

PERFORMANCE - GENERAL : The effect of unbalanced voltage on polyphase induction motors is equivalent to the introduction of a “negative sequence voltage” having a rotation opposite to that occurring with balanced voltages. This negative sequence voltage produces in the air gap a flux rotating against the rotation of the rotor, tending to produce high currents. A small negative sequence voltage may produce in the windings currents considerably in excess of those present under balanced voltage conditions.

B. UNBALANCED DEFINED : The voltage unbalance (or negative sequence voltage) in percent may be defined as follows :

$$\text{Percent Voltage Unbalanced} = 100 \times \frac{\text{Maximum voltage deviation from average voltage}}{\text{Average voltage}}$$

Example : With voltage of 220, 215 and 210 the average is 215, the maximum deviation from the average is 5, and the percent unbalance = $100 \times 5 / 215 = 2.3$ percent.

C. TEMPERATURE RISE AND LOAD CARRYING CAPACITY : A relatively small unbalance in voltage will cause a considerable increase in temperature rise. In the phase with the highest current, the percentage increase in temperature rise will be approximately two times the square of the percentage voltage unbalance. The increase in losses and, consequently, the increase in average heating of the whole winding will be slightly lower than the winding with the highest current.

To illustrate the severity of this condition, an approximate 3.5 percent voltage unbalance will cause an approximate 25 percent increase in temperature rise.

D. TORQUES : The locked-rotor torque and break-down torque are decreased when the voltage is unbalanced. If the voltage unbalance should be extremely severe, the torques might not be adequate for application.

E. FULL-LOAD SPEED : The full-load speed is reduced slightly when the motor operates at unbalanced voltages.

F. CURRENTS : The locked-rotor current will be unbalanced to the same degree that the voltages are unbalanced but the locked rotor Kva will increase only slightly.

The currents at normal operating speed with unbalanced voltages will be greatly unbalanced in the order of approximately 6 to 10 times the voltage unbalance. This introduces a complex problem in selecting the proper overload protective devices, particularly since devices selected for one set of unbalanced conditions may be inadequate for a different set of unbalanced voltages. Increasing the size of the overload protective device is not a solution in as much as protection against heating from overload and from single-phase operation is lost.