App Note: Estimating Power for Wye Circuits

2/1/1999

This application note describes a technique for estimating the power consumption of a wye circuit. The power consumption of a wye circuit can be computed as the sum of the power flowing in each phase wire:
$PTOTAL = Va \cdot ia \cdot \cos(\theta a) + Vb \cdot ib \cdot \cos(\theta b) + Vc \cdot ic \cdot \cos(\theta c)$

Where θ is the phase angle between voltage and current. The equation to convert from phase angle to power factor (*PF*) is:

$PF = \cos(\theta)$

To accurately estimate the load, you will need to know the power factor or phase angle of the load. Purely resistive loads (incandescent lights, electric heaters, etc.) have a power factor of 1.0. Motors and other loads can have lower power factors, typically ranging from 0.5 to 1.0.

If the load is balanced and the power factor is known, then the equation for the total power is:

$PTOTAL = 3 \cdot V \cdot i \cdot PF$

Where *V* is the voltages of any of the phases with respect to neutral, and *i* is the current in any of the phases (A, B, or C), and *PF* is the power factor of the load.

If the load is not balanced (i.e. the phase voltages or currents are not all equal), then you must use the following equation for the total power.

$PTOTAL = Va \cdot ia \cdot PFa + Vb \cdot ib \cdot PFb + Vc \cdot ic \cdot PFc$

Where *Va* is the voltage between phase A and neutral, *ia* is the current in the phase A wire, and *PFa* is the power factor of the load connected to phase A.

Example 1:

You have a resistive electric heater (*PF* = 1.0) that runs off of a 208 VAC (120 VAC phase-to-neutral) three-phase wye circuit. We will assume that this is a balanced load.

ia = 30.0 Amps *Va* = 120 VAC
PTOTAL = 3 × 120 × 30.0 × 1.0 = 10800 Watts

Note, wye circuits are generally referred to by their phase-to-phase voltage, even though the load is powered from the phase-to-neutral voltage. The phase-to-neutral voltage is equal to the phase-to-phase voltage divided by 1.732 (the square root of 3). So the 208 VAC wye circuit above has a 120 VAC phase-to-neutral voltage.

Example 2:

You have an electric motor (*PF* = 0.7) that runs off of a 480 VAC (277 VAC phase-to-neutral) three-phase wye circuit.

ia = 25.0 Amps *Va* = 277 VAC
PTOTAL = 3 × 277 × 25.0 × 0.7 = 14543 Watts

Continental Control Systems, LLC.
Voice: +1 303-444-7422 ● Toll-Free (USA Only): +1 888-928-8663 ● Fax: +1 303-444-2903
Email: techsupport@ccontrolsys.com ● Web Site: www.wattnode.com