# Appendix E
# Power Factor Correction Capacitors

## CAUTIONS:

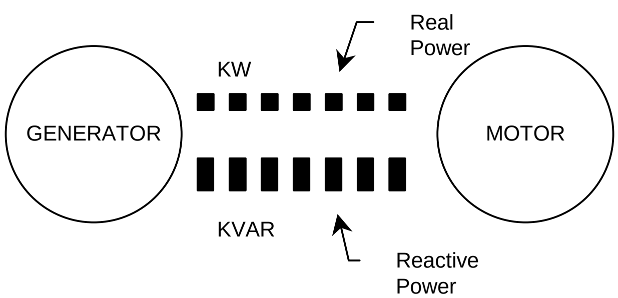
- Do not over correct the power factor of products described in this catalog. Correcting full load power factor beyond approximately 95% will potentially result in severe non-warranty damage to motor and driven equipment.
- Refer to your Emerson Technical Representative for assistance on applying Power Factor Correction Capacitors on Multi-Speed Motors.
- On single voltage motors with Part Winding Start (PWS), Double Delta or Wye Delta Starting, Emerson recommends the capacitor be connected to the motor side of contactors 1-2-3 in the motor starter.
  - If this is unacceptable, then two separate capacitors should be supplied, each with one-half of the desired KVAR rating. One capacitor should be connected to the 1-2-3 motor leads, the second connected to 4-5-6 (or 7-8-9 as applicable).
- Do not apply Power Factor Correction Capacitors to a variable frequency drive. Serious damage to the VFD will result if capacitors are used between the motor and drive. Consult the drive supplier.
- Refer to your Emerson Technical Representative if any questions exist.

## APPLICATION:

Application of Power Factor Correction Capacitors to three phase Squirrel Cage Induction Motors (SCIM) is beneficial because the power used by industrial and municipal facilities has two components.

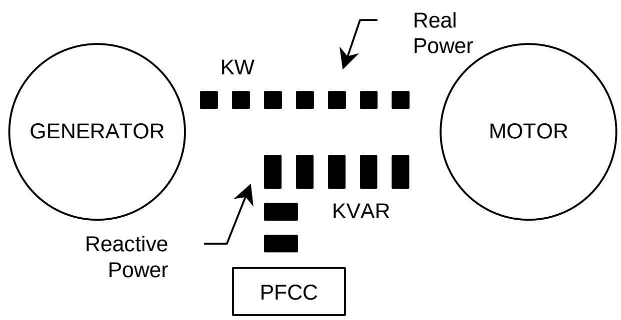
1. Real Power (KW) which produces work.
2. Reactive Power (KVAR) needed to generate the rotating magnetic field required for the operation of electric motors. No useful work is performed by this component.

Reactive Power is sometimes called "wattless power" because inductive electrical equipment such as motors must take from the electrical distribution system more current than is necessary to do the work involved. The ratio of working current to total current is called "Power Factor". The function of Power Factor Correction Capacitors is to increase the power factor by supplying the "wattless power" when installed at or near inductive electrical equipment.




This is an illustration of an SCIM under partially loaded conditions without Power Factor Correction Capacitors (PFCC). Here the power feeder line must supply useful real power and reactive or magnetizing currents.

Installing a PFCC near the same motor will supply the reactive or magnetizing current required to operate it. The total current required of the power feeder line is reduced to the value of the useful real current only.



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Power Factor Correction Capacitors can lower electrical costs. In many areas the cost of electricity includes a penalty charge for low power factor. Installation of Power Factor Correction Capacitors on the distribution system within the plant makes it unnecessary for the utility to supply the wattless or the non-working power required by the inductive electrical equipment connected to it. Savings the utility realizes in reduced generation, transmission, and distribution costs are passed on to the plant in the form of lower electrical bills.

Savings are also possible in the form of increased KVA capacity of plant electrical distribution systems. Installation of PFCC's to furnish the non-productive current requirements makes it possible to increase the plant connected load, as much as 15 to 20 percent, without a corresponding increase in size of transformers, conductors and protective devices making up the distribution system which services the load.

## PRICING EXAMPLE:

Listed in the engineering data section of this catalog is the maximum amount of KVAR allowed to be applied to the specific product described. This generally corrects the motor's full load power factor to 95%. Should a Customer require correction to a lower value, apply the following formula to obtain the required KVAR. KVAR is the unit for rating PFCC and is equal to 1000 volt-amperes of reactive power. This indicates how much reactive power the capacitor will provide.

Example: How many KVAR's are needed to improve the motors existing full load power factor to 92%?

$$\text{Actual Power} = \frac{\text{Volts x Amps x \%P.F. x 1.732}}{1000}$$

$$\text{Actual Power} = \frac{460 \times 582 \times 0.843 \times 1.732}{1000}$$

Actual Power = 390.89 KW

Motor is 500 HP, 1200 RPM, 460 Volts with 84.3% Full Load Power Factor, ODP Horizontal Standard Efficient Type "R" with 582 Full Load Amps.

Obtain from Table 33-1 (next page) the KW Multiplier at the intersection of 84% original power factor and 92% desired power factor: PF Multiplier = 0.22.

KVAR = 390.89 x 0.22 = 86

Performance Data indicates 125 KVAR is maximum, 86 is needed; correction to 92% is possible.

From the 480 Volt PFCC Pricing Chart, the closest rating to 86 required KVAR but not exceeding 125 maximum KVAR is 90. Select 90 KVAR PFCC with $2395 List Price and Discount Symbol DS-3PC, to correct full load power factor to 92.0%.

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## KW MULTIPLIERS:

| TABLE 33-1 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ORIGINAL POWER FACTOR | KW MULTIPLIERS TO DETERMINE CAPACITOR KVAR REQUIRED | | | | | | | | | | | | | | | |
| | CORRECTED POWER FACTOR | | | | | | | | | | | | | | | |
| | 0.80 | 0.81 | 0.82 | 0.83 | 0.84 | 0.85 | 0.86 | 0.87 | 0.88 | 0.89 | 0.90 | 0.91 | 0.92 | 0.93 | 0.94 | 0.95 |
| 0.60 | 0.583 | 0.609 | 0.635 | 0.661 | 0.687 | 0.713 | 0.740 | 0.766 | 0.793 | 0.821 | 0.849 | 0.877 | 0.907 | 0.938 | 0.970 | 1.004 |
| 0.61 | 0.549 | 0.575 | 0.601 | 0.627 | 0.653 | 0.679 | 0.706 | 0.732 | 0.759 | 0.787 | 0.815 | 0.843 | 0.873 | 0.904 | 0.936 | 0.970 |
| 0.62 | 0.516 | 0.542 | 0.568 | 0.594 | 0.620 | 0.646 | 0.673 | 0.699 | 0.726 | 0.754 | 0.782 | 0.810 | 0.840 | 0.871 | 0.903 | 0.937 |
| 0.63 | 0.483 | 0.509 | 0.535 | 0.561 | 0.587 | 0.613 | 0.640 | 0.666 | 0.693 | 0.721 | 0.749 | 0.777 | 0.807 | 0.838 | 0.870 | 0.904 |
| 0.64 | 0.451 | 0.474 | 0.503 | 0.529 | 0.555 | 0.581 | 0.608 | 0.634 | 0.661 | 0.689 | 0.717 | 0.745 | 0.775 | 0.806 | 0.838 | 0.872 |
| 0.65 | 0.419 | 0.445 | 0.471 | 0.497 | 0.523 | 0.549 | 0.576 | 0.602 | 0.629 | 0.657 | 0.685 | 0.713 | 0.743 | 0.774 | 0.806 | 0.840 |
| 0.66 | 0.388 | 0.414 | 0.440 | 0.466 | 0.492 | 0.518 | 0.545 | 0.571 | 0.598 | 0.626 | 0.654 | 0.682 | 0.712 | 0.743 | 0.775 | 0.809 |
| 0.67 | 0.358 | 0.384 | 0.410 | 0.436 | 0.462 | 0.488 | 0.515 | 0.541 | 0.568 | 0.596 | 0.624 | 0.652 | 0.682 | 0.713 | 0.745 | 0.779 |
| 0.68 | 0.328 | 0.354 | 0.380 | 0.406 | 0.432 | 0.458 | 0.485 | 0.511 | 0.538 | 0.566 | 0.594 | 0.622 | 0.652 | 0.683 | 0.715 | 0.749 |
| 0.69 | 0.299 | 0.325 | 0.351 | 0.377 | 0.403 | 0.429 | 0.456 | 0.482 | 0.509 | 0.537 | 0.565 | 0.593 | 0.623 | 0.654 | 0.686 | 0.720 |
| 0.70 | 0.270 | 0.296 | 0.322 | 0.348 | 0.374 | 0.400 | 0.427 | 0.453 | 0.480 | 0.508 | 0.536 | 0.564 | 0.594 | 0.625 | 0.657 | 0.691 |
| 0.71 | 0.242 | 0.268 | 0.294 | 0.320 | 0.346 | 0.372 | 0.399 | 0.425 | 0.452 | 0.480 | 0.508 | 0.536 | 0.566 | 0.597 | 0.629 | 0.663 |
| 0.72 | 0.214 | 0.240 | 0.266 | 0.292 | 0.318 | 0.344 | 0.371 | 0.397 | 0.424 | 0.452 | 0.480 | 0.508 | 0.538 | 0.569 | 0.601 | 0.635 |
| 0.73 | 0.186 | 0.212 | 0.238 | 0.264 | 0.290 | 0.316 | 0.343 | 0.369 | 0.396 | 0.424 | 0.452 | 0.480 | 0.510 | 0.541 | 0.573 | 0.607 |
| 0.74 | 0.159 | 0.185 | 0.211 | 0.237 | 0.263 | 0.289 | 0.316 | 0.342 | 0.369 | 0.397 | 0.425 | 0.453 | 0.483 | 0.514 | 0.546 | 0.580 |
| 0.75 | 0.132 | 0.158 | 0.184 | 0.210 | 0.236 | 0.262 | 0.289 | 0.315 | 0.342 | 0.370 | 0.398 | 0.426 | 0.456 | 0.487 | 0.519 | 0.553 |
| 0.76 | 0.105 | 0.131 | 0.157 | 0.183 | 0.209 | 0.235 | 0.262 | 0.288 | 0.315 | 0.343 | 0.371 | 0.399 | 0.429 | 0.460 | 0.492 | 0.526 |
| 0.77 | 0.079 | 0.105 | 0.131 | 0.157 | 0.183 | 0.209 | 0.236 | 0.262 | 0.289 | 0.317 | 0.345 | 0.373 | 0.403 | 0.434 | 0.466 | 0.500 |
| 0.78 | 0.052 | 0.078 | 0.104 | 0.130 | 0.156 | 0.182 | 0.209 | 0.235 | 0.262 | 0.290 | 0.318 | 0.346 | 0.376 | 0.407 | 0.439 | 0.473 |
| 0.79 | 0.026 | 0.052 | 0.078 | 0.104 | 0.130 | 0.156 | 0.183 | 0.209 | 0.236 | 0.264 | 0.292 | 0.320 | 0.350 | 0.381 | 0.413 | 0.447 |
| 0.80 | 0.000 | 0.026 | 0.052 | 0.078 | 0.104 | 0.130 | 0.157 | 0.183 | 0.210 | 0.238 | 0.266 | 0.294 | 0.324 | 0.355 | 0.387 | 0.421 |
| 0.81 | | 0.000 | 0.026 | 0.052 | 0.078 | 0.104 | 0.131 | 0.157 | 0.184 | 0.212 | 0.240 | 0.268 | 0.298 | 0.329 | 0.361 | 0.395 |
| 0.82 | | | 0.000 | 0.026 | 0.052 | 0.078 | 0.105 | 0.131 | 0.158 | 0.186 | 0.214 | 0.242 | 0.272 | 0.303 | 0.335 | 0.369 |
| 0.83 | | | | 0.000 | 0.026 | 0.052 | 0.079 | 0.105 | 0.132 | 0.160 | 0.188 | 0.216 | 0.246 | 0.277 | 0.309 | 0.343 |
| 0.84 | | | | | 0.000 | 0.026 | 0.053 | 0.079 | 0.106 | 0.134 | 0.162 | 0.190 | 0.220 | 0.251 | 0.283 | 0.317 |
| 0.85 | | | | | | 0.000 | 0.027 | 0.053 | 0.080 | 0.108 | 0.136 | 0.164 | 0.194 | 0.225 | 0.257 | 0.291 |
| 0.86 | | | | | | | 0.000 | 0.026 | 0.053 | 0.081 | 0.109 | 0.137 | 0.167 | 0.198 | 0.230 | 0.264 |
| 0.87 | | | | | | | | 0.000 | 0.027 | 0.055 | 0.083 | 0.111 | 0.141 | 0.172 | 0.204 | 0.238 |
| 0.88 | | | | | | | | | 0.000 | 0.028 | 0.056 | 0.084 | 0.114 | 0.145 | 0.177 | 0.211 |
| 0.89 | | | | | | | | | | 0.000 | 0.028 | 0.056 | 0.086 | 0.117 | 0.149 | 0.183 |
| 0.90 | | | | | | | | | | | 0.000 | 0.028 | 0.058 | 0.089 | 0.121 | 0.155 |
| 0.91 | | | | | | | | | | | | 0.000 | 0.030 | 0.061 | 0.093 | 0.127 |
| 0.92 | | | | | | | | | | | | | 0.000 | 0.031 | 0.063 | 0.097 |
| 0.93 | | | | | | | | | | | | | | 0.000 | 0.032 | 0.066 |
| 0.94 | | | | | | | | | | | | | | | 0.000 | 0.034 |
| 0.95 | | | | | | | | | | | | | | | | 0.000 |