ESP Systems

Information

Prepared By

ESP Systems
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OUTLINE OF THE ESP SYSTEMS APPROACH

Initial Survey

The initial reading tests and measures the electrical load(s) and the distribution(s) in a facility. From this information, both the impedance or z factor of the system and the X/R ratio are determined. X being the reactance of the system and R being the resistance of the system. From that, we are able to point out the areas in your plant where energy is being wasted.

To obtain an accurate report of savings and payback, the following criteria/data are required:

- Plant operations must be equal to or greater than 70% at the time the measurements are to be taken otherwise distorted results will be obtained.
- Access to the main distribution(s).
- Copies of the most recent 12-month electric bills. Just the monthly total charge is not sufficient. The computer analysis we perform incorporates the actual KWH consumed, the energy charge, KWD, KWD charges, and any discounts.
- Explanations of any unscheduled operating changes for the past year from normal yearly cycle/operations.
- Details of any future changes to normal plant operations, such as, expansion, product changes cutbacks, etc.
- List of any known problems suffered in the electrical system, such as, surges, harmonics, unusual failure or breakdown of equipment or machinery, etc.
- If Power Factor Correction Capacitors are installed. If they are, we require a list of where they are installed, the type, and the sizes in KVAR.
- Access to the main transformer is preferred. This is to obtain the size (KVA), impedance, primary and secondary transformer voltage ratings, delta or wye configurations, and if it is dry or liquid cooled.
- The estimated percent of DC load related to the normal total load.
- Notification of any variable frequency drives and SCR controls.
- Number of transformers/total transformers on each electric bill.
- If metered on the primary side or the secondary side.
- Site plan of electrical system, if available.
- Hours of Operation. This refers to the adjusted hours of continuous normal operation of the electrical load reflecting “percent in operation” in hours per week, per each measurement location.

Proposal

Once the initial survey has been completed, an ESP Systems proposal will be presented. The proposal contains the following information:

- Executive Summary
- ESP Systems, Benefits and Features
- Introduction and Qualification
- Engineering Analysis
  - Electric Bill Breakdown
Link Analysis

Upon acceptance of the proposal, a link analysis will be performed. The link analysis is conducted for the following reasons:

- To check the original measurements and any possible variations thereof.
- To take measurements or to identify a more economical or effective method to address the problem(s) and savings.
- To determine the location at the site where the system will be connected.
- To determine breakers/disconnects, cables, and conduit sizes, and what is presently available at the facility.

The link analysis is a complex computer analysis that identifies the effects of various large loads switching ON and OFF on various sub mains and the hand shaking effect that occurs between each of the sub mains or branch circuits.

The following situations are a guide to when and where the link analysis measurements will be taken:

- Re-measure main distribution(s).
- Distribution panels with one or more motor loads of 50HP or greater.
- Distribution panels 200Amps or greater.
- Distribution panels where welders or significant DC loads are connected.
- Distribution panels or motors which have a specific engineering problem that the ESP System is targeted to solve.
- The distance of sub main feeds between the main distribution(s) and distribution panels.

Note: If the period between the original measurements and the link analysis is in excess of three months, it will be necessary to provide copies of the electric bills for the period from the last measurement to the time of the link analysis.
Physical Mounting of System Components

- ESP Systems must be installed within 20 linear feet of the distribution feeder attachment point.
- Each system will be installed using good engineering practice and will be in accordance with applicable national and local codes.
- If an ESP System is to be mounted near a ceiling, a minimum of 12 inches is required between the top of the unit and the ceiling.
- If an ESP System is to be mounted side by side, a minimum of 1 inch between enclosures is required.

Ambient Temperatures

High ambient temperatures will reduce the life of the ESP System. Therefore, the system should be located in an area of unrestricted ventilation and mounted away from hot objects and surfaces.

Maximum safe ambient temperature is 50°C. Should the temperature fall below –40°C before the ES System is energized, internal damage to the capacitance cells may occur when the system is turned on. To prevent this, the components should be brought to at least -12°C before being energized. If extremely low temperatures are expected, it is advisable to keep the capacitors energized in order to maintain their internal temperature above the critical point.
**ESP-SYSTEMS OPERATING PARAMETERS**

ESP Systems provide the following standard benefits and features for an electrical distribution:

1. Improves and levels out the voltage, thereby, increasing equipment efficiency and longevity.
2. It can balance the three phases, thereby, reducing Kilowatt Demand while increasing longevity of the system.
3. Filters harmonics, surges and transients, thereby, improving longevity of equipment and eliminating downtime.
4. Reduces line, eddy current, and hysteresis losses, thereby, reducing the Kilowatt Demand and Kilowatt Hour consumption.
5. Improves power factor by reducing reactive and apparent power, thereby, improving system efficiency while eliminating possible related charges. This is done without any capacitor's deleterious side effects.
6. Frees up wasted KVA capacity of the electrical system, thereby, allowing additional loads without requiring any transformers or capital expenditure.

An ESP System is comprised of a combination of components which include inductors, reactors, capacitors, resistors, filters, contactors, breakers, Regulator (microprocessors). The unique features of the ESP System are achieved by the design of the system and its Ladder Logic response.

The sampling rate of an ESP unit is over 3800 samples per second all the way up to 15000 samples per second. This sampling rate is handled by utilizing Motorola microprocessors HC6811 and HC6816. The Micro-Processor, samples voltage, amperage, power factor, and current threshold. After the samples have been taken, it calls for different stages and different configurations and different hybrid configurations of the stages to address a particular or multiple problems that exist. The unit then reads again to see that the steps it took corrected the problem(s). If the problem(s) were not corrected, it stops and samples again. If the problem is fixed, it continues to correct the problem(s). In other words, it works with the plant’s electrical load. As the load changes, the performance of the system changes – it moves with the load. The more problems there are, the more the system will activate the various stages. The less the load, the less the system will bring on and off line.

The primary operation of an ESP system is based on tuned tank circuits - LCR (inductive/reactive, capacitive, resistive). These tuned tank circuits have minimal resistive components, therefore, they do not waste energy but save energy.

\[
\begin{align*}
L & \quad C \quad R \\
\text{C} &= -90^\circ \text{ leading PF} \\
\text{L} &= +90^\circ \text{ lagging PF} \\
\text{R} &= 0^\circ \text{ PF=1} \\
\end{align*}
\]

\[
\begin{align*}
i &= C*(dv/dt) \\
V &= L*(di/dt)
\end{align*}
\]
The principle of the operation is based on Ladder Logic for the activation of the various circuits. There are 18 circuits per stage in an ESP System. The system is sized for three phase facilities, operating from 208 volts to 345 kilovolts regardless of the line frequency (40Hz to 400Hz). The largest system installed is overseas with a size of 300 Megawatts.

ESP System's multistage system is triple protected with each stage independently monitored, protected, and activated which means that each stage stands by itself. This is a definite advantage in case of any failure of any components in a stage, it will isolate itself off line and the rest of the system will continue to deliver its functions. The system is triple protected and in 98% of the cases, the system is connected in the distribution in parallel ensuring that it will not disrupt the plant’s operation.

In most cases, contactors of different ratings are used because 99.9% of the time you do not need that fast of a response to rectify a problem. We have the technology which we can offer for a much faster response if it is required. The design is to deliver a more uniform and damped response because it does not require that immediate response to the load and inrush currents.

The system is equipped with a self diagnostic feature (SDF) which will identify any component failure in itself on both per phase and per stage basis. The reason this system is equipped with a SDF is, since the systems are worldwide, it would be too expensive to send technicians. The in-house electricians will be able to identify the problems of the system in ten to fifteen minutes.

**SUMMARY OF WHAT IS ESP SYSTEMS?**

ESP Systems (dynamic) is an integrated system which is equipped with a microprocessor based Regulator, which monitors voltage, current, power factor, and current threshold at 3840-15000 samples per second.

The system consists of multi-stage LCR tank circuits which are activated according to the preset designed parameters based on the Ladder Logic Principle.

The system can be designed for applications at low, medium, and high voltages as well as various international line frequencies.

The system is equipped with a unique Self Diagnostic Feature (SDF) which identifies the status/failure of components on a per phase and per stage basis.

*ESP SYSTEMS ARE VERY LOW MAINTENANCE!*
DESIGNING OF ESP SYSTEMS

The actual designing of an ESP System can only begin after a link analysis has been performed. This is similar to a load flow. Measurements are taken on the secondary load side of the main transformer on the common buss as well as each subsequent feeder downstream of the main distribution. The common buss reading identifies the overall picture and the behaviour of the load profile on the whole for the facility. The measurements downstream help to identify any specific problems at any one of the downstream feeders.

If the load profile of the distribution fall within the certain criteria/parameters of the problems being addressed, only one ESP System unit would be installed on the common buss of the main distribution. The reason the unit is installed on the main common buss is to protect the facility from any negative effects from the high voltage side as well as any problems caused by the facility’s operation. In effect, this protects the facility from the outside and inside.

Any variations of the facility’s load, such as, inrush currents, short-circuits, will be protected as well as from any deleterious effects from the high voltage side. This can only be accomplished by having multiple impedances in the electrical system. There are three levels of impedance which are designed to address the problems of the facility – lower, equal to load, and higher impedances. A lower impedance introduces a path of least resistance to filter harmonics, surges, transients, spikes, and other variances which may “hit” the facility. If the impedance is lower, according to Kirchoff’s Law, all the problems will “hit” the ESP System unit first and not the facility’s loads. A load/equal impedance to the facility’s electrical system is able to correct imbalanced conditions based on X/R ratio and z factor. A higher impedance than the facility’s electrical system impedance allows the stabilization of the voltage.

This design set up of the ESP System allows the correction of multiple problems at once, which results in energy savings and power quality. If there are specific problems
downstream at a sub-feeder, for more effectiveness and economic reasons, a unit will be installed onto that particular feeder. Again, this will only be done if the load profile of the facility’s load exceeds the standard design criteria set for the industry. This will isolate the specific problem(s) at the specific load feeder and filter them out so the common buss will not see these problems and as a result, the losses associated between the feeder and the main distribution will be eliminated.

ESP Systems' Standard Model Specifications

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**PROBLEMS AND THE ESP SYSTEMS SOLUTION**

**Voltage**

95% of problems faced in industry and commerce relates to voltage. For a low voltage condition (under rated voltage), you can expect higher current and more losses, etc. For a high voltage condition, you can expect breakdown of equipment/machinery and insulation.

In line with the above two conditions, if we have imbalanced voltages between the phases (single phase loads are most of the problem), you can expect, depending on the stability of the supply voltage from the utility company and plant conditions, voltage imbalance. If we have a 5% imbalance in the voltage, according to NEMA, this can cause a 50% increase in motor temperatures ($2 \times \Delta V^2$). This causes heat dissipation which increases KWD and over time KWH.

If we assume the same 5% imbalanced voltage condition and a motor with a horsepower rating of 10, the de-rated real/effective horsepower would be 7.0-7.5 HP.

If we have under voltage, over voltage, and/or imbalanced voltage conditions, we can expect the following problems:

- Overheating of motors lead to insulation breakdown.
- Imbalanced currents.
- Negative voltage sequence.
- Motor bearings failure.
- Speed variation in motors.
- Reduced production quality.
- Reduced motor efficiency.
In line with the above problems, we can expect energy wasted and reduced power quality through:

- Increased maintenance of equipment and machinery.
- Wasted energy which leads to higher electric bill – KWD, KWH.
- Wasted investment and operational capital.
- Use of oversized machinery.
- More difficult to provide adequate overload protection.
- Increased noise and vibration.

Voltage Improvement and Stability
ESP Systems - Feature #1 - Standard

Unlike UPS, SPS, and Voltage Stabilizers that:

- Waste energy.
- Connect in series.
- Generate harmonics.
- Have limited fixed sizes and are not expandable.
- Are bulky and expensive.

The Solution - ESP Systems

If we have the above conditions in a facility, ESP Systems offers two solutions – Voltage Improvement and Voltage Stability. It stabilizes the three phases from the effects from the supply side and effects from the facility (minimizes), at the same time, improves the magnitude of the voltage as a result of reactive power and resistive power in imbalanced conditions. The end result is a steady state voltage and the rating of the voltage would be based on the secondary transformer voltage rating. This results in improved system efficiency and savings of energy.
Current

Imbalanced currents have the following adverse effects:

- Negative voltage sequence.
- Circulating currents.
- Increased current in neutral conductor (causes imbalanced currents and harmonics).
- Increased neutral to ground voltage (stray voltage or tigal voltage - reduced power quality and wasted energy).
- Overheating of motors which leads to insulation breakdown.
- Reduced motor efficiency.
- Motor bearings failure.

In line with the above problems, we can expect energy wasted and reduced power quality through:

- Increased maintenance of equipment and machinery.
- Wasted energy/higher electric bills – KWD and KWH.
- Wasted investment and operation capital.

Three-Phase Balancing

ESP Systems - Feature #2 - Standard

Unlike any other equipment in existence!

The Solution - ESP Systems

Again, we are addressing energy savings and power quality. ESP Systems offers three-phase balancing (the only product we are aware of that does this) based on X/R ratio and Z factor. This accomplishes two things:

1) reduces overall current, both components of current are reduced – resistive power and reactive power. As well as,
2) balances the three phases, thus eliminating the problems of imbalanced currents.
An example of how ESP Systems balances the three phases:

Assume:
Phase A = 800 Amps, Phase B = 1100 Amps, Phase C = 800 Amps, Phase Rotation = ABC.

Based on X/R ratio and Z (impedance), ESP Systems’ LCR circuits would be configured in the following sequence to balance the three phases.

Surges and Transients

Voltage surge, transient or swell – voltage is higher than the rating of the voltage and the duration is less than or equal to half a cycle.

Voltage sag – is the reduction of the magnitude of the voltage from the nominal rated value that is assigned for a duration of less than or equal to half a cycle.

Surges and transients have the following adverse effects:

- Increased maintenance and down time.
- Decrease lifetime of equipment.
- Cause computers to stop execution of programs.
- Create false data in computers.
- Erase data in computer memory.
- Result in hardware damage.
- Cause damage in wire/cable insulation in transformers and motors.
- Cause nuisance tripping of adjustable-speed drives.
In line with the above problems, we can expect energy wasted and reduced power quality through:

- Increased investment in plant and equipment.
- Wasted energy – KW, KVA, KWH.

For surges and transients, industry can provide a lot of different products to address these problems. But, all surge suppressors have two major functions:

1) whether it is a MOV, Zener diode, silicone avalanche diode, they have one thing in common, the higher the voltage goes over the threshold rating of the device, the lower the resistance becomes and the closer it gets to zero. The ideal working condition of these devices is to channel the magnitude of that phase to ground. The idea is to clip the excess, this does protect the equipment but, if the magnitude of the spike exceeds its designed joules/second, its tanks will rupture and you take it for granted that it is protecting the equipment (but it is not).

2) when it takes a spike from one phase and channels it to ground (protecting the equipment), it is wasting the true RMS value (voltage) that otherwise could be collected. If we could protect the equipment and not waste energy, this would be ideal.

**Surge and Transient Filtering**

*ESP Systems Feature #3 – Standard*

Unlike MOV’s, Zener’s, and other Surge Suppressers that:

- Have limited joules/second.
- Re-channel the energy to ground/neutral.
- No status indicators.

**The Solution - ESP Systems**

ESP Systems offers to clip the surge or transient, protecting the equipment and it also absorbs the magnitude of the surge or transient (true RMS value) an infinite number of times and channels it inside the tank circuits of each delta configuration and releases it 120° out of phase. Thereby, accomplishing the two criteria, saving the energy (although minute) but still the savings are there and power quality.
An example of how ESP Systems, filters surges and transients:

ESP Systems, clips surges or transients and releases it 120° out of phase.

Harmonics

Harmonics by definition is multiple images of line frequencies. In North America, the line frequency is 60Hz, therefore, H₃ = 180Hz, H₅ = 300Hz, etc. Major causes of harmonics are non-linear loads, such as, computers, electronic equipment, robotics, electronic lighting ballasts, variable-speed drives, frequency inverters, UPS systems, DC drives, battery chargers, etc. These devices are becoming more and more common in industry. As a result, the more total harmonic distortion, the more the distortion of waveforms, whether voltage or current.
Harmonics cause the following adverse side-effects:

- Overheated transformers (K factor) and rotating equipment. Electrical fires in industry are generally caused by overheated transformers. The more electronic equipment and non-linear loads in the electrical distribution, the less the efficiency of the transformer and the more we have to compensate for the de-rating of that transformer. For example, if we have a transformer rated as 1000KVA, 480V, 1200A, and non-linear loads of 50% (not uncommon in today’s industry), we have to de-rate the transformer by 50%. Therefore, the transformer sizing becomes 500KVA. This has to be done because, based on all meters in the industry (meters on distribution panels), they measure average RMS value and they monitor the fundamental waveform. If there are harmonics present in the system, if you super impose the harmonics curves onto the fundamental, this is what the meters register because the value of that is true RMS value.

If you took a true RMS meter and took a measurement on voltage and current, for example, take the true RMS value based on FFT (that is what the transformer registers), and compare it to average RMS value, the value of true RMS is much higher than the average RMS values. The difference between the two magnitudes, chances are, is caused by harmonics. This may be taken for granted. Example – look at the panel meter, it reads 800Amps for a 1000KVA transformer, it appears like there is no problem, but, if you take a true RMS measurement, chances are the draw is much more than 800Amps. This could lead to overheating/loading of cables, transformers, protective equipment, buss bars, etc., causing problems without even knowing it.

- Neutral overloading (due to imbalanced conditions and/or harmonics present which leads to) / unacceptable neutral-to-ground voltages – which means – current form of the neutral, based on the impedance, can expect a stray voltage which is undesirable and needs to be filtered out.

- Distorted voltage and waveforms – represents a typical distortion. There are standards in industry on this. Example – IEC 555 and IEC 1000.

- Failed capacitor banks – capacitors/reactors (\(X_c = 1/(2\pi fC)\)). The higher the frequency, the lower \(X_c\) becomes. The lower \(X_c\) becomes, the closer \(X_c\) reaches zero which is a short circuit and the capacitor will rupture. To our knowledge, if we are dealing with multiple cell configurations of capacitors, there is not a single capacitor manufacturer in the world that is monitoring these individual cell failures or the values of the failures. If this happens, inadvertently, the system is thrown off balance because the supply voltage across the terminals of the capacitors changes/are different.

- Breakers and fuses tripping – all breakers and fuses are designed, manufactured, and tested based on the true RMS value and the heat content of the amperage draw. From time to time, a breaker trips, the technician goes and takes a measurement expecting to find a short circuit but there is no short circuit. He turns the breaker on and it works. Quite often harmonics under a resonance condition, in particular, are the cause of this type of problem.
• Unreliable operation of electronic equipment and generators. As we know, \( t = \frac{1}{f} \). The higher the frequency, the lower the \( t \) (period), the faster the firing order of the SCRs, and the more breakdowns we can expect in our more sensitive equipment and the faster responsive equipment purchased for production.

• Erroneous register of electric meters. A number of studies and papers have been released on this topic. That is, our electric meters are calibrated for 60Hz. If we have a higher frequency due to harmonics in the system, the higher the frequency, the higher the percentage error in the register.

• Wasted energy – Inefficient distribution of power. All the energy that is presently being wasted in/distributed in the distribution, cables, switchgears, bussbars, transformers (all these true RMS values), if we can filter them out and ideally re-use it (if possible), will free KVA capacity in the distribution, cables, switchgears, bussbars, transformers. This would result in two major benefits: 1) energy savings and, 2) power quality.

In line with the above problems, we can expect energy wasted and reduced power quality through:

- Increased maintenance of equipment and machinery.
- Wasted energy/higher electric bills – KWD and KWH.

**Broadband Harmonics Filtering**

ESP Systems - Feature #4 – Standard

Unlike active filters that:

- Waste energy.
- Connect in series.
- Generate harmonics (through injection).
- Have limited fixed sizes and are not expandable.
- Are bulky and expensive.

The Solution - **ESP Systems**

ESP Systems, offers broadband harmonics filtering and the elimination of associated wasted energy. The filtering of harmonics is handled through the LCR circuits with the key component being the inductor/reactor. The filtering characteristics of the circuits consist of Low Pass – Untuned, High Pass – Untuned, and Tuned.
Power Factor

\[ PF = \cos \theta = \frac{\text{Real Power (KW)}}{\text{Apparent Power (KVA)}} \]

Power factor is the phase shift between voltage and current. A lagging power factor is generally caused as a result of inductive loads and particularly motors not being fully loaded.

Low power factor causes the following adverse side effects:

- Increased line losses – \( I^2R \)
- Wasted generation capacity (KVA).
- Wasted distribution/transformer capacity (KVA).
- Wasted system capacity (KVA).
- Reduced system efficiency (KW).
- Increased maximum demand (KVA) and related charges.
- Possible power factor charges.

In line with the above problems, we can expect energy wasted and reduced power quality through:

- Increased maintenance of equipment and machinery.
- Wasted energy / higher electric bills – KWD and KWH.
- Wasted investment and operation capital.

The oldest solution for a low power factor in industry, in terms of counter balancing the lagging power factor, are capacitors. But, there are problems associated with capacitors which industry is staying away from because of the potential side-effects to today’s sensitive equipment (ex. electronics, computers, etc.).
Characteristics of Power Factor Correction Capacitors (PFCC’s):

- Over-voltage, unregulated supply. Across the terminals of the capacitors, voltage supplied by the capacitors is higher than the supply/system voltage. This increases the magnitude of the voltage and as a result with the impedance being lower, this increases the susceptibility for surges and transients. Low impedance (is the path of least resistance), and higher voltage, resulting in a spike over riding on the peak of the sine wave or anywhere along the wave. This would increase the overall magnitude and the impact of the surge, transient, or spike and therefore, increasing the damaging effects. All this could be happening and you would not even know it.

- Harmonics magnification – discussed above.

- Resonance and overheating ($X_c = X_l$). Regardless of which capacitors are used, automatic, static-dynamic, or aerostatic, the $X_c$ is constant, but $X_l$ (inductive/reactive), is the load which is constantly changing, as it changes through the course of operation. If $X_c = X_l$, a resonance condition occurs. This results in overvoltage conditions, overheating, and the damaging effects of these conditions.

- Capacitor cell failure ($X_c = 1/(2\pi fC)$). Ideally, we want $f = 60$Hz, but, if harmonics are present, it is not possible (higher number). The higher the value, the lower $X_c$ becomes and approaches zero, resulting in capacitor breakdown, etc.

- Susceptibility to surges and transients, reduced $Z$(impedance). Discussed earlier.

- “Ringing” effect during capacitor charging, oscillation.

- No cell failure protection/monitoring. If you have a cell failure, inadvertently the supply voltage to the load is thrown off balance. Comparatively speaking, in a three phase system, one phase is drawing more than the other phases or one phase is drawing less than the other phases. In either condition, a negative voltage sequence and circulating currents occur and the losses associated with these conditions. If a cell is lost, dropping the voltage of that phase, an unbalanced supply voltage to the loads results.

- Leading power factor in low-load or no-load conditions.

- Release KVA capacity. Reduced inductive reactive current/power.

- Increase power factor.

- Increased torque and KW, based on percent loading.

Power Factor Improvement
ESP Systems - Feature #5 - Standard

Unlike PFCC's / capacitor bank's adverse side-effects (mentioned above):
The Solution - ESP Systems

Improving power factor is a great idea because it increases the efficiency of the distribution, reduces losses, and power factor charges are eliminated (if charged). ESP Systems is able to reduce/eliminate this phase shift and deliver a steady state power factor between 94%-Unity regardless of the plant’s load conditions without any side effects.

KVA Capacity

Wasted KVA has the following adverse effects:

- Additional load requires an increase in supply size.
- Additional load requires larger disconnecting means.
- Additional load requires higher rated protecting devices.
- Cable/bus ampacity must be rated higher than necessary.

In line with the above conditions, the results are:

- Unnecessary capital expenditure for such wasted KVA capacity.
- More space required for additional equipment.

KVA Capacity Improvement
ESP Systems - Feature #6 - Standard

Unlike PFCC's / capacitor bank's adverse side effects…
The Solution - **ESP Systems**

Since ESP Systems reduces/eliminates power factor losses, eliminates harmonic losses, and other losses (negative voltage sequence, circulating currents, hysteresis, etc.), this translates into released KVA (useful power instead of wasted power). It will release KVA in the distribution system, whether it is needed or not, it is available. If you need the increased KVA for expansion, you have it. If you do not need this extra capacity, your equipment will run cooler and more efficiently. As a result, resistive power and reactive power will both be reduced.

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**Brownouts**

Brownout by definition is low voltage for an extended period of time (greater than half a cycle) in which the magnitude of the voltage is reduced.

Brownouts cause the following adverse effects:

- Temporary low line voltage.
- Shutdowns.
- Loss of microprocessor memory.
- Loss of control.
- Reduced motor torque, which can lead to stalling.
- Overheating of motors – insulation breakdown.
- Protective device tripping.
- Speed variation.

In line with the above conditions, the results would be:

- Increased maintenance and downtime.
- Increased operating expenses.
Brownout Protection
ESP Systems - Feature #7 - Optional

Unlike UPS, SPS, and Voltage Stabilizers that:

- Waste energy.
- Connect in series.
- Generate harmonics.
- Have limited fixed sizes and are not expandable.
- Are bulky and expensive.

The Solution - ESP Systems

ESP Systems offers to improve the voltage to the secondary nameplate of the transformer thereby delivering steady state voltage to the equipment and machinery.

Intermittent Supply Failure

Generally, intermittent supply failures are caused by the utility company switching loads, lines, and source supplies. The fastest this switching can occur is three to five cycles. During this period, there is a complete drop-out. This may or may not be a concern for all industries but intermittent supply failure takes its toll on the operation and efficiency of equipment and machinery.

Supply failure causes the following adverse effects:

- Voltage control relay tripping.
- Phase imbalance relay tripping.
• Plant and equipment shutdown – downtime.
• Loss of critical microprocessor memory.
• Possible jogging, pinching, and stalling of motors.
• Loss of control and resetting of equipment.
• Loss of production.

Interruption Supply Failure Protection
ESP Systems - Feature #8 - Optional

The Solution - ESP Systems

ESP Systems is able to supply a steady state (as a drop-out occurs) sine wave to the distribution for up to 1 second.

Specific Harmonics

Harmonics cause the following adverse effects:

• Overheating of transformers (K-Factor), and rotating equipment.
• Increased hysteresis losses.
• Distorted voltage and current waveforms.
• Failed capacitor banks.
• Breakers and fuses tripping.
• Erroneous register of electric meters.
• Neutral overloading / unacceptable neutral-to-ground voltages.
• Unreliable operation of electronic equipment and generators.
In line with the above problems, we can expect energy wasted and reduced power quality through:

- Wasted capacity – Inefficient distribution of power.
- Increased maintenance of equipment and machinery.
- Wasted energy / higher electric bills (KW,KWH).

**Specific Harmonics Filtering**
ESP Systems - Feature #9 - Optional

Unlike active filters that:

- Waste energy.
- Connect in series.
- Generate harmonics (through injection).
- Have limited fixed sizes and are not expandable.
- Are bulky and expensive.

The Solution - **ESP Systems**

ESP Systems filters specific and multiple harmonics to a non-destructive level resulting in energy savings, improved production, and increased equipment efficiency and longevity.

**Phase Loss**

Phase loss causes the following adverse effects:

- Imbalanced operation of three phase motors, resulting in insulation breakdown and destruction.
- Increased downtime.
- Loss of production.
- Major maintenance and replacement capital requirement.
Phase Synthesis
ESP Systems Feature #10 - Optional

Unlike any other device in existence.

The Solution - ESP Systems

In case of a phase loss, ESP Systems can quickly detect and manufacture the lost phase from the remaining two phases, ensuring a continuous supply of power to the plant and eliminating loss of valuable production time.

An example of how ESP Systems generates the lost phase:

Assume: A phase is lost and the phase rotation is ABC.

Steps Involved:

1) Retard B phase by 90°. This is accomplished by making it inductive.

2) Advance C phase by 90°. This is done through capacitance.

3) This leaves 60° to be compensated for to finish establishing the A phase. The compensations which have been made thus far will result in oscillations because of the load changes. In order to lock the A phase, a zero phase-shift has to be introduced. This is accomplished through introducing close tolerance resistors. The close tolerance resistors pull 30° from each side (B1 and C1) and lock/stabilize the voltage of A phase into place.
Implementation of ESP Systems's phase synthesis unit:

The installation of the ESP Systems, phase synthesis unit would be between the main transformer and the plant’s main distribution panel. The operating time of the phase synthesis unit is continuous/indefinite (until the lost phase is restored).

If the utility company losses a phase, the protection devices (short-circuit relays, fault currents, etc.) of the plant have to be bypassed. If this is not done, every time the ESP System's phase synthesis unit comes on, it will trip these protection devices. A bypass is used from the secondary transformer and the plant’s load so there will be no feedback from the lost phase. In other words, if A phase is lost, interlocks will open and close to make this phase in series through the phase synthesis unit.

Certain criteria have to be taken into account to see if a phase synthesis unit can be installed in a plant. Some of these criteria are:

1) make sure the ampacity is there for the conductors to carry the load of the other two phases.
2) the sizing/rating of the short-circuit relays on the primary side so they do not trip.
3) is the transformer capable of sustaining this type of operation.
4) the full load of the main transformer has to be less than 67% at the time the phase synthesis unit comes on. If the full load of the transformer is greater than 67%, the phase synthesis unit will not engage. Etc.

The ESP phase synthesis unit is not really intended for North America because phase loss situations are rare but will be installed if a customer requires it.

Summary: ESP System Benefits

Savings

1 – Reduces KW Demand
2 – Reduces KWH Consumption
3 – Eliminates Power Factor Penalty
4 – Reduces Monthly Electric Bill
5 – Reduces Maintenance & Downtime

Power Quality

1 – Improves Voltage
2 – Balances Three Phases
3 – Filters Surges, Transients
4 – Filters Harmonics
5 – Improves Power Factor

Customer Satisfaction Is Our Ultimate Goal!