Determining Current References from P and Q commands

- Reference: See Chapter 8 in Yazdani and Iravani, specifically section 8.4

**Park's Transformation in Matrix Form**

Using any of these transformations:

\[ V_{0dq}(t) = P(t) \cdot \begin{pmatrix} v_a(t) \\ v_b(t) \\ v_c(t) \end{pmatrix} \]

\[ I_{0dq}(t) = P(t) \cdot \begin{pmatrix} i_a(t) \\ i_b(t) \\ i_c(t) \end{pmatrix} \]

**In DQ reference frame using option 1 for the transformation matrix:**

\[ P_{0dq\_option1} = \frac{3}{2} \left( v_d \cdot i_d + v_q \cdot i_q + v_0 \cdot i_0 \right) \]

\[ Q_{0dq\_option1} = \frac{3}{2} \left( v_q \cdot i_d - v_d \cdot i_q \right) \]

- Note: we need the 3/2 term because of 2/3 constant in transformation matrix.
- This applies for transformation implemented in ATPDraw in class and in PSCAD/EMTDC
- The Q equation will have a negative sign in front in PSCAD/EMTDC
- When we define the reference for $v_d$ to align with the positive peak $v_a(t)$ at the point of interconnect, then $v_q$ is zero.
- In addition, $i_0$ is always 0 in a three wire system, so the $P_{0dq\_option1}$ reduces to:

$$P_{0dq\_option1} = \frac{3}{2} (v_d \cdot i_d)$$

$$Q_{0dq\_option1} = -\frac{3}{2} (v_d \cdot i_q)$$

- Note this will have a positive sign in PSCAD/EMTDC

- Given a $P_{\text{command}}$ and $Q_{\text{command}}$ we can create $I_{d\_ref}$ and $I_{q\_ref}$ with the following:

$$I_{d\_ref} = \frac{2}{3} \left( \frac{P_{\text{command}}}{v_d} \right)$$

where $v_d$ is measured voltage

$$I_{q\_ref} = -\frac{2}{3} \left( \frac{Q_{\text{command}}}{v_d} \right)$$

where $v_d$ is again a measured voltage

**DQ reference frame using option 2 for the transformation matrix:**

$$P_{0dq\_option2} = (v_d \cdot i_d + v_q \cdot i_q + v_0 \cdot i_0)$$

$$Q_{0dq\_option2} = (v_q \cdot i_d - v_d \cdot i_q)$$

- Note: we do not need with the SQRT(2/3) in the transformation matrix
- This applies using the built-in transformation in ATPDraw

- When we define the reference for $v_d$ to align with the positive peak $v_a(t)$ at the point of interconnect, then $v_q$ is zero.
- In addition, $i_0$ is always 0 in a three wire system, so the $P_{0dq\_option1}$ reduces to:

$$P_{0dq\_option2} = (v_d \cdot i_d)$$

$$Q_{0dq\_option2} = -v_d \cdot i_q$$
• Given a $P_{\text{command}}$ and $Q_{\text{command}}$ we can create $I_{d\text{ref}}$ and $I_{q\text{ref}}$ with the following:

$$
I_{d\text{ref}} = \left( \frac{P_{\text{command}}}{v_d} \right) \quad \text{where } v_d \text{ is measured voltage}
$$

$$
I_{q\text{ref}} = \left( \frac{-Q_{\text{command}}}{v_d} \right) \quad \text{where } v_d \text{ is measured voltage}
$$

**ATPDraw implementation**

- $P_{\text{ref}}$ and $Q_{\text{ref}}$ and $P_{3\text{ph}}$ and $Q_{3\text{ph}}$
ATPDraw component for ABC to 0dq or 0-alpha-beta

PSCAD/EMTDC implementation
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