GRIDSENSE™

Voltage and Current Unbalance

Voltage unbalance in a three-phase system is marked by a difference in the phase voltages, or when the phase separation is not 120 degrees. Current unbalance is similar, except the values are for current instead of voltage. Large levels of current unbalance generally cause voltage unbalance.

A PowerMonic 45, configured for voltage unbalance, is installed at a motor to determine the cause of overheating.

Voltage unbalance is normally calculated using two methods.

1. The first method involves expressing the negative sequence voltage as a percentage of the positive sequence voltage (the method used in the PowerMonic).
2. The second method uses the maximum deviation from the mean of the three line values expressed as a percentage of the mean of the three line voltages. The PowerMonic can provide these values by exporting the voltage data to a spreadsheet and then calculating the unbalance.

Current unbalanced is calculated similarly using current values.

Causes of Voltage and Current Unbalance

Current unbalance may be caused by the following (as noted above, current unbalance is the primary cause of voltage unbalance):

- **Large and/or unequal distribution of single-phase load** – This can occur when low voltage single-phase services are connected to the phase closest to the neutral. The same problem can occur at medium voltage levels when single-phase distribution transformers are connected to the conductors that are easiest to reach.
- **Phase to phase loads** – This occurs with some equipment that simply requires single phase, but at line-to-line voltage (e.g., a 415 volt welder).
- **Unbalanced three phase loads** – Some three phase loads are comprised of both single and three-phase equipment. It is important that these loads are balanced to meet the power company's requirements.

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Unequal impedances of a three-phase transmission and distribution network can also cause voltage unbalance. This occurs when the overhead transmission or distribution system does not have adequate transposition of the phases in order to balance the system impedance.

Effects of Voltage Unbalance

Resistive loads are relatively unaffected by voltage unbalance, but it causes additional heating/losses with three-phase motors. Motor torque and speed will be negatively affected and the motor may produce excessive noise. The voltage unbalance also causes an increase in current unbalance well in excess of the voltage unbalance percentage. Fig. 1 shows how motors should be de-rated based on the percentage of voltage unbalance.

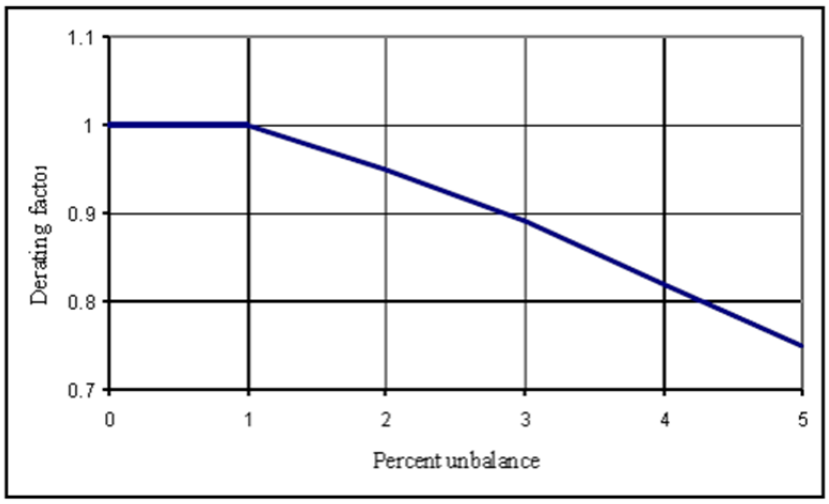

Figure 1. De-rating curve for motors

Variable speed drives (VSD) may trip off due to an increase in AC line currents caused by a compensation for the voltage unbalance. Increased thermal stress of VSD diodes and dc link capacitors and additional triplen harmonics can also occur.

Required Standard (Australia)

The National Electricity Rules sets the limits for voltage unbalance (Fig. 3). Current balance requirements are also set by the National Electricity Rules, distributor or state based Service Rules, and in state-based legislation. Check the requirements for the location being logged.

Table 1: Voltage unbalance limits

Nominal Supply Voltage	Negative Sequence Voltage(% of Nominal Voltage)			
Column 1	Column 2	Column 3	Column 4	Column 5
	no contingency event	credible contingency event	General	Once per hour
	30 minute average	30 minute average	10 minute average	1 minute average
>100kV	0.5%	0.7%	1.0%	2.0%
10kV to100kV	1.3%	1.3%	2.0%	2.5%
<10kV	2.0%	2.0%	2.5%	3.0%

Measurement of Voltage Unbalance

To measure voltage unbalance, the PowerMonic 45 power quality analyzer should be set to 10-minute averages, which will suffice in most instances. However, voltage or current unbalance protection may be tripping and shorter averages may be better suited to determining the cause.

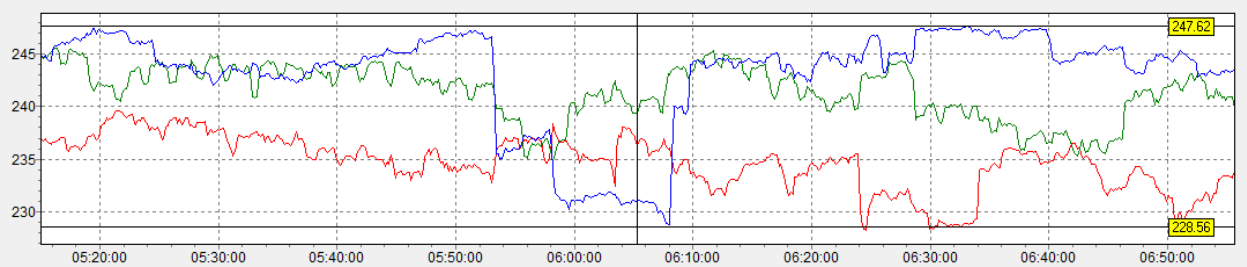

Figure 2. Graph showing excessive voltage unbalance to a motor