Power Factor

Correction

Inductance

Capacitive

Inductance

As we have seen, gas discharge lamps require some form of control gear to create arc strikes which tend to be in the form of heavily inductive coils such as chokes (ballasts) and transformer windings, motor windings. This causes a reduction in efficiency due to a loss in power factor.

An inductive load will cause the current to Lag the voltage causing higher currents.

Capacitive

Leading PF is caused by a net capacitive load.
The supply current is higher than for a truly resistive load.
Leading power factor means that the current leads the voltage, that is, the load is capacitive.

You can keep PF leading or lagging as long as you want but electricity companies will charge you for use of reactive power in order to supplement the cost of putting bigger cables into their feeders to factories - higher current means bigger cables more loss.

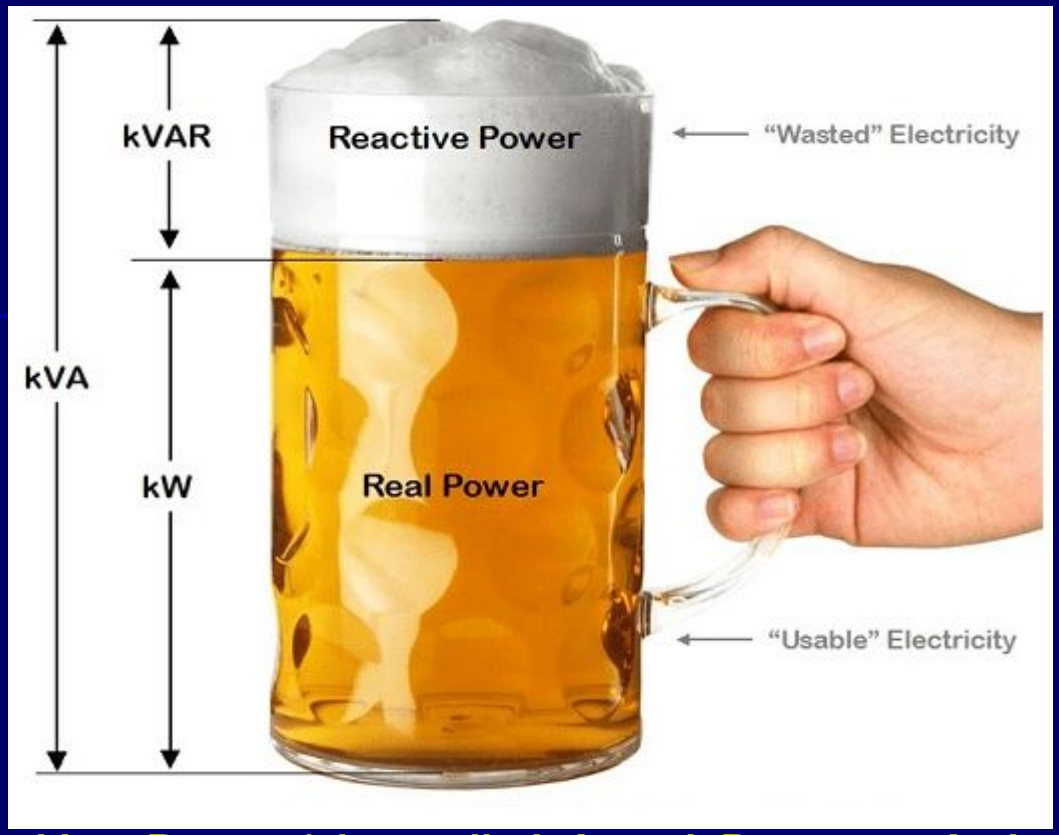
Power Factor

The current in a circuit consists of two main components ; (i) the current contributing to the power being absorbed and, (ii) the magnetising current (sometimes referred to as the "idle" or "wattless" current). The power factor is the relationship between these two components and is commonly shown as:-

$$\text{Power Factor} = \frac{\text{Load in Watts (power absorbed or power input)}}{\text{Supply voltage} \times \text{Total circuit current}}$$

Typically, full load power factors are in the range 0.65 to 0.95.
A low power factor is to everyone's' disadvantage, particularly the Supply Authority, since it limits the capacity of their generating equipment. In order to operate at their designed output, circuits should, ideally, have a power factor of unity, or 1

Active Power = Volts x Amps x Cos Ø .



- **KW - Working Power (also called Actual Power or Active Power or Real Power)** :- It is the power that actually powers the equipment and performs useful work.

- **kVAR - Reactive Power** :- It is the power that magnetic equipment (transformer, motor and relay)needs to produce the magnetizing flux.

- **kVA - Apparent Power** :- It is the hypotenuse "Of the power triangle" of KVAR and KW.

Power Factor (P.F.) is the ratio of Working Power to Apparent Power.

$$P.F. = \frac{KW}{KVA}$$

Looking at our beer mug analogy above, power factor would be the ratio of beer (***KW***) to beer plus foam (***KVA***).

$$P.F. = \frac{KW}{KW + KVAR}$$

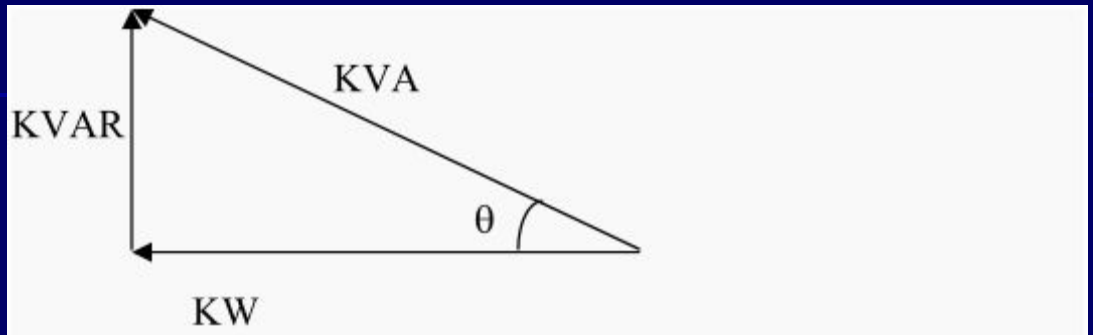
$$P.F. = \frac{Beer}{Beer + Foam}$$

Thus, for a given KVA:

1. The more foam you have (*the higher the percentage of KVAR*), the lower your ratio of KW (*beer*) to KVA (*beer plus foam*). Thus, the lower your power factor.
2. The less foam you have (*the lower the percentage of KVAR*), the higher your ratio of KW (*beer*) to KVA (*beer plus foam*). In fact, as your foam (*or KVAR*) approaches zero, your power factor approaches 1.0.

Power Triangle

The "***Power Triangle***" illustrates this relationship between ***KW***, ***KVA***, ***KVAR***, and ***Power Factor***:



$$P.F. = \frac{KW}{KVA} = COS\ \theta$$

$$P.F. = \frac{KVAR}{KVA} = SIN\ \theta$$

$$KVA = \sqrt{KW^2 + KVAR^2} = KV * I * \sqrt{3}$$

<u>Note that in an ideal world looking at the beer mug analogy:</u>

1. KVAR would be ***very small*** (*foam would be approaching zero*)
2. KW and KVA would be ***almost equal*** (*more beer; less foam*)

Power Factor Correction

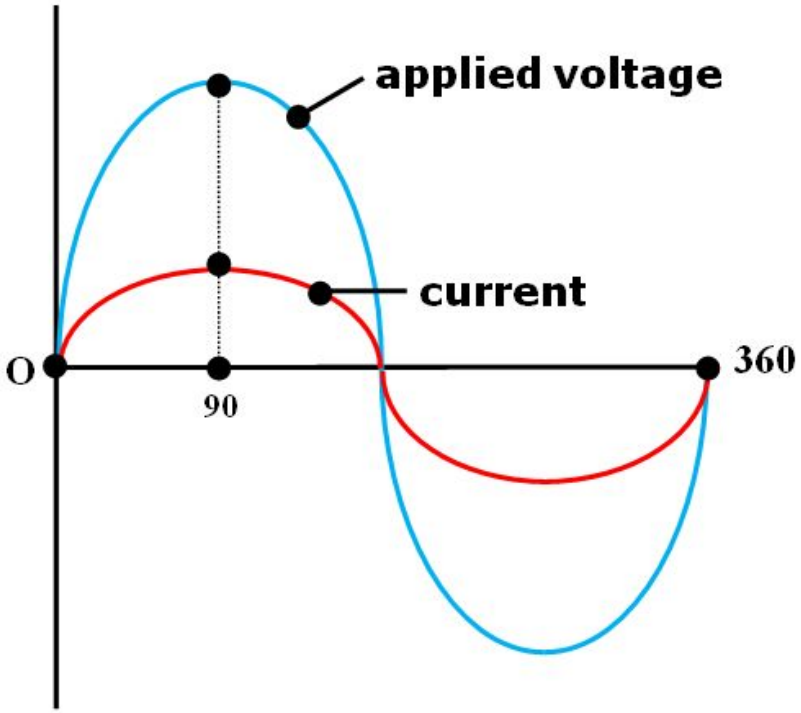
Theoretically in a purely inductive circuit the voltage will lead the current by 90^0 or vice versa the current will lag the voltage by 90^0. And in a purely capacitive circuit the voltage will lag the current by 90^0 or vice versa the current will lead the voltage by 90^0

One way to remember this is the use of the acronym CIVIL

C	**I**	**V**	**I**	**L**
Capacitive	current	voltage	current	Inductive

Current Leads Voltage Current Lags voltage

Unity Power Factor



Unity Power Factor 1

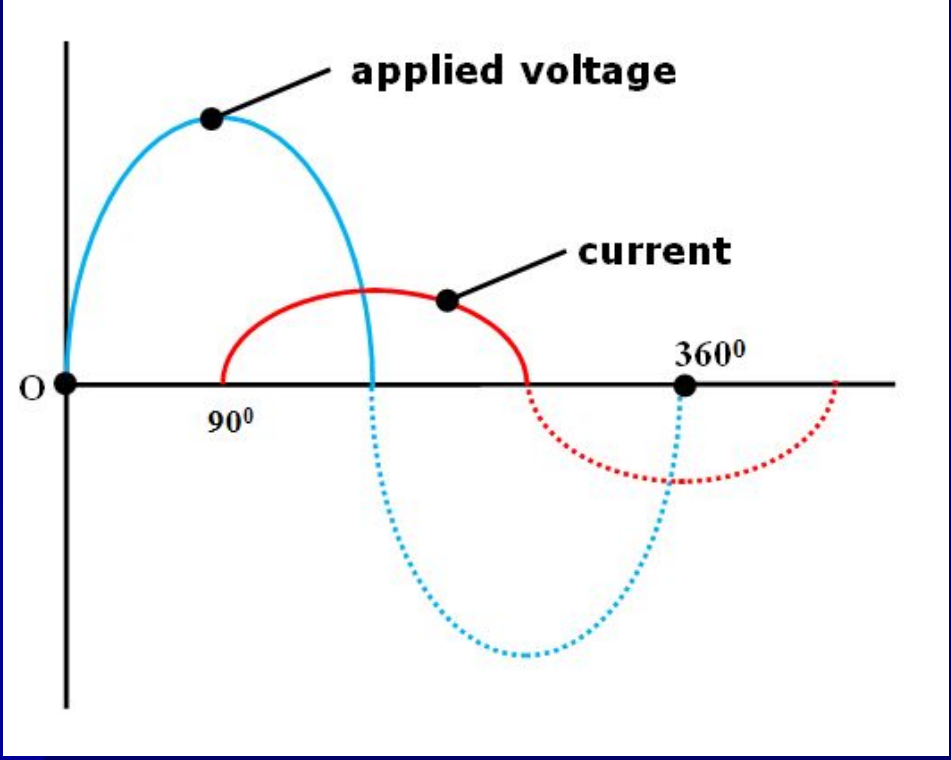
Current is in phase with the voltage

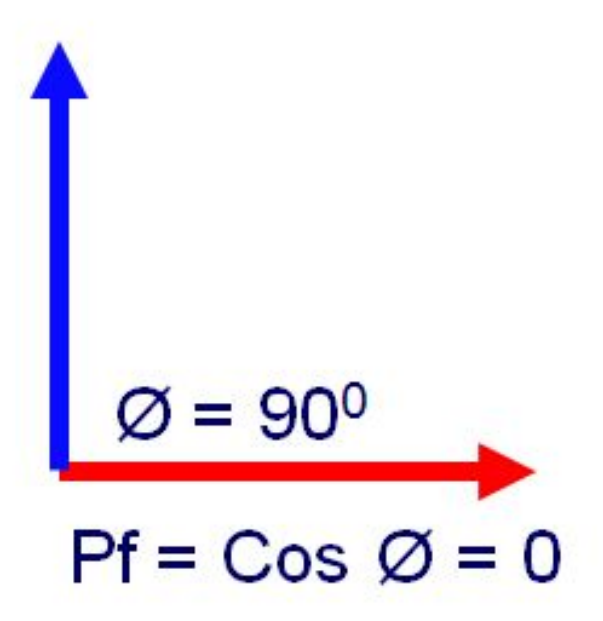
Zero degree angle of difference

P = V X I

Power Factor Lagging

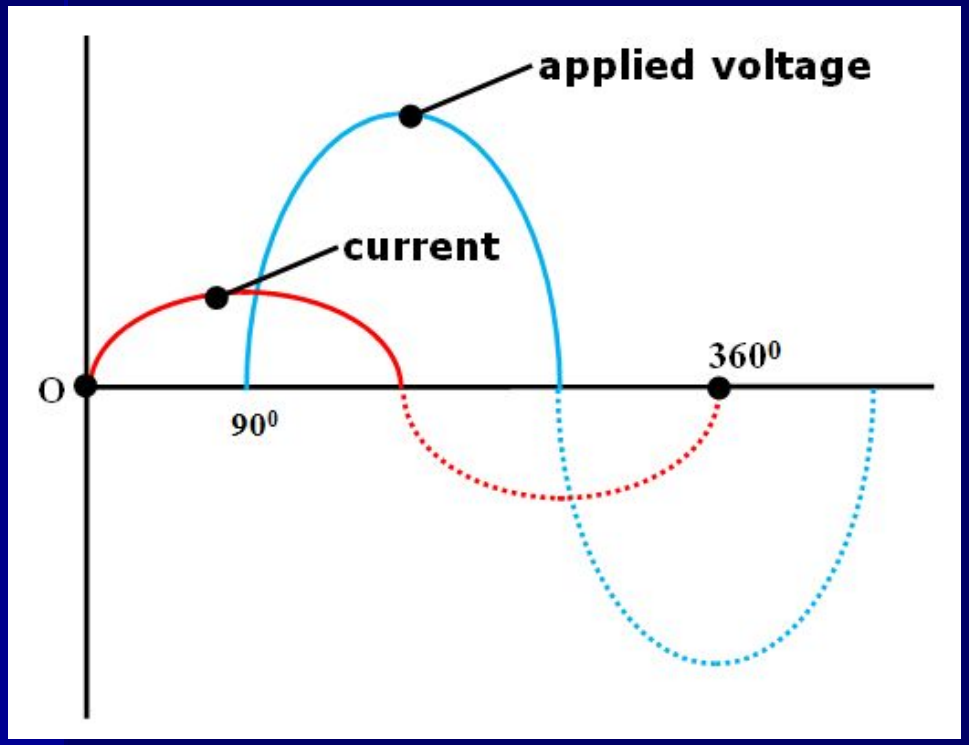
Clearly if the voltage and current are out of phase by 90^0 the power produced will be considerably less

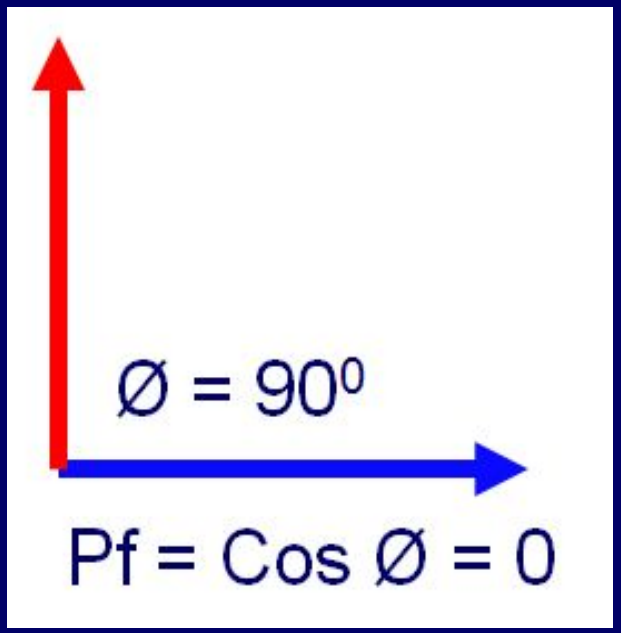


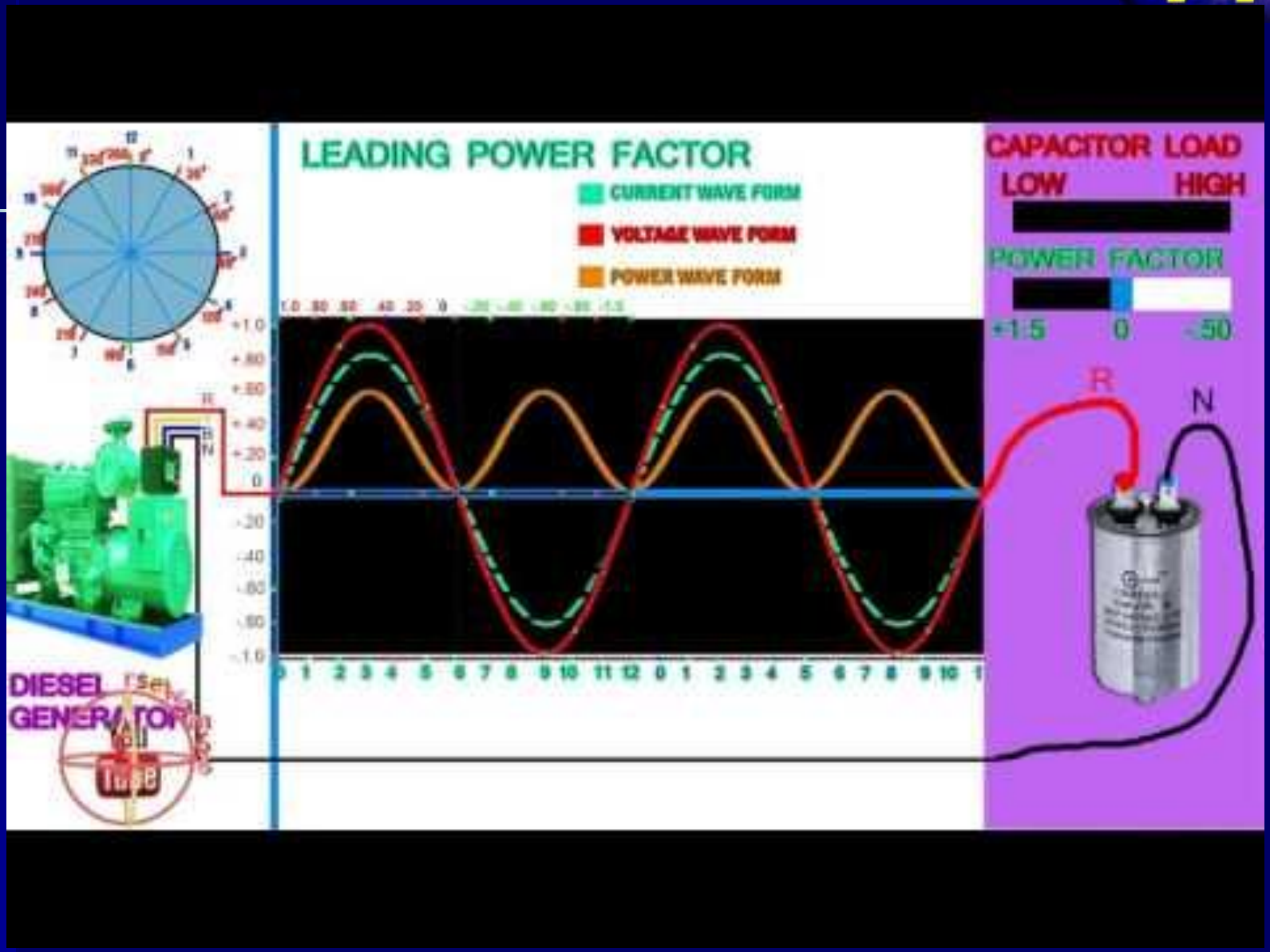


Power Factor Leading

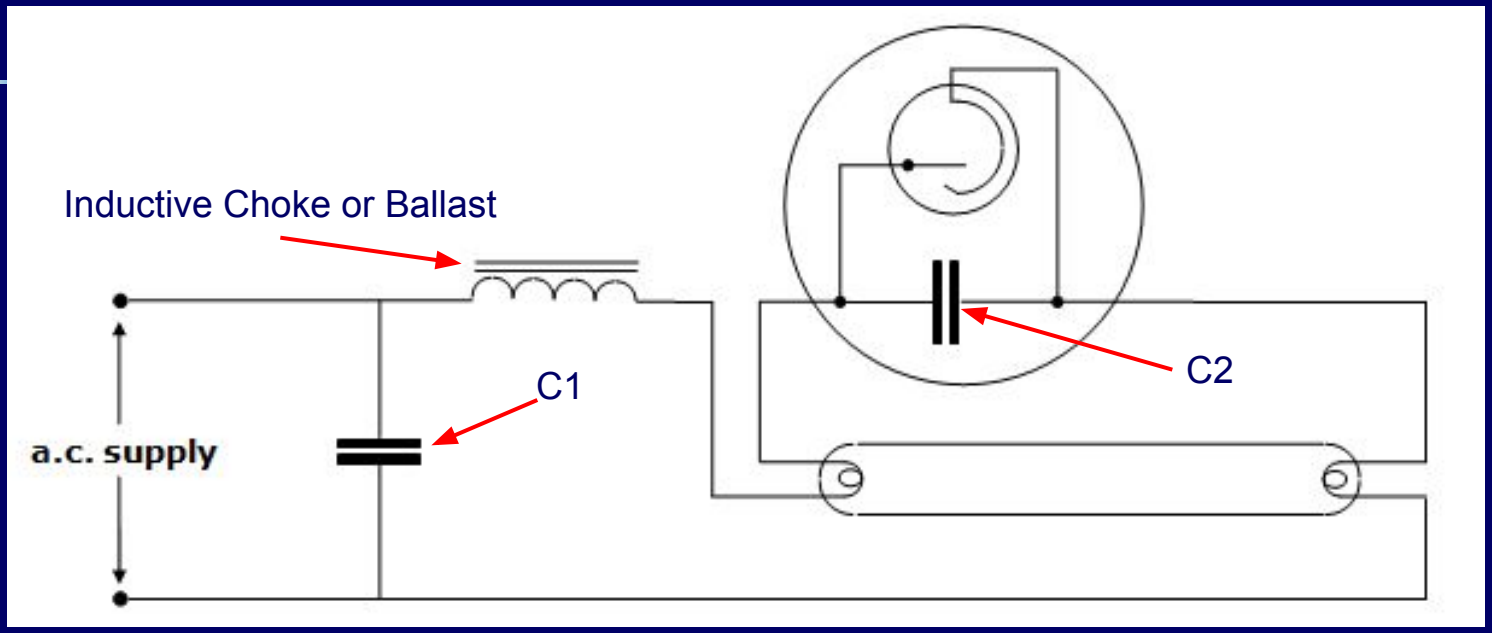
These situations can never actually be possible as all circuits with coils will have some value of inductance.







Power Factor Correction



By adding a capacitor (C1) in parallel with the supply we can bring the current and voltage nearer to unity power factor. The capacitor (C2) across the starter is used for RFI suppression.