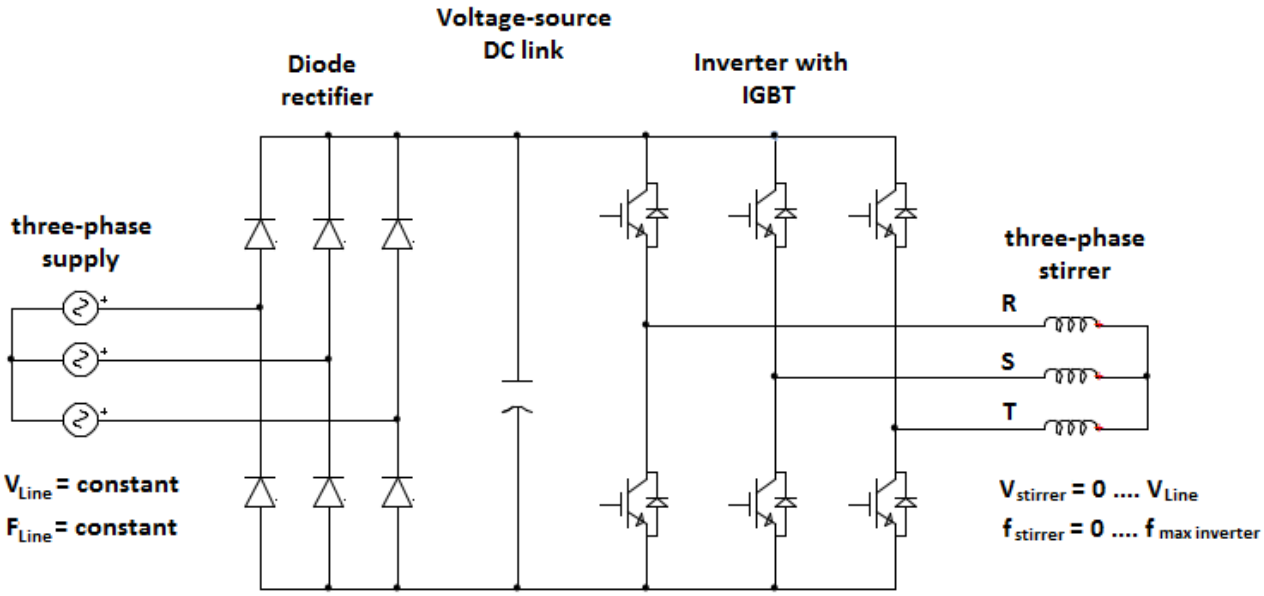
PRODUCT DESCRIPTION

Most of input AC/DC converter in the AC/AC inverters consist of a three phase diode rectifier.
Tipically the output load of the diode rectifier consist of a DC link capacitor and one or more three phase PWM converters. At the input side, the diode rectifier is ideally supplied with a constant voltage V_{line} and a constant frequency f_{line} (50Hz in this document) from a three-phase power supply;
really the AC input line voltage is supplied by an insulating transformer with a line reactor series connected.



Schematic system

Harmonic effect on the supply system of 6-pulse diode rectifier circuits

A line reactor with a relative short-circuit voltage of 2% is generally connected on the line side of tha AC/DC diode rectifier.

With 6-pulse diode rectifier, only odd harmonic current and odd harmonic voltage that cannot be divided by 3 occur, with the following harmonic number h:

$h = n \cdot 6 \pm 1 \quad where\ n = 1, 2, 3 \ldots\ldots$

i.e.

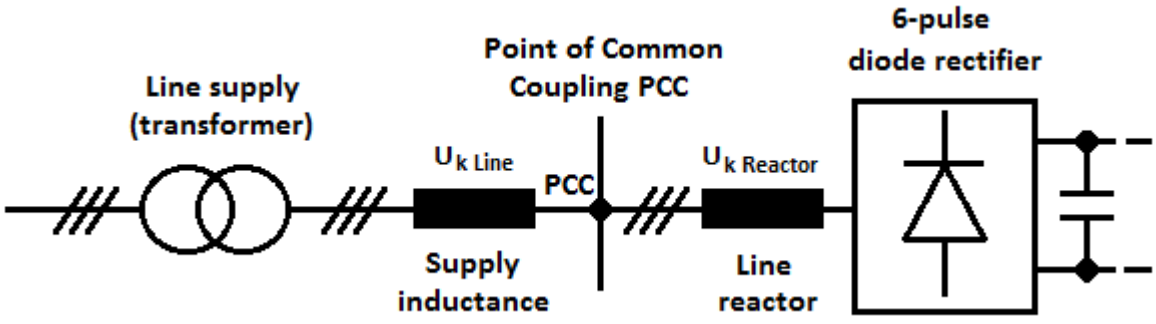
$h = 5, 7, 11, 13, 17, 19, 23, 25, 29, 31 \ldots\ldots$

The magnitude order of the individual harmonic current is mainly determined by the 6-pulse diode rectifier. However, the power supply inductance, which mainly consists of inductance of the supply transformer, and the inductance of the line reactor also have significant effect. The larger this inductance, the better the line current because it is smoothed and the lower the harmonic current are, especially the harmonic current 5th and 7th which they are larger.

Typical harmonic current of 6-pulse diode rectifier as a function of supply inductance are specified in the following. The amplitude of supply inductance depends by the power of transformer that supply the 6-pulse diode rectifier as well as the line reactor (relative short-circuit voltage of the line reactor = 2%). Data shown in the following table refer to two cases.

In the first case the nominal power of the insulating transformer is much greater than the output load nominal power and the line reactor with u_k = 2% (strong supply system).

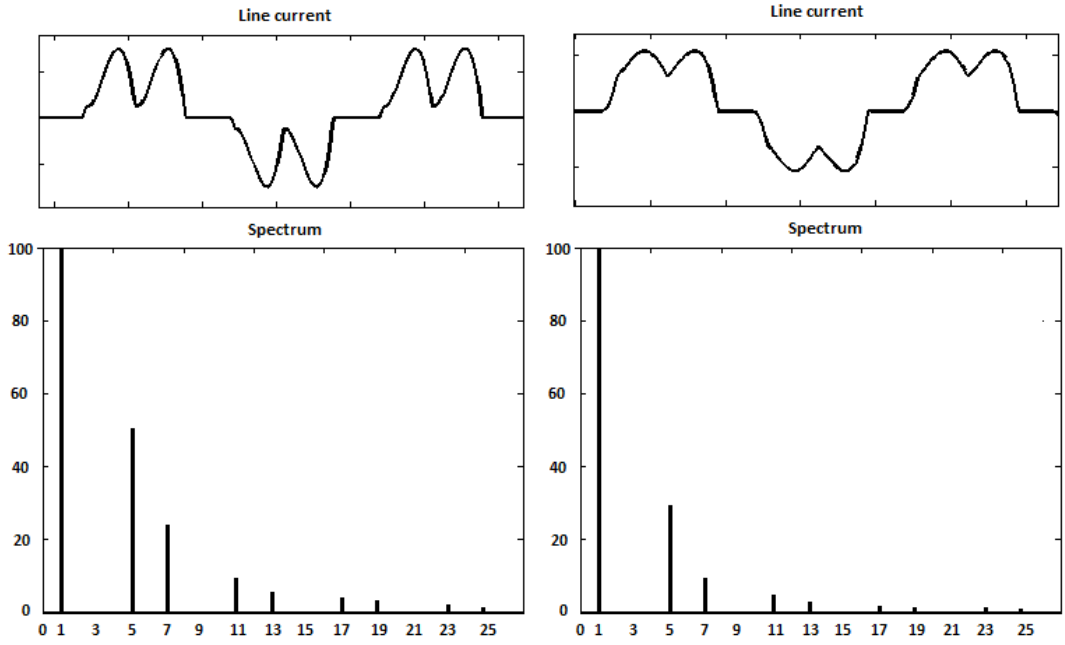
In the second case the nominal power of the insulating transformer is similar to the output load nominal power and the line reactor with u_k =2% (weak supply system).



6-pulse diode rectifier with line reactor on a three-phase supply

Supply system with lower supply reactor "Strong supply system"										
h	1	5	7	11	13	17	19	23	25	THD(I)
I_h	100%	48.22%	23.46%	8.06%	5.18%	3.69%	2.21%	2.14%	1.30%	54.75%
Supply system with high supply reactor "Weak supply system"										
h	1	5	7	11	13	17	19	23	25	THD(I)
I_h	100%	27.32%	7.72%	5.31%	3.36%	1.72%	1.61%	0.94%	0.79%	29.28%

Typical harmonic currents of 6-pulse diode rectifier with line reactor $u_K = 2\%$

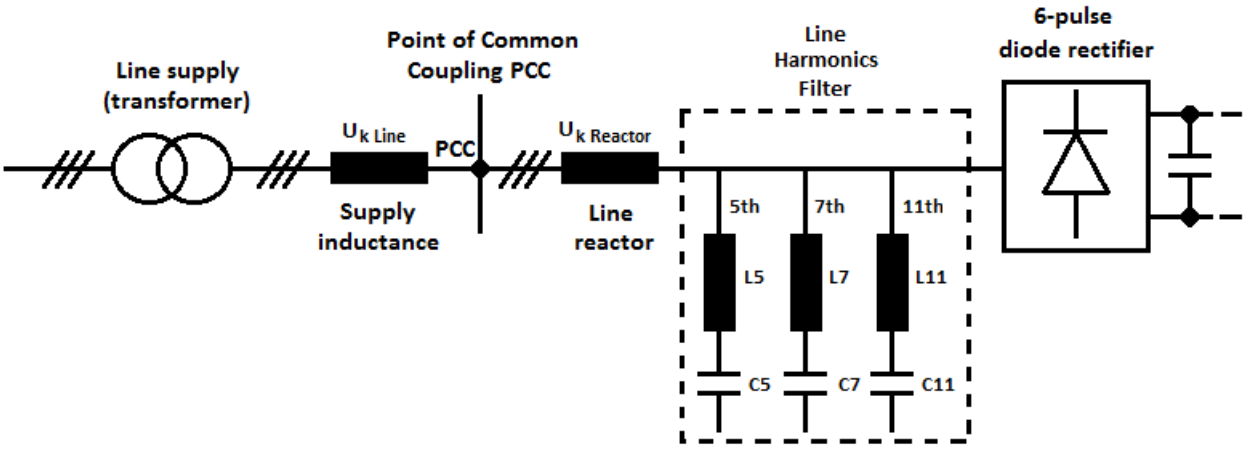


Line current and his spectral representation of a 6-pulse diode rectifier with line reactor $u_K = 2\%$ (specified in %) , with strong supply system (left) and weak supply system (right)

Harmonic effect on the supply system of 6-pulse rectifier circuits with Line Harmonic Filter

A typical approach for line current harmonic reduction is to use a Line Harmonics Filter (LHF).

A Line Harmonics Filter is a passive LC-notch-filter that mainly filters out the 5th, 7th harmonics or in some cases the 5th, 7th and 11th harmonics in the line current of 6-pulse diode rectifier and in this way significantly reduces the harmonic effect at the PCC (point of common coupling). A Line Harmonics Filter is installed between the line reactor and converter. The line reactor is also used to detune the filter from the electrical system and other filters resonance point.



6-pulse diode rectifier with line reactor and Line Harmonics Filter LHF on a three-phase supply

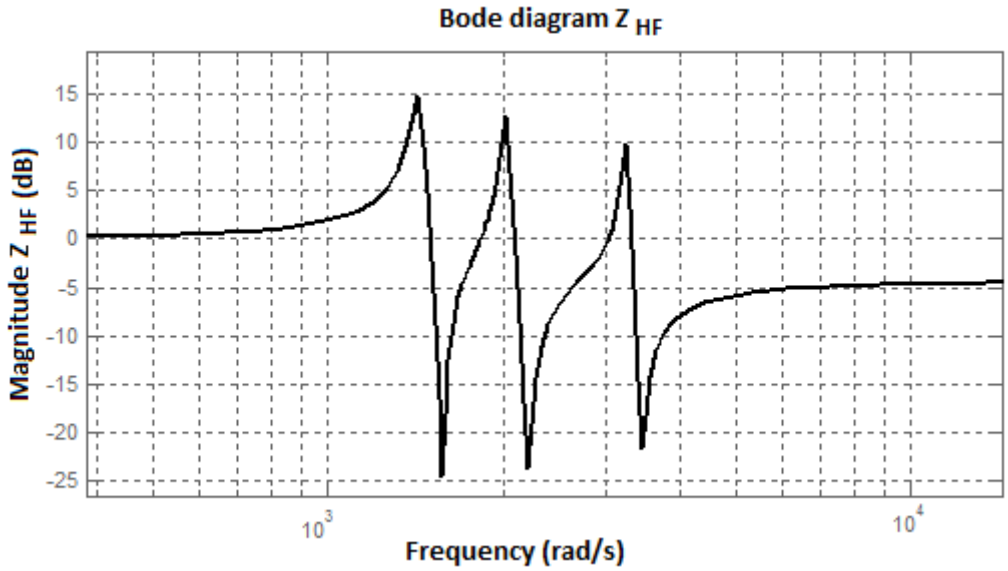
A typical impedance of a Line Harmonics Filter respect the line impedance(Z_{HF}) is shown in the following figure for a 5th, 7th and 11th harmonics filter for weak supply system and strong supply system respectively, were

$$Z_{HF} = \frac{Z_{LHF}}{Z_{LHF} + Z_S}$$

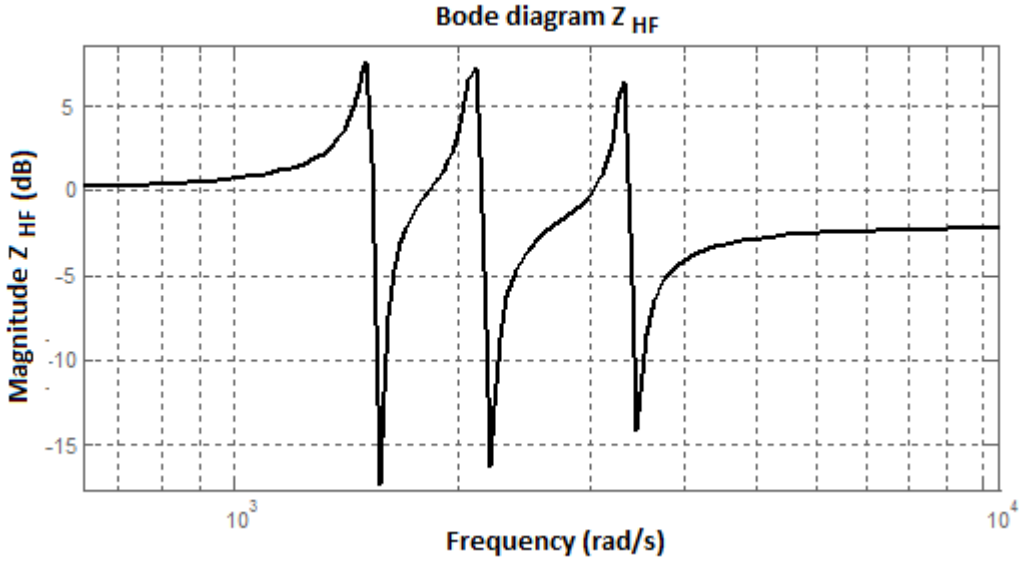
with Z_S the impedance of line and Z_{LHF} the total filter impedance.

Supply system influence the magnitude of impedance of Z_{HF}.

Z_{HF} influence the magnitude of the harmonic currents but not his spectrum. The 6-pulse diode rectifier causes the some odd harmonic currents and voltage but with lower magnitude for those filtered (near the resonance of Z_{LHF} , 5th, 7th and 11th harmonics in figure) .



Magnitude of Line Harmonics Filter impedance for 5th, 7th and 11th harmonics for weak supply system

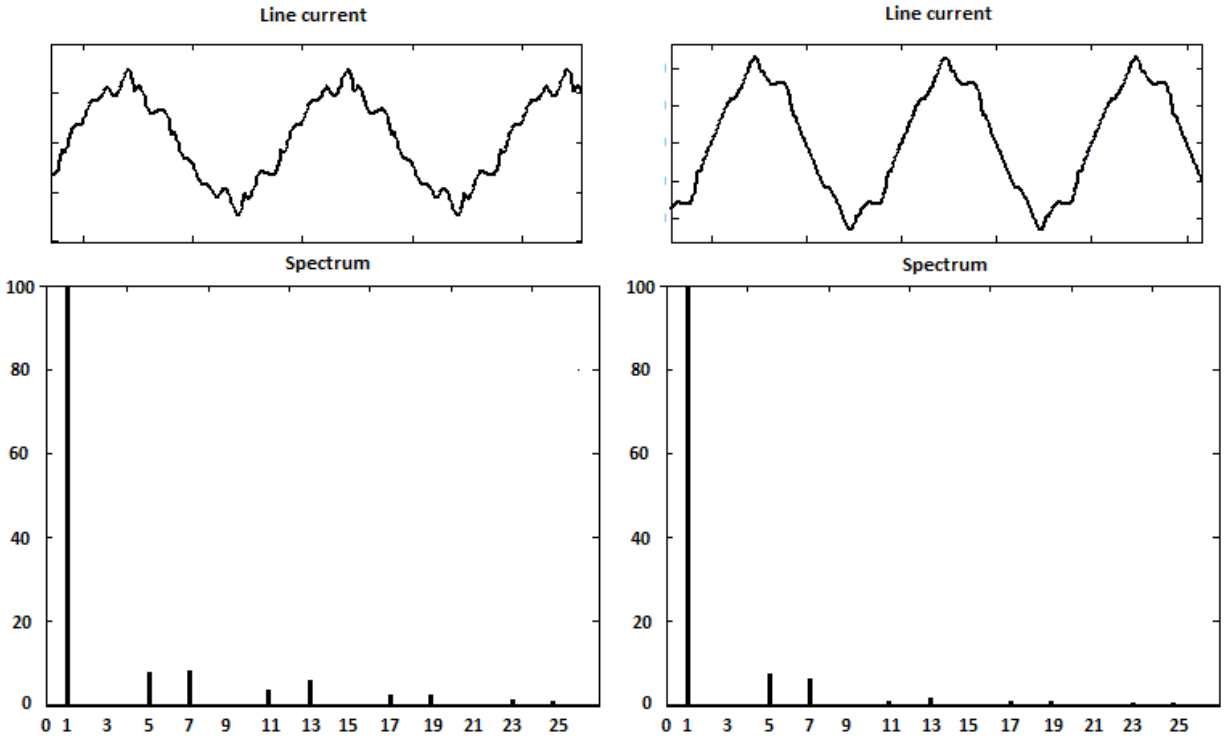


Magnitude of Line Harmonics Filter impedance for 5th, 7th and 11th harmonics for strong supply system

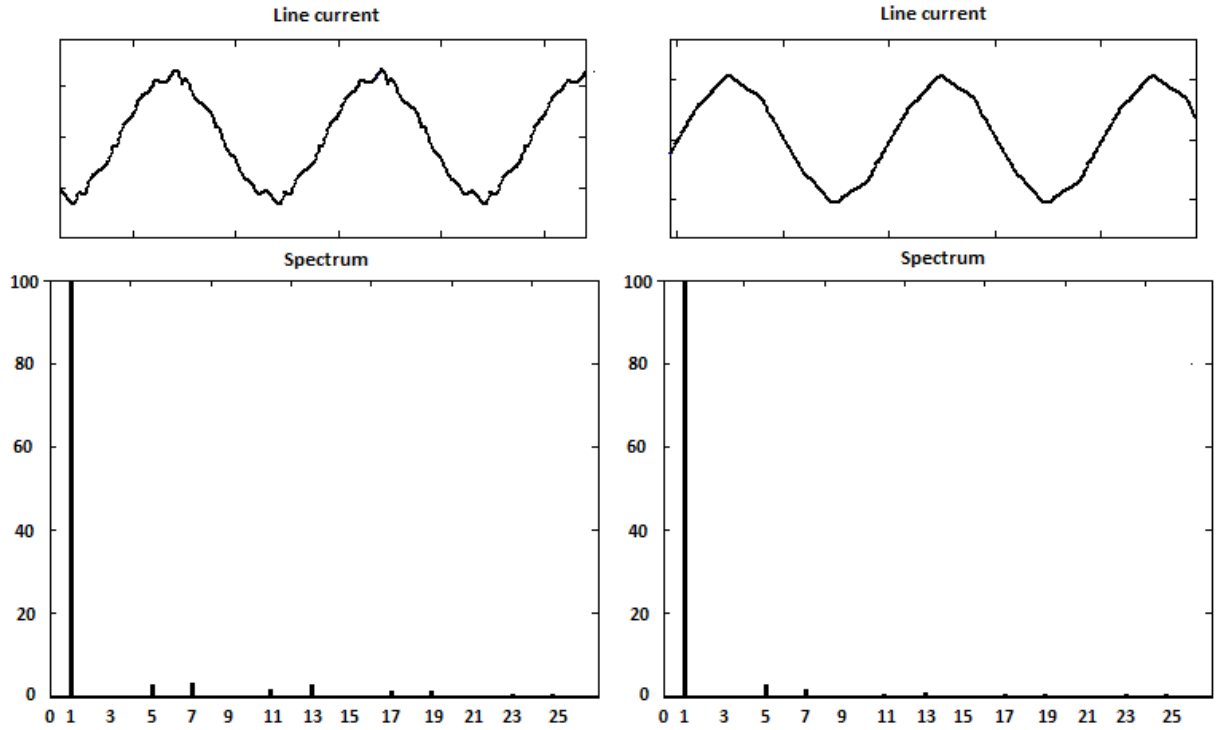
Below is possible to see the amplitude of harmonic current for the different load condition in the two case of “strong supply system” and “weak supply system”

Supply system with lower supply reactor "Strong supply system"										
100%of load										
h	1	5	7	11	13	17	19	23	25	THD(I)
I_h	100%	7.68%	6.77%	0.91%	1.38%	1.06%	0.84%	0.69%	0.45%	10.55%
75%of load										
h	1	5	7	11	13	17	19	23	25	THD(I)
I_h	100%	8.05%	7.49%	1.60%	0.97%	1.69%	0.77%	1.01%	0.57%	11.42%
50%of load										
h	1	5	7	11	13	17	19	23	25	THD(I)
I_h	100%	8.42%	8.45%	2.72%	2.02%	2.48%	1.52%	1.19%	1.08%	12.91%
25% of load										
h	1	5	7	11	13	17	19	23	25	THD(I)
I_h	100%	8.36%	9.15%	4.43%	6.2%	2.45%	2.81%	1.14%	1.09%	15.22%
Supply system with high supply reactor " Weak supply system"										
100% of load										
h	1	5	7	11	13	17	19	23	25	THD(I)
I_h	100%	3.23%	2.78%	0.33%	0.87%	0.42%	0.53%	0.28%	0.28%	4.46%
75% of load										
h	1	5	7	11	13	17	19	23	25	THD(I)
I_h	100%	3.40%	3.14%	0.65%	0.4%	0.91%	0.43%	0.56%	0.28%	4.89%
50% of load										
h	1	5	7	11	13	17	19	23	25	THD(I)
I_h	100%	3.55%	3.51%	1.07%	1.15%	1.39%	0.77%	0.75%	0.58%	5.61%
25% of load										
h	1	5	7	11	13	17	19	23	25	THD(I)
I_h	100%	3.52%	3.78%	1.71%	3.6%	1.53%	1.65%	0.65%	0.77%	7.06%

Harmonic current of 6-pulse diode rectifier with Line Harmonic Filter for 5th, 7th and 11th harmonics.



Line current and its spectral representation of 6-pulse diode rectifier with line harmonic filter for 5th, 7th and 11th harmonics (specified in %), with strong supply system, at 25% load (left) and at 100% load (right)



Line current and its spectral representation of 6-pulse diode rectifier with line harmonic filter for 5th, 7th and 11th harmonics (specified in %), with weak supply system, at 25% load (left) and at 100% load (right)

TECHNICAL FEATURES

Below is possible to see the technical features of the three phase line harmonic filter.

Type	Nominal voltage V	Nominal current A	Power loss (kW)	Line harmonic filter orders	Dimension (LxHxB) mm	Weight (Kg)
LHF-3-100	**480**	**100**	**0,4**	**5th, 7th, 11th**	**500x500x700**	**180**
LHF-3-200	**480**	**200**	**0,6**	**5th, 7th, 11th**	**500x500x900**	**250**
LHF-3-300	**480**	**300**	**0,8**	**5th, 7th, 11th**	**500x500x1200**	**350**

	Common data
Input voltage (rms voltage)	360-480 Vac +/- 10%
AC fundamental frequency	40 – 70 Hz
Load type	3 phase diode rectifier
THD input current at 100% load *	4,46
THD input current at 75% load *	4,89
THD input current at 50% load *	5,61
THD input current at 25% load *	7,06
THD input current at 100% load **	10,5
THD input current at 75% load **	11,4
THD input current at 50% load **	12,4
THD input current at 25% load **	15,2
Load type	3 phase diode rectifier
Input/ output size bolts	M10 for LHF-3-100 type M12 for the others type
Maximum ambient temperature without derating ***	40℃
Required cooling type	With external fan, minimum flow rate of 200 mc/h
Maximum altitude	1000 mt. over sea level
Degree of protection	IP21

‘* With nominal power of input transformer < 1.4 * (Load nominal Power)
‘** With nominal power of input transformer > 10 * (Load nominal Power)
*** with the external fan with flow rate > 200 mc/h