Low Voltage Products

Low Voltage Capacitors
Power Factor Correction Solutions

Power and productivity
for a better world™

Low Voltage Capacitors
Reliability for Power Factor Correction

Dry type design
The ABB Low Voltage Capacitors, called CLMD, use dry type dielectric and therefore avoid any risk of leakage or pollution in the environment.

Very low losses
Dielectric losses are less than 0.2 Watt per kvar. Total losses, including discharge resistors, are less than 0.5 Watt per kvar.

Long life - Self-healing
In the event of a fault developing in the capacitor's dielectric, the metalized electrode adjacent to the fault is immediately vaporized, thus insulating the fault. The capacitor then continues normal operation.

Fire protection
All elements within the CLMD capacitor are surrounded by vermiculite which is an inorganic, inert, fire proof and non toxic granular material. In the event of any failure the vermiculite absorbs safely the energy produced within the capacitor box and extinguishes any possible flames.

Unique protection system
A unique Sequential Protection System ensures that each individual element can be disconnected from the circuit at the end of its life.

Easy to install - light weight
The CLMD capacitor light weight makes it easy to handle and install.

High reliability
The use of robust terminals removes the risk of damage during installation and reduces maintenance requirements.

Security
Thermal equalizers are fitted to surround each capacitor element and provide effective heat dissipation. The CLMD capacitor is equipped with discharge resistors.

ISO 9001
Our ISO 9001 Quality System registration provides the strongest assurance of our product quality.

ISO 14001
The CLMD capacitor has a dry type dielectric and is free from liquids or other impregnating agents. It has been designed for environmentally friendly manufacturing. Our ISO 14001 certification guarantees our commitment to the environment.

Figure 1: LV capacitors series

Low Voltage Capacitors
Construction

Principal components of a 3-phase capacitor

Principal components of a 3-phase ABB capacitor include:

1. Sequential protection system:

– Self-healing capacitor elements
One or more self-healing capacitor elements are installed for each phase. In case of dielectric breakdown, the fault is cleared by evaporation of the metalized layer around the breakdown with negligible loss of capacitance and continued operation of the capacitor!

– Internally protected elements
A unique Sequential Protection System including the IPE design (IPE - internally protected elements) ensures that each individual element can be disconnected from the circuit at the end of the element's life.

– Non-flammable dry vermiculite filler
Vermiculite is a dry, granular insulating material that is solid, inert and fire proof. This material fills all open spaces in the enclosure to isolate the capacitor elements and exclude free oxygen.

2. Discharge resistors

Discharge resistors (one for each phase) are sized to ensure safe discharge of the capacitor to less than 50 volts in one minute or less as required by the National Electrical Code (NEC).

3. Terminal studs

Large terminal studs are located inside the enclosure at the top of the capacitor for quick and easy cable connections.

4. Enclosure

All ABB enclosures are made of welded heavy gauge steel. Available enclosure types include Indoor NEMA 1, Outdoor Rain tight NEMA 3R, and Indoor Dust tight NEMA 12.

What is the significance of dry type design?

ABB low voltage capacitors contain no free liquids and are filled with a unique non-flammable granular material called vermiculite. Environmental and personnel concerns associated with leakage or flammability of conventional oil-filled units are eliminated; and kvar for kvar, vermiculite filled units weigh 30% to 60% less than their oil filled counterparts.

Vermiculite is used as an insulating material in the walls and ceilings of new buildings. Its properties have been extensively documented and recognized as an ideal material for safety and environmental considerations.

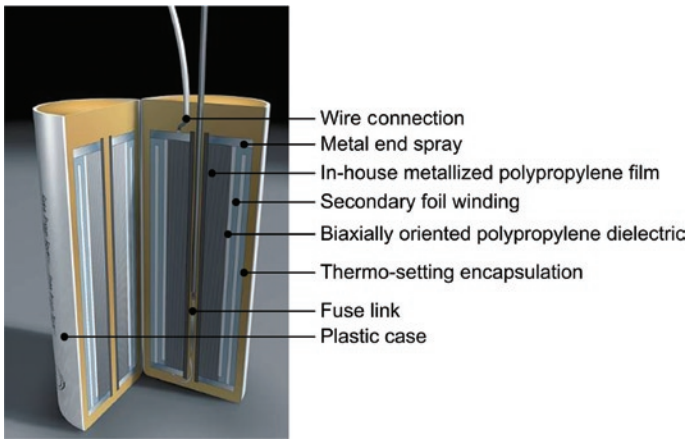


Figure 2: IPE construction

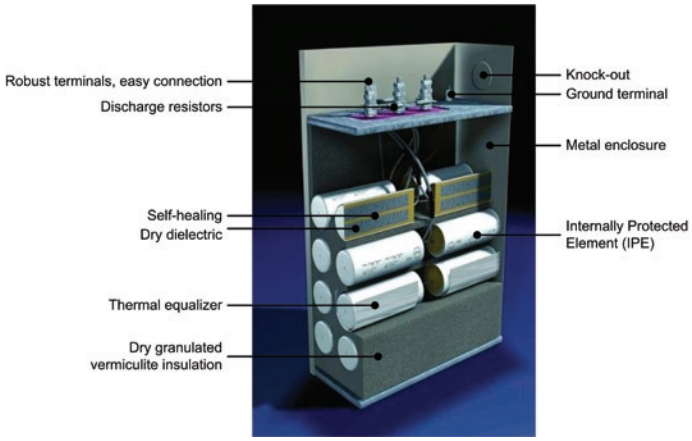


Figure 3: Low voltage capacitor construction

Low Voltage Capacitors
Construction

What is a metalized-film element?

Metalized-film is a microscopically thin layer of conducting material (called an electrode), usually aluminium or zinc on an underlying layer of insulating film. The electrode thickness averages only .01 microns while insulating (polypropylene) film ranges from 5 to 10 microns in thickness depending upon the design voltage of the capacitor (the higher the voltage rating, the thicker the insulating film).

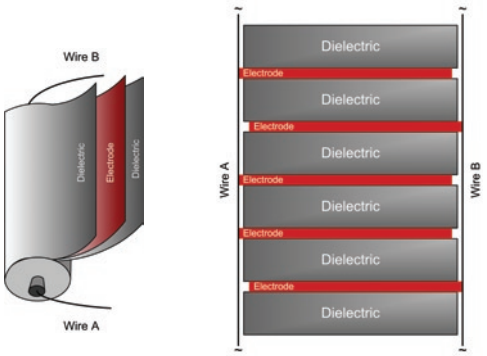


Figure 4: Metalized-film element

More about self-healing elements

"Self-healing" is a characteristic which is unique to metalized electrode capacitors. All capacitor normally experience insulation breakdown as a result of the accumulated effect of temperature, voltage stress, impurities in the insulating medium, etc. When this happens in a non-"metalized" design, the electrodes are short-circuited and the capacitor ceases its production of reactive power. In an ABB metalized-film unit, however, these individual insulation breakdowns do not mean the shutdown of the capacitor. The faults self-heal themselves and the capacitor continues operation. The conducting electrode is very thin; when a short circuit develops as a result of a fault in the insulating dielectric, the thin electrode vaporizes around the area of the fault. This vaporization continues until sufficient separation exists between the faulted electrodes to overcome the voltage level.

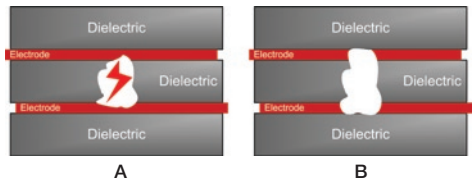


Figure 5: Self-healing element

The entire process of self-healing takes "microseconds" and the amount of electrode which is lost is negligible in comparison to the total surface area of the element. The result is the metalized-film unit may self-heal hundreds of times during its long life and still retain virtually all of its rated capacitance.

The IPE sequential protection system

ABB's metalized-film self-healing capacitor elements will have a longer life than their conventional foil design counterparts for the above reason. However, accumulated effects of time, temperature, voltage stress, etc., eventually effect capacitor life.

ABB's sequential protection system featuring patented Internally Protected Elements (IPE) design provides increased protection to facilities and personnel not available from other capacitor designs. This proven design allows for self-healing throughout the life of the capacitor to insure the maximum length of reliable service and still provide short circuit protection in each element when self-healing can no longer continue. This is accomplished by a combination of unique winding construction and an internal fuse link (See Fig. 6) within each element which safely and selectively disconnects each individual element. ABB capacitors do not rely on mechanical pressure interrupters and additional line fuses have disadvantages associated with that kind of construction.

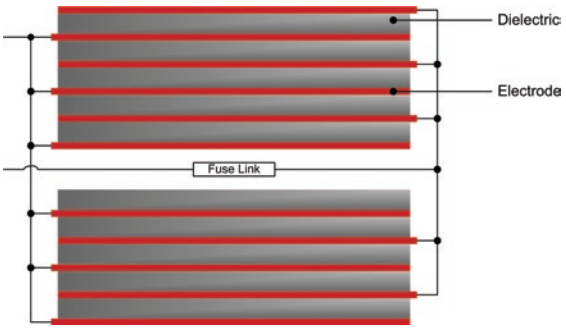


Figure 6: IPE sequential protection system

Advantages of metalized-film elements

There are two electrode layers separated by one layer of insulating film. Thousands of these layers are tightly wound around a core in such a manner that the edge of one electrode is exposed on one side of the element and the edge of the other electrode is exposed on the other side of the element. Wires are then connected to each side of the element. The element is enclosed in a container and then filled with a hardening protective sealant.

1. Self-healing design

Self-healing refers to a process where a short circuit between electrodes vaporizes the electrode around the fault (see Fig. 5a) until the fault is eliminated. The element continues to function with negligible loss of performance (see Fig. 5b).

2. Low internal losses

Due to the high dielectric efficiency of the metalized-film, the

internal losses are extremely low. ABB metalized-film design losses are limited to .5 watts per kvar including the losses across the discharge resistors.

3. Small element size

Due to the thin electrode and dielectric, metalized-film elements are small and compact in size resulting in smaller, more powerful capacitors.

The capacitance of any element design is inversely proportional to the separation between electrodes. In other words, if the separation between conducting surfaces is cut in half, the effective capacitance is doubled in addition to reducing the physical size of the element by half.

What are discharge resistors?

As all the capacitor elements store electrical power like a battery, the capacitor will maintain a near full charge even when not energized. As this is a potentially dangerous condition to unsuspecting plant personnel that might be inspecting the capacitor terminals and wiring, discharge resistors are connected between all of the terminals. When the capacitor is shut off, these discharge resistors drain the capacitor elements of their stored electrical charge. It is recommended, however, that capacitor terminals should ALWAYS be short-circuited before touching the terminals.

Technical specifications

Voltage range	From 240V to 600V nominal (other voltages available 208V to 750V upon request)
Frequency	50Hz; 60Hz
Connection	3-phase as standard construction (single-phase on request)
Discharge resistors	Permanently connected built-in discharge resistors, sized to ensure safe discharge of the capacitor to less than 50Vdc in 1 minute after a switch off
Terminals	– CLMD 13: 3 terminal blocks – Gauge 22 – 6 AWG (CU only) – CLMD 33: Std 5/16" studs, made of silicon-brass – CLMD 43-53-63-83: with threaded rods 5/16", 3/8", 1/2" according to the power of the capacitor
Ground	CLMD 13: ground connection on the enclosure fixation CLMD 33: ground connection on the enclosure fixation and 5/16" stud CLMD 43-53-63-83: Std 5/16" studs, made of silicon-bronze
Conduit knockout	CLMD 13: ½" ko, 22mm (7/8") od (required "-TC" suffix for knockout) CLMD 33-43-53-63-83: ¾" ko, 29mm (1 1/8") od, 1" ko, 35mm (1 3/8") od
Case material	Zinc electroplated mild steel
Color	ASA61 or ANSI-61 gray paint finish, powder coat finish
Fixing	Mounting feet with 2 fixation holes
Type rating	NEMA 1, NEMA 12, NEMA 3R
Temperature range	-25°C to +55°C (-13F to +130F)
Rated ambient temperature	40°C / 104F
Minimum distance between units	CLMD 13-33: 19mm (3/4") CLMD 43-53-63-83 : 51mm (2")
Minimum distance between units and wall	CLMD 13-33: 19mm (3/4") CLMD 43-53-63-83 : 51mm (2")
Losses (discharge resistors included)	< 0.5 Watt/kvar for 380 V rated voltage and above
Tolerance on capacitance	0% + 15%
Voltage test	– Between terminals: 2.15 Un for 10 seconds – Between terminals and ground: 3 kVac for 1 minute
Overcurrent tolerance	135% of rated current, continuously
Overvoltage tolerance	110% of rated voltage, continuously
Internal cables and insulation	All internal conductors utilize stranded, tin plated copper wire. Insulation is fire-retardant, rated 105°C (220F)
Approvals	CSA approved C22.2 / UL listed / Complies with applicable requirements of IEC, EEMAC, ANSI and IEEE std 18

Note: ABB's patented IPE design eliminates the need for additional overcurrent protection when capacitors are electrically connected on the load side of a motor starter circuit breaker or fusible disconnect switch.

Ordering Information

3 Phase, 60Hz configurations								
Capacitor type	Voltage	Enclosure size	Enclosure type	kvar rating	Option 1	Option 2	Option 3	UL/CSA
C	48	8	G	100	3F	2LF	- O	U
C = Individual F = Fixed Bank	24 = 240V 48 = 480V 60 = 600V	1 = CLMD 13 3 = CLMD 33 4 = CLMD 43 5 = CLMD 53 6 = CLMD 63 8 = CLMD 83	G = NEMA 1 D = NEMA 12 R = NEMA 3R		3F = Supplemental Fuse Protection (N/A in CLMD 13) 3FI = Fuses protection and blown fuse indicator lights (N/A in CLMD 13 and 3R enclosures)	2LF = Two-light status indication, Front enclosure mounted (N/A in CLMD 13, 33 and 3R enclosures) 2LE = Two-light status indication, End enclosure mounted (N/A in CLMD 13, 33 and 3R enclosures)	- O = for CLMD 13 and 33 replacement capacitor only	C = CSA U = UL

Notes:
1) For 208 volt applications, derate the 240V capacitors. The kvar at 208V will be .75 times the kvar at 240V. e.g. 15kvar at 208V is equal to 20kvar at 240V.
2) For 660V application, derate the 600V capacitors. The kvar at 660V will be 1.211 times the kvar at 600V. e.g. 100 kvar at 600V is equal to 120 KVAR at 660V.
3) The capacitor state indication system consists of two yellow LED lights which illuminate only when the capacitor is energized and functioning at 65% or more of its rated kvar capacity. The two light systems will indicate a failure in any one of the three phases of the capacitor.
4) For fixed capacitor banks, only CLMD 63 and CLMD 83 enclosure size are available (see fixed bank section for more details).
5) Fixed banks capacitor available options are 3F, 3FI and 2LF.
6) Wall mount kit can be used for CLMD 13-83 (part number WM83-KIT – 6 gauge bracket).
7) CLMD 33 open style for replacement unit requires adapter plate (part number ADAPTER CLMD 33).
8) Single phase capacitors are available, please contact your local field office.
9) 50Hz option is available, please contact your local field office.

Examples

Kvar rating	Voltage	Options	Part number
50	480	NEMA 1, fuse protection, fuse blown indicator, UL listed	C485G50-3FI-U
75	480	NEMA 12, fuse protection, light Indicator on front, UL listed	C486D75-3F-2LF-U
80	600	NEMA 1, status Indicators on the side, CSA certified	C606G60-2LE-C
100	600	NEMA 12, fuse protection, fuse blown indication, status indicators on front, CSA certified	C608D100-3FI-2LF-C
400	480	Fixed bank, NEMA 3R, UL	F488R400-U

Enclosure types

Type	Description	Enclosure types				
		Open type	NEMA 1	NEMA 12	NEMA 3R	NEMA 4-4X
CLMD 13	Standard capacitor unit	•	•			
CLMD 33	Standard capacitor unit and with HRC fuses (Stud mounted)	•	•	•		
CLMD 43	Standard capacitor unit		•	•	•	
CLMD 53	Standard capacitor unit		•	•	•	
CLMD 63	Standard capacitor unit		•	•	•	
CLMD 83	Standard capacitor unit		•	•	•	
CLMD-PJ	Pump Jack		•	•	•	•

Maximum rating (non-fused)

Type	Description	Kvar maximum		
		240V	480V	600V
CLMD 13	Standard capacitor unit	10	15	15
CLMD 33	Standard capacitor unit	14	30	30
CLMD 43	Standard capacitor unit	14	30	25
CLMD 53	Standard capacitor unit	30	50	40
CLMD 63	Standard capacitor unit	60	75	80
CLMD 83	Standard capacitor unit	-	100	100
CLMD-PJ	Pump Jack	-	30	30

Ordering Part Numbers

CLMD 13 and CLMD 33 enclosure size

The CLMD 13 and CLMD 33 capacitors are ideally suited for use in motor control centers, control panels and other indoor applications. Standard features include:

– Indoor steel enclosure
– Easy electrical connection by means of a terminal block mounted on top of the capacitor enclosure
– Convenient ground lug mounted on top of the capacitor enclosure
– Mounting feet for easy installation
– Lightweight, small dimensions, totally dry construction

Standard capacitors, individual Non-fused (refer to the ordering information for more options).

240V / 60Hz / 3 Phase		
Enclosure serie	Kvar rating	NEMA 1
13	1.5	C241G1.5
	2.0	C241G2
	3.5	C241G3.5
	4.0	C241G4
	5.0	C241G5
	7.0	C241G5
	10.0	C241G10

480V / 60Hz / 3 Phase		
Enclosure serie	Kvar rating	NEMA 1
13	2.0	C481G2
	3.0	C481G3
	4.0	C481G4
	5.0	C481G5
	7.5	C481G7.5
	10.0	C481G10
	12.5	C481G12.5
	15.0	C481G15

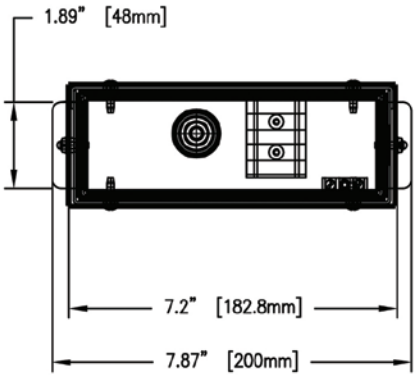
600V / 60Hz / 3 Phase		
Enclosure serie	Kvar rating	NEMA 1
13	2.0	C601G2
	3.0	C601G3
	4.0	C601G4
	5.0	C601G5
	7.5	C601G7.5
	10.0	C601G10
	12.5	C601G12.5
	15.0	C601G15

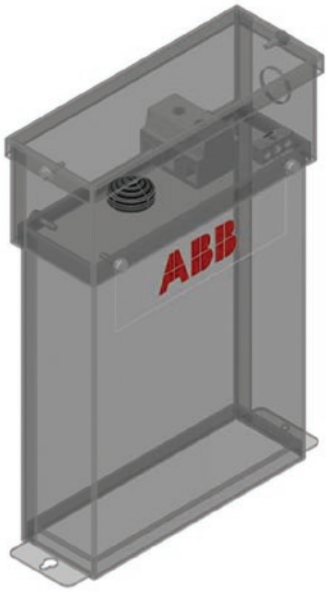
240V / 60Hz / 3 Phase		
Enclosure serie	Kvar rating	NEMA 1
33	2.0	C243G2
	4.0	C243G4
	5.0	C243G5
	7.0	C243G7
	10.0	C243G10
	14.0	C243G14

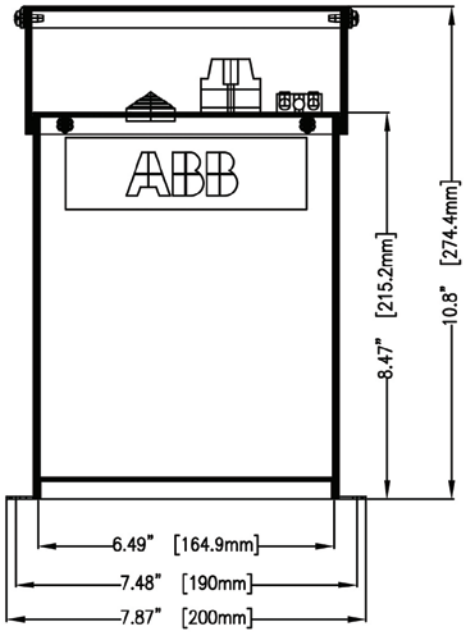
480V / 60Hz / 3 Phase		
Enclosure serie	Kvar rating	NEMA 1
33	2.0	C483G2
	3.0	C483G3
	4.0	C483G4
	5.0	C483G5
	7.5	C483G7.5
	10.0	C483G10
	12.5	C483G12.5
	15.0	C483G15
	17.5	C483G17.5
	20.0	C483G20
	25.0	C483G25
	30.0	C483G30

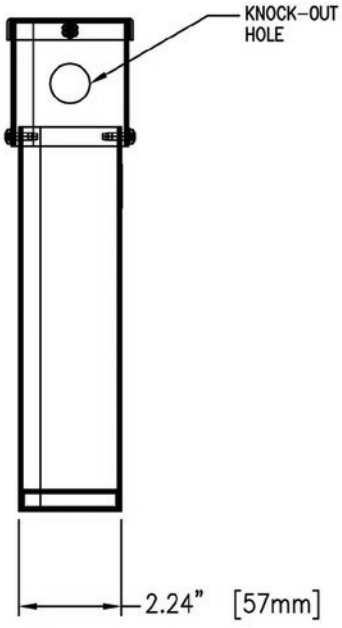
600V / 60Hz / 3 Phase		
Enclosure serie	Kvar rating	NEMA 1
33	2.0	C603G2
	3.0	C603G3
	4.0	C603G4
	5.0	C603G5
	7.5	C603G7.5
	10.0	C603G10
	12.5	C603G12.5
	15.0	C603G15
	17.5	C603G17.5
	20.0	C603G20
	25.0	C603G25
	30.0	C603G30

Dimensions
CLMD 13 Enclosure

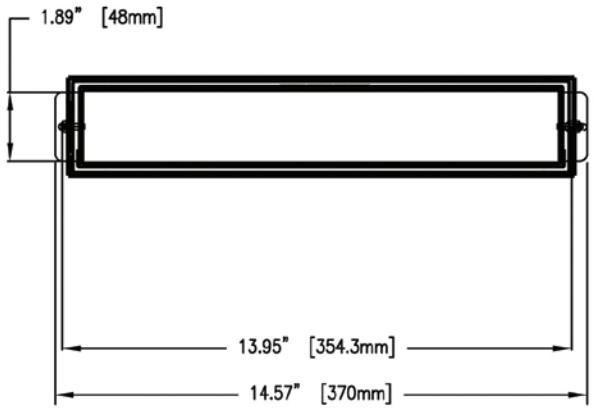


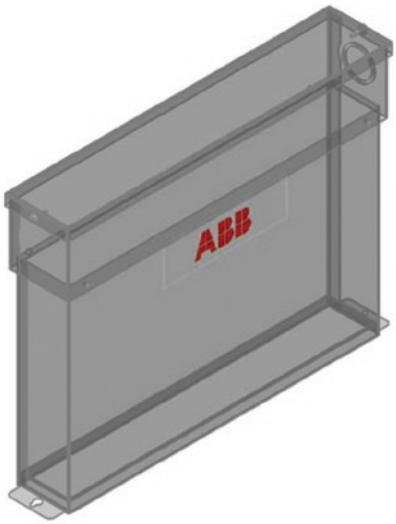


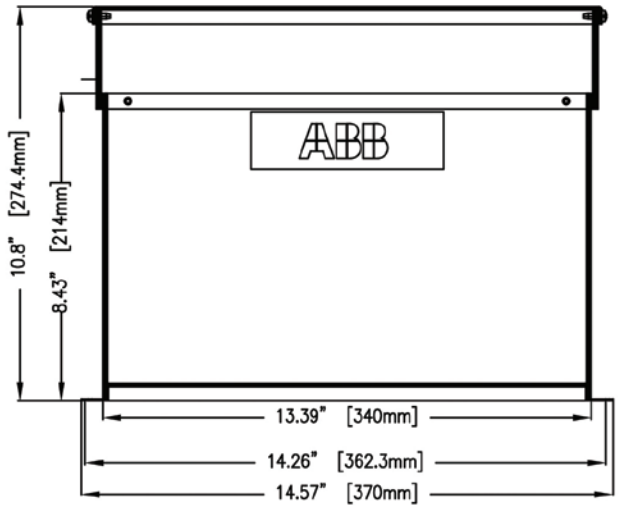


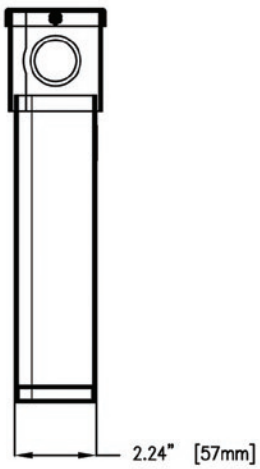


Dimensions
CLMD 33 Enclosure









Ordering Part Numbers
CLMD 43 to 83 Enclosure

CLMD 43 to 83 standard capacitors are suitable for general power factor correction applications, for connection directly at the reactive source.

Features include:
– Dry, environmentally safe construction
– Self healing capability
– Patented internal protected elements
– TYPE 1, 3R, 12
– Easy electrical connection to large terminals
– Convenient grounding lug
– Mounting feet for easy installation

Individual Non-fused (refer to the ordering information for more options)

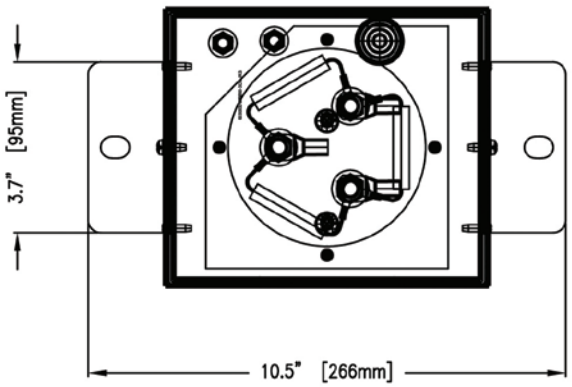
240V / 60Hz / 3 Phase		
Enclosure serie	**Kvar rating**	**NEMA 1**
43	2.2	C244G2
	3.5	C244G3.5
	5.0	C244G5
	7.0	C244G7
	10.0*	C244G10
	14.0*	C244G14
53	20.0	C245G20
	25.0	C245G25
	30.0	C245G30
63	40.0	C246G40
	50.0	C246G50
	60.0	C246G60

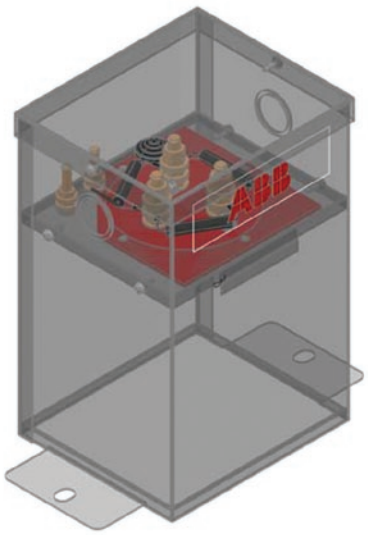
480V / 60Hz / 3 Phase		
Enclosure serie	**Kvar rating**	**NEMA 1**
43	2.0	C484G2
	3.0	C484G3
	4.0	C484G4
	5.0	C484G5
	7.5	C484G7.5
	10.0	C484G10
	12.5	C484G12.5
	15.0	C484G15
	17.5	C484G17.5
	20.0*	C484G20
	25.0*	C484G25
	30.0*	C484G30
53	35.0	C485G35
	40.0	C485G40
	45.0	C485G45
	50.0	C485G50
63	60.0	C486G60
	70.0	C486G70
	75.0	C486G75
83	80.0	C488G80
	90.0	C488G90
	100.0	C488G100

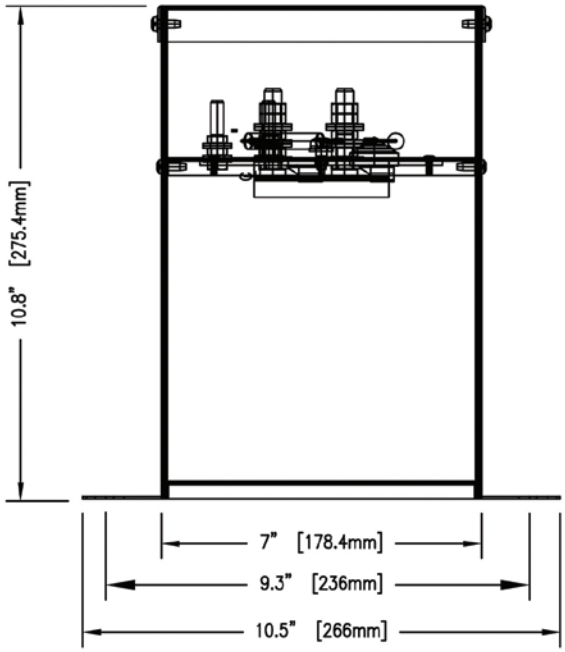
600V / 60Hz / 3 Phase		
Enclosure serie	**Kvar rating**	**NEMA 1**
43	2.0	C604G2
	3.0	C604G3
	74.0	C604G4
	5.0	C604G5
	7.5	C604G7.5
	10.0	C604G10
	12.5	C604G12.5
	14.0	C604G14
	15.0	C604G15
	17.5*	C604G17.5
	20.0*	C604G20
	25.0*	C604G25
53	30.0	C605G30
	35.0	C605G35
	40.0	C605G40
63	45.0	C606G45
	50.0	C606G50
	60.0	C606G60
	70.0	C606G70
	75.0	C606G75
	80.0	C606G80
83	90.0	C608G90
	100.0	C608G100

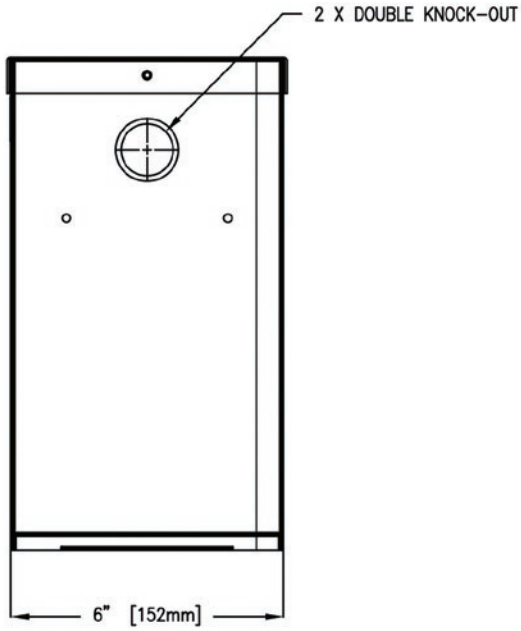
*For -3F/3FI option the enclosure will change to a CLMD 53.

Dimensions
CLMD 43 Enclosure

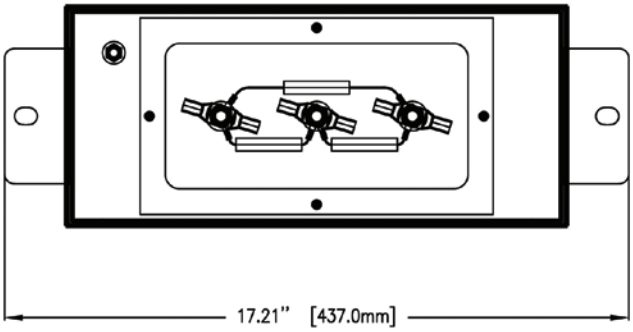


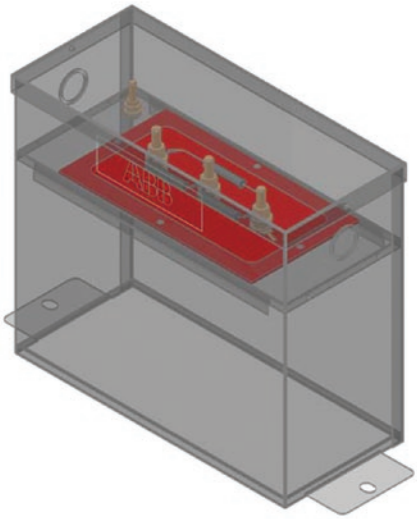


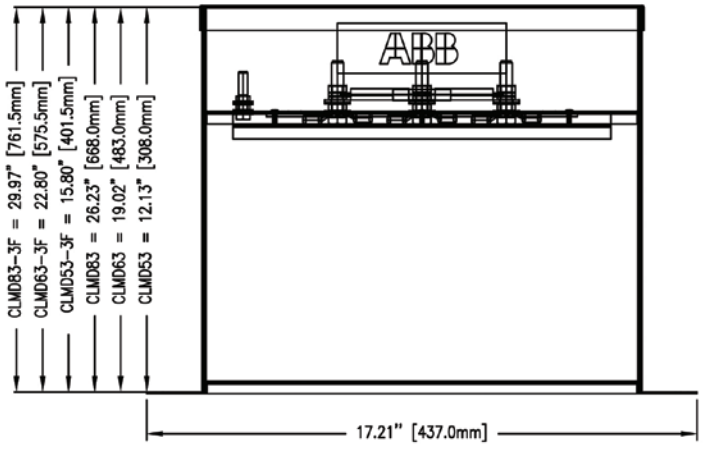


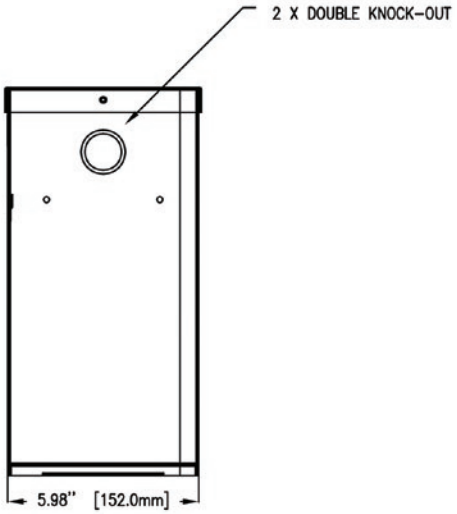


Dimensions
CLMD 53 to 83 Enclosure

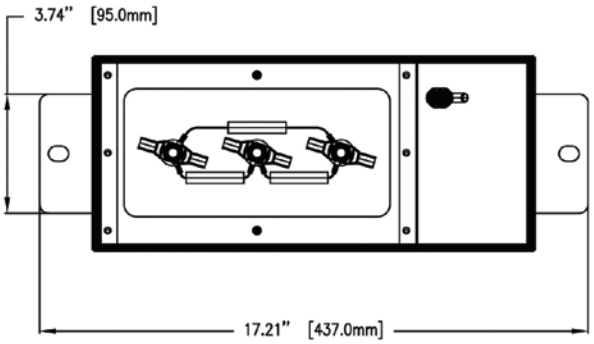


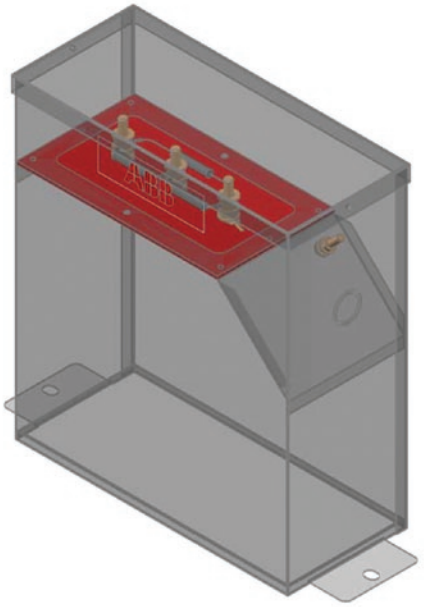


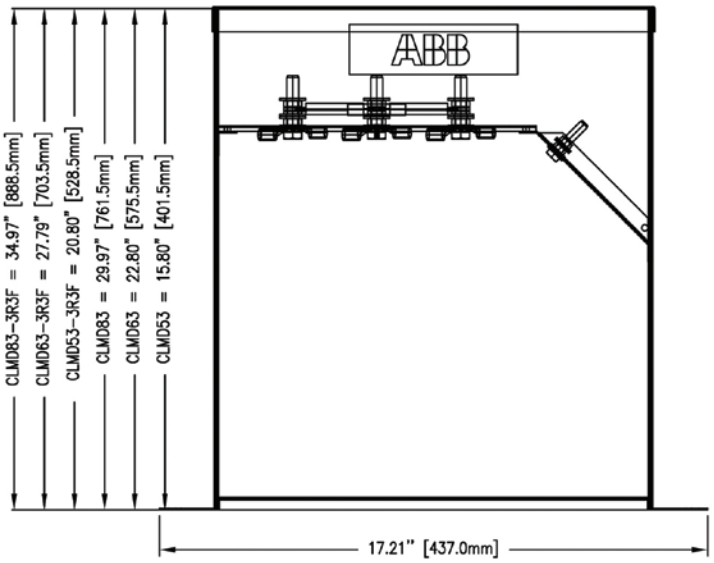


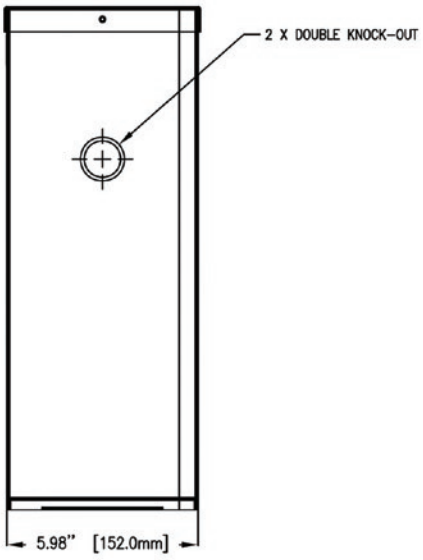


Dimensions
CLMD 53 to 83 3R Enclosure







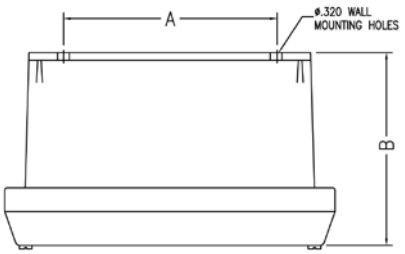


Pump Jack Capacitor

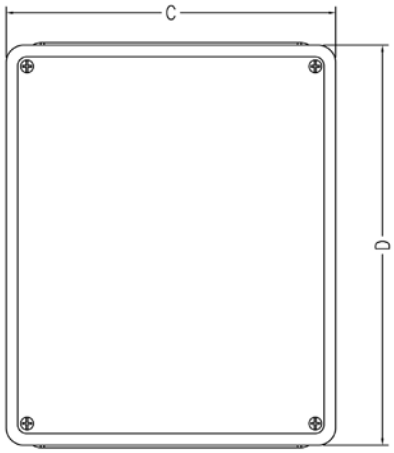
The CLMD-PJ capacitor is ideally suited for outdoor applications like oil-field pumping units.

Standard features include:
– Outdoor, weatherproof enclosure NEMA 1/12/3R/4/4x
– 1 meter (3') of wire for ease of installation
– Convenient pole-mounting design
– Lightweight, totally dry construction

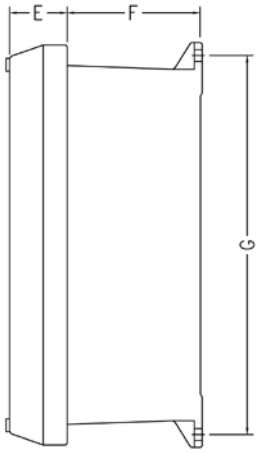
Dimensions



TOP VIEW



FRONT VIEW



RIGHT SIDE VIEW

480V / 60Hz / 3 Phase		
Enclosure serie	Kvar rating	NEMA 1
23	2.0	P482P2
	3.0	P482P3
	4.0	P482P4
	5.0	P482P5
	6.0	P482P6
	7.5	P482P7.5
	10.0	P482P10
	12.5	P481P12.5
	15.0	P481P15
	17.5	P482P17.5
	20.0	P482P20
	22.0	P482P22
	25.0	P482P25
	30.0	P482P30

600V / 60Hz / 3 Phase		
Enclosure serie	Kvar rating	NEMA 1
23	2.0	P602P2
	3.0	P602P3
	4.0	P602P4
	5.0	P602P5
	7.5	P602P7.5
	10.0	P602P10
	12.5	P602P12.5
	15.0	P602P15
	17.5	P602P17.5
	20.0	P602P20
	22.0	P602P22
	25.0	P602P25
	30.0	P602P30

	A	B	C	D	E	F	G
Pump Jack 1 – 15kvar	6.05" 152.8mm	5.43" 137.9mm	9.31" 236.5mm	11.31" 287.3mm	1.62" 41.1mm	3.75" 95.2mm	10.72" 272.3mm
Pump Jack 16 – 30kvar	10.00" 254.1mm	8.26" 209.8mm	13.32" 338.3mm	15.32" 389.1mm	3.24" 82.4mm	4.99" 126.7mm	14.76" 374.8mm

Fixed Capacitor Bank

Fixed capacitor banks are suitable for direct compensation where fixed power factor correction is desired.

Some of the features:
– Dry environmentally safe construction
– Self healing capability
– Patented Internal Protected Elements
– Individual capacitors connected by power distribution blocs
– Indoor, dust tight or rain tight enclosure
– Individual capacitor cells are UL listed or CSA certified; overall assembly follows NEMA 1, 3R or 12 construction
– Easy mounting
– Easy electrical connection to large terminals
– Convenient grounding lug

Individual Non-fused (refer to the Ordering Information for more options)

480V / 60Hz / 3 Phase

Enclosure serie	Kvar rating	Qty/Kvar	Nema 1	Nema 3R	Nema 12
CLMD-3	120	2/60	F486G120	F486R120	F486D120
	140	2/70	F486G140	F486R140	F486D140
	150	3/50	F486G150	F486R150	F486D150
	180	2/90	F488G180	F488R180	F488D180
	200	2/100	F488G200	F488R200	F488D200
	225	3/75	F486G225	F486R225	F486D225
	250	2/100+1/50	F488G250	F488R250	F488D250
	300	3/100	F488G300	F488R300	F488D300
CLMD-5	350	3/100+1/50	F488G350	F488R350	F488D350
	400	4/100	F488G400	F488R400	F488D400
	450	5/90	F488G450	F488R450	F488D450
	500	5/100	F488G500	F488R500	F488D500

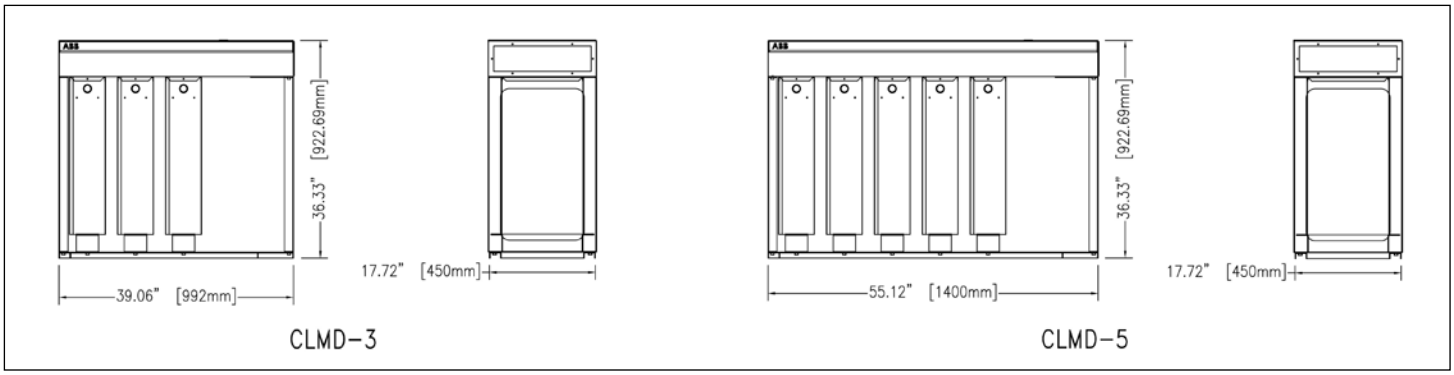
240V / 60Hz / 3 Phase

Enclosure serie	Kvar rating	Qty/Kvar	Nema 1	Nema 3R	Nema 12
CLMD-3	70	2/35	F246G70	F246R70	F246D70
	80	2/40	F246G80	F246R80	F246D80
	90	2/45	F246G90	F246R90	F246D90
	100	2/50	F246G100	F246R100	F246D100
	110	2/55	F246G110	F246R110	F246D110
	120	2/60	F246G120	F246R120	F246D120
	130	2/35	F246G130	F246R130	F246D130
	150	3/50	F246G150	F246R150	F246D150
	160	2/50 +1/60	F246G160	F246R160	F246D160
	180	3/60	F246G180	F246R180	F246D180
CLMD-5	200	4/50	F246G200	F246R200	F246D200
	250	5/50	F246G250	F246R250	F246D250
	300	5/60	F246G300	F246R300	F246D300

600V / 60Hz / 3 Phase

Enclosure serie	Kvar rating	Qty/Kvar	Nema 1	Nema 3R	Nema 12
CLMD-3	120	2/60	F606G120	F606R120	F606D120
	140	2/70	F606G140	F606R140	F606D140
	150	3/50	F606G150	F606R150	F606D150
	180	2/90	F608G180	F608R180	F608D180
	200	2/100	F608G200	F608R200	F608D200
	225	3/75	F606G225	F606R225	F606D225
	250	2/100+1/50	F608G250	F608R250	F608D250
	300	3/100	F608G300	F608R300	F608D300
CLMD-5	350	3/100+1/50	F608G350	F608R350	F608D350
	400	4/100	F608G400	F608R400	F608D400
	450	5/90	F608G450	F608R450	F608D450
	500	5/100	F608G500	F608R500	F608D500

Dimensions



Sizing Low Voltage Capacitors at the Motor Load

Sizing capacitors at the motor load

When the determination is made that power factor correction capacitors ARE a good investment for a particular electrical system, you need to know:
– How many capacitors are needed?
– What sizes are appropriate?

The capacitor provides a local source of reactive current. With respect to inductive motor load, this reactive power is the magnetizing or “no-load current“ which the motor requires to operate.

A capacitor is properly sized when its full load current rating is 90% of the no-load current of the motor. This 90% rating avoids overcorrection and the accompanying problems such as overvoltages.

One selection method: Using formulas.

If no-load current is known...

The most accurate method of selecting a capacitor is to take the no-load current of the motor, and multiply by .90 (90%). Take this resulting figure, turn to the appropriate catalog page, and determine which kvar size is needed, catalog number, enclosure type, and price.

EXAMPLE: Size a capacitor for a 100hp, 460V 3-phase motor which has a full load current of 124 amps and a noload current of 37 amps.

1. Multiply the no-load current figure of 37 amps by 90%.
   37 no load amps X 90% = 33 no load amps

2. Turning to the catalog page for 480 volt, 3-phase capacitors, find the closest amp rating to, but NOT OVER 33 amps. See table 1, sample part number chart. Per the sample chart the closest amperage is 30.1 amps. The proper capacitor unit, then is 25 kvar and the appropriate catalog number depends on the type enclosure desired.

NOTE: The formula method corrects power factor to approximately .95

If the no load current is not known...

If the no-load current is unknown, a reasonable estimate for 3-phase motors is to take the full load amps and multiply by 30%. Then take that figure and multiply times the 90% rating figure being used to avoid overcorrection and overvoltages.

EXAMPLE: Size a capacitor for a 75hp, 460V 3-phase motor which has a full load current of 92 amps and an unknown noload current.

1. First, find the no-load current by multiplying the full load current times 30%.
   92 (full load amps) X 30% = 28 estimated no-load amps

2. Multiply 28 no-load amps by 90%.
   28 no-load amps X 90% = 25 no-load amps

3. Now examine the capacitor selection chart for 480 volt, 3-phase capacitors. Refer again to Table 1. Here it will be seen that the closest capacitor to 25 amps full load current without going over is a 20 kvar unit, rated at 24.1 amps.

4. The correct selection, then, is 20 kvar!

Table 1 – 480 Volt, 60 Hz – 3-Phase

Enclosure size type CLMD	Kvar rating	Rated current per phase (Amps)	Approx. shipping weight (lbs.)	Indoor - NEMA 1 catalog no.
43	2	2.4	8	C484G2
	3	3.6	8	C484G3
	4	4.8	8	C484G4
	5	6.0	8	C484G5
	7.5	9.0	8	C484G7.5
	10	12.0	8	C484G10
	15	18.0	8	C484G15
	20	24.1	13	C484G20
	25	30.1	13	C484G25
53	30	36.1	13	C485G30
	35	42.1	22	C485G35

Sizing Capacitors
An Alternate Selection Method Using Charts

An Alternate Selection Method Using Charts

Table 2 – Suggested maximum capacitor ratings for T-frame EEMAC class B motors (600V and below)

INDUCTION MOTOR RATING (HP)	NOMINAL MOTOR SPEED											
	3600 R/MIN		1800 R/MIN		1200 R/MIN		900 R/MIN		720 R/MIN		600 R/MIN	
	CAPACITOR RATING (kvar)	LINE CURRENT REDUCTION (%)	CAPACITOR RATING (kvar)	LINE CURRENT REDUCTIONS (%)	CAPACITOR RATING (kvar)	LINE CURRENT REDUCTION (%)	CAPACITOR RATING (kvar)	LINE CURRENT REDUCTION (%)	CAPACITOR RATING (kvar)	LINE CURRENT REDUCTION (%)	CAPACITOR RATING (kvar)	LINE CURRENT REDUCTION (%)
3	1.5	14	1.5	23	2.5	28	3	38	3	40	4	40
5	2	14	2.5	22	3	26	4	31	4	40	5	40
7.5	2.5	14	3	20	4	21	5	28	5	38	6	45
10	4	14	4	18	5	21	6	27	7.5	36	8	38
15	5	12	5	18	6	20	7.5	24	8	32	10	34
20	6	12	6	17	7.5	19	9	23	12	25	18	30
25	7.5	12	7.5	17	8	19	10	23	12	25	18	30
30	8	11	8	16	10	19	14	22	15	24	22.5	30
40	12	12	13	15	16	19	18	21	22.5	24	25	30
50	15	12	18	15	20	19	22.5	21	24	24	30	30
60	18	12	21	14	22.5	17	26	20	30	22	35	28
75	20	12	23	14	25	15	28	17	33	14	40	19
100	22.5	11	30	14	30	12	35	16	40	15	45	17
125	25	10	36	12	35	12	42	14	45	15	50	17
150	30	10	42	12	40	12	52.5	14	52.5	14	60	17
200	35	10	50	11	50	10	65	13	68	13	90	17
250	40	11	60	10	62.5	10	82	13	87.5	13	100	17
300	45	11	68	10	75	12	100	14	100	13	120	17
350	50	12	75	8	90	12	120	13	120	13	135	15
400	75	10	80	8	100	12	130	13	140	13	150	15
450	80	8	90	8	120	10	140	12	160	14	160	15
500	100	8	120	9	150	12	160	12	180	13	180	15

Applies to three-phase, 60Hz motors when switched with capacitors as a single unit.

Another method of selecting the proper capacitor employs the use of only a selection chart shown in table 2, 3 or 4. These tables take other variables such as motor RPM into consideration in making recommendations for capacitor applications. They are convenient because they only require that the user know the horsepower and RPM of the motor. Both tables estimate the percentage reduction in full load current drawn by the motor as a result of the capacitor's installation.

WARNING! NEVER OVERSIZE CAPACITORS OR EXCEED 1.0 POWER FACTOR OR RESULTING PROBLEMS WITH THE MOTOR CAN OCCUR!!

If calculations or a kvar determination chart indicate a kvar rating not found in a pricing and selection chart, always refer to the next lower kvar rating!

EXAMPLE: A manufacturer needs to determine the proper capacitors required for a 1200 RPM, 75HP T-Frame EEMAC class B motor.

1. First find 75 in the horsepower column of the chart. (table 2)

2. Locate the 1200 RPM capacitor rating (kvar) column. Note the figure of 25 kvar.

NOTE: Using the above charts for selecting capacitors will correct power to approximately .95.

Table 3 – 2300V and 4160V motors, enclosure open – including dripproof and splashproof, normal starting torque and current, NEMA design "B" and larger motors of similar design.

Nominal motor speed in rpm and number of poles												
Induction-motor horsepower rating	3600 RPM 2		1800 RPM 4		1200 RPM 6		900 RPM 8		720 RPM 10		600 RPM 12	
	kvar	%AR	kvar	%AR	kvar	%AR	kvar	%AR	kvar	%AR	kvar	%AR
100	20	7	25	10	25	11	25	11	30	12	45	17
125	30	7	30	9	30	10	30	10	30	11	45	15
150	30	7	30	8	30	8	30	9	30	11	60	15
200	30	7	30	6	45	8	60	9	60	10	75	14
250	45	7	45	5	60	8	60	9	75	10	90	14
300	45	7	45	5	75	8	75	9	75	9	90	12
350	45	6	45	5	75	8	75	9	75	9	90	11
400	60	5	60	5	75	6	90	9	90	9	90	10
450	75	5	60	5	75	6	90	8	90	8	90	8
500	75	5	75	5	90	6	120	8	120	8	120	8
600	75	5	90	5	90	5	120	7	120	8	135	8
700	90	5	90	5	90	5	135	7	150	8	150	8
800	90	5	120	5	120	5	150	7	150	8	150	8

Table 4 – 2300V and 4160V motors, totally enclosed, fan cooled, normal starting torque, normal starting current, NEMA design "B" and larger motors of similar design.

Nominal motor speed in rpm and number of poles												
Induction-motor horsepower rating	3600 RPM 2		1800 RPM 4		1200 RPM 6		900 RPM 8		720 RPM 10		600 RPM 12	
	kvar	%AR	kvar	%AR	kvar	%AR	kvar	%AR	kvar	%AR	kvar	%AR
100	20	5	20	8	20	8	30	11	30	12	30	14
125	20	5	25	7	30	8	30	11	30	11	45	14
150	20	5	30	7	30	8	45	11	45	11	60	14
200	30	5	45	7	45	8	45	11	45	11	75	14
250	30	5	45	7	60	8	60	9	75	11	75	14
300	45	5	45	7	60	8	75	9	90	11	90	14
350	60	5	60	7	90	8	90	9	90	11	135	14
400	60	5	75	7	90	8	90	9	90	11	135	13
450	60	5	90	7	90	8	90	9	90	10	135	13
500	75	5	120	7	135	8	135	9	135	10	150	13

Sizing Capacitors

Table 5 – 480 Volt, 60 Hz – 3-Phase

ORIGINAL POWER FACTOR IN PER CENT	DESIRED CORRECTED POWER FACTOR IN PER CENT																				
	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
50	0.982	1.008	1.034	1.060	1.086	1.112	1.139	1.165	1.192	1.220	1.248	1.276	1.306	1.337	1.369	1.403	1.442	1.481	1.529	1.590	1.732
51	.937	.962	.989	1.015	1.041	1.067	1.094	1.120	1.147	1.175	1.203	1.231	1.261	1.292	1.324	1.358	1.395	1.436	1.484	1.544	1.687
52	.893	.919	.945	.971	.997	1.023	1.050	1.076	1.103	1.131	1.159	1.187	1.217	1.248	1.280	1.314	1.351	1.392	1.440	1.500	1.643
53	.850	.876	.902	.928	.954	.980	1.007	1.033	1.060	1.088	1.116	1.144	1.174	1.205	1.237	1.271	1.308	1.349	1.397	1.457	1.600
54	.809	.835	.861	.887	.913	.939	.966	.992	1.019	1.047	1.075	1.103	1.133	1.164	1.196	1.230	1.267	1.308	1.356	1.416	1.669
55	.769	.795	.821	.847	.873	.899	.926	.952	.979	1.007	1.035	1.063	1.090	1.124	1.156	1.190	1.228	1.268	1.316	1.377	1.519
56	.730	.756	.782	.808	.834	.860	.887	.913	.940	.968	.996	1.024	1.051	1.085	1.117	1.151	1.189	1.229	1.277	1.338	1.480
57	.692	.718	.744	.770	.796	.822	.849	.875	.902	.930	.958	.986	1.013	1.047	1.079	1.113	1.151	1.191	1.239	1.300	1.442
58	.655	.681	.707	.733	.759	.785	.812	.838	.865	.893	.921	.949	.976	1.010	1.042	1.076	1.114	1.154	1.202	1.263	1.405
59	.618	.644	.670	.696	.722	.748	.775	.801	.828	.856	.884	.912	.939	.973	1.005	1.039	1.077	1.117	1.165	1.226	1.368
60	.584	.610	.636	.662	.688	.714	.741	.767	.794	.822	.850	.878	.907	.939	.971	1.005	1.043	1.083	1.131	1.192	1.334
61	.549	.575	.601	.627	.653	.679	.706	.732	.759	.787	.815	.843	.870	.907	.936	.970	1.008	1.048	1.096	1.157	1.299
62	.515	.541	.567	.593	.619	.645	.672	.698	.725	.753	.781	.809	.836	.870	.902	.936	.974	1.014	1.062	1.123	1.265
63	.483	.509	.535	.561	.587	.613	.640	.666	.693	.721	.749	.777	.804	.838	.870	.904	.942	.982	1.030	1.091	1.233
64	.450	.476	.502	.528	.554	.580	.607	.633	.660	.688	.716	.744	.771	.805	.837	.871	.909	.949	.997	1.058	1.200
65	.419	.445	.471	.497	.523	.549	.576	.602	.629	.657	.685	.713	.740	.774	.806	.840	.878	.918	.966	1.027	1.169
66	.368	.414	.440	.466	.492	.518	.545	.571	.598	.626	.654	.682	.709	.743	.775	.809	.847	.887	.935	.996	1.138
67	.358	.384	.410	.436	.462	.488	.515	.541	.568	.596	.624	.652	.679	.713	.745	.779	.817	.857	.905	.966	1.108
68	.329	.355	.381	.407	.433	.459	.486	.512	.539	.567	.595	.623	.650	.684	.716	.750	.788	.828	.876	.937	1.079
69	.299	.325	.351	.377	.403	.429	.456	.482	.509	.537	.565	.593	.620	.654	.686	.720	.758	.798	.840	.907	1.049
70	.270	.296	.322	.348	.374	.400	.427	.453	.480	.508	.536	.564	.591	.625	.657	.691	.729	.769	.811	.878	1.020
71	.242	.268	.294	.320	.346	.372	.399	.425	.452	.480	.508	.536	.563	.597	.629	.663	.701	.741	.783	.850	.992
72	.213	.239	.265	.291	.317	.343	.370	.396	.423	.451	.479	.507	.538	.568	.600	.634	.672	.712	.754	.821	.963
73	.186	.212	.238	.264	.290	.316	.343	.369	.396	.424	.452	.480	.507	.541	.573	.607	.645	.685	.727	.794	.936
74	.159	.185	.211	.237	.263	.289	.316	.342	.369	.397	.425	.453	.480	.514	.546	.580	.616	.658	.700	.767	.909
75	.132	.158	.184	.210	.236	.262	.289	.315	.342	.370	.398	.426	.453	.487	.519	.553	.591	.631	.673	.740	.882
76	.105	.131	.157	.183	.209	.235	.262	.288	.315	.343	.371	.399	.426	.460	.492	.526	.564	.604	.652	.713	.855
77	.079	.105	.131	.157	.183	.209	.236	.262	.289	.317	.345	.373	.400	.434	.466	.500	.538	.578	.620	.687	.829
78	.053	.079	.105	.131	.157	.183	.210	.236	.263	.291	.319	.347	.374	.408	.440	.474	.512	.552	.594	.661	.803
79	.026	.052	.078	.104	.130	.156	.183	.209	.236	.264	.292	.320	.347	.381	.413	.447	.485	.525	.567	.634	.776
80	.000	.026	.052	.078	.104	.130	.157	.183	.210	.238	.266	.294	.321	.355	.387	.421	.459	.499	.541	.608	.750
81	-	.000	.026	.052	.078	.104	.131	.157	.184	.212	.240	.268	.295	.329	.361	.395	.433	.473	.515	.582	.724
82	-	-	.000	.026	.052	.078	.105	.131	.158	.186	.214	.242	.269	.303	.335	.369	.407	.447	.489	.556	.698
83	-	-	-	.000	.026	.052	.079	.105	.132	.160	.188	.216	.243	.277	.309	.343	.381	.421	.463	.530	.672
84	-	-	-	-	.000	.026	.053	.079	.106	.134	.162	.190	.217	.251	.283	.317	.355	.395	.437	.504	.645
85	-	-	-	-	-	.000	.027	.053	.080	.108	.136	.164	.191	.225	.257	.291	.329	.369	.417	.478	.620
86	-	-	-	-	-	-	.000	.026	.053	.081	.109	.137	.167	.198	.230	.265	.301	.343	.390	.451	.593
87	-	-	-	-	-	-	-	.000	.027	.055	.082	.111	.141	.172	.204	.238	.275	.317	.364	.425	.567
88	-	-	-	-	-	-	-	-	.000	.028	.056	.084	.114	.145	.177	.211	.248	.290	.337	.398	.540
89	-	-	-	-	-	-	-	-	-	.000	.028	.056	.086	.117	.149	.183	.220	.262	.309	.370	.512
90	-	-	-	-	-	-	-	-	-	-	.000	.028	.058	.089	.121	.155	.192	.234	.281	.342	.484
91	-	-	-	-	-	-	-	-	-	-	-	.000	.030	.061	.093	.127	.164	.206	.253	.314	.456
92	-	-	-	-	-	-	-	-	-	-	-	-	.000	.031	.063	.097	.134	.176	.223	.284	.426
93	-	-	-	-	-	-	-	-	-	-	-	-	-	.000	.032	.066	.103	.145	.192	.253	.395
94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.000	.034	.071	.113	.160	.221	.363
95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.000	.037	.079	.126	.187	.328
96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.000	.042	.089	.150	.292
97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.000	.047	.108	.251
98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.000	.061	.203
99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.000	.142

Sizing capacitors for improving system power factor

Sizing and selecting capacitors for system power factor correction is calculated using a power factor correction chart. Before this chart can be used, however, the total kW requirement needs to be known for the ENTIRE system in addition to the PRESENT and DESIRED power factors.

EXAMPLE: A plant has a present power factor level of .75; a load draws 806 amps at 480V; average power consumption of 500kW; and a desired power factor level of .90. Compute the necessary capacitance required and select the proper automatic and fixed bank unit.

1. First, look at the left hand column of the power factor correction chart entitled “original power factor”. Find your current power factor level of .75.

2. Second, follow the column of figures to the right of the .75 figure until you come to the column entitled “.90” (your desired power factor level).

3. The number in that row is .398. Now multiply this figure by the total plant kW of 500:
   .398 X 500kW = 199 kvar

4. The resulting total of 199 represents the amount of capacitive power (kvar) required to bring the power factor to the desired level of .90.

5. Refer to previous pages for appropriate kvar rating.

NOTE: When selecting automatic bank units, select the closest kvar rating to the amount of kvar desired based on present and future applications. If the desired rating is not listed, the next higher kvar rating should be selected. When selecting fixed bank units, however, select the kvar rating WITHOUT GOING OVER (see warning, page 17) the desired capacitance level.

In this example for the automatic capacitor bank, 200 kvar is the closest to the desired 199 kvar. For the fixed capacitor bank, 180 kvar should be selected without going over the desired kvar of 199.

1. First, power factor has to be calculated. Power factor is equal to active power (kW) divided by apparent power (kVA).

Sizing Capacitors

What if present power factor cannot be determined because kVA is unknown?

1. First, find the apparent power (kVA). kVA demand on a 3-phase system is equal to:
   kVA = (VOLTS x AMPS x √3) ÷ 1000

2. The voltage and amperage of the distribution system will be known. Again, using the above example, we know that the distribution system is 480 volts and draws 806 amps. Therefore:
   (480 VOLTS x 806 AMPS x √3) ÷ 1000 = 670kVA

3. Now power factor can be solved for:
   500kW / 670kVA = .746 pf

4. With the power factor now known, the power factor Improvement chart can be used as before.

How is the power factor correction chart used if existing power factor level is unknown?

1. First, power factor has to be calculated. Power factor is equal to active power (kW) divided by apparent power (kVA). kW will be known because it is the total amount of power consumed over a given period of time and is the amount shown on a utility bill. Therefore:
   pf = kW / kVA

2. Using the above example, 500kW divided by 670kVA equals a present power factor (pf) of .746.
   500kW / 670kVA = .746 pf

3. When DETERMINING power factor, always round off to the next higher rating. Therefore, the .746 power factor figure is rounded off to .75.

4. Now that present power factor is known, the above problem can be solved as before.

Fixed capacitor banks

480 Volt, 60 Hz – 3-Phase

Enclosure size	Total kvar	Individual capacitors qty/kvar	Enclosure type indoor - NEMA 1
CLMD-3	120	2/60	F486G120
	140	2/70	F486G140
	160	2/80	F488G160
	180	2/90	F488G180
	200	2/100	F488G200
	210	3/70	F488G210

FINAL EXAMPLE: A manufacturer has a 480 volt, 3-phase metered demand of 460kW. An ammeter on the system shows total current draw of 770 amps. Existing power factor and apparent power (kVA) are unknown. What is the existing system power factor and how much capacitance is required to correct to .92?

1. First, solve for kVA.
   (480 VOLTS x 770 AMPS x √3) ÷ 1000 = 640kVA

2. Next, solve for power factor.
   460kW / 640kVA = .72 POWER FACTOR

3. To correct the power factor from .72 to .92 refer to the power factor correction chart on page 18. A factor of .534 will be determined.

4. The final step is to multiply the 460kW figure by the correction factor of .534.
   460kW X .534 = 245 kvar

This system would require the installation of 245 kvar of capacitance to improve the power factor to .92. Refer to the appropriate automatic or fixed bank catalog pages, select the proper voltage and phase, then identify the proper catalog number.

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1SXP981001D0202/April 2011

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