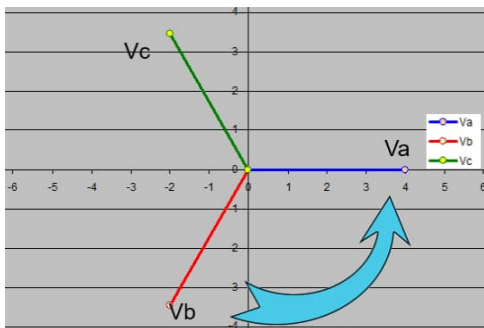


Three-Phase Voltage Imbalances

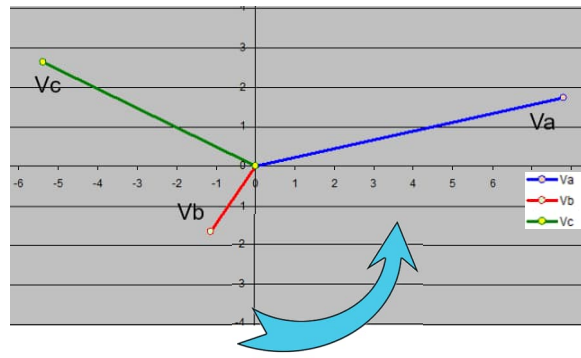
How do I calculate them?

Normally, three-phase power might be expected to have the same voltage magnitude for each phase and with the phases 120 degrees from each other. This is often not the case though when measured values are observed.



Balanced input voltages have all three vectors

with equal magnitudes that are 120° apart.



Unbalanced input voltages would have vectors with

different magnitudes or they are not 120° apart.

Unbalanced voltages can cause problems for motors and Variable Frequency Drives (VFDs). Motors that are run across-the-line would require a significant derate depending on the amount of voltage imbalance that is present in the system. The graph below shows the derating curve from NEMA MG1 14.36. While the text there does not recommend operating a motor in the case that the voltage imbalance is above 5-percent, it shows a derating factor for the rated horsepower of the motor up to that level.

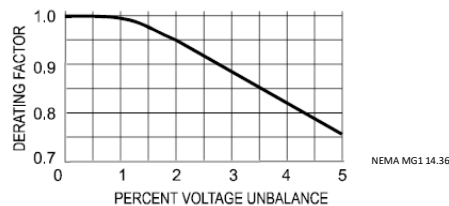


Figure 14-1

When a motor is controlled by a VFD, we can expect to see balanced voltages on the output to the motor even with unbalanced input voltages to the drive. This is because the output of the drive is buffered from the input of the drive by the DC bus. Now the concern is for the input power requirements for the VFD. Here, a relatively small voltage imbalance of only up to 3-percent is typically allowed. This is because a small voltage imbalance leads to a relatively large current imbalance at the input of the drive. This makes for more heating in the input bridge rectifier section of the drive and results in more AC voltage ripple riding on the dc bus capacitors. If this were to be allowed, it could cause excessive heating and it may even shorten the life of the capacitors.

So, now the question may come up about how to calculate the voltage imbalance based on measured values for the voltages at the input of a drive. It turns out there are many different methods for deriving this value. The true definition of voltage imbalance involves a bit of complex algebra and the ratio of the negative sequence component to the positive sequence component. This method would require knowing the magnitudes and phase angles for the voltages, so it is a bit more involved than some of the available approximations that give similar results.

Here we will be using the method from NEMA MG1 14.36.2 where the **Voltage Imbalance** can be defined by:

Vunb (in percent) = 100 X (maximum voltage deviation from average voltage / average voltage)

Example: For measured line-line voltages of 460, 467 and 450, what is the calculated voltage imbalance?

-First calculate the average voltage: $(460 + 467 + 450) / 3 = 459$

-Then find the absolute value of the maximum deviation from the average voltage of 459: $459 - 450 = 9$

Solution: $V_{unb} = 100 \times (9 / 459) = 1.96\%$

If the voltage imbalance that is measured is above the value allowed based on the input power requirements for the drive, there are some possible solutions. Often this imbalance is due to single-phase loads connected to two of the legs of the three-phase power. If this is the case, it may be possible to move some of these loads to balance the power drawn from the phases. Another possible solution is to consider adding an input AC line reactor to the drive. This can have enough of a balancing effect on the voltages to bring them back within spec.