

# COMBILINE



USA INSTRUCTION MANUAL

KEB COMBILINE

Mat.No.
00U0HU0-K081

**KEB**



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# Safety Instructions


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## 1. Safety Instructions

The directions in this chapter must be absolutely observed for the following reasons:


- **Safety for people and machines**
- **Function and susceptibility to faults**
- **Technical inspector acceptance and certification**
- **Guarantee and warranties**

### 1.1 General instructions

	<b>Only Qualified Electrical Technician</b>	<p>All work from the transport, to installation and start-up as well as maintenance may only be done by qualified personnel (IEC 364 and/or CENELEC HD 384 and IEC-Report 664 and note national safety regulations). According to this manual qualified personnel means those who are able to recognise and judge the possible dangers based on their technical training and experience and those with knowledge of the relevant standards and who are familiar with the field of power transmission (VDE 0100, EN 50178, EN 60204 as well as the appropriate regulations for your area).</p>
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### 1.2 Intended use

Frequency inverters / servo drives are drive components which are intended for installation into electrical systems or machines. They serve exclusively for step less speed regulation / control of three-phase asynchronous / permanent magnet motors. Use for other purpose is not recommended and may lead to equipment damage.




	<b>Verify Electric Power System</b>	<p>The KEB harmonic filter is to be used for reduction of harmonic current distortion on the main supply network. The filter is a pass through filter connected in the supply line comparable to a standard AC choke with a laminated iron core. An almost sinusoidal current is drawn from the line side of the filter and optimum conditions are created for the inverter or other electrical equipment using a B6 front end rectifier.</p> <p>Operation of the harmonic filter is exclusively permissible when connected to electrical distribution systems in compliance with ANSI C84.1-1995 and IEEE-519-1992! Electrical systems not in compliance can lead to reduction of the filter's effectiveness and also to destruction of the filter module.</p> <p>External reactive power compensation must be limited such that the total electrical network does not become over compensated.</p>
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### 1.3 Electrical connection

Before any installation and connection work, the electrical system must be switched off and secured to prevent accidental turn on and exposure to live electrical parts.

	<b>Verify Connection</b>	<p>The harmonic filter must not be energized until it is determined that the installation and connection complies with NFPA-70 or CSA 22.1.</p> <p>Alterations to the harmonic filter are not allowed. The warranty is void if the product is altered or disassembled or operated in contradiction to these instructions.</p>
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1.4 Personal protection

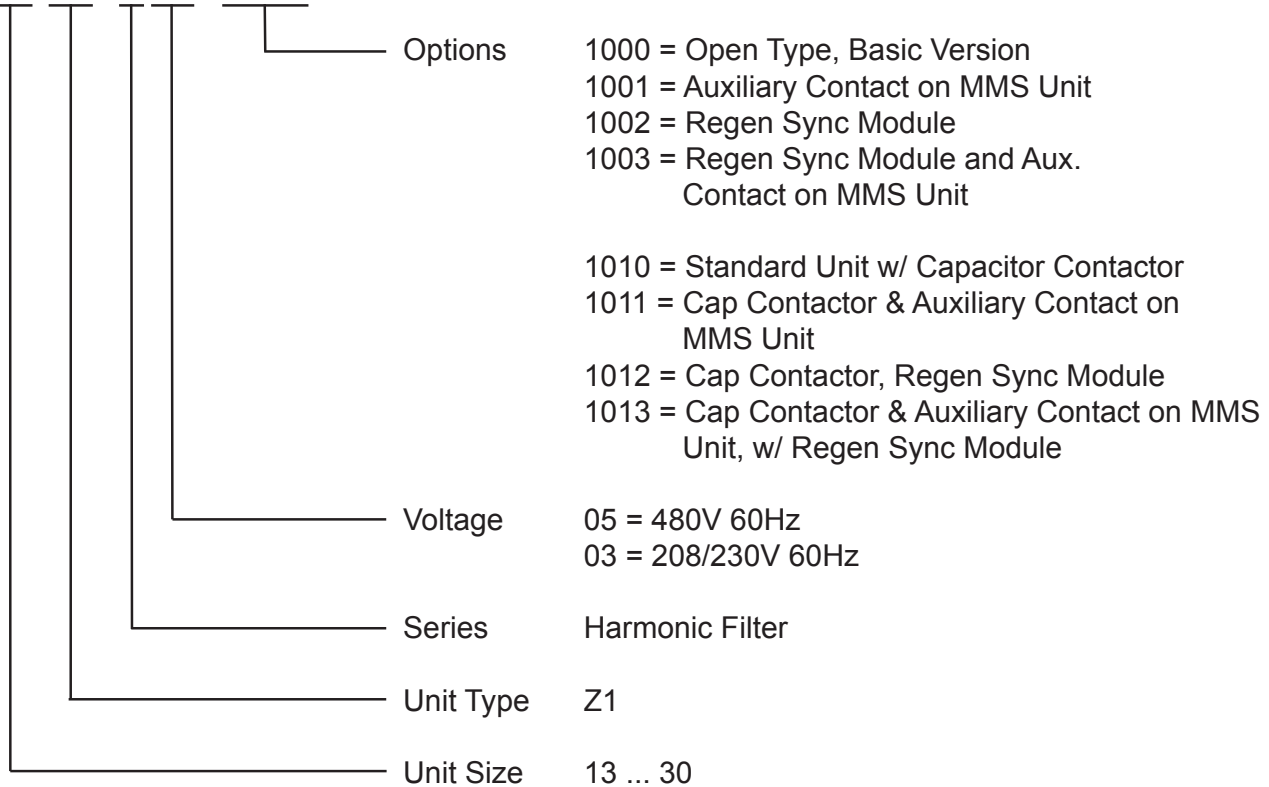
	<p><b>Protect Against Accidental Contact</b></p>	<p>Dangerous voltage can be present at the main connection point of the KEB Harmonic Filter. The filter shall be installed inside a suitable enclosure to prevent accidental contact or unintended contact with live electrical parts.</p> <p>The supplied frequency inverter and the harmonic filter form a technical unit and for this they may not be separated from the mains independently. An exception is when several frequency inverters are used i.e. several KEB COMBIVERT are supplied from one common harmonic filter. If a separate switching off is necessary for this type of application, use a discharge choke or a power contactor with discharging resistor.</p> <p>Otherwise the complete system must be switched off and the following rules are valid.</p>
	<p><b>Note Capacitor Discharge Time</b></p>	<p>Before any installation and connection work, the system must be switched off and secured.</p> <p>The capacitors in the KEB Harmonic filter and connected motor control device may store a charge. Always wait 5 minutes after switch off before working on any electrical connections.</p>
	<p><b>Cyclic Turn ON and Turn OFF</b></p>	<p>With applications requiring the frequency inverter / servo drive to be switched on and off cyclically, maintain an off-time of at least 5 min. If you require shorter cycle times please contact KEB.</p>

# Unit Description

## 2. Unit Description

### 2.1 Part Number Information

17.Z1.C05-1000



### 2.2 Technical Data and Environmental Conditions

Voltage Class	230V/480V
Rated Voltage	230V/480V
Permissible Range of the Rated Voltage	188V to 253V / 432V to 528V
Mains Frequency	60Hz
Overload Capacity EN 60146-1-1/duty class III	150% for 60 sec. every 10 min.
Efficiency @ Rated Current <sup>1) 2)</sup>	> 99%
THDI @ Rated Current <sup>3)</sup>	<= 8%
Power Factor (cos phi) <sup>1)</sup>	ca. 0.99 (>= 0.90 for load levels > 55% of rated)
Storage Temperature	-25...70 °C (-13...158 °F)
Operation Temperature Sizes 480V, 16-21 (20hp - 60hp)	-10...45 °C (14...113 °F)
Operation Temperature Sizes 230V, 13-19 (7.5hp - 40hp)	-10...45 °C (14...113 °F)
Operation Temperature Sizes 480V, 22-30 (75hp - 400hp)	-10...50 °C (14...122 °F)
Type of Protection (EN 60529)	IP20 / "Open Type"
Environment (IEC 664-1):	Pollution degree 2
Climatic Category (EN 60721-3-3)	3K3
1) Rated Operation (voltage, current, power, etc)	
2) At power supply capacity >= 30kW motor rating power at the frequency inverter	
3) $I_{sc}/I_n >= 20$	

**2.3 Rated values for 208/230V 60Hz series THDI = 8%**  
Table 2.2

Part number	13.Z1.C03-1000	14.Z1.C03-1000	15.Z1.C03-1000	16.Z1.C03-1000	17.Z1.C03-1000	18.Z1.C03-1000	19.Z1.C03-1000
Power Rated [hp]	7.5	10	15	20	25	30	40
Current Rated @ 208V [A]	18	22	29	42	55	69	82
Current Rated @ 230V [A]	20	26	37	49	62	74	97
Voltage Rated [V]	208/230V ±10%						
Frequency Rated	60Hz						
Power Loss [W]	94	115	208	247	296	352	480
Recommended wire gauge [AWG]	10	10	8	6	4	4	2
Recommended wire gauge [mm <sup>2</sup> ]	6	6	10	16	25	25	35
Stud Size for Ring Connector <sup>1)</sup> [mm]	-	-	-	-	M8	M8	M10
Terminal Torque [Nm]	3	3	4	4	12	12	20
Ground Stud Size [mm]	M8	M8	M8	M8	M8	M8	M12
Max. Circuit Protection <sup>2)</sup> [A]	30	40	60	75	95	115	150
SCCR [kA]	10	10	10	10	10	10	10
Manual Motor Starter Current Setting <sup>3)</sup> [A]	8	10	12	15	25	28	38

- 1) Ring connectors must be UL listed (ZMVV) devices and must be crimped on with the manufacturers listed crimp tool and die.
- 2) These values are recommended. A circuit breaker is recommended since it clears all phases simultaneously. However, the actual required branch circuit protection for the connected motor control takes precedence.
- 3) Protects capacitors. Factory and recommended setting. When two values are given there are two MMS units and refer to the setting of each.

## Unit Description

### 2.4 Rated values for 480V 60Hz series THDI = 8%

Table 2.3

Part number	16.Z1.C05-1000	17.Z1.C05-1000	18.Z1.C05-1000	19.Z1.C05-1000	20.Z1.C05-1000	21.Z1.C05-1000	22.Z1.C05-1000	23.Z1.C05-1000	24.Z1.C05-1000	25.Z1.C05-1000	27.Z1.C05-1000	28.Z1.C05-1000	29.Z1.C05-1000	30.Z1.C05-1000
Power Rated [hp]	20	25	30	40	50	60	75	100	125	150	200	250	300	400
Current Rated [A]	23	28	34	43	55	62	90	115	150	190	230	290	360	400
Voltage Rated [V]	480V (432...528 +/- 0V)													
Frequency Rated	60Hz													
Power Loss <sup>4)</sup> [W]	234	291	333	450	533	675	825	1125	1350	1650	1800	2238	2686	3580
Recommended wire gauge [AWG]	10	10	8	8	6	6	2	2	2/0	3/0	4/0	350 MCM	500 MCM	600 MCM
Recommended wire gauge [mm <sup>2</sup> ]	6.0	6.0	10	10	16	16	35	35	70	95	120	185	240	300
Stud Size for Ring Connector <sup>1)</sup> [mm]	-	-	-	-	-	-	M8	M8	M10	M10	M12	M12	M16	M16
Terminal Torque [Nm]	3	3	3	3	4	4	12	12	20	20	31	31	60	60
Ground Stud Size [mm]	M8	M8	M8	M8	M8	M8	M8	M8	M12	M12	M12	M12	M12	M12
Max. Circuit Protection <sup>2)</sup> [A]	35	40	50	70	80	90	130	170	220	280	340	430	540	600
SCCR [kA]	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Manual Motor Starter Current Setting <sup>3)</sup> [A]	9	10	13	17	21	22	36	41	60	70	73 / 8	65 / 33	63 / 63	80 / 80

1) Ring connectors must be UL listed (ZMVV) devices and must be crimped on with the manufacturers listed crimp tool and die.

2) These values are recommended. A circuit breaker is recommended since it clears all phases simultaneously. However, the actual required branch circuit protection for the connected motor control takes precedence.

3) Protects capacitors. Factory and recommended setting. When two values are given there are two MMS units and refer to the setting of each.

4) Power Loss at the rated current.



## 2.5 Description

### 2.5.1 International Standards

The KEB harmonic filter is a new innovative solution, which can be readily included into the electrical system during the planning phase. Given ample physical space in the electrical control cabinet, it could also be added afterward in the field. The harmonic filter provides the user with compliance of growing international power quality standards.

The following standards are met with the use of the KEB harmonic filter:

•	IEEE 519-1992 (USA)
•	G5/4 Engineering Recommendation (GB)
•	EN 61000-3-2 (up to 16A)
•	EN 61000-3-12 (16-75A)
•	EN 61000-3-4
•	EN 12015 (European lift norm)
•	AS 2279 (Australian)
•	COP, supply rules (Hongkong)
•	Quality of Electric Energy Supply, Harmonics in Public Supply Networks (China)

### 2.5.2 Advantages

The following advantages are given by means of the special design of the KEB COMBILINE harmonic filter:

•	Separate filter and capacitor mounting plate; This enables installation into small spaces as the capacitor mounting can be up to 2 meters away from the filter
•	Overall structure is compact; small space requirements for installation
•	Installation solution ready-to-connect
•	Significant reduction of the capacitive current during no-load operation
•	No tendency for AC or DC voltage oscillation during rapid load change
•	Significantly smaller voltage drop in comparison to line choke
•	Increase inverter lifetime by means of the trapezoidal output voltage and resulting square-wave current
•	Reduction of THDI to $\leq 8\%$ , Given $I_{sc}/I_L \geq 20$
•	Optional THDI $< 5\%$ (special design)
•	Large power range because parallel connection of filter modules is possible. I.e. two units could be used to feed the double input of the KEB W housing inverter.
•	Very high efficiency, due to the use of high grade steel and high frequency coil winding system
•	Easier mounting compared to a trap filter
•	Damping against oscillation on main line
•	3 phase current protection device for capacitors prevents voltage imbalance in case of activation
•	3 phase UL listed high harmonic capacitors for increased life and reliability

## Unit Description

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### 2.5.3 Applications

The KEB COMBILINE Harmonic Filter can be used to reduce the value of THDI to a level  $\leq 8\%$ . The conditions required for this assume the ratio of short circuit current to load current ( $I_{sc}/I_L$ ) is 20 or greater, the maximum pre-distortion of the voltage is not greater than 2%, and the filter is operating at its rated current value.

Under all other conditions the THDI value is still greatly reduced and will none the less provide great benefit to the building power system.

Applications:

•	To achieve compliance with power quality standards
•	Used in place of a line choke to provide smaller voltage drop - results in increases motor torque.
•	Reduction of effective input current to the motor control. Reactive power (kVAR) is greatly reduced, eliminating the need to oversize upstream devices, transformers, power generators, etc.
•	Protection of motor control against voltage spikes or irregularities on the main line
•	Reduction of load on "weak" electrical systems
•	Effectively triples DC bus capacitor lifetime
•	Can be equipped with a synchronization module for use with the R6-S Line Regenerative unit

### 2.5.4 Reactive-Power Compensation and Resonance Danger Mitigation

Reactive-power compensation equipment is used by the utility companies to compensate for lagging power factor on the utility grid. As these systems automatically adjust against the load on the grid, voltage transients can be created. These transients occur at the medium voltage (MV) level and are easily transferred down to the low voltage (LV) level which most factories and buildings operate at. These can be especially troublesome when the utility is still using capacitor only compensation. The transients can excite the resonance of the building power system resulting in unintended shut down of equipment or worse destruction of equipment. Whether or not the facility has good power quality does not determine the risk factor for system resonance. It is primarily determined by the size of the feed transformer from MV to LV and the level of capacitive load within the facility. Larger transformers provide low impedance electrical systems to the facility. These low impedance systems are more prone to resonate than high impedance systems. As a result capacitive loads (leading PF) within the facility must be minimized.

Therefore it is important to select a harmonic filter such as the KEB COMBILINE filter. Due to the unique KEB filter design, the amount of capacitance and the relative level of capacitive current at no load is much lower than with competitive filters. The result is that the use of the KEB filter reduces the risk of resonance danger.

### 2.5.5 Filter Capacitor Circuit

The capacitors used in the KEB COMBILINE filter are high performance AC film capacitors. They are designed for long life and to endure the potential voltages which occur naturally on the main line. The capacitor circuit is protected using a 3 phase manual motor starter. These device were chosen specifically to provide short circuit protection as well as overload protection for the capacitors. Most important, the device is a 3 phase protection device and in the event that a fault occurs, all three phases to the capacitors are switched off. Many competitive filters utilize multiple single phase fuses as capacitor protection. In the even one fuse opens, the capacitor bank becomes unbalanced and almost immediately the harmonic distortion will increase to levels greatly above the limits. In extreme cases an unbalanced capacitor bank can increase the ripple on the DC bus of the connected VFD and cause the VFD to fail prematurely.

The MMS units may be optionally provided with auxiliary contacts. The auxiliary contacts confirm the position of the ON/OFF switch as well as indicate whether the MMS unit has tripped. The contacts are installed on the MMS units and should be wired to the machine control, to provide status indication.

In some cases it may be required to disconnect the capacitors during no load idle periods. In this case, the KEB COMBILINE FILTER can be supplied with contactor(s) installed in the capacitor circuit(s). The contactors must be controlled by the machine control unit and shall only be allowed to change states, switch ON or switch OFF, when the connected VFD is disabled (no motor current). The contactor has 120VAC coils and should be driven from a pilot control relay. Auxiliary contacts on the contactor(s) can be used to monitor the status of the contactor and to synchronize the enabling of the VFD.

#### 2.5.6 Temperature Sensors

The KEB COMBILINE is delivered as standard with temperature sensors which can be used to monitor the temperature of the windings of the filter. The first sensor T1/T2 is a normally closed cut out switch which opens in the event the windings become too hot. Normally this should only occur if the filter is overloaded for extended periods of time, or that the ambient conditions are such that the filter is overheating. The second sensor T3/T4, is a KTY type sensor which can provide a linear temperature which is directly proportional to the actual winding temperature. This sensor can be directly to KEB VFDs or KTY inputs on machine controls. The advantage with this sensor is that it can be used to provide feedback about an imminent overheat condition. In critical systems, rather than simply shutting down the system, the machine control can decide to reduce the system load in order to reduce the temperature and keep the system running. This sensor is only installed on the larger units 75hp and above. Finally the last sensor is a normally open temperature sensor which switches on when the windings reach 100C. This sensor can be used as pilot duty to drive a separate relay which can then switch control cabinet cooling fans ON and OFF. Note that the larger filters, size 22 (75hp) and larger, cooling fans are required.

#### 2.5.7 Cooling Fans

The larger filters size 22 and greater require forced cooling across the filter core. Since the KEB COMBILINE filter is designed to be installed inside a machine control cabinet, it is not desirable to allow the filter core to reach excessive temperatures in the range of 200C. The infrared radiation from the core at that temperature could melt or damage nearby components in the control cabinet. Therefore with this in mind, it is desired to keep the core temperature below 150C.

## Unit Description

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### 2.6 Dimensions

#### 2.6.1 Core Dimensions

<b>480V Harmonic Filter Core Dimensions [mm] Open Type IP20 (Sizes 20 - 150 hp)</b>												
Part number	Figure	B	C	H1	H2	H3	T1	L1	L2	L3	D1	D2
16Z1C05-1000	1	290	280	140	145	161	318	272	185	108	10	18
17Z1C05-1000	1	316	280	152	160	173	334	292	200	112	10	16
18Z1C05-1000	1	352	320	144	150	157	364	328	224	104	10	16
19Z1C05-1000	1	352	320	170	170	185	364	328	224	130	10	16
20Z1C05-1000	1	352	330	184	190	205	364	328	224	144	10	16
21Z1C05-1000	1	352	330	195	210	223	365	328	224	155	10	16
22Z1C05-1000	2	492	525	189	300	280	500	468	344	149	10	16
23Z1C05-1000	2	492	525	202	310	301	504	468	344	162	10	16
24Z1C05-1000	3	662	630	248	310	326	558	626	466	188	15	24
25Z1C05-1000	3	662	650	248	330	324	568	626	466	188	15	24

<b>480V Harmonic Filter Core Dimensions [mm] Open Type IP20 (Sizes 200 - 400 hp)</b>												
Part number	Figure	B	C	H1	H2	H3	T1	L1	L2	L3	D1	D2
27Z1C05-1000	4	662	660	278	330	358	562	626	466	218	14.5	24
28Z1C05-1000	4	662	660	298	380	378	559	626	466	238	14.5	24
29Z1C05-1000	4	662	740	318	470	470	559	626	466	258	14.5	24
30Z1C05-1000	4	662	740	318	470	470	565	626	466	258	14.5	24

<b>230V Harmonic Filter Core Dimensions [mm] Open Type IP20 (Sizes 7.5 - 40 hp)</b>												
Part number	Figure	B	C	H	H1	H2	T1	L1	L2	L3	D1	D2
13Z1C03-1000	1	352	320	144	150	157	364	328	224	104	10	16
14Z1C03-1000	1	352	320	170	170	185	364	328	224	130	10	16
15Z1C03-1000	1	352	330	184	190	205	364	328	224	144	10	16
16Z1C03-1000	1	352	330	195	210	223	365	328	224	155	10	16
17Z1C03-1000	2	492	525	189	300	280	438	468	344	149	10	16
18Z1C03-1000	2	492	525	202	310	301	438	468	344	162	10	16
19Z1C03-1000	3	662	630	248	310	326	537	626	466	188	15	24

Figure 1

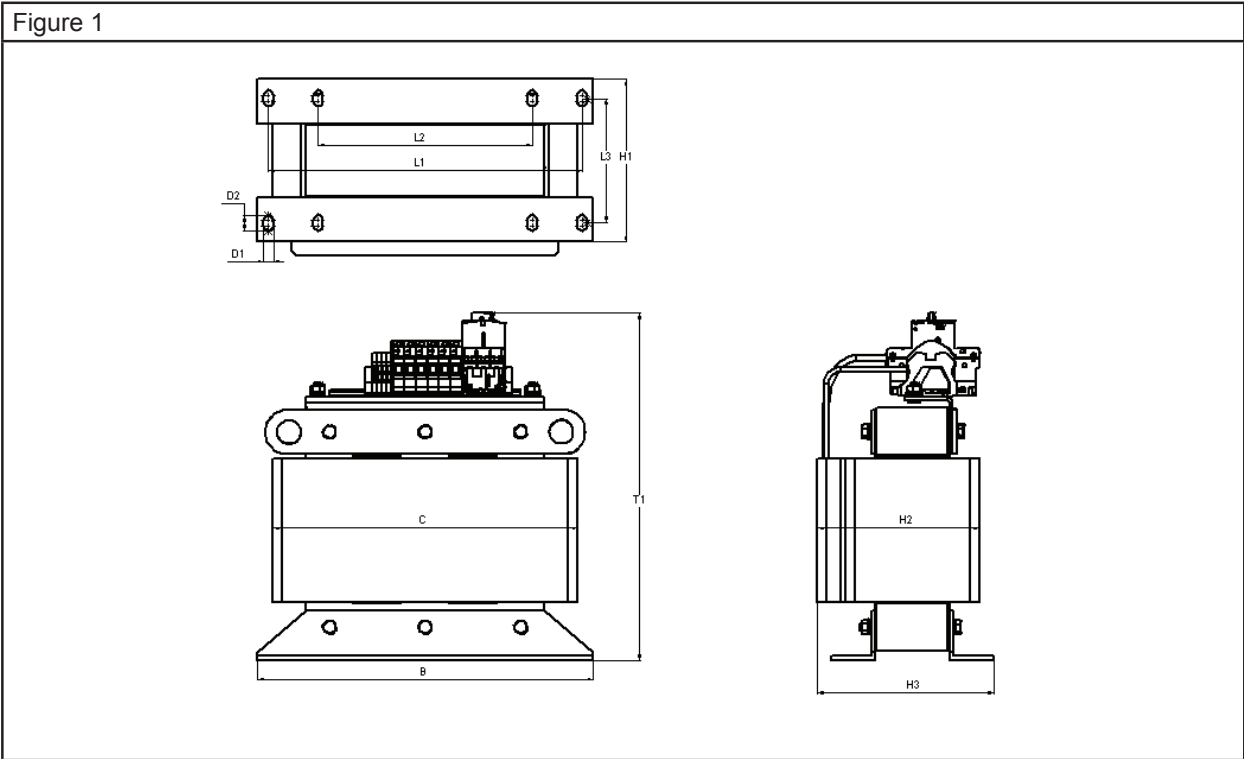
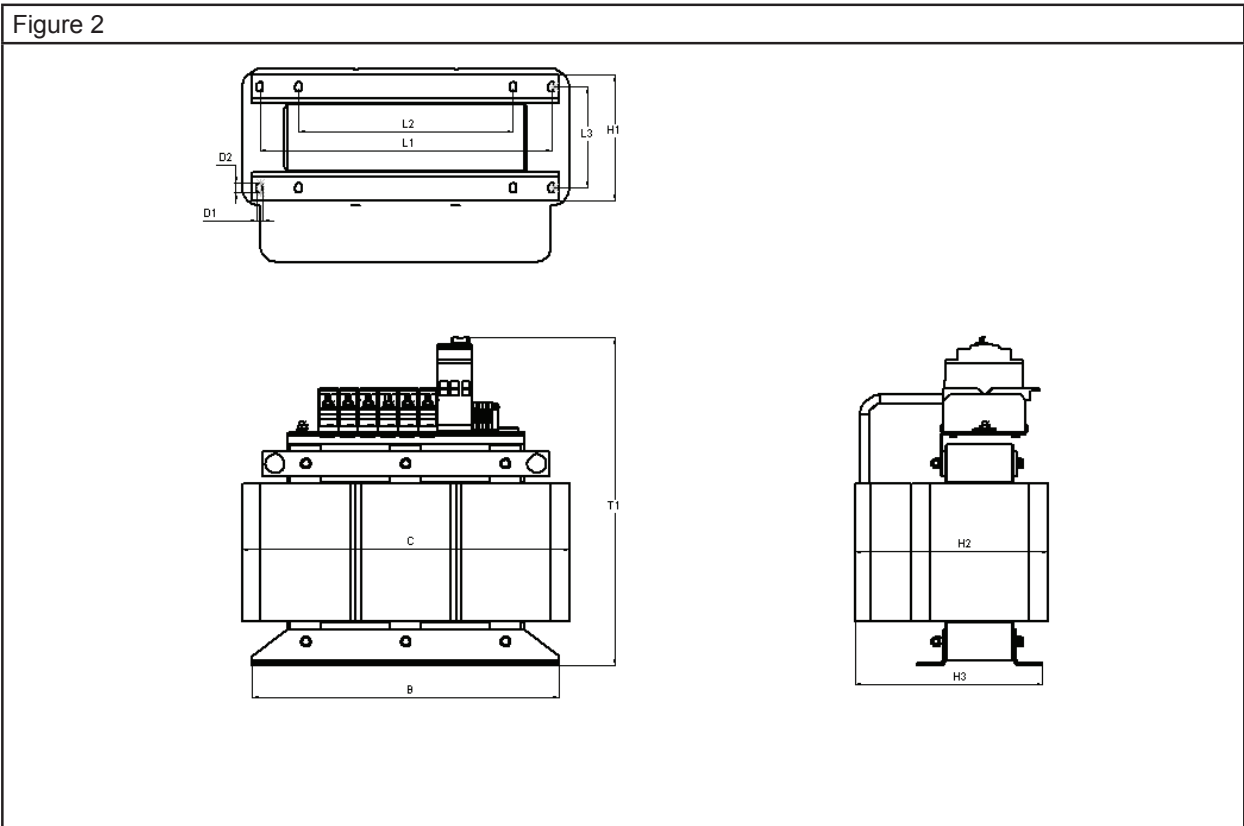


Figure 2



# Unit Description

Figure 3

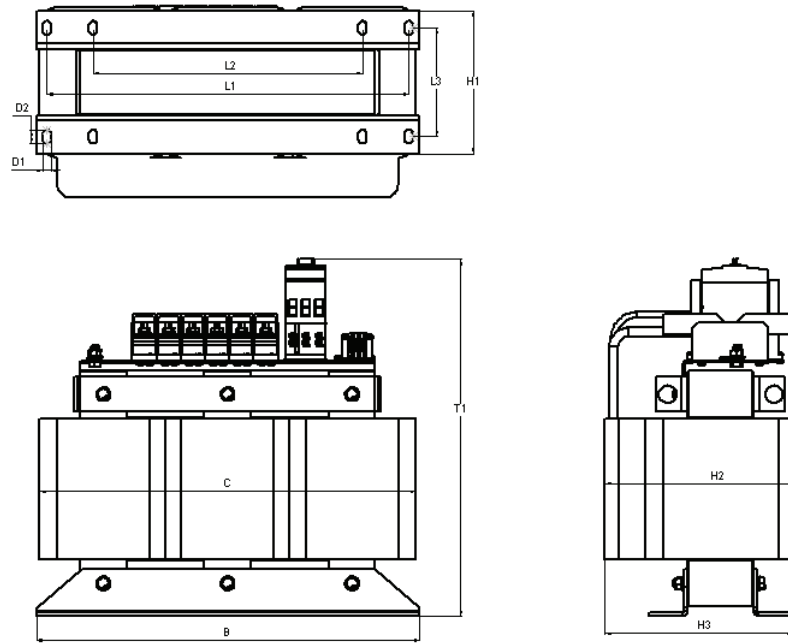
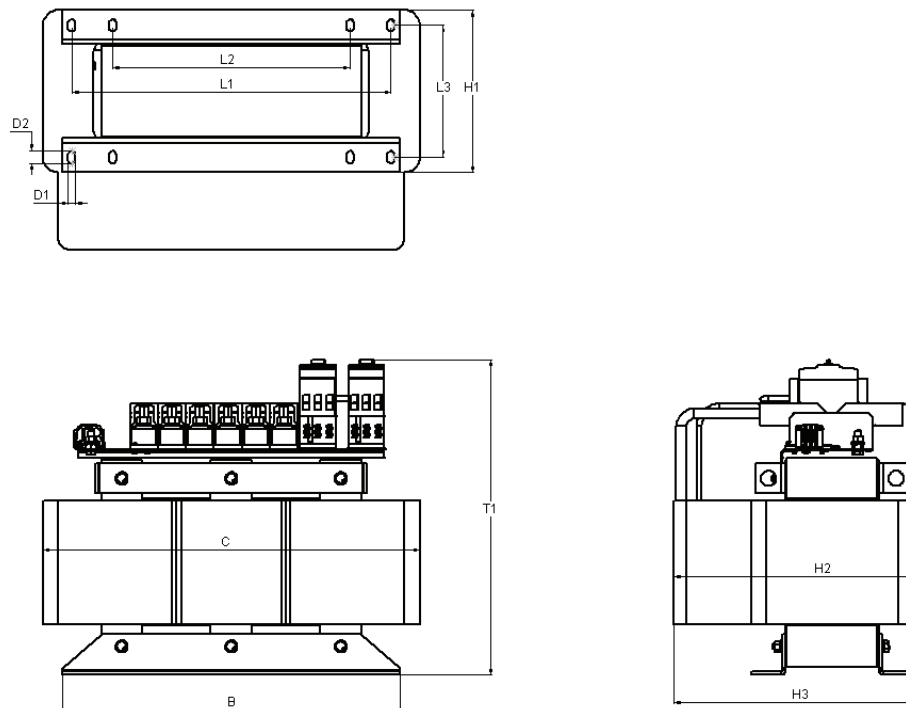


Figure 4



## 2.6.2 Capacitor Assembly Dimensions

<b>480V Capacitor Assembly Dimensions [mm] Open Type IP20 (20-75hp)</b>										
Filter Part Number	Number of assemblies	Fig.	B	H1	H2	T1	T2	L1	L2	D
16Z1C05-1000	1	4	300	140	160	230	---	275	285	6.6
17Z1C05-1000	1	4	300	140	160	230	---	275	285	6.6
18Z1C05-1000	1	4	300	140	160	231	---	275	285	6.6
19Z1C05-1000	1	4	300	140	160	274	---	275	285	6.6
20Z1C05-1000	1	4	300	140	160	215	---	275	285	6.6
21Z1C05-1000	1	4	300	140	160	270	---	275	285	6.6
22Z1C05-1000	1	4	300	140	160	219	---	275	285	6.6
<b>480V Capacitor Assembly Dimensions [mm] Open Type IP20 (100-400hp)</b>										
23Z1C05-1000	1	5	435	140	158	270	---	405	415	6.6
24Z1C05-1000	1	5	435	140	158	218	270	405	415	6.6
25Z1C05-1000	1	5	435	140	158	218	328	405	415	6.6
27Z1C05-1000 <sup>1)</sup>	2	4/5	300/435	140	160/158	231/218	218	275/405	285/415	6.6
28Z1C05-1000 <sup>1)</sup>	2	4/5	300/435	140	160/158	328	328	275/405	285/415	6.6
29Z1C05-1000 <sup>1)</sup>	2	5/5	435	140	158	328	328	405	415	6.6
30Z1C05-1000 <sup>1)</sup>	2	5/5	435	140	158	218	218	405	415	6.6

1) Sizes 27-30 require two capacitor assemblies. Note figures 4 & 5 for sizes 27 & 28 and two times figure 5 for 29 & 30.

<b>230V Capacitor Assembly Dimensions [mm] Open Type IP20 (7.5-40hp)</b>										
Filter part number	Number of assemblies	Figure	B	H1	H2	T1	T2	L1	L2	D
13Z1C03-1000	1	4	300	140	160	270	---	275	285	6.6
14Z1C03-1000	1	4	300	140	160	270	---	275	285	6.6
15Z1C03-1000	1	4	300	140	160	328	---	275	285	6.6
16Z1C03-1000	1	4	300	140	160	219	---	275	285	6.6
17Z1C03-1000	1	5	435	140	158	218	231	405	415	6.6
18Z1C03-1000	1	5	435	140	158	218	270	405	415	6.6
19Z1C03-1000	1	5	435	140	158	218	218	405	415	6.6

# Unit Description

Figure 4 - Single capacitor assembly

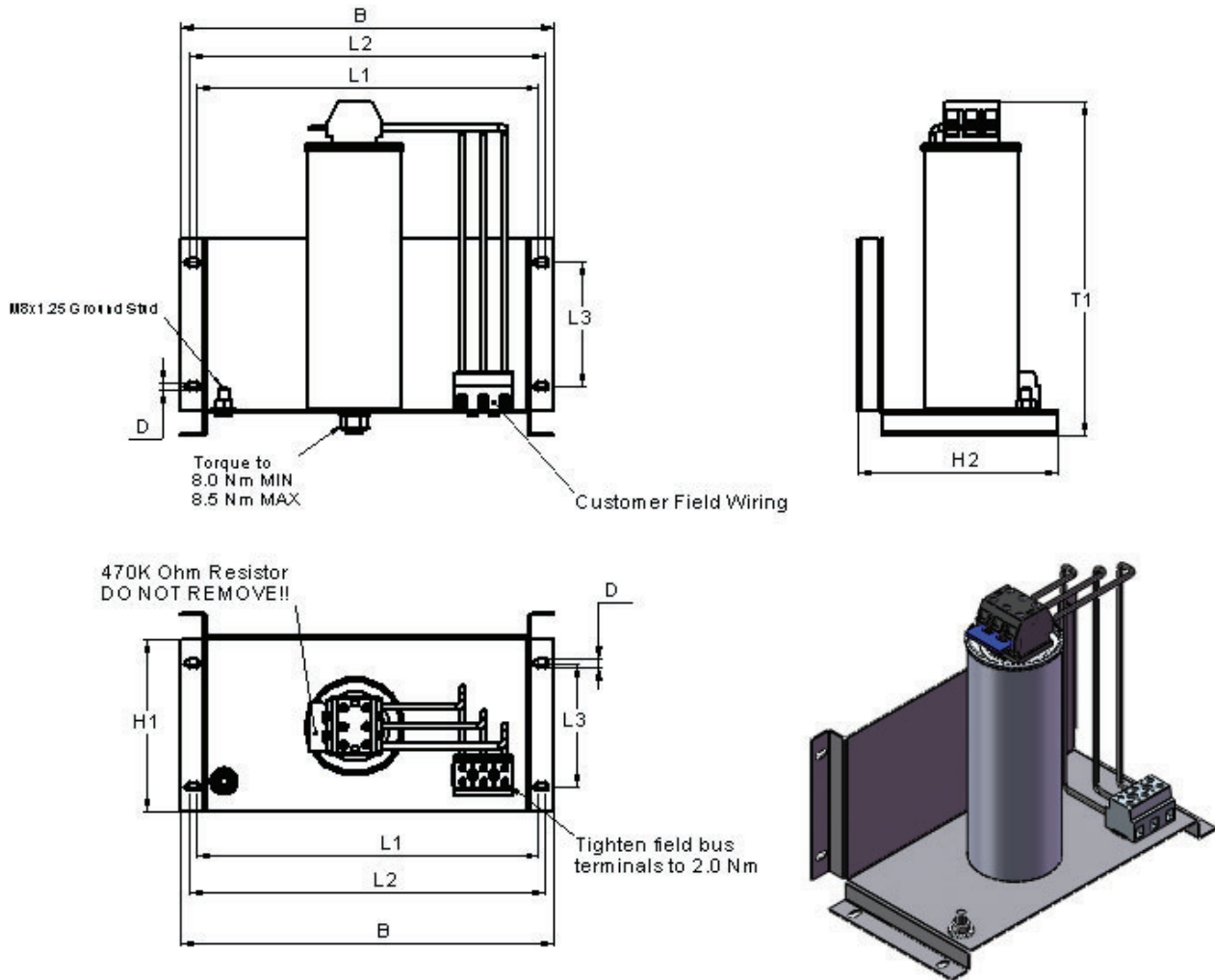


Figure 4a - Single capacitor assembly with contactor

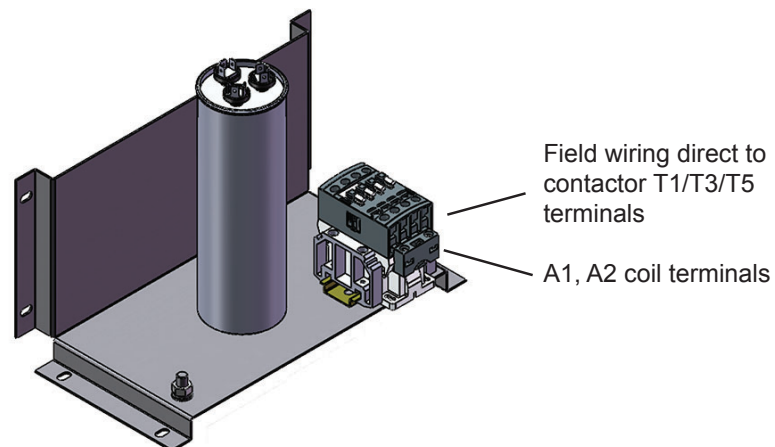




Figure 5 Double capacitor assembly

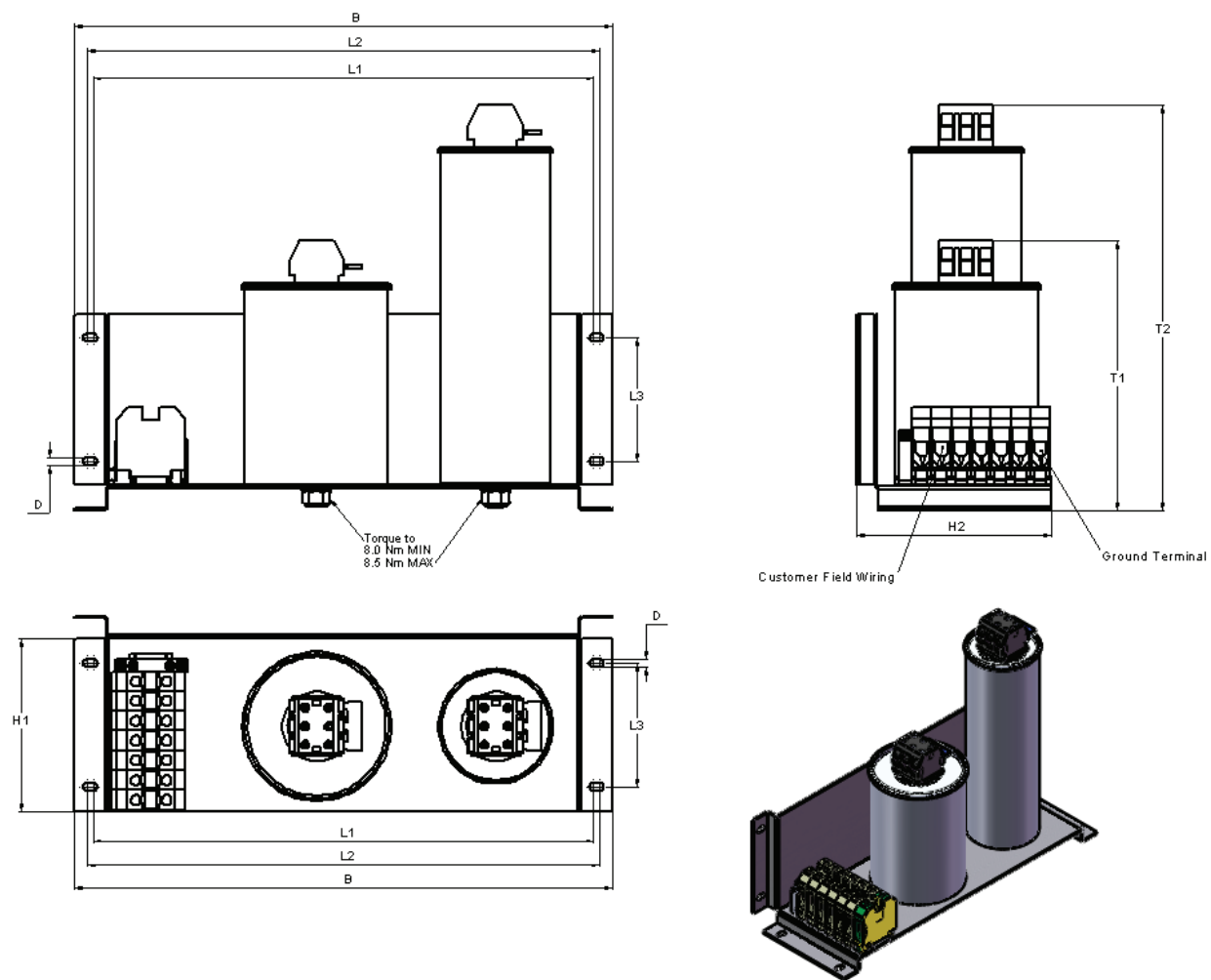
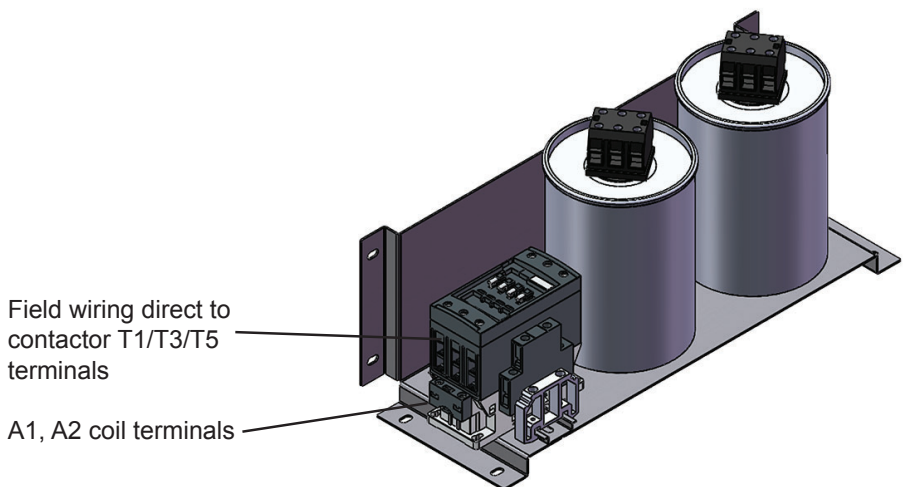


Figure 5a Double capacitor assembly with contactors



# Installation

## 3. Installation Open Type / IP20 Units

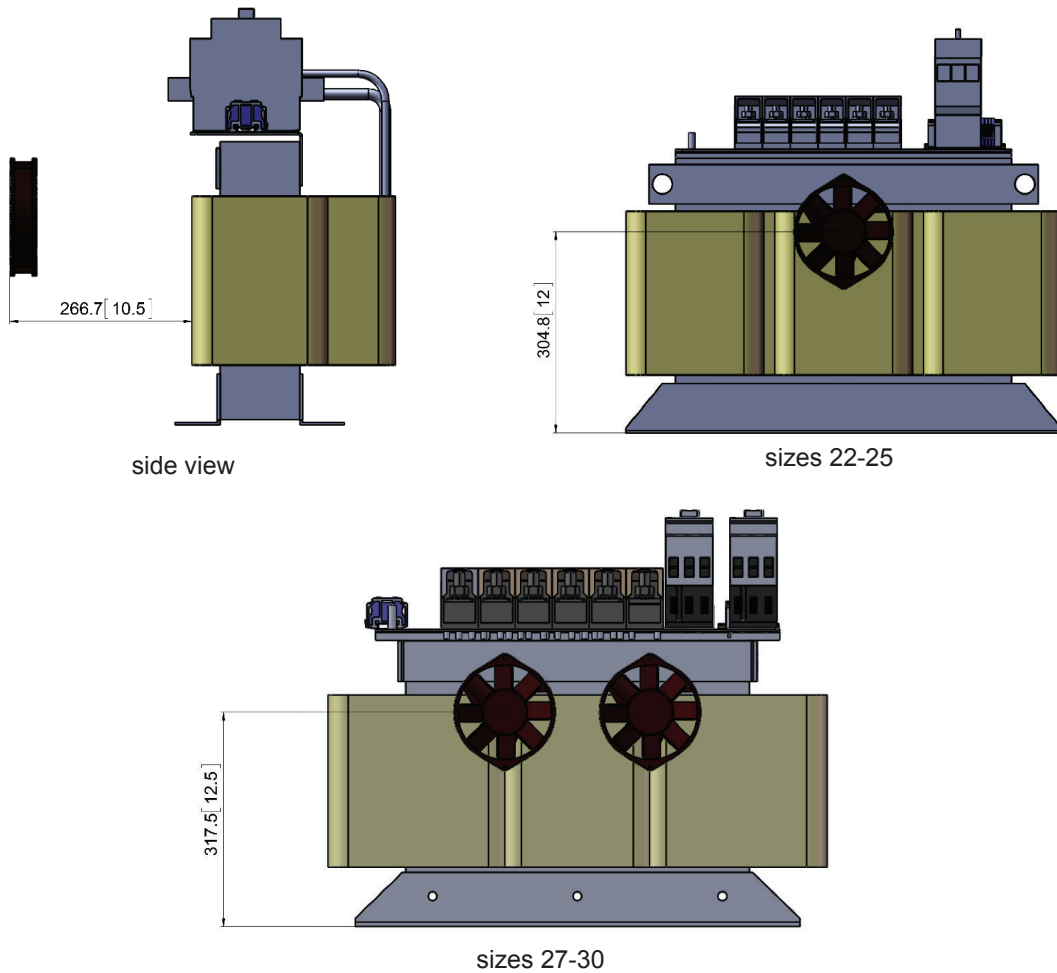
### 3.1 Inductive Core Installation Instructions

The KEB harmonic filter is classified as an open type / IP20 device and must be installed inside of a suitable enclosure. During installation pay attention to the following:	
•	When operating continuously at rated load the filter will become hot. Care should be taken that this heat is kept away from the motor control device. Best mounting practice is on the bottom of the enclosure or perhaps above the motor control such that the heat from the filter can not directly influence the AC motor control.
•	Provide a clearance to other devices around the unit of no less than 150mm (6 in) . Take care if the filter is mounting vertically no to place heat sensitive devices immediately above the filter. 150mm is the minimum requirement but more may be needed for continuous operation at 100% load.
•	A distance of 75 mm ( 3 in) must be maintained to cabinet walls or sub panel. Route all loose wiring away from the inductive core.
•	In elevator applications where the duty cycle is often less than 50%, the heating of the filter will be significantly less. In these applications the clearance distance of 150mm (6 in) can be reduced to 75mm (3 in).
•	Maximum wire length of 5 m (16.5ft) between harmonic filter and inverter may not be exceeded. Contact KEB if longer lengths are required.
•	Prevent airborne contamination or particulate from building up on the filter.
•	The maximum ambient temperature may not be exceeded at continuous rated load.
•	The larger units, size 22 (480V) or size 17 (230V) and greater, <u>require</u> forced air flow over the filter core to maintain the operating temperature. When the unit is mounted on the bottom of the control cabinet, a fan located in the side wall or door can provide the necessary air flow as well as necessary cooling of the control cabinet. See table 3.1 below.
•	Units, sized 16-21 (480V) or 13-16 (230V), can be mounted with the mounting feet horizontally or vertically.
•	Units, sized 22-29 (480V) or 17-19 (230V), shall be mounted with the mounting feet horizontally.

Table 3.1

Recommended Means of Cooling		
480V Units		
Sizes	Required Air Speed Across the Inductive Core	Example cooling fan at a distance of 26.6 cm [10.5 in] or less.
16,17,18,19,20,21	Nothing Required	None
22,23,24,25	7.5 m/sec	One 15 cm [6 in] axial fan rated at 360 m <sup>3</sup> /hr [212 cfm]
27,28,29,30	7.5 m/sec	Two 15 cm [6 in] axial fans rated at 360 m <sup>3</sup> /hr [212 cfm] placed side by side
208/230V Units		
13,14,15,16, 17, 18, 19	Nothing Required	None

The following images show example fan placement for optimum cooling. The dimensions are approximate and provide a general location. The units are mm[in].



### 3.2 Harmonic Filter Capacitor Assembly Installation Instructions

The KEB harmonic filter capacitor assembly is classified as an open type / IP20 device and must be installed inside of a suitable enclosure. During installation pay attention to the following:

- Capacitor assembly may be below or beside the harmonic filter core. In order to avoid damage or destruction of the capacitors by overheat, the capacitors must be positioned away from the filter such that they are out of the direct heat flow.
- The capacitor assembly shall be mounted such that the capacitor sits vertically (terminals on top).
- Maximum wire length is 2m (6.6 ft) between the inductive core and the capacitor assembly.
- Wire used should be a high strand count, (type MTW or welding wire) in order to get optimum filter effect.

# Installation

## 3.3 Electrical Connection



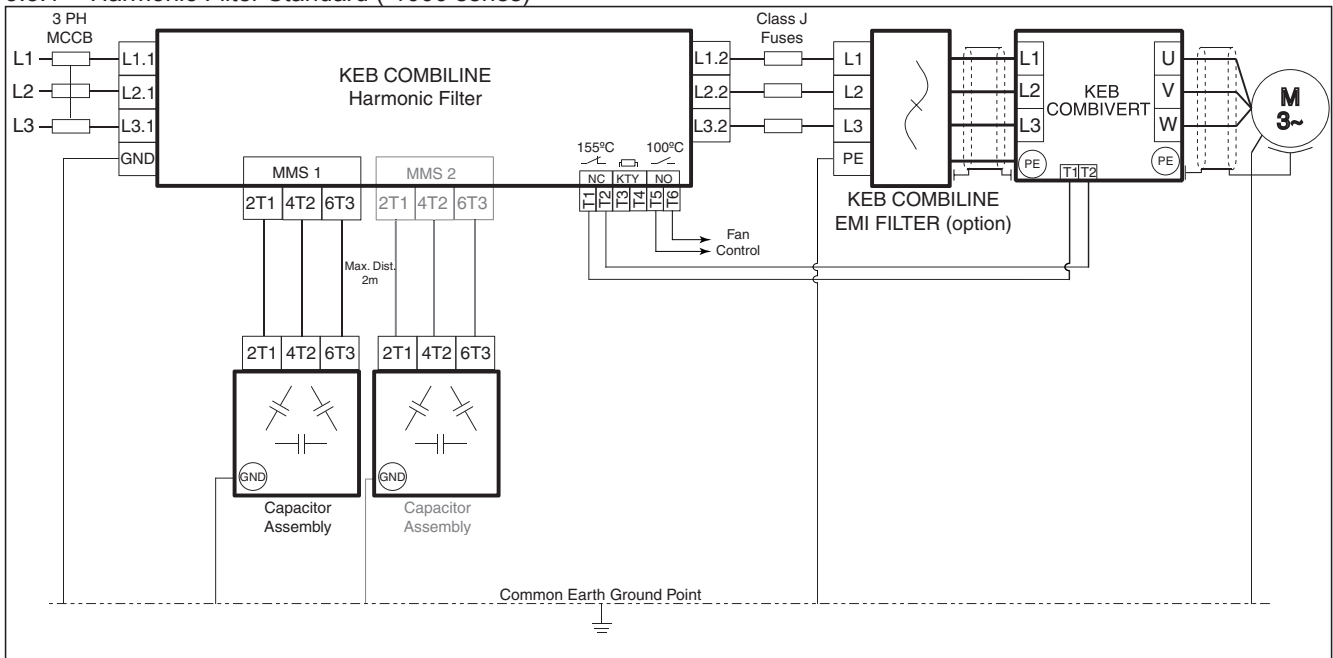
•	Wire the filter to NFPA 70 Class 1 requirements. Use the recommend wire gauges from tables 2.2 and 3.2. Use 600V UL or CSA listed 75°C copper conductors with UL or CSA listed ring terminals where applicable.
•	Tighten the terminal connections to the torques specified in tables 2.2 and 3.2.
•	Branch circuit protection must be provided and shall have a rating of not more than 150% of the rated filter current or the recommended rating of the connected AC motor control, whichever is lower.
•	The recommend protection device is a UL 489 listed MCCB 3 phase circuit breaker. As this will clear all three phases at once. Alternately, if fuses must be used, UL 248 listed Class J shall be used.
•	 It is necessary to provide supplemental protection to the connected AC motor control. Class J high speed fuses shall be placed between the harmonic filter and the AC motor control. The recommended fuse in this case is MERSEN HSJ "High Speed J". Refer to diagrams 3.3.1 to 3.2.5.
•	 In case the filter is connected to a COMBIVERT R6 regenerative unit, supplemental protection between the filter and the COMBIVERT R6 is mandatory. Class J high speed fuses shall be placed between the harmonic filter and the R6 Regen unit. The recommended fuse in this case is MERSEN HSJ "High Speed J". Refer to diagrams 3.3.2.
•	MMS2 and the second capacitor assembly are only present on the larger sizes 27 - 30 (200hp - 400hp).

Table 3.3

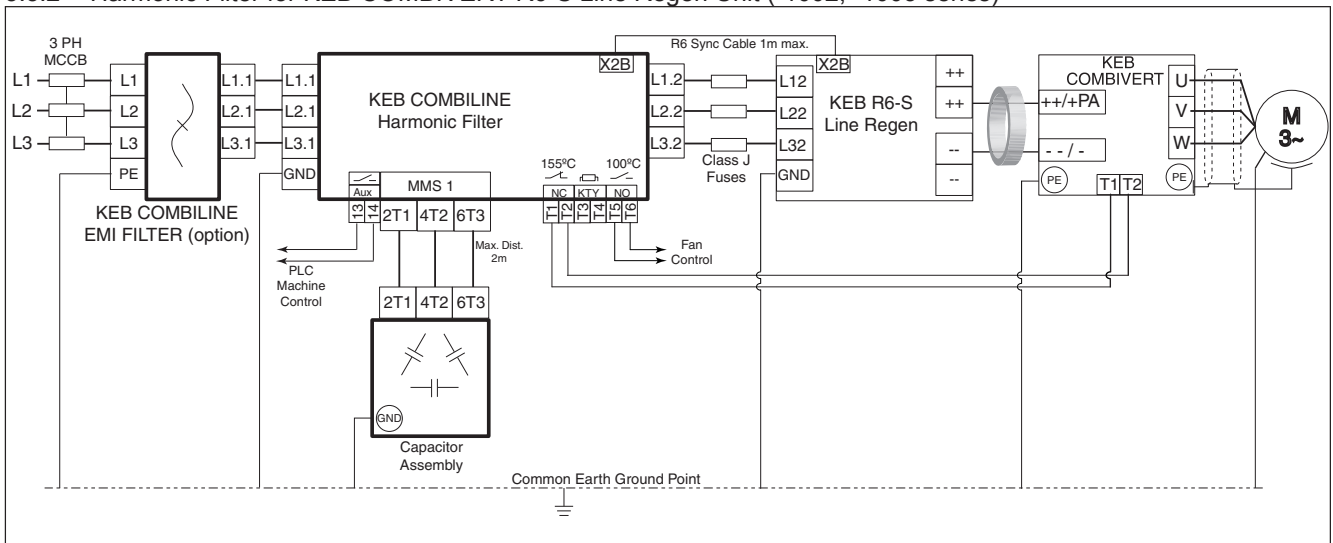
Recommended Capacitor Field Wiring Gauge Size			
480V Units			
Sizes	Manual Motor Starter Rating	Wire Size	Capacitor Connection [Tighten torque]
16,17	MMS 10A	one set of 3 wires 12 AWG or 4 mm <sup>2</sup>	Fast-on [crimped] <sup>1)</sup>
18,19	MMS 20A	one set of 3 wires 12 AWG or 4 mm <sup>2</sup>	Terminal block [2 Nm]
20,21	MMS 25A	one set of 3 wires 10 AWG or 6 mm <sup>2</sup>	Terminal block [2 Nm]
22,23	MMS 50A	one set of 3 wires 8 AWG or 10 mm <sup>2</sup>	Terminal block [4 Nm]
24	MMS 63A	one set of 3 wires 6 AWG or 16 mm <sup>2</sup>	Terminal block [4 Nm]
25	MMS 75A	one set of 3 wires 4 AWG or 25 mm <sup>2</sup>	Terminal block [4 Nm]
27	MMS1 75A MMS2 10A	one set of 3 wires 4 AWG or 25 mm <sup>2</sup> one set of 3 wires 12 AWG or 25mm <sup>2</sup>	Terminal block [4 Nm] for (4 AWG) Fast-on [crimped] <sup>1)</sup> for (12 AWG)
28	MMS1 63A MMS2 50A	one set of 3 wires 4 AWG or 25 mm <sup>2</sup> one set of 3 wires 8 AWG or 10 mm <sup>2</sup>	Terminal block [4 Nm] for (4AWG) Terminal block [2 Nm] for (8AWG)
29	MMS1 63A MMS2 63A	one set of 3 wires 4 AWG or 25 mm <sup>2</sup> one set of 3 wires 4 AWG or 25 mm <sup>2</sup>	Terminal block [4 Nm] Terminal block [4 Nm]
30	MMS1 75A MMS2 75A	one set of 3 wires 4 AWG or 25 mm <sup>2</sup> one set of 3 wires 4 AWG or 25 mm <sup>2</sup>	Terminal block [4 Nm] Terminal block [4 Nm]
208/230V Units			
13,14	MMS 10A	one set of 3 wires 12 AWG or 4 mm <sup>2</sup>	Terminal block [2 Nm]
15,16	MMS 16A	one set of 3 wires 12 AWG or 4 mm <sup>2</sup>	Terminal block [2 Nm]
17	MMS 50A	one set of 3 wires 10 AWG or 6 mm <sup>2</sup>	Terminal block [4 Nm]
18	MMS 50A	one set of 3 wires 8 AWG or 10 mm <sup>2</sup>	Terminal block [4 Nm]
19	MMS 50A	one set of 3 wires 8 AWG or 10 mm <sup>2</sup>	Terminal block [4 Nm]

1) Fast-on connectors are Panduit Number DNF14-250FIB and must be crimped on using the Panduit CT-1525 crimp tool.

### 3.3.1 Harmonic Filter Standard (-1000 series)



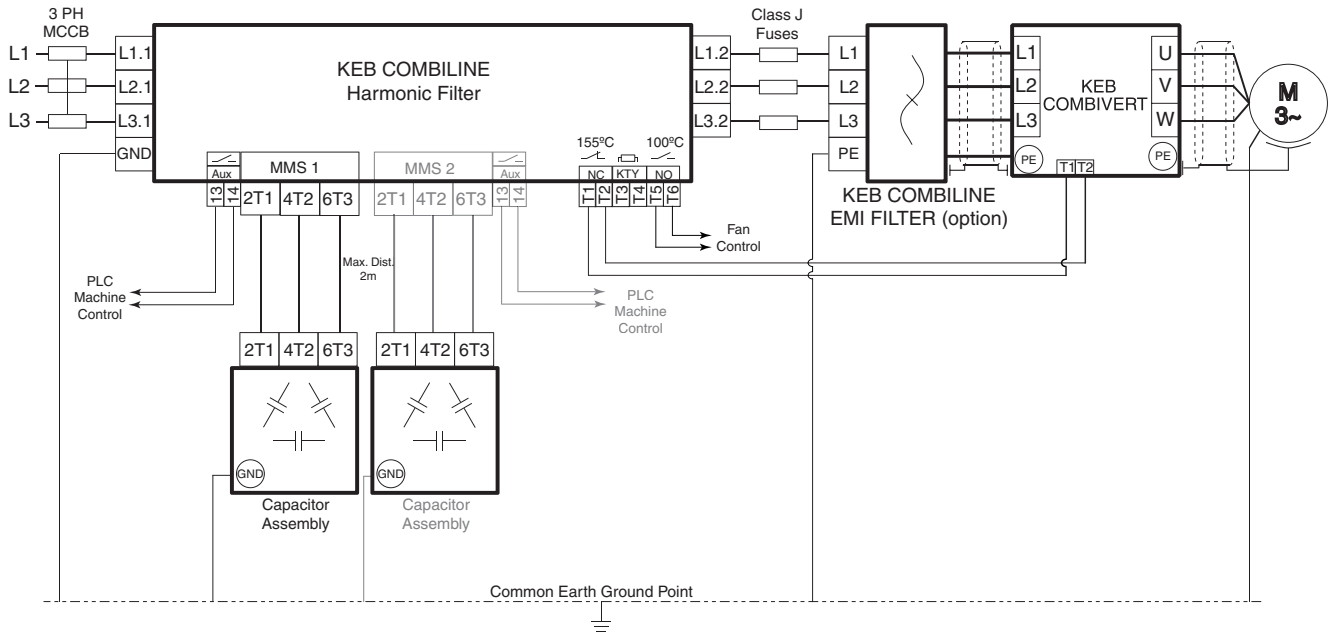
### 3.3.2 Harmonic Filter for KEB COMBIVERT R6-S Line Regen Unit (-1002, -1003 series)



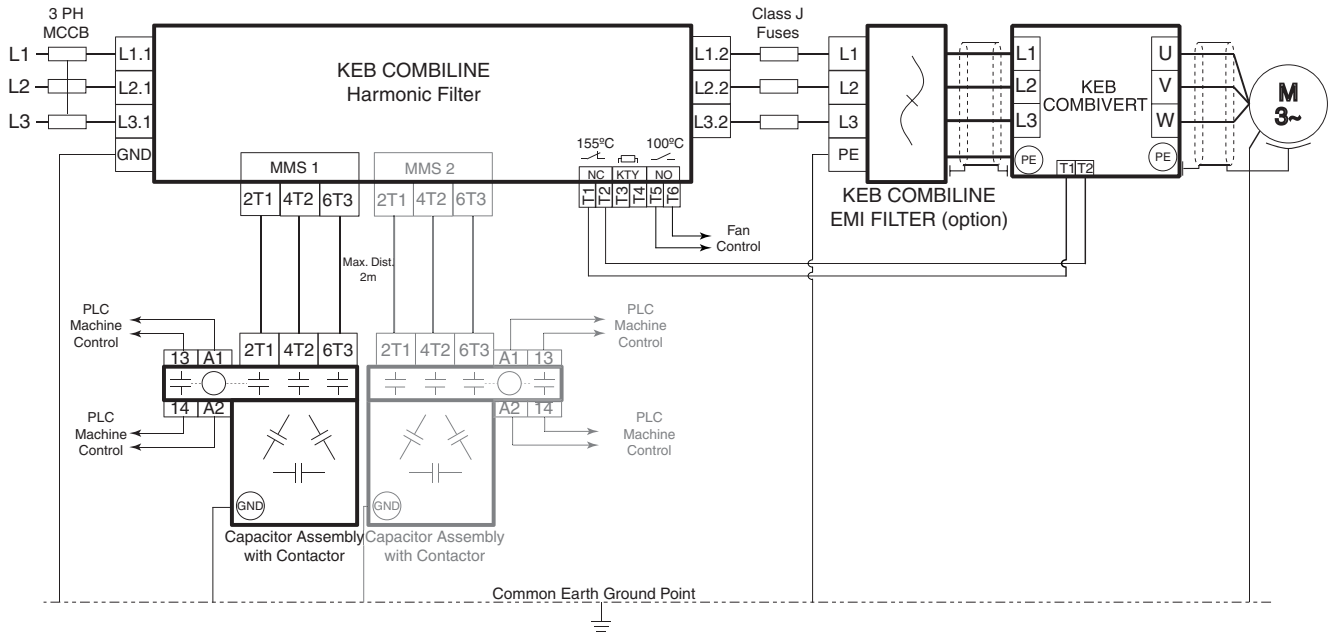
- MMS 2 is only installed on filter sizes 27,28,29,30.
- The -1002 series filters have a synchronization device installed which connects to the COMBIVERT R6S regen unit. This solution is only available for filter sizes 13-16 230V and 16 to 21 480V.
- In general the -1000 series filters can be used together with the COMBIVERT R6N regenerative unit. In this case the additional synchronization connection is not required. The diagram is the same but without the X2B connection. This solution is available for the power range utilizing the size 15 and 19 R6N units. Always refer to the instruction manual of the regenerative unit for complete connection requirements.
- High Speed Class J Fuses (e.g. Mersen HSJ) are required between the harmonic filter and the VFD. These fuses should be sized as specified in the VFD instruction manual.

# Installation

## 3.3.3 Harmonic Filter Aux MMS Contacts (-1001 series)

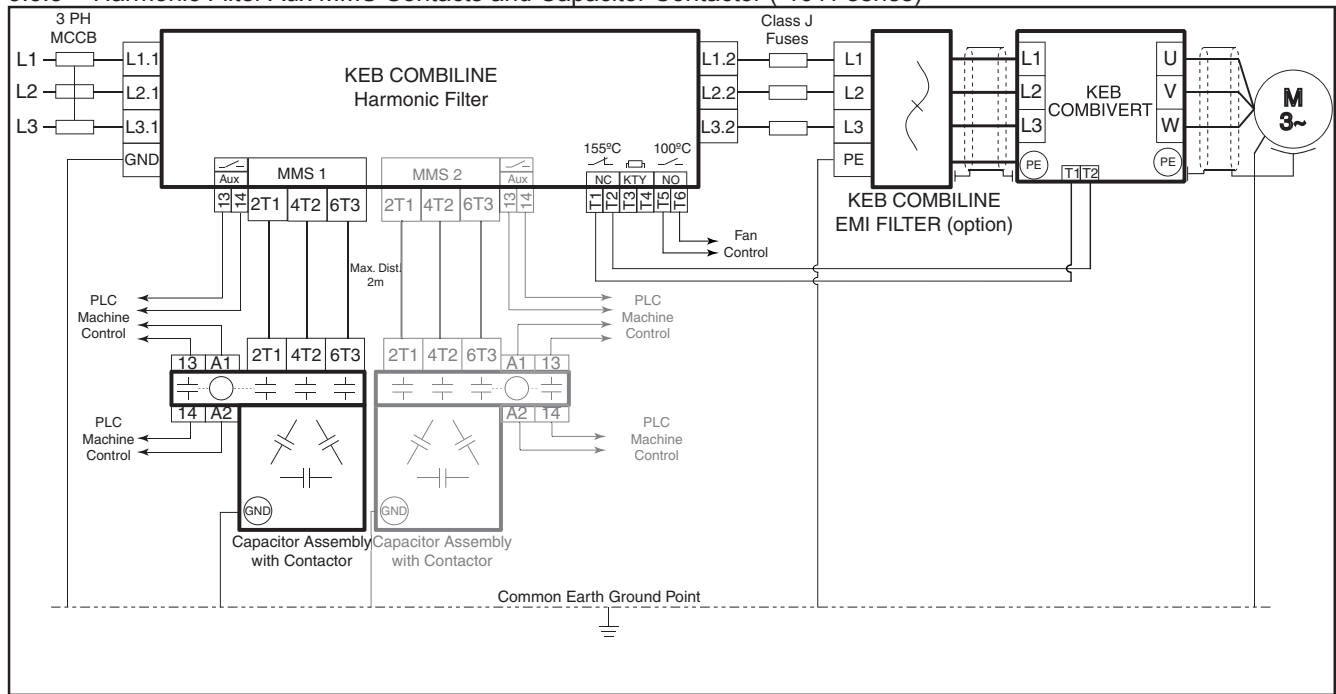


## 3.3.4 Harmonic Filter Capacitor Contactor (-1010 series)



- MMS 2 is only installed on filter sizes 27,28,29,30.
- High Speed Class J Fuses (e.g. Mersen HSJ) are required between the harmonic filter and the VFD. These fuses should be sized as specified in the VFD instruction manual.

### 3.3.5 Harmonic Filter Aux MMS Contacts and Capacitor Contactor (-1011 series)



- The -10x1 series filters have auxiliary contacts installed on the MMS units protecting the capacitors. The normally open auxiliary and signal contacts should be wired in series and then monitored by the machine control. If the contacts open, it indicates the capacitors may be damaged and have been taken out of the circuit. A warning to the machine operator can be given to indicate the harmonic levels are not correct.
- The -101x series filters have contactors installed on the capacitor assemblies which can be used to switch out the capacitors during idle periods. The contactors shall be controlled by the machine control and shall be switched ON before the connected VFD is enabled and should be switched OFF after the connected VFD is disabled. The normally open auxiliary contact (13/14) can be used to synchronize the timing with the VFD and confirm the contactor is closed. The control signals shall be 120VAC or 230VAC rather than 24VDC due to the proximity of high voltage, high frequency harmonic currents. The contactor coil (A1/A2) is 100...250VAC 50/60hz.

### 3.4 Temperature Sensors

The smaller units (sizes 16 to 21) have two temperature sensors and the larger units (sizes 22 to 30) have three. Their function and use is described below.

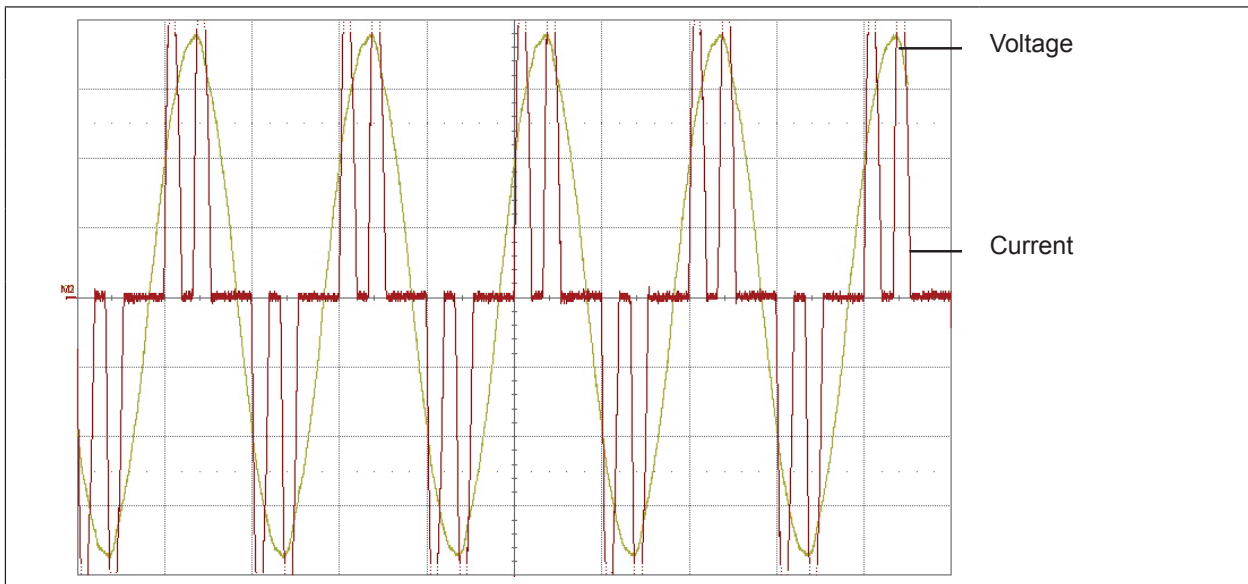
- T1/T2: is the over heat cut out switch and will open when the maximum winding temperature is reached. It should be connected to T1/T2 on the connected VFD and the overheat alarm on the VFD shall be enabled. Consult the VFD instructions for details. The contact rating is 230VAC / 2A pilot duty. This can also be monitored by a PLC input as the sensor is double insulated from the high voltage in the core.
- T3/T4: is a KTY84 sensor which can be evaluated for the actual core temperature, i.e. to provide custom hysteresis for fan control. This can be monitored by an external KTY amplifier device or when the KEB COMBIVERT VFD has the KTY temperature sensor option, it can be connected to T1/T2 on the KEB COMBIVERT. The sensor is double insulated from the high voltage in the core.
- T5/T6 can be used for controlling an external fan. The contact rating is 230VAC / 2A pilot duty. An external relay shall be connected to T5/T6 and used to cycle voltage supply of the fans ON and OFF.

# Waveforms

## 4. Example waveforms

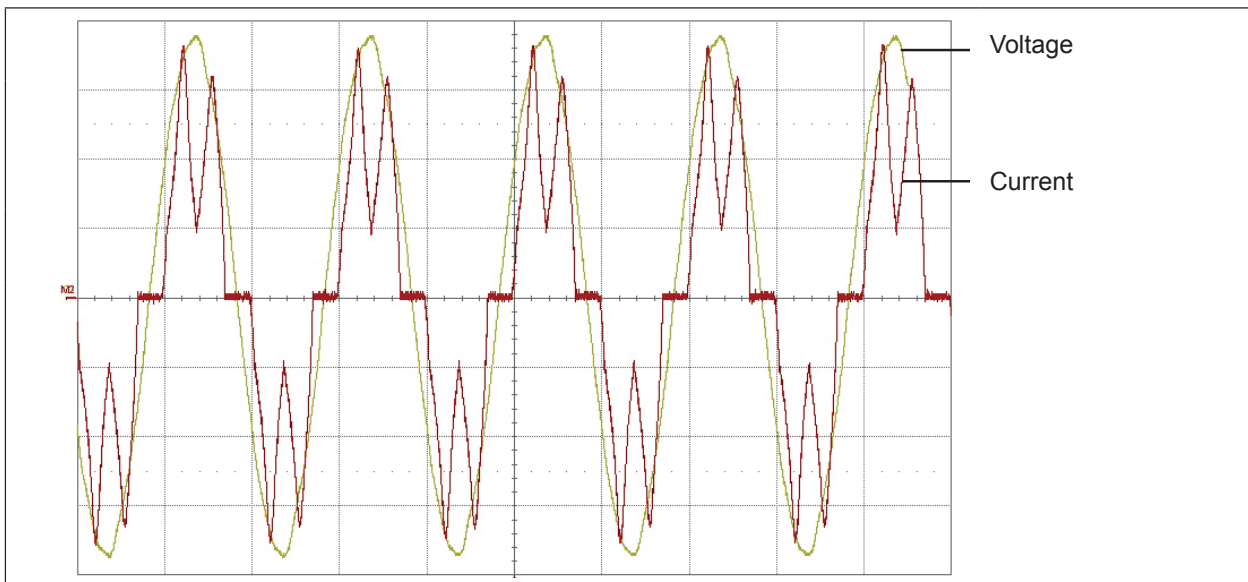
### 4.1 Voltage and current at the main line

Without a line choke high current peaks (5 to 10 times the rms value) occur resulting in a high ripple current in the DC bus of the motor control. This also means higher ripple voltage on the DC bus which can lead to torque ripple or reduced torque output from the motor.



### 4.2 Voltage and current with line choke impedance = 3% 480V/60Hz (4% 400V/50Hz)

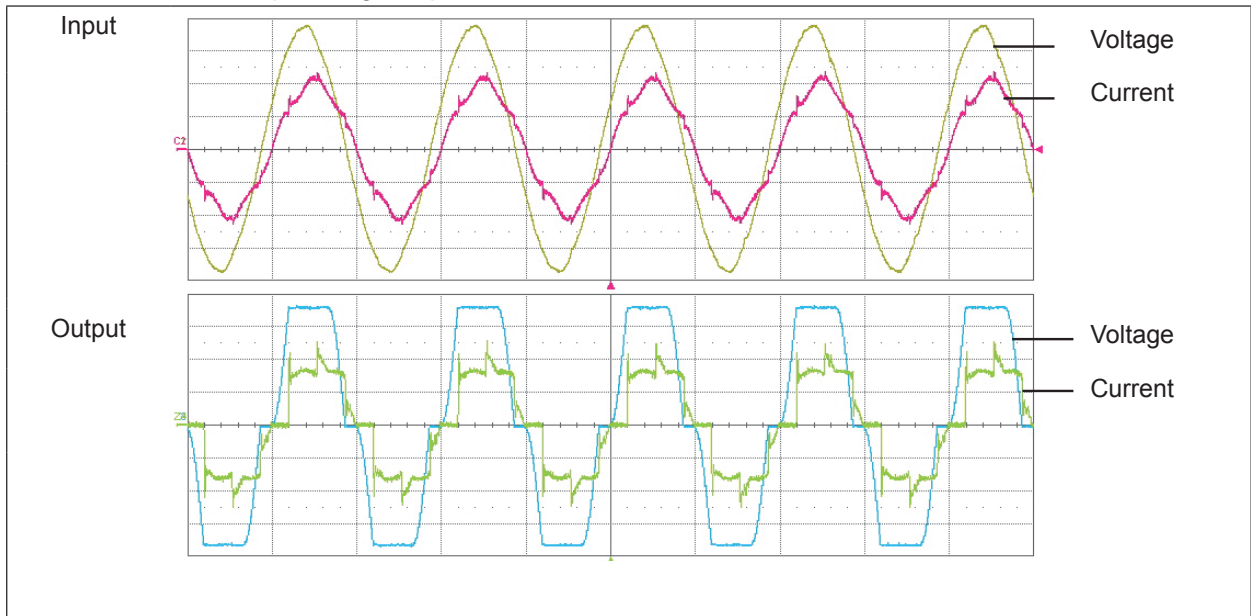
With inductance (line choke) the peak amplitude of the current is reduced to a range of 3 to 5 times the rms value. This means lower ripple current in the DC bus of the motor control. This reduces heating in the capacitors and effectively extends the lifetime by a factor of two.





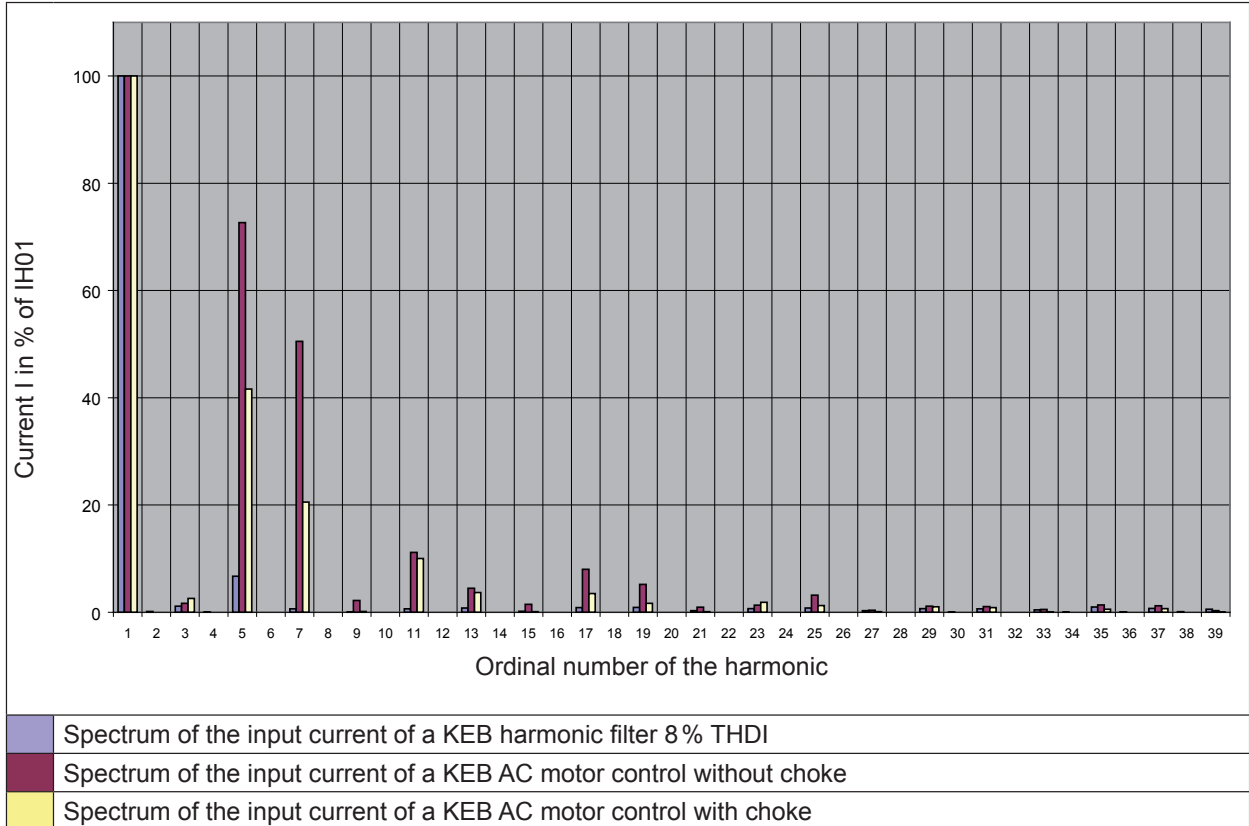
**4.3 Voltage and current with the harmonic filter THDI < 8%**

With the harmonic filter, the line-side current is sinusoidal. The peak amplitude of the current is 1.4 times the rms value. The output of the filter provides a nearly ideal rectangular voltage and current waveform into the motor control resulting in diode conduction of almost 180 degrees. The voltage on the DC bus is practically flat and the DC bus capacitors see minimum ripple current. This results in a further extension of life to 3+ times the nominal. Furthermore the average voltage value of the DC bus does not sag much in comparison to the first two cases. The result is more motor torque at higher speeds.



5. Annex

5.1 Fourier Analysis / Spectrum



5.2 Formula and Abbreviations

THD (Total Harmonic Distortion) 
$$THD = \sqrt{\sum_{n=2}^{40} \left(\frac{I_N}{I_1}\right)^2}$$

THDV (Total Harmonic Distortion Voltage)  
 THDI (Total Harmonic Distortion Current)

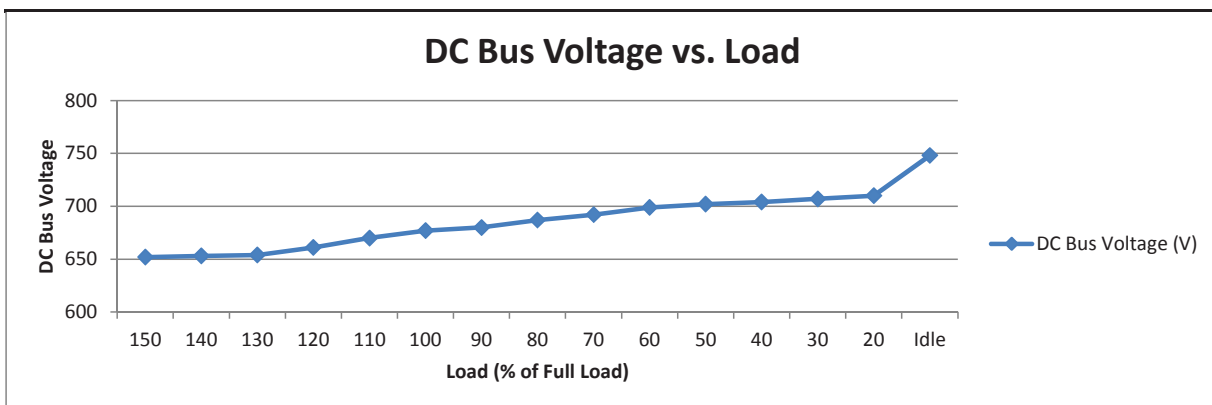
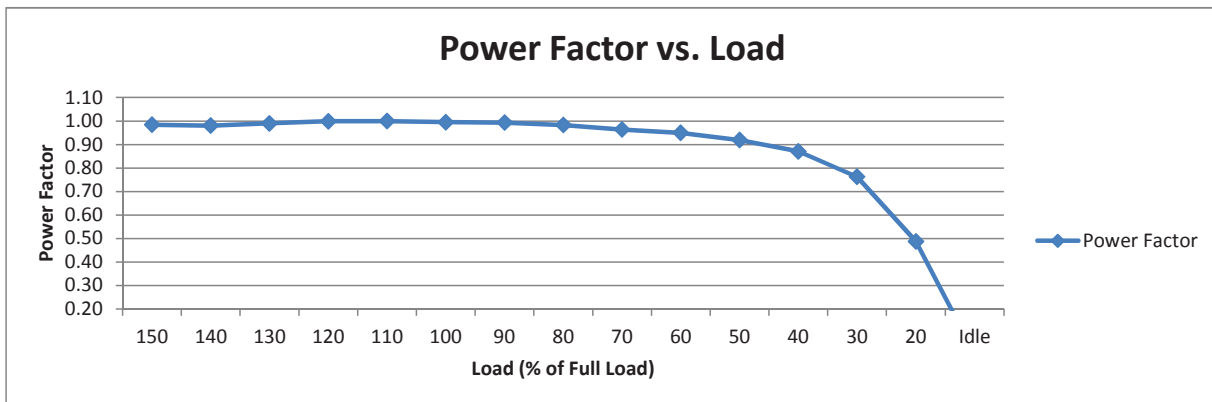
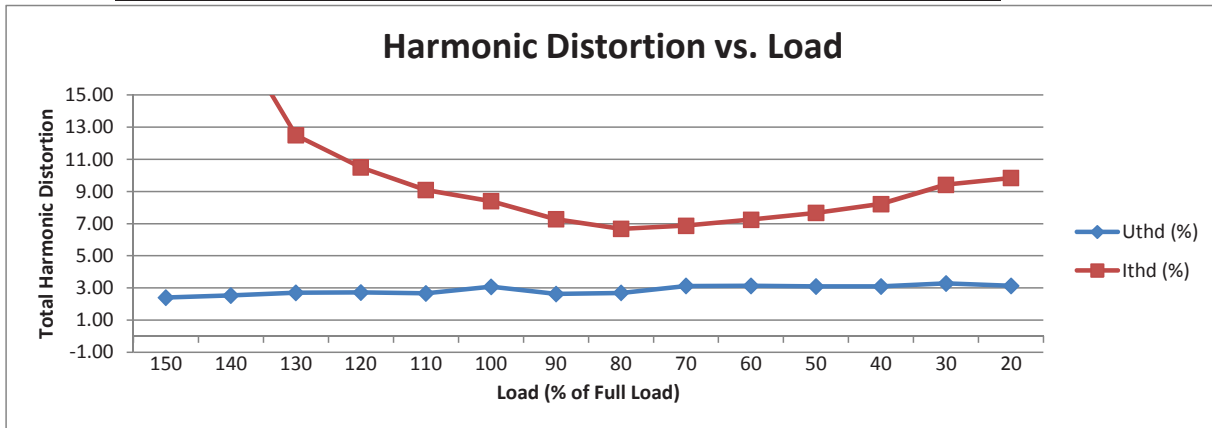
PWHD (Partial Weighted Harmonic Distortion) 
$$PWHD = \sqrt{\sum_{n=14}^{40} n \left(\frac{I_N}{I_1}\right)^2}$$

$S_{rtd}$  (Rated Apparent Power of the Equipment) 
$$S_{rtd} = \sqrt{3} * V_{Line} * I_L$$

$R_{sce}$  (Short-circuit Ratio) 
$$R_{sce} = \frac{S_{sc}}{S_{rtd}}$$

$I_{sc}/I_L$  (Short-circuit current Ratio) 
$$I_{sc}/I_L = \frac{I_{sc}}{I_L}$$

### 5.3 Representative Performance Curves



### 5.4 Product Certification

The following marks on the device indicate compliance with the following standards.

	<p>230V sizes 13-16, 480V sizes 16-21            Indicates Investigated to Canadian National Standard, C22.2 No. 14-2012.            Indicates Investigated to United States Standard, UL 508, 17th Edition.</p>
	<p>230V sizes 17-19, 480V sizes 22-30            Indicates Investigated to Canadian National Standard, C22.2 No. 14-13.            Indicates Investigated to United States Standard, UL 508, 17th Edition.</p>



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