Dry Type Distribution Transformers

NON-LINEAR TRANSFORMER PRESENTATION
Dry Type Distribution Transformers

PROBLEM: HARMONICS CAUSE EXCESSIVE TRANSFORMER HEATING

- Increased Losses
- Proximity
- Skin Effect
- Stray Losses
- Circulating Effect
- Triplenn Harmonics Add in Neutral
- Increased Eddy Currents
- Core Saturation
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NOTHING NEW:

• Rectifier Transformers
• Power Supply Transformers
• Precipitation Transformers
• Filament Transformers
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WHAT IS NEW:

Many New Sources

- Electronic Ballasts
- Switching Mode Power Supplies
- Solid State Motor Drives
CUTLER-HAMMER TYPE KT
DRY TYPE DISTRIBUTION
TRANSFORMERS
FOR
NONLINEAR LOADS
REMEMBER!

The nonlinear transformer does not generate, nor does it eliminate harmonics. The transformer “tolerates” the nonlinear load condition.
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LINEAR VS NONLINEAR LOADS

LINEAR LOADS:
A load that does not affect the input waveform, which is a pure sinewave, composed of a 60 hz component with no multiple frequencies.

NONLINEAR LOADS:
A load that distorts the input sinewave such that the resultant waveform is composed of a 60 hz component and multiple frequency components called harmonics.
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Voltage Wave

Current Is Demanded Only At The Peaks Of The Voltage Wave

Current Wave
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HARMONICS
GAS PUMP ANALOGY
NON-LINEAR TRANSFORMERS
WHAT ARE HARMONICS?

<table>
<thead>
<tr>
<th>Harmonic</th>
<th>Frequency in Hz</th>
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<tbody>
<tr>
<td>Fundamental</td>
<td>60</td>
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<tr>
<td>3rd</td>
<td>180</td>
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<tr>
<td>5th</td>
<td>300</td>
</tr>
<tr>
<td>7th</td>
<td>420</td>
</tr>
<tr>
<td>9th</td>
<td>540</td>
</tr>
<tr>
<td>11th</td>
<td>660</td>
</tr>
<tr>
<td>etc.</td>
<td>etc.</td>
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</table>
Dry Type Distribution Transformers

RECENT HISTORY

1990  ITC Introduces “K-Factor” Transformer

Nov. 1990 - ITC Receives UL Listing


UL  Standard 1561
    Effective 1992
    Much Discussion
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NON-LINEAR TRANSFORMERS
Pertinent Facts

- Rated by K Factor
- K Factor Related to Heat
- Band Aid - Don’t Solve the Problem
- Tolerate Intolerable Condition
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KEY DESIGN FEATURES

1. Reduced Induction Core
2. Properly Sized Winding Conductors
3. Oversized Neutral
NON-LINEAR TRANSFORMERS
WHAT IS K FACTOR?

\[ K = \sum (I_h)^2 (h)^2 \]

Ih = Percent Current at Harmonic h

h = Harmonic Order, i.e. 3rd, 5th, 7th, etc.
# K FACTOR CALCULATION

<table>
<thead>
<tr>
<th>h</th>
<th>Ih</th>
<th>(Ih)^2</th>
<th>h^2</th>
<th>(Ih)^2h^2</th>
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<tr>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
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<td>3</td>
<td>0.1000</td>
<td>0.0100</td>
<td>9</td>
<td>0.0900</td>
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<td>0.0225</td>
<td>25</td>
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<td>81</td>
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<td>SUM</td>
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K FACTOR
A common industry term for the amount of harmonics produced by a given load is the **K Factor**.

The larger the **K Factor**, the more harmonics are present. Linear loads, for example, have a **K Factor** of 1.

Transformers may carry a **K Factor** rating to define the transformer’s ability to withstand the additional heating generated by the harmonic currents.

**Standard Industry K FACTOR Transformer Ratings:**

<table>
<thead>
<tr>
<th>K-4</th>
<th>K-30</th>
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<tbody>
<tr>
<td>K-9</td>
<td>K-40</td>
</tr>
<tr>
<td>K-13</td>
<td>K-50</td>
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<tr>
<td>K-20</td>
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K-FACTOR REDUCTION
Multiple Loads

- Harmonic Cancellation
- 3rd Harmonic Reduction in Delta-Wye Transformer
- Source Impedance Effects
- Linear Load Dilution
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HARMONIC CANCELLATION

Compaq 386/33L
K = 12.1

Compaq Portable
K = 13.6

Packard Bell
K = 9.5

K = 7.8
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NON-LINEAR TRANSFORMERS
UL LISTING

- No UL listing for K Factor means transformer is rated only for linear loads.

- UL listing requires label stating: “Suitable for non-sinusoidal current loads with K Factor not to exceed ___”.

- K Factors can be 4, 9, 13, 20, 30, 40, or 50.
FEATURES AT A GLANCE

- Three phase 480 delta - 208Y / 120 standard. Other voltage combinations are available.
- Class 220 deg C insulation system.
- Available with 150, 115, or 80 deg C winding rise.
- Aluminum windings are standard (copper optional).
- NEMA 2 ventilated enclosure.
- An electrostatic shield and 200% neutral are standard features.