TECHPRO PLUS

Voltage and Current Unbalance

February,2025

ABSTRACT

Voltage and Current Unbalance are a significant power quality issues that can negatively affect power system performance and reliability. The abstract provides a description of the causes, effects, and techniques of simplified Voltage and Current Unbalance Calculation methods.

Contents

Voltage and Current Unbalance

The condition of Voltage and Current Unbalance is when the voltages or currents in a three-phase power system are not equal in magnitude or do not differ 120 degrees in phase. The unbalance can have negative effects on electrical equipment and the power system.

Voltage Unbalance

Causes of Voltage Unbalance

1. **Unequal Distribution of Single-Phase Loads:**

   Voltage unbalance is often caused by uneven single-phase distribution. When phases carry significantly different loads, the resulting voltage drops are unequal, leading to an unbalanced system.

2. **Significant Single-Phase Loads:**

   The presence of large single-phase loads, such as high-power motors or welders, can induce significant voltage drops on the supplying phase, worsening voltage unbalance.

3. **Open or High-Resistance Connections:**

   Open circuits or high-resistance connections (e.g., loose, corroded, or damaged) impede current flow and can cause voltage unbalances due to localized voltage drops.

4. **Equipment Malfunctions:**

   Equipment failures (e.g., in transformers or generators) can disrupt balanced voltage distribution, leading to significant voltage unbalance.

5. **Unequal Transformer Impedances:**

   Variations in transformer phase impedances lead to unequal voltage drops, resulting in voltage unbalance.

Effects of Voltage Unbalance on Equipment and System Performance

1. **Overheating of Motors and Transformers:**

    Voltage unbalance causes excessive heat in motors and transformers, accelerating insulation breakdown and leading to premature failure.

2. **Increased Current and Losses:**

    Voltage unbalance increases resistive losses (I^2R) in conductors and equipment, wasting energy and adding to the system's thermal burden.

3. **Reduced System Efficiency:**

    The combined effect of increased losses and heat generation reduces overall power system efficiency and increases operating costs.

4. **Premature Equipment Failure:**

    Overheating, electrical stress, and insulation degradation significantly reduce the lifespan of equipment like motors, transformers, and conductors, increasing replacement and maintenance costs.

5. **Increased Vibration and Noise in Motors:**

    Voltage unbalance causes pulsating torques in motors, leading to increased vibration and noise. This not only creates disturbances but also accelerates motor failure.

Current Unbalance

Causes of Voltage Unbalance

1. **Voltage Unbalance**:

   Unequal phase voltages cause current unbalance, leading to disproportionate current flow.

2. **Unequal Impedances**:

   Differences in conductor lengths, cable types, or transformer characteristics create impedance variations, resulting in uneven current distribution.

3. **Unbalanced Loads**:

   Uneven load distribution across phases causes current unbalance, even if voltages are balanced, especially when loads have different power factors.

4. **Equipment Malfunctions**:

   Faults in transformers, generators, or motors disrupt current flow, leading to unbalance.

5. **External Factors**:

   Environmental changes, electromagnetic interference, or load fluctuations can also contribute to current unbalance.

Effects of Current Unbalance on Equipment and System Performance

1. **Elevated Energy Losses:**

   Current unbalance raises resistive losses, reducing system efficiency and increasing operating costs.

2. **Equipment Malfunction:**

   Current unbalance disrupts the performance of motors, transformers, and protective relays, leading to inefficiency and unpredictable operation.

3. **Diminished Equipment Lifespan:**

   Excess heating from unbalance accelerates insulation and component degradation, shortening equipment lifetime.

4. **Excessive Component Heating:**

   Uneven current flow causes localized overheating in conductors and transformers, increasing failure risks and fire hazards.

5. **Compromised System Safety:**

   Unbalance weakens protective devices like fuses and breakers, heightening fault risks and endangering system integrity and personnel safety.

Key Points

- Current unbalance is often a consequence of voltage unbalance. Addressing the voltage unbalance often resolves the current unbalance.
- Both voltage and current unbalance can have significant detrimental effects on electrical equipment and the power system.
- Regular monitoring and correction of unbalances are crucial to ensure reliable and efficient operation of the power system. This includes checking connections, balancing loads, and maintaining equipment.

Calculating Voltage and Current Unbalance

The Several methods exist for calculating unbalance. A common and simple method using the **Percentage Unbalance** or the **NEMA (National Electrical Manufacturers Association) definition**, following these formulas:

1. Calculate the Average Voltage or Current:

$$V_{avg} = \frac{(V_{ab}+V_{bc}+V_{cd})}{3} \quad \text{For Voltage}$$

$$I_{avg} = \frac{(I_{ab}+I_{bc}+I_{cd})}{3} \quad \text{For Current}$$

In **MS Excel** We use Average function; **Syntax is =AVERAGE ()**

Where V_{ab}, V_{bc} and V_{cd} are the line-to-neutral voltages and I_{ab}, I_{bc} and I_{cd} are the line currents for phases AB, BC, and CD respectively.

2. Calculate the <u>Deviation</u> of Each Phase from the Average:

$\Delta V_{ab} = |V_{ab} - V_{avg}|$

$\Delta V_{bc} = |V_{bc} - V_{avg}|$

$\Delta V_{cd} = |V_{cd} - V_{avg}|$

$\Delta I_{ab} = |I_{ab} - I_{avg}|$

$\Delta I_{bc} = |I_{bc} - I_{avg}|$

$\Delta I_{cd} = |I_{cd} - I_{avg}|$

3. Calculate the <u>Maximum Deviation</u>:

ΔV_{max} = MAX (ΔV_{ab}, ΔV_{bc}, ΔV_{cd})

ΔI_{max} = MAX (ΔI_{ab}, ΔI_{bc}, ΔI_{cd})

In **MS Excel** We use Maximum Function; **Syntax is =MAX ()**

4. Calculate the <u>Percentage Unbalance</u>:

Voltage Unbalance (%) = (ΔV_{max} / V_{avg}) * 100

Current Unbalance (%) = (ΔI_{max} / I_{avg}) * 100

Example:

The line-to-neutral voltages are: V_{ab} = 470V, V_{bc} = 485V, V_{cd} = 460V And Voltage Unbalance at most 8 %:

1. V_{avg} = (470 + 485 + 460) / 3 = 471.667 V
2. ΔV_{ab} = |470 - 471.667| = 1.667V

   ΔV_{bc} = |485 - 471.667| = 13.333V

   ΔV_{cd} = |460 - 471.667| = 11.667V
3. ΔV_{max} = 13.333V
4. Voltage Unbalance (%) = (13.333/ 471.667) * 100 = 2.827%
5. Voltage Unbalance is within acceptable limits. The measured value is 2.827%, which is below the 8% threshold.

Calculating Voltage and Current Unbalance using MS Excel

Download this file : Voltage and Current Unbalance is calculated

Conclusion

The paper concludes that voltage and current unbalance can lead to increased losses, excessive wear, and potential damage to electrical equipment. The percentage of unbalance is calculated by dividing the maximum deviation from the average value by the average value, then multiplying by 100. It's crucial to keep the unbalanced percentage low to prevent system inefficiencies. The NEMA guidelines offer a benchmark for acceptable levels of unbalance, ensuring the protection and optimal functioning of equipment.

References

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