TECHNICAL APPLICATION NOTE **TS 02-000I Issue 0**

MOTOR CAPACITORS

These **Technical application notes** try to facilitate to our customers and/or representatives, concrete answer to problems and doubts that can arise in the use of motor capacitors.

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Codification of capacitors according to **DIN 40040 / VDE 560-8**

Motor capacitors are codified by means of five digits. First three digits constitute the Climatic Range of the capacitor and they establish the environment conditions in which it can work. Last two digits give information on the capacitor reliability.

Example: **H P F N T**

DIGITS: 1st 2nd 3rd 4th 5th

CLIMATIC RANGE							RELIABILITY			
1st digit		2nd digit		3rd digit			4th digit		5th digit	
Lower limit temperature		Higher limit temperature[1)]		Admissible limits of relative humidity (%)[2)]			Nº of failures for 10^9 components-hour[5)]		Expected life[5)]	
Letter	EC	Letter	EC	Letter	Mean[3)]	Max.[4)]	Letter	Nº	Letter	hours
G	- 40	**S**	70				**M**	1000	**S**	30000
H	- 25	**R**	75	**F**	# 75	# 95	**N**	3000	**T**	10000
J	- 10	**P**	85				**P**	10000	**U**	3000
K	0	**M**	100				**Q**	30000	**V**	1000

1) Temperature measured on the surface of the capacitor

2) In motor capacitors it is usual to use only the **F** range

3) Yearly mean value

4) Maximum value for a period non higher than to 30 days per year

5) Pairs **MS**, **NT**, **PU** and **QV** give a failure rate (at the end of the expected life) lower than 3 % Example: **NT**, $3000 \cdot 10^{-9} \cdot h^{-1} \cdot 10000\ h = 0.03$ (3 %)

In the example **HPF NT**, meaning of the letters is then:

H	Lower limit temperature	- 25 EC
P	Higher limit temperature	85 EC
F	Limits of relative humidity	# 75 % Mean; # 95 % Max.
N	Failure rate (at the end of expected life)	# 3 %
T	Expected life	10000 h

Selection of capacitance on motor capacitors

Selection of a permanent capacitor for a single phase motor implies the consideration of technical and economical aspects.

As the winding of a single phase motor can be done in very different ways (division of the winding space between the main winding and the auxiliary winding, selection of the number of winding turns and sections of the winding, and so on), it is not possible to give universal rules to determine the capacitance and the working voltage of the capacitor for a certain power of the motor.

It is then always necessary to apply the criteria established by the motor manufacturer.

However, following it is exposed a calculation procedure with the only aim of being useful for a first evaluation and give an approximate idea of the values of the permanent capacitor:

> It is considered that in general, for each CV of power, a motor capacitor requires **approximately** a reactive power of 1 kvar.

Power of the capacitor can be then determined from the following formula:

$$Q_C = 1.35\,P \quad \text{(kvar)} \qquad [1]$$

Where: Q_C = Capacitor power in kvar
P = Motor power in kW

As the reactive power of the capacitor is being given by:

$$Q_C = U_C^2 \cdot 2 \cdot \pi \cdot f \cdot C \cdot 10^{-9} \quad \text{(kvar)}$$

Where: U_C = Capacitor voltage in V
f = Rated frequency in Hz
C = Capacitance of the capacitor in µF

Capacitance of the capacitor will be then given by:

$$C = \frac{Q_C}{U_C^2 \cdot 2 \cdot \pi \cdot f \cdot 10^{-9}} \quad (\mu F) \qquad [2]$$

Voltage between terminals of the capacitor can be calculated from the current of the auxiliary winding of the motor:

$$\mathbf{U_C = \frac{I_A \cdot 10^6}{2 \cdot \pi \cdot f \cdot C} \quad (V)} \qquad \textbf{[3]}$$

Where: I_A = Current of the auxiliary winding in A

Example: Motor of power **P = 0.05 kW**, with a current in the auxiliary winding of $\mathbf{I_A = 0.17\ A}$

First of all it is calculated the necessary power **[1]**:

$$Q_C = 1.35 \cdot 0.05 = 0.0675 \text{ kvar}$$

immediately after, equations **[2]** and **[3]** are proposed

$$C = \frac{0.0675}{U_C^2 \cdot 2 \cdot \pi \cdot 50 \cdot 10^{-9}} \quad (\mu F)$$

$$U_C = \frac{0.17 \cdot 10^6}{2 \cdot \pi \cdot 50 \cdot C} \quad (V)$$

By resolving the system, it is obtained the following result:

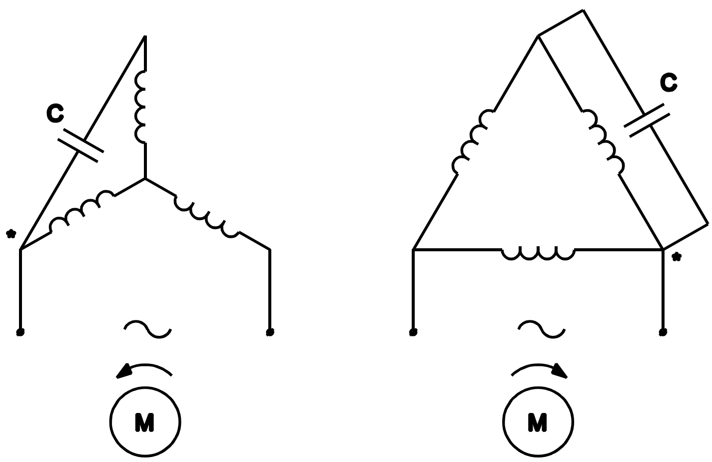
C = 1.4 µF	$\mathbf{U_C}$ **= 397 V**

TECHNICAL APPLICATION NOTE **TS 02-012I Issue 0**

Use of three phase motors in single phase networks

A three-phase motor can be used in a single phase network with the help of a permanent capacitor. Even it is impossible to get the same original working conditions, this system allows to extend the application field of certain types of tools and machinery.

Connection diagram is shown in the figure



Remark: The change of the connection terminal * of the capacitor allows to invert the turning sense of the motor.

Selection of the capacitor

Approximate values of the capacitance on the required capacitor are indicated in the following table. Due to the crossing of the capacitor current through the winding of the motor, its working voltage is higher than the one of the network

Network voltage (V)	Capacitor C	Capacitor voltage U_C
220 V	- 70 µF/kW	- 250 V
110 V	- 240 µF/kW	- 125 V
380 V	- 22 µF/kW	- 430 V

Output of the motor

Values that can be expected from a three-phase motor connected to a single-phase network are those following:

Starting torque: from the 25 to the 30% of the rated one
Maximum voltage: from the 70 to the 80% of the rated power

REMARK: If the starting torque is not enough, it can be improved by adding a motor start capacitor with a capacitance value of approximately two times the pointed. This capacitor must be dimensioned after having carried out test of real application test.