FMA Guidance Note GN05
Power, Power Factor and Harmonics

Fans need to be driven in order to move air and motors are generally the machines that do the driving. This Guidance Note specifically concerns electric motors applied to fan applications.

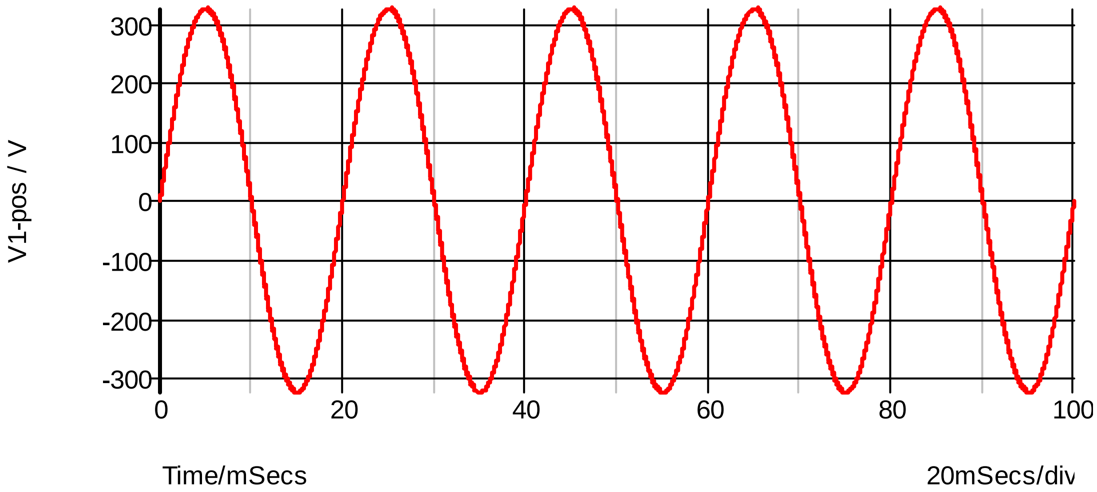
There are many different types of electric motor in use today for driving fans such as :

- Shaded pole motors
- Single phase permanent split capacitor motors
- Three phase induction motors
- Inverter driven induction motors
- Brushless DC, or Electronically Commutated (EC) motors

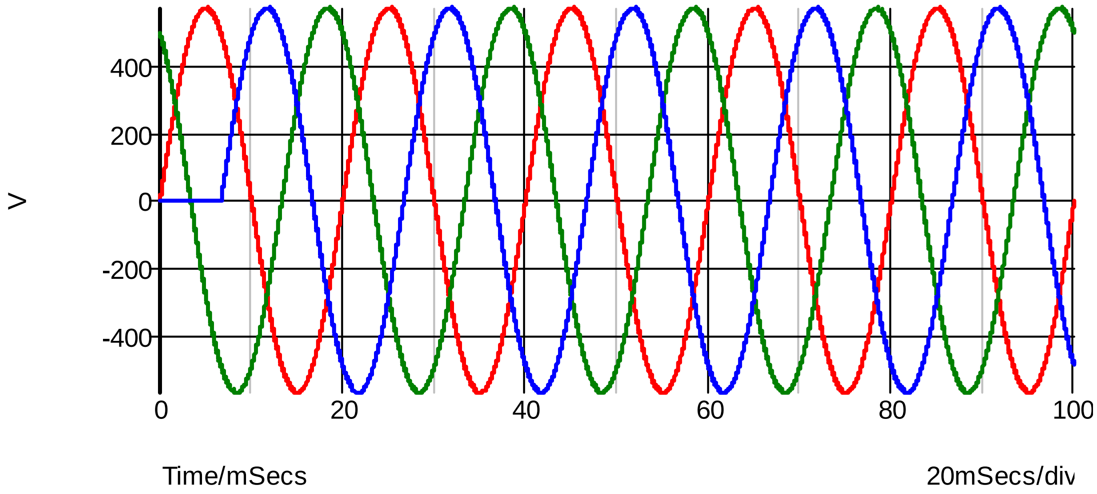
In all cases these motors need to be connected to a mains supply, to draw electrical power from the supply and convert it to mechanical power to drive the fan. Different types of motors make this conversion in more or less efficient ways but in all cases they draw power from the mains supply network.

With more emphasis today on conversion efficiency and motor speed control in fan applications, the nature of the power consumed by the motor and the way that we measure motor, and therefore fan, input power is of relevance.

Many of us are familiar with the concept of mains supply voltage and the diagrams below show typical single phase and three phase mains supply voltage waveforms



Single Phase 230V RMS Mains Voltage Waveform



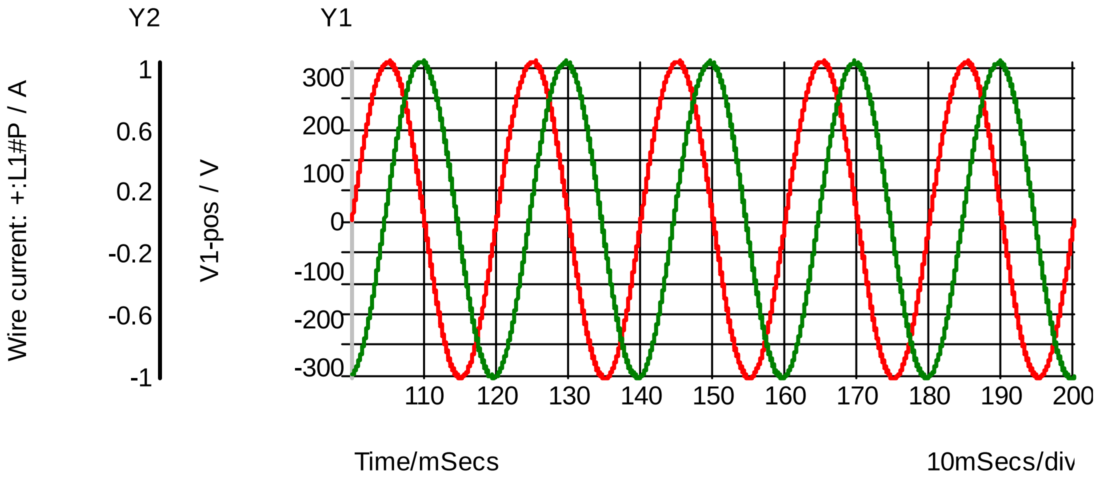
Three Phase 400V RMS Mains Voltage Waveform

When this mains supply waveform is applied to a motor the resulting current waveform, and hence power drawn by the motor, is dependent on the type of motor attached and whether there is a speed controller between the mains supply and the motor.

In single phase applications, one of two cases will be present :

Case 1 – Passive Motors with no speed controllers

Shaded pole motors, capacitor run motors fall into this category. Typical resulting voltage and current waveforms are as shown in the following diagram :



In this case the voltage and current waveforms are both sinusoidal with a phase angle between them.

Power consumed by the motor is given by :

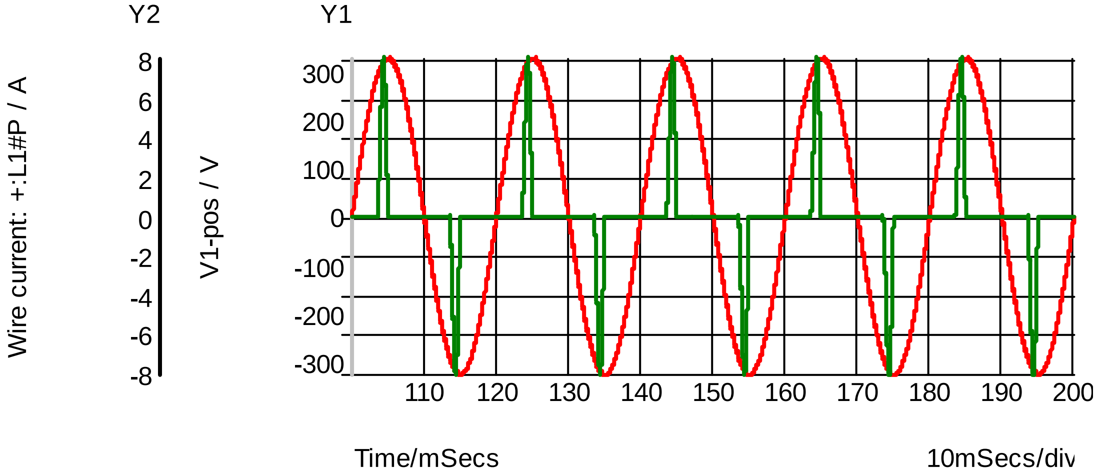
Power = V_{rms} x I_{rms} x cos Ø Where V_{rms} = RMS supply voltage

I_{rms} = RMS supply current

cos Ø = Power factor

Case 2 – Active motors with or without speed control

Inverter controlled induction motors and brushless dc (EC) motors fall into this category. Typical resulting voltage and current waveforms are shown in the following diagram :



In this case, power consumed by the motor is no longer given by the simple equation shown above. Power consumed by the motor is given by:

Power = (1/T) x ∫ v(t) x i(t) dt

Power factor under this type of waveform has no clear definition since, whilst the voltage waveform is a single sinusoidal waveform, the current waveform does not consist of a single sine wave.

Harmonics are electric voltages and currents that appear on the electric power system as a result of non-linear electric loads. Harmonic frequencies in the power grid are a frequent cause of power quality problems.

Three-phase electric power systems have at least three conductors carrying voltage waveforms that are 2π⁄3 radians (120°, 1⁄3 of a cycle) offset in time.

30 August 2012