UTILITY APPLICATIONS OF POWER ELECTRONICS

SESSION no. 29

ECE 529
Specific application
In more detail on a
Develop simulation model
2
Pose a report based on
Are there any topics that
It can be a topic we aren't
Choose a topic
Class Project
5 - 7 pages
ECE529 Homework #4

Due Session 34 (April 12)

A large industrial facility has a total load of 4MW load at unity pf, includes some loads that are sensitive to voltage sags that will trip when a sag lasting more that 4 cycles occurs. The plant is currently fed by a 13.8 kV distribution feeder. Your task is to rate a dynamic compensation scheme to correct for the voltage sags such that the RMS load voltage stays above 0.95 pu during a voltage sag down to 0.67 pu. A one-line diagram of the system is given below. All of the per unit impedances are on a 4 MVA base, with voltage bases starting from the equivalent source.

![Diagram](image)

A. First consider using STATCOM, where a 3 phase fault occurs at the location shown. What is the MVA injection needed at the STATCOM location shown in the above figure (where it says STATCOM (part A), to raise the voltage to 0.95 pu until the fault is cleared. Calculate the real and reactive power the STATCOM needs to supply.

B. Instead, consider using a static series compensator with energy storage, such as a dynamic voltage restorer (DVR). Calculate what voltage the DVR must provide to compensate for the voltage sag in part A rather than using the STATCOM. If the sag lasts for 9 cycles, how much energy must the DVR supply?

C. Now suppose that the compensator of part B sees a 50% voltage sag on one phase with a 30 degree phase shift in the voltage on that phase during the sag. What is the magnitude and angle of the voltage that is needed to restore the voltage to 0.95 p.u. on that phase (you don't need to analyze the circuit to try to create this condition). How much energy must the DVR supply if the sag lasts for 9 cycles.
\[ V_{\text{dev}} \rightarrow \text{correct} \ 0.7 \text{ L} = 0.45 \text{ L} \]
\[ \begin{align*}
1^0 \delta_{\tau_0} \rho_d &= (1)b \\
0^0 \delta_{\tau_0} \rho_d &= (1)d
\end{align*} \]

\[ \begin{align*}
\left( \begin{array}{cc}
1 & 0 \\
1 & 0
\end{array} \right) \left( \begin{array}{cc}
1 & \lambda - \lambda \\
1 & \lambda
\end{array} \right) \frac{2}{\varepsilon} &= (1) \delta_{\tau_0} \rho_d
\end{align*} \]

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\end{align*} \]

Note: We need the \(3/2\) term because of the constant in transformation matrix.

- Phasor form: 1st
- Phasor form: 2nd

L = \frac{v_0}{\ell} W

\[ \begin{align*}
\lambda &= \frac{v_0}{\ell} W = 2.25 \text{ MW} \\
\lambda &= \frac{v_0}{\ell} W = 3.89 \text{ MW}
\end{align*} \]
Note that the zero sequence part of the compensator current is assumed to be zero.

This is due to the assumption that the compensator is a three-wire device (more than a YSC).

Return and the ability to compensate zero sequence terms is inherently ungrounded, so the converter topology needs to change to add a ground.
Case 1: Just consider harmonics.
Compensator Currents.

For most of this example we will stick with just the 3 phase complex power phasor solutions.

\[
\frac{2}{R S} \left[ \sum_{k \neq 1} \frac{Z}{(Z - \frac{2}{R S})} \right] = 0 \quad L(0)
\]

\[
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\]

RS = 128
Now find the component currents:

\[ \begin{align*}
I_{\text{source}} &= I_{\text{load}} - I_{\text{compABC}} \\
I_{\text{source}}^2 &= (I_{\text{load}} - I_{\text{compABC}})^2
\end{align*} \]
Note that $V_a$ and $i_n$ are not in phase.
By subtracting average $P$, but not average $Q$.

$\text{comp} \langle (1) \rangle = \text{comp} \langle (1) \rangle$

$\text{comp} \langle (0) \rangle = \text{comp} \langle (1) \rangle$

$\left( \begin{array}{c} (1) \delta d - (1) d \\ (1) \delta \lambda - (1) \lambda \end{array} \right) \cdot \left( \begin{array}{c} (1) \lambda - (1) \lambda \\ (1) \lambda + (1) \lambda \end{array} \right) \cdot \frac{\varepsilon + (1) \lambda}{\varepsilon + (1) \lambda} = \text{comp} \langle (1) \rangle$

Case 2: This time perform PF correction and harmonic compensation.
Now find the components currents:

\[
\begin{align*}
\hat{I}_{\text{source}}(1) &= (I_{\text{loadA}}(1) - I_{\text{compA}}(1)) \\
\hat{I}_{\text{sourceB}}(1) &= (I_{\text{loadB}}(1) - I_{\text{compB}}(1)) \\
\hat{I}_{\text{sourceC}}(1) &= (I_{\text{loadC}}(1) - I_{\text{compC}}(1))
\end{align*}
\]

\[
\begin{align*}
\hat{I}_{\text{compA}}(1) &= p(0) - 1 \\
\hat{I}_{\text{compB}}(1) &= p(0) - 1 \\
\hat{I}_{\text{compC}}(1) &= p(0) - 1
\end{align*}
\]
Note that currents are balanced, \(v_a(t)\) and \(i_a(t)\) are in phase now. Unity power factor.

\[
\begin{align*}
\text{Source} A : & 
\text{Source} B : \\
\text{Source} C : & \\
\text{Load A} : & \\
\text{Load B} : & \\
\text{Load C} : & \\
\text{Current Components} : & \\
\end{align*}
\]

Now find the compound currents.
\[ a_1 = 1 \quad a_2 = 1 \quad a_3 = 1 \quad a_4 = 1 \quad a_5 = 1 \quad a_6 = 1 \quad a_7 = 1 \quad a_8 = 1 \quad a_9 = 1 \quad \]

\[ I_1 = I_2 = I_3 = I_4 = I_5 = I_6 = I_7 = I_8 = I_9 = 1 \]

\[ 0 = 0 \quad 0 = 0 \quad 0 = 0 \quad 0 = 0 \quad 0 = 0 \quad 0 = 0 \quad 0 = 0 \quad 0 = 0 \quad 0 = 0 \quad 0 = 0 \]

- Notice since functions are cosines, the phase of the signs changed.
- Negative signs and phase.

Harmonic amplitudes (assumed harmonic ratios with only fundamental frequencies and harmonics removed). Note the

\[ f_{1A} = (1) A \quad f_{13A} = (1) A \quad f_{11A} = (1) A \quad f_{15A} = (1) A \]

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Sinusoidal harmonic terms for first 15 harmonics of a square wave (magnitude will be added later).

* Load current as a function of time

\[ I_{mag} = 100A \quad I_{amp} = 100A \quad I_{phase} = 0° \quad I_{max} = 100A \]

\[ I = I_{mag} \sin(\omega t) \]

Define array of time and determine angular frequency:

\[ t = 1.302 \times 10^{-4} \quad \Omega = \frac{128.60Hz}{1} \]

Initial measured currents:

Active Filterting and Reactive Power Control