Calculating Power Consumption for a NetworkAIR FM

Abstract

This application note provides guidance for the proper real power consumption measurement and proper method of calculating power consumption in the FM unit. This note also prevents inaccurate conclusions about efficiency based improper power measurement calculations.

Introduction

Often it becomes necessary to calculate the exact power consumption of a piece of electrical equipment. This may be necessary to measure the device's efficiency (known as COP or Coefficient Of Performance for cooling systems), support or disprove the existence of a suspected problem, or to quantify the amount of load a device is placing on the upstream electrical infrastructure. This task can be somewhat complicated when the device under inspection is the FM unit, or any modern precision cooling system.

Identify the problem or methodology

The reason for the difficulty in calculating power consumption is that a precision cooling system has several modes of operation which can be active to varying degrees, all consuming different amounts of electrical power. Operating Load Amps (OLA) are listed in the FM Series technical data manual for various system configurations. However, it may be necessary to make field measurements in order to perform detailed efficiency studies since published OLA's are based on worst case modes of operation. Some components in the FM such as humidifier and reheat are capable of proportional operation, allowing for significant variance in power consumption based on return air conditions. The worst case modes, while possible, may occur very infrequently depending on site and application specifics.

Solution discussion

One must first decide whether it is desired to calculate real power, reactive power, or apparent power. Each has implications on upstream electrical infrastructure sizing, but real power is of primary concern in efficiency studies, so discussion will therefore be confined to this quantity. The basic equation for real power in a balanced 3 phase system is shown in Eq. 1.

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$$P = \sqrt{3} * V_L * I_L * pf \quad \textit{Eq. 1}$$

V_L and I_L are line voltage and line current respectively, and pf is system power factor. Each of these quantities is easily obtainable with a power quality analyzer, such as the Fluke 43. This quantity represents the entire 3 phase real power consumed by a balanced 3 phase load. For a rough measurement, this equation will yield satisfactory results when measuring power consumed by an FM unit, but if high accuracy is needed, each of the 3 phases should be measured individually and summed. This will take into account uneven phase loading (kept to a minimum by design in the FM series) as well as small variations between phase voltages that occur in most buildings. When this method is used, Eq. 2 applies.

$$P = V_a I_a * pf_a + V_b I_b * pf_b + V_c I_c * pf_c \quad \textit{Eq. 2}$$

V_x and I_x are phase voltages and currents in Eq. 2, and pf_x is the single phase power factor associated with each phase voltage and current pair. The only way to perform a highly accurate calculation of an FM unit's actual power consumption is to measure the 9 variables in Eq. 2. Because of the multi-mode operation of the FM system, each of these 9 variables will change depending on the air conditions in the room and set-points of the unit. Possible modes of operation include cooling, dehumidification, reheat, and humidification, as well as some combinations of each. Both short term (on the order of hours) and long term (seasonal) variations in power consumption will likely be observed, and assuming the end goal is to obtain an efficiency measurement, provisions should be made to average these variations when performing power calculations. Short term variations will likely be due to cycling on and off of compressors, and to a lesser extent humidification and reheat (if equipped). For example, power consumption on a 75% loaded FM unit will be overestimated if a single measurement is made while both compressors are running, and underestimated if a single measurement is made while 1 compressor is running. This is because the 75% capacity is realized by running 1 compressor and cycling the second on a 50% duty cycle. There are 2 ways to account for this when performing an application specific efficiency measurement.

Some power quality analyzers have long term trending capability. This feature can be used to make a graphical plot of phase currents, voltages, and power factor over hours, days or weeks. The average values over the period of the experiment are entered in Eq. 2, and average real power consumption is obtained.

If such a power quality analyzer is not available, a manual measurement must be taken for each of the FM's modes of operation and weighted according to how long that mode of operation occurred. By looking at the run-hours for each mode (available at FM Powerview) it can be seen which modes are occurring and for how long. Eq. 2 is computed for each mode that is observed to occur, then time averaged to arrive at an average power. For example, if the unit were observed to operate in 3 modes;

1.) 2 compressor cooling
2.) 1 compressor cooling

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3.) 1 compressor dehumidification with reheat

for times t_1, t_2, and t_3 respectively, the average power consumption would be found as in Eq. 3.

$$P_{avg} = \frac{P_1 * t_1 + P_2 * t_2 + P_3 * t_3}{t_1 + t_2 + t_3} \quad \text{Eq. 3}$$

P_1, P_2 and P_3 are each calculated with Eq. 2 using measured phase currents, voltages and power factors associated with that mode.

Recommendations and Conclusions

The most important thing to consider when collecting power consumption information on multi-mode devices such as precision cooling systems is that instantaneous power consumption can vary drastically from average power consumption. Operating Load Amperages (OLA's) published by manufacturers give a worst case current, but do not take into account site specific application characteristics. These characteristics may result in proportional operation and duty cycle variations causing different average power consumption from that predicted by OLA's. Efficiency comparisons between cooling systems of different manufacturers are not meaningful unless average power consumptions under identical load conditions are calculated in the manner described.

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