hz]	50 / 60 +/- 2								
Input phases	3	3		3		3		3	
Rated input current [A]	72	85		106		136		172	
Recommended maximum input fuse [A]	80	100		125		175		200	
Recommended wire gauge[1] [awg]	4	3		1		2/O		3/O	
Output Ratings									
Rated output power [kVA]	52	62		80		104		125	
Rated motor power [kW]	37	45		55		75		90	
Rated output current [A]	65	77		96		124		156	
Peak current (30 seconds)[2] [A]	112	135		172		225		270	
Over current fault (E.OC) trip level [A]	135	162		207		270		324	
Overload curve (see annex)	1								
Output voltage [V]	3 x 0...Vsupply								
Output frequency [Hz]	Generally 0 to 1600Hz (limited by control board and carrier frequency)								
Rated switching frequency [kHz]	8	4	8	4	8	2	8	4	8
Maximum switching frequency [kHz]	16	16	16	16	16	12	8	8	8
Power loss at rated operation[3] [W]	900	1000	1100	1200	1500	1300	1900	2000	2400
Stall current at 4kHz [A]	75	90	90	115	115	128	150	180	180
Stall current at 8kHz [A]	75	63	90	80	115	90	150	117	180
Stall current at 16kHz [A]	34	45	54	46	51	–	–	–	–
Braking Circuit									
Min. braking resistance [4] [Ohm]	9	9		9		6	5	4	
Typ. braking resistance [4] [Ohm]	13	11		9		6	6	6	
Max. braking current [A]	88	88		88		133	160	200	
Installation Information									
Max. shielded motor cable length [5] [ft]	165								
Tightening torque for terminal strip [in lb]	53					133			
Environmental									
Max. heat sink temperature TOH [°C]	90°C / 194°F								
Storage temperature [°C]	-25...70 °C / -13...158°F								
Operating temperature [°C]	-10...45 °C / 14...113°F								
Housing design / protection	Chassis / IP20								
Relative humidity	max. 95% without condensation								
Approvals									
Tested in accordance with...	EN 61800-3 /UL508C								
Standards for emitted interference	EN 55011 Class B / EN 55022 Class A								
Standards for noise immunity	IEC 1000-4-2 / -3 / -4 / -5/ -6								
Climatic category	3K3 in accordance with EN 50178								

1) The wire gauge is based on the maximum fuse rating, copper wire with minimum 75°C insulation rating, THHW or equivalent. If branch circuit protection is selected based on rated input current, the wire size could be reduced.
2) With the regulated systems F5-M as well as F5-S 5% must be subtracted as control reserve
3) Rated operation means, rated input voltage, rated output current, and rated carrier frequency.
4) This data is only valid for units with internal brake transistor GTR 7 (see "unit identification")
5) The maximum cable length is the same for all carrier frequencies.

Inverter Size	25	26	27
Recommended Motor Power [hp]	**150**	**175**	**200**
Housing size	**U**	**U**	**U**
Input Ratings			
Supply voltage [V]	305...500 ±0 (460 V Nominal voltage)		
Supply voltage frequency [Hz]	50 / 60 +/- 2		
Input phases	3	3	3
Rated input current [A]	198	231	264
Recommended maximum input fuse [A]	250	310	450
Recommended wire gauge[1)] [kcmil]	250	350	150
Output Ratings			
Rated output power [kVA]	145	173	208
Rated motor power [kW]	110	132	160
Rated output current [A]	180	210	240
Peak current (30 seconds)[2)] [A]	263	313	375
Over current fault (E.OC) trip level [A]	315	375	450
Overload curve (see annex)	2		
Output voltage [V]	3 x 0…Vsupply		
Output frequency [Hz]	Generally 800Hz (but it is limited by the control card)		
Rated switching frequency [kHz]	4	4	2
Maximum switching frequency [kHz]	8	8	8
Power loss at rated operation[3)] [W]	2300	2800	3100
Stall current at 4kHz [A]	210	250	240
Stall current at 8kHz [A]	168	162	180
Braking Circuit			
Min. braking resistance [4)] [Ohm]	2,5	2,5	2,5
Typ. braking resistance [4)] [Ohm]	4,3	3,8	3,3
Max. braking current [A]	200	200	200
Installation Information			
Max. shielded motor cable length [5)] [ft]	165		
Tightening torque for terminal strip	220		
Environmental			
Max. heat sink temperature TOH [°C]	90°C / 194°F		
Storage temperature [°C]	-25...70 °C / -13...158°F		
Operating temperature [°C]	-10...45 °C / 14...113°F		
Housing design / protection	Chassis / IP20		
Relative humidity	max. 95% without condensation		
Approvals			
Tested in accordance with…	EN 61800-3 /UL508C		
Standards for emitted interference	EN 55011 Class B / EN 55022 Class A		
Standards for noise immunity	IEC 1000-4-2 / -3 / -4 / -5/ -6		
Climatic category	3K3 in accordance with EN 50178		

1) The wire gauge is based on the maximum fuse rating, copper wire with minimum 75°C insulation rating, THHW or equivalent. If branch circuit protection is selected based on rated input current, the wire size could be reduced.
2) With the regulated systems F5-M as well as F5-S 5% must be subtracted as control reserve
3) Rated operation means, rated input voltage, rated output current, and rated carrier frequency.
4) This data is only valid for units with internal brake transistor GTR 7 (see "unit identification")
5) The maximum cable length is the same for all carrier frequencies.

2.3 Dimensions and Weight



Housing	A (width)	B (height)	C (with Operator) (depth)	F	G	H	Weight
A	3.00	7.52 *	5.67 (6.22)	0.197	–	6.89	2.0 lbs 2.4 lbs w/filter
B	3.54	8.66 *	6.30 (6.85)	0.197	–	8.27	4.4 lbs
D	3.54	9.84 *	7.13 (7.68)	0.197	–	9.45	6.6 lbs
E	5.12	11.4 *	8.19 (8.74)	0.276	–	10.8	11 lbs
G	6.69	13.4	10.0	0.276	5.91	13.0	22 lbs
H	11.7	13.4	10.0	0.276	9.84	13.0	31 lbs
R	13.4	20.5	14.0	0.394	11.8	19.5	55 lbs
U	13.4	31.5	14.0	0.394	11.8	30.5	165 lbs

Dimensions in inches

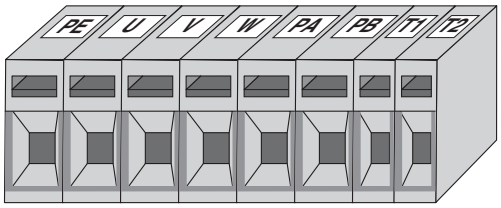
*) This dimension will be greater when using the shielding plate which comes with the EMI filter.

2.4 Survey of Power Circuit Terminals

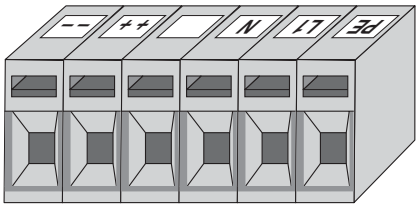
Housing size A

1 phase

Motor side



Supply side

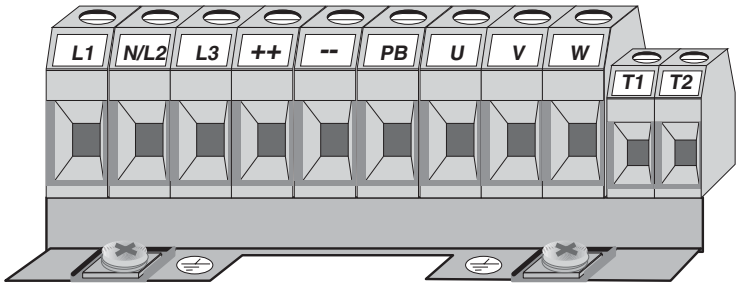


U, V, W	Motor connection	**L1, N**	1 phase supply connection
PA, PB	Connection for braking resistor	(L2)	(connect two hot leads e.g. L1,L2 from
T1, T2	Connection for temperature sensor		a 208V 3 phase system)
PE	Connection for earth ground	**++, --**	DC supply connection

Housing size B,D,E

1 phase or 3 phase

⚠ **Note always verify input voltage with name plate for proper connection 230V or 460V**



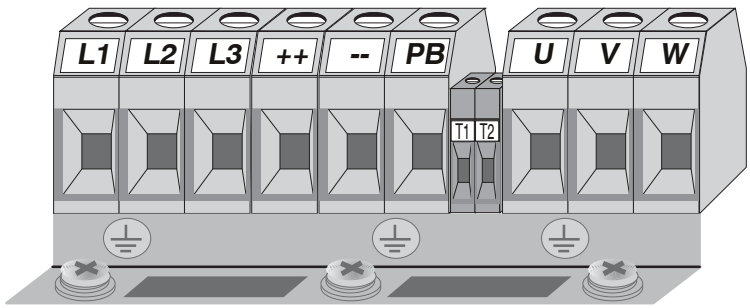
L1, N/L2	1 phase supply voltage only 230V units. (Connect two hot leads e.g. L1,L2 from a 208V 3phase system)
L1, L2, L3	3 phase supply voltage
++, - -	Connection for DC supply
++, PB	Connection for braking resistor
U, V, W	Motor connection
T1, T2	Connection for temperature sensor
⏚	Connection for earth ground

Terminal Tightening Torque: 4.5 inlb

Housing size G

3 phase

⚠ **Note always verify input voltage with name plate for proper connection 230V or 460V**

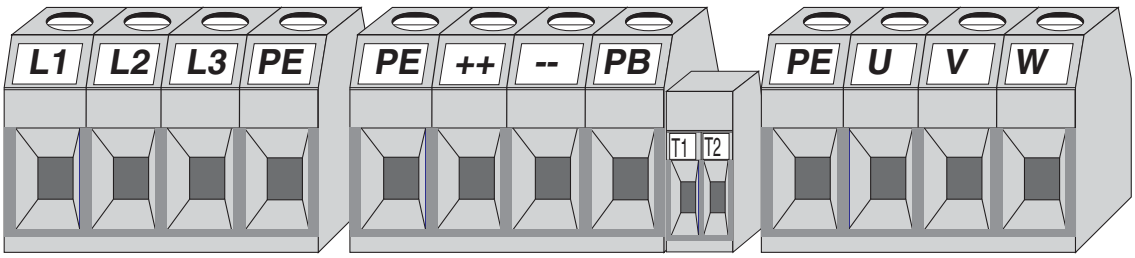


L1, L2, L3	3 phase supply voltage
++, - -	Connection for DC supply
++, PB	Connection for braking resistor
T1, T2	Connection for temperature sensor
U, V, W	Motor connection
⏚	Connection for earth ground

Terminal Tightening Torque: 11 inlb

Housing size H

Note always verify input voltage with name plate for proper connection 230V or 460V

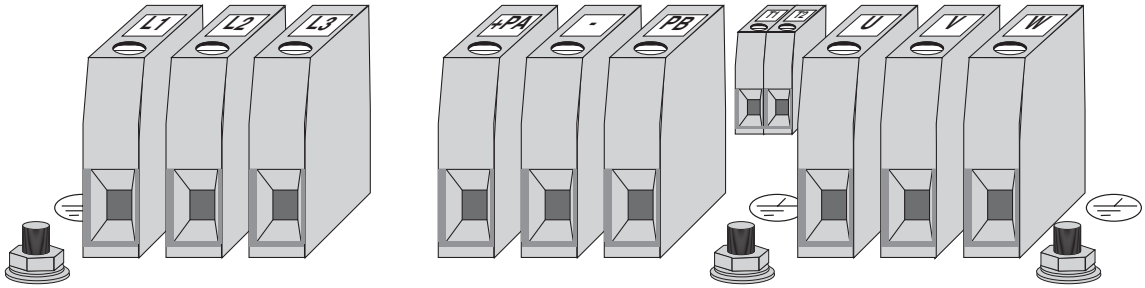


L1, L2, L3	3 phase supply voltage	**T1, T2**	Connection for temperature sensor
+ +, - -	DC supply connection	**U, V, W**	Motor connection
+ +, PB	Connection for braking resistor	**PE**	Connection for earth ground

Terminal Tightening Torque: 22 inlb

Housing size R and U

Note always verify input voltage with name plate for proper connection



L1, L2, L3	3 phase supply voltage	**T1, T2**	Connection for temperature sensor
+ +, - -	DC supply connection	**U, V, W**	Motor connection
+ +, PB	Connection for braking resistor	⏚	Connection for earth ground

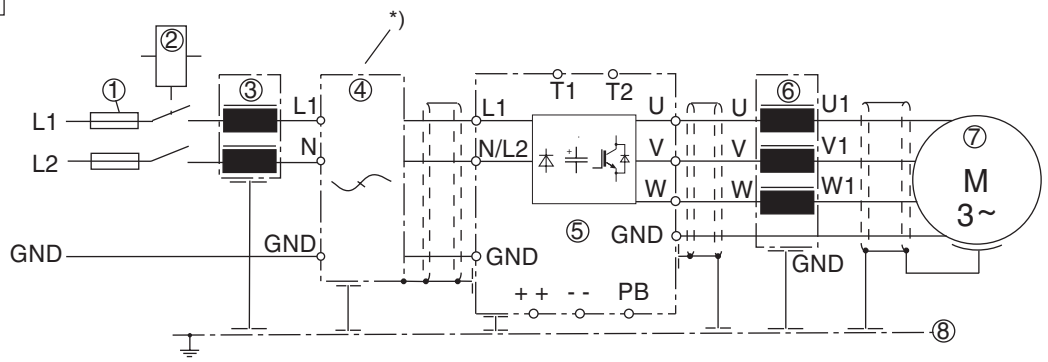
Terminal Tightening Torque: R housings 53 inlb
U housings size 23/24 130inlb
U housings sizes > 24 220 inlb

2.5 Connection of Power Circuit

If the supply voltage is connected to the motor terminals, the unit will be destroyed!	Pay attention to the supply voltage 230/460V and the correct polarity of the motor!

1-phase connection

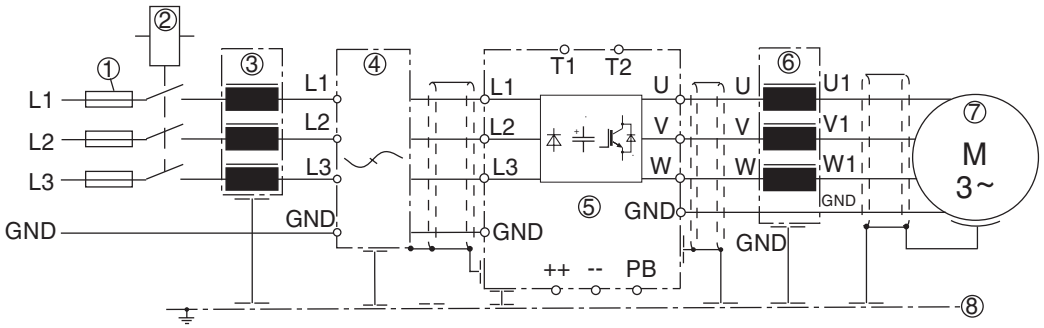
Use type LPJ fuses for branch circuit protection.



* For units with integrated radio interference suppression (see "Part Number") the external radio interference suppression filter is omitted.

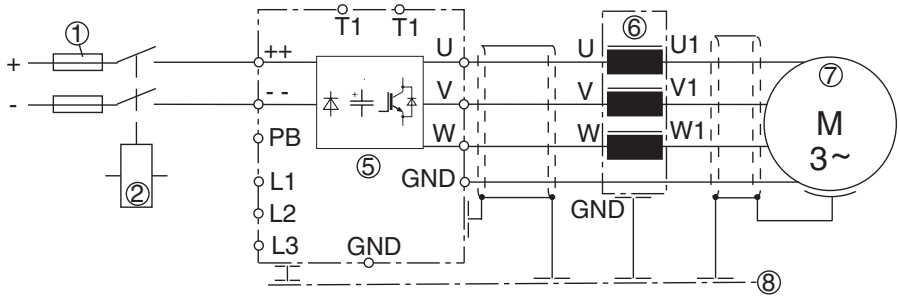
3-phase connection

Use type LPJ fuses for branch circuit protection.



DC power supply

250...370 VDC (230V-class)
420...720V DC (460V-class)
Use type FWP fuses for branch circuit protection.



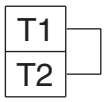
① **Supply fuse**	⑤ **COMBIVERT F5**
② **Disconnect switch or contactor**	⑥ **Motor choke or output filter (do not use with F5M or F5S)**
③ **Line choke**	⑦ **Motor**
④ **Interference suppression filter**	⑧ **Sub panel in control cabinet**

External motor temperature sensor
(for all units)

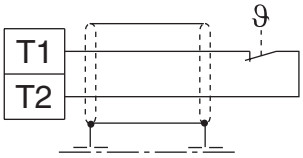
On F5 B/G units it is necessary to activate the function through parameter CP.28.

Don't install temperature sensor wires with other control wires.

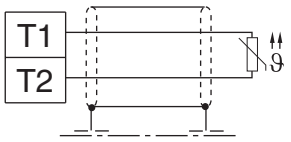
Must use double shield when running temperature sensor wires with motor wires



F5-M/S:
Bridge, when no sensor is connected

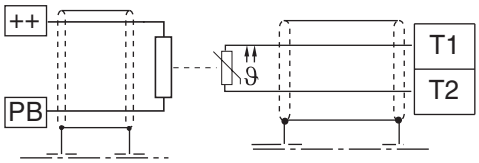


Thermal switch
(NC-contact)



Temperature sensor (PTC)
1650Ω...4kΩ tripping resistance
750Ω...1650Ω reset resistance

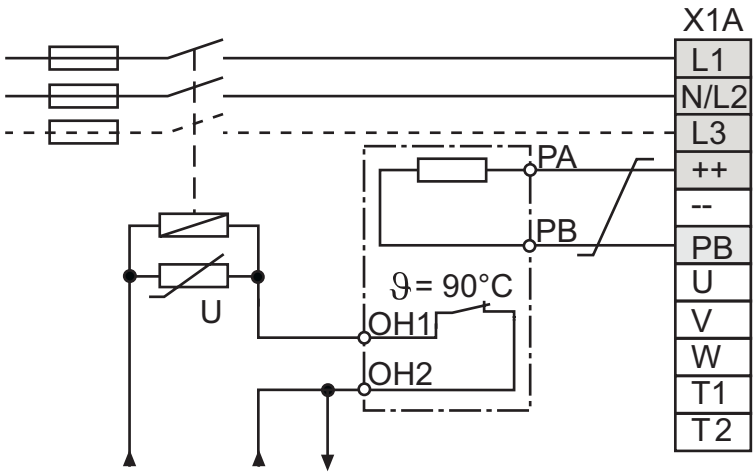
Braking resistor



Optional Connection
connect only when resistor has valid temperature sensor, e.g. back mount resistors

Braking resistor with line side over temperature cutoff

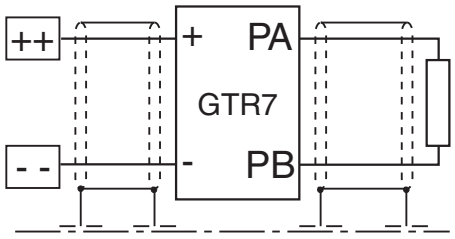
This is the only way to turn off voltage to the resistor in the event of failure of the internal braking transistor of the inverter.



24VDC or 120VAC contactor control voltage

Note: a NC thermal switch not PTC device on the resistor is required.

Braking module



3. Accessories

3.1 Braking Resistor

The COMBIVERT F5 inverter can be equipped with an external braking resistor for limited 4 quadrant operation. The energy the motor regens into the inverter during deceleration is dissipated through the internal braking transistor to the braking resistor.

The braking resistor heats up during braking. If it is installed inside a control cabinet, sufficient interior cooling must be provided! The resistor should be mounted above and a minimum of 9 inches away from the inverter or in a separate enclosure!

3.1.1 Selection of the Braking Resistor

Different braking resistors are available from KEBCO. They are selected according to their application requirements. The selection formulas and technical data of the resistors are listed on the following pages. The procedure for selecting a braking resistor is outlined below.

1. Establish desired braking time.
2. Calculate braking time without braking resistor (t_{Bmin}).
3. If the desired braking time is shorter than the calculated braking time, it will be necessary to use a braking resistor. ($t_B < t_{Bmin}$)
4. Calculate braking torque (T_B) taking the load torque (T_L) into account. T_L is a positive value for friction and windage and negative for overhauling loads.
5. Calculate peak braking power (P_B). This must always be calculated for the "worst case" (n_{max} to standstill).
6. Selection of the braking resistors:
   a) The resistor should be selected so that $P_R > P_B$.
   b) P_N is to be selected according to the duty cycle factor (d.c.f.).
   The braking resistors may only be used for the specified value. The maximum ON period of the braking resistor may not be exceeded.
   6 % d.c.f. = maximum braking time 8 s
   25 % d.c.f. = maximum braking time 30 s
   40 % d.c.f. = maximum braking time 48 s
   Longer ON periods require specially-designed braking resistors. Take into account the current through the braking transistor.
7. Check whether the desired braking time is attained with the selected braking resistor (t_{Bmin}).

Note: Consider the capacity of the braking resistor and motor. The braking torque may not exceed the rated torque of the motor by more than 1.5 times. To realize maximum possible braking torque, the frequency inverter must be sized for the increased motor current.

Braking time

The braking time is adjusted in the frequency inverter through the deceleration parameters. If the selected deceleration time is too short, either the peak inverter current level or the maximum DC bus voltage will be exceeded. The error message ***E.OC*** or ***E.OP*** will result. The following formulas can be used to determine an allowable braking time.

Formulas

1. Braking time without braking resistor

$$t_{Bmin} = \frac{(J_M + J_L) \cdot (n_1 - n_2)}{307 \cdot (K \cdot T_N + T_L)}$$

Valid range: $n_1 > n_N$

(field weakening)

2. Braking torque (required)

$$T_B = \frac{(J_M + J_L) \cdot (n_1 - n_2)}{307 \cdot t_B} - T_L$$

Conditions: $T_B - 1.5 \cdot T_N$

$f < 1.4$ x rated frequency of motor

3. Peak braking power

$$P_B = \frac{T_B \cdot n_1}{7.04}$$

Conditions: $P_B < P_R$

4. Braking time with braking resistor

$$t_{Bmin} = \frac{(J_M + J_L) \cdot (n_1 - n_2)}{307 \cdot \left(K \cdot T_N + T_L + \frac{P_R \cdot 7.04}{(n_1 - n_2)}\right)}$$

Valid range: $n_1 > n_N$

Conditions: $\frac{P_R \cdot 9.55}{(n_1 - n_2)} - T_N \cdot (1.5 - K)$

$f < 1.4$ x rated frequency of motor

$P_B < P_R$

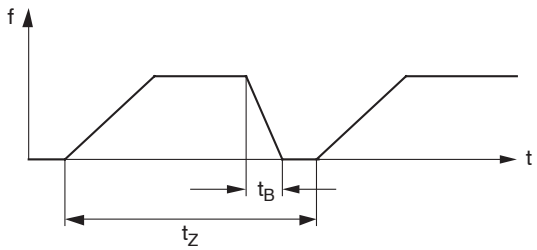
On period d.c.f.

ON period d.c.f for cycle time $t_Z < 120$ s

$$d.c.f = \frac{t_B}{t_Z} \cdot 100\ \%$$

ON period d.c.f for cycle time $t_Z > 120$ s

$$d.c.f = \frac{t_B}{120\ s} \cdot 100\ \%$$



Definitions

K = 0.25 for motors up to 2 hp
0.20 for motors 3 to 5 hp
0.15 for motors 7.5 to15 hp
0.08 for motors 20 to 60 hp
0.05 for motors 75 to 400 hp

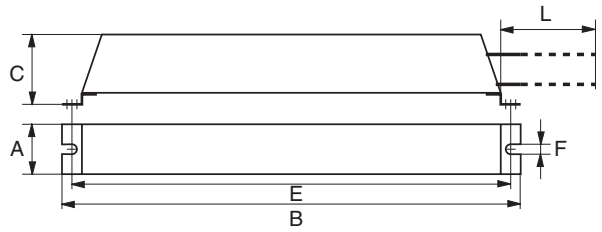
J_M	=	Moment of inertia of the motor	[lb ft²]	T_B	=	Braking torque (required)	[ft lbs]
J_L	=	Moment of inertia of the load	[lb ft²]	T_L	=	Load torque	[ft lbs]
n_1	=	Motor speed before deceleration	[rpm]	t_B	=	Braking time (required)	[s]
n_2	=	Motor speed after deceleration (Stand still = 0 rpm)	[rpm]	t_{Bmin}	=	Minimum braking time	[s]
				t_Z	=	Cycle time	[s]
n_N	=	Motor rated speed	[rpm]	P_B	=	Peak braking power	[W]
T_N	=	Motor rated torque	[ft lbs]	P_R	=	Peak power dissipation of the resistor	[W]

3.1.2 Panel Mount Brake Resistors

Technical data braking resistor

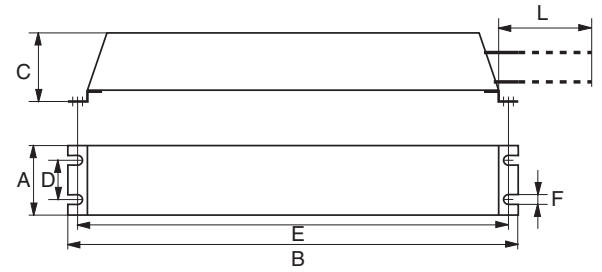
Part number	R_B [OHM]	P_{Rated} [kW]	COMBIVERT	Nominal power[1] [W] 6 s	25 s	40 s
230 V - Class						
07.BR.100-1180	180	44	05, 07	800	300	180
09.BR.100-1100	100	82	07, 09	1500	500	300
10.BR.100-1683	68	120	07, 09, 10, 13(E)	2200	800	500
12.BR.100-1333	33	250	10, 13(G)	4400	1300	750
13.BR.100-1273	27	300	13(G), 14	5400	1500	900
14.BR.100-1203	20	450	13(G), 14	7300	1800	1100
15.BR.110-1133	13	630	14, 15	10000	3200	1800
16.BR.110-1103	10	850	15, 16	14000	3600	2200
17.BR.110-1073	7	1100	15, 16, 17	21000	5400	3100
18.BR.110-1053*	5	1900	17,18	28000	7200	4400
19.BR.110-1356*	3.5	2200	19,20	42000	10800	6200
20.BR.110-1256*	2.5	3800	20,21	56000	14400	8800
*consult KEBCO for exact specifications						
400 V - Class						
07.BR.100-6620	620	56	05, 07	900	300	180
09.BR.100-6390	390	90	07, 09	1500	500	300
10.BR.100-6270	270	130	07, 09, 10	2100	800	500
12.BR.100-6150	150	230	12	3700	1300	750
13.BR.100-6110	110	350	12, 13	5000	1500	900
14.BR.100-6853	85	410	12, 13, 14	6500	1800	1100
15.BR.110-6563	56	620	12(E), 13(E,G), 14, 15	10000	3200	1800
16.BR.110-6423	42	820	13(G), 14(G), 15, 16	13500	3600	2200
17.BR.110-6303	30	1200	15(H), 16, 17	18500	5400	3100
18.BR.226-6203	20	1700	17(R), 18, 19	27500	7500	4500
19.BR.226-6153	15	2300	17(R), 18, 19, 20	37000	10000	6000
20.BR.226-6123	12	2900	18(R), 19(R), 20, 21	46000	12500	7500
21.BR.226-6103	10	3000	18(R), 19(R), 20, 21, 22	55000	15000	9000
22.BR.226-6866	8,6	4000	21(L), 22(L), 23	64000	17500	10000
23.BR.226-6676	6,7	5200	22(L), 23, 24(U)	82000	22000	12500
24.BR.226-6506	5	6900	23(U), 24(U), 25(U)	110000	30000	18000
25.BR.226-6436	4,3	8100	24(U), 25(U), 26(U), 27(U)	130000	35000	20000
26.BR.226-6386	3,8	9200	25, 26, 27(U)	145000	40000	22500
27.BR.226-6336	3,3	10000	25, 26, 27(U)	170000	45000	25000
28.BR.226-6226	2,2	15000	28(W), 29(W), 30(W)	250000	67000	37000
29.BR.226-6176	1,7	20000	28(W), 29(W), 30(W)	325000	90000	50000
30.BR.226-6136	1,3	26000	28(W), 29(W), 30(W)	425000	112000	62000

1) Permissible power dissipation of the resistor is dependent on the duty cycle factor; braking time divided by 120 seconds. The calculated peak braking time must be ≤ the load of the resistor.



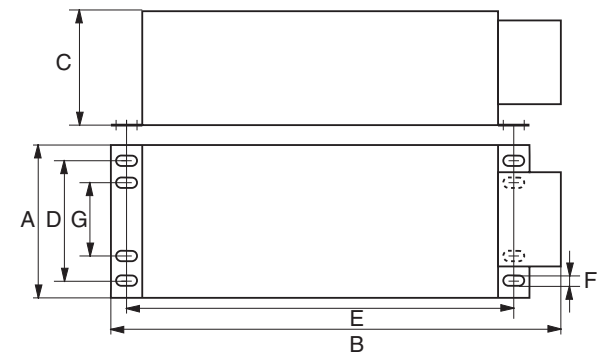
Part number	A	B	C	D	E	F	L
07.BR.100-xxxx	0.95	6.5	1.57	-	5.67	0.20	39.0
09.BR.100-xxxx	0.95	9.5	1.57	-	8.74	0.20	39.0
10.BR.100-xxxx	0.95	11.8	1.57	-	11.22	0.20	39.0
12.BR.100-xxxx	1.0	11.8	3.15	-	11.22	0.20	39.0
13.BR.100-xxxx	1.0	15.75	3.15	-	15.16	0.20	39.0
14.BR.100-xxxx	1.0	15.75	3.15	-	15.16	0.20	39.0
15.BR.110-xxxx	2.48	14.6	3.78	-	13.98	0.20	39.0
16.BR.110-xxxx	2.48	18.5	3.78	-	17.91	0.20	39.0

Dimensions in inches



Part number	A	B	C	D	E	F	L
17.BR.110-xxxx	3.54	18.5	3.78	1.97	17.91	0.20	39.0
18.BR.110-1103	= 2 x 16.BR.110-1103						
19.BR.110-xxxx	= 2 x 17.BR.110-1073						
20.BR.110-xxxx	= 4 x 16.BR.110-1103						

Dimensions in inches



Part number	A	B	C	D	E	F	G
18.BR.226-6203	10.5	24.1	4.57	9.45	20.71	0.25x0.4	6.93
19.BR.226-6153	10.5	24.1	4.57	9.45	20.71	0.25x0.4	6.93
20.BR.226-6123	10.5	24.8	8.7	9.45	20.71	0.25x0.4	6.93
21.BR.226-6103	10.5	24.8	8.7	9.45	20.71	0.25x0.4	6.93
22.BR.226-6866	10.5	24.8	10.7	9.45	20.71	0.25x0.4	6.93
23.BR.226-6676	10.5	24.8	10.7	9.45	20.71	0.25x0.4	6.93
24.BR.226-6506	= 2 x 21.BR.226-6103						
25.BR.226-6436	= 2 x 22.BR.226-6866						
26.BR.226-6386	= 1 x 22.BR.226-6866 + 1 x 23.BR.226-6676						
27.BR.226-6336	= 2 x 23.BR.226-6676						
28.BR.226-6226	= 3 x 23.BR.226-6676						
29.BR.226-6176	= 4 x 23.BR.226-6676						
30.BR.226-6136	= 5 x 23.BR.226-6676						

Dimensions in inches

Risk of Fire!

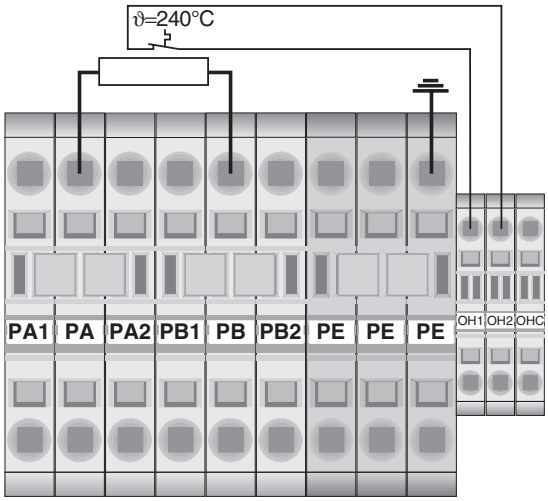
In order to safe guard against overheating braking resistors, it is absolutely necessary to connect the thermal contact of the braking resistor to the inverter (See connection to T1/T2 terminals on page 25). Overheating can have the following causes:

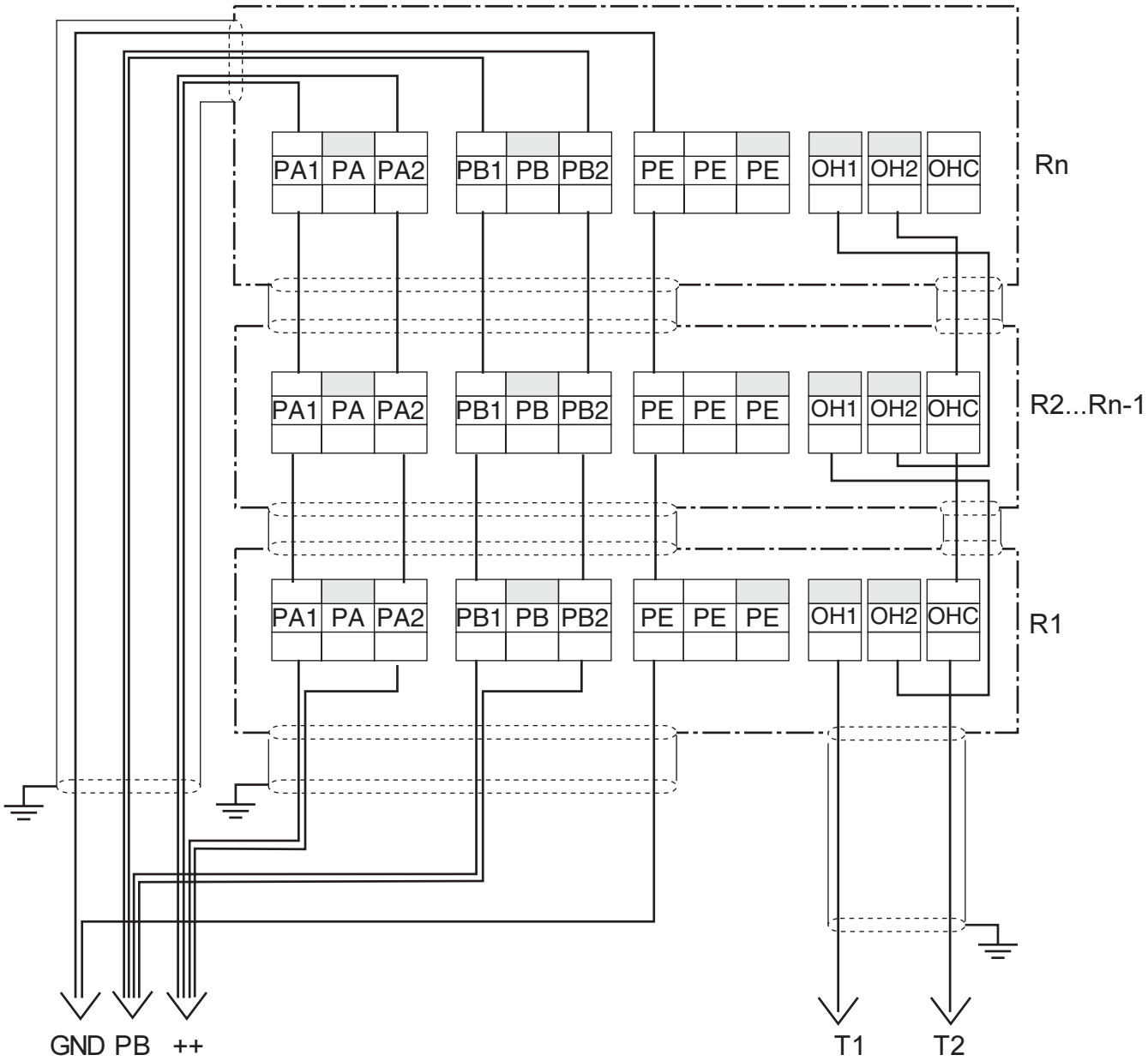
- ramps are too short
- too many stops per minute
- under dimensioned braking resistor
- input voltage too high, i.e. > 525VAC
- defective braking transistor in the inverter

If the braking transistor in the inverter fails, then the only means of preventing the destruction of the resistor is by disconnecting the inverter from the line via a contactor. The contactor can be opened using the fault relay on the inverter.

3.1.3 Parallel Connection of Braking Resistors

Terminal strip braking resistor

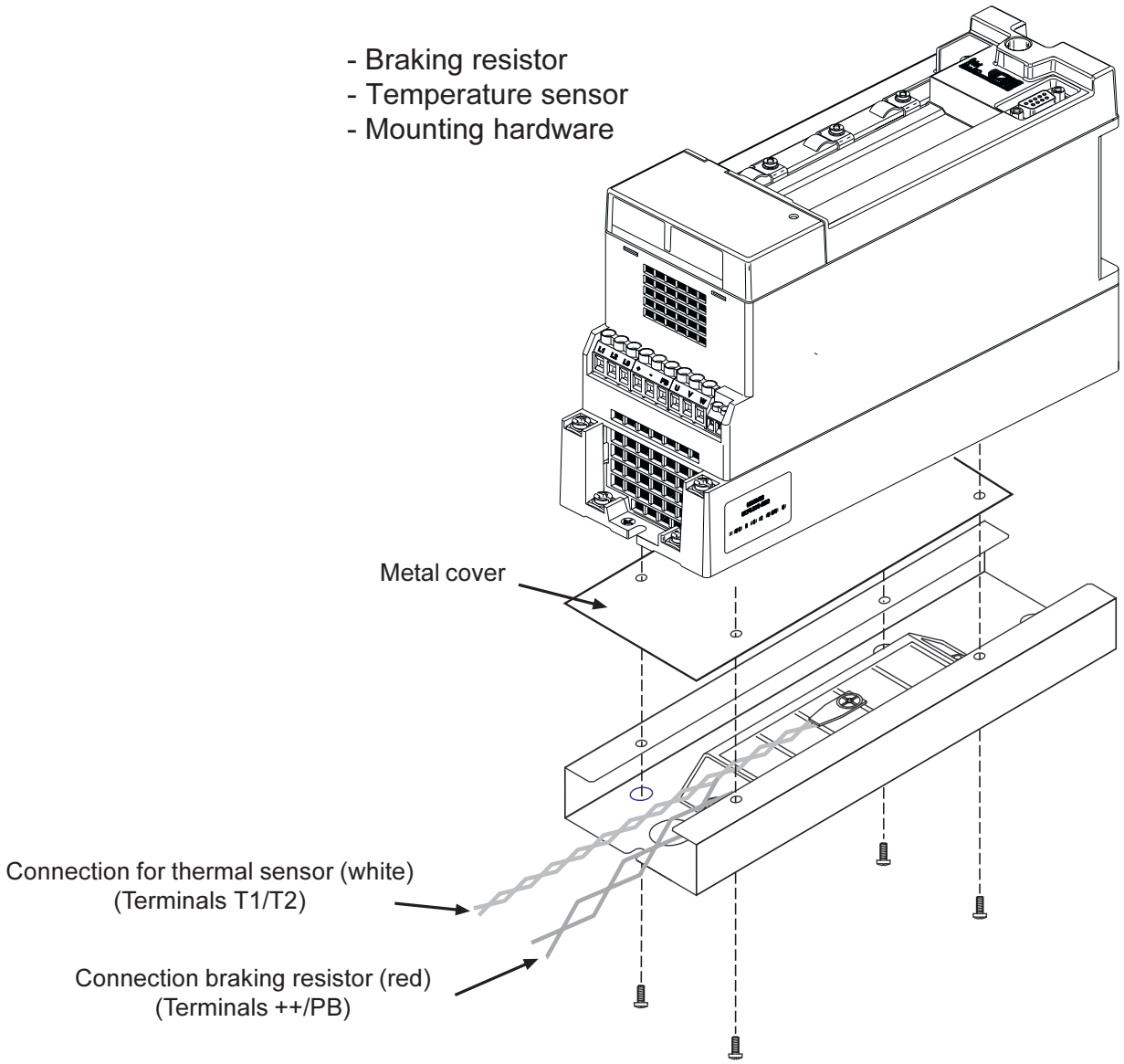




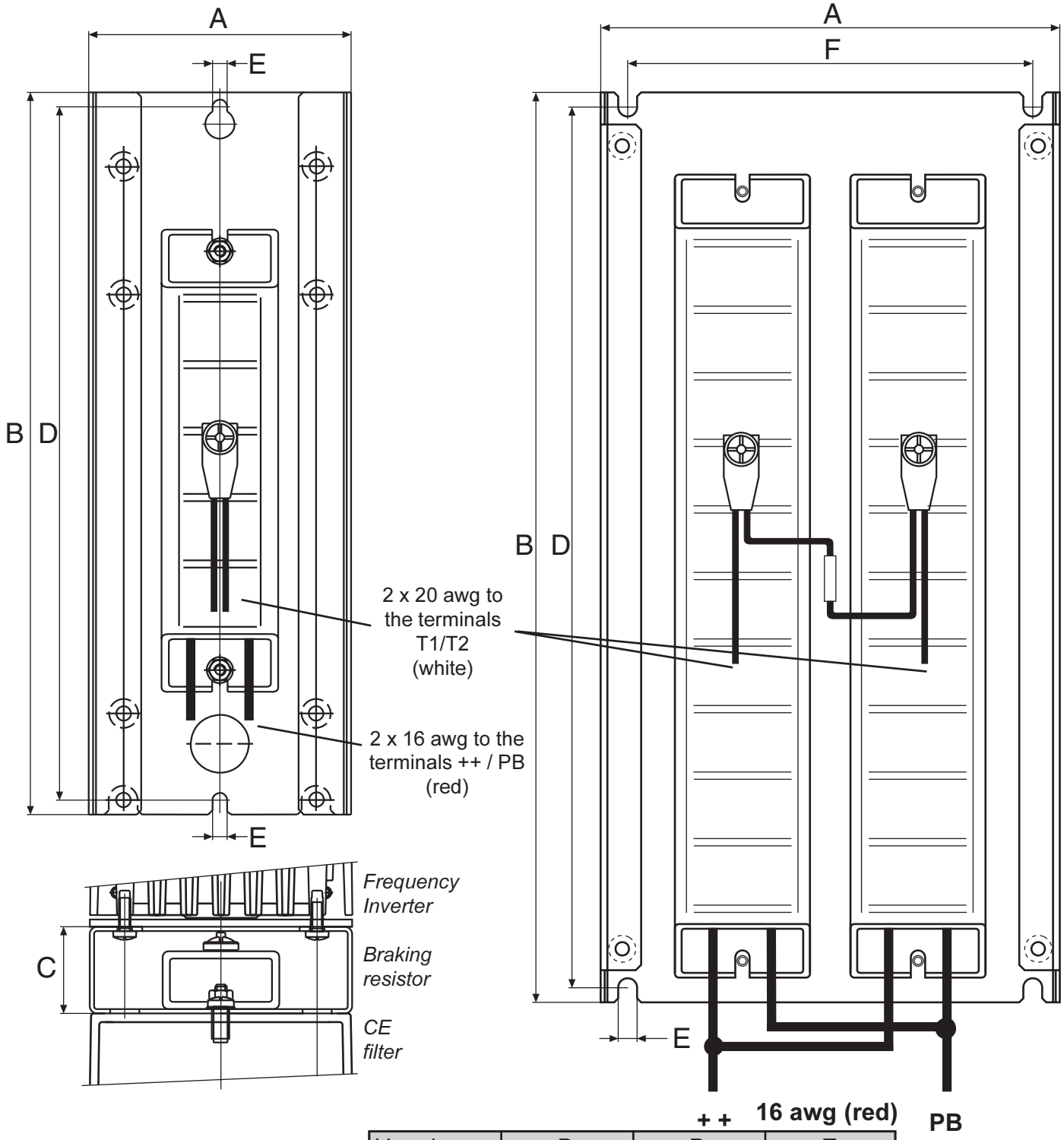
3.1.4 Back Mount Braking Resistor

The inverter mounted braking resistor is designed with space savings in mind. The resistor is mounted directly under the heatsink of the inverter. The heat generated flows vertically out the top of the unit. It should be used only in applications where the braking time is kept to a minimum. The resistor kit consists of:

- Braking resistor
- Temperature sensor
- Mounting hardware



Use with 230V inverters size		**07,09**	**10**	**09,10,12**	**13**	**14**
Use with 460V inverters size		**07,09,10**	**10,12**	**10,12,13,14**	**12,13,14,**	**13,14,15**
Housing		B	B	D	E	E
Braking resistor	[Ω]	160	82	82	60	60
Continuous power dissapation	[W]	35	35	35	60	2 x 60
One time peak power (max. 3s) 230V	[W]	900	1700	1700	2400	2400
One time peak power (max. 3s) 460V	[W]	3400	6650	6650	9100	9100
Power at 5% d.c.f.	[W]	700	700	700	1200	2400
Power at 10% d.c.f.	[W]	350	350	350	600	1200
Power at 20% d.c.f.	[W]	175	175	175	300	600
Power at 40% d.c.f.	[W]	90	90	90	150	300
Weight	lb	2	2	2	3	3.5
Partnumber of the kit		09.F5.B90-0300	12.F5.B90-0300	12.F5.D90-4300	14.F5.E90-4300	15.F5.E90-4300



Dimensions
Back mount braking resistors

Housing ->	B	D	E
A [in]	3.5	3.5	5.1
B [in]	8.7	9.8	11.4
C [in]	1.2	1.2	1.2
D [in]	8.4	9.5	10.8
E [in]	0.20	0.20	0.28
F [in]	-	-	5.9

3.2 Input Filters

3.2.1 Line Choke

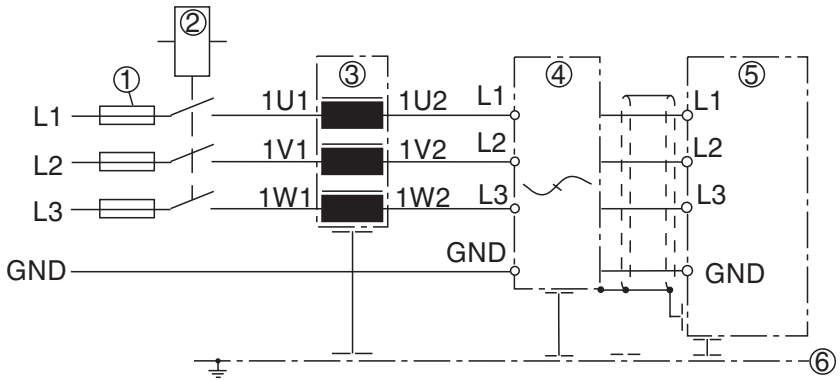
The KEBCO line choke reduces the harmonics of the input current and the displacement power factor of the inverter improves from 0.5... 0.6 to approximately 0.8... 0.9.

Conducted high frequency interference is reduced up to 30 db in the frequency range from 10 kHz to approximately 300 kHz.

In addition, the noise immunity of the system is improved and the lifetime of the DC-bus capacitors increases.

Connection of the line choke

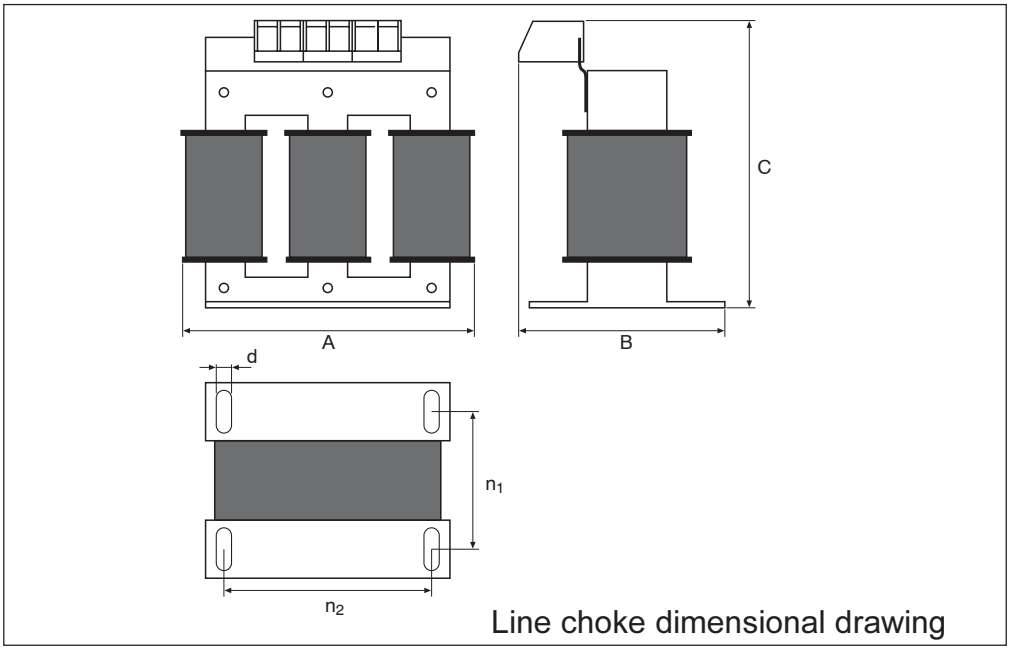
① **Supply fuse**
② **Disconnect switch or contactor**
③ **Line choke**
④ **Interference suppression filter**
⑤ **KEB COMBIVERT F5**
⑥ **Sub panel in control cabinet**



Line Chokes - Additional Information

Interference and or voltage spikes on the supply voltage are created when large loads such as heaters, motors, arc-welders etc. are turned on and off. In some instances, switching in and out large power factor correction capacitors either in the factory or on the utility grid can also lead to large voltage spikes appearing at the inverter. These spikes are typically short in time duration but high enough in voltage to create nuisance tripping of the inverter (i.e. over voltage). The voltage spike enters the inverter and raises the DC bus voltage level above the predefined limit, 400V in 230V units and 800V in 460V units. The protection circuits in the inverter activate leading to an interruption in the operation of the unit. The choke prevents these spikes from reaching the inverter eliminating the problem. 3% impedance chokes are generally sufficient. However 5% will help further reduce harmonic current on the line and will allow the system to better comply with the IEEE519 standard.

When installing larger inverters (100 hp and greater), harmonic distortion in the line current can become a problem. This distortion is caused by the diode bridge rectifier which serves as the input to all inverters. This distortion can create large fluctuations in the line voltage within a facility leading to problems with other equipment. The choke reduces the distortion of the current, there by eliminating the associated problems.



Line choke dimensional drawing

230V-Class														
For hp	Phases	I_N [A]	P_{loss} [W]	Imp. [%]	Part number	Dimensions [inches]						Wire awg	Weight [lb]
						A	B	C	n_1	n_2	d		
			14.5	3	**U0.90.290-0401**								
1	3	4	20	5	**U0.90.290-0402**	4.4	2.75	4.1	1.98	1.44	0.31 x 0.56	22-14	4
			19.5	3	**U0.90.290-0801**								7
2	3	8	29	5	**U0.90.290-0802**	6	3	4.75	2.1	2	0.31 x 0.62	22-14	8
			26	3	**U0.90.290-1201**								9
3	3	12	31	5	**U0.90.290.1202**	6	3.25	5	2.1	2	0.31 x 0.62	22-5	10
			36	3	**U0.90.290-1801**		3.25		2.1				9
5	3	18	43	5	**U0.90.290-1802**	6	3.5	5.25	2.48	2	0.31 x 0.62	22-5	12
			48	3	**U0.90.290-2501**								11
7.5	3	25	52	5	**U0.90.290-2502**	7.25	3.43	6	2.35	3	0.38 x 0.75	22-5	14
			49	3	**U0.90.290-3501**				2.6				14
10	3	35	54	5	**U0.90.290-3502**	7.25	4	5.75	2.75	3	0.38 x 0.75	22-5	16
			54	3	**U0.90.290-4501**								23
15	3	45	62	5	**U0.90.290-4502**	9	4.75	7.35	3.16	3	0.38 x 0.75	18-4	28
			64	3	**U0.90.290-5501**								24
20	3	55	67	5	**U0.90.290-5502**	9	4.66	7.35	3.16	3	0.38 x 0.75	18-4	27
			82	3	**U0.90.290-8001**								43
25	3	80	86	5	**U0.90.290-8002**	10.8	5.62	8.5	3.47	3.63	0.38 x 0.75	22-1	51
			94	3	**U0.90.291-0001**		7		3.47				47
30	3	100	84	5	**U0.90.291-0002**	11	6.63	8.5	3.66	3.63	0.38 x 0.75	6-0	51
			108	3	**U0.90.291-3001**	9	6.38	7.25	3.16	3	3.75 x 0.56	2-0000	29
40	3	130	84	5	**U0.90.291-3002**	11.25	6.63	8.5	3.66	3.63	0.38 x 0.75	2-0000	62
			116	3	**U0.90.291-6001**	10.8	6.75		3.16				42
50	3	160	149	5	**U0.90.291-6002**	11	7	8.5	3.47	3.63	0.38 x 0.75	2-0000	51
			124	3	**U0.90.292-0001**	10.8	7.25		4.16				49
60	3	200	168	5	**U0.90.292-0002**	11.5	8.25	8.5	4.41	3.63	0.38 x 0.75	2-0000	67

Dimensions in inches

460V-Class														
For hp	Phases	I_N [A]	P_{loss} [W]	Imp. %	Part number	Dimensions A	B	C	n1	n2	d	Wire [awg]	Weight [lb]
			7.5	3	**U0.90.290-0201**								4
1	3	2	11.3	5	**U0.90.290-0202**	4.4	2.75	4.1	1.98	1.44	0.31 x 0.56	22..14	4
			20	3	**U0.90.290-0402**		4.75		1.98				4
2	3	4	25	5	**U0.90.290-0403**	4.4	3.12	4.1	2.35	1.44	0.31 x 0.56	22..14	4
			20	3	**U0.90.290-0402**		4.75		1.98				4
3	3	4	25	5	**U0.90.290-0403**	4.4	3.12	4.1	2.35	1.44	0.31 x 0.56	22..14	4
			29	3	**U0.90.290-0802**		3		2.1				8
5	3	8	25.3	5	**U0.90.290-0803**	6	3.37	4.75	2.48	2	0.31 x 0.62	22..14	11
			31	3	**U0.90.290-1202**		3.25		2.1				10
7.5	3	12	41	5	**U0.90.290-1203**	6	3.87	5	2.75	2	0.31 x 0.62	22...5	18
			43	3	**U0.90.290-1802**	6	3.5	5.25	2.48				12
10	3	18	43	5	**U0.90.290-1803**	8	4	6	2.6	2	0.31 x 0.62	22...5	16
			52	3	**U0.90.290-2502**		3.43		2.35				14
15	3	25	61	5	**U0.90.290-2503**	7.25	4.25	6	3.1	3	0.38 x 0.75	22...5	20
			54	3	**U0.90.290-3502**	7.25	4	5.75	2.75			22...5	16
20	3	35	54	5	**U0.90.290-3503**	9	4.75	7.5	3.16	3	0.38 x 0.75	18...4	30
			54	3	**U0.90.290-3502**	7.25	4	5.75	2.75			22...5	16
25	3	35	54	5	**U0.90.290-3503**	9	4.75	7.5	3.16	3	0.38 x 0.75	18...4	30
			62	3	**U0.90.290-4502**		4.75	7.35	3.16				28
30	3	45	65	5	**U0.90.290-4503**	9	5.3	7.25	3.66	3	0.38 x 0.75	18...4	39
			67	3	**U0.90.290-5502**		4.66	7.35	3.16				27
40	3	55	71	5	**U0.90.290-5503**	9	5.41	7.5	3.91	3	0.38 x 0.75	18...4	41
			86	3	**U0.90.290-8002**		5.62		3.47			12...1	51
50	3	80	96	5	**U0.90.290-8003**	10.8	6.75	8.5	4.16	3.63	0.38 x 0.75	6…0	61
			86	3	**U0.90.290-8002**		5.62		3.47			12...1	51
60	3	80	96	5	**U0.90.290-8003**	10.8	6.75	8.5	4.16	3.63	0.38 x 0.75	6…0	61
			84	3	**U0.90.291-0002**		6.63		3.66				51
75	3	100	108	5	**U0.90.291-0003**	11	7.62	8.5	4.16	3.63	0.375 x 0.75	6…0	74
			180	3	**U0.90.291-3002**		6.63		3.66				62
100	3	130	128	5	**U0.90.291-3003**	11.25	8.5	8.5	4.18	3.63	0.38 x 0.75	2…4/0	64
			149	3	**U0.90.291-6002**	11	7		3.47				51
125	3	160	138	5	**U0.90.291-6003**	11.25	8	8.5	4.66	3.63	0.38 x 0.75	2…4/0	72
			168	3	**U0.90.292-0002**		8.25		4.41				67
150	3	200	146	5	**U0.90.292-0003**	11.5	10	8.5	5.91	3.63	0.38 x 0.75	2…4/0	100
			231	3	**U0.90.292-5002**	15	10.3		5.16				106
175	3	250	219	5	**U0.90.292-5003**	14.5	11.3	11.3	5.82	4.6	0.56	2/0..500	143
			231	3	**U0.90.292-5002**	15	10.3		5.16				106
200	3	250	219	5	**U0.90.292-5003**	14.5	11.3	11.3	5.82	4.6	0.56	2/0..500	143

Dimensions in inches

3.2.2 EMI (CE) - Filter

The KEBCO COMBIVERT frequency inverters are optionally available with EMI filters. Depending on the housing size they are available from the factory already mounted to the inverter or as filter kits for installation by the user. These filters allow the KEBCO COMBIVERT to meet the CE EMC directive 89/339. All filters are dimensioned for the inverter's rated current and are designed to meet the conducted emission limit as defined by EN55011/B. If the motor wires are shielded and longer than the maximum values listed in the tables on pages 15-20, consult KEBCO for the proper filter. Also for a delta connected line or for a low ground leakage filter solutions contact KEBCO.

The filter kits contain all required hardware for installation. Filters for sizes up to 200 hp include the shielded supply wires which connect the filter to the inverter. Depending on the available space and filter type, the filter can either be installed under the frequency inverter (sub-mounted), or beside the frequency inverter (side mounted).

EMI (CE) - Filter 230V-Class				
For Inverter size / housing	Phases	Kit incl. Filter	Filter	Back mounting with housing
05,07 / A	1	internal option	-	-
07 / B	1	07.U5.B0B-1010	07.E5.T60-0061	B
09,10 / B	1	10.U5.B0B-1000	10.E5.T60-0001	B
09,10 / D	1	10.U5.B0D-1000	10.E5.T60-0002	D
07,09,10 / B	3	10.U5.B0B-2000	12.E5.T60-1001	B
09,10 / D	3	10.U5.B0D-2000	13.E5.T60-1001	D
12 / D	3	12.U5.B0D-2000	14.E5.T60-1001	D
13 / E	3	13.U5.B0E-2000	15.E4.T60-1001	E
14 / E	3	14.U5.B0E-2000	16.E5.T60-1001	E
14,15 / G	3	15.U5.B0G-2000	16.E4.T60-1001	G
15,16 / H	3	16.U5.B0H-2000	19.E4.T60-1001	H
17,18 / R	3	18.U5.B0R-2000	20.E4.T60-1001	R
19 / R	3	19.U5.B0R-2000	22.E4.T60-1001	R
20,21 / R	3	21.U5.B0R-2000	23.E4.T60-1001	side mount

EMI (CE) Filter 460V-Class				
For Inverter Size / housing	Phases	Kit incl. Filter	Filter	Back mount with housing
07,09,10 / B	3	10.U5.B0B-3000	10.E5.T60-1001	B
07,09,10 / D	3	10.U5.B0D-3000	10.E5.T60-1002	D
12 / B	3	12.U5.B0B-3000	12.E5.T60-1001	B
12,13 / D	3	13.U5.B0D-3000	13.E5.T60-1001	D
14 / D	3	14.U5-B0D-3000	14.E5.T60-1001	D
12,13,14 / E	3	14.U5-B0E-3000	14.E4.T60-1001	E
15 / E	3	15.U5.B0E-3000	15.E4.T60-1001	E
16,17 / G	3	17.U5.B0G-3000	16.E4.T60-1001	G
18 / H	3	18.U5.B0H-3000	18.E4.T60-1001	H
19 / H	3	19.U5.B0H-3000	19.E4.T60-1001	H
20 / R	3	20.F5.x3R-xxxx	20.E4.T60-1001	internal mount
21,22,23 / R	3	2x.F5.x3R-xxxx	22.E4.T60-1001	internal mount
23 / U	3	23.U5.B0U-3000	23.E4.T60-1001	side mount
24,25 / U	3	25.U5.B0U-3000	25.F4-T60-1001	side mount
26,27 / U	3	27.U5.B0U-3000	27.E4-T60-1001	side mount

Fig. 1

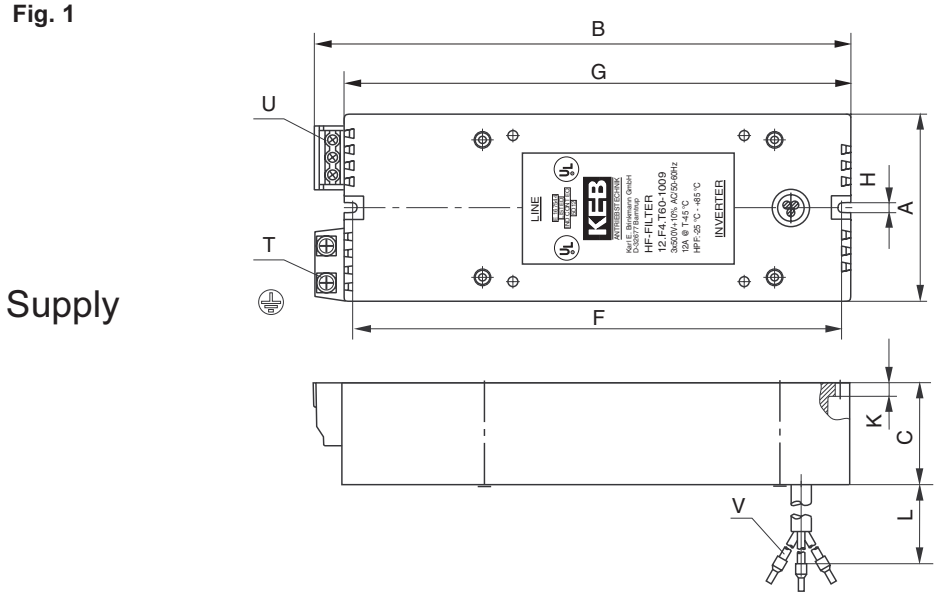
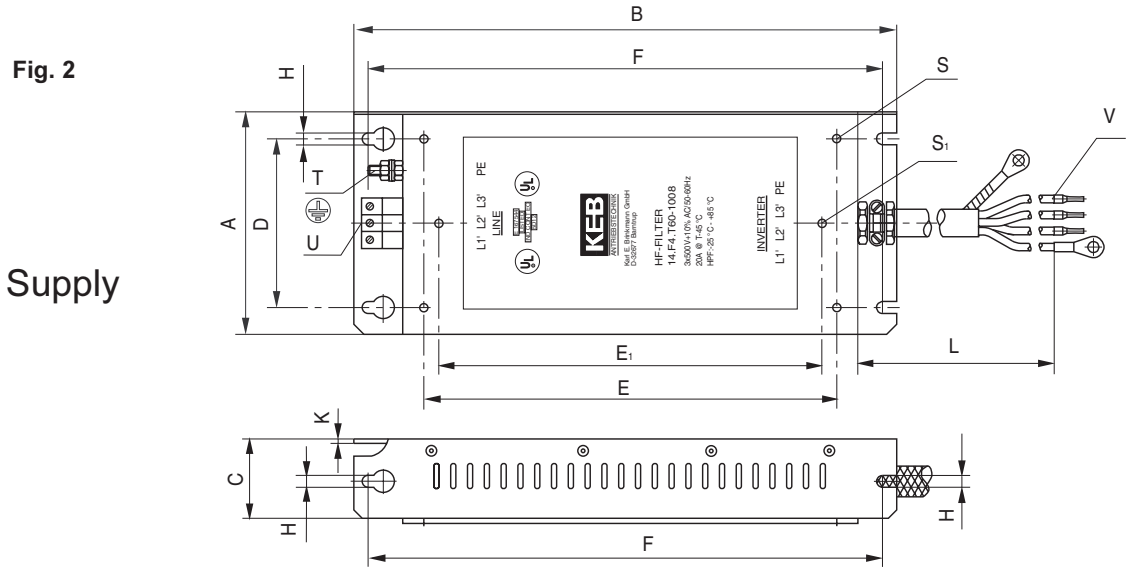
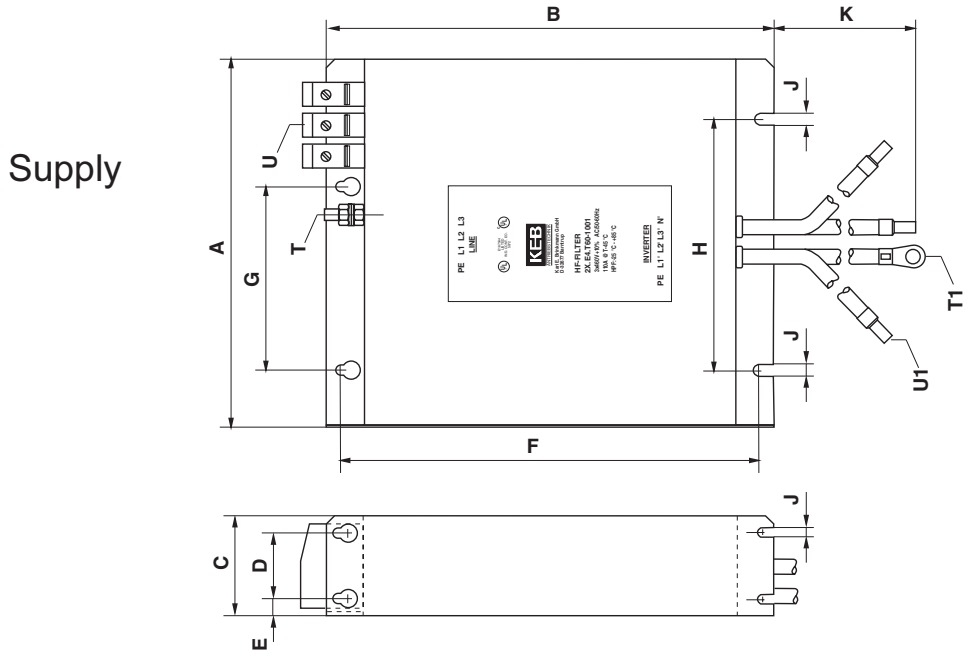


Fig. 2



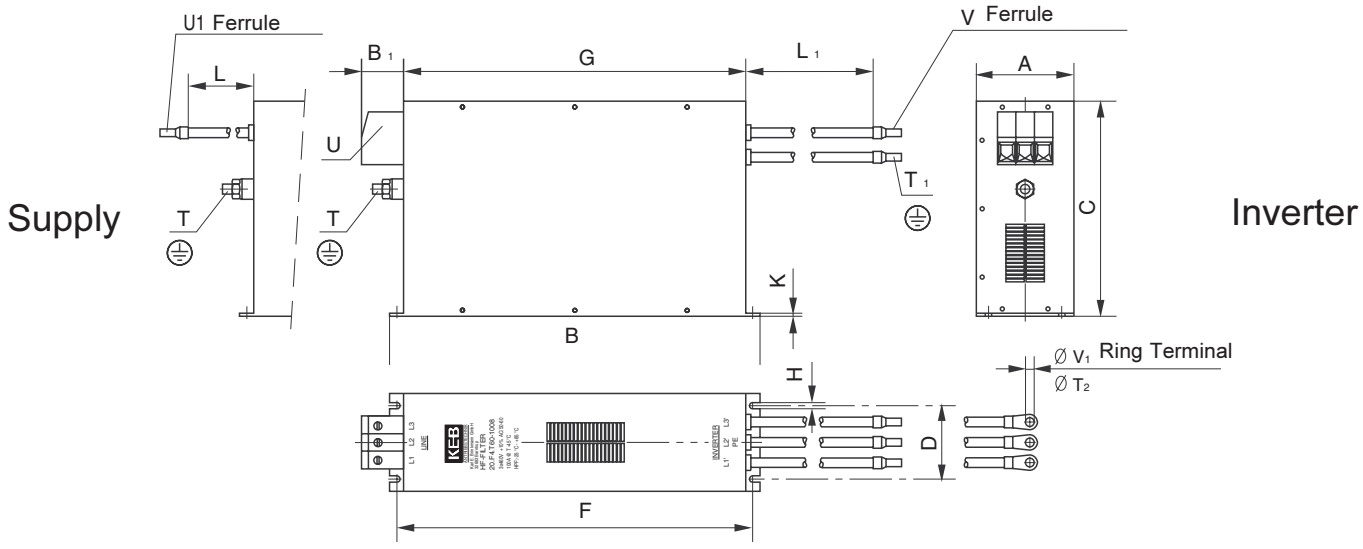
Rated current																LINE	INVERTER		
Voltage	V max.		Fig.	A	B	C	D	E	E1	F	G	H	K	S	S1	T	U	V	L	Weight
KEB Art.No.:	[V]	[A]															Terminal Strip	Shielded Cable		[lbs]
07.E5.T60-0061		8															2x 4mm²	2x AWG 14		
10.E5.T60-0001	1x250	22	1	3.5	9.8	1.6	-	-	-			0.2	0.2	-	-		2x AWG 10			2.0
10.E5.T60-0002		22			11.2													2x AWG 10	4.33	
10.E5.T60-1001		8			9.8															
10.E5.T60-1002		8			11.2															
12.E5.T60-1001	3x500	16	1	3.5	9.8	1.6						0.2	0.2			M4	3x 4mm²			
13.E5.T60-1001		16			11.2		-	-	-					-	-		3x AWG 10			2.9
14.E5.T60-1001		22				2.0												3x AWG 14		3.3
14.E4.T60-1001		22																4x AWG 12	15.7	
15.E4.T60-1001		30		5.2	13.9	2.0	3.9	-	10.8	13.2	-	0.3	0.1	-	M6	M6	3x 10mm²	4x AWG 10	15.7	3.3
16.E5.T60-1001		50															3x AWG 6			
16.E4.T60-1001	3x500	50	2	7.1	16.3	2.2	5.9	13.0	-	15.7	-	0.3	0.1	M6	-	M6		4x AWG 8	15.7	7.0
18.E4.T60-1001		65		11.8	17.5	2.6	9.8	13.0	-	16.5	-	0.3	0.2	M6	-	M6	3x 25mm²	4x AWG 6	13.8	11.2
19.E4.T60-1001		75															3x AWG 2	4x AWG 4	13.8	13.4

Dimensions in inches unless specified otherwise



Rated Current / Maximum Voltage / KEB Art.Nr.:	[V]	[A]	Pv [W]	A	B	C	D	E	F	G	H	I	K	LINE T	LINE U [mm]	INVERTER T1	INVERTER U1 [mm]	Wt. [lbs]
20.E4.T60-1001	3x	110	58	10.6	15.7	2.5	1.57	0.47	15.2	5.5	7.87	0.26	15.7	M8	3x 50	3x25	for M8	15.8
22.E4.T60-1001	500	130	90													3x35		17.4

Dimensions in inches unless specified otherwise



Rated Current / Maximum Voltage / KEB Art.Nr.:	[V]	[A]	Pv [W]	A	B	B1	C	D	F	G	H	K	L	L1	LINE T	LINE U Terminal cross sec.	LINE U1 Wire dia. [mm²]	INVERTER T1 Wire dia. [mm²]	INVERTER T2 [mm]	INVERTER V Wire dia. [mm²]	INVERTER V1	Wt. [lbs]
23.E4.T60-1001	3x	180	102	4.3	18.7	-	9.4	3.1	17.8	17.3	0.26	0.16	40.9	21.7	M10	-	3x95	-	M8	3x95	-	31.9
25.E4.T60-1001	500	250	116		24.8				9.4	9.4						-	3x95		M10	3x95		31.9
27.E4.T60-1001		330	137													-	3x150			3x150		37.6

Dimensions in inches unless otherwise specified

3.3 Output Filters

3.3.1 Motor Choke

There are several reasons to install a choke between the inverter and the motor. These reasons depend on the following variables: operating voltage, inverter size, motor type, motor cable type (shielded or not) and motor cable length. The conditions around the usage of the chokes are described below.

Shielded motor cables are recommend to reduce the possibility of noise interfering with other components, i.e. sensors, controllers. However by shielding the wires, a good capacitance coupling to earth ground is created. As the motor cable length increases, the coupling capacitance increases, resulting in higher ground leakage currents and higher levels of conducted EMI on the line. As a result, with longer shielding cables the inverter and KEB EMI filter may no longer comply with the EN norm regarding conducted interference. Thus it is necessary to use a motor choke to reduce these levels.

If the inverter is rated for 1, 2 and 3 hp and it is operated with a high carrier frequency, it may be necessary to use a motor choke even with relatively short cable lengths. Capacitive current flows between the motor leads U,V,W and to ground via the shield, as a result adding to the motor current. The resulting current typically exceeds the rated current of the inverter causing nuisance over load or over current faults. This does not effect the larger hp units since the capacitive current is proportional to the cable length and is roughly the same for all sizes of inverters.

When the motor cables are 100 to 150 feet in length, voltage peaks several times greater than the rated voltage of the motor can begin to appear at the motor. By using motors which have a high insulation breakdown rating, usually listed in volts (1600V or higher), the choke can be eliminated. However, if standard motors with normal insulation ratings are used, the choke is highly recommended.

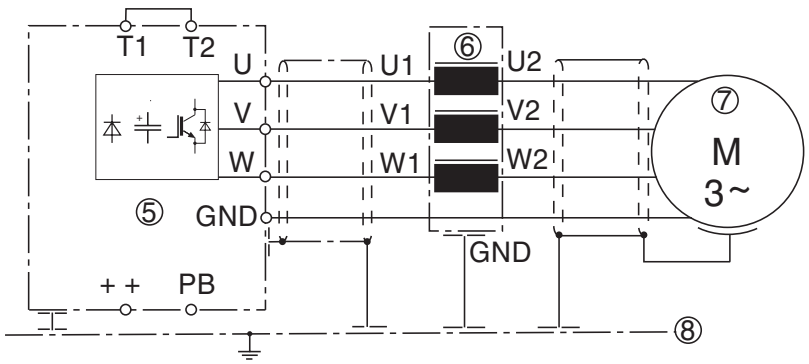
Finally, as the motor cables become longer, it is possible for voltage peaks to appear at the motor and the inverter's terminal strip. In this case the motor windings may have a high insulation rating protecting the motor, but the inverter has only a 1200V rating on the power IGBTs. As a result a motor choke is always recommended when the cables are longer.

Taking all these factors into consideration, the maximum cable length, per inverter size and carrier frequency is listed in the tables on pages 15-20. For cable lengths greater than list a choke is recommended.

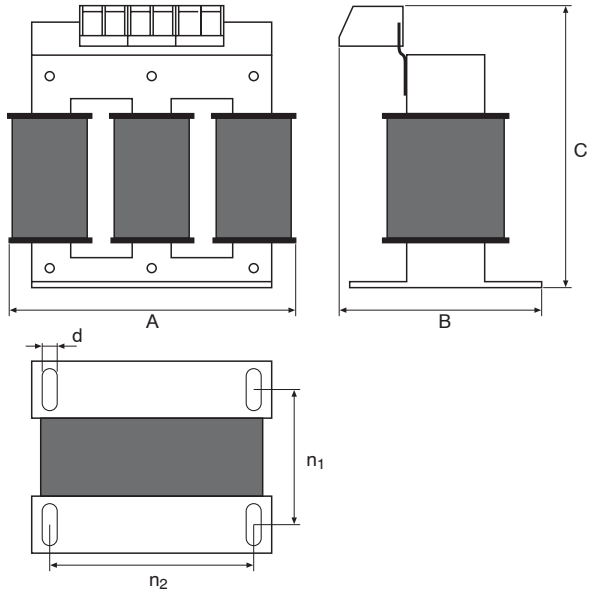
Choke sizing-motor chokes should be selected such that the rated current of the choke is equal to or greater than the rated current of the inverter. Three percent chokes are sufficient. However, 5% chokes will reduce the audible PWM noise in the motor when operating at lower carrier frequencies.

Connection of the motor choke

(5) **KEB COMBIVERT**
(6) **Motor choke**
(7) **Motor**
(8) **Sub panel in control cabinet**



Motor choke dimensional drawing



230V-Class														
For hp	Phases	I_N [A]	P_{loss} [W]	Imp. [%]	**Part number**	Dimensions [inches] A	B	C	n_1	n_2	d	Wire awg	Weight [lb]
			14.5	3	**U0.90.290-0401**								
1	3	4	20	5	**U0.90.290-0402**	4.4	2.75	4.1	1.98	1.44	0.31 x 0.56	22-14	4
			19.5	3	**U0.90.290-0801**								7
2	3	8	29	5	**U0.90.290-0802**	6	3	4.75	2.1	2	0.31 x 0.62	22-14	8
			26	3	**U0.90.290-1201**								9
3	3	12	31	5	**U0.90.290.1202**	6	3.25	5	2.1	2	0.31 x 0.62	22-5	10
			36	3	**U0.90.290-1801**		3.25		2.1				9
5	3	18	43	5	**U0.90.290-1802**	6	3.5	5.25	2.48	2	0.31 x 0.62	22-5	12
			48	3	**U0.90.290-2501**								11
7.5	3	25	52	5	**U0.90.290-2502**	7.25	3.43	6	2.35	3	0.38 x 0.75	22-5	14
			49	3	**U0.90.290-3501**				2.6				14
10	3	35	54	5	**U0.90.290-3502**	7.25	4	5.75	2.75	3	0.38 x 0.75	22-5	16
			54	3	**U0.90.290-4501**								23
15	3	45	62	5	**U0.90.290-4502**	9	4.75	7.35	3.16	3	0.38 x 0.75	18-4	28
			64	3	**U0.90.290-5501**								24
20	3	55	67	5	**U0.90.290-5502**	9	4.66	7.35	3.16	3	0.38 x 0.75	18-4	27
			82	3	**U0.90.290-8001**								43
25	3	80	86	5	**U0.90.290-8002**	10.8	5.62	8.5	3.47	3.63	0.38 x 0.75	22-1	51
			94	3	**U0.90.291-0001**		7		3.47				47
30	3	100	84	5	**U0.90.291-0002**	11	6.63	8.5	3.66	3.63	0.38 x 0.75	6-0	51
			108	3	**U0.90.291-3001**	9	6.38	7.25	3.16	3	3.75 x 0.56	2-0000	29
40	3	130	84	5	**U0.90.291-3002**	11.25	6.63	8.5	3.66	3.63	0.38 x 0.75	2-0000	62
			116	3	**U0.90.291-6001**	10.8	6.75		3.16				42
50	3	160	149	5	**U0.90.291-6002**	11	7	8.5	3.47	3.63	0.38 x 0.75	2-0000	51
			124	3	**U0.90.292-0001**	10.8	7.25		4.16				49
60	3	200	168	5	**U0.90.292-0002**	11.5	8.25	8.5	4.41	3.63	0.38 x 0.75	2-0000	67

Dimensions in inches

460V-Class													
For hp	Phases	I_N [A]	P_{loss} [W]	Imp. %	Part number	Dimensions A	B	C	n1	n2	d	Wire [awg]	Weight [lb]
			7.5	3	**U0.90.290-0201**								4
1	3	2	11.3	5	**U0.90.290-0202**	4.4	2.75	4.1	1.98	1.44	0.31 x 0.56	22..14	4
			20	3	**U0.90.290-0402**		4.75		1.98				4
2	3	4	25	5	**U0.90.290-0403**	4.4	3.12	4.1	2.35	1.44	0.31 x 0.56	22..14	4
			20	3	**U0.90.290-0402**		4.75		1.98				4
3	3	4	25	5	**U0.90.290-0403**	4.4	3.12	4.1	2.35	1.44	0.31 x 0.56	22..14	4
			29	3	**U0.90.290-0802**		3		2.1				8
5	3	8	25.3	5	**U0.90.290-0803**	6	3.37	4.75	2.48	2	0.31 x 0.62	22..14	11
			31	3	**U0.90.290-1202**		3.25		2.1				10
7.5	3	12	41	5	**U0.90.290-1203**	6	3.87	5	2.75	2	0.31 x 0.62	22...5	18
			43	3	**U0.90.290-1802**	6	3.5	5.25	2.48				12
10	3	18	43	5	**U0.90.290-1803**	8	4	6	2.6	2	0.31 x 0.62	22...5	16
			52	3	**U0.90.290-2502**		3.43		2.35				14
15	3	25	61	5	**U0.90.290-2503**	7.25	4.25	6	3.1	3	0.38 x 0.75	22...5	20
			54	3	**U0.90.290-3502**	7.25	4	5.75	2.75			22...5	16
20	3	35	54	5	**U0.90.290-3503**	9	4.75	7.5	3.16	3	0.38 x 0.75	18...4	30
			54	3	**U0.90.290-3502**	7.25	4	5.75	2.75			22...5	16
25	3	35	54	5	**U0.90.290-3503**	9	4.75	7.5	3.16	3	0.38 x 0.75	18...4	30
			62	3	**U0.90.290-4502**		4.75	7.35	3.16				28
30	3	45	65	5	**U0.90.290-4503**	9	5.3	7.25	3.66	3	0.38 x 0.75	18...4	39
			67	3	**U0.90.290-5502**		4.66	7.35	3.16				27
40	3	55	71	5	**U0.90.290-5503**	9	5.41	7.5	3.91	3	0.38 x 0.75	18...4	41
			86	3	**U0.90.290-8002**		5.62		3.47			12...1	51
50	3	80	96	5	**U0.90.290-8003**	10.8	6.75	8.5	4.16	3.63	0.38 x 0.75	6…0	61
			86	3	**U0.90.290-8002**		5.62		3.47			12...1	51
60	3	80	96	5	**U0.90.290-8003**	10.8	6.75	8.5	4.16	3.63	0.38 x 0.75	6…0	61
			84	3	**U0.90.291-0002**		6.63		3.66				51
75	3	100	108	5	**U0.90.291-0003**	11	7.62	8.5	4.16	3.63	0.375 x 0.75	6…0	74
			180	3	**U0.90.291-3002**		6.63		3.66				62
100	3	130	128	5	**U0.90.291-3003**	11.25	8.5	8.5	4.18	3.63	0.38 x 0.75	2…4/0	64
			149	3	**U0.90.291-6002**	11	7		3.47				51
125	3	160	138	5	**U0.90.291-6003**	11.25	8	8.5	4.66	3.63	0.38 x 0.75	2…4/0	72
			168	3	**U0.90.292-0002**		8.25		4.41				67
150	3	200	146	5	**U0.90.292-0003**	11.5	10	8.5	5.91	3.63	0.38 x 0.75	2…4/0	100
			231	3	**U0.90.292-5002**	15	10.3		5.16				106
175	3	250	219	5	**U0.90.292-5003**	14.5	11.3	11.3	5.82	4.6	0.56	2/0..500	143
			231	3	**U0.90.292-5002**	15	10.3		5.16				106
200	3	250	219	5	**U0.90.292-5003**	14.5	11.3	11.3	5.82	4.6	0.56	2/0..500	143

Dimensions in inches

3.3.2 PWM to Sine Filter

When controlling the motor with pulse width modulation (PWM), the motor can be subject to very rapid voltage rise times, dv/dt of 5…10kV/uSec. This rapid turn on can create many side effects with long cable runs greater than 150 feet, the primary problem being voltage peaks either at the motor or at the inverter. If a motor with suitable winding insulation is used then the inverter becomes the limiting factor since the output transistors are only rated for 1200V.

Installing a PWM to sine filter converts the PWM voltage to standard AC sine wave voltage phase to phase. As a result all of the problems associated with long cable runs, high dv/dt, and high voltage peaks are eliminated. The phase to ground voltage still contains some PWM voltage therefore shielded motor cables are still recommended. The standard-PWM to sine filters are designed for a maximum output frequency of 120 Hz.

For more information consult KEBCO. Ask for our AF series output filters.

3.3.3 PWM to Sine Filter Plus

The KEBCO PWM to sine filter plus creates sinusoidal voltages phase to phase and phase to ground. All problems with long motor leads are eliminated and it is no longer necessary to use shielded motor cable. This filter is recommended for extremely long motor cables, >300ft. Additionally, these filters can be used when retrofitting older installations with inverters. The filter allows the use of the existing motor cables instead of requiring a new shielded cable to be installed.

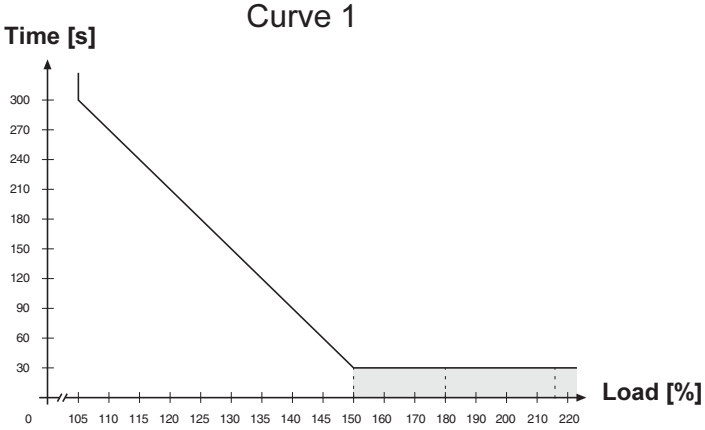
With loads >150% inverter-rated current (I_N) the next higher filter must be used. Min. 8 kHz (better 16 kHz) carrier frequency are required. The filter is dimensioned for a maximum output frequency of 100 Hz.

For more information consult KEBCO. Ask for our AF series output filters.

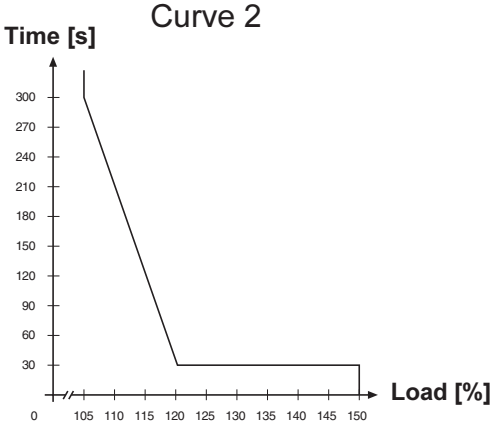
4. Annex

4.1 Overload Characteristic

Curve 1



Curve 2

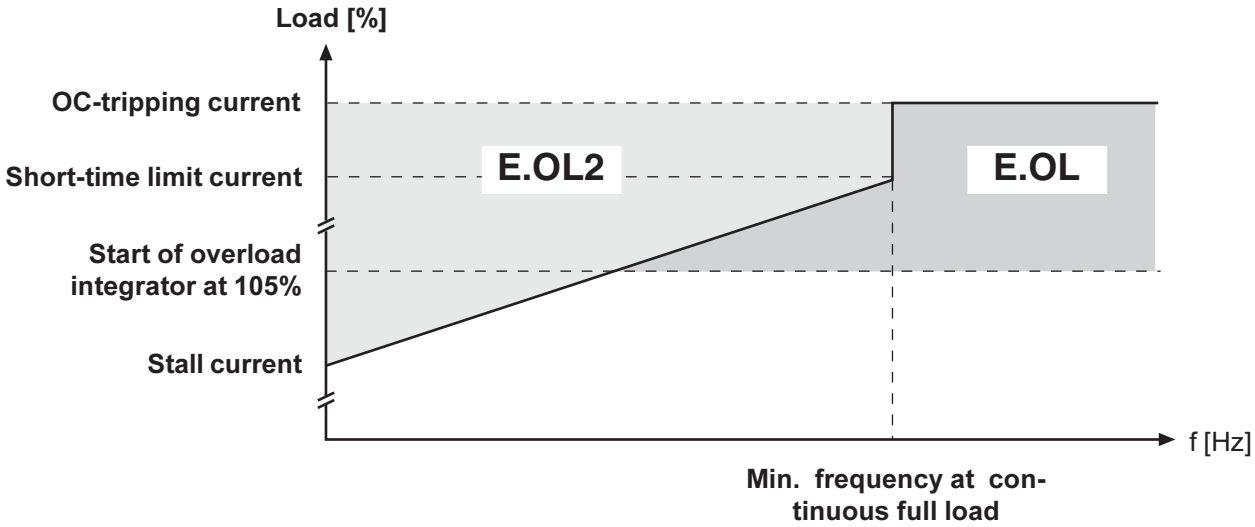


The characteristic declines device-dependently in this range (see rating plate)

On exceeding a load of 105% the overload timer starts. When falling below the timer counts backwards. If the timer achieves value for the overload characteristic that corresponds to the inverter, the error E.OL is triggered.

4.2 Overload protection in the lower speed range

(only valid for F5-M and F5-S, stall current see technical data)



If the permissible current is exceeded a PT1-element (τ=280ms) starts, after its sequence of operation the error E.OL2 is triggered.

NOTES

NOTES

Special Notice to Customer

Prior to delivery all products pass several quality and performance inspections in order to guarantee the product is free from defects in manufacturing. When used in accordance with the operating instructions, failure of the unit is not likely. However, if you have reason for concern please contact KEBCO at 651-454-6162 and ask for "inverter technical support". From this point our technical support engineers can help you determine the cause of the problems and also the proper solution.

Listed values in this manual are standard values only and do not pertain to special units. We reserve the right to make technical changes without notification.

KEBCO Limited Warranty

KEBCO Inc. will repair or replace, at KEBCO's discretion, any inverter which shows signs of defect in material, workmanship or fails to meet factory specifications with in one year from original date of shipment from KEBCO in St. Paul. Operation of the inverter outside the rated specifications printed in the instruction manuals will void the warranty.

KEBCO does not assume any liability for cost of removal, cost of installation, down time, production delays, return shipping, or damage to other items associated with the inverter, for failures which occur during or after the warranty period.

To make a warranty claim contact the Electronic repair department at the number listed above, and request a Return Goods Authorization (RGA) number. The inverter is to be shipped prepaid to the address listed below. Suitable packaging must be provided to prevent the inverter from incurring damages during shipping as damages of this nature will void the warranty.

KEBCO will inspect the inverter to determine the cause of the problems in the inverter and will repair or replace the inverter at its discretion.

KEBCO Inc.
Attn. ELECTRONIC REPAIR (RGA#)
1335 Mendota Heights Road
St. Paul, MN 55120

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