Environmental Potentials

Power Quality For The Digital Age

Electrical Losses due to Skin Effect and Proximity Effect

AN ENVIRONMENTAL POTENTIALS WHITE PAPER

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Heat in the System

Reducing heat in the electrical system is critical to improving power quality. Wire is the heart of the electrical distribution system. A typical facility can have tens of thousands of feet of wire throughout the facility and wire is a major source of heat. Heat prematurely degrades wire quality causing both energy losses and burnout of the wire.

The resistance in an electrical system is never constant. It depends on various factors such as humidity, length of wire and high frequency noise. Wire is the main conduit of electricity and is central to the electrical system. Resistance in the wire converts a portion of electrical energy into heat.

Heat in the wire decreases the efficiency of the distribution system. It also creates a fire hazard. Contraction and expansion of wire due to cooling and heating of wire loosens wire connections. This makes it possible for the electricity to arc and the heat output can reach 1800 degrees Fahrenheit. This is enough heat to ignite wood or insulation.

Skin effect and proximity effect are the two major sources of heat in wire.

Skin Effect

Skin effect is the trend of current to flow on the circumference of the wire so that the current density is greater at the surface than at the core. High frequency noise in the range of 1kHz-1.5MHz increases the inductive reactance of the wire. This forces the electrical charge towards the outer surface of the wire. This means that the total available space of the wire is not used to carry the electrical power.

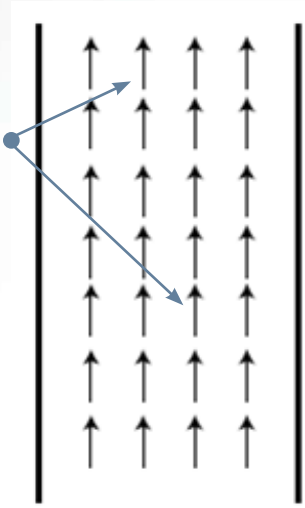


Figure 1, the flow of charge is using all of the available space of the wire. This is an efficient use of wire.

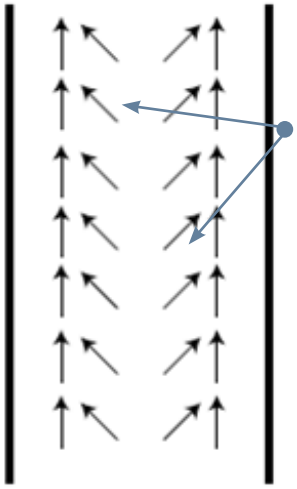


Figure 2 Shows the flow of charge in wire when skin effect takes hold. Due to HF noise, the charge is being pushed to the circumference of the wire.

Figures one and two, show the cross sectional view of an electrical wire. Figure one is the optimal use of wire. The charge flows smoothly through the wire. Figure two shows the charge being pushed to the circumference due to high frequency noise.

Overcrowded electrons at the circumference of the wire will not find sufficient room to travel increasing friction among them. This will lead to release of frictional energy also known as heat. Generated heat from the wire will leave the wire through its plastic insulation. Prolonged exposure of plastic to the heat will decrease the life span of the wire.

Proximity Effect

Along with skin effect, proximity effect is a common problem found in every electrical system. Proximity effect is defined as the jumping magnetic field from one conductor to another conductor nearby. The major causes of proximity effect are closeness of the wires, bends in the wire, skin effect and high frequency noise.

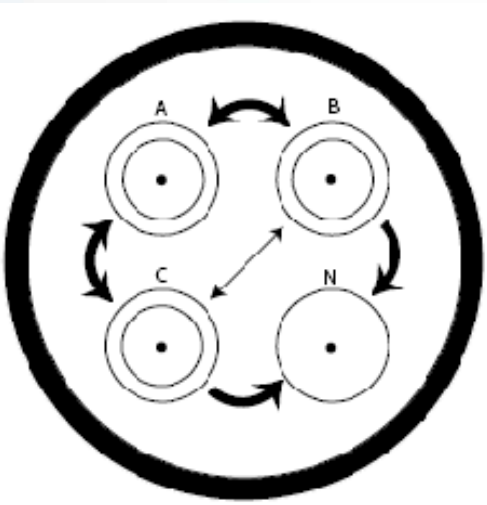


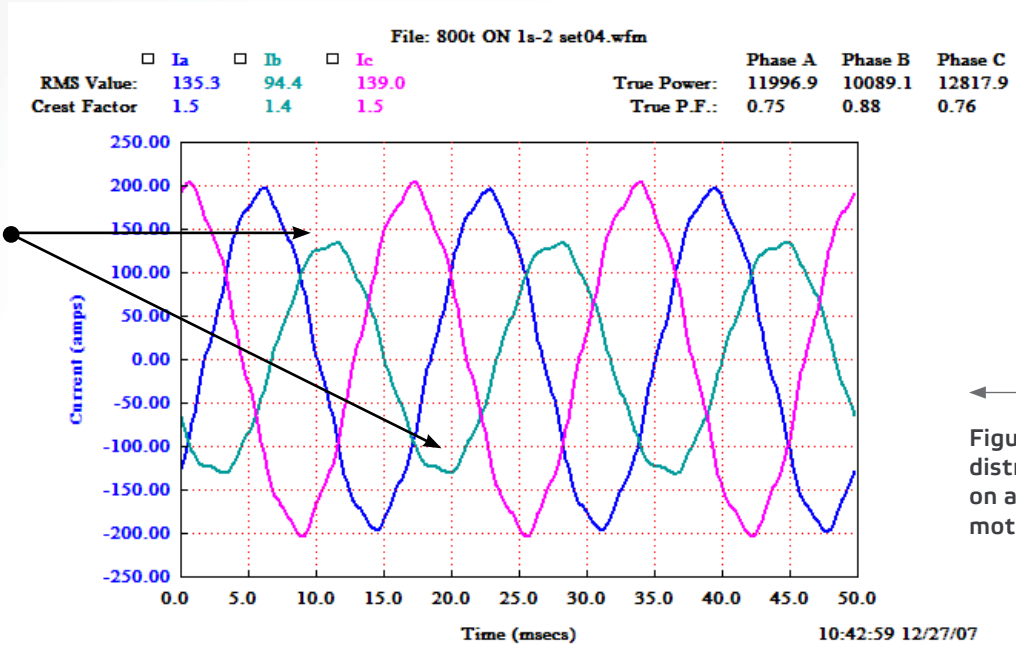
Figure 3. Crosss sectional view of a three phase wire with the neutral showing proximity effect

Figure three shows the cross sectional view of wire with three phases and a neutral. The charge can jump from phase to phase or phase to neutral. In the event of high frequencies skin effect will result in the sharing of magnetic fields of three phase conductors. This will cause unequal field distribution. Unequal field distribution means the three phase conductors on the same wire will not carry the same amount of current.

For a three phase load to perform properly, the current distribution in all three phases must be equal. Imbalance in the current distribution leads to improper function of the load, poor power factor and less efficient. Proximity effect is the main cause of imbalanced load distribution. Proximity effect significantly increases the AC resistance of the conductor thus resulting in losses.

Skin Effect & Proximity Effect in Real World

Load imbalance is defined as the imbalance in the current distribution to the load. In a three phase electrical signal, the magnitude of the current in all three phases should be equal. Unequal distribution in the three phases results in decreased performance of the load.



Due to skin effect and proximity effect phase b has significantly less current than phases a & c.

Figure 4. Current distribution on a three phase motor before EP

This reading was taken at a press machine that would complete 23.5 presses per 4 minute cycle and shows significant imbalance in current distribution. Phase A has 135.3 amps; phase B only has 94.4 amps while phase C has 139.0 amps. This unequal distribution will significantly decrease equipment performance.

To correct this imbalance skin effect and proximity effect must be eliminated. Environmental Potentials' patented waveform correction technology filters harmful high frequency noise which decrease skin effect and proximity effect.

The following chart was taken at the same press machine three months after installing EP's patented waveform correction technology.

After installing EP, skin effect and proximity effect are removed. Balancing the current levels for phases a, b & c.

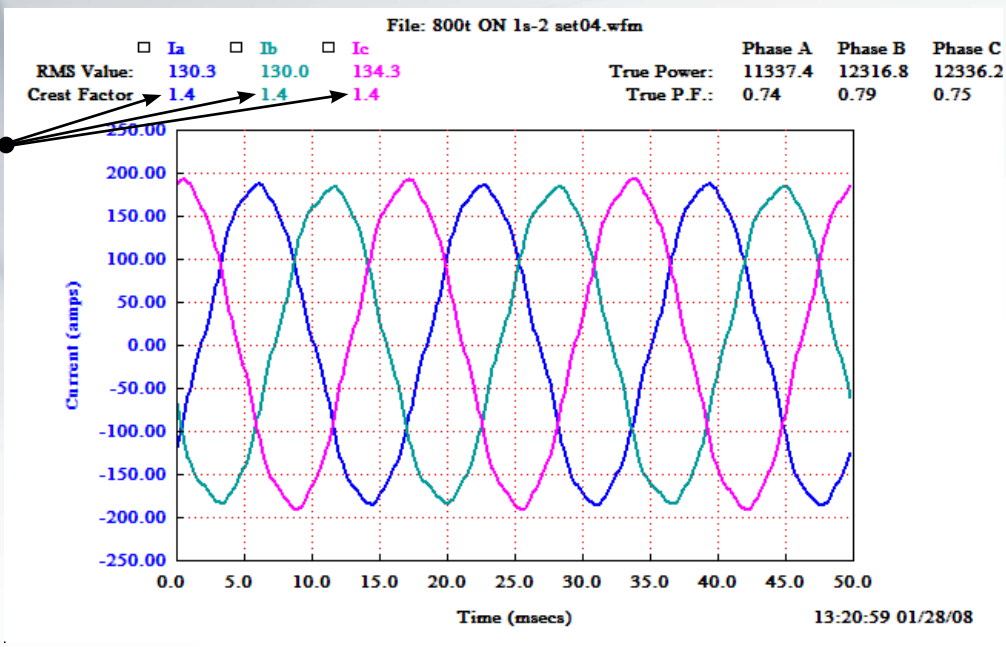


Figure 5. Current distribution on a three phase motor 3 months after EP

The current has been significantly corrected. Phase A has 130.3 amps; phase B phase 130.0 amps while phase C has 134.3 amps. After three months of installation on the 800 ton press machine increased more than 48 percent to 35 presses per 4 minute cycle. Heat losses on this motor were reduced by more than 14 percent during this same 3 month period.

Conclusion

Heat in the electrical distribution system is a major source of electrical losses in facilities. Wire is the heart of the distribution system and a major source of heat. High frequency noise in the range of 1kHz-1.5MHz is responsible for skin effect and proximity effect in wire. Skin effect and proximity effect are major contributors to heat losses and imbalance in current distribution.

Environmental Potentials' patented waveform correction technology is the safest and most efficient method of removing harmful noise from the system. EP waveform correctors are powerful low pass filters, which not only remove noise but also maintains the sinusoidal nature of the waveform. This significantly reduces heat and electrical losses.