Application Note:
Viewing Unbalance Data in the DataView® PEL Control Panel

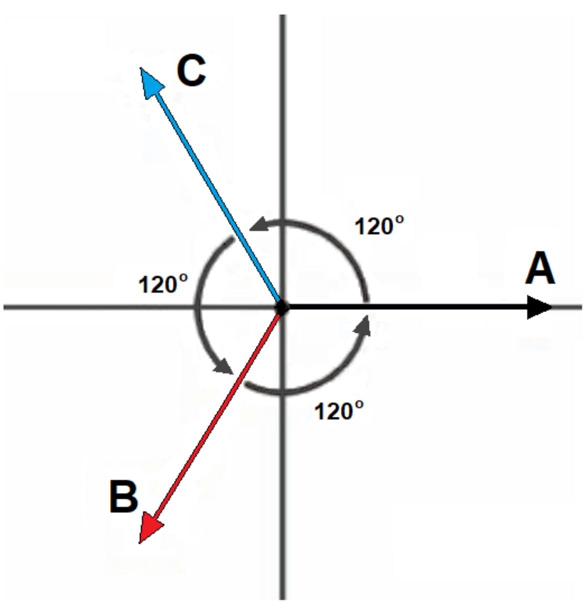
When viewing PEL 105 real-time data in the DataView® PEL Control Panel, you now have the option to display unbalance data. In three-phase AC distribution networks, unbalance (sometimes referred to as imbalance) is the ratio of the negative-sequence or zero-sequence component to the positive-sequence (fundamental) component. This ratio is expressed as a percentage between 0 and 100%, and can be applied to either voltage or current.

Unbalance percentage indicates the efficiency of your distribution network. Reducing unbalance can save significant energy costs. For example, the power quality standard EN50160 (used primarily in Europe and also applicable in other regions) specifies that unbalance should not exceed 2% at the point of common coupling (PCC).

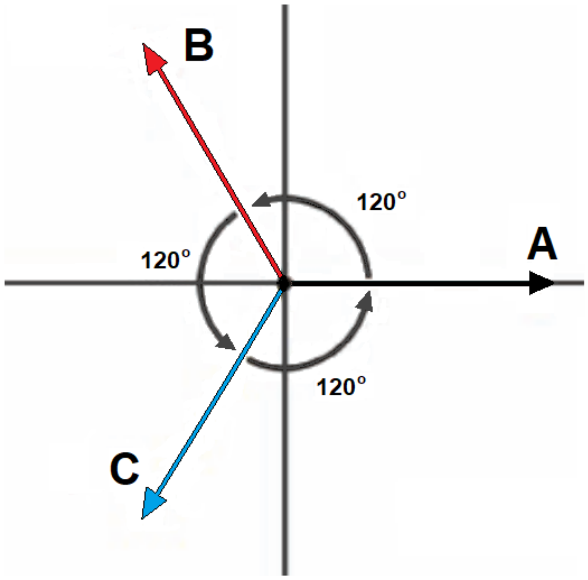
Positive, Negative, and Zero Sequence

To understand what unbalance data means for your distribution system, it's important to be familiar with the concept of phase sequence. In three-phase networks, there are three sets of independent components for both current and voltage. These are called positive sequence, negative sequence, and zero sequence:

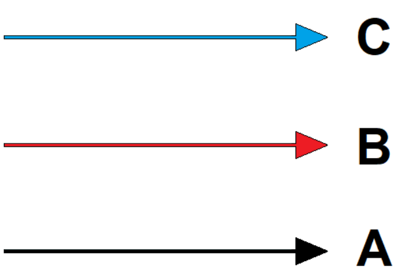
- **Positive sequence** (also called fundamental) represents three equal phasors phase-displaced by 120° with the same phase sequence as the original phasors supplied by generators ("A-B-C" sequence). The positive sequence component is always present and indicates the current flowing from source to load.



- **Negative sequence** represents three equal phasors, phase-displaced by 120° with each other, with the opposite phase sequence to that of the original phasors. The negative sequence component displays “A-C-B” sequence, and indicates current flowing from load to source.



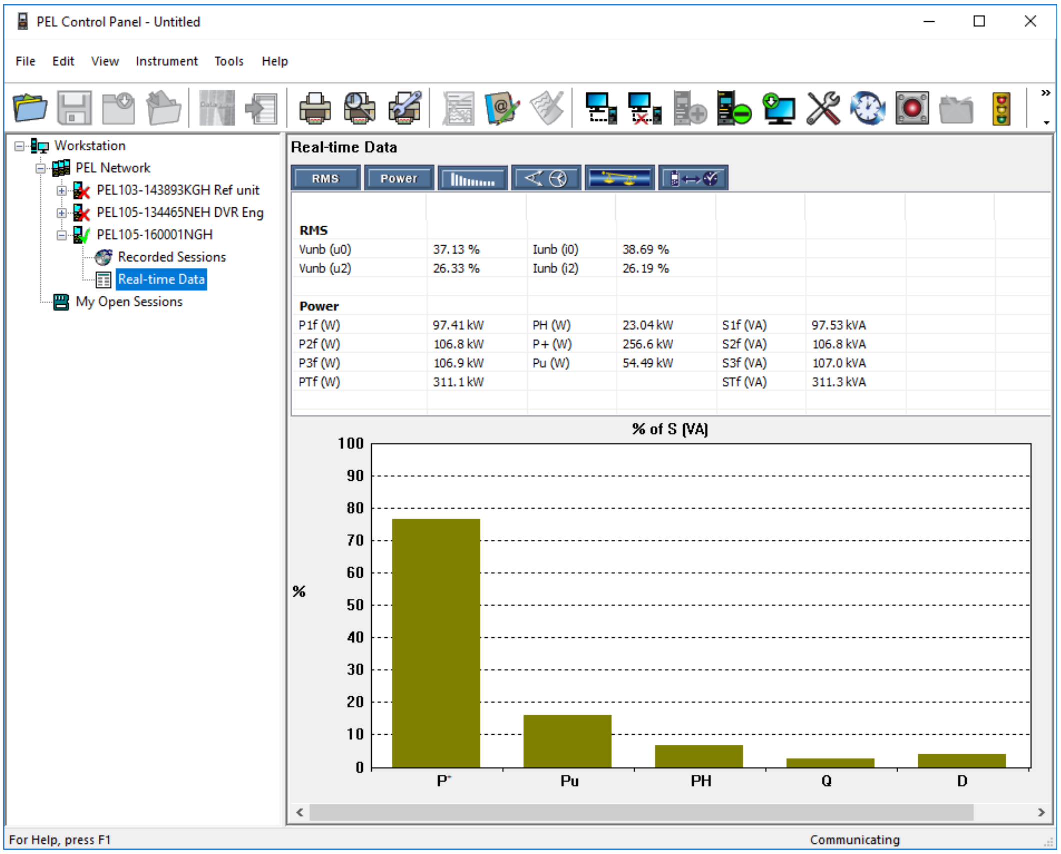
- **Zero sequence** represents the component of the unbalanced phasors that is equal in magnitude and phase.



In a balanced three-phase system operating in normal conditions, only the positive sequence component is present. In the real world, however, 3-phase systems are rarely perfectly balanced. Significantly unbalanced systems indicate the existence of a negative sequence that can be harmful to polyphase loads such as induction motors.

DataView PEL Control Panel

To view PEL 105 unbalance data channels in the PEL Control Panel, click the Unbalance  button in the Real-time Data frame. (Note that this button only appears for PEL 105 instruments.)



At the top of the frame is a table displaying a variety of parameters. The first four are unbalance values:

- **Vunb (u0):** zero-sequence voltage unbalance
- **Vunb (u2)**: negative-sequence voltage unbalance
- **Iunb (i0)**: zero-sequence current unbalance
- **Iunb (i2)**: negative-sequence current unbalance

Each of these values is expressed as a percentage of its fundamental value. For example, in the preceding illustration, **Vunb (u0)** is 37.13%. This means that the zero-sequence voltage is 37.13% the size of the positive sequence voltage. Similarly, the **Iunb (i0)** value indicates the zero-sequence current is 38.69% the size of the positive sequence current.

In an efficient distribution system, the unbalance percentages should be close to zero. The percentages shown in the preceding example indicate that unbalance is a serious issue in the distribution network under measurement, with significant power being lost due to network inefficiency. Below the unbalance data are a number of power parameters. Note that some of these may not be displayed, depending on the type of distribution under measurement:

- **P (P1 , P2, P3, PT)**: active power for phase 1, 2, 3, and total respectively
- **Pf (P1f, P2f, P3f, PTf)**: fundamental active power for phase 1, 2, 3, and total respectively
- **PH**: harmonics active power
- **P+**: total fundamental active power of the positive-sequence power (balanced power)
- **Pu**: total fundamental active power of the negative- and zero-sequence power (unbalanced power)
- **Q (Q1, Q2, Q3, QT)**: fundamental reactive power for phase 1, 2, 3, and total respectively
- **D (D1, D2, D3, DT)**: harmonic distortion power for phase 1, 2, 3, and total respectively
- **S (S1, S2, S3, ST)**: apparent power for phase 1, 2, 3, and total respectively
- **Sf (S1f, S2f, S3f, STf)**: fundamental apparent power for phase 1, 2, 3, and total respectively
- **V+**: Positive-sequence phase-to-neutral voltage
- **V^0**: zero-sequence phase-to-neutral voltage
- **V-**: negative-sequence phase-to-neutral voltage
- **I+**: positive-sequence current
- **I^0**: zero-sequence current
- **I-**: negative-sequence current

Below this table is a histogram (bar chart graph) displaying the percentage of P (active power) that is represented by P+, Pu, PH (harmonic active power), Q (fundamental reactive power), and D (harmonic distortion power) respectively.

The relationships between these parameters are as follows:

> **PTf** (total fundamental active power) = **P+** (total fundamental balanced power) + **Pu** (total fundamental unbalanced power)
>
> **PT** (total active power) = **PTf** + **PH** (harmonics active power)
>
> **S^2** (apparent power^2) = **PT^2** + **QT^2** (total fundamental reactive power^2) + **DT^2** (total harmonic distortion power^2)

Ideally, P+ should be at or close to 100%, while the sum of the remaining variables should be near zero. The lower the P+ percentage (and thus the higher the total sum of Pu, PH, Q, and D), the more your distribution system is wasting energy. For instance, in the preceding illustration P+ is around 77%. This indicates that inefficiencies in your distribution system are wasting approximately 23% of the power received from the source.