

VFD Phase Monitoring Capabilities of the NetworkAIR FM

Abstract

This application note explains the means by which NetworkAIR FM monitors and takes protective action based on input electrical fault conditions.

Introduction

A particularly important aspect of any 3 phase electro-mechanical system's operation is its response to various fault conditions on the electrical supply bus. Fault conditions including phase to ground, phase to phase, and one or more phases open can and will occur for a variety of reasons related to upstream electrical infrastructure problems. Critical equipment should be designed in a manner that minimizes the risk of internal damage should one of these fault conditions occur. The FM unit performs phase monitoring through its variable frequency fan motor drives.

Identify the problem or methodology

The FM unit consists of 4 major 3 phase loads, as well as several smaller 1 phase control related loads. The 3 phase loads are; compressors, fans, reheat coils, and humidifier. The 1 phase loads consist of the main controller, multiple communication boards, and various relays & solenoids. 3 phase rotating loads can be susceptible to damage upon loss of 1 phase. The reason for this is that with only 2 phases connected, the rotor and field rotation within the motor are no longer coincident, resulting in decreased induced voltage and increased armature current. The motor will coast down, possibly stopping, and armature currents up to the theoretical maximum (locked rotor current) may occur through the windings that are still receiving power. This will result in an overheat condition, and possibly irreparable damage to winding insulation. To avoid costly replacement of compressors, a means of protection against this fault must be incorporated.

Solution discussion

In general, the non-rotating 3 phase loads, (humidifier and reheat coils) in the FM unit are not vulnerable to damage upon loss of 1 phase. These loads will simply continue operating at a reduced output, or may shut off altogether if their control circuitry is affected. The single phase loads are connected across L1 and L2. Therefore, if L1 and / or L2 are subject to a L-L, L-G fault,

or open circuit, the FM unit will immediately shut down due to loss of controller. This narrows the necessary discussion of phase monitoring and protection to the compressors and fans, and to open circuit or L-G faults on L3.

VFD drives operate by rectifying incoming AC power to an intermediate DC bus, and then back to AC by way of pulse width modulated IGBT circuits. The VFD drive monitors the status of the incoming AC power indirectly by observing DC bus voltage quality. If DC bus voltage falls excessively the VFD assumes an upstream problem exists, and will provide either an under-voltage or loss of input phase alarm, shutting off the fans in the process. With the fans off, the FM unit's main controller will detect loss of airflow and shut down any operating compressors well before significant temperature rise has put winding insulation at risk. This sequence occurs whenever DC bus voltage cannot be maintained above 200VDC (208VAC models) or 400VDC (480VAC models). Interestingly, a lightly loaded VFD can maintain these voltages through partial rectification during loss of 1 phase and may continue normal operation. However, this state is (fortunately) not attainable in FM units due to the relatively large fan load. The incoming AC bus voltages necessary for rated VFD operations are; 200-230VAC (208VAC models) or 380-480VAC (480VAC models) with +10% -15% permissible fluctuation. If balanced input voltage falls to 165VAC (208VAC models) or 300VAC (480VAC models) the VFD ceases operation in 15ms.

Recommendations and Conclusions

No components in an FM unit are at risk of damage resulting from input main line faults or open circuits. The VFD drive protects fan motors from ever seeing imbalanced current, and ensures the compressors can never see imbalanced current long enough to cause any damaging temperature rise. As a backup protection for the compressors, each has 3 over-temperature sensors located in the armature windings. These serve to remove power to the compressor prior to insulation damage occurring, should a simultaneous control fault prevent the FM unit shut down on loss of airflow.