L&T SWITCHGEAR
SAFE & SURE

Reactive Power Management Products

LARSEN & TOUBRO

About Us

Larsen & Toubro 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.

Switchgear Factory, Mumbai

Switchgear Factory, Ahmednagar

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Reactive Power Management

Power Capacitors

Reactors

Thyristor Switching Modules

Capacitor Duty Contactors

MCBs

MCCBs

Quasar Meters

Indicating Devices

Wire

Reactive Power Management Products

Power Capacitors

- **Cylindrical Type**
  - 
    Standard Duty
    Range: 1-25 kVAr
  - 
    Heavy Duty Gas Filled
    Range: 3-25 kVAr
- **Box Type**
  - 
    Standard Duty
    Range: 5-30 kVAr
  - 
    Heavy Duty
    Range: 5-50 kVAr
  - 
    LTXL: Ultra HeavyDuty
    Range: 5-100 kVAr
    (single unit)

Detuned Harmonics Filter Reactors
(5-100 kVAr)

Thyristor Switching Modules
(10-50 kVAr)

APFC Panels

Principles of Power Factor Correction

A vast majority of electrical loads in low voltage industrial installations are inductive in nature. Typical examples are motors, transformers, drives & fluorescent lighting. Such loads consume both active and reactive power. The active power is used by the load to meet its real output requirements whereas reactive power is used by the load to meet its magnetic field requirements. The reactive power (inductive) is always 90^{o} lagging with respect to active power as shown in figure1. Figure 2 & 3 show the flow of kW, kVAr and kVA in a network.

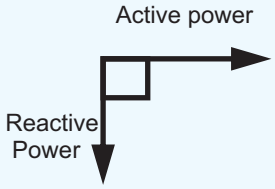


Figure 1:
Phase relationship between Active and Reactive power

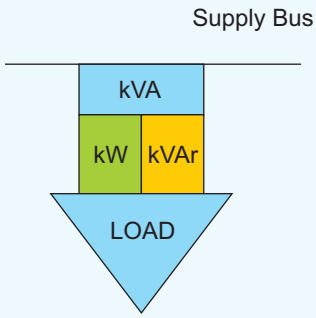


Figure 2:
Network without Capacitor

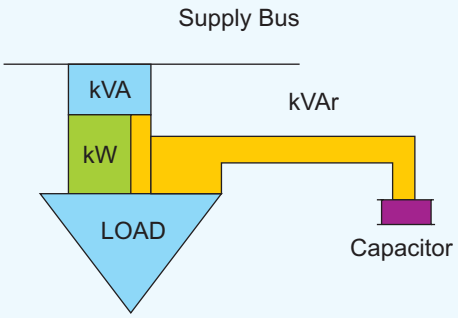


Figure 3:
Network with Capacitor

Flow of active and reactive power always takes place in electrical installations. This means that the supply system has to be capable of supplying both active and reactive power. The supply of reactive power from the system results in reduced installation efficiency due to:

- Increased current flow for a given load
- Higher voltage drops in the system
- Increase in losses of transformers, switchgear and cables
- Higher kVA demand from supply system as given in figure 2
- Higher electricity cost due to levy of penalties / loss of incentives

It is therefore necessary to reduce & manage the flow of reactive power to achieve higher efficiency of the electrical system and reduction in cost of electricity consumed.
The most cost effective method of reducing and managing reactive power is by power factor improvement through **Power Capacitors**. The concept of reduction in kVA demand from the system is shown in figure 3.

Benefit of power factor correction

PF Correction

Reduction in kVAr demand

Reduction in kVA demand

- Reduction in Transformer Rating

Reduction in Line current

- Reduction in Power loss
- Reduction in cable size
- Reduction in switchgear rating

Selection of Capacitor - 5 Step Approach

Power Factor Correction Capacitors have been used for many years as the most cost effective solution for PF improvement. Modern electrical networks are continuously evolving into more complex installations due to the increasing usage of non-linear loads, sophisticated control & automation, UPS systems, energy efficiency improvement devices etc.

This evolution is also accompanied by increased dependency on captive power generation as well as growing concerns about incoming supply power quality.

In this background, it is necessary to involve also the Power Factor Correction solution to a higher level so as to ensure sustainable achievement of high PF & acceptable harmonic distortion levels.

The selection of the correct type of PFC Capacitors & Filter reactors thus needs better understanding of the various issues involved.

This publication outlines a “5 Step” technology based approach, simplified for easier understanding to enable the correct selection of PFC Capacitors & Filter Reactors.

Selection of Capacitors

Step 1:	**Calculation of kVAr required for Industries & Distribution Networks**
Step 2:	**Selection of Capacitor Duty**
Step 3:	**To Avoid Risk of Harmonic Application and Resonance**
Step 4:	**To Achieve Target PF**
Step 5:	**To Achieve Dynamic and Transient Free Unity PF**

Step 1: Calculation of kVAr required for Industries & Distribution Networks

In electrical installations, the operating load kW and its average power factor (PF) can be ascertained from the electricity bill. Alternatively, it can also be easily evaluated by the formula:

Average PF = kW/kVA

Operating load kW = kVA Demand x Average PF

The Average PF is considered as the initial PF and the final PF can be suitably assumed as target PF. In such cases required capacitor kVAr can be calculated as sited in below table.

Example to calculate the required kVAr compensation for a 500 kW installation to improve the PF from 0.75 to 0.96

kVAr = kW x multiplying factor from table = 500 x 0.590 = 295 kVAr

Note: Table is based on the following formula: kVAr required = kW ($\tan\emptyset_1 - \tan\emptyset_2$)
where $\emptyset_1 = \cos^{-1}(PF_1)$ and $\emptyset_2 = \cos^{-1}(PF_2)$.

Initial PF	Target PF									
	0.9	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99
0.4	1.807	1.836	1.865	1.896	1.928	1.963	2.000	2.041	2.088	2.149
0.42	1.676	1.705	1.735	1.766	1.798	1.832	1.869	1.910	1.958	2.018
0.44	1.557	1.585	1.615	1.646	1.678	1.712	1.749	1.790	1.838	1.898
0.46	1.446	1.475	1.504	1.535	1.567	1.602	1.639	1.680	1.727	1.788
0.48	1.343	1.372	1.402	1.432	1.465	1.499	1.536	1.577	1.625	1.685
0.5	1.248	1.276	1.306	1.337	1.369	1.403	1.440	1.481	1.529	1.590
0.52	1.158	1.187	1.217	1.247	1.280	1.314	1.351	1.392	1.440	1.500
0.54	1.074	1.103	1.133	1.163	1.196	1.230	1.267	1.308	1.356	1.416
0.56	0.995	1.024	1.053	1.084	1.116	1.151	1.188	1.229	1.276	1.337
0.58	0.920	0.949	0.979	1.009	1.042	1.076	1.113	1.154	1.201	1.262
0.6	0.849	0.878	0.907	0.938	0.970	1.005	1.042	1.083	1.130	1.191
0.62	0.781	0.810	0.839	0.870	0.903	0.937	0.974	1.015	1.062	1.123
0.64	0.716	0.745	0.775	0.805	0.838	0.872	0.909	0.950	0.998	1.058
0.66	0.654	0.683	0.712	0.743	0.775	0.810	0.847	0.888	0.935	0.996
0.68	0.594	0.623	0.652	0.683	0.715	0.750	0.787	0.828	0.875	0.936
0.7	0.536	0.565	0.594	0.625	0.657	0.692	0.729	0.770	0.817	0.878
0.72	0.480	0.508	0.538	0.569	0.061	0.635	0.672	0.713	0.761	0.821
0.74	0.425	0.453	0.483	0.514	0.546	0.580	0.617	0.658	0.706	0.766
0.75	0.38	0.426	0.456	0.487	0.519	0.553	0.590	0.631	0.679	0.739
0.76	0.371	0.400	0.429	0.460	0.492	0.526	0.563	0.605	0.652	0.713
0.78	0.318	0.347	0.376	0.407	0.439	0.474	0.511	0.552	0.699	0.660
0.8	0.266	0.294	0.324	0.355	0.387	0.421	0.458	0.499	0.547	0.608
0.82	0.214	0.242	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.556
0.84	0.162	0.190	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503
0.85	0.135	0.164	0.194	0.225	0.257	0.291	0.328	0.369	0.417	0.477
0.86	0.109	0.138	0.167	0.198	0.230	0.265	0.302	0.343	0.390	0.451
0.87	0.082	0.111	0.141	0.172	0.204	0.238	0.275	0.316	0.364	0.424
0.88	0.055	0.084	0.114	0.145	0.177	0.211	0.248	0.289	0.337	0.397
0.89	0.028	0.057	0.086	0.117	0.149	0.184	0.221	0.262	0.309	0.370
0.9		0.029	0.058	0.089	0.121	0.156	0.193	0.234	0.281	0.342
0.91		0.030	0.060	0.093	0.127	0.164	0.205	0.253	0.313	0.313
0.92				0.031	0.063	0.097	0.134	0.175	0.223	0.284
0.93					0.032	0.067	0.104	0.145	0.192	0.253
0.94						0.034	0.071	0.112	0.160	0.220
0.95							0.037	0.078	0.126	0.186

Step 2: Selection of Capacitor Duty

Selecting the type of Capacitor is the first decision to be made. Power Factor Correction Capacitors can be classified as follows:

- Standard duty
- Heavy duty
- LTXL: Ultra Heavy duty

The criteria for this classification is based on the following:

- Operating life
- Permissible over voltage & over current coupled with the time duration
- Number of switching operations per year
- Peak inrush current withstand capability
- Operating ambient temperature

Duty	Over Current	Permissible Over Voltage @rated Voltage 440V	Peak Inrush Currents	Ambient Temperature	Maximum switching operations/ year
Standard Duty	1.5 x In	1.1 Un	200 x In	-25°C to 55°C	5000
Heavy Duty	1.8 x In	1.2 Un	300 x In	-25°C to 55°C	6000
LTXL: Ultra Heavy Duty	3 x In	1.3 Un	500 x In	-25°C to 70°C	20000

It is strongly recommended that the above table be followed as a guideline for selecting the appropriate capacitor for a given application. While choosing the type of duty it is also very important to identify the % age non-linear load in the system. The method of calculating the % age non-linear load is shown below:

Calculation of Non - linear Load:

Example:

Installed transformer rating = 1000 kVA
Non - linear loads = 100 kVA
% non - linear loads = (non - linear loads / transformer rating) x 100
= (100 / 1000) x 100
= 10%

Examples of non - linear load
UPS, Arc / induction furnace, Rectifiers, AC / DC Drives, Computer, CFL lamps, CNC machines, etc.

% Age Non - linear Load	Type of Duty
≥10%	Standard Duty
Upto 15%	Heavy Duty
Upto 25%	Ultra Heavy Duty
Above 25% to 30%	Use Capacitor + Reactor (detuned filters)
Above 30%	Hybrid filters (Active filter + detuned filters)*

*For solutions contact L&T

Step 3: To Avoid Risk of Harmonic Application and Resonance

To make a choice between the use of Capacitors or Capacitors + Filter reactors. This is important, because it is necessary to avoid the risk of "Resonance" as the phenomena of "Resonance" can lead to current and harmonic amplification which can cause wide spread damage to all Electrical & Electronic equipment in the installation including Capacitors. This can be avoided by installing capacitor + filter reactor.

Caution: It is safer to select a combination of "Capacitor + Filter reactor" so as to ensure that PF improvement is achieved in a reliable manner and the risk of resonance is avoided.

Capacitor Technology & Construction Details

Capacitors are manufactured in three different types such as Standard duty, Heavy duty and Ultra Heavy duty. The Standard duty capacitors are manufactured using standard thickness of dielectric material with heavy edge metallization. Heavy duty capacitors are manufactured using thicker material and in lower width which increases current handling capacity as well as reduces temperature rise. Ultra Heavy duty capacitors are manufactured using thicker material, in lower width and have greater ability to handle in-rush current.

Step 4: To Achieve Target PF

To estimate whether fixed compensation or automatic compensation is to be used. In order to achieve high power factor i.e., close to unity PF, the following guideline may be adopted to make a decision.
If the total kVAr required by the installation is less than 15% of the rating of the incoming supply transformers, then the use of fixed capacitors may be adopted at various points in the installation.
If the kVAr required by the installation is more than 15% of the rating of the incoming supply transformers, then automatic power factor correction solution needs to be adopted.
APFC panels with suitable kVAr outputs may be distributed and connected across various points within the installation.

Note: As in the case of selection of capacitors De-tuned filter APFC panels must be selected if non-linear loads exceed as per previous table.

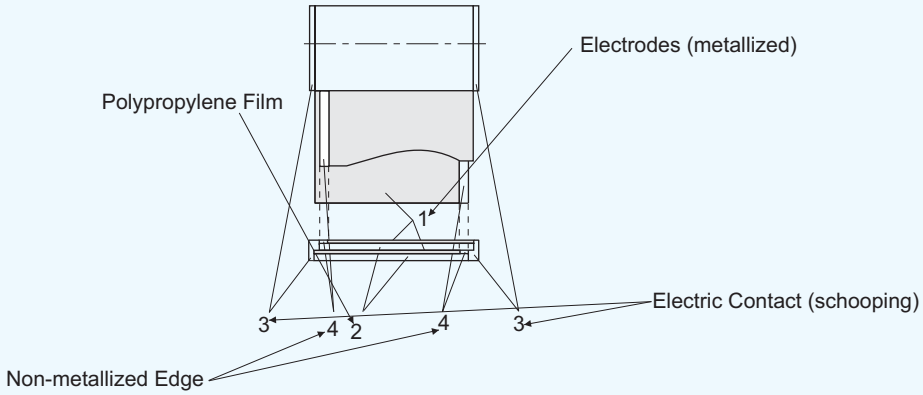
Step 5: To Achieve Dynamic and Transient Free Unity PF

To decide whether transient free PF correction is required. This is due to the fact that conventional switching techniques of capacitors involving electro-mechanical contactors will give rise to transient phenomena. This transient phenomena can interact with impedances present in the installation to create "Surges". This occurrence of surges can cause serious damage to sensitive electronics and automation resulting in either their malfunction or permanent damage. The transient phenomenon is a sudden rise in voltage or current at the point of switching.
In this background, it is important to ensure that all the capacitors installed are switched in a transient free manner so as to ensure reliable performance of the installation.
In such a situation, it is necessary to specify the use of Thyristor switches for transient free switching of Capacitors.

Note: Thyristor switching can also be used for dynamic compensation which is needed if the fluctuation of loads is very high; such as lifts, welding load is very high; fast presses etc.

Capacitor Technology

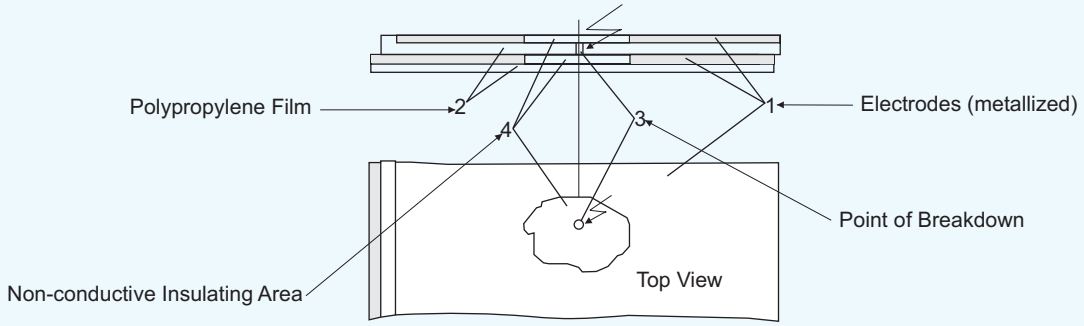
Capacitors are used in many diverse applications, and many different capacitor technologies are available. In low voltage applications, LT cylindrical capacitors which are made in accordance with metallized polypropylene technology have proved to be most appropriate and also the most cost effective. Dependent on the nominal voltage of the capacitor, the thickness of the polypropylene film will differ.



Design of LT Capacitor

Self - Healing

At the end of service life, or due to inadmissible electrical or thermal overload, an insulation breakdown may occur. A breakdown causes a small arc which evaporates the metal layer around the point of breakdown and re-establishes the insulation at the place of perforation. After electric breakdown, the capacitor can still be used. The decrease of Capacitance caused by a self-healing process is less than 100 pF. The self-healing process lasts for a few microseconds only and the energy necessary for healing can be measured only by means of sensitive instruments.



Self - Healing Breakdown

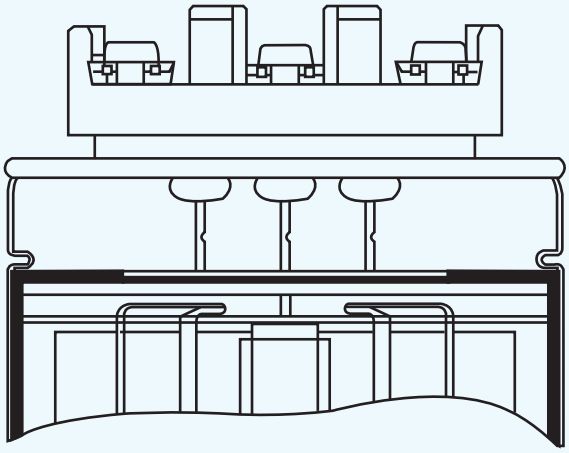
Self - Healing Breakdown

For a self-healing dielectric, impregnation is basically not required. However, our LT-type capacitors are impregnated to eliminate environmental influences and to guarantee reliable, long-term operation. Vacuum impregnation eliminates air and moisture, improves “self-healing” and reduces thermal resistance.

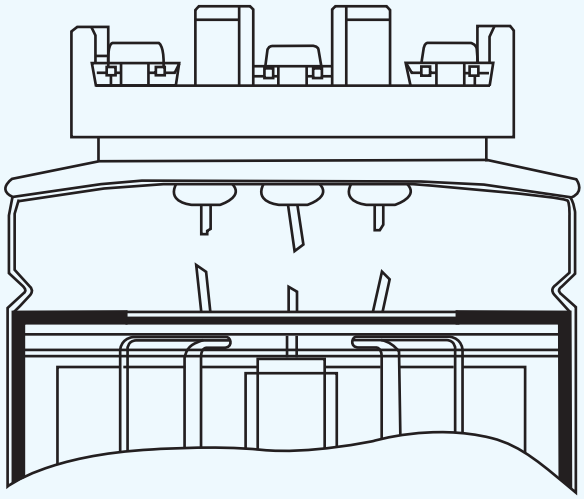
Over pressure Tear - off Fuse

At the end of service life, due to inadmissible electrical or thermal overload, an over pressure builds up and causes an expansion of the cover. Expansion over a certain limit causes the tear-off of the internal fuses. The active capacitor elements are thus cut-off from the source of supply. The pressure within the casing separates the breaking point so rapidly that no harmful arc can occur.

Operating Condition



Torn - off Condition



Box Type Capacitors

Technologically similar to cylindrical capacitors, box type capacitors consist of a number of three phase cylindrical capacitor cells. The individual cells are wired together and mounted on a steel frame. The steel frame together with the cells is housed in a common sheet steel casing. The enclosure is powder coated and is designed to protect the capacitor cells from dust and moisture. Ease of mounting is ensured by 4 drillings at the bottom of the container.

This design ensures highest safety by:

- Self healing technology
- Over pressure tear - off fuse
- Robust steel container
- Massive connection studs

Standard Duty Capacitors

L&T Standard Duty Capacitors are metalized polypropylene capacitors from 1kVAr to 25kVAr in cylindrical configuration and 1-50kVAr in box type configuration. These capacitors come with a stacked winding and are impregnated with a biodegradable soft resin. These capacitors are self healing type.

The Capacitors come with an over pressure disconnector and finger proof terminals. They can be used to provide effective power factor correction in industrial and semi industrial applications.

Technical Details

		Cylindrical	Box
Range (kVAr)		1 - 25	1 - 50
Standards		IEC 60831	IEC 60831
Impregnation		Resin	Resin
Over Voltage withstand	**10%**	12 h in 24 h	12 h in 24 h
	15%	30 m in 24 h	30 m in 24 h
	20%	5 m	5 m
	30%	1 m	1 m
Over Current withstand		1.5*In	1.5*In
Inrush Current withstand		200*In	200*In
No of Operations/ year		5000	5000
Terminals		Clamptite	Clamptite
Ambient Temperature (^{0}C)		-25 / D	-25 / D
Operating Losses Dielectric		<0.2W / kVAr	<0.2W / kVAr
Total Operating losses		<0.45W / kVAr	<0.45W / kVAr

Heavy Duty Capacitors

L&T Heavy Duty Capacitors are available from 3-25kVAr in cylindrical and from 5-50kVAr in box type construction. These capacitors have an inrush current withstand of 300 In and an overload withstand capacity of 1.8 In. These capacitors have all features of standard capacitors like over pressure disconnector and self healing.

The cylindrical Capacitors are subjected to an extended period of drying after which the casing is filled with an inert gas to prevent corrosion of the winding elements and inner electrical contacts. Compact design ensures space saving. Heavy Duty capacitors have a long life of 130000 hours.

Technical Details

		Cylindrical	Box
Range (kVAr)		3 - 25	5 - 50
Standards		IEC 60831	IEC 60831
Impregnation		Inert Gas	Resin
Voltage		440, 480, 525, 690V	440, 480, 525V
Over Voltage withstand	**10%**	12 h in 24 h	12 h in 24 h
	15%	30 m in 24 h	30 m in 24 h
	20%	5 m	5 m
	30%	1 m	1 m
Over Current withstand		1.8*In	1.8*In
Inrush current withstand		250*In	300*In
No. of Operations / year		8000	8000
Terminals		Faston / Screw	Faston / Screw
Ambient Temperature (^{0}C)		-40 / D	-25 / D
Operating Losses Dielectric		<0.2W / kVAr	<0.2W / kVAr
Total Operating Losses		<0.35W / kVAr	<0.35W / kVAr

LTXL: Ultra Heavy Duty Capacitor

The LTXL range of capacitors are designed for Ultra heavy duty applications and can withstand heavy load fluctuations, high inrush current and harmonics.

Applications

- Applications such as welding, steel rolling, etc., with heavy load fluctuations and high thermal loading
- Systems with high harmonic distortion levels (non linear load >15%)
- Systems with high dv / dt
- Tuned harmonic filter

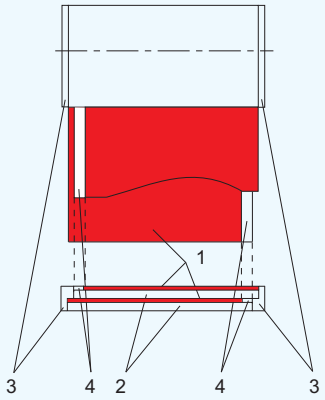
Features

- Long life expectancy (upto 300000 hrs)
- Maximum inrush current withstand capability (upto 500 times I_R)
- Low power loss (0.35 W/kVAr)
- Shock hazard protected terminals
- Internal fuse

The life of a capacitor largely depends upon its operating temperature. LTXL box type capacitors use advanced APP technology. By employing thicker aluminum foil, thicker polypropylene film and special impregnates, LTXL box type capacitor is able to operate at lower temperatures and hence achieve a longer life. These capacitors are thus able to withstand stringent operating conditions. The higher surface area and special epoxy based coating also ensures better heat dissipation. The capacitor is design to operate at ambient temperature up to 70^{0}C

Capacitor Technology

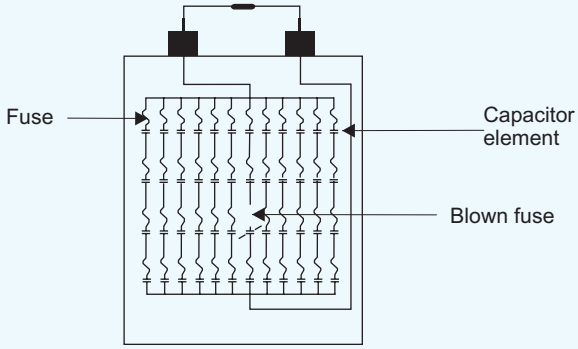
In LTXL box, two polypropylene films and two Al films are grouped together as shown in the figure below. The wave-cut and heavy edge metalized films are then rolled to form a capacitor element. Many such capacitor elements are pressed and stacked together and are internally connected in parallel. Depending upon the rating of the capacitor, the number of stacks differ. These stacks are placed inside a case and are vacuum impregnated with non-PCB, biodegradable impregnates.



1 Al Film
2 Polypropylene Film
3 Electric Contact (schooping)
4 Bare PP Film Edge

Design of LT Capacitor

Each capacitor elements is protected by an internal fuse as shown in the figure below. If there is an internal short circuit in any of the capacitor element, the fuse of that corresponding capacitor elements will blow.



Technical Details

	LTXL Box
Range	5 - 100 kVAr
Type	Ultra Heavy Duty
Standards	IS 13585-1994, IEC 60931-2002
Rated Frequency	50 Hz, 60 Hz
Rated Voltage	415 / 440V, 480V, 525V, 690V, 850V, 1000V
Over Voltage	+10% (12h/24h), +15% (30m/24h), +20% (5m/24hrs), +30% (1m/24hrs)
Over current	Upto 3 x I_N
Peak Inrush current	Upto 500 x I_N
Operating Losses (Dielectric)	< 0.2 W / kVAr
Operating Losses (Total)	< 0.35 W / kVAr
Tolerance on Capacitance	-5 / +10% as per IS
Degree of Protection	IP52 with terminal cap
Ambient Temperature	-25°C to 70°C
Cooling	Natural or forced air cooling
Permissible Relative Humidity	Max 95%
Maximum Operating Altitude	4000m above sea level
Mounting	Upright
Safety Features	Internal Fuse
Impregnation	Non PCB, biodegradable oil
Casing	CRCA
Dielectric Composition	Biaxillay oriented polypropylene film with aluminum foil electrode
Terminals	Porcelain Bushing
Discharge Resistors / Time	Discharge Resistors fitted, Standard discharge time 60 seconds, Other discharge times on request
Switching Operations (maximum)	20000 switchings per year, 50000 switchings per year (with reactor)

Reactors - Harmonic Filters

The increasing use of modern power electronic apparatus (drives, uninterruptible power supplies, etc) produces nonlinear current and thus influences and loads the network with harmonics (line pollution). The capacitance of the power capacitor forms a resonant circuit in conjunction with the feeding transformer. Experience shows that the self-resonant frequency of this circuit is typically between 250 and 500 Hz, i.e. in the region of the 5th and 7th harmonics. Such a resonance can lead to the following undesirable effects:

- Overloading of capacitors
- Overloading of transformers and transmission equipment
- Interference with metering and control systems, computers and electrical gear
- Resonance elevation, i.e. amplification of harmonics
- Voltage distortion

These resonance phenomena can be avoided by connecting capacitors in series with filter reactors in the PFC system. These so called “detuned” PFC systems are scaled in a way that the self-resonant frequency is below the lowest line harmonic and the detuned PFC system is purely inductive as seen by harmonics above this frequency. For the base line frequency (50 or 60 Hz usually), the detuned system on the other hand acts purely capacitive, thus correcting the reactive power.

Technical Details

Standards	IEC 60289
Rated Voltage (V)	440, 690, 850, & 1000V
Rated Frequency (F)	50
Max Permissible Operating Voltage	1.05 Un Continuously, 1.1 Un for 8 hours
Max Permissible Operating Current	1.06 In High Linearity, 1.8 In Continuously
Duty Cycle	100%
Class of Protection	I
Ambient Temperature	40^{0}C
Insulation Class	Class F
Protection	Thermal Switch
De-Tuning	5.67%, 7% & 14%

Thyristor Switching Modules

The usage of new technologies in modern industry has negative impacts on electric power quality of the main supply networks, e.g. frequent high load fluctuations and harmonic oscillation. Excessive currents, increased losses and flickering will not only influence the supply capacity but will also have a significant impact on the operation of sensitive electronic devices.

The solution is dynamic power factor correction system. With the thyristor module we provide the main component- “The Electronic Switch”- for dynamic power factor correction. The LT-TSM module series offers fast electronically controlled, self-observing thyristor switches for capacitive loads up to 200 kVAr, that are capable to switch PFC capacitors within a few milliseconds nearly without a limitation to the number of switchings during the capacitor lifetime. These switching modules are easy to install, have a fast reaction time of 5 msec and come with a built-in indications of operations, faults and activation.

Technical Details

	LT TSM 10	LT TSM 25	LT TSM 50
Rated Voltage (V)	440V		
Frequency (Hz)	50 / 60		
Rating (kVAr)	10	25	50
Losses PD (W)	35	75	150
LED Display per Phase	2	2	2
Ambient Temperature (^{0}C)	-10 to 55		
Signal Voltage Required	24 Vdc (20mA)		
Reaction Time (msec)	5		
Peak Inverse Voltage (PIV)	2.2kV		

Automatic Power Factor Correction Panel

Modern power networks cater to a wide variety of electrical and power electronics loads, which create a varying power demand on the supply system. In case of such varying loads, the power factor also varies as a function of the load requirements. It therefore becomes practically difficult to maintain consistent power factor by the use of fixed compensation i.e. fixed capacitors which shall need to be manually switched to suit the variations of the load. This will lead to situations where the installation can have a low power factor leading to higher demand charges and levy of power factor penalties.

In addition to not being able to achieve the desired power factor it is also possible that the use of fixed compensation can also result in leading power factor under certain load conditions. This is also unhealthy for the installation as it can result in over voltages, saturation of transformers, maloperation of diesel generating sets, penalties by electricity supply authorities etc.

Consequently the use of fixed compensation has limitations in this context. It is therefore necessary to automatically vary, without manual intervention, the compensation to suit the load requirements.
This is achieved by using on Automatic Power Factor Correction (APFC) system which can ensure consistently high power factor without any manual intervention. In addition, the occurrence of leading power factor will be prevented.

APFC products are fully automatic in operation and can be used to achieve:

- Consistently high power factor under fluctuating load conditions
- Elimination of low power factor penalty levied by electrical supply authorities
- Reduced kVA demand charges
- Lower energy consumption in the installation by reducing losses
- Preventive leading power factor in an installation

The basic operation is as follows:

- To continuously sense and monitor the load condition by the use of external CT (whose output is fed to the control relay)
- To automatically switch ON and OFF relevant capacitor steps on to ensure consistent power factor
- To ensure easy user interface for enabling reliable understanding of system operations carried outs etc.
- To protect against any electrical faults in a manner that will ensure safe isolation of the power factor correction equipment

Salient Features:

Standardise panel design with we pre-selected switchgear and step sizes allows user for easier panel selection. The incoming switchgear provided, fault interrupting capability has > 36kA. Aluminium busbar system suitable for withstanding 50 kA fault current. Minimal joints in all the connections to ensure better reliability and lower losses.

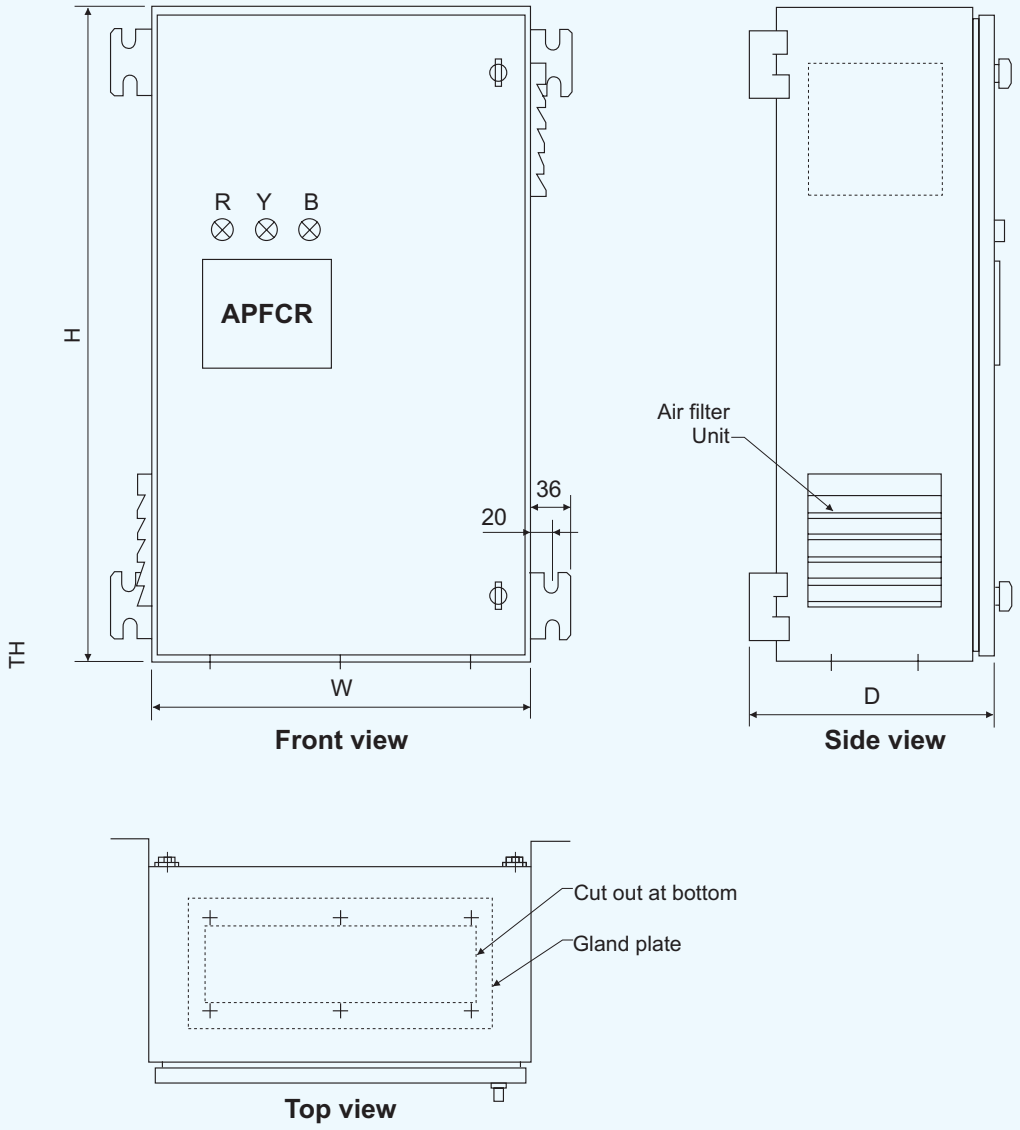
Standard Automatic Power Factor Control Panel suitable for 3Ph, 440V AC, 50 Hz Auto

Power Range	35 kVAr to 500 kVAr
Rated Voltage	440 V / 415 V / 380 V / 400 V
Rated Frequency	50 Hz
Short Circuit Rating	> 36kA
Altitude	1000 m
Duty	Continuous
Ambient temperature	-5°C to + 40°C
Standards	IEC - 61921
Power Supply	Three phase, four line
Relay current input signal	-- / 5A, from CT on line
Relay voltage input signal	Tapped internally
The Enclosure	The load bearing structure is made of 2mm sheet steel The front door and partition are made of 1.6 mm sheet steel The internal components are accessible on opening the front door The protection rating is IP42 / IP54
Installation	Indoor, wall mounted, in a well ventilated non-dusty environment, cable entry from bottom
Incomer	3 Pole MCCBs upto 630A, 3 Pole ACBs above 630A
Internal wiring	Cylindrical, dry type three phase units (see table for step ratings)
Capacitors	The capacitors are equipped with discharge device, and over pressure device Three pole Capacitor duty contactors of adequate ratings for respective steps
Contactors	A microprocessor based relay upto 12 output contacts for switching contactors
The Controller Protection	Having PF indication, built in time delays, and alarm indication for CT reversal apart from the protections associated with the capacitor itself, there is a thermostat which disconnects the entire panel in the event of excessive temperature rise in the enclosure. As a safety measure, an inter lock is provided so that when the front door is opened, the entire panel will trip.
Branch Protection	MCCBs for providing short circuit protection and isolation

APFC Ratings and Dimensions

Cat. No.	Panel Rating (kVAr)	Step size (kVAr)	Switching Device	Type of Capacitor	Reactor	Branch protection	Main Incommer	Dimensions (W x D x H)
LTAPFH0351B2	35	2 x12.5 + 2 x 5	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	600, 375, 1100
LTAPFH0501B2	50	2 x 12.5 + 2 x 10 + 1 x 5	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	600, 375, 1100
LTAPFH0751B2	75	2 x 25 + 2 x 10 + 1 x 5	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	750, 375, 1200
LTAPFH1001B2	100	50 + 25 + 15 + 10	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	750, 375, 1200
LTAPFH1002B2	100	2 x 12.5 + 25 + 50	Contactor	Heavy Duty	7%	DU MCCB	dsine MCCB	800, 650, 1550
LTAPFH1003B2	100	2 x 12.5 + 25 + 50	Thyristor	Heavy Duty	7%	HSF	dsine MCCB	800, 700, 1850
LTAPFH1251B2	125	2 x 12.5 + 2 x 25 + 50	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	750, 375, 1200
LTAPFH1252B2	125	2 x 12.5 + 2 x 25 + 50	Contactor	Heavy Duty	7%	DU MCCB	dsine MCCB	800, 650, 1550
LTAPFH1253B2	125	2 x 12.5 + 2 x 25 + 50	Thyristor	Heavy Duty	7%	HSF	dsine MCCB	1150, 700, 1550
LTAPFH1501B2	150	2 x 12.5 + 3 x 25 + 50	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	850, 400, 1200
LTAPFH1502B2	150	2 x 12.5 + 3 x 25 + 50	Contactor	Heavy Duty	7%	DU MCCB	dsine MCCB	800, 650, 1850
LTAPFH1503B2	150	2 x 12.5 + 3 x 25 + 50	Thyristor	Heavy Duty	7%	HSF	dsine MCCB	1150, 700, 1550
LTAPFH1751B2	175	2 x 12.5 + 2 x 25 + 2 x 50	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	850, 400, 1200
LTAPFH1752B2	175	2 x 12.5 + 2 x 25 + 2 x 50	Contactor	Heavy Duty	7%	DU MCCB	dsine MCCB	800, 650, 1850
LTAPFH1753B2	175	2 x 12.5 + 2 x 25 + 2 x 50	Thyristor	Heavy Duty	7%	HSF	dsine MCCB	1150, 700, 1550
LTAPFH2001B2	200	2 x 12.5 + 25 + 3 x 50	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	850, 400, 1200
LTAPFH2002B2	200	2 x 12.5 + 1 x 25 + 3 x 50	Contactor	Heavy Duty	7%	DU MCCB	dsine MCCB	900, 700, 1850
LTAPFH2003B2	200	2 x 12.5 +1 x 25 + 3 x 50	Thyristor	Heavy Duty	7%	HSF	dsine MCCB	1150, 700, 1550
LTAPFH2251B2	225	2 x 12.5 + 4 x 50	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	850, 400, 1200
LTAPFH2252B2	225	3 x 12.5 + 4 x 50	Contactor	Heavy Duty	7%	DU MCCB	dsine MCCB	900, 700, 1850
LTAPFH2253B2	225	4 x 12.5 + 4 x 50	Thyristor	Heavy Duty	7%	HSF	dsine MCCB	1150, 700, 1550
LTAPFH2501B2	250	2 x 25 + 4 x 50	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	850, 400, 1200
LTAPFH2502B2	250	2 x 25 + 4 x 50	Contactor	Heavy Duty	7%	DU MCCB	dsine MCCB	900, 700, 1850
LTAPFH2503B2	250	2 x 25 + 4 x 50	Thyristor	Heavy Duty	7%	HSF	dsine MCCB	1150, 700, 1550
LTAPFH2751B2	275	1 x 100 + 3 x 50 + 2 x 12.5	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	1000, 400, 1800
LTAPFH2752B2	275	1 x 100 + 3 x5 0 + 2 x 12.5	Contactor	Heavy Duty	7%	DU MCCB	dsine MCCB	900, 700, 1850
LTAPFH2753B2	275	1 x 100 + 3 x 50 + 2 x 12.5	Thyristor	Heavy Duty	7%	HSF	dsine MCCB	1150, 700, 1850
LTAPFH3001B2	300	1 x 100 + 3 x 50 + 2 x 25	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	1000, 400, 1800
LTAPFH3002B2	300	1 x 100 + 3 x 50 + 2 x 25	Contactor	Heavy Duty	7%	DU MCCB	dsine MCCB	900, 700, 1850
LTAPFH3003B2	300	1 x 100 + 3 x 50 + 2 x 25	Thyristor	Heavy Duty	7%	HSF	dsine MCCB	1150, 700, 1850
LTAPFH3501B2	350	1x100 + 3 x 50 + 4 x 25	Contactor	Heavy Duty	-	DU MCCB	dsine MCCB	1000, 700, 2100
LTAPFH3502B2	350	1 x 100 + 3 x 50 + 4 x 25	Contactor	Heavy Duty	7%	DU MCCB	dsine MCCB	1000, 800, 2100
LTAPFH3503B2	350	1 x 100 + 3 x 50 + 4 x 25	Thyristor	Heavy Duty	7%	HSF	dsine MCCB	1000, 800, 2100
LTAPFH4001B2	400	2 x 100 + 2 x 50 + 4 x 25	Contactor	Heavy Duty	-	DU MCCB	ACB	1000, 700, 2100
LTAPFH4002B2	400	2 x 100 + 2 x 50 + 4 x 25	Contactor	Heavy Duty	7%	DU MCCB	ACB	1000, 800, 2100
LTAPFH4003B2	400	2 x 100 + 2 x 50 + 4 x 25	Thyristor	Heavy Duty	7%	HSF	ACB	1000, 800, 2100
LTAPFH4501B2	450	2 x 100 + 4 x 50 + 2 x 25	Contactor	Heavy Duty	-	DU MCCB	ACB	1200, 700, 2100
LTAPFH4502B2	450	2 x 100 + 4 x 50 + 2 x 25	Contactor	Heavy Duty	7%	DU MCCB	ACB	1200, 1000, 2100
LTAPFH4503B2	450	2 x 100 + 4 x 50 + 2 x 25	Thyristor	Heavy Duty	7%	HSF	ACB	1200, 1000, 2100
LTAPFH5001B2	500	3 x 100 + 3 x 50 + 2 x 25	Contactor	Heavy Duty	-	DU MCCB	ACB	1200, 700, 2100
LTAPFH5002B2	500	3 x 100 + 3 x 50 + 2 x 25	Contactor	Heavy Duty	7%	DU MCCB	ACB	1200, 1000, 2100
LTAPFH5003B2	500	3 x 100 + 3 x 50 + 2 x 25	Thyristor	Heavy Duty	7%	HSF	ACB	1200, 1000, 2100

Overall Dimensions of APFC Panel



Notes:

- Wall mounted : upto 100kVr
- Floor mounted : above 100kVr
- Recommended front access : 1000mm
- Recommended side clearance : 1000mm
- Paint shade : ral 7032 Powder coated
- Tolerance on dimensions : ±10mm
- Cable entry : bottom

Capacitor Duty Contactors - Type MPX

Switching of capacitors in Automatic power factor (APFC) panels are always challenging because of the inrush current. When capacitors are switched directly by using power contactors, the peak value of the inrush current may shoot above 200 times the rated current. This can harm power capacitors and other equipments in the panel. A simple solution to reduce the inrush current is by switching the capacitors through capacitor duty contactors. These special purpose contactors have auxiliary contacts that have series resistors of 4 Ω. These auxiliary contacts close before the main contacts, which reduce the inrush current to less than 20 times the rated current. The capacitor duty contactors have **de-latching technology**, in which, the auxiliary contacts will remain closed only for a few milliseconds. During breaking operation, the arcing occurs only at main contacts. This will ensure longer life of the contactor.

Technical Specification

Type Designation	Cat. Nos.	Rated operational current (A)	Rating (kVAr)				Mechanical Life (in Millions)	Electrical Life (in Millions)	Max. operating frequency (operations / hr)
			230 VAC	400 / 415 VAC	440 VAC	690 VAC			
MPX 8	ST41807	12	4.5	8	9	10	20	0.2	120
MPX 12	ST41808	18	7	12.5	14	16	20	0.2	120
MPX 15	ST41809	23	9	15	17	20	20	0.2	120
MPX 25	ST41810	36	14	25	27.5	30	20	0.2	120
MPX 30	ST41811	43	17	30	33	36	20	0.2	120
MPX 50	ST41812	75	30	50	56	65	15	0.2	120
MPX 60	ST41813	90	34	60	65	70	15	0.2	120

Power Factor Control and Monitoring Relays

- (8 & 14 Stages) Intelligent Power Factor Controller Relay

Salient Features

- On line display of system PF
- Easy setting through - front panel push button
- Suitable for non-uniform banks
- LED indication for alarm code, no. of Banks selected, PF status-lead / lag / unity
- Auto / Manual mode
- Measurement sensitivity of 1%
- Automatic C/K correction
- Display of cuttent, Voltage, KVAR, & Capacitor values

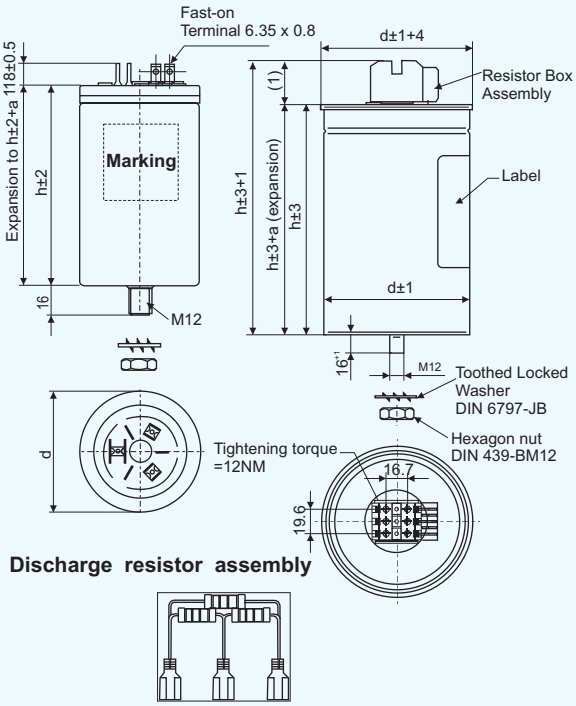
Model	RPM-8	RPM-14
Description	Automatic Power Factor Controller 8 stage	Automatic Power Factor Controller 14 stage
Design	Microcontroller Based	Microcontroller Based
Functions Available	Automatic PF control upto 8 stage	Automatic PF control upto 14 stage
Settings	Switching time 1-255 Sec. in step of 1 sec for same Bank switching Auto C/K selection PF control range 1% to 120% of rated current	Switching time 1-255 Sec. in step of 1 sec for same Bank switching Auto C/K selection PF control range 1% to 120% of rated current
Other Features	Can accept unequal banks Display of PF, V, I, KVAr LED indications for faults Alarm signal for CT reversal, under current, Under compensation, over compensation, over voltage, 1 A / 5 A field selectable	Can accept unequal banks Display of PF, V, I, KVAr LED indications for faults Alarm signal for CT reversal, under current, Under compensation, over compensation, over voltage, 1 A / 5 A field selectable
Burden on CT	0.3 VA	0.3 VA
Burden on PT	15 VA	15 VA
Operating temp	0^{o}C to 60^{o}C	0^{o}C to 60^{o}C
Weight	< 2kg	< 2kg
Output Contacts	8 N/O 1 N/O contact for alarm	14 N/O 1 N/O contact for alarm
Dim W x H x D in mm	144 x 144 x 100	144 x 144 x 100
Panel Cutout	138 x 138	138 x 138
Auxiliary supply	240 V AC	240 V AC

Dimensions

Standard Duty Capacitors

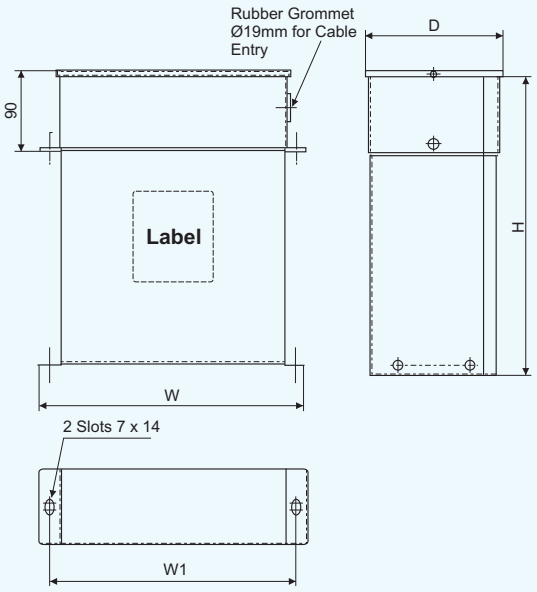
Cylindrical Type

Sr. No.	Voltage (V)	Power (Q) kVAr		Capacitance (µf)	Rated current (A)	Dimension in (mm²)		Cat. Nos.
		50Hz	60 Hz			D	H	
1	440 V	1	1	16.44	1.31	45	130	LTCCF301B2
2	440 V	2	2	32.88	2.62	50	130	LTCCF302B2
3	440 V	3	4	49.32	3.94	50	165	LTCCF303B2
4	440 V	4	5	65.77	5.25	63.5	165	LTCCF304B2
5	440 V	5	6	82.21	6.56	63.5	225	LTCCF305B2
6	440 V	6	7	98.65	7.87	63.5	225	LTCCF306B2
7	440 V	7.5	9	123.31	9.84	75	162	LTCCS307B2
8	440 V	8.33	10	136.96	10.93	78.4	195	LTCCS308B2
9	440 V	10	12	164.42	13.12	75	198	LTCCS310B2
10	440 V	12.5	15	205.52	16.40	75	270	LTCCS312B2
11	440 V	15	18	246.62	19.68	75	270	LTCCS315B2
12	440 V	20	24	328.83	26.24	90	270	LTCCS320B2
13	440 V	25	30	411.04	32.80	90	270	LTCCS325B2



Box Type

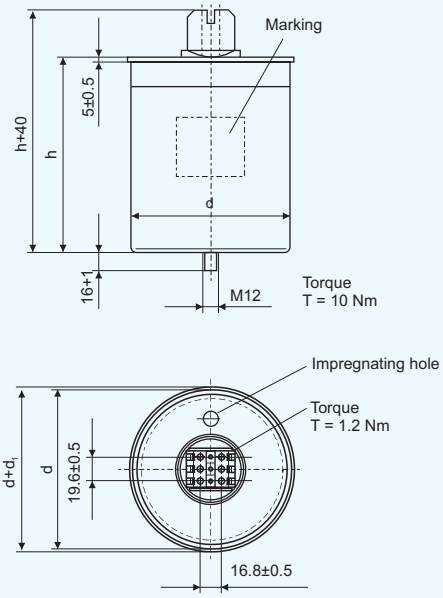
Sr. No.	Voltage (Vn)	Power (Qn) (kVAr)		Capacitance (µf)	Rated current (A)	Dimensions in (mm)			Cat. Nos.
		50Hz	60 Hz			H	W	D	
1	440 V	1	1	16.44	1.31	125	140	40	LTBCF301B2
2	440 V	2	2	32.88	2.62	125	140	40	LTBCF302B2
3	440 V	3	4	49.32	3.94	145	170	50	LTBCF303B2
4	440 V	4	5	65.77	5.25	145	170	50	LTBCF304B2
5	440 V	5	6	82.21	6.56	175	170	50	LTBCF305B2
6	440 V	6	7	98.65	7.87	175	170	50	LTBCF306B2
7	440 V	7.5	9	123.31	9.84	283	263	80	LTBCS307B2
8	440 V	8.33	10	136.96	10.93	283	263	80	LTBCS308B2
9	440 V	10	12	164.42	13.12	283	263	80	LTBCS310B2
10	440 V	12.5	15	205.52	16.40	283	263	80	LTBCS312B2
11	440 V	15	18	246.62	19.68	383	263	80	LTBCS315B2
12	440 V	20	24	328.83	26.24	383	263	80	LTBCS320B2
13	440 V	25	30	411.04	32.80	383	263	80	LTBCS325B2
14	440 V	30	36	493.25	39.37	383	263	80	LTBCS330B2



Heavy Duty Capacitors

Cylindrical Type

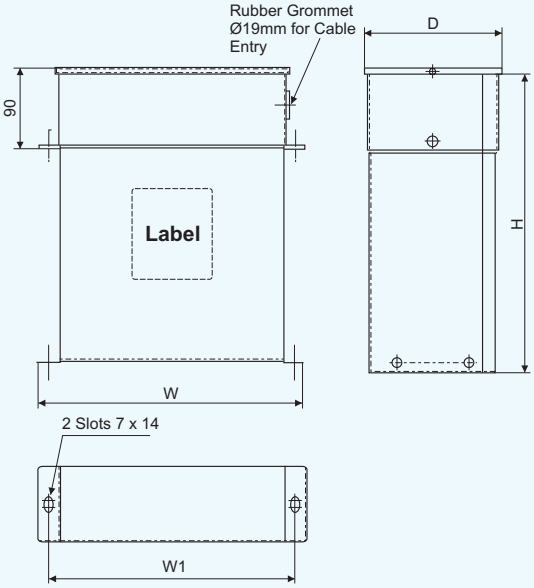
Sr. No.	Voltage (Vn)	Power (Qn) (kVAr)		Capacitance (µf)	Rated current (A)	Dimensions in (mm)		Cat. Nos.
		50Hz	60 Hz			H	D	
1	440 V	5	6	82.21	6.56	190	64	LTCCN305B2
2	440 V	7.5	9	123.31	9.84	190	64	LTCCN307B2
3	440 V	8.33	10	136.96	10.93	190	64	LTCCN308B2
4	440 V	10	12	164.42	13.12	265	64	LTCCN310B2
5	440 V	12.5	15	205.52	16.40	265	64	LTCCN312B2
6	440 V	15	18	246.62	19.68	190	84.4	LTCCN315B2
7	440 V	20	24	328.83	26.24	265	84.4	LTCCN320B2
8	440 V	25	30	411.04	32.80	265	84.4	LTCCN325B2



d_1= 2 ... 6 mm (depending on the capacitor type;
for details please refer to the data sheet)
Creepage distance 12.7 mm min. Clearance 9.6 mm min.

Box Type

Sr. No.	Voltage (Vn)	Power (Qn) (kVAr)		Capacitance (µf)	Rated current (A)	Dimensions in (mm)			Cat. Nos.
		50Hz	60Hz			H	W	D	
1	440 V	5	6	82.21	6.56	240	205	60	LTBCH305B2
2	440 V	7.5	9	123.31	9.84	240	205	60	LTBCH307B2
3	440 V	8.33	10	136.96	10.93	325	263	80	LTBCH308B2
4	440 V	10	12	164.42	13.12	325	263	80	LTBCH310B2
5	440 V	12.5	15	205.52	16.40	325	263	80	LTBCH312B2
6	440 V	15	18	246.62	19.68	325	263	160	LTBCH315B2
7	440 V	20	24	328.83	26.24	325	263	160	LTBCH320B2
8	440 V	25	30	411.04	32.80	325	263	160	LTBCH325B2
9	440 V	30	36	493.25	39.37	325	263	160	LTBCH330B2
10	440 V	50	60	822.08	65.61	375	263	320	LTBCH350B2

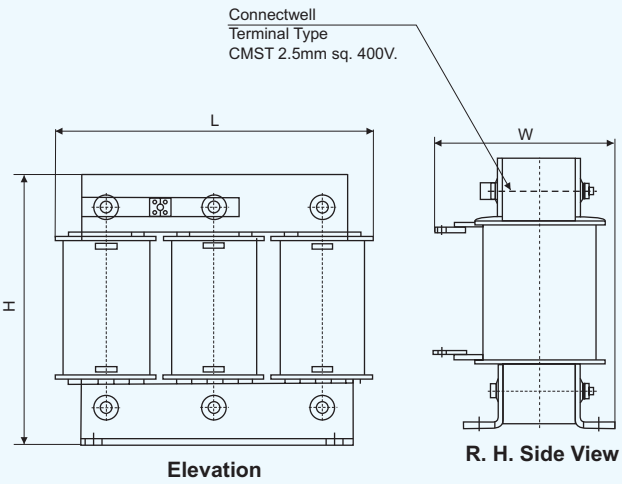


LTXL: Ultra Heavy Duty Capacitor

Sr. No.	Rating (kVAr)	Voltage (Vn)	Capacitance (µF)	Rated current (A)	H (mm)	W (mm)	D (mm)	Cat. Nos.
1	5	440	40.10	6.56	115	270	115	LTBCU305B2
2	10	440	82.2	13.12	175	270	115	LTBCU310B2
3	15	440	123.3	16.4	225	270	115	LTBCU315B2
4	20	440	164.4	26.24	300	270	115	LTBCU320B2
5	25	440	205.5	32.80	350	270	115	LTBCU325B2
6	30	440	246.6	39.36	400	270	115	LTBCU330B2
7	50	440	411	65.6	575	270	115	LTBCU350B2

7% detuned copper reactor (440 V)

Rating (kVAr)	Inductance (mH)	Rated current (A)	L (mm)	W W (± mm)	H (mm)	Cat. Nos.
5	9.28 mH	6.6	175	96	157	LTFR0705B2
10	4.64 mH	13.1	178	125	161	LTFR0710B2
15	3.1 mH	19.8	225	150	230	LTFR0715B2
20	2.33 mH	26.4	226	152	205	LTFR0720B2
25	1.86 mH	32.8	226	152	205	LTFR0725B2
50	0.93 mH	65.6	260	207	240	LTFR0750B2
75	0.62 mH	98.4	300	182	270	LTFR0775B2

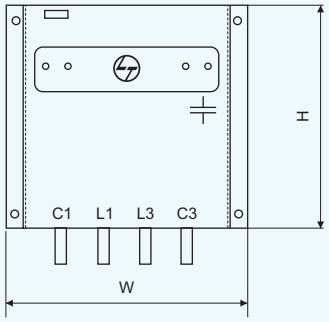


Elevation

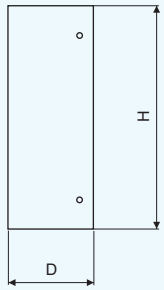
R. H. Side View

Thyristor Switching Modules

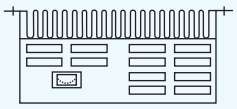
Rating (kVAr)	Max. RMS Current (A)	W (mm)	D (mm)	H (mm)	Cat. Nos.
10	20	153	75	153	LTTSM10B2
25	50	156	171	200	LTTSM25B2
50	100	156	171	200	LTTSM50B2



Front View



Side View



Top View

Ordering Information of Capacitors

Cat. No.	L	T	C	C	S	3	2	5	B	2
	L&T Capacitors		Type		Duty	Phase	kVAr Rating		Voltage	
			C - Cyl		F, S - Standard	3P - 3			B - 440 V	
			B - Box		H - Heavy				C - 480 V	
					N - Heavy gas filled				A - 415 V	
					U - Ultra heavy LTXL				H - 525 V	
									W - 690 V	
									Y - 850 V	
									Z - 1000 V	

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Product improvement is a continuous process. For the latest information and special applications, please contact any of our offices listed here.

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