LARSEN & TOUBRO

ACTIVE HARMONIC FILTER

L&T SWITCHGEAR
SAFE & SURE

ABOUT US

Switchgear Factory, Navi Mumbai

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Larsen & Toubro is a technology-driven company that infuses engineering with imagination. The Company offers a wide range of advanced solutions in the field of Engineering, Construction, Electrical & Automation, Machinery and Information Technology.

L&T Switchgear, a part of the Electrical & Automation business, is India's largest manufacturer of low voltage switchgear, with the scale, sophistication and range to meet global benchmarks. With over five decades of experience in this field, the Company today enjoys a leadership position in the Indian market with a growing international presence.

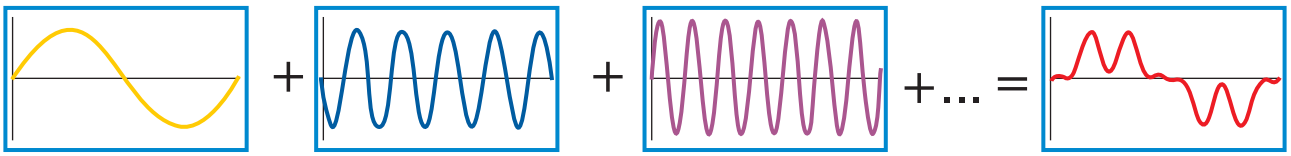
It offers a complete range of products including powergear, controlgear, industrial automation, building electricals & automation, reactive power management, energy meters, and protective relays. These products conform to Indian and International Standards.

HARMONIC MITIGATION

HARMONICS

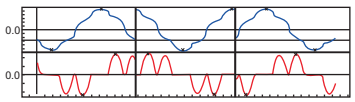
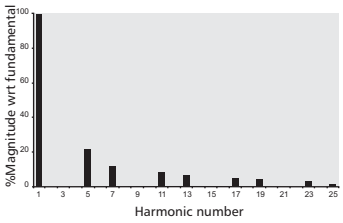
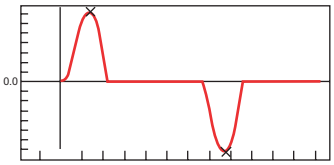
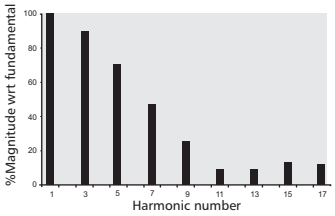
Harmonics is defined as a component of periodic wave (or a signal) whose frequency is integral multiple of the fundamental frequency. Non linear loads such as rectifiers, inverters, variable speed drives, furnaces, etc. create harmonics.

These currents consist of a fundamental frequency component rated at 50 Hz, plus a series of overlapping currents, with frequencies that are multiples of the fundamental frequency. The result is deformation of the current (and, as a consequence, voltage) that has a series of associated secondary effects.



Fundamental Wave 50 Hz | Harmonic wave of 5th order 250 Hz | Harmonic wave of 7th order 350 Hz | Distorted wave

TYPES OF HARMONIC LOADS

Type of load	Wave shape	Harmonic spectrum THD I
• 6 Pulse and 12 Pulse drive* (VFD & UPS) • Three-phase / Single-phase rectifiers • Arc / Induction furnace		
• Discharge lamps / CFL • Single-phase converters • Computer, IT loads • SMPs • TVs		

* Harmonics are inversely proportional to (n±1) for an n-Pulse drive

ILL EFFECTS OF HARMONICS

Type of equipment	Effect of Harmonics
Rotating machines	Increased losses, over heating due to skin effect as higher frequency current flows on cable periphery increasing cable resistance, pulsating torque due to negative phase sequence harmonics
Transformer, switch-gear, power cables	Over-heating, increased power consumption
Protective relays	Mal-operation, nuisance tripping
Power electronics	Mal-operation, failure
Power capacitors	High currents & failure due to overload

The above malfunctions are not always felt immediately after the system is installed, but the effects may be felt in the long term and are difficult to distinguish from the natural ageing of equipment. Hence it is high time to have some basic knowledge about harmonics and find solutions for the same.

BENEFITS OF HARMONICS MITIGATION

- **Reduction in operating expenses**

  Harmonic mitigation contributes to reduced power losses in transformers, cables, switchgear. Harmonic mitigation helps in reducing the energy losses

- **Reduction in capital expenditure**

  Harmonic mitigation reduces the r.m.s. value of the current and it eliminates the need to oversize transformers and hence switchgear, cables and busbars

- **Improved business performance**

  Harmonics are responsible for increased line currents, resulting in additional power losses and increased temperature in transformers, cables, motors, capacitors. The consequence may be the unwanted tripping of circuit breakers or protection relays. This might cause significant financial losses linked to a process interruption

IEEE 519-1992 GUIDELINES ON HARMONIC LIMITS

The following are the guidelines on limits for current and voltage harmonics at point of common coupling (PCC) set by IEEE

Table 1: Maximum Harmonic Current Distortion in % I_L

Individual Harmonic Order (Odd Harmonics)						
I_{sc} / I_L	<11	11⩽h<17	17 ⩽h<23	23 ⩽h< 35	35⩽h	TDD
<20	4.0%	2.0%	1.5%	0.6%	0.3%	5.0%
20 - 50	7.0%	3.5%	2.5%	1.0%	0.5%	8.0%
50 - 100	10.0%	4.5%	4.0%	1.5%	0.7%	12.0%
100 - 1000	12.0 %	5.5%	5.0%	2.0%	1.0%	15.0 %
>1000	15.0%	7.0%	6.0%	2.5%	1.4%	20.0%

where
I_{sc} = maximum short-circuit current at PCC [Can be calculated as MVA/(%Z x V)].
I_L = maximum demand load current (fundamental frequency component) at PCC.

A system's impedance limits the short circuit current for that system. Systems with higher I_{SC}/ I_L have smaller impedances and thus they contribute less in the overall voltage distortion of the power system to which they are connected. Thus, the TDD limits become less stringent for systems with higher I_{SC}/ I_L values.

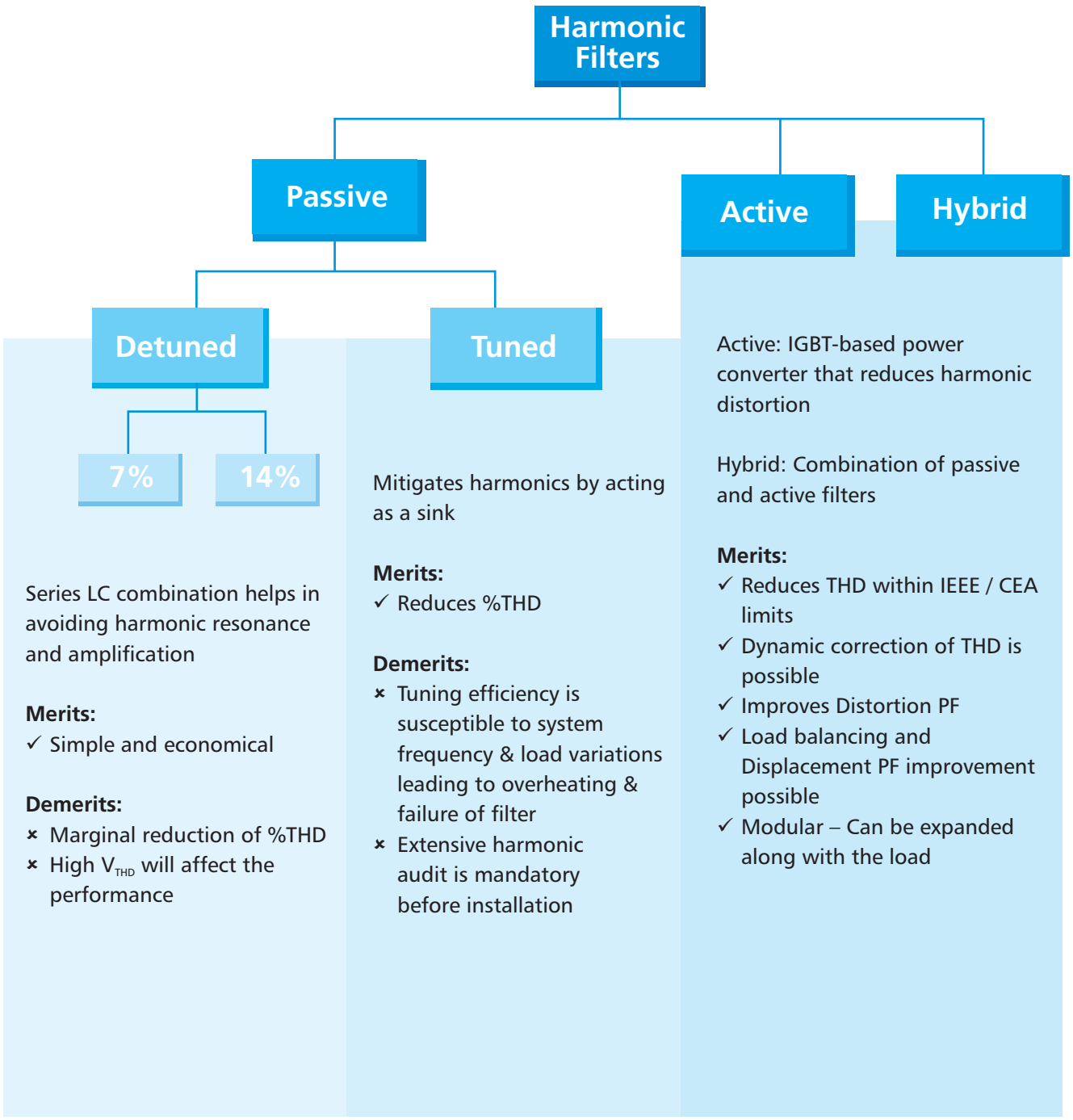
Table 2: Voltage Distortion Limits

Bus Voltage at PCC	Individual Voltage Distortion	V_{THD}
⩽69 kV	3.0%	5.0%
69 kV < V ⩽160 kV	1.5%	2.5%
> 160 kV	1.0%	1.5%

SOLUTIONS FOR HARMONIC MITIGATION

For any electrical system, which is expected to be harmonics rich, it is recommended to study the harmonics level, analyze and then a proper solution should be employed.

The different solutions employed are as follows:



Series LC combination helps in avoiding harmonic resonance and amplification

Merits:
- ✓ Simple and economical

Demerits:
- × Marginal reduction of %THD
- × High V_{THD} will affect the performance

Mitigates harmonics by acting as a sink

Merits:
- ✓ Reduces %THD

Demerits:
- × Tuning efficiency is susceptible to system frequency & load variations leading to overheating & failure of filter
- × Extensive harmonic audit is mandatory before installation

Active: IGBT-based power converter that reduces harmonic distortion

Hybrid: Combination of passive and active filters

Merits:
- ✓ Reduces THD within IEEE / CEA limits
- ✓ Dynamic correction of THD is possible
- ✓ Improves Distortion PF
- ✓ Load balancing and Displacement PF improvement possible
- ✓ Modular – Can be expanded along with the load

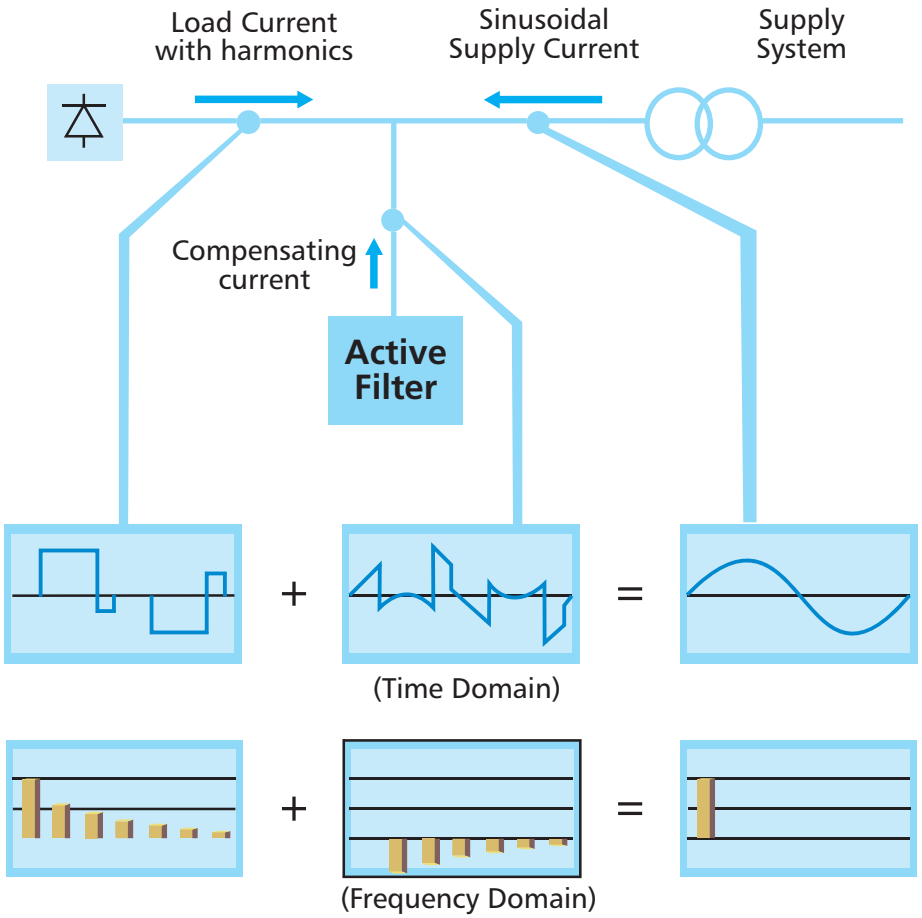
ACTIVE HARMONIC FILTERS

Active Harmonic filters are the most ideal solution for power quality problems caused, in either industrial or commercial facilities, for harmonic filtering, phase balancing and reactive power compensation.

PRINCIPLE OF OPERATION

The compensation is achieved with the counter-phase injection of harmonic currents that are identical to those existing in the installation.

This achieves a signal with practically no harmonic distortion under the filter connection point.
The current is automatically regulated by a digital signal processor.



FUNCTION

- **Harmonic Filtering:**

  The filters reduce harmonics up to the 50th order (2500 Hz) reducing distortion power factor. Selection of specific harmonic order for filtering helps in optimizing filtering efficiency

  3 Phase 4 Wire filter configuration ensures reduction in neutral current that can reach up to 200% of rated value due to triple-N harmonics

THD TOTAL

	LOAD	MAINS
L1	21%	5%
L2	18%	5%
L3	19%	5%

Harmonic Filtering

VOLTAGE & CURRENT

		CURRENT	
	VOLTAGE	LOAD	MAINS
L1	232 V	199 A	220 A
L2	231 V	206 A	221 A
L3	231 V	255 A	221 A
FREQUENCY	50 Hz		

Phase Balancing

- **Phase Unbalance Correction:**

  This function ensures balanced current on the supply side in 3 Phase 4 Wire filter configuration

- **Power Factor Correction:**

  This filter ensures close to unity displacement power factor for both lagging (inductive) and leading (capacitive) current systems. With improvement in both distortion and displacement power factor, true power factor is also improved

POWER MAINS

	P	Q	S	PF
L1	41.6 kW	5.92 kVAr	42.02 kVA	0.99
L2	38.9 kW	5.52 kVAr	39.29 kVA	0.99
L3	48.0 kW	6.80 kVAr	48.48 kVA	0.99

Reactive Compensation

FEATURES & BENEFITS:

Features	Advantages	Benefits
Any number of units of different ratings can be connected in parallel	Modularity & Expandability	Filter can be expanded as per the future load requirements
The response time of the filter is less than 1 ms	Very high speed of operation	Power factor can be maintained even in case of very frequently changing load
Provision of Alarms	Easy diagnosis of fault conditions	Safety to devices and operators
LCD touch screen HMI	Easy configuration and parameter monitoring	Ease of installation and maintenance, User-friendly

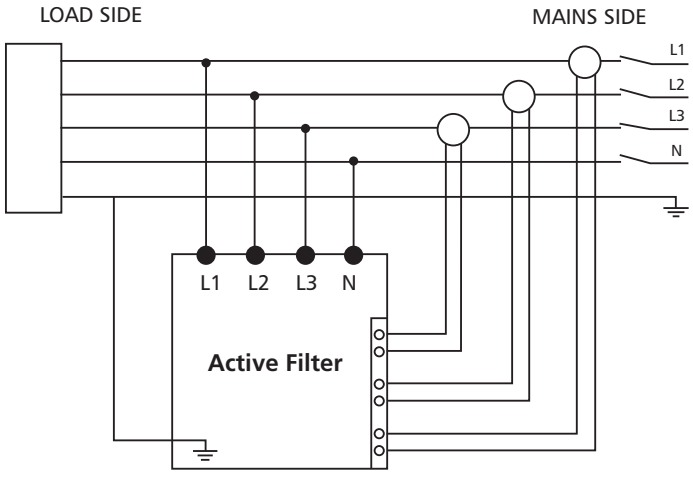
The active filter is ideal in any application that has a large variation of loads, a wide spectrum of harmonics that must be compensated. Non-linear loads that are heavily distributed in the form of small network loads, so that it is not possible to use individual passive filters.

The most common applications are:
- Variable frequency drives
- Computer loads
- UPS
- CFL Lamps

In other words, its application is in any industry where large non-linear loads are present with high THD. Such high THD are prevalent in the following industries:

- Automotive Industry
- Data centres
- Wind turbines
- Building & Infrastructure
- Textile Industry
- Paper mills
- Sugar plants
- Pharmaceutical Industry
- Cement Industry
- Oil & gas exploration
- Water treatment
- Granite & stone polishing

CONNECTION DIAGRAM

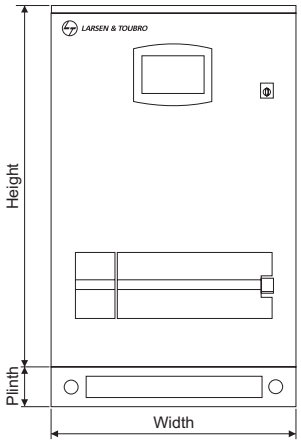


TECHNICAL SPECIFICATIONS

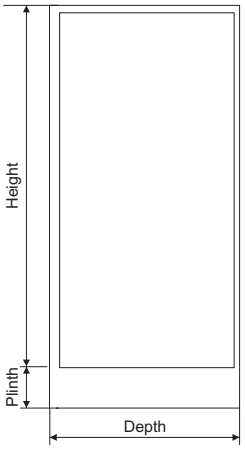
INPUT									
Model	**AHF - 4W/3W**								
Normal Voltage	400V AC ±10%, 3Ph 4 Wire/3 Wire								
Current Rating	30A	60A	75A	150A	100A	200A	300A	400A	600A
Frequency	50Hz,+/-5%								
FILTER									
Harmonic Range	2^{nd} to 50^{th} order								
Harmonic Selection	Any 20 Harmonic can be selected at a time								
Harmonic Attenuation Ratio	Up to 96% at rated current								
Response time	<1 ms								
Function Selection	Harmonic filtering, Power factor correction, Load balancing								
Overload (peak value)	125% at 10 msec								
Current Transformer	30A	60A	75A	150A	100A	200A	300A	400A	600A
	500A:5A	1000A:5A		3000A:5A			5000A:5A		6000A:5A
	Class 1, 15VA rating								
PHYSICAL CHARACTERISTICS									
Protection Class	IP20 (IP31 or IP41 optional)								
Cooling	Forced air								
Cable entry	Front - Bottom								
ENVIRONMENTAL									
Operating Temperature	0 to 40 Deg C								
Relative Humidity	95% (Non condensing)								
Maximum operating altitude without de-rating	1000 m								
Acoustic noise at 1m from Panel front (Ref ISO3746)	< 65 db			< 68 db				< 70 db	
USER INTERFACE									
User Parameter Setting	LCD touch screen HMI								
PROTECTIONS AND STANDARDS									
Protections	MCCB & fast acting semiconductor fuses								
Alarms	DC over voltage, Over load trip, Over temperature alarm & trip, Over current, No synchronisation, Mains abnormal, DC under voltage, Active filter trip, Wrong phase, No faults, Fast DC overvoltage, Inductor over temperature trip								
Reference Design Standard	IEC 60146								
Safety Standard	EN 50178								
Electromagnetic Compatibility	EN 55011, IEC EN 50081-2, IEC 61000-4-2, IEC 61000-4-3, IEC 61000-4-4, IEC 61000-4-5, IEC 610004-6, IEC 61000-6-2								

OVERALL DIMENSIONS

AHF - 3W/4W 30/60/75/100



Front view



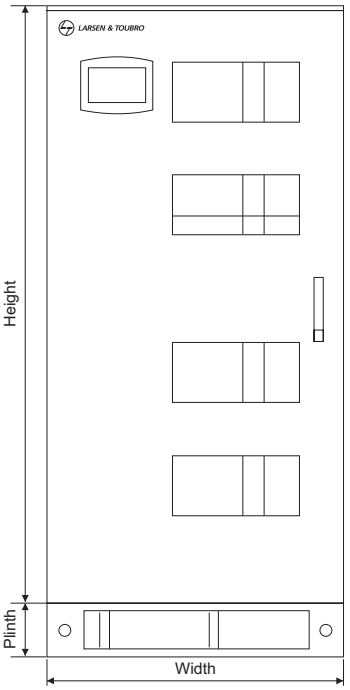
Side view

3 Ph 3 Wire / 4 Wire, 400 V Active Filter						
Cat No.	Model No.	Dimensions (mm)				
		Weight (kg)	Width	Depth	Height	Plinth
AHF030331D2	AHF - 3W- 30A	45	550	300	800	Wall-Mounting
AHF030341D2	AHF - 4W - 30A	48				
AHF060331D2	AHF - 3W- 60A	65	620	450	1000	100
AHF060341D2	AHF - 4W - 60A	70				
AHF075331D2	AHF - 3W- 75A	75	620	450	1000	100
AHF075341D2	AHF - 4W - 75A	80				
AHF100331D2	AHF - 3W- 100A	85	620	450	1000	100
AHF100341D2	AHF - 4W - 100A	90				

AHF - 3W/4W 200/300/400/600

3 Ph 3 Wire / 4 Wire, 400 V Active Filter						
Cat No.	Model No.	Dimensions (mm)				
		Weight (kg)	Width	Depth	Height	Plinth
AHF150331D2	AHF - 3W- 150A	175	800	850	1600	150
AHF150341D2	AHF - 4W- 150A	205				
AHF200331D2	AHF - 3W- 200A	225	800	850	1600	150
AHF200341D2	AHF - 4W - 200A	265				
AHF300331D2	AHF - 3W- 300A	310	800	850	1600	150
AHF300341D2	AHF - 4W - 300A	365				
AHF400331D2	AHF - 3W- 400A	430	1000	900	1600	150
AHF400341D2	AHF - 4W - 400A	*	*	*	*	*
AHF600331D2	AHF - 3W- 600A	600	1000	900	1600	150
AHF600341D2	AHF - 4W - 600A	*	*	*	*	*

* Please contact nearest branch



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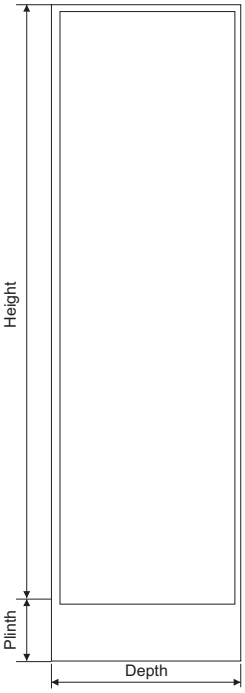

Side view

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