Phase Conversion

Introduction

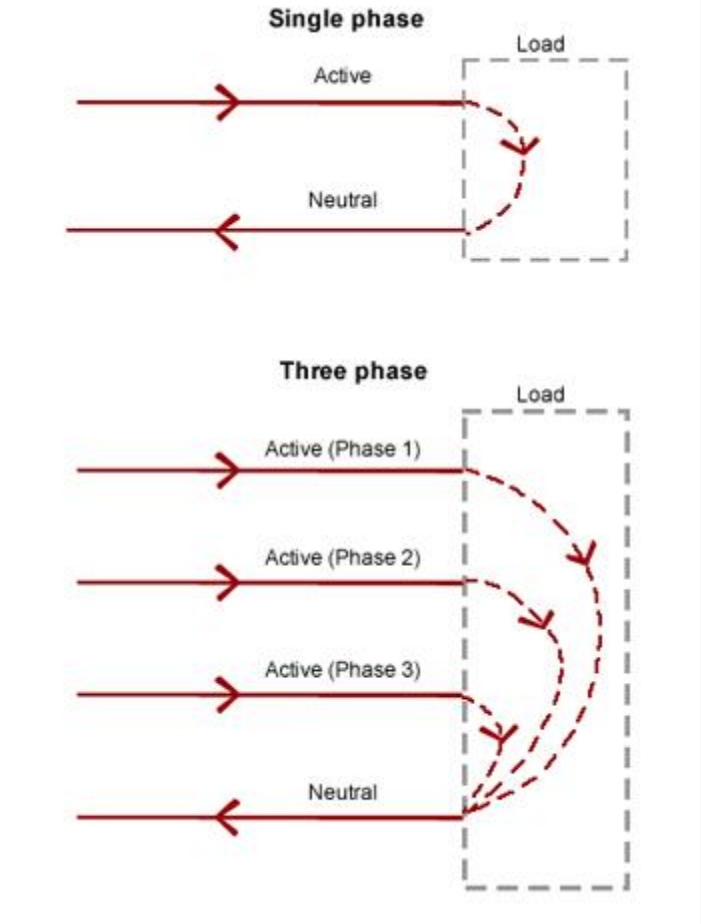

Figure 1. 1-phase vs 3-phase sytem

Single (1-phase) or multi (3-phase) phase voltage systems are the most common voltage systems used in the power network. In terms of power consumption single phase system is used for low voltage application, where the supplied devices are smaller loads; such in commercial or domestical usage, small industry or utility workshops etc. Typically, single phase devices are the most common devices found in our household (floor lamp, microwave oven, coffee machine, fan, PC...). Multi phase system is used for all voltage levels (typically multi phase refers to the 3-phase). In high voltage (from 30 kV) it is used for transmission of electric power, in medium voltage (up to 30 kV) for transmission and as a supply to the powerful 3-phase AC motors and in low voltage (up to 1 kV) as a supply to the 3-phase AC motors or heaters.

1-phase VS 3-phase

Electricity is either connected at 230 or 240 V (1-phase, which accounts for the majority of domestic situations), or 400 and 415 V (3-phase). The latter is better suited to providing for powerful appliances and fixed plant, and is more commonly used by industrial and larger commercial users.

1-phase comes to the home with two wires: active and neutral. The neutral wire is connected to earth (water pipe, earth stake, etc.) at the switchboard.

3-phase has four wires: three actives (called phases) and one neutral. The neutral wire is earthed at the switchboard. The common appliancies are:

- Big electric motors (usually more than 2 kW) need 3-phase power. This includes large workshop equipment.

- Large domestic installations sometimes have 3-phase because it distributes the total load in a way that ensures that the current in each phase is lower.

Example: Imagine the total electrical load is 24 kW (that's a lot for a domestic installation). For a normal, 1-phase power supply at 240 V, the maximum current would be 100 A. Derived from the Ohm's law: the current in amperes multiplied by voltage in volts gives power in watts (Power = Voltage x Current).

If a 3-phase supply is available, then the 24 kW are divided by 3, meaning that 8 kW is being used per phase. Now the current per phase is also down to a third of what it would be with a single phase supply (about 30 A per phase, rather than 100 A). Putting that in perspective, then 100 W lighting fixtures represent 1 kW of power, which equates to a bit under 40 A.

Typically, connection fees for 3-phase are higher, and there are fixed annual charges as well for 3-phase so don’t contemplate it for a new home unless you really need it.

Rural connections and SWER

Depending on your locality you may be connected to a SWER line. These are used in many country areas. Single wire, earth return (SWER) delivers single phase power. It’s an economical way of distributing power, because only one transmission line (active) is needed. There is no neutral - instead the earth is employed as the ‘return’ conductor.

If three-phase motors have to be used, a 1-phase to 3-phase power converter has to be installed by the electricity consumer.

Phase Conversion

Power Electronics

A phase converter is a device that produces 3-phase electrical power from a 1-phase source, thus allowing the operation of 3-phase equipment at a site that only has 1-phase electrical service. Phase converters are the economical option, however power quality is often compromised with poor voltage balancing and for most equipment loads, an oversized converter must be specified to enable motor start-up. These inefficiencies lead to increased energy consumption and eventually may cause damage to the 3-phase equipment, especially digital or electronic machinery.

Manual Modification

In the case of simple thermal loads which are supplied by the 3-phase system, then the conversion to 1-phase can be made by changing the wiring system inside installation. This applies to the older 3-

phase heaters, ovens or water boilers. In newer versions of those devices usually we can find some of the power electronics, which needs to be powered by the line voltage i.e. 400 Volts. Before proceeding further few things should be kept in mind :

1) Device power could be tripple lowered (i.e. 18 kW will become 6 kW),

2) 1-phase must sustain 3-phase load (i.e. 18 kW , which is 78 A load for 231 V),

3) Cable installations could be endangered (overloaded),

4) Protection device could be damaged (if not resized accordingly),

5) Device efficency could be lowered (i.e. tripple time to reach operating point),

6) If power electronics is stored inside those devices, better to avoid phase conversion, due to the certain damages.

Also, it is possible to adjust total resistance of the load, by rewiring resistors into parallel or series connection, to get lower or higher values.

Parallel conection will provide lower resistance values. The simpliest is to use one phase, then the total resistance R_t is the phase resistance:

$$R_t = R_1$$

If only two phases will be used then the total resistance is calculated as:

$$R_t = \frac{R_1 * R_2}{R_1 + R_2}$$

In case of all three phases:

$$R_t = \frac{R_1 * R_2 * R_3}{R_1 + R_2 + R_3}$$

Series conection will provide higher resistance values, since total resistance is the sum of all involved resistances.

Source:

http://www.openelectrical.org/wiki/index.php?title=Phase_Conversion