

Voltage Optimisation

Voltage Optimisation and Power Factor Correction have been around since the turn of the 20th century and although in many cases their individual benefits and attributes make them a viable form of energy reduction in the right environment, in truth it is only recently that they have been considered as a powerful energy saving technology which when combined offer complimentary correction to improve energy efficiency and reduce consumption across a whole site.

There is now momentum towards a global low carbon economy with creation of the Paris Agreement, the impact around climate change, increase in energy costs, introduction of penalties for inefficient users and a need to reduce demand as electricity tariffs move towards time of day demand based billing.

Voltage Optimisation reduces energy consumption in voltage dependent loads by reducing and in some cases controlling voltage levels to within European Harmonised voltage levels to return an energy saving. Power Factor Correction improves the overall efficiency of an electrical supply by the controlled introduction of capacitors onto an electrical systems.

What is Voltage Optimisation?

Voltage Optimisation is a term used around voltage management when a desire to reduce energy consumption is managed by adjusting and controlling voltage levels on a user's site.

Voltage optimisation is a transformer based technology that comes in many forms, fixed ratio, multi tap, stabilising or regulating and works by controlling the incoming grid voltage to return an energy saving.

The principal is based around supplying a voltage level more suitable to the actual electrical device in order for it to perform its task more efficiently and in line with limits of European harmonized voltage while basic design is a low loss series connected transformer designed to optimise a whole site or individual loads to target the most optimizable loads.

There are benefits over a whole site isolating transformer as the voltage optimizer would normally offer a greater range of adjustment to target a higher level of savings and is inherently more efficient with less losses.

Put simply, Voltage Optimisation is a form of Voltage Management specifically designed for reducing energy consumption.

Basic electrical law dictates that power required by certain loads is proportional to the square of the voltage while a supply voltage in excess of the nominal harmonized 230V/400V may result in an electrical device consuming more energy than need be.

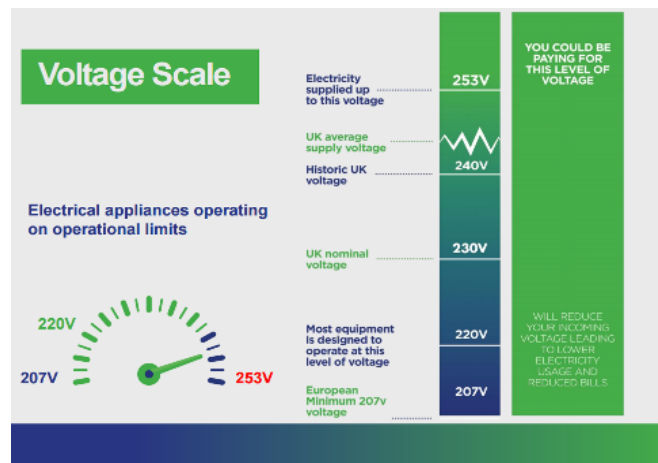
Voltage Levels

For many years, the single-phase supply voltage in the UK was 240V +/- 6% which allowed for grid voltages from 226V to 254V (390V to 440V 3 phase) although most mainland European voltage levels were historically based on a 220V system (380V)

An agreement in 1988 was reached to create a common voltage level throughout Europe based on a 230V / 400V system which would come into effect from the 1st January 1995 and known as Voltage Harmonisation.

The first stage of voltage Harmonisation required a supply voltage of 230V -6% / +10%, allowing for grid voltages from 216V to 253V (376V to 440V) which remains the official UK stance today

It is planned to introduce a second stage of voltage Harmonisation to widen the band of tolerance to 230V +/-10%, this would mean grid voltages from 207V to 253V (360V to 440V) and has been proposed to bring voltage levels throughout Europe in line with Electricity Quality and Supply Regulations (EQS) where any piece of equipment with the CE mark can be safely operated on the local electricity supply anywhere in Europe and between voltage levels of 207V to 253V (360V to 440V)



To simplify the market for electrical equipment, the European Union has introduced the Low Voltage Directive (LVD) 2006/95/EC to regulate the operating voltage of electrical equipment to be supplied in Europe. Equipment that meets the standard bears the CE mark and is designed to operate within harmonized voltage levels.

In reality through, nothing has changed, voltage levels on average in the UK remain around 242v (419V) as the costs to reduce voltages at grid level are too inhibitive and unnecessary as we remain within the harmonized voltage limits.

CE mark compliance simply dictates that the device must operate safely between harmonized limits, it does not however state that it must operate efficiently or maintain its design lifespan.

It could be argued that Voltage Optimisation therefore exploits the CE Mark regulations as a lower voltage level is applied to the electrical device and closer to the nominal design voltage of 230V rather than at the UK average voltage of 242V.

Consideration should also be given towards accelerated deterioration of the electrical device at the higher voltage levels, voltage can be described as a pressure, there is therefore an opportunity to regulate the pressure more towards mainland European levels to protect the device and maintain its designed life span while returning a level of energy saving.

Most electrical devices are now manufactured more for the wider European market rather than the unique challenges faced in the UK, a classic example is the operation of LED lighting, higher voltage levels increase the risk of premature failure of the driver circuits while at lower regulated levels, the pressure is reduced and the design lifespan achieved.

Savings & Benefits of Voltage Optimisation

One thing is for sure, Voltage Optimisation will not benefit every site although for the right type of sites, the benefits can be great in both financial terms and environmental.

Financial savings depend very much on the type of operation and load dynamics which can in broad terms be separated into two main categories:

- Voltage Dependent
- Voltage Independent

Voltage Dependent Loads

A voltage dependent load is an electrical device whose energy consumption varies with the voltage being applied to it, these type of loads will normally benefit from voltage control in the form of reduced energy consumption, examples of voltage dependent loads are:

- GLS Halogen lamps including energy saving types that also use filament technology where reducing the supply voltage will result in a directly proportional reduction in power consumption although the lower voltage may also reduce the light output slightly
- Fluorescent lamps with inductive ballast (also known as switch start)
- Metal Halide / SON lamps
- Many motors are oversized for their application and often operate for all or much of the time at partial load which leads to increased losses, a motor in general could be described as voltage dependent and therefore would consume less energy through voltage optimisation.

Most motor loads do not operate anywhere near their design capability and frequently are operated outside of their rated output, when operating within 70-90 per cent of their rated output they are very efficient with less losses and effectively voltage independent.

If motor loads form a significant part of a sites overall load, careful consideration should be taken to evaluate the dynamics of each motor load to evaluate savings

Voltage Independent Loads

A voltage independent load is an electrical device whose energy consumption does not vary with the voltage being applied to it, these type of loads will not normally benefit from voltage control, examples of voltage independent loads are:

- Fluorescent lamps with electronic ballast (also known as high frequency)
- LED lamps with Integrated Circuit based Driver (there is a benefit in the form of longevity as lighting installations operating at the higher voltage levels may deteriorate more quickly than those operating at a lower controlled voltage level)
- Motor loads controlled by variable speed drive (VSD)
- Most electronic systems like computers for example are designed to accept a wide range of input voltages while operating with fixed output and are therefore voltage independent although as with some lighting systems, operating electronic equipment at the higher voltage levels may accelerate deterioration of the primary AC power supply

Process Loads

Most process loads are generally motor loads that are electronically controlled, careful consideration therefore should be given when evaluating process loads for energy reduction as the potential energy savings through voltage optimisation is dependent on how the loads are controlled.

Resistive Loads

In general, resistive heating loads operating at a higher voltage level will result in an increase in power demand and vice versa although dependent on the control, resistive loads could be described as Voltage Dependent or Voltage Independent.

Time based resistive loads with thermostatic control are generally deemed as voltage independent as the purpose of the electrical device is to carry out a specific task like a Kettle for example where receiving a lower voltage results in water taking longer to boil and consuming the same amount of energy.

Resistive heating loads that have less control and generally switched on for a fixed period of time could be described as Voltage Dependent and offer a significant reduction in energy consumption.

Consideration should also be given to the rating of a basic resistive load, a 2000 watt load based on a nominal voltage of 230v although operating at 250V for example would consume

approximately 2300 watts, an increase of 15%, resulting in higher energy costs, excessive heat and accelerated deterioration

Where are the Savings?

- Savings are mainly achieved around a kw/h reduction as the electrical device operates closer to its fundamental design voltage, the main areas of saving on an electricity bill are detailed below:
- Reduced kw/h consumption
- Dependent on the load dynamics, the savings will come from a kw/h reduction.
- Reduction in Demand
- A small reduction in demand is possible although this is not normally significant enough to reduce Authorised Supply Capacity charges.
- Reactive Power Charges
- Reactive power charges may reduce slightly as demand reduces.
- Reduced Emissions
- Significant reductions in CO₂ emissions can be achieved as consumption is normally directly associated with kw/h consumption.
- Reduced Maintenance Costs
- A device operating at a higher pressure than need be to perform the same task will not last as long as a device with a regulated pressure.

Voltage Optimisation Design

Static - Fixed Voltage Optimisation

A System delivering a fixed percentage of voltage reduction and normally commissioned during installation as the most appropriate “tap” is selected to achieve the desired voltage reduction.

The optimised voltage will be proportionate to the incoming voltage.

Dynamic Voltage Optimisation System

A System usually combined with a degree of control to adjust the voltage level without interruption to the supply. Typically, the control system would react to fluctuations in grid voltage to ensure minimum voltage levels are not compromised.

Optimised voltage will be proportionate to the incoming voltage - additional control measures deal with exaggerated fluctuation in grid voltage.

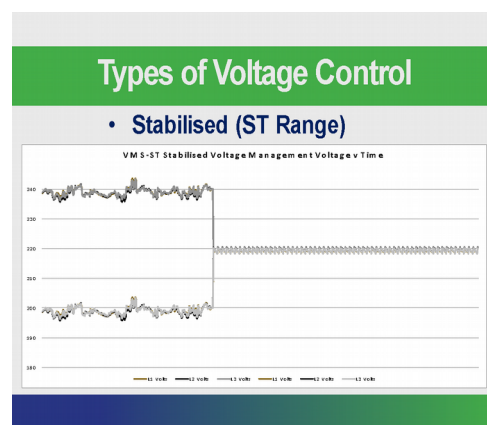
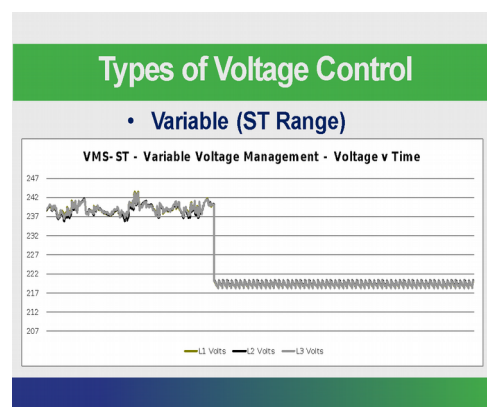
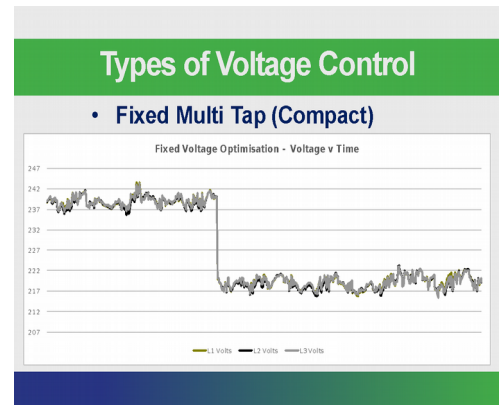
Voltage Stabilisation

A system to reduce and control the output voltage level to a programmable optimised level irrespective of incoming grid voltage.

The optimised voltage will be automatically controlled to within 1 or 2 volts of the desired optimised voltage level at all times irrespective of grid fluctuations and within the capabilities of the voltage stabiliser provided the grid voltage does not fall below the desired optimised voltage

Voltage Stabilisation / Regulation

A system to control the output voltage level to a programmable optimised level irrespective of incoming grid voltage being high or low, unlike a



voltage stabiliser, a regulator would also increase the voltage to the pre programmed optimised voltage level in the event of low grid voltages.

The optimised voltage will be automatically controlled to within 1 or 2 volts of the desired optimised voltage level at all times irrespective of grid fluctuations and within the capabilities of the voltage stabiliser

Considerations

To determine the impact Voltage Optimisation could have on a sites energy consumption, a detailed survey should be carried out to understand the dynamics of the load and to determine how much of the electrical equipment is voltage dependent and what proportion of the total energy consumption that represents.

The survey should also include detailed load monitoring for a period of time suitable to ensure all load types and processes are recorded in order to evaluate voltage levels, phase balance, demand levels and volt drop throughout the site.

If most of a sites electrical consumption is made up of voltage dependent loads, savings are likely to be high, savings on voltage independent loads are likely to be poor although benefits still exist as operating equipment close to its fundamental design voltage may maintain the life expectancy in line with the manufactures expectations.

System features should also be considered and based on the return of investment, the dynamics of the load, site conditions in respect of voltage fluctuation and the level of functionality required.

Bypass features should be considered to disconnect the Voltage Optimisation system from the supply in order to perform maintenance procedures for example. A bypass switch can be installed to electrically disconnecting and isolate the Voltage Optimiser from the electrical circuit and reconnect the electrical supply. The site load is therefore diverted through the bypass mechanism and the Voltage Optimiser isolated in the bypass state.

Voltage Optimisation System Installation

Installation is in series with the main supply and therefore it is vitally important to ensure the correct level of due diligence is carried out in the form of a detailed survey.

It is also recommended that a suitably rated protective device is integrated into the optimiser, this is especially critical if the optimizer has been rated for the size of demand and not the capabilities of the existing supply ie matched to the maximum demand (plus an approximate 30% overload) rather than the current rating of the main supply.

A voltage optimiser could also be installed on sub supplies or individual loads to target the most optimisable loads.

Combined Voltage Optimisation & Power Factor Correction

Voltage Optimisation & Power Factor Correction are complementary technologies that work very well in synergy as a powerful energy saver that is extremely visible on energy bills.

A combined approach introduces the best of both technologies to reduce energy consumption, remove reactive power penalties, reduce carbon emissions, reduce capacity and availability charges, improve utility and protect electrical equipment from higher than need be voltage levels.

The combined approach also helps each individual technology, the power factor correction system reduces circuit currents to reduce demand on the voltage optimiser while the voltage optimiser reduces voltage levels to avoid premature failure of the power factor correction capacitors.

Combining the technologies offers two chances to reduce energy spend and reduce harmful emissions in one single installation while enhancing the return on investment and reducing ongoing maintenance costs, all with immediate effect



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